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

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Abstract

Theory predicts that capital should flow to countries where economic growth and the return to capital is highest. However, in the post-World War II period, per-capita GDP grew almost three times faster in East Asia than in Latin America, yet capital flowed in greater quantities into Latin America. In this paper we propose a 3-country 2-sector growth model, augmented by "wedges" to quantify and evaluate the importance of international capital market imperfections versus domestic imperfections in explaining this anomalous behavior of capital flows. We find that during the 1950's capital controls where important, but domestic conditions dominate. And contrary to what has been thought, after 1960 capital controls in Asia encouraged borrowing.

1 Introduction

For the last 25 years, standard economic theory, beginning with Lucas (1990) and continuing through Gourinchas and Jeanne (2013), among others, predicts that capital should flow to countries where the productivity of capital and economic growth is relatively high. However, the actual pattern of international capital flows stands in sharp contrast to these predictions. Ohanian and Wright (2008) showed that capital has not systematically flowed to regions with the highest capital returns, measured using either the marginal product of capital from a standard Cobb-Douglas technology, or measured using the intertemporal marginal rate of substitution from time separable

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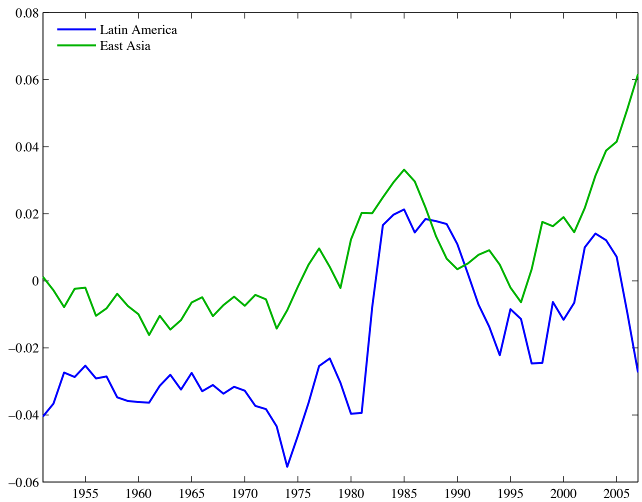
Figure 1: Net Exports (% GDP)



preferences with log utility over consumption. Gourinchas and Jeanne (2013) showed that between 1980 and 2000, that capital flows on average were negatively related to growth in total factor productivity (TFP), rather than positively related, as predicted by neoclassical growth theory.

Perhaps the most striking example of capital flows that are at variance with standard theory is the contrast between flows to post-World War II Latin America and post World War II East Asia. Figure 1 shows next exports for East Asia (Japan, South Korea, Singapore, Hong Kong and Taiwan), compared to net exports for the major Latin American countries, which include Argentina, Brazil, Chile, Colombia, Mexico among others. The figure shows that very little capital flowed to East Asia after World War II, despite the fact that the economies of this region boomed during the postwar period. In contrast, there were large international capital flows to Latin America during this period, despite the fact that productivity growth and economic activity in this region were comparatively low. In fact, Cole et al (2005) document that Latin American economic growth and productivity growth substantially lagged behind the growth of not only the Asian Tigers, but also behind that of virtually all countries in Western and Northern Europe and North America during this period.

Two very different interpretations of this anomalous pattern of international capital flows are as follows. One is that i*nternational capital market imperfections*, including capital controls, and other impediments to international transactions, are the key factor in understanding why capital does not flow to high return and high growth regions (see Edwards (2007) for a discussion of this view and for a number of references). This hypothesis implies that much more capital would have flowed to East Asia if international capital markets been more open in Asia. This view is widely held among economists who have studied Asia, as this region adopted severe regulations and controls on international capital flows after World War II. A very different interpretation of these anomalous capital flows is that *domestic imperfections, particularly domestic capital market distortions,* are the key factor in understanding international capital flows (see Alfaro et al (2011)). This hypothesis suggests that the lack of capital flows to apparently high return countries is not only because of restrictions on international capital flows, but rather importantly reflects domestic distortions.

Relatively little is known about the comparative quantitative importance of international versus domestic imperfections for understanding international capital flows, because of the inherent difficulty in measuring the various imperfections and distortions that impact capital markets. More broadly, the size of international and domestic imperfections, how these imperfections have changed over time, and how they have impacted world economic activity and allocations remain important open questions.

This paper estimates the size of these imperfections and analyzes how they have impacted global capital flows and world economic activity between 1950 and 2008. Our modeling approach is to develop an open economy, general equilibrium framework that is tailored for measuring domestic and international distortions and quantifying their economic impact. Our empirical approach is to construct an international panel dataset which includes measures of per capita output, consumption, investment, hours worked, and international capital flows. We choose the major countries from North America, South America, Europe, and Asia that are reasonably characterized as having market economies over the 1950 - 2008 period. We use country-specific historical data sources to insure that the data is as accurate as possible.

We adapt the business cycle accounting framework of Chari et al (2007) and Cole and Ohanian (2002), both of which focus on a closed economy, to an open economy setting by introducing an *international wedge*, in which a country-specific tax is applied to the purchase of international contingent claims. This country-specific international wedge, in addition to productivity, labor, domestic capital, and government wedges, is sufficient for the model to completely account for the observed variations in output, consumption, investment, labor, and capital flows, just as the four latter wedges are sufficient to account completely for consumption, investment, output, and hours in the closed economy framework.

Specifically, we develop a three-region general equilibrium model, in which the regions are Latin America, East Asia, and the rest of the world (ROW), which is primarily North America, Western and Northern Europe, Australia and New Zealand. We estimate the parameters of the model, and we construct time series of the five wedges using the panel dataset. We then conduct several experiments in which we change the values of specific wedges and/or their stochastic processes, that correspond to policy interventions regarding both international capital market distortions and domestic distortions. These experiments allow us to quantify the importance of international capital market and domestic market imperfections, and to assess how events such as the Latin American debt crisis of the 1980s, and how capital controls and regulations adopted in a number of countries, have impacted global capital flows and more broadly, world economic activity.

We report four main findings. One is that there is substantial variation in both domestic and international distortions that have quantiatively important implications for international capital flows. Specifically, labor wedges in all three regions vary by as much as 50 percent within each region over this period. Our measure of international capital market distortions, which is the tax rate on trading international contingent claims varies by as much as 10 percentage points withing a region, as does the dometic capital wedge. Accordingly, we find that capital flows would have been very different for much of the post- World War II period had the variability in international and domestic imperfections been plausibly reduced, with consumption and labor allocations in these regions differing by as much as 10 - 20 percent compared to their actual levels.

Another main finding is that domestic distortions have played a much larger role in accounting for international capital flows than is typically recognized in the literature. Specifically, we find that domestic labor market and capital market distortions explain as much as 20% of Asian capital flows and as much as 55% of Latin American capital flows during the first two decades of our sample. These effects of domestic distortions on Asian capital flows can be three times as large as the effect of removing the implicit tax rate on Asia's purchases of international contingent claims.

The third main finding is that the impact of international capital market distortions are large very recently, despite the fact that many countries have liberalized their international capital markets. Specifically, we find that the implicit tax on international transactions can explain up to 30% of Asian capital flows during the past two decades and that contrary to what has been thought, after 1960 capital controls encouraged borrowing in Asia by as much as 20% of GDP. The fact that the impact of international capital market distortions is still large despite liberalization, in part reflects the legacy of the accumulation of international capital market distortions over time. Thus, even if international capital market imperfections are entirely removed, the history of international distortions can affect economic activity long after those distortions are eliminated.

Finally, the fourth main finding is that general equilibrium effects are important. ROW distortions can explain up to 60% of the behavior of capital flows to Asia.

The remainder of the paper is organized as follows. Section 2 discusses previous literature. Section 3 presents the model economy and describes how the closed economy wedge methodology is adapted to the open economy setting. Section 4 describes the methodology. Section 5 shows the implied wedges and the counterfactual results, and section 6 concludes.

2 Previous Literature

This paper connects with a number of prominent literatures, including studies of international capital market efficiency, studies of international risk-sharing, studies of differences in international rates of return and capital productivities, and studies of the direction of international capital flows. These studies typically use partial equilibrium frameworks. This approach simplifies analysis considerably, and has provided insights into international capital markets, but these studies often require strong auxiliary assumptions. Moreover, these auxiliary assumptions often are required because the studies within these literatures, for simplicity, often do not model related issues that have potentially important implications. For example, studies of international capital market efficiency implicitly make assumptions about the size of the gains from trade in international capital. Studies of the direction of capital flows implicitly make assumptions about international and/or domestic capital market efficiency, and/or about rates of return. In contrast, this paper develops a general equilibrium analysis that provides a framework, comprised of a multi-country general equilibrium model and a panel dataset of international capital flows and macroeconomic activity, for studying all of these factors systematically, and in turn allows us to measure the size of the gains of trade in international capital, and the size of international capital market imperfections, and of domestic capital and labor market imperfections. We discuss some of the issues regarding the importance of auxiliary assumptions in related literatures below.

Much of the literature on international capital market efficiency takes an approach that requires strong auxiliary assumptions about the sources of gains from inter-temporal trade. As a consequence, these tests often have low power against plausible alternatives. Our approach is intended as a complement to this literature that has some important new advantages in being robust to some auxiliary assumptions, and allowing testing of other auxiliary assumptions.

To understand our argument, consider the best known test of the efficiency of international capital flows due to Feldstein and Horioka (1980). They study actual capital flows in a cross section of countries (this approach has also been adopted by Bayoumi and Rose 1993, Dooley, Frankel and Mathieson 1987, Frankel 1992, Sinn 1992, Taylor 1996, and Tesar 1991). Essentially, they examine the correlation between domestic savings and domestic investment, noting that if capital flows are zero the two must be equal. While this tautologically indicates whether capital flows are positive, the absence of capital flows is not sure indicator of the presence of intertional capital market inefficiencies. Most obviously, capital flows might be small in a world with capital market imperfections because the gains from international trade in capital are small. Other counterexamples have been proposed by other authors (Obstfeld 1986). In other words, these counterexamples demonstrate the low power of the test against plausible alternatives. Some authors have also examined the relationship between savings and investment over time for given countries (eg Feldstein 1983 and Feldstein and Bachetta

1992). Gourinchas and Jeanne (2005) also study differences in savings and investment rates and their relationship to rates of return as proxied by growth rates.

A large literature has examined the extent of risk sharing across countries (a non-exhaustive list includes Crucini 1999, Crucini and Hess 1999, Lewis 1996 and 2000, Obstfeld 1989, 1993, and 1994, and van Wincoop 1994 and 1999). These tests are typically sensitive to specific assumptions about the functional form of the utility function: homotheticity, separability and the elasticity of substitution between different types of consumption (durable and non-durable, for example), or between consumption and leisure, although some relatively non-parametric calculations have been attempted (eg Atkeson and Bayoumi 1993). Although sensitivity to functional form assumptions can never be entirely avoided, the methods we propose below are robust to some functional form assumptions, while the robustness to other assumptions can be examined and we are able to provide diagnostic measures for departures from perfect risk sharing. We discuss this further below.

Another literatures has examined the direction of international capital flows, and whether or not capital flows towards countries with high rates of return. Lucas (1990) for example, examines this under the implicit assumption that countries that are poor are "capital scarce" and thus have high rates of return to capital, and he finds that capital flows from poor countries to rich countries. Caselli and Feyrer (2007) study differences in the marginal product of capital across countries. Caselli and Feyrer find that the marginal product of capital is quite similar across countries in 1996 after using World Bank estimates to adjust capital's share of income for non-reproducible factors of production, including land and natural resources, and after making adjustments for differences in the relative price of investment goods. They find that the marginal product of capital differences are smaller today than they were 30 years ago, which leads them to conclude that international capital market distortions have declined over time. However, the resulting estimates of marginal products are very low, so that after accounting for depreciation the return to investing in capital is negative in most countries, which casts doubt on the estimates.

The most related analysis to this paper is by Gourinchas and Jeanne (2013), who focus on assessing whether international capital, on average, flows to countries with high TFP growth. They also construct two wedges - an investment wedge, which is equivalent to a tax on capital income, and a savings wedge, which is equivalent to a tax on saving - to understand the forces that impacted capital flows during this period. They examine individual countries, using time-averaged data between 1980 and 2000, and find that capital doesnt flow to high TFP growth countries. They find that the main factor accounting for this is the savings wedge, rather than the investment wedge.

Our paper complements Gourinchas and Jeanne along a number of dimensions. One is that our approach allows us to measure the size and nature of distortions to international capital markets as well as domestic capital markets over time, whereas Gourinchas and Jeanne's analysis does not identify these differences. These differences are important, however, in terms of understanding whether international capital flows are primarily impacted by factors within a country, such as domestic policies, or whether they are impacted by international factors. Another dimension is that we are able to study regions simulataneously within a general equilibrium model, whereas Gourinchas and Jeanne focus on looking at individual countries in isolation. The general equilibrium approach allows us to analyze how domestic capital market distortions, domestic labor market distortions, and international capital market distortions work together in determining allocations and capital flows. Another is that our dataset extends back to 1950, which allows us to study regions in the immediate postwar period, and continuing through time, whereas Gourinchas and Jeanne look at data averages between the 1980 - 2000 period. Studying these factors over a longer period of time and without averaging reveals interesting and different findings relative to Gourinchas and Jeanne, including the importance of domestic capital market distortions.

3 An Open Economy Business Cycle Accounting Framework

We first summarize a quantitative framework that we will use to measure changes in capital market efficiency and to quantify their impact on macroeconomic activity over time. The framework extends the closed-economy business cycle accounting approach of Chari, Kehoe, and McGrattan (2007) to a general equilibrium open economy accounting framework. Consider a world populated by j countries each with N_{jt} population at time $t = 0, 1, ...$ In our case $j = R$, L, A, where R stands for the "Rest of the World," L stands for "Latin America," and A stands for "Asia". The decisions of each country are made by a representative agent with standard preferences over consumption and leisure ordered by

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

While these preferences are quite standard, we importantly note that many of the results below can be established for more general preference orderings.

At $t = 0$ each country j chooses a state contingent stream of consumption levels C_{jt}, purchases of capital to be rented out next period K_{jt+1} and state contingent international bond holdings B_{jt+1} subject to a sequence of flow budget constraints for each state and date

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

with initial capital K_{j0} and bonds B_{j0} given. Here, q_{t+1} is the price of a bond that pays off in a particular state in period $t+1$, W_{jt} is the wage and r_{jt}^{K} the rental rate of capital in country j, T_{jt} are government transfers, Ψ_{jt} is a sequence of interest penalties taken as given by the country, and which facilitates asymptotic stationary relative consumptions across countries, P_{jt}^{K} is the price of new capital goods, and P_{jt}^{*K} is the price of old capital goods. The τ^{i} for $i=h,B,K$ represent taxes or "wedges" on wage income (labor wedge), interest income (international wedge) and capital services income (capital wedge) respectively. All revenue from these taxes above the government spending level G_{jt} are rebated in lump sum fashion each period. Note that the wedges on wage income and capital services income are standard in the business cycle accounting literature (see Cole and Ohanian (2002), and Chari, Kehoe, and McGrattan (2007), but the wedge on interest income from international bonds is added to to create an open economy accounting framework. This term drives a wedge between world intertemporal prices and the returns received by individuals in a specific country. This wedge captures not only taxes on international financial transactions, but is a proxy for other capital market imperfections including capital controls and other regulations that impede capital flows. The estimated stochastic process for this term will allow us to construct a time series measure of variation over time in international capital market efficiency by country that we will document, interpret within the context of institutional and regulatory changes at the regional level, and that we will use to assess to assess its impact on macroeconomic activity.

Each country has two representative firms. The first hires labor and capital to produce the consumption good from a standard Cobb-Douglas technology $A_{jt}K_{jt}^{\alpha}h_{jt}N_{jt}^{1-\alpha}$. The second type of firm produces new capital goods K_{jt+1} using X_{jt} units of deferred consumption and K_{jt} units of the old capital good. Their objective function is $P_{jt}^{K}K_{jt+1}-X_{jt}-P_{jt}^{*K}K_{jt}$, and they face a capital accumulation equation with adjustment costs ϕ of the form:

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

One of the j countries is designated a reference country R for which productivity and population evolve according to

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

while for the other j countries, we have $A_{jt}=a_{jt}A_{Rt}$, and $N_{jt}=n_{jt}N_{Rt}$. This ensures that the long run (steady state) levels of consumption and consumption per capita are not degenerate. The levels of government spending and the wedges follow first order autoregressive processes.

We let $a_{Rt}=n_{Rt}=1$, $Z_t=A_{Rt}^{1/(1-\alpha)}N_{Rt}$ be effective labor, with $z_{t+1}=Z_{t+1}/Z_t$ the growth of effective labor and we define $\pi_{t+1}=A_{Rt+1}/A_{Rt}$ and $\eta_{t+1}=N_{Rt+1}/N_{Rt}$. This implies $z_{t+1} = \pi_{t+1}^{1/(1-\alpha)} \eta_{t+1}$. Dividing real variables by Z_{t-1} and denoting the result with lower case letters, this allows us to write down an intensive form version of the economy in which households maximize

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

subject to

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

The first order optimality conditions of the consumption good firm

$$w_{jt} = (1-\alpha) a_{jt} \pi_t \left(\frac{k_{tj}}{h_{tj} n_{jt} \eta_t} \right)^{\alpha}, \text{ and } r_{jt}^K = \alpha a_{jt} \pi_t \left(\frac{k_{jt}}{h_{jt} n_{jt} \eta_t} \right)^{-(1-\alpha)},$$

while for the investment good producing firm they are

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

One technical issue arises. From the FOC in b, if one country is our reference country R we have,

$$\frac{c_{jt+1}/n_{jt+1}}{c_{Rt+1}} = \frac{c_{jt}/n_{jt}}{c_{Rt}} \frac{1 - \tau_{jt+1}^B + \Psi_{jt}}{1 - \tau_{Rt+1}^B + \Psi_{Rt}}.$$

This means we cannot separately identify each country's the international wedge τ^B (and interest penalty term Ψ). In what follows we normalize these levels for our reference country to zero. This means that for all $j \neq R$ we can define relative consumptions $\theta_{jt} = (c_{jt}/n_{jt}) / c_{Rt}$, from which $\theta_{jt+1} = \theta_{jt} \left(1 - \tau_{jt+1}^B + \Psi_{jt+1} \right)$. This generates non-stationary relative consumption levels, and so in order to ensure stationarity, we assume that the steady state international wedge for each country is zero, and that in equilibrium

$$\Psi_{jt} = \left(1 - \tau_{jt+1}^B \right) \left[\left(\frac{\theta_{jt}}{\psi_{j0}} \right)^{-\psi_{j1}} - 1 \right],$$

which generates

$$\ln \theta_{jt+1} = \psi_{j1} \ln \psi_{j0} + (1 - \psi_{j1}) \ln \theta_{jt} + \ln \left(1 - \tau_{jt+1}^B \right), \tag{1}$$

so that the steady state consumption ratio weighted by population is then ψ_{j0}. Note that as the wedge is in general not iid, we have autoregressive innovations:

$$\ln\left(1-\tau^{B}_{jt+1}\right)=\mu_j^{\tau^B}\ln\left(1-\tau^{B}_{jt}\right)+\sigma_j^{\tau^B}\varepsilon_{jt}^{\tau^B}. \tag{2}$$

In the model for each country there are 6 exogenous and 2 endogenous state variables. For J large, this necessitates using perturbation methods to solve the model. This process is simplified further by solving an equivalent pseudo-social planners problem, see Appendix for details.

It is important to point out that, aside from the technical details underlying the method, the basic approach is intuitive and (somewhat) robust to alternative assumptions. Identification of the wedges is quite intuitive. The international wedge, for example, is determined by differences in consumption growth rates across countries. Likewise, the capital wedge is identified by differences in estimated marginal products of capital (from capital/output ratios) from growth rates of consumption within a country. Up to some concerns about functional forms and parameter values, which we return to in a moment, these comparisons take a relatively modest stand as to the source of gains from inter-temporal trade. To see this, consider the example of a limited commitment model of international financial frictions along the lines of Kehoe and Perri (2002). In this 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 international wedge should never be positive when net exports are negative. Intuitively, this is because the limited commitment constraint does not bind when the country receives a positive net resource transfer. Likewise, a defaultable debt model along the lines of Eaton and Gersovitz (1981) predicts that the international wedge should be zero whenever the country is a net saver (that is, have positive net financial assets) regardless of whether or not the country is motivated to save to insure future consumption fluctuations, or to take advantage of profitable overseas investments.

This is not to say that the approach is free of restrictions imposed by functional forms and parameter values. However, we argue that these concerns are small relative to the alternatives. On the question of functional forms, the long run balanced growth observed for many economies places relatively strong restrictions on the sets of functional forms for production and utility that are admissible. Essentially, at least asymptotically, both have to be invariant to scale suggesting that preferences need to be asymptotically iso-elastic (that is, have constant inter-temporal elasticities of substitution asymptotically) and that production functions need to have constant returns to scale. In addition, under relatively minor restrictions on the behavior of the marginal product of capital (essentially, analogs of the Inada conditions) it can be shown that all "neoclassical" production functions are asymptotically Cobb-Douglas (see Barelli and de Abreu Pessoa 2003 and Litina and Palivos 2008).

In any case, the robustness of our functional form assumptions can be assessed by replicating the above analysis under different assumptions. Likewise, robustness to alternative parameter values can be assessed. For example, differences in discount rates would lead to different consumption growth rates even in the absence of international market imperfections, as would different inter-temporal elasticities of substitution as long as world interest rates do not equal country discount rates. It is typically thought, for example, that wealthier countries are more able to substitute inter-temporally than are poorer countries which are closer to subsistence consumption levels. The extent to which this can explain lower consumption growth in poor countries can be assessed by replicating the above analysis under different assumptions for the inter-temporal elasticity of substitution. Furthermore, these parameters can also be estimated and their equality formally tested.

In summary, while we do not claim that our approach is free from auxiliary assumptions, we argue that it is exposed to fewer auxiliary assumptions about the sources of gains from trade, and that assumptions about functional forms and parameter values can be assessed using conventional econometric and economic methods.

In the next section we describe the application of this framework to post-war Asian and Latin American capital flows where data is already available.

4 Methodology

Our methodology follows that of CKM. We use data for each of the three regions together with the optimality conditions of the model to pin down the wedges. We use data on output, consumption, investment, hours worked, population and net-exports for Latin America and Asia to compute seventeen wedges. If we fit the wedges back into our model we recover the original data.

We use a maximum likelihood estimation procedure and apply the Kalman filter to a linearized version of the model to compute the values of the wedges. We use Bayesian estimation to simultaneously recover the processes for the wedges and some of the parameters of the model.

Just as in CKM, to evaluate the effect of each wedge we conduct a counterfactual experiment where we simulate the economy with that wedge fixed at its initial value. Each experiment isolates the direct effect of the wedge, but retains its forecasting effect on the other wedges. This procedure ensures that the expectations of the wedges are identical to those in a model where all the wedges are present at the same time.

4.1 Data and Processes for the wedges

Our data for the Rest of the World is from OECD sources. We use the World Bank Global Development Indicators for Asia and Latin America, and we supplement using

Mitchell 2001 and other country specific sources.

In the data real output, consumption, investment and population are nonstationary even with respect to a log-linear trend.[1] To make the data comparable to the model, we follow the approach presented in Fernandez-Villaverde and Rubio-Ramirez (2007) and assume random walks for the two processes that are commonly thought to be extremely persistent: the efficiency wedge for the rest of the world A_R and population for the rest of the world N_R. Thus, the growth rates of the efficiency wedge (π) and population for the rest of the world (η) are assumed to follow first-order autoregressive processes. We denote by π_{ss} the mean growth rate of the efficiency wedge for the rest of the world and by η_{ss} the mean growth rate of population.

As mentioned earlier, from the optimality conditions of the model we can see that all variables grow at a factor $(\pi_{ss})^{\frac{1}{1-\alpha}}\eta_{ss}$. Then, if we take the first differences of the efficiency wedge and population by defining $\pi_t = \frac{A_{Rt}}{A_{Rt-1}} = \pi_{ss}\exp(\sigma_\pi \varepsilon_{\pi_t})$ and $\eta_t = \frac{N_t}{N_{t-1}} = \eta_{ss}\exp(\sigma_N \varepsilon_{Nt})$, we can derive an aggregate trend $Z_t = A_{Rt}^{1/(1-\alpha)} N_{Rt}$, which is common to all the variables. Hence, we define detrended variables of the form $x_t = \frac{X_t}{Z_{t-1}}$.

We assume that the rest of the wedges (with the exeption of the international wedge) follow first-order autoregressive processes around their steady-state values:

$$\ln a_{jt+1} = (1-\rho_j^a)\ln a_{jss} + \rho_j^a \ln a_{jt} + \sigma_j^a \varepsilon_{jt}^a,$$

$$\ln n_{jt+1} = (1-\rho_j^n)\ln n_{jss} + \rho_j^n \ln n_{jt} + \sigma_j^n \varepsilon_{jt}^n,$$

$$\ln \tau_{jt+1}^i = (1-\rho_j^{\tau^i})\ln \tau_{jss}^i + \rho_j^{\tau^i} \ln \tau_{jt}^i + \sigma_j^{\tau^i} \varepsilon_{jt}^{\tau^i},$$

and

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

where $i = h, k$, $j = L, A$ for the productivity and population processess, and$j = R, L, A$ for the rest.

4.2 Calibration and Estimation

Our model has 10 structural parameters and 55 parameters that characterize the wedges. The 10 structural parameters are standard to the business-cycle literature. We set the share of capital in the Cobb-Douglas production function α to 0.36, the discount factor β to 0.96, the depreciation rate δ to 7% per year, γ to 1.5 and we normalize ψ to 1. The parameter ν in the investment adjustment costs is set to 2.7 such

[1]Cogley and Nason (1995) and Canova (1998) show that the use of the Hodrick-Prescott filter introduces significant biases into the data by amplifying business-cycle frequencies.

Table 1: Population and Efficiency Wedge Parameters

Parameter	Value	Parameter	Value
π_{ss}	1.0085	ρ^a_L	0.99
η_{ss}	1.0067	ρ^a_A	0.89
a_{Lss}	0.37	ρ^n_L	0.99
a_{Ass}	0.77	ρ^n_A	0.97
η_{Lss}	1.13	σ^n_L	0.003
η_{Ass}	0.29	σ^n_A	0.004

Table 2: International and Government Wedge Parameters

International Wedge							
ψ_{L0}	ψ_{A0}	$(1-\psi_{L1})$	$(1-\psi_{A1})$	$\mu^{\tau^B}_L$	$\mu^{\tau^B}_A$	$\sigma^{\tau^B}_L$	$\sigma^{\tau^B}_A$
0.13	0.95	0.94	0.94	0.24	0.36	0.03	0.02

Government Wedge								
g_{Rss}	g_{Lss}	g_{Ass}	ρ^g_R	ρ^g_L	ρ^g_A	σ^g_R	σ^g_L	σ^g_A
0.19	0.18	0.12	0.73	0.80	0.86	0.03	0.05	0.17

that Tobin's q is around 4, and the parameter b_j in the investment adjustment costs is set such that they are absent in steady state for each region.

Some of the parameters of the wedges are easy to identify by using the data or data together with the optimality conditions of the model, helping us reduce the number of parameters that are estimated using Bayesian methods and improve identification.

We use population data for the rest of the world to identify η and its AR(1) process, and combined with population data for Latin America and Asia we can identify n_L and n_A and their autorregressive processess. Table 1 shows the results. Using η_{ss}, together with the assumption that the world grows at 2% ($z_{ss} = 1.02$) and using the growth rate of the model economy we can pin down π_{ss}. We make an educated guess about the fficiency wedge parameters that are not well identified by the model by using the Solow residual.

The international wedge can be directly identified using consumption and population data (see Equations 1 and 2), so its traightforward to estimate its ARMA(1) process, see Table 2.

The AR(1) process for the government wedge can also be estimated directly from the data and the results are in Table 2.

We calibrate the steady state of the labor and capital wedges to fit the mean of per-capita hours worked and the capital to output ratio in the data, $\tau^h_{Rss} = 1.9$, $\tau^h_{Lss} = 0.84$, $\tau^h_{Ass} = 1.17$, $\tau^k_{Rss} = 0.96$, $\tau^k_{Lss} = 0.95$, $\tau^k_{Ass} = 0.99$.

The remaining parameters are estimated using Bayesian methods (see An and Schorfheide (2007)). Linearized equations of the model combined with the linearized

Table 3: 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	0.97	0.99
$\rho_R^{\tau^K}$	Beta	0.99	0.01	0.98	0.98
$\rho_L^{\tau^K}$	Beta	0.90	0.09	0.83	0.83
$\rho_A^{\tau^K}$	Beta	0.90	0.09	0.73	0.76
σ_π	IGamma	0.02	0.01	0.02	0.01
σ^a_L	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	0.02	0.01

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

Our model explains by construction 100% of the variation in the data and thus provides the decomposition we need for the business cycle accounting exercise.

5 Results

5.1 Behavior of the Wedges

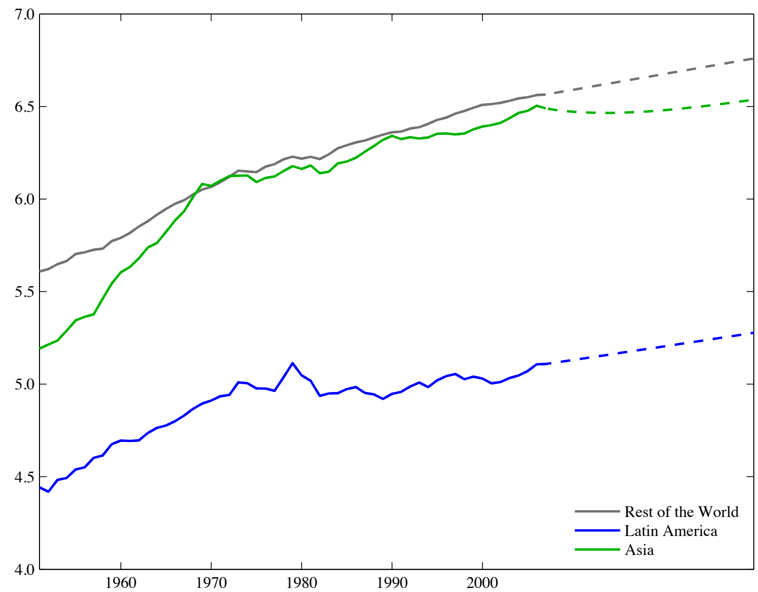
It is well known that institutional factors have played a key role in the adoption and subsequent removal of capital controls and other regulatory impediments to international capital flows. But previous research has been challenged in terms of quantifying the size of these distortions. Specifically, measuring the effective size of these controls within an economic model context, much less quantifying the impact of these impediments, has been difficult. This reflects the fact that controls, regulations, and international transaction taxes and fees are complicated, they vary considerably over time, and moreover, they may or may not be enforced. To see this, consider the case of Japan, which incorporated substantial regulations and restrictions on capital flows in the postwar period, as their goal was to limit new debt accumulation and thereby not weaken their international credit rating (Pyle (1996)). Restrictive capital controls were in place in the 1950s and 1960s, particularly on foreign direct investment, though on the other hand, Japan 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 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. Our estimated international capital flow wedges provide a measure of the importance of these various complicated controls, taxes, and fees. Moreover, we will interpret the movements in these wedges within the context of the evolution of the controls, taxes, and fees as summarized above.

The following figures depict the model estimates of the pseudo social planners wedges, along with the predicted future path of these wedges estimated from the data. Figure 2 reports our estimates of total factor productivity across the three economies (the "efficiency wedge"). The figure shows that productivity growth in Asia during the 1950s and 1960s was considerably faster than that observed in either Latin America, or the rest of the world on average, which further suggests capital should have flowed to Asia.

Figure 3 reports our estimate of the labor wedge. A number greater than one here denotes employment at levels greater than predicted by the model, which is interpreted as a subsidy to labor; a number less than one identifies relatively low employment which is interpreted as frictions that have effects analogous to a labor tax. The Figure shows that Latin America faced larger labor wedges than all other regions in the early decades of this period, although these labor wedges improve towards the end. Asia started with relatively low labor wedges that improve further.

The labor wedge can reflect various factors that impact the relationship between the household's marginal rate of subsitution between consumption and leisure and the marginal product of labor, including changes in labor and consumption taxes, (see Chari, Kehoe, and McGrattan (2007), Ohanian, Raffo, and Rogerson (2008)), changes in employment protection and other restrictions on hiring or firing that are broadly identified as labor market rigidities (see Cole and Ohanian (2015)), changes in unemployment benefits policies (see Cole and Ohanian (2002)), and changes in firm monopoly power (see Chari, Kehoe, and McGrattan (2007)). Of these factors, those that have received the most attention using cross-country /panel data are changes in taxes and

Figure 2: The Efficiency Wedge

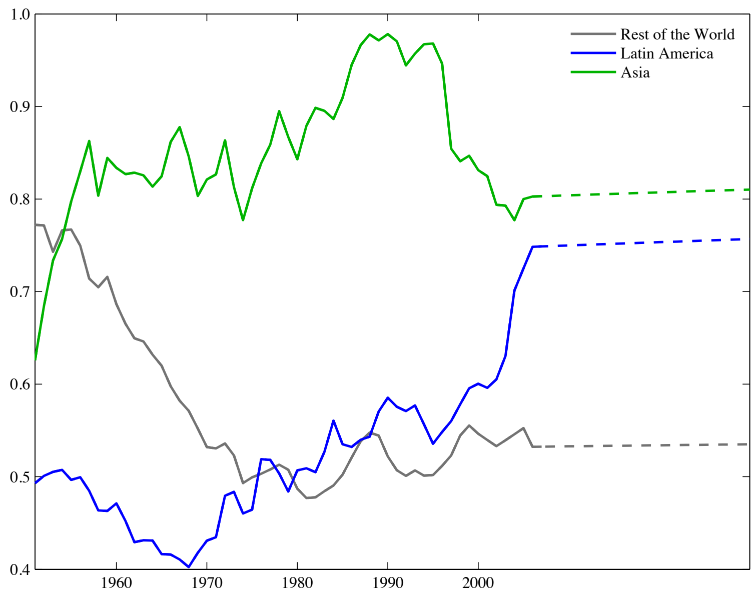


changes in labor market rigidities. We find a number of similarities between the labor wedge estimated here and results from studies of specific labor market distortions and taxes that suggest that our estimated labor wedge is reasonably capturing policy changes that impact the labor market.

In terms of taxes, studies have documented and analyzed changes in labor income and consumption taxes as these factors impact the labor wedge over the period that we study. Given data availability, these studies are largely limited to the OECD countries,which include many of the countries in our ROW category. 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. To compare these findings to our estimated ROW labor wedge, note that our ROW labor wedge will be averaged over these European countries and over other OECD countries that did not have large tax changes, such as the U.S. and Canada. Given this pattern of large changes in European countries, and small changes in the other ROW countries, it is plausible that movements in our ROW average may indeed reflect the large tax increases that occurred in Europe. With this perspective, we find a strong similarity between our ROW labor wedge and the tax-wedge results from Prescott (2002) and Ohanian, Raffo, and Rogerson (2006).

In terms of labor market rigidities, and distortions, there are a number of studies that construct measures of these distortions across countries. To our knowledge, the most comprehensive study in terms of the number of countries and years is by Campos and Nugent (2009), who construct a panel dataset from 145 countries between 1950

Figure 3: The Labor Wedge



and 2004 of a de jure employment law rigidity index. Their approach is similar to that of Botero, Djankov, La Porta, Lopez-de-Silanes, and Shleifer QJE 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 spans the full period of time that we analyze. We are unaware of other measures of labor market distortions that cover the full period which we study.

Our measure of labor wedges has some qualitatively similar patters to those reported by Campos and Nugent (2009). Specifically, Campos and Nugent's measure of aggregated Latin American labor market rigidity shows gradual and modest improvement in terms of declining rigidity from the 1960s until the mid-1990s, and then shows considerably lower rigidity from 1995-2004. Our Latin American labor wedge is qualitatively very similar, as it declines moderately between the 1960s to the mid-1990s, and then declines considerably between the mid-1990s and 2004. The Campos and Nugent measure of aggregated European labor market rigidity shows increased rigidity from the 1950s up until the mid-1980s. This is qualitatively similar to the rest of the world labor wedge, which increases from the 1950s until the mid-1980s. For Asia, Campos and Nugent report an increase in rigidity after the mid-1990's and little change before that. Our Asian labor wedge increases after the mid-1990s, which is qualitativley similar to Campos and Nugent. However, our Asian labor wedge declines considerlaby before then. This may reflect factors that are not considered by Campos and Nugent, or may be the consequence of populations in the Asian countries moving from rural areas, in which labor markets may not be as efficient, to more urban areas.

Figure 4 presents our estimates of the capital wedge. Recall that this wedge affects the Euler equation; it 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. We interpret this wedge as an estimate of domestic capital market distortions. The ROW and Latin America have a capital tax (a wedge less than one), while Asia starts with an increasing distortion that falls dramatically between 1960 and 1980. Latin America is estimated as having larger domestic capital market distortions through the mid 1980's, to then fall in between those of Asia and ROW. Figures 3 and 4 together suggest that domestic factor market distortions in Asia were relatively large at the beginning of the sample, and declined quickly throughout the middle decades of the sample. This is one potential explanation for the relatively low capital flows into Asia during this period.

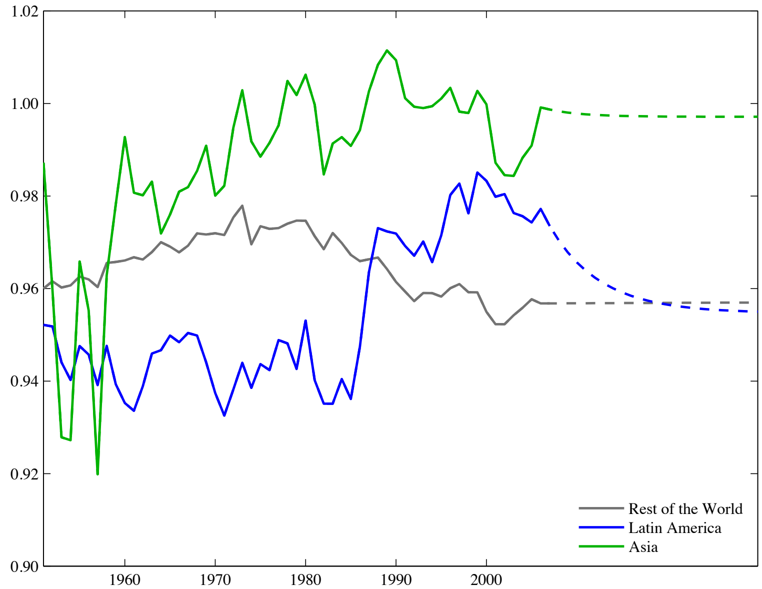
The IMF has surveyed changes in capital market regulations and restrictions for a number of countries between 1973 and 2005, and have ranked a number of financial market indicators, including credit controls, interest controls, privatization of banks, entry barriers to banking, banking supervision, bank reserve and requirements. They score these indicators on a ranking between 0-4, which ranges between fully repressed (0) to fully liberalized (4). Their database provides a time series of these scores, as well as indicators of reforms, major reforms, reversals, or major reversals in these individual policies for each year.

The changes in capital market regulations and restrictions constructed by the IMF are plausibly related to the operation of financial markets and therefore should also be related to the estimate capital wedges, with improvement in regulations and restrictions being associated with a narrower capital wedge. Since there is no direct mapping between the IMF measures and the capital wedges, we compare whether the trends in our estimates of capital wedges line up with the trends the IMF measures of capital market. We find that they do.

We summarize the pattern of the IMF evaluations for the four largest Latin American countries: Argentina, Brazil, Chile, and Mexico. These countries adopted a number of financial liberalization reforms throughout this period, with the exception of the early – mid 1980s, which coincides with Latin American debt crises. This pattern of trend improvement in capital market regulations and restrictions, with some reversal in the 1980s, is consistent with the estimated capital wedge of Latin America.

Specifically, in 1973, Argentina, Brazil, and Chilean financial markets were ranked as "fully repressed", and Mexico was ranked as "partially repressed". These countries then implemented reforms in the 1970s that were fairly similar, with 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 their capital markets, including the reduction of entry barriers, further

Figure 4: The Capital Wedge



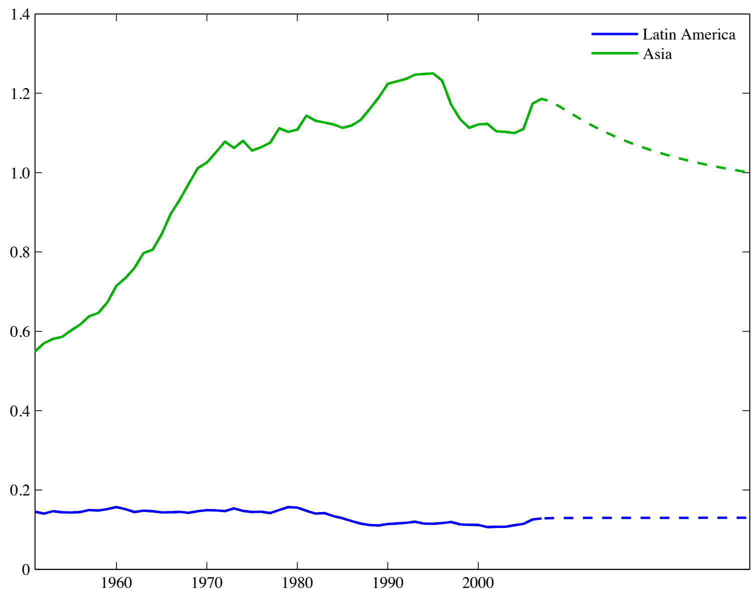
privatization of commercial banks, less reliance on interest rate and credit controls, and more market-based security market policies. By 2005, these countries primarily all had composite rankings that ranged between fully liberalized and partially liberalized financial markets.

The IMF qualitative assessment dovetails with our quantitative estimates of the capital wedge. Specifically, the Latin American capital wedge narrows in the 1970s, it then widens very slightly in the early-mid 1980s, which is the period of some policy reversals, and then it narrows again over the remainder of the period as Latin American implements additional financial market reforms.

For Asia, we summarize changes for Hong Kong, Japan, Singapore, Taiwan, and South Korea, and compare these patterns to our estimates of the Asian capital wedge. In 1973, the IMF ranked the financial markets of Taiwan as fully repressed, of Japan as partially repressed, and of Hong Kong and Singapore as partially liberalized. These countries almost exclusively adopt financial market liberalizations. The 1970s and 1980s saw almost all countries liberalize in terms of modernized security market policies, and less reliance on interest rate controls and credit controls. By 2005, all countries were ranked as fully liberalized or close to fully liberalized. These patterns dovetail with our estimated capital wedges for Asia, which shows a trend narrowing of the wedge over this same period. This narrowing is consistent with the persistent improvement in financial market liberalization enacted by these Asian countries over this period.

The role of capital controls, as estimated from the international wedge, is depicted in Figures 5 and 6. Figure 5 plots the international wedge from the pseudo planners

Figure 5: The Cumulative International Wedge



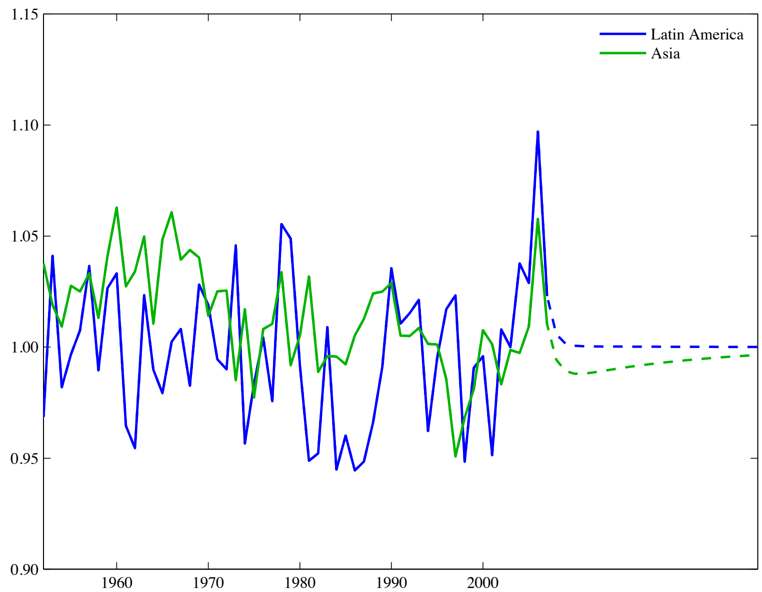
problem while Figure 6 recovers the international wedge from the competitive equilibrium problem. Since all wedges are relative to the rest of the world, there are only two lines in these Figures. Figure 6 shows that the international wedge for Asia was greater than one in the early years of the sample. This means that Asia was faced with a tax on borrowing (or alternatively a subsidy on international savings) in the early years of the period (a number greater than one makes repayments on debts larger and hence more negative, and increases the return on foreign savings). Latin America, by contrast, had wedges that were frequently negative during this period, which acts as a subsidy on borrowing.

By the 1990s these wedges had largely converged. This is consistent with the pattern identified in Figure **??** which shows that capital flows to the two regions become more synchronized towards the end of the sample. Overall, the results for the international wedge are supportive of a role for capital controls, or other frictions in international capital markets, in discouraging capital flows into Asia and encouraging flows into Latin America.

5.2 Counterfactuals and Decompositions

We now conduct experiments to assess the impact of various policy changes on capital flows by removing the evolution of the wedges. For this exercise we will focus on the effect of the labor, capital and international wedges. Where the labor and capital wedges reflect domestic frictions and the international wedge reflects international frictions. The order in which we remove a wedge matters, and there are more than forty thousand

Figure 6: The Competitive Equilibrium International Wedge



ways (orderings) in which we can remove them. For computational reasons we will aproximate this number by removing the wedges in random order ten thousand times, and then average over all of these combinations. In order to quatinfy the impact of the labor and capital wedges (or remove them), we treat them parametrically and fix them at their initial value.[2] To quantify the impact of changes in international capital market imperfections, we treat the international wedge parametrically and fix its value to one. Note that every time we remove a wedge (fix it to its initial value and resolve the model) relative initial wealth will jump as well. This is undesirable. In order to maintain the initial wealth of each region constant throughout all the conterfactual experiments, we iterate to find the initial jump in relative consumption.

Figures 7 and 8 show the counterfactual results for Latin America and Asia, respectively. In each period, the effect of all wedges in absolute value accounts for a 100% of the change in net-exports (the sum of the bars). A negative bar, means that had that wedge not been there, then there would have been capital inflows to the region. A positive bar, means that had that wedge not been in place then there would have been capital outflows to the region. As a result, the sign of the barchart indicates the direction in which each wedge was affecting capital flows.

Figure 7 shows the effect of removing its own wedges and an aggregate of all remainding wedges on Latin American net-exports. We can see that throughout the first half of the period, their capital and international wedge were promoting capital inflows, while their labor wedge was preventing even more capital from flowing in. During the

[2]Following Chari, Kehoe and McGrattan (2007).

second half of the period the roles of the wedges reverse. Their capital and international wedge were preventing capital from flowing into Latin America and the labor wedge was helping capital inflows.

The intuition behing these results is as follows. The Latin American labor wedge in the initial period is low compared to its values in the first half of the period and then its high. Thus, fixing the Latin American labor wedge at its initial level initialy reduces and then increases the price of labor. Consequently, while the cost of labor is relatively low, Latin American hours worked and investment rise, attracting capital flows to finance a consumption boom. Then, when the cost of labor becomes relatively high, hours worked and investment decrease causing consumption to contract and capital to flow out. The pattern of the capital wedge in Latin America implies that the initial value is lower than values for the remainder of the 1950s through the 1980s. This means that through the 80's the cost of capital is lower, generating a large increase in investment and hours worked that is enough to increase consumption and save abroad. After the 1980's investment and hours flatten out and there are capital inflows to smooth consumption.

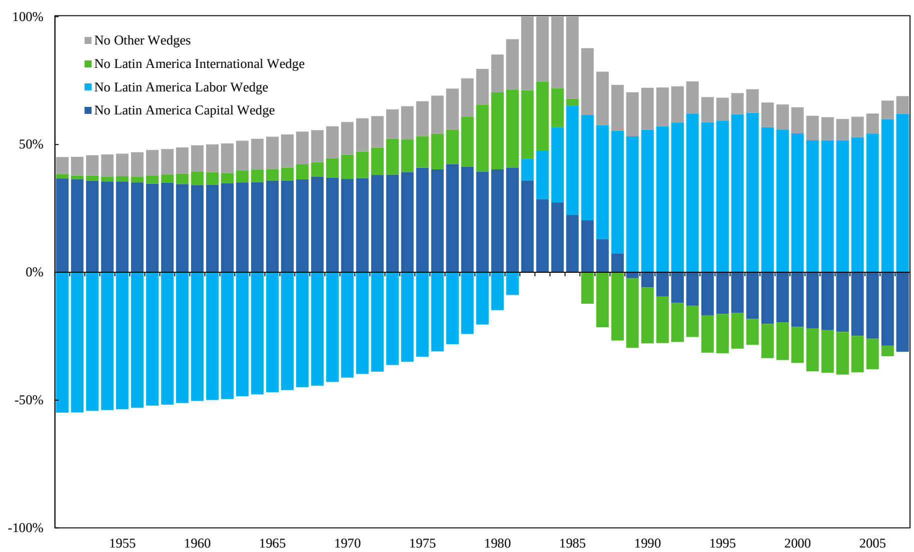
Interestingly enough, we see, that during the Latin American debt crises, the capital flow reversal that we observed would have been even larger if these frictions were not in place. Overall, we find that if we were to remove all domestic and international frictions, then Latin America would have received even larger inflows during the first decade and then would have experienced capital outflows.

Figure 8 shows the results of the counterfactual exercises for Asian net-exports. There are two graphs in the figure. The first graph shows the effect of removing their own wedges, and the second graph shows the result of removing the labor and capital wedge for ROW. As we can see, for the first decade, their own international wedge was preventing capital from flowing in but quantitatively its not playing a central role. After 1963, the Asian international wedge was actually encouraging capital to flow into the region.

From the first graph of the figure, we can see that the labor wedge plays a much more prominent role during the first two decades, and that it was preventing capital from flowing in throughout the whole period. Note that by fixing the Asian labor wedge to its initial value, we are imposing a comparatively high tax on labor income, as this wedge declines by about 35 percent over time. This implies that in the counterfactual, labor input is reduced which in turn reduces incentives to invest in Asia. As a result, output and labor fall considerably compared to the data, and Asia receives substantial capital inflows which are used to smooth consumption.

The role of their capital wedge is smaller than that of the labor wedge, but it was encouraging capital inflows through the first half of the period and preveting capital from flowing in towards the end. For Asia, the initial capital wedge is low relative to its value for the rest of the 1950s through the 1970s and the intuition behind its effect its very much the same as for the Latin American counterfactual. Finally, we can see that

Figure 7: Net-Exports Counterfactuals for Latin America



all other wedges (from Latin America and ROW) played a significant role in preventing capital inflows to Asia, specially during the first twenty years.

The second graph of Figure 8 expands on this result. It shows that the capital wedge for ROW was preventing capital from flowing into Asia for the first two decades and a half, while the labor wedge was fostering capital inflows. However the effect of the capital wedge was larger, meaning that domestic wedges for ROW where preventing capital from flowing into Asia for this earlier part of the period. This result shows the great importance of the general equilibrium effects for understanding the direction of capital flows.

In summary, we find that both international and domestic wedges have had very large impacts on capital flows. For Latin American capital flows, domestic frictions have clearly been more important than international factors and for Asia domestic frictions also explain the relatively low capital inflows during the first two decades of our sample. Towards the end of the sample, international factors become more important for Asian capital flows even though at this point many countries have liberalized their international capital markets.

Tables 4 and 5 summarize the absolute relative contribution of the labor, capital and international wedges for capital flows in each decade of our sample.[3] Table 4 shows the results for Latin America. As we can see during the 50s and 60s, domestic conditions (τ_L^h plus τ_L^k) explain between 48% and 55% of the movements in capital flows, while international conditions (τ_L^B) only explain between 3% and 6%.

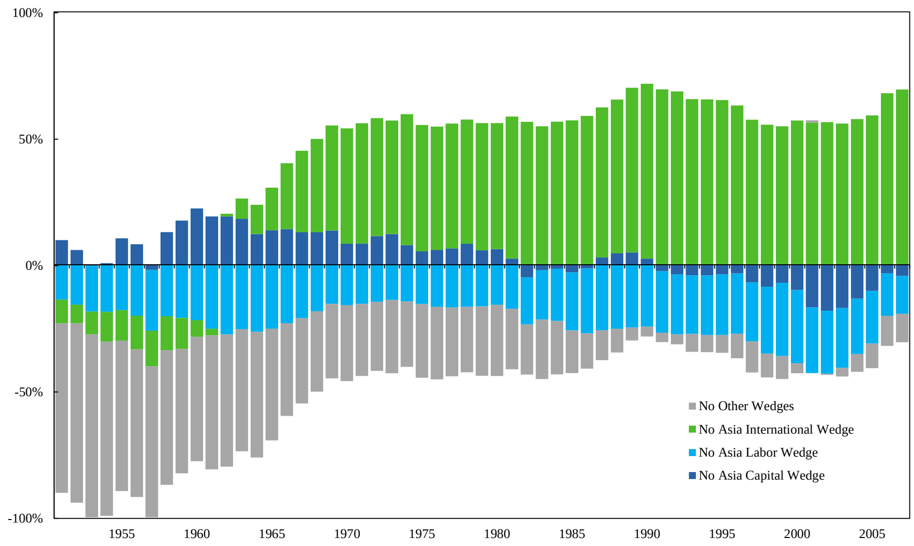
Table 5 shows that for Asia, during the decade of the 1950s domestic conditions (τ_A^h plus τ_A^k) were three times more important than international conditions (τ_A^B) and during the 1960s domestic frictions explained 21% percent of capital flows while international frictions only explained 13%. Towards the end of the sample international capital imperfections become between two and three times more important than domestic imperfections.

6 Final Remarks

This paper applied an open economy business cycle accounting framework to analyze the size and pattern of domestic and international wedges and their impacts on the world economy. To our knowledge, this is the first systematic quantitative measurement of international capital market wedges, which is facilitated by the application of standard neoclassical growth theory. We find that domestic and international wedges are large, and that even modest differences in their evolution over time would have had very large impacts on capital flows, the location of production, and allocations.

[3] Each number in the table is 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.

Figure 8: Net-Exports Counterfactuals for Asia



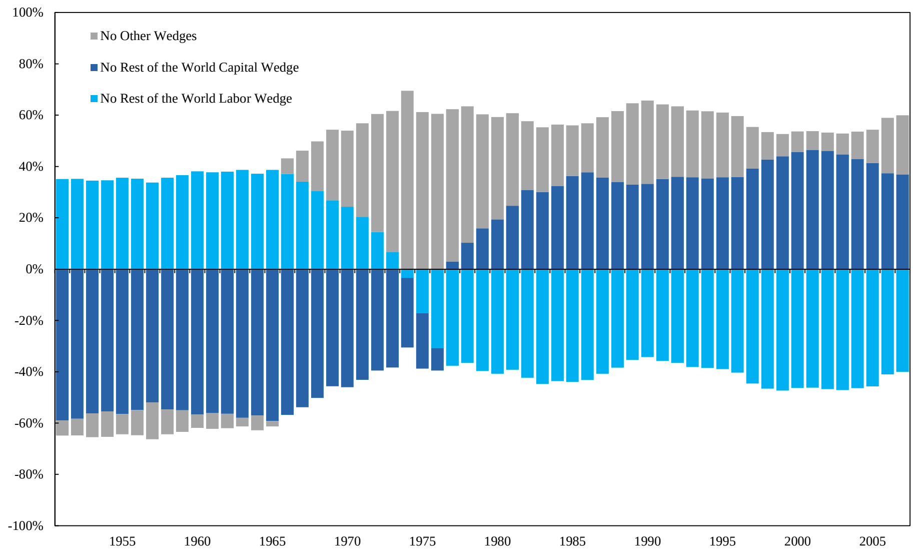


Table 4: Contribution of the different wedges for Latin American Net-Exports, by decade.

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.17	0.17	0.15	0.14	0.12	0.13
τ_L^h	0.36	0.30	0.25	0.27	0.38	0.38
τ_A^h	0.04	0.05	0.06	0.07	0.05	0.03
τ_R^k	0.15	0.15	0.14	0.13	0.15	0.15
τ_L^k	0.19	0.18	0.18	0.13	0.10	0.16
τ_A^k	0.03	0.04	0.04	0.05	0.03	0.02
τ_L^B	0.03	0.06	0.12	0.13	0.11	0.09
τ_A^B	0.03	0.04	0.07	0.08	0.06	0.04

Table 5: Contribution of the different wedges for Asian Net-Exports, by decade.

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.21	0.18	0.15	0.23	0.25	0.29
τ_L^h	0.11	0.10	0.08	0.08	0.06	0.06
τ_A^h	0.10	0.14	0.12	0.12	0.11	0.07
τ_R^k	0.41	0.30	0.15	0.19	0.24	0.28
τ_L^k	0.07	0.06	0.06	0.04	0.03	0.04
τ_A^k	0.05	0.07	0.05	0.02	0.02	0.04
τ_L^B	0.01	0.02	0.03	0.02	0.02	0.02
τ_A^B	0.04	0.13	0.34	0.31	0.28	0.20

Appendix

Appendix A

Consider a social planner who's problem is to choose state, date and country contingent sequences of C, K, H to maximize

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

subject to a resource constraint for each state and date

$$\sum_j\left\{C_{jt} + \chi^I_{jt}X_{jt} + G_{jt}\right\} = \sum_j \chi^I_{jt}A_{jt}K^{\alpha}_{jt}\left(h_{jt}N_{jt}\right)^{1-\alpha} + T^{SP}_t$$

and the capital evolution equations above. Here the χ are the social planner version of wedges (as in the competitive equilibrium problem, we normalize $\chi^C_{Rt} = 1$ for all t). Note that the investment wedge now appears in the utility function and the production function, as well as multiplying investment in the resource constraint.

After substituting and rearranging we obtain the intensive form social planners problem of maximizing

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

subject to sequences of

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

and the intensive form capital accumulation equation. The social planner takes the sequences of $t^{SP\prime}s$ as constant. If in equilibrium, we suppose that these transfers "rebate" the "revenues" from the investment wedge, then we can write the sequence of constraints as

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

The proof that the solution to the pseudo-planners problem attains the equilibrium of the competitive equilibrium problem follows from a straightforward comparison of the first order necessary (and sufficient) conditions for an optimum noting that the mapping between competitive equilibrium wedges τ and social planners wedges χ, for labor and investment are given by

$$\begin{aligned}\chi^H_{jt} &= \frac{1}{1-\tau^h_{jt}},\\ \frac{\chi^C_{jt+1}}{\chi^C_{jt}}\frac{\chi^I_{jt+1}}{\chi^I_{jt}} &= 1-\tau^K_{jt+1}.\end{aligned}$$

For consumption, the first order condition for the social planners problem is

$$\theta_{jt} = \chi_{jt}^C,$$

and so will have the same form as in the CE problem as long as

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

for $1 - \rho_j^C = \psi_{j1}$ and $\chi_{jSS}^C = \psi_{j0}$. Importantly, the ε_{jt} must have an autoregressive structure with the same parameters as the process for τ_{jt}^B (this is because the competitive equilibrium international wedge governs the change in the social planners international wedge).

One last technical difficulty needs to be dealt with. In order to use the pseudo social planners problem to study the effect of interventions in the competitive equilibrium problem, it is in general necessary to alter the initial conditions for the χ_{j0}^C in the social planners problem. That is, if we want to analyze the effect of an intervention in the competitive equilibrium economy *keeping initial wealth constant*, it is necessary for χ_j^C to "jump" with the intervention. This can be done using the relationship between bonds and real allocations of the intensive form competitive equilibrium problem

$$b_{jt} = -E\left[nx_{jt} + q_{t,t+1} z_t nx_{j,t+1} + q_{t,t+1} q_{t+1,t+2} z_t z_{t+1} nx_{j,t+2} + ...\right],$$

where net exports are given by

$$nx_{jt} = y_{jt} - c_{jt} - x_{jt} - g_{jt}.$$

Appendix B

Derivation of Bonds

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

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

where I have followed the notes in defining

$$\eta_{t+1} = \frac{N_{Rt+1}}{N_{Rt}}.$$

In the code, we have written $n\,(+1)$ which I am assuming is the same thing.

The above is all in terms of "natural units". To turn this into model units (lower case) we proceed as follows

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

so that

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

I think this is NOT what we have in the code, as we are using NX_{jt} instead of nx_{jt}.

If we want to turn things into ratios with respect to output, we get

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

so that

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

If we proceed relative to output, then we need to change the definition of the current account

Derivation of the Current Account

Conceptually, a true measure of the current account is the change in net foreign assets. There are two ways to measure these: start and end of period levels. These give rise to versions 1 and 2 in the code. Now the start of period definition is given as follows:

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

so that

$$\begin{aligned}\frac{CA^1_{jt}}{Y_{jt}} &= \frac{B_{jt+1}}{Y_{jt+1}}\frac{Y_{jt+1}}{Y_{jt}} - \frac{B_{jt}}{Y_{jt}} \\ &= \frac{B_{jt+1}}{Y_{jt+1}}\frac{y_{jt+1}}{y_{jt}}z_t - \frac{B_{jt}}{Y_{jt}}.\end{aligned}$$

Recalling also that

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

we can write the current account as

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

where the last term is net factor income (which can be thought of as earned between t and $t+1$)

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

As in the code, I propose we measure it as above and then use this relationship to derive net factor income relative to output as

$$\frac{NFI_{jt}}{Y_{jt}} = \frac{CA^1_{jt}}{Y_{jt}} - \frac{NX_{jt}}{Y_{jt}}.$$

The end of period definition is

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

This differs from the previouos version in adding net factor income between periods $t-1$ and t to net exports in period t, as opposed to income earned between t and $t+1$. This yields, relative to output

$$\begin{aligned} \frac{CA^2_{jt}}{Y_{jt}} &= \frac{NX_{jt}}{Y_{jt}} + \frac{B_{jt} - E_{t-1}\left[q_{t-1,t}B_{jt}\right]}{Y_{jt}} \\ &= \frac{NX_{jt}}{Y_{jt}} + \frac{NFI_{jt-1}}{Y_{jt-1}}\frac{Y_{jt-1}}{Y_{jt}} \\ &= \frac{NX_{jt}}{Y_{jt}} + \frac{NFI_{jt-1}}{Y_{jt-1}}\frac{y_{jt-1}}{y_{jt}}\frac{1}{z_{t-1}}. \end{aligned}$$

As noted previously, current accounts are not measured this way in practice. Specifically, it does not count capital gains or losses on foreign assets, and only net interest income. One way to measure this would be to define it in terms of expected profits and losses

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

Intuitively, if you think that

$$q_{t-1,t} = \frac{1}{1 + r_{t-1,t}},$$

then

$$1 - q_{t-1,t} = \frac{r_{t-1,t}}{1 + r_{t-1,t}},$$

so that

$$B_{jt}\left(1-q_{t-1,t}\right)=r_{t-1,t}\frac{B_{jt}}{1+r_{t-1,t}},$$

so that the term in the brackets can be thought of as interest earned between periods $t-1$ and t on assets that payoff at t discounted back to $t-1$.

It seems most natural (in my opinion) to define this alternative version of the current account

$$CA_{jt}^{3}=NX_{jt}+NII_{jt+1},$$

which can be rearranged to yield, relative to output

$$\begin{aligned}\frac{CA_{jt}^{3}}{Y_{jt}} &= \frac{NX_{jt}}{Y_{jt}}+E_{t}\left[\frac{B_{jt+1}}{Y_{jt+1}}\frac{Y_{jt+1}}{Y_{jt}}\left(1-q_{t,t+1}\right)\right] \\ &= \frac{NX_{jt}}{Y_{jt}}+E_{t}\left[\frac{B_{jt+1}}{Y_{jt+1}}\frac{y_{jt+1}}{y_{jt}}z_{t}\left(1-q_{t,t+1}\right)\right].\end{aligned}$$

NOTE: This also does not seem to line up with what we have in the code.

In the code we do something similar, but with different timing. There we compute an average interest rate $\bar{r}_{t-1,t}$ as

$$\begin{aligned}\bar{q}_{t-1,t} &= E_{t-1}\left[q_{t-1,t}\right], \\ 1+\bar{r}_{t-1,t} &= 1/\bar{q}_{t-1,t}.\end{aligned}$$

Then in the code

$$\frac{CA_{jt}^{CODE}}{Y_{jt}}=\frac{NX_{jt}}{Y_{jt}}+\frac{\bar{r}_{t-1,t}}{1+\bar{r}_{t-1,t}}\frac{B_{jt}}{Y_{jt}}.$$

Another alternative, maybe the best one, would be to define

$$CA_{jt}^{4}=NX_{jt}+NII_{jt},$$

so that

$$\frac{CA_{jt}^{4}}{Y_{jt}}=\frac{NX_{jt}}{Y_{jt}}+\frac{E_{t-1}\left[B_{jt}\left(1-q_{t-1,t}\right)\right]}{Y_{jt}}.$$

Appendix C

Figure 9 plots the government wedge identified form the data.

Appendix D

Appendix E

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Figure 9: The Government Wedge

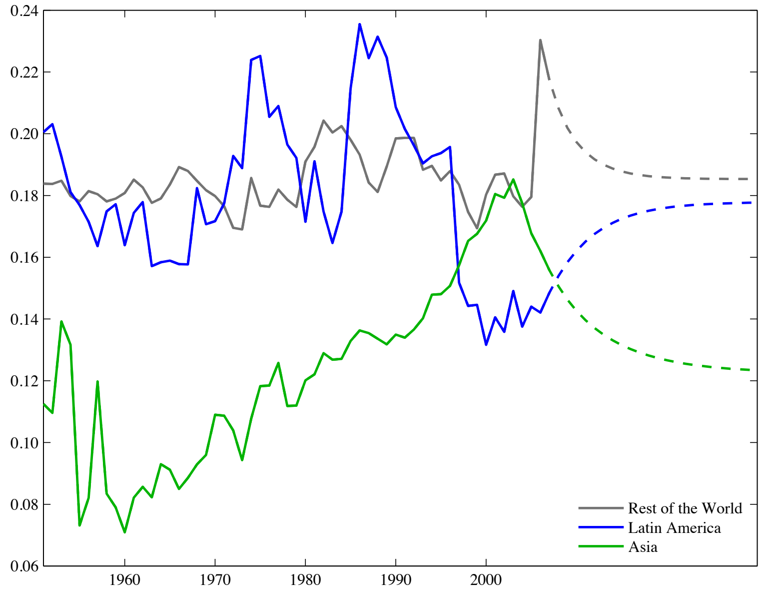


Figure 10: Implied Bonds

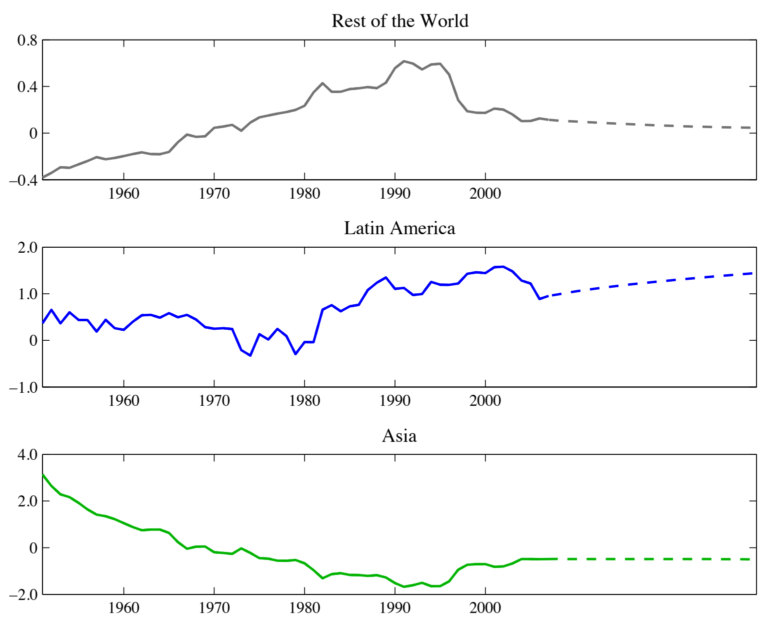


Figure 11: Implied Current Accounts

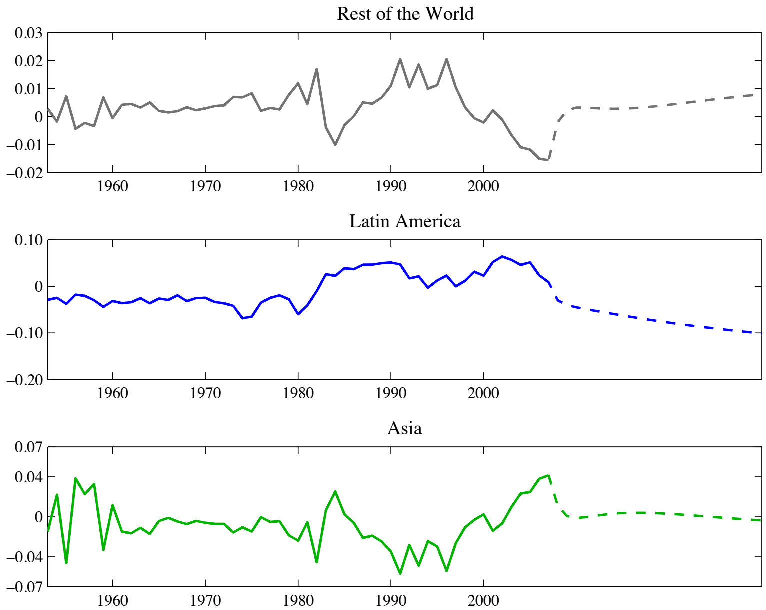


Table 6: Contribution of the different wedges for Latin American Consumption, by decade.

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.10	0.11	0.12	0.17	0.23	0.26
τ_L^h	0.51	0.50	0.46	0.35	0.24	0.17
τ_A^h	0.04	0.04	0.04	0.04	0.04	0.03
τ_R^k	0.13	0.08	0.08	0.16	0.22	0.26
τ_L^k	0.15	0.16	0.16	0.13	0.09	0.08
τ_A^k	0.03	0.03	0.02	0.02	0.02	0.02
τ_L^B	0.03	0.05	0.09	0.09	0.12	0.14
τ_A^B	0.02	0.03	0.04	0.05	0.05	0.04

Table 7: Contribution of the different wedges for Asian Consumption, by decade.

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.24	0.20	0.14	0.25	0.28	0.31
τ_L^h	0.12	0.11	0.10	0.08	0.06	0.06
τ_A^h	0.07	0.07	0.05	0.02	0.02	0.02
τ_R^k	0.41	0.36	0.17	0.17	0.25	0.30
τ_L^k	0.08	0.07	0.08	0.05	0.03	0.04
τ_A^k	0.04	0.05	0.05	0.03	0.02	0.02
τ_L^B	0.01	0.02	0.04	0.02	0.02	0.03
τ_A^B	0.03	0.12	0.38	0.38	0.32	0.23

Table 8: Contribution of the different wedges for Latin American Output, by decade.

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.15	0.08	0.06	0.07	0.06	0.06
τ_L^h	0.28	0.50	0.53	0.51	0.49	0.47
τ_A^h	0.06	0.03	0.02	0.02	0.02	0.01
τ_R^k	0.16	0.07	0.06	0.07	0.08	0.08
τ_L^k	0.22	0.24	0.26	0.27	0.29	0.31
τ_A^k	0.05	0.02	0.01	0.01	0.01	0.01
τ_L^B	0.04	0.03	0.03	0.03	0.03	0.03
τ_A^B	0.04	0.02	0.02	0.02	0.02	0.01

Table 9: Contribution of the different wedges for Asian Output, by decade.

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.22	0.15	0.23	0.24	0.23	0.27
τ_L^h	0.12	0.10	0.08	0.07	0.06	0.06
τ_A^h	0.18	0.29	0.17	0.20	0.21	0.15
τ_R^k	0.30	0.21	0.25	0.24	0.23	0.26
τ_L^k	0.08	0.07	0.04	0.03	0.03	0.04
τ_A^k	0.06	0.07	0.10	0.12	0.14	0.16
τ_L^B	0.02	0.02	0.01	0.01	0.01	0.01
τ_A^B	0.04	0.10	0.12	0.09	0.08	0.06

Table 10: Contribution of the Wedges, sample average

	Wedge							
Variable	τ_R^h	τ_L^h	τ_A^h	τ_R^k	τ_L^k	τ_A^k	τ_L^B	τ_A^B
C_R	0.38	0.08	0.02	0.39	0.05	0.01	0.02	0.05
C_L	0.16	0.38	0.04	0.15	0.13	0.02	0.08	0.04
C_A	0.23	0.09	0.05	0.28	0.06	0.03	0.02	0.24
Y_R	0.33	0.07	0.01	0.51	0.04	0.02	0.01	0.02
Y_L	0.08	0.46	0.03	0.09	0.26	0.02	0.03	0.02
Y_A	0.22	0.08	0.20	0.25	0.05	0.11	0.01	0.08
NX_R	0.22	0.16	0.06	0.25	0.10	0.03	0.02	0.14
NX_L	0.15	0.32	0.05	0.14	0.16	0.04	0.09	0.05
NX_A	0.21	0.08	0.11	0.26	0.05	0.04	0.02	0.22

Figure 12: Gross Domestic Product

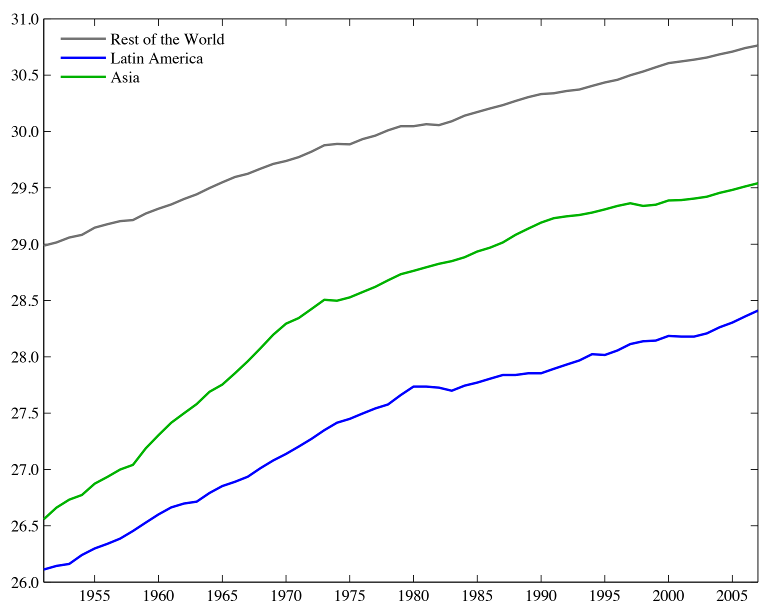


Figure 13: Consumption

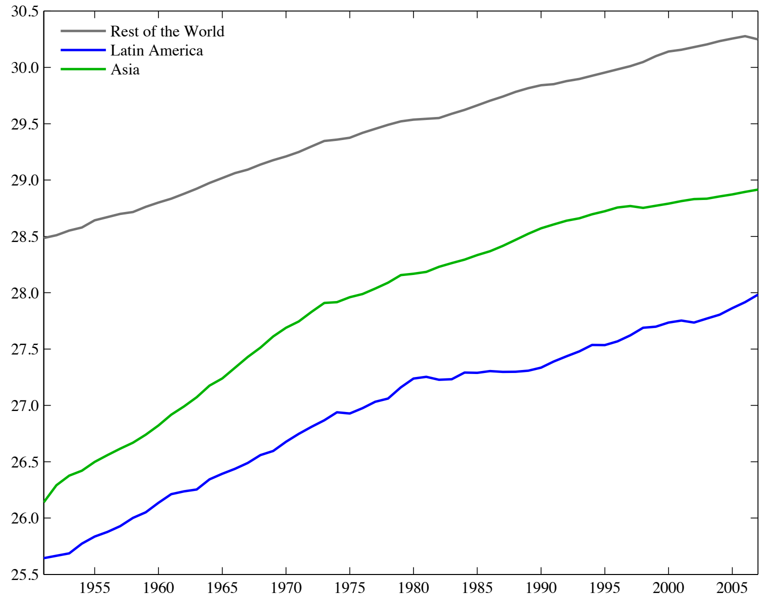


Figure 14: Investment

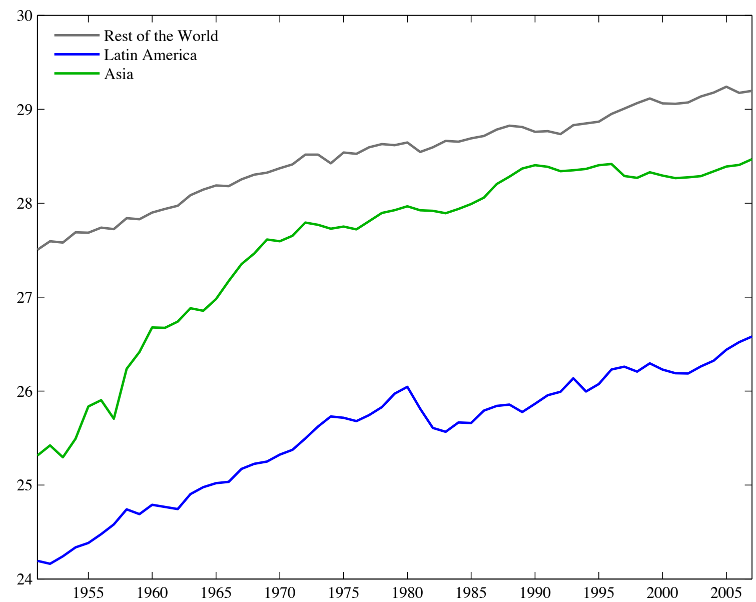


Figure 15: Per-capita Hours Worked

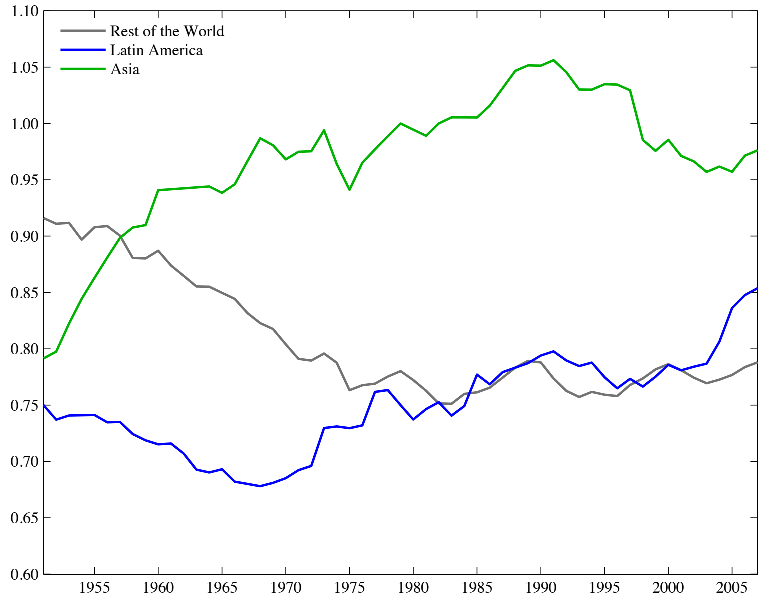
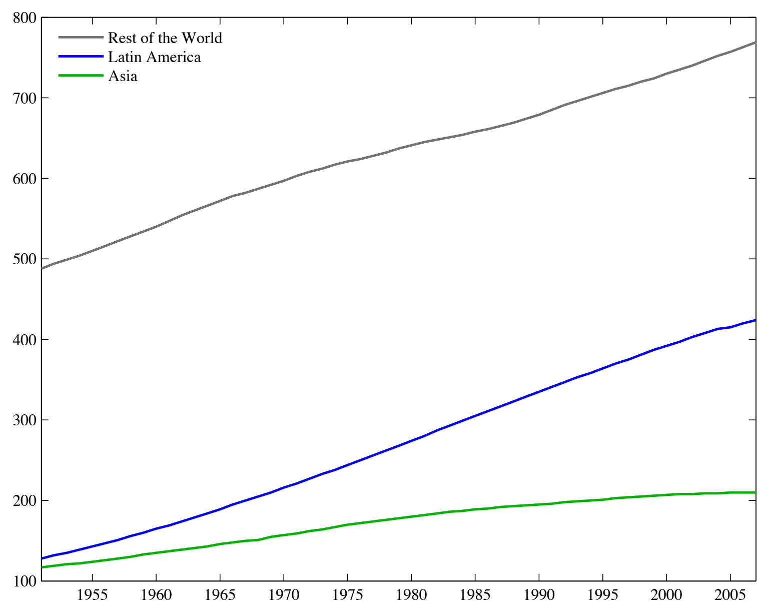


Figure 16: Population



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