Precaution Versus Mercantilism: Reserve Accumulation, Capital Controls, and the Real Exchange Rate*

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Abstract

We document a new international stylized fact describing the relationship between real exchange rates and external asset holdings. Economists have long argued that the real exchange rate is associated with the net international investment position, appreciating as external wealth increases. This mechanism has been seen as central for international payments equilibrium and relative price adjustments. However, we argue that the effect of external assets held by the public sector—reserve accumulation—on real exchange rates may be quite different from that of privately held external assets, and that capital controls are a critical factor behind this difference. For 1975–2007, controlling for GDP per capita and the terms of trade, we find that a one percentage point increase in external assets relative to GDP (net of reserves) is related to an 0.24 percent real exchange rate appreciation. On the contrary, a one percentage point increase in reserve accumulation relative to GDP has virtually no effect on the real exchange rate in financially open countries (low capital controls), and is related to a 1.65 percent real exchange rate *depreciation* in financially closed countries (high capital controls). Results are stronger in developing countries and in more recent periods. Gross, rather than net, positions matter. We present a theoretical model to account for the stylized fact. The framework encompasses so-called *precautionary* and *mercantilist* motives for reserve accumulation, and also explains how the optimal capital account policy—the mix of reserve accumulation and capital controls—is determined. Further empirical support arises from evidence that reserve accumulation is associated with a trade surplus, along with higher GDP and TFP growth in countries with high capital controls, findings that are consistent with the mechanisms of our model.

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1. Introduction

Economists have long struggled to understand the mechanics of the real exchange rate. In an old tradition stretching back centuries, via John Maynard Keynes (1929), and at least as far as David Hume (1741), the debate over the relative price levels of different countries and the international payments equilibrium stands out as one of oldest subjects in the field's history. In the standard view, there is a clear steady-state relationship *in the long run* between the level of the real exchange rate (RER) and the stock of net foreign assets (NFA): the real exchange rate should be more appreciated if net foreign assets rise to a higher level, all else equal.[1]

This standard prediction is fairly intuitive: suppose, say, that the home country has a shock that generates higher net external wealth, assume that it obeys the long run budget constraint, smooths consumption, and that there is imperfect substitutabilty of home and foreign goods (to rule out the implausible corner case of "immaculate transfer"); then home will desire to consume more going forwards relative to output; home must run trade deficits to achieve this, which will entail a change in price equilibrium such that home goods increase in price relative to foreign. Empirically, the seminal work of Lane and Milesi-Ferretti (2004) made a careful assessment of this relationship and confirmed a positive conditional correlation between real exchange rates and net foreign assets.

In this paper, we re-evaluate the relationship, in theory and in the data, with a new focus on external assets held by the public sector, i.e., international reserve accumulation. Until the 1990s the magnitude of reserves had not been significant compared to overall external asset position for most countries. However, reserve accumulation in recent years, especially in emerging economies, has been very rapid and now comprises a large chunk of their external balance sheet.[2]

Why should we care? The central claim of our paper is that reserve accumulation matters for the debate at hand: it has profound but distinct role to play as a force driving the real exchange rates, but this force can be quite different than that of other international assets on the balance sheet. As a first step, we argue that the real exchange rate may

[1] At high frequency, the association between changes, or levels, of real exchange rates (or nominal exchange rates) and net foreign assets could be determined by various underlying shocks and propagation mechanisms. In general, some of these can have a positive or negative relationship in different models and at different time frequencies. However, with annual frequency and with long-horizon data, the aforementioned relationship is what empirically stands out.

[2] Obstfeld, Shambaugh, and Taylor (2010) note that the average reserve to GDP ratio has risen to more than 20 percent of GDP in emerging markets, while in advanced countries it has stayed steady at about 4 percent. Bussière, Cheng, Chinn, and Lisack (2015) find that accumulation decelerated after the 2008 financial crisis.

depreciate especially strongly in response to reserve accumulation when capital controls are in place. In a benchmark theoretical framework, we show how the real exchange rate depends on reserve accumulation and capital controls. Then, in empirical work, we add the aforementioned features to build on Lane and Milesi-Ferretti (2004) for 75 countries over 1975–2007.[3]

We confirm that the marginal effect of private asset accumulation on the real exchange rate is mostly positive, consistent with the older findings. However, we then show that the effect of reserve accumulation on the real exchange rate is, in general, exactly the opposite: there is a negative association between net external assets held by the public sector (reserves) and the real exchange rate. And, further, this effect varies with financial openness, where we construct a binary indicator of capital control based on the financial openness index of Chinn and Ito (2008). The effect of reserve accumulation on the real exchange rate is close to zero in financially open countries, but strongly negative in financially closed countries. In cross-sectional analysis for the period of 1975–2007, we find that when net external assets to GDP (net of reserves) increases by one percentage point, the real exchange rate appreciates by 0.24 percent. However when reserve accumulation to GDP increases by one percentage point, the real exchange rate *depreciates* by 1.65 percent in financially closed countries and is virtually unchanged (rising 0.12 percent) in financially open countries.

In addition, we also argue that the negative effect of reserve accumulation on the real exchange rate is varying over time, and heterogeneous between advanced countries and developing countries.[4] If we focus on developing countries and the more recent period of 1986–2007, our results become even more pronounced. That is, the effects of reserves on real exchange rates are most prominent for the high-reserve-accumulating countries and periods. For example, in cross section for 1975–1996 for developing countries, when reserve accumulation to GDP increases by one percentage point, the real exchange rate appreciates by 0.12 percent. But the effects are not statistically significant regardless of financial openness. For the period 1986–2007, the effect is -1.06 percent overall, but -1.39 in financially closed countries and -0.08 in financially open countries. This differential pattern disappears in the subset of advanced countries.

We find that including oil exporting countries strengthens the magnitude and the

[3] In our empirical work, we can include or exclude the Global Financial Crisis period (2008–2011) as a robustness check. We believe that real exchange rate fluctuation during a financial crisis period is really an independent topic. See, e.g., Burstein, Eichenbaum and Rebelo (2005) for a discussion of real exchange rate determination during crisis.

[4] In this paper, we will refer to both emerging countries and other less-developed countries collectively as "developing countries."

statistical significance of the negative association, but the results are mostly robust without oil exporters. Also, using other capital control measures or other standard real exchange rate indices from IMF or BIS does not alter the results. We also confirm all our results in extensive panel data analysis, complemented by subperiod analyses and exhaustive robustness tests.

What could explain these results? In the theory part of this paper we develop a rationale for our empirical results, based on Jeanne (2013). We use a small open economy model and distinguish tradable and nontradable goods. The law of one price holds at the tradable goods level. What we call the *capital account policy*—which means reserve accumulation and capital control choices—then shapes the equilibrium current account balance and, therefore, the trade balance. In this setup, the relative price level of one country, the real exchange rate, is proportional to the relative price of nontradable goods to tradable goods. Thus, in the convention used in this paper, the real exchange rate appreciates when it increases. Therefore, as we will assume a fixed endowment of nontradable goods, the real exchange rate will depend on the supply of tradable goods which may vary intertemporally. If an economy has a positive external wealth shock, its consumption of tradable goods and its external assets will increase to smooth out the consumption of tradable goods. This will cause real exchange rate appreciation, and this is the prediction of the standard model: the usual wealth effect of external assets on the real exchange rate and their positive association. We then add several new ingredients to the standard model that can generate scenarios where this prediction is overturned.

First, we show that public external saving—i.e., reserve accumulation—can be an important additional channel which affects the allocation of tradable goods consumption between current and future periods, and hence the real exchange rate. Given the endowment of tradable goods, if tradable consumption decreases as the public sector increases its external savings, the relative price of nontradable goods goes down as the relative marginal utility of tradable to nontradable goods consumption goes up. If the current reserve accumulation is high enough, current consumption of the tradable goods may decrease and the relative price of nontradable goods may also then decrease. The real exchange rate may then depreciate, and the price level of the home country decreases, reversing the predictions of the standard model.

Second, we consider how capital controls can be an important factor modulating this mechanism in our framework. That is to say, the marginal effect of reserve accumulation on the real exchange rate varies with the degree of financial openness. In our model it turns out that the effectiveness of deliberate policy efforts to change the capital account (i.e., reserve accumulation) will depend on the extent to which public savings are offset by private capital flows. With this rationale spelled out in the model, we argue that capital account policy needs to view reserve accumulation and capital control together as jointly determining the equilibrium macroeconomic outcome.

Third, and finally, we provide a framework for understanding the choices of capital account policies of reserve accumulation and capital control. Here the model encompasses both the so-called *mercantilist* and *precautionary* motives for reserve accumulations and connects capital account policies with real exchange rate determination. We embed the *mercantilist* motive (cf. Rodrik (2008)) which explains reserve accumulation as a means to promote export sectors and hence future economic growth. If exports generate a positive technology spillover, then this learning-by-doing externality on growth implies that reserve accumulation can be beneficial by expanding the export sector. However private agents cannot internalize the externality, so the government will intervene with capital account policies. We embed the *precautionary* motive (cf. Jeanne and Rancière (2011)) which holds that a country accumulates reserves to avert output or consumption losses in a "sudden stop" crises. Under this view, the government accumulates foreign reserves as insurance against loss of credit access. Rather than asserting that one motive outperforms the other, we incorporate both motives into an integrated framework. For tractability, we presume that there are two parameters which represent the degree of learning-by-doing externality and the degree of crisis loss, respectively. The optimal capital account policy then naturally takes these two parameters into account and we show how this determines the level of reserve accumulation and capital control simultaneously.

Our new model thus makes key predictions on many dimensions: on reserve accumulation and capital control policies; on gross versus net external positions; and on public versus private asset positions. It is therefore richer than the standard model, and offers a range of testable predictions. The intuition for its main predictions is as follows:

- If an economy is more vulnerable to a crisis, the government will want to accumulate more precautionary savings in the form of reserves. At the same time the private sector will want to expand its balance sheet as a reaction to the government financing of the additional reserves; they will increase their holdings of the domestic bonds that the government sells (this is effectively the same as present and future tax payments, under Ricardian Equivalence); and at the same time they will increase their issuance of external debt to fund these outgoings and maintain consumption smoothing. If more such private external borrowing is needed, the government then wants to liberalize capital controls (i.e., impose lower capital flow taxes) trading that off against the mercantilist incentive to impose such taxes to promote export-led growth accompanied by a weaker real exchange rate.

- On the other hand, if an economy has more learning-by-doing externalities related to a trade surplus, the government will seek to improve its trade balance. To achieve this, the government will want to accumulate reserves. At the same time, they will also want to mute private capital flows, so less private external borrowing is needed, and the government then wants to tighten capital controls (i.e., impose higher capital flow taxes) which now aligns with the mercantilist incentive to impose such taxes to promote export-led growth accompanied by a weaker real exchange rate.

To provide more specific details on the mechanisms, the model predicts the following key linkages from deep parameters to the public/private components of the international investment position. First, there is a simple, positive standard wealth effect which links increases in private sector wealth to increases in the optimal stock of private external assets. Second, there is an offsetting balance-sheet mechanism which links increases in the vulnerability to a crisis to increases in both the optimal *stock* of public external assets and private external liabilities. Lastly, the model displays a positive linkage between a learning-by-doing externality and the optimal *stock* of public external assets, which arises from a "mercantilistic" real depreciation channel.

Consequently, after tracing out these balance sheet impacts, our model shows that the endogenous real exchange rate will tend to be higher (more appreciated) with more wealth, will have a flat response to higher vulnerability to a crisis, and will tend to be lower (more depreciated) with a larger learning-by-doing externality.

Our goal is to use the model as a laboratory to examine the relationship between the real exchange rate, reserve accumulation, and capital controls, and then compare the model with the data. Of course, our model may not capture the full range of factors driving reserve accumulation. Nonetheless, the framework is insightful in capturing some key mechanisms, and it could have important implications for debates not just in international macro-finance, but in growth and development. We close with some corroborating evidence showing the association between reserve accumulation and outcomes such as the trade surplus, GDP growth, and TFP growth; reserve accumulation is strongly associated with the trade surplus, GDP and TFP growth in financially closed economies. However, the association disappears in financially open economies. We believe the patterns support our theoretical mechanism.

In the next section, we present a simple theory of real exchange rate determination which builds on Jeanne (2013). Then, in Section 3, we lay out our empirical analysis: we provide our empirical specification of real exchange rate determination, show our results, and check robustness. Section 4 documents a new rationale for capital account policies and Section 5 concludes.

Literature Review To close out this introduction we briefly relate our arguments to the existing literature. Our paper is related to several lines of prior work. Most notably, the relationship between RER and NFA is empirically documented in Lane and Milesi-Ferretti (2004), who confirm a positive association. Controlling for relative GDP and the terms of trade, they find statistically significant results in line with the standard wealth effect.[5] However, they do not distinguish external assets held by the official sector—reserve accumulation—nor do they take capital controls into account. As the recent reserve accumulations in emerging markets have been so dramatic, the marginal effect of net external assets estimated using pre-2004 data may no longer hold and in this paper we expand the observations from 1975 up to 2007 (or 2011), covering more of the recent high-accumulation period.

Reserve accumulations in emerging markets have been large for the last couple of decades. Reserve accumulation used to be understood as a policy instrument for maintaining nominal exchange rate stability, or as a fund to cope with short-term payments difficulties. However as argued in Obstfeld, Shambaugh, and Taylor (2010), Jeanne and Rancière (2011) and others, current levels of reserve accumulation seem too high to be rationalized by the old conventional wisdom. Furthermore Gourinchas and Jeanne (2013) and Alfaro, Kalemli-Ozcan, and Volosovych (2014) argue that it is also related to the *allocation puzzle*: capital flows uphill (poor to rich), instead of downhill (rich to poor).

One strand of literature advocates the so-called *mercantilist* motive as a rationale for reserve accumulation. Dooley, Folkerts-Landau, and Garber (2004) and Korinek and Serven (2016) argue that emerging economies have been devaluing their currencies in order to facilitate their export sectors and growth, and that reserve accumulation is the policy instrument used to undervalue the currency. Michaud and Rothert (2014) specifically focus on China and claim that, if a learning-by-doing externality links to the size of the manufacturing production, borrowing constraints facilitate growth. Choi and Pyun (2017) show that the same allocation induced by the borrowing constraints could be implemented through reserve accumulation and capital controls jointly.[6]

On the other hand, a different strand of literature focused on crises and financial stability has emphasized the *precautionary* motive for reserve accumulation. Jeanne and

[5] See also Lane and Milesi-Ferretti (2002). In Ricci, Milesi-Ferretti, and Lee (2008), instead of the terms of trade and relative GDP, they control for commodity terms of trade and productivity differentials and obtain similar results. Galstyan and Velic (2017) analyze nonlinearities in short-run RER dynamics. They measure RER misalignments of using public debts as fundamentals, and estimate the dynamics of RER mean reversion incorporating a debt threshold. Interestingly, they find negative long-run movement between RER strength and public debt.

[6] Rabe (2014) evaluates the welfare gains for China of reserve accumulation using a quantitative model, and concludes that the "mercantilist" motive by itself cannot account for the high level of Chinese reserves.

Rancière (2011) provide a framework where reserve accumulation is in essence an insurance contract, approximated by a state-contingent contract with international investors. Likewise, Hur and Kondo (2013) cite increased roll-over risk after the 1990s as an important determinant. Obstfeld, Shambaugh, and Taylor (2010) propose a precautionary rationale based on the a "double drain" model. They incorporate monetary base (M2) which proxies for the financial development of the economy, and the liquid wealth which could potentially escape via capital flight during a crisis; they predict the level of reserve accumulation with more accuracy than previous empirical models. Almost a decade ago, Aizenman and Lee (2007) sought to empirically compare the mercantilist and the precautionary motives. They used econometric specifications where international reserves are regressed on proxy variables which are thought to be related to the mercantilist view such as lagged export growth, and variables which are related to precautionary motive such as a crisis dummy. They compared the effects and concluded that the precautionary motive view was more supported by the evidence at that time. But rationales may shift, and Ghosh, Ostry, and Tsangarides (2016) have argued that the motives of emerging economies to increase reserves have varied over time.

Several empirical studies document that more international reserves actually decreases the likelihood of financial crises, consistent with *precautionary* view. Frankel and Saravelos (2012) claim that reserve accumulation and past movements in the real exchange rate were the two leading indicators of the varying incidence of the Global Financial Crisis. More broadly, Gourinchas and Obstfeld (2012) use panel analysis of many countries and years to conclude that higher foreign reserves are associated with a reduced probability of a crisis in emerging markets, all else equal. Obstfeld, Shambaugh, and Taylor (2009) document that higher reserves compared to predicted levels were associated with smaller subsequent nominal exchange rate depreciations after 2008.

Even if these types of studies are successful in revealing the true motives behind the reserve accumulation, they do not address the effect of the accumulation on real exchange rates.[7] Our empirical work provides new stylized facts concerning external adjustment and real exchange rates. We argue that to account for how external assets affect the real exchange rate it is important to figure out whether the assets are held by the public or private sector, and also to consider whether the real exchange rate could be misaligned due to externalities. With our new perspective and empirical findings, we fill some of the gaps left by the previous literature.

[7] For a discussion of a more narrowly-defined effect of reserve accumulation (sterilized intervention) on nominal or real exchange rate, see Blanchard, Adler and de Carvalho Filho (2015) or Adler, Lisack, and Mano (2015)

We stress the role of gross external asset positions throughout our analysis. Several very recent and contemporaneous papers also claim that this is important in understanding reserve accumulations. In these papers, increases in reserves can be understood as capital outflows by the government, the effects of which depend on the behavior of offsetting private capital inflows. These can depend on capital controls, or other financial or institutional frictions. Bayoumi, Gagnon, and Saborowski (2015) empirically estimate the determinants of medium-term current accounts and find reserve accumulation to be a critical factor: a one dollar increase in reserve accumulation causes a 42 cent increase in current account balances. Especially they stress the importance of capital controls: an additional one dollar increase in reserve accumulation increases current account balances more in financially closed countries. Jeanne (2013) argues that nominal devaluation is not plausible especially in the long run. He instead claims that reserve accumulation combined with capital control is an instrument to depreciate the *real* exchange rate in the Chinese economy. By having capital account policies, he argues that the Chinese government tries to control the gross external position to affect the real exchange rate. In a similar vein, Benigno and Fornaro (2012) construct a quantitative model of real devaluation where reserve accumulation with imperfect capital mobility depreciates the real exchange rate and thus reallocates production inputs to the tradable sector, boosting growth. Bacchetta, Benhima, and Kalantzis (2013) claim that the policy combination of capital controls and international reserve is the optimal policy, similar to ours. However, they take a different perspective, focusing on the best policy to overcome international borrowing constraints, and abstracting from real exchange rate undervaluation and the mercantilist view.

An alternative viewpoint does not see reserve accumulation as a policy instrument to curb private capital inflows. Works by Alfaro and Kanzcuk (2009) and Bianchi, Hatchondo and Martinez (2013) lean toward a sovereign-focused model of reserve accumulation which incorporates crises and a role for the gross external position; these papers ask why a government holds external asset and liability positions simultaneously as it copes with crises. The former address the question and conclude that hoarding reserves is sub-optimal; the latter argue that by having a duration mismatch between external assets and liabilities, reserve accumulation may be helpful in managing a sudden stop.

There is little, or weak, empirical evidence that capital controls reduce the probability of crisis, and theory can cut both ways with no clear consensus. After the recent Global Financial Crisis, a vast literature has debated this issue. Because of a pecuniary externality in the model, Bianchi (2011) and Jeanne and Korinek (2010) call for capital controls; meanwhile Benigno, Chen, Otrok, Rebucci, and Young (2016) call for exchange rate policy during the crisis, instead of ex-ante capital controls. Turning to the data, Glick and Hutchison (2011) claim that capital controls have not effectively insulated economies from currency crises in recent years. However, Bussière et al. (2015) argue that countries with high reserves suffered less during the Global Financial Crisis, and that the effect of reserves is slightly stronger when combined with capital controls. The interaction results are not robust without outliers, however. So we interpret the current state of empirical evidence as saying that the effect of capital controls on crisis risk is minimal and unproven.

Finally, our work is related to the literature on capital account policies and economic growth. Rodrik (2008) argues that undervaluation of the currency stimulates economic growth. Our paper is consistent with that argument, and embeds it in a formal model. The joint capital account policy choice, over reserve accumulation and capital controls, which is associated with a real exchange rate outcome, also maps into trade surplus and economic growth outcomes. We therefore also contribute to the discussion of whether financial account openness is related to economic growth, and by what channels. Kose, Prasad, Rogoff, and Wei (2009) argue that financial globalization leads to economic growth in developing countries, but with many nuances. In that same vein, we will conclude with the argument that—in our model and in reality—countries which have exploited a growth externality from the export sector, and which accumulated high reserves combined with less financial openness, did indeed attain higher GDP and TFP growth outcomes.

2. The Basic Model with Exogenous Capital Account Policies

In this section we introduce a theoretical benchmark model to guide our empirical analysis. The model builds on Jeanne (2013) and it incorporates both reserve accumulation and capital controls as two policy instruments. This sets us up for a later section, where we will explore how the combination of two policy instruments will enable the government to target two economic outcome variables.

Specifically, the government can control both the level of reserve accumulation (for precautionary reasons) and the level of exports (for mercantilist reasons). Through these choices, the resulting endogenous level of consumption ties down the real exchange rate outcome as well, yielding novel predictions about the RER-NFA relationship in a variety of parameter scenarios. In particular, our model implies a new and notable deviation from the standard positive wealth effect of NFA on RER. Instead, we show how reserve accumulation and RER can have a *negative* relationship, and we find that the degree of negativity is magnified when the degree of capital control is high.

We assume a small open economy with two goods (tradable and nontradable), two periods ($t = 1, 2$), and two financial markets (domestic and international). The economy has a representative private agent who consumes a composite good, issues an international bond, holds a domestic bond issued by the government, pays a "capital control" tax on issued international bonds, and receives (or pays) lump-sum government transfers (tax). The government is the counterpart in the lump-sum tax or transfer, issues domestic bonds, receives the "capital control" tax on international bonds, and accumulates an external asset (i.e., international reserves). We assume that foreign investors cannot participate in the domestic financial market. For the moment, we presume that government decisions are exogenous, but we will endogenize them in the next section.

We assume that the utility maximization problem of the representative agent is

$$max_{\{c^T_{1,2},\, c^N_{1,2},\, d^*,\, a\}} \quad \left\{ u(c_1) + \frac{1}{1+r^*} u(c_2) \right\},$$

where the agent's utility is derived from a composite good composed of tradable and nontradable goods with constant elasticity, such that

$$c_t = \left(\left(\theta^T\right)^{\frac{1}{\sigma}} {c^T_t}^{\frac{\sigma-1}{\sigma}} + (\theta^N)^{\frac{1}{\sigma}} {c^N_t}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

the maximization is subject to the budget constraints

$$c^T_1 + p_1 c^N_1 + a + \tau(d^*, \kappa) \quad \leq \quad (1+\omega) y^T + p_1 y^N + d^* + T_1, \tag{2}$$

$$c^T_2 + p_2 c^N_2 + (1+r^*) d^* \quad \leq \quad (1+\bar{g}) y^T + p_2 y^N + (1+r) a + T_2, \tag{3}$$

and where $u(\cdot)$ is a standard CRRA utility function with risk-aversion parameter γ; c^T_t and c^N_t denote tradable and nontradable goods consumption levels in period t, respectively; ω is a fraction of tradable output, representing the shock to initial external wealth, or equivalently the initial endowment shock; the tradable goods is a numeraire and p_t is the price of the nontradable goods in period t; y^T and y^N are the tradable and nontradable endowment levels in period t, respectively; d^* is the international bond issued (i.e., the external private debt); a is the domestic bond issued by the government; r and r^* are the domestic and international interest rates, respectively (and, for simplicity, r^* is the agent's discount rate); $\bar{g}$ is the growth rate of the domestic tradable goods sector; $\tau(d^*, \kappa)$ is the "capital control" tax schedule on external debt, which may be nonlinear in the debt issues, and also depends on the degree of capital control measured by a shift parameter κ; and T_t is the government lump-sum transfer to the agent (or tax, if negative).

The government budget constraint is

$$rsrv^* + T_1 \leq a + \tau(d^*, \kappa), \tag{4}$$
$$T_2 + (1+r)a \leq (1+r^*)rsrv^*, \tag{5}$$

where $rsrv^*$ is the official external asset, that is reserve accumulation.

A key concept for us is the real exchange rate (RER), defined as

$$rer_t \equiv p_t.$$

Nontradable consumption will be equal to nontradable endowment each period, and thus the market for nontradable goods clears trivially. But tradable consumption can be intertemporally adjusted by way of external asset holdings.

Combining budget constraints (2), (3), (4), (5), the feasible consumption sets are

$$c_1^T = (1+\omega)y^T - (rsrv^* - d^*); \tag{6}$$
$$c_2^T = (1+\bar{g})y^T + (1+r^*)(rsrv^* - d^*); \tag{7}$$
$$c_1^N = c_2^N = y^N. \tag{8}$$

It should be noted that $rsrv^* - d^*$ is the economy's net foreign asset holding (NFA), another key concept for us.

We will also assume that the "capital control" tax schedule is weakly increasing and non-concave with each argument,

$$\begin{aligned} 0 &\leq \tau_i(d^*, \kappa) < 1 \qquad \text{for } i = 1,2, \\ 0 &\leq \tau_{ij}(d^*, \kappa) \qquad\qquad \text{for } i,j = 1,2. \end{aligned}$$

where $\tau_i(\cdot)$, $\tau_{ij}(\cdot)$ denote the partial derivative with respect to ith and jth arguments.

Note that, since the government levies the tax on the level of the private capital outflow d^*, the second derivative condition implies that the marginal tax rate is increasing with the level of private borrowing.

Now, to solve the model, we denote the Lagrangian multipliers for the agent's budget constraints (2) and (3) as λ_1 and $\frac{1}{1+r^*}\lambda_2$, respectively. The equilibrium conditions are then

$$\frac{\theta^N}{\theta^T}\frac{c_t^T}{c_t^N} = p_t^{\sigma}, \quad \text{for } t = 1,2; \tag{9}$$
$$1 - \tau_1(d^*, \kappa) = \frac{\lambda_2}{\lambda_1}; \tag{10}$$

$$1 - \tau_1(d^*, \kappa) \;=\; \frac{1+r^*}{1+r}. \tag{11}$$

The first condition (9) links relative consumption to the price of the nontradable goods, and hence the real exchange rate. In our model, the endowment of the nontradable goods is fixed and cannot be transferred intertemporally, so any variation in the current real exchange rate is directly tied to variations in the current consumption level of the tradable good; RER will go up (down), that is appreciate (depreciate), if and only if the tradable consumption increases (decreases). Thus, if initial wealth increases, raising current consumption, the current real exchange rate will appreciate, the standard result.

We can now establish three propositions regarding real exchange rate.

Proposition 1. *Given the level of reserve accumulation ($rsrv^*$) and the degree of capital control parameter (κ), and increase in the current endowment of tradable goods (ω) will cause an appreciation of the current real exchange rate,*

$$\frac{\partial rer_1}{\partial \omega} \;\geq\; 0.$$

Proof. See Appendix. □

This first result is intuitive. It implies that the country experiences a stronger currency as its current endowment (or, equivalently, its external wealth) increases, the standard positive wealth effect. This first proposition could be seen to be empirically supported by the well-established positive correlation in the current literature between external asset holdings and the real exchange rate. This mechanism will also operate in our model, all else equal, and will continue to be supported by the evidence we show later.

Proposition 2. *Given current endowment (ω) and the degree of capital control index (κ), increasing reserve accumulation ($rsrv^*$) will depreciate the current real exchange rate. That is,*

$$\frac{\partial rer_1}{\partial rsrv^*} \;\leq\; 0.$$

Proof. See Appendix. □

Proposition 3. *Given current endowment (ω) and reserve accumulation ($rsrv^*$), increasing the degree of capital control index (κ) will depreciate the current real exchange rate, That is,*

$$\frac{\partial rer_1}{\partial \kappa} \;\leq\; 0.$$

Proof. See Appendix. □

These two results builds on equilibrium condition (10), where reserves and marginal "capital control" tax rate together affect (compared to the economy without any tax on the international debt) the intertemporal decision between period 1 and 2. For example, if the growth rate $\bar{g} - \omega$ exceeds the international interest rate r^*, the agent will try to increase her current consumption to a level that exceeds her endowment in the period 1, by issuing an external bond in the international financial market. However if the government imposes a tax on the bond so issued, it will be more costly for her to transfer goods from the future to the present. So she would then reduce her intertemporal consumption re-allocation according to the magnitude of the marginal tax rate. If the marginal tax rate is higher, the agent will borrow less and consume less in period 1, and we know from the first condition that this will lead to a current real exchange rate depreciation.

Finally, we note one final and important simplifying feature of our model. The third equilibrium condition (11) implies that domestic interest rate has to be equated to international interest rate adjusted for the marginal tax wedge. Indeed, this result is independent of whether reserve accumulation is financed by a lump-sum tax or by issuing domestic bonds. For example, suppose that the government levies a lump-sum tax to finance the reserve accumulation. The same economy can be replicated with domestic bond issuance equivalent to the lump-sum tax, as long as the government offers a domestic interest rate that satisfies the equilibrium condition (11). This simplifies our model enormously. Although it is an important issue, we will focus mainly on reserve accumulation through lump-sum taxation, and abstract from domestic bond issuance.

3. Empirical Analysis

3.1. Data

In this section, we describe the data and variables used in our empirical work. The sample includes 22 advanced and 53 developing and emerging economies, as listed in Table A.6.[8] For these countries, we constructed a balanced annual panel of net foreign assets excluding reserves, international reserves, relative outputs, the terms of trade, and

[8] We include as many countries as the data permits. For the dataset of Lane and Milesi-Ferretti (2007), we linearly interpolate missing data for the early periods (70's and early 80's) of Brazil and China. We exclude countries with more than seven missing observations in the data set of financial openness index *KAOPEN* from Chinn and Ito (2008), except for countries such as China, Netherlands, Switzerland, etc. We further exclude financial centers, countries with very high net foreign assets (more than 500% of GDP), extremely volatile real exchange rate movement (more than 150% depreciation between periods), some very small or poor countries, and dollarized economies. The following countries are filtered out by these criteria: Hong Kong, Singapore, Mauritius, Kuwait, Ghana, Grenada, Malta, Ethiopia, El Salvador, and Panama. The inclusion or exclusion of these filtered countries does not change our overall results.

capital control indices. We mainly focus on the 1975–2007 period, but will also check the robustness of our results with an extension to include the Global Financial Crisis period 2008–2011.

For net foreign assets and international reserves, we take data from the standard source, Lane and Milesi-Ferretti (2007). Net foreign assets is defined as

$$\begin{aligned} \text{NFA} &= \text{Foreign Assets} - \text{Foreign Liabilities} \\ &= (\text{FDIA + EQA + DEBTA + RES}) - (\text{FDIL + EQL + DEBTL})\,, \end{aligned}$$

where RES is international reserve assets; FDIA, EQA, and DEBTA denote foreign direct investment assets, equity investment assets, and debt investment assets, respectively; and FDIL, EQL, and DEBTL denote foreign direct investment liabilities, equity investment liabilities, and debt investment liabilities, respectively.

However, we are interested in implication of net external assets held by the private sector and the public sector. Therefore we decompose NFA into private and official components, rewriting the terms as

$$\begin{aligned} \text{NFA} &= \text{Foreign Assets net of Reserves} - \text{Foreign Liabilities} + \text{Reserves} \\ &= (\text{NFA} - \text{RES}) + \text{RES}, \end{aligned}$$

where we will then define the following new variables normalized by GDP,

$$NFAxR \equiv (\text{NFA} - \text{RES}) \;/\; \text{GDP}, \qquad RSRV \equiv \text{RES} \;/\; \text{GDP}.$$

For key control variables, following Lane and Milesi-Ferretti (2004), we construct relative output and real (effective) exchange rates using trade weights. Let

$$\psi_{ij} = \frac{M_i}{M_i + X_i}\, m^i_j + \frac{X_i}{M_i + X_i}\, x^i_j\,,$$

be the the trade weight of country i with country j, where M_i and X_i are country i's imports and exports, m^i_j is the share of country i's imports originating from country j, and x^j_i is the share of country i's exports going to country j. We calculate the trade patterns for the period 1994–96 and take averages over those years.[9] The real effective exchange rate (denoted $REER$) is constructed as the ratio between the home CPI and the trade-weighted partner's CPI.[10] Both indices are calculated in a common currency (U.S. dollar) using

[9]We use the *Direction of Trade Statistics* (DOTS) from IMF to obtain bilateral trade data.

[10]The IFS effective exchange rates are based on trade weights over the period of 1999–2001 and incorporate

period-average nominal exchange rate. Relative output (denoted YD) will be constructed similarly as the ratio of home country real GDP per capita to the trade-weighted partner countries' real GDP per capita. Thus, we define

$$REER_i = \prod_{j \neq i} \left[\frac{P_i}{P_j} \right]^{\psi_{ij}}, \qquad YD_i = \prod_{j \neq i} \left[\frac{y_i}{y_j} \right]^{\psi_{ij}},$$

where P_i is the CPI of country i in common currency, and y_i is the real GDP per capita of country i.[11] We take CPI and GDP data from *International Financial Statistics* (IFS) by IMF, and from *Penn World Table 7.1*, *FRED*, or from the central bank of the economy if missing. For real GDP per capita we take data from national accounts divided by population from IFS as default and use $rgdp$ from *Penn World Table 7.1* if the data are missing in *IFS*.[12]

The terms of trade is defined as the ratio of a country's export prices to import prices:

$$TT_i = \frac{P^{ex}}{P^{im}},$$

where data are from *IFS*. We use ratios of export to import unit values if these are missing.[13]

Finally, we take the financial openness index $KAOPEN$ from Chinn and Ito (2008) and construct a continuous capital controls measure $KAControl$ by inverting its sign,

$$KAControl = -KAOPEN,$$

where $KAOPEN$ is a standardized (mean 0, s.d. 1) measure of *de jure* financial openness from IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*.[14]

service trade if available. Weights are barely different from ours. In a robustness check, we use the IMF real effective exchange rate indices and results are similar. Bayoumi, Jayanthi, and Lee (2006) provide details of the IMF index.

[11]We note that our sample does not cover most of the Eastern European countries and Russia, former communist countries due to the data availabilities.

[12]Note the use of country fixed effects estimation (or diff-in-diff) below will mean that the cross-country non-comparability of units of non-PWT real GDP per capita variables will not be of any consequence

[13]As argued in Lane and Milesi-Ferretti (2004), we presume the terms of trade are endogenous to an individual economy if and only if it has significant market power in international markets. With the inclusion of the terms of trade in our empirical real exchange rate analysis, our results support the predictions of the model, which stresses the relative price between nontradable and tradable goods sectors.

[14]Most of cross-country time series of capital controls are *de jure* measures based on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*, which captures legal restrictions. Empirically-based *de facto* indicators of capital account restrictions are very hard to construct. We claim that a *de jure* type of measure is a more appropriate index for our analysis as in our theory it should correspond to κ, the measure of restrictions or overall "capital control" in the form of a shifter to the tax schedule on external debt ($\tau(d^*, \kappa)$), as defined above.

For most of our analysis, however, we derive a binary version of this capital control measure, denoted *KAClosed* $\in \{0, 1\}$, as shown in Table A.6. Our reasoning is that we focus on long-run effects of capital account policies, and also on relative openness rather than the absolute level of openness. We note that the *KAOPEN* measure is stable during the period, and focus more on changes in reserve accumulation. Also, the Chinn-Ito measure is constructed over rolling windows, and is vulnerable to measurement errors. Thus, for many countries, the level changes little over time and this may obscure long run-trends and trigger collinearity problems. So, in most of the analysis in this paper, we take the median of the index *KAControl* over the subperiod under analysis, and we construct a binary indicator *KAClosed* for financially open economies and financially closed economies, equal to 1 (0) for those with an index above (below) the median. We note that, as a robustness check, we will incorporate alternative capital control measures and the overall results do not change.

We choose 1975, 1986, 1997, and 2008 as breaks when we divide the whole period into the four subperiods:

$$\begin{aligned} &1975\text{–}1985 : \text{Period1}, \qquad &1986\text{–}1996 : \text{Period2}, \\ &1997\text{–}2007 : \text{Period3}, \qquad &2008\text{–}2011 : \text{Period4}. \end{aligned}$$

Table 1 shows period averages of the variables designed to measure the two policy instruments, *RSRV* and *KAControl*, with patterns as one might expect. The average reserve accumulation of advanced countries was stable at around 5% to 7% in all periods. At the same time, the average capital control index was low and falling in this group. In contrast, the average reserve accumulation in developing countries sharply increased from 9% at the start to 17% in period 3, and around 25% in period 4. Meanwhile, though at much higher levels, capital controls have been slowly relaxed in developing countries.[15] If we further divide the sample into financial openness bins using the *KAClosed* binary indicator, we can see that average reserve accumulation was higher in financially open economies up until 1996, but higher in financially closed economies thereafter.

3.2. Results

Determinants of the Real Exchange Rate: Preliminary Panel Analysis We begin with a baseline empirical specification for 1975–2007 to give some preliminary evidence on our theoretical model. We take the average of each variable in periods 1, 2, and 3, and estimate the model with OLS. We run the following panel specification with country and

[15] We provide a rationale for this slower pace of capital control liberalization in Section 4.

Table 1: *Summary Statistics: Average Values for Reserve Accumulation and Capital Control Variables*

	Period1 (1975–1985)	Period2 (1986–1996)	Period3 (1997–2007)	Period4 (2008–2011)
(a) Advanced Countries				
RSRV (%of GDP)	5.15%	6.71%	5.91%	7.69%
KAControl (standardized)	−0.51	−1.44	−2.26	−2.17
(b) Developing Countries				
RSRV (%of GDP)	8.90%	8.80%	16.44%	25.45%
KAControl (standardized)	0.58	0.56	−0.11	−0.25
(c) Financially Open Economies				
RSRV (%of GDP)	8.49%	8.67%	11.14%	15.26%
KAControl (standardized)	−0.47	−0.99	−1.97	−1.96
(d) Financially Closed Economies				
RSRV (%of GDP)	7.09%	7.69%	15.63%	25.35%
KAControl (standardized)	1.04	0.97	0.53	0.37

period fixed effects:

$$\begin{aligned}\log(REER_{i,T}) \quad = \quad & \alpha_i + D_T + \beta^{NFAxR} NFAxR_{i,T} + \beta^{RSRV} RSRV_{i,T} \\ & + \beta^{KAControl} KAControl_{i,T} \\ & + \beta^{YD} \log\left(YD_{i,T}\right) + \beta^{TT} \log\left(TT_{i,T}\right) + \epsilon_{i,T}, \end{aligned} \tag{12}$$

where T is period 1, 2, or 3, D_T is a period fixed effect, and α_i is a country fixed effect.

Estimates of equation (12) are shown in Table 2. In column (1) we show the result using the full sample period 123. Conditional on relative GDP and the terms of trade, an increase in NFA to GDP (net of reserves) of one percentage point is associated with a real exchange rate appreciation of 0.18 percent. This is consistent with previous studies and the standard wealth effect. However, a one percentage point increase in reserve accumulation as a share of GDP is associated with a real exchange rate depreciation of 0.95 percent. And a one unit increase in the capital control index is associated with a real exchange rate depreciation of 0.08 percent.

Note also that we can split the sample, and if we focus on period 12, the negative association between reserve accumulation and GDP disappears, suggesting that earlier work on shorter samples was not at fault, but was unlikely to pick up this effect given the data then at hand. In column (2), an increase in NFA to GDP (net of reserves) of one percentage point is associated with a real exchange rate appreciation of 0.39 percent in the

Table 2: *Determinants of the Real Effective Exchange Rate: Three-Period Panel with Fixed Effects*

Dependent variable: log(REER)	Full Sample		
	Period 123 (1975–2007)	Period 12 (1975–1996)	Period 23 (1986–2007)
	(1)	(2)	(3)
NFAxR	0.18*	0.39**	0.12*
	(1.71)	(2.16)	(1.70)
RSRV	-0.95***	0.16	-0.98***
	(-2.70)	(0.26)	(-2.92)
KAControl	-0.08***	-0.11***	-0.04**
	(-3.73)	(-3.67)	(-2.17)
ln YD	0.10	-0.13	0.08
	(1.11)	(-0.80)	(0.87)
ln TT	0.11	0.46***	-0.09
	(1.17)	(2.75)	(-0.74)
Observations	225	150	150
Countries	75	75	75
R^2	0.310	0.349	0.268

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. We take the average over 11 years for each variable (in levels) and perform a three (or two)-period panel analysis. *t*-statistics in parentheses based on heteroskedasticity consistent standard errors.

earlier period. At the same time, a one percentage point increase in reserve accumulation as a share of GDP is associated with a real exchange rate appreciation 0.16 percent, but this is statistically insignificant. A one unit increase in the capital control index is associated with a real exchange rate depreciation of 0.11 percent. When we focus on the later period 23 in column (3), reserve accumulation is now significantly associated with real exchange rate depreciation, with a large coefficient of 0.98. Thus, the negative coefficient stands out during this latter period, and the result for the full sample is mainly driven by period 23. The positive association between NFA and the real exchange rate is preserved in period 23, and the effect of capital controls is weaker.

Overall, and especially in recent times, the coefficients on reserves and capital controls are both statistically significant, and work in ways that can overturn or offset the standard wealth effect. The key message is that to fully understand the effect of NFA changes on the real exchange rate, we need to allow for the complex interactions of capital account policies in the form of reserve accumulation and capital controls. This, in a nutshell, is the key message of this paper, supported by a set of new empirical findings which line up with the predictions of the new theoretical model presented above. The rest of this paper is, in essence, a thorough robustness and consistency check on these results.

Determinants of the Real Exchange Rate: Cross-Sectional Analysis Next we focus on OLS difference-in-differences estimation. This provides for comparability with prior work, with a specification like that in the seminal work of Lane and Milesi-Ferretti (2004), using a balanced 3-period cross-section.

As noted, although we are interested in two policy instruments, our baseline approach stresses the effect of reserve accumulations on the real exchange rate, *given the level of capital controls*. Some reasons, again, are that the capital control measure shows little variation over time and this measure is very vulnerable to measurement errors. Thus, we argue that instead of the raw capital control index, our binary indicator *KAClosed* is a more appropriate measure in terms of taking the model to empirics. We presume that each country is either financially open or closed. We then use our binary capital controls indicator in an interaction term with reserves changes.

We calculate the average of each variable for each period 1, 2, and 3. Then we take the difference between periods. More specifically, for country i, and variable x, we define $\Delta x_{i,T_1T_2} = x_{i,T_2} - x_{i,T_1}$, where T_1T_2 are 12, or 23 (i.e., periods 1 to 2, and 2 to 3).

We start the analysis with the interaction term omitted and estimate

$$\begin{aligned} \Delta \log(REER_{i,T_1T_2}) \quad = \quad & \alpha + D_T + \beta^{NFAxR} \Delta NFAxR_{i,T_1T_2} + \beta^{RSRV} \Delta RSRV_{i,T_1T_2} \\ & + \beta^{YD} \Delta log\left(YD_{i,T_1T_2}\right) + \beta^{TT} \Delta log\left(TT_{i,T_1T_2}\right) + \epsilon_i, \end{aligned} \tag{13}$$

where T_1T_2 is period 12 or period 23. We add a period fixed effect D_T to this regression in cases where we pool period 12 and period 23, which we label period123. Note that since the real effective exchange rate, relative GDP per capita, and terms of trade are log indices, it is meaningless to compare levels of these variables, hence our use of difference-in-differences.

We obtained estimates for equation (13) and in Table 3 we show the result of the pooled regression for period 123. Again column (1) shows a departure from previous studies: we find that the marginal effect of reserve accumulation is clearly different from that of external assets held by a private sector. Conditional on relative GDP and the terms of trade, an increase in NFA to GDP (net of reserves) of one percentage point is associated with a real exchange rate appreciation of 0.19 percent, which is the standard wealth effect and consistent with the previous literature. However, an increase in reserve accumulation to GDP of one percentage point is associated with a real exchange rate depreciation of 0.89 percent. An F-test shows the hypothesis that $\beta^{NFAxR} = \beta^{RSRV}$ can be rejected at the 1 percent significance level.

Next we argue that the new result is mainly driven by developing countries. We split

Table 3: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis*

Dependent variable: Δ log(REER)	Periods 12 (Average 86–96 minus Average 75–85) & 23 (Average 97–07 minus Average 86–96), Pooled Sample					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.19*	0.24**	-0.12	NA	0.20	0.25**
	(1.84)	(2.40)	(-1.43)		(1.66)	(2.17)
Δ RSRV	-0.89***	0.12	-0.01		-0.97**	-0.05
	(-2.68)	(0.35)	(-0.02)		(-2.49)	(-0.11)
Δ RSRV × KAClosed		-1.77***				-1.52***
		(-3.77)				(-2.81)
Δ ln YD	0.11	0.10	0.04		0.03	0.02
	(0.98)	(0.98)	(0.28)		(0.26)	(0.20)
Δ ln TT	0.07	0.11	0.34***		0.04	0.07
	(0.64)	(1.02)	(2.87)		(0.31)	(0.63)
Period23 Dummy	0.10**	0.11***	-0.04		0.20***	0.19***
	(2.32)	(2.61)	(-0.88)		(3.43)	(3.40)
Observations	150	150	44		106	106
Countries	75	75	22		53	53
R^2	0.10	0.15	0.19		0.13	0.17
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.76	0.82		0.01	0.52
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.00				0.00

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. We take the average over 11 years for each variable (in differences) and perform a pooled cross-sectional analysis. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

the sample into developing countries and advanced countries. In column (5) of Table 3, we see the result for developing countries for period 123: here a one percentage point increase in NFA to GDP (net of reserves) is associated with a 0.20 percent appreciation of the real exchange rate, while a one percentage point increase in reserves to GDP is associated with an 0.97 percent depreciation of the real exchange rate. In advanced countries, the terms of trade is the only statistically significant factor that affects the real exchange rate, with no statistically meaningful impacts of NFA or reserve accumulation.

We now claim, as before, that the result is also mainly driven by the later period. Instead of a pooled regression, we estimate a separate regression for equation (13) by period. Tables 4 and 5 show these results for period 12 and period 23, respectively. We find that the negative relationship between the real exchange rate and reserves is very prominent in period 23. Column (1) in Table 4 shows that in period 12 the coefficient on NFAxR is positive and statistically significant while reserve accumulation coefficient is also positively related to the real exchange rate: a one percentage point increase in

Table 4: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis*

	Period 12 (Average 86–96 minus Average 75–85)					
Dependent variable: Δ log(REER)	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.38**	0.39**	0.19	0.15	0.33*	0.34*
	(2.19)	(2.22)	(0.73)	(0.56)	(1.73)	(1.75)
Δ RSRV	0.32	0.62	0.21	0.10	0.12	0.35
	(0.50)	(0.81)	(0.31)	(0.14)	(0.18)	(0.42)
Δ RSRV $\times$ KAClosed		-1.53		1.79		-1.01
		(-0.86)		(0.95)		(-0.54)
Δ ln YD	-0.10	-0.09	-0.33	-0.25	-0.18	-0.17
	(-0.60)	(-0.56)	(-0.81)	(-0.54)	(-1.05)	(-1.03)
Δ ln TT	0.43**	0.40**	0.45**	0.49**	0.36*	0.34*
	(2.47)	(2.30)	(2.52)	(2.55)	(1.74)	(1.69)
Observations	75	75	22	22	53	53
Countries	75	75	22	22	53	53
R^2	0.16	0.17	0.17	0.18	0.12	0.13
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.93	0.77	0.98	0.95	0.79	0.99
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.29		0.42		0.49

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. We take the average over 11 years for each variable (in differences) and perform a cross-sectional analysis. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

external assets to GDP (net of reserves) is associated with an 0.38 percent appreciation of the real exchange rate while an one percentage point increase in reserves to GDP is associated with a statistically insignificant 0.32 percent appreciation. On the contrary, the effect is clearly different in the period 23. Column (1) in Table 5 shows that a one percentage point increase in NFAxR is associated with an 0.15 percent appreciation of the real exchange rate. However a one percentage point increase in reserves to GDP is associated with a 0.96 percent depreciation of the real exchange rate. The latter is not only statistically significant but the magnitude is also very large. The all-country results are again driven by developing economies. The column (1) results in Tables 4 and 5 are broadly similar to the column (5) results in the same table.

We claim that the negative relationship between reserves and RER is therefore clearly emerging as a strong feature of developing countries and in the more recent period of high reserve accumulation. As for the advanced countries, the results show a positive wealth effect on real exchange rates in period 12. However the result is far from robust: the coefficient is statistically insignificant and changes sign in the subsequent period. In column (3) of Table 5, we could not find any statistically significant factor explaining the

Table 5: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis*

Dependent variable: Δ log(REER)	Period 23 (Average 97–07 minus Average 86–96)					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.15**	0.19***	-0.17	NA	0.22**	0.28***
	(2.12)	(2.83)	(-1.50)		(2.21)	(2.96)
Δ RSRV	-0.96***	-0.23	-0.12		-1.06***	-0.08
	(-3.37)	(-0.62)	(-0.14)		(-2.72)	(-0.15)
Δ RSRV × KAClosed		-1.06**				-1.31**
		(-2.33)				(-2.40)
Δ ln YD	0.13	0.14*	-0.03		0.16	0.15
	(1.57)	(1.74)	(-0.11)		(1.62)	(1.52)
Δ ln TT	-0.16	-0.14	0.34		-0.15	-0.14
	(-1.22)	(-1.12)	(1.69)		(-1.10)	(-1.05)
Observations	75	75	22		53	53
Countries	75	75	22		53	53
R^2	0.18	0.22	0.16		0.18	0.24
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.28	0.96		0.01	0.50
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.01				0.01

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. We take the average over 11 years for each variable (in differences) and perform a cross-sectional analysis. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

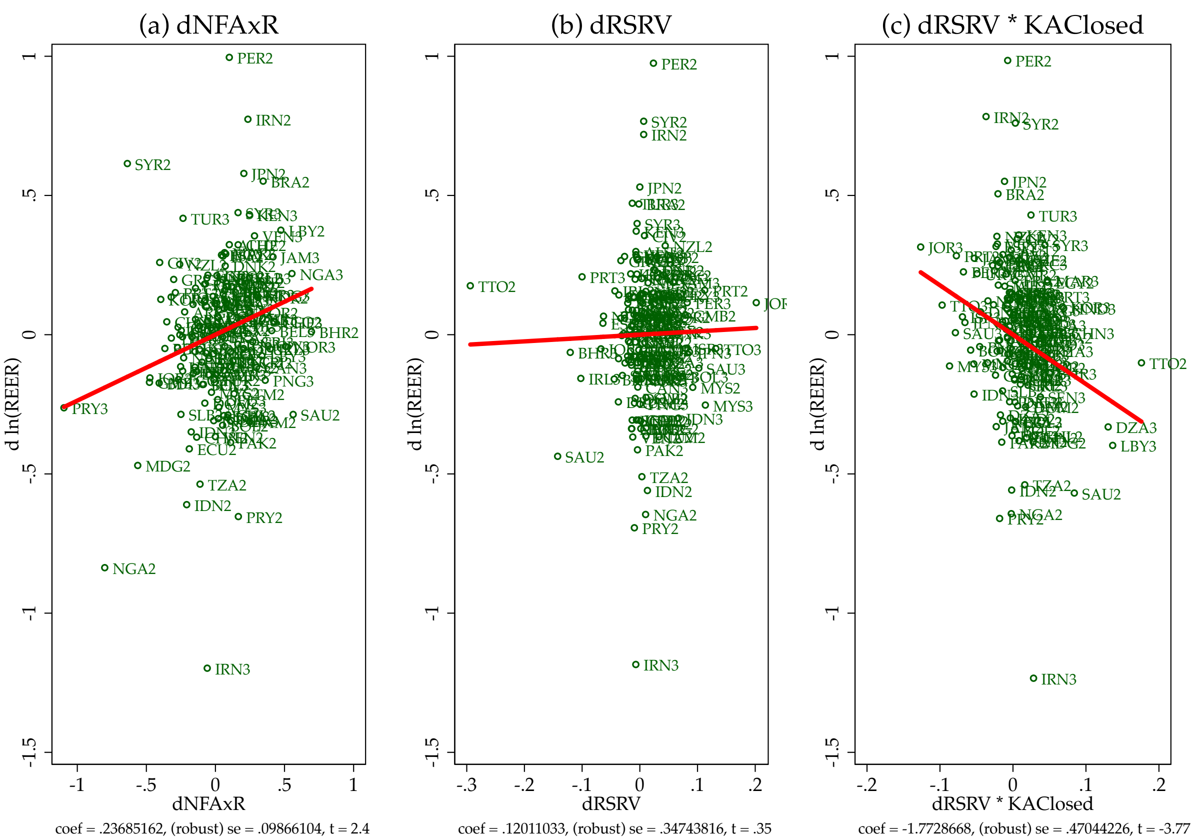
real exchange rate for this subsample.[16]

This concludes our comparisons with prior work. Next we extend the specification, and we ask whether, in line with our model, the effect of reserve accumulation on the real exchange rate varies with the degree of capital controls. Thus we incorporate a capital control interaction in the estimation of equation (13). We claim, again consistent with our model, that the marginal effect is mostly neutral in countries with high financial openness, and negative in countries with low financial openness.

Column (2) in Table 3 shows the main result, and confirms that the association of reserves with the real exchange rate in financially open economies is weaker than that of NFA to GDP (net of reserves). However the association of reserves with the real exchange rate varies with financial openness: a one percentage point increase in reserves to GDP is associated with a statistically insignificant 0.12 percent real appreciation in financially open countries, but a statistically significant 1.65 percent (0.12-1.77 percent) real depreciation in financially closed economies. We also note that the wealth effect NFA

[16] We note that, since the study by Lane and Milesi-Ferretti (2004), the "External Wealth of Nations" data have been revised. Among advanced countries, data for France and Netherlands are substantially revised. With a small sample size the results for advanced countries are possibly affected by just a few outliers.

Figure 1: *The Real Exchange Rate Determination: Partial Scatters, All Countries, Periods 12 & 23*



Notes: Pooled cross-sectional analysis for 75 countries over the period 1975–2007. The REER increases when appreciates. We take the average of variables over the periods 1975–1985, 1986–1996, and 1997–2007, then take the difference for pooled cross-sectional analysis. Results correspond to Table 3, column (2).

to GDP (net of reserves), is robust and stable as compared to the results in column (1).

To get a clearer view of the story, Figure 1 shows partial scatterplots using the results for the augmented specification (column (2)). The negative relationship between reserves and the real exchange rate is seen in a quantitatively large and statistically significant downward slope, a finding is consistent with our model. There is a clear departure in the marginal effect of reserve accumulation, as compared to NFA net of reserves, and it varies with the financial openness measure.

Once again, we also see a distinction between the results in period 12 and the period 23, with the new findings emerging more strongly in later periods. In period 12, the effect of RSRV and NFAxR is similar, as in Column (2), and the coefficient on reserves and the interaction term is not statistically significant. However in period 23, there is a much clearer distinction. Column (2) in Table 5 shows that a one percentage point increase in reserves to GDP is associated with a statistically insignificant 0.23 percent real depreciation in financially open countries, but a statistically significant 1.29 percent real depreciation in financially closed economies. An F-test shows that the hypothesis $\beta^{NFAXR} = \beta^{RSRV \times Ccontrol}$ can be rejected for developing countries during the period.

Again, the result is mainly driven by developing countries. If we compare columns (4) and (6) of Tables 4 and 5, the results are similar in developing countries but not in advanced countries. We argue that our new findings are clearest in high-reserve-accumulation periods and countries of recent international economic experience.

Determinants of the Real Exchange Rate: Panel Analysis Next, to make full use of the all the observations in our dataset, we explored panel estimation, using annual data, with the specification

$$\begin{aligned} log(REER_{it}) &= \alpha_i + D_t + \beta^{NFAxR} NFAxR_{it} + \beta^{RSRV} RSRV_{it} \\ &\quad + \beta^{YD} log(YD_{it}) + \beta^{TT} log(TT_{it}) + \epsilon_{it}, \end{aligned} \tag{14}$$

where D_t denotes a year fixed effect, and t denotes years rather than the period T. Here we split the sample into financially open and closed economies based on $KAClosed$. We now have many more observations and many results will appear statistically more significant.

Regression estimates for equation (14) are shown in Tables 6, 7, and 8. We can see that the wealth effect of NFAxR has a mostly positive effect in all cases. Column (1) in Table 6 shows that that a one percentage point increase in NFA to GDP (net of reserves) is associated with an 0.17 percent appreciation of the real exchange rate. The coefficient from within estimation is thus similar to that in cross-sectional analysis, which was 0.19 percent. Again, it is consistent with the result of Lane and Milesi-Ferretti (2004), and mostly driven by developing countries. However we see a difference in the advanced countries group. Column (2) in Table 7 for advanced countries in period12 shows that a one percentage point increase in NFA to GDP (net of reserves) is associated with a 0.22 percent appreciation of the real exchange rate. However, the result is not stable and vanishes in the period of 1997–2007. As in cross sections, the real exchange rate depreciation with reserve accumulation is clear in developing countries, and the magnitude is higher during the time period of 1986–2007. Column (3) in Table 6 shows that a one percentage point increase in reserve accumulation is associated with a 0.89 percent depreciation. Column (3) in Table 7 shows that the effect of reserves is -0.57 percentage point for period 12, where Table 8 shows that the effect is not only more significant, but large in magnitude, with a coefficient of -0.91 percent, in period 23.

Table 6: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects*

	Period 123 (1975–2007)				
Dependent variable: log(REER)	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.17***	-0.03	0.19**	0.12	0.21**
	(2.74)	(-0.63)	(2.55)	(1.56)	(2.47)
RSRV	-0.98***	0.20	-0.89***	-0.24	-1.28***
	(-3.39)	(0.63)	(-2.78)	(-0.84)	(-3.88)
ln YD	0.16**	0.05	0.10	0.22	0.11*
	(2.10)	(0.39)	(1.28)	(0.91)	(1.86)
ln TT	-0.03	0.12	-0.06	0.06	-0.08
	(-0.56)	(1.54)	(-0.90)	(1.07)	(-0.90)
Observations	2,475	726	1,749	1,254	1,221
Countries	75	22	53	38	37
R^2	0.188	0.23	0.273	0.092	0.31
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.000	0.506	0.003	0.257	0.000

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

Now we turn to the role of capital controls. We simply split the sample into two subgroups by financial openness, using *KAClosed*. Note that except for Iceland and Greece, during the period 12, all other advanced countries had high financial openness index and thus are grouped in financially open countries. The implication of the within estimation is consistent with the cross-sectional analysis, and also confirms that the effect of reserves varies over time. Columns (4) and (5) in Table 7 show the result for period 12: a one-percent increase in reserve accumulation is associated with a statistically insignificant 0.33 percent depreciation of real exchange rate for financially open economies, and 1.06 percent depreciation for financially closed. In columns (4) and (5) in Table 8, a one-percent increase in reserve accumulation is associated with a 0.41 percent and a 1.19 percent depreciation in financially closed and open economies, respectively.

3.3. Trade Balance and Capital Account Policies

In this section, we document how capital account policies are associated with the trade balance. From national accounting and the balance of payments, we know that the adjustment in the current account—trade balance plus net factor income from abroad—is associated with a capital account deficit— i.e., an increase in net foreign assets (private assets plus reserves). In our model the trade balance is an important channel through which reserve accumulation affects the real exchange rate. As another major new result,

Table 7: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects*

Dependent variable: log(REER)	Period 12 (1975–1996)				
	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.32***	0.22*	0.30**	0.14	0.42**
	(2.83)	(1.74)	(2.40)	(1.39)	(2.65)
RSRV	-0.48*	0.38	-0.57**	-0.33	-1.06***
	(-1.75)	(0.88)	(-2.04)	(-1.13)	(-2.95)
ln YD	0.04	-0.10	-0.05	0.42***	-0.21
	(0.31)	(-0.37)	(-0.35)	(2.85)	(-1.51)
ln TT	0.02	0.13	-0.02	0.11	-0.06
	(0.36)	(1.50)	(-0.20)	(1.42)	(-0.55)
Observations	1,650	484	1,166	836	814
Countries	75	22	53	38	37
R^2	0.158	0.26	0.25	0.24	0.209
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.020	0.725	0.016	0.164	0.001

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

Table 8: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects*

Dependent variable: log(REER)	Period 23 (1986–2007)				
	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.13**	-0.07	0.17**	0.11**	0.23**
	(2.21)	(-1.57)	(2.19)	(2.06)	(2.65)
RSRV	-0.90***	-0.06	-0.91**	-0.41*	-1.19***
	(-3.07)	(-0.24)	(-2.59)	(-1.77)	(-3.33)
ln YD	0.14*	0.05	0.14	-0.10	0.19**
	(1.69)	(0.43)	(1.50)	(-0.57)	(2.08)
ln TT	-0.18**	0.11	-0.19**	-0.04	-0.26***
	(-2.38)	(1.05)	(-2.37)	(-0.36)	(-3.00)
Observations	1,650	484	1,166	836	814
Countries	75	22	53	38	37
R^2	0.174	0.17	0.21	0.067	0.267
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.001	0.986	0.003	0.033	0.000

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

we perform a separate empirical consistency check for this.

We now analyze the relationship between the trade balance and our capital account policy instruments, reserve accumulation and capital controls, to see if these relationships are also consistent with the theory. Letting NX be the ratio of net exports to GDP, we estimate cross-section specifications of the form

$$\begin{aligned}\Delta NX_{i,T_1T_2} &= \alpha + D_T + \beta^{NFAxR}\Delta NFAXR_{i,T_1T_2} + \beta^{RSRV}\Delta RSRV_{i,T_1T_2} \\ &\quad + \beta^{R\&KAClosed}\Delta RSRV_{i,T_1T_2} \times KAClosed_i + \epsilon_i, \end{aligned} \tag{15}$$

where T_1T_2 is period 12 and period 23, and for annual panels we estimate

$$NX_{it} = \alpha_i + D_t + \beta^{NFAxR} NFAxR_{it} + \beta^{RSRV} RSRV_{it} + \epsilon_{it}. \tag{16}$$

In Tables 9 and 10, we provide estimates for equations (15) and (16). Consistent with our model and intuitions, we find that the marginal change in net exports is correlated with the marginal change in reserves. On the other hand, the effect of a marginal change in NFAxR is relatively flat. In Table 9, column (1), we find that a one percentage point increase in $RSRV$ is associated with an 0.22 percentage point increase in NX, while a one percentage point increase in $NFAxR$ is virtually unrelated to a change in NX. This bilateral association is again mostly driven by developing countries (see column 5). But when we look at just the advanced countries (column 3), a one percentage point increase in $NFAxR$ is associated with an 0.07 percentage point increase in NX, while $RSRV$ is negatively associated with NX.

When we incorporate the interaction term of $RSRV$ with $KAClosed$, we see that most of the correlation between reserves and net exports is driven by observations where capital controls are in place. In column (2), a one percentage point increase in $RSRV$ is associated with an 0.34 increase in NX (0.06+0.28) in financially closed economies, but only 0.06 in financially open economies. Differences are quantitatively large even if statistical significance is not as pronounced as in the results for real exchange rate determination.

Moving on, the results from the annual panel strengthen our claims with much higher levels of statistical significance, as expected. In Table 10, again, NX is more correlated with $RSRV$ than with $NFAxR$, and this result is stronger in developing countries or in financially closed economies. For the full sample (column 1), a one percentage point increase in $RSRV$ is associated with an 0.16 increase in NX. However, if we estimate with the subsample of developing countries (or with financially closed economies), this

Table 9: *Trade Balances and Reserve Accumulations: Cross-Sectional Analysis*

Dependent variable: ΔNet Exports	Periods 12 (Average 86–96 minus Average 75–85) & 23 (Average 97–07 minus Average 86–96), Pooled Sample					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	-0.01	-0.02	0.07**	NA	-0.03	-0.04
	(-0.44)	(-0.71)	(2.09)		(-1.02)	(-1.31)
Δ RSRV	0.22**	0.06	-0.29		0.27**	0.10
	(2.23)	(0.47)	(-1.66)		(2.39)	(0.66)
Δ RSRV × KAClosed		0.28				0.28
		(1.64)				(1.44)
Period23 Dummy	0.01	0.00	-0.02*		0.01	0.01
	(0.53)	(0.44)	(-1.72)		(0.56)	(0.65)
Observations	144	144	43		101	101
Countries	73	73	22		51	51
R^2	0.06	0.08	0.22		0.08	0.10
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.03	0.56	0.07		0.02	0.39
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.09				0.12

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

Table 10: *Trade Balances and Reserve Accumulations: Annual Panel with Fixed Effects*

Dependent variable: Net Exports	Period 123 (1975–2007)				
	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.00	0.06*	-0.01	0.01	-0.00
	(0.22)	(2.01)	(-0.42)	(0.30)	(-0.12)
RSRV	0.16**	-0.25	0.20**	0.11	0.24**
	(2.16)	(-1.40)	(2.61)	(1.03)	(2.21)
Observations	2379	705	1674	1211	1168
Countries	75	22	53	38	37
R^2	0.08	0.30	0.09	0.08	0.10
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.06	0.12	0.02	0.41	0.05

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

effect becomes much larger. In columns (3) (or (5)), a one percentage point increase in $RSRV$ is associated with an 0.20 (or 0.24) increase in NX in developing countries (respectively, financially closed economies). Again, by contrast, it is interesting that in advanced countries, NX is more correlated with $NFAxR$ than $RSRV$.

Summing up, the choice of capital account policies, in the form of the mix of reserve accumulation and capital controls, is indeed effective at controlling trade balances. Overall, these results on net exports provide a strong and independent confirmation of our theoretical mechanisms.

3.4. Robustness Checks

So far we document how the complex interactions of capital account policies in the form of reserve accumulation and capital controls overturn the standard wealth effect. In this chapter we provide thorough robustness checks on these results. We mainly report results of annual panels and those of cross-sectional analysis can be found in the appendix.

Robustness Check: Other Capital Control Indices In this section, we check the validity of various other measures of capital controls. First, we incorporate a continuous measure of capital controls, $KAControl$, instead of the binary code, $KAClosed$. Specifically, we estimate annual panels

$$\begin{aligned} log\left(REER_{it}\right) &= \alpha_i + D_t + \beta^{NFAxR} NFAxR_{it} + \beta^{RSRV} RSRV_{it} \\ &\quad + \beta^{R\&KAControl} RSRV_{it} \cdot KAControl_{it} + \beta^{KAControl} KAControl_{it} \\ &\quad + \beta^{YD} log(YD_{it}) + \beta^{TT} log(TT_{it}) + \epsilon_{it}. \end{aligned} \tag{17}$$

Second, in addition, following (14), we can again split the sample into financially open and closed economies, replacing $KAClosed$ with alternative binary indicators constructed from several other capital control measures. Most capital account openness indices are built from the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions*. Methods of construction and country-year coverage may vary, and there is a possibility for sample selection bias. However, our results are mostly robust under alternative capital control measures. We employ the capital controls measures from Edwards (2007) and Fernández, Klein, Rebucci, Schindler, and Uribe (2015), and we also try using the capital account openness measure from Quinn and Toyoda (2008). These are available for the years 1975–2005, 1995–2011, and 1975–2005, respectively. We show the results using these measures in Table 12.

Table 11: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects, Continuous Capital Control Measures*

Dependent variable: log(REER)	Period 123 (1975–2007)					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
NFAxR	0.17**	0.19***	-0.01	-0.01	0.18**	0.23***
	(2.64)	(3.07)	(-0.28)	(-0.18)	(2.47)	(3.13)
RSRV	-0.96***	-0.91***	0.14	0.24	-0.90***	-0.77***
	(-3.29)	(-3.91)	(0.48)	(0.84)	(-2.78)	(-3.27)
RSRV×KAControl		-0.26**		0.07		-0.37***
		(-2.07)		(0.37)		(-2.70)
KAControl	-0.05***	-0.02	-0.03	-0.03	-0.03	0.02
	(-3.14)	(-1.02)	(-1.27)	(-1.60)	(-1.66)	(0.71)
ln YD	0.15*	0.15*	-0.04	-0.04	0.11	0.09
	(1.75)	(1.80)	(-0.26)	(-0.24)	(1.16)	(1.02)
ln TT	-0.02	-0.02	0.12	0.13	-0.04	-0.05
	(-0.28)	(-0.27)	(1.42)	(1.49)	(-0.65)	(-0.72)
Observations	2446	2446	720	720	1726	1726
Countries	75	75	22	22	53	53
R^2	0.21	0.22	0.26	0.26	0.27	0.29
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.00	0.63	0.41	0.00	0.00
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAControl}$		0.00		0.67		0.00

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. *t*-statistics in parentheses based on heteroskedasticity consistent standard errors.

In Table 11, we confirm that the effect of NFAxR is again mostly positively related to real exchange rates (i.e., appreciation), and the effect of RSRV is mostly negatively related to real exchange rates (i.e., depreciation). Furthermore, consistent with our theory and similar to results with the binary code, *KAClosed*, there is a clear complementarity between *RSRV* and *KAControl*. In column (1) of Table 11, we can see the effect of *RSRV* and *KAControl* on real exchange rates is negative. If we incorporate the interaction term in column (2), the effect of *RSRV* is nonlinearly decreasing if added with more stringent capital account controls. In Table 12, we confirm that the effects of other widely used capital control measures show very similar patterns.[17]

Robustness Check: Crisis Period It could be argued that our proposed framework should work even with disturbing times, so as a further robustness check we repeat the key estimations, but including the period 2008–2011 in the analysis, where we refer to

[17]For the capital controls measure of Fernández et al. (2015), we show the result for period 23, as their data only start in 1995.

Table 12: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects, Other Capital Control Measures*

Dependent variable:	Edwards Period123		Quinn and Toyoda Period123		Fernández et. al. Period 23	
log(REER)	Financially Open	Financially Closed	Financially Open	Financially Closed	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)	(6)
NFAxR	0.17**	0.17*	0.22**	0.13	0.04	0.20**
	(2.29)	(1.76)	(2.22)	(1.12)	(0.88)	(2.63)
RSRV	-0.34	-1.16***	-0.18	-1.37***	-1.04**	-0.54***
	(-1.08)	(-3.40)	(-0.39)	(-4.65)	(-2.21)	(-2.88)
lnYD	0.36**	0.09	-0.09	0.08	-0.47*	0.00
	(2.06)	(1.06)	(-0.25)	(0.90)	(-1.78)	(0.01)
lnTT	0.08**	-0.11	0.02	-0.10	-0.18**	-0.42***
	(2.23)	(-1.10)	(0.28)	(-0.93)	(-2.50)	(-3.78)
Observations	1,188	1,188	1,089	1,056	660	660
Countries	36	36	33	32	30	30
R^2	0.21	0.22	0.09	0.26	0.17	0.23
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.14	0.00	0.09	0.00	0.03	0.00

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

this last window as period4. Here we check whether the results change if we include the Global Financial Crisis years in the sample.

In Table 13, we document results for period 1234 and period 34. Again, the negative effect of reserves holds in the crisis period. Thus the relationship between reserves and real exchange rates is preserved even in the crisis period.[18]

Robustness Check: Oil Exporting Countries Many oil exporting countries hoard significant amounts of reserves. For example, the average reserve to GDP ratio of oil exporting countries in our sample in period 3 (1997–2007) is 19.98%, which is much higher than the average of all developing countries.[19] The magnitude of coefficients changes and the statistical significance decreases in cross-sectional analysis, though results in panel analysis are broadly robust. Table 14 in this section show that our analyses are broadly robust to the exclusion of these countries. Here we show the results of the same panel analysis without oil exporting countries. In column (1) of Table 14, a one percentage point increase in NFAxR is still associated with an 0.22 percent appreciation of the real

[18]We note that *KAClosed* indicators are reassigned over the period 1234.

[19]The fourteen oil exporting countries in our sample are as follows: Algeria, Bahrain, Cameroon, Ecuador, Indonesia, Iran, Libya, Nigeria, Norway, Mexico, Saudi Arabia, Syrian Arab Republic, Trinidad and Tobago, and Venezuela.

Table 13: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects With Crisis Period*

Dependent variable:	Full		Advanced		Developing		Financially Open		Financially Closed	
log(REER)	Period1234	Period34	Period1234	Period34	Period1234	Period34	Period1234	Period34	Period1234	Period34
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NFAxR	0.08*	0.02	0.03	0.04*	0.17***	0.06	0.09	0.06	0.06	0.01
	(1.91)	(1.31)	(1.33)	(2.02)	(2.73)	(1.11)	(1.40)	(1.37)	(1.29)	(0.48)
RSRV	-0.73***	-0.45***	-0.09	-0.34	-0.72***	-0.44***	-0.32	-0.24***	-0.73***	-0.46***
	(-6.03)	(-5.25)	(-0.51)	(-1.56)	(-4.69)	(-4.11)	(-1.57)	(-3.24)	(-7.66)	(-6.48)
ln YD	0.16**	0.14	-0.03	0.32	0.09	0.11	0.21	0.39***	0.10	0.02
	(2.32)	(1.29)	(-0.31)	(1.54)	(1.49)	(0.88)	(0.93)	(3.20)	(1.69)	(0.12)
ln TT	-0.02	-0.15*	0.12	0.21**	-0.05	-0.18*	0.08	-0.04	-0.10	-0.26**
	(-0.37)	(-1.67)	(1.27)	(2.60)	(-0.80)	(-1.90)	(1.35)	(-0.32)	(-1.15)	(-2.04)
Observations	2775	1125	814	330	1961	795	1406	570	1369	555
Countries	75	75	22	22	53	53	38	38	37	37
R^2	0.18	0.20	0.24	0.40	0.27	0.24	0.10	0.17	0.28	0.27
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.00	0.49	0.08	0.00	0.00	0.07	0.00	0.00	0.00

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

Table 14: *Determinants of Real Effective Exchange Rate: Annual Panel with Fixed Effects Without Oil Exporting Countries*

	Period 123 (1975–2007)				
Dependent variable: log(REER)	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.22***	-0.017	0.27***	0.10	0.28***
	(4.11)	(-0.29)	(4.19)	(1.32)	(3.84)
RSRV	-0.66***	0.31	-0.33	-0.48	-0.57**
	(-2.84)	(1.04)	(-1.24)	(-1.34)	(-2.10)
ln YD	0.080	0.068	0.0027	-0.047	0.056
	(0.95)	(0.53)	(0.032)	(-0.14)	(0.92)
ln TT	-0.0048	0.16	-0.045	0.11	-0.068
	(-0.083)	(1.70)	(-0.78)	(1.42)	(-0.88)
Observations	2013	693	1320	990	1023
Countries	63	21	40	30	31
R^2	0.16	0.24	0.30	0.08	0.36
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.33	0.04	0.12	0.01

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

exchange rate. Also, a one percentage point increase in reserve accumulation to GDP is associated with a statistically significant 0.66 percent depreciation of the real exchange rate. Column (4) and (5) of the same Table confirm that the effect stands out in financially closed economies.

Robustness Check : Other Real Effective Exchange Rates As a final robustness check in this section, we explore whether our results are robust to the use of alternative real effective exchange rate indices. Ready-made real effective exchange rate indices are available from IMF and BIS, from 1980 onwards and from 1995 onwards, respectively. We repeat our main analyses with all available observations: 54 countries for the IMF index and 41 countries for the BIS index. In Tables A.5, 15, and 16, we report our results. We note that again, our overall results are mostly consistent, the only exception being that the positive association between NFAxR and the real exchange rate is not as robust as using the small-sample BIS index.

Table 15: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effect, IMF REER Index*

	1980–2007 (IMF REER available from 1980 onwards)				
Dependent variable: log(REER)	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.16***	-0.07	0.25***	0.04	0.22**
	(2.82)	(-1.53)	(2.95)	(0.56)	(2.29)
RSRV	-0.73***	0.27	-0.68**	-0.22	-0.91***
	(-3.23)	(1.63)	(-2.72)	(-0.72)	(-3.58)
ln YD	0.24*	0.10	0.10	0.39**	0.07
	(1.94)	(0.68)	(1.01)	(2.21)	(0.76)
ln TT	-0.06	0.20*	-0.09	0.08	-0.15**
	(-0.96)	(1.85)	(-1.51)	(0.99)	(-2.25)
Observations	1,534	631	903	942	592
Countries	54	22	32	33	21
R^2	0.33	0.15	0.51	0.21	0.53
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.09	0.00	0.44	0.00

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

Table 16: *Determinants of the Real Effective Exchange Rate: Annual Panel with Fixed Effects, BIS REER Index*

	1994–2007 (BIS REER available from 1994 onwards)				
Dependent variable: log(REER)	Full Sample	Advanced Countries	Developing Countries	Financially Open	Financially Closed
	(1)	(2)	(3)	(4)	(5)
NFAxR	0.04	-0.09**	0.21*	-0.01	0.17
	(0.67)	(-2.32)	(2.06)	(-0.09)	(1.69)
RSRV	-0.40***	-0.11	-0.28**	-0.47***	-0.29*
	(-3.60)	(-0.40)	(-2.13)	(-3.81)	(-1.95)
ln YD	0.27**	0.32**	0.21	0.36*	0.19
	(2.24)	(2.08)	(1.53)	(1.97)	(1.32)
ln TT	-0.21**	0.24**	-0.30***	-0.03	-0.31***
	(-2.63)	(2.60)	(-4.52)	(-0.33)	(-4.51)
Observations	574	308	266	392	182
Countries	41	21	19	28	13
R^2	0.23	0.39	0.38	0.24	0.37
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.94	0.01	0.00	0.01

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

4. Growth Externality, Financial Crisis, and Capital Account Policies

4.1. Extending the Model with Endogenous Capital Account Policies

So far we have documented the striking relationship between the real exchange rate and reserves, taking as given the exogenous policy choices by the government with regard to capital account policies (its desires for a particular combination of reserves and controls). But this is only a partial framework. Now, to close the model, we aim to account for and endogenize the government's decision about the two policy instruments. We incorporate two basic mechanisms which we use to model each of the two standard rationales for reserve accumulation to develop an integrated framework.

To make headway, we now add an initial period ($t = 0$) and assume that financial transactions are made at the initial period. Also we assume that agents are infinitesimally small and of measure one. With this in place, we allow for the economy to have two frictions.

- First, there is a risk of crisis, which is a state of output loss *and* temporary exclusion from international financial markets. After all financial decisions are made, the economy enters the period where there is a small, given probability of a crisis loss. But in crisis the private agent cannot issue additional bonds, since she is excluded from borrowing, and cannot insure. Instead, the government has a motive to stockpile reserves ex-ante (as insurance) which can be liquidated if a crisis hits.[20]
- Second, aggregate exports are assumed to drive a growth externality (of standard learning-by-doing type). We assume current period exports will enhance productivity in the future. However, private agents cannot internalize their own contributions to this channel as they are atomistically small. Hence, the government has a motive to intervene to adjust the trade balance using capital account policies so as to thereby increase overall welfare.[21]

These two frictions provide the rationales behind what we refer to as the *precautionary* and *mercantilist* motives for reserve accumulation, respectively. We presume that the benevolent government optimally combines two policies to alleviate the two frictions. As the magnitude of the two frictions—the expected size of output loss due to a crisis and

[20] We assume that the level of reserves cannot be negative, i.e., in what follows $rsrv^* \geq 0$.

[21] This government intervention is effectively the same as an export subsidy. However, the capital account policy considered here is a second-best instrument to implement the allocation, as compared to an export subsidy. For further discussion, see Benigno and Fornaro (2012), Korinek (2016), and Korinek and Serven (2016).

the degree of growth externality from exports—are allowed to vary, the policies interact endogenously and, consequently, they then influence the real exchange rate in general equilibrium.

In an international setting, we envisage that each economy may have different parameters which govern the growth externality and crisis loss. Some intuition then develops as follows. If the home country is more vulnerable to a crisis, it tries to have more reserves and exchanges more assets with international investors. This will induce a large gross external position. In our model, reserve accumulation can be liquidated when a crisis hits and thus represents a form of insurance.[22] Thus, the optimal policy combination will be high reserve accumulation with financial openness.

However, if the home country faces a larger growth externality, it will have high reserve accumulation but it will also want to deploy capital controls. As in Jeanne (2013), capital account policies affect the trade balance, and can boost exports. The optimal capital account policies will thus be mapped from the two deep parameters.

To formalize, in period 0, the agent makes decisions on financial asset holdings, the levels of international debt d^* and domestic assets a, along with consumption profiles. In period 1, after financial decisions have been made, output is realized, financial transactions are made, and agents consume. At this time, the economy is vulnerable to a crisis with fixed probability π.

If there is a crisis, it has two features. First, there is a $\xi^T(\xi^N)$ share of output loss in tradable (nontradable) goods endowments. Second, private agents are excluded from international financial markets and thus cannot issue debt to buffer consumption loss.[23] The government is also excluded, and cannot issue international debt either, but it *can* instead sell accumulated reserves from the past, subject to an early liquidation penalty.[24] If there is no crisis, there is a growth externality from international trade; an increase in net exports will enhance the productivity of the tradable sector next period.

We assume the growth rate of the tradable sector is endogenously determined as

$$g = \bar{g} + g(ex, \nu), \quad \text{if there is no crisis,} \tag{18}$$

[22]The private agent does not have access to such an insurance instrument, by assumption, and will still have to honor the financial contract which she made before the state is realized. The model can easily encompass the same equilibrium allocation with the assumption that the private agents can also engage in holding reserves with slightly additional costs.

[23]The exclusion is temporary at period 1. The agent is still obligated to repay the debt at period 2, and there is no default.

[24]Alternatively, we can model a buffer stock of liquid assets with long-term liabilities. We instead add an initial period for the decision of financial transactions to be consistent with Section 2.

where ex denotes net exports in period 1 and the parameter ν measures size of the growth externality.[25] The externality vanishes if there is a crisis, and the growth rate is then

$$\hat{g} = \bar{g}, \quad \text{if there is a crisis,} \tag{19}$$

where, from now on, variables with a hat sign will stand for variables in a crisis.

Constrained Social Planner's Problem In this section, we present the allocation for the social planner's problem with the given constraints aforementioned. We show the full illustration of the private agent's problem and the government's problem in the appendix (for which some equation references appear here), and we prove that the social planner's allocation can be replicated by the benevolent government.

By combining budget constraints, (53), (54), (55), (56), (4), (5), (58), and (59), we find a feasible consumption set,

$$\begin{aligned}
c_1^T &= (1+\omega)y^T - (rsrv^* - d^*), && (20)\\
c_2^T &= (1+g(ex,\nu))\, y^T + (1+r^*)(rsrv^* - d^*), && (21)\\
\hat{c}_1^T &= (1+\omega-\xi^T)y^T - \eta(rsrv^*, y^T) - (-d^*), && (22)\\
\hat{c}_2^T &= (1+\bar{g})y^T + (1+r^*)(-d^*), && (23)\\
c_1^N &= y^N, && (24)\\
\hat{c}_1^N &= (1-\xi^N)y^N, && (25)\\
c_2^N &= y^N, && (26)\\
\hat{c}_2^N &= y^N. && (27)
\end{aligned}$$

Again, variables with a hat sign stand for variables in the crisis state. From equations (20), (21), (22) and (23), we can see that tradable consumption is intertemporarily allocated through $(rsrv^* - d^*)$ in the non-crisis state, and through $(-d^*)$ in the crisis state. Note that aggregate exports in the non-crisis state can be rewritten as

$$ex = (1+\omega)y^T - c_1^T = rsrv^* - d^*, \tag{28}$$

and note also that $\eta(rsrv^*, y^T)$ is an early liquidation penalty paid to international investors who buy the reserves, and which is a function of $rsrv^*$ and y^T.

[25]We note that the assumption that net exports induce a growth externality is a standard simplification in the literature. Please see Korinek (2016) and Korinek and Serven (2016) for the detailed debates.

The constrained social planner's problem is then as follows:

$$U^{social} \equiv \max_{\substack{\{c^T_{1,2}, c^N_{1,2}, \hat{c}^T_{1,2}, \hat{c}^N_{1,2},\\ rsrv^*, d^*\}}} \left\{ (1-\pi) \left[u(c_1) + \frac{u(c_2)}{1+r^*} \right] + \pi \left[u(\hat{c}_1) + \frac{u(\hat{c}_2)}{1+r^*} \right] \right\}, \tag{29}$$

subject to (20), (21), (22), (23), (24), (25), (26), (27), and (28).

Analytical Solutions for Social Planner's Problem In the above problem, the social planner's objective is to achieve the optimal levels of reserve accumulation $rsrv^{*opt}$ and external debt holdings d^{*opt}, taking into account the two frictions. By pinning down external debt and external asset positions simultaneously, we argue that this problem is clearly identically equivalent to determining the *gross capital position* and the *net capital position*. Given that mapping, we can now present the analytical solution with some additional assumptions for ease of exposition.

We henceforth assume that the growth externality from aggregate exports takes a simple linear form,

$$g(ex, \nu) = \nu \cdot \frac{ex}{y^T}. \tag{30}$$

Also for analytical tractability we assume the penalty for early liquidation of reserves to be a constant fraction of tradable output y^T,

$$\eta(rsrv^*, y^T) = \bar{\eta} y^T. \tag{31}$$

Now let us define $(1-\pi)\lambda_1$, $\frac{(1-\pi)}{1+r^*}\lambda_2$, $\pi\hat{\lambda}_1$, and $\frac{\pi}{1+r^*}\hat{\lambda}_2$ to be the Lagrangian multipliers for the constraints (20), (21), (22), and (23) in the constrained social planner's problem. After several steps of tedious algebra, we can obtain some key equilibrium conditions as follows,

$$\lambda_1 = \frac{1+r^*+\nu}{1+r^*}\lambda_2, \tag{32}$$

$$\hat{\lambda}_1 = \frac{1+r^*}{1+r^*}\hat{\lambda}_2. \tag{33}$$

These first and second equilibrium conditions are related to the intertemporal consumption decisions in the non-crisis and crisis state, respectively. Note that we have assumed that the probability of crisis is fixed, so we can therefore divide the problem into two independent problems.[26]

The intuition is fairly simple. With reference to the non-crisis state problem, the decision of the *net capital position* has to be made here since it simultaneously determines both the trade balance and the consequent tradable goods allocation between the current and future periods, taking the growth externality (ν) into account, and this tradeoff is embodied in equilibrium condition (32). However, with reference to the crisis state problem, the decision of the *gross capital position* has to be made here, since it determines the war-chest available to buffer against output loss. Liquidating reserves allows more tradable goods to be reallocated into a current crisis state from the post-crisis future state, and this tradeoff is embodied in equilibrium condition (33).[27]

To make more progress with explicit solutions, we make some functional form assumptions. Let us henceforth assume log utility (constant relative risk aversion of one, $\gamma = 1$) and a unit elasticity between tradable and nontradable goods ($\sigma = 1$). The intertemporal decisions then become linear and we can derive closed form solutions, with

$$d^{*opt} = \frac{1}{2+r^*}\Big((1+\bar{g}) - (1+\omega-\xi^T-\bar{\eta})\Big)\cdot y^T, \tag{34}$$

$$rsrv^{*opt} = \frac{1}{2+r^*}\left(\frac{\nu}{1+r^*+\nu}(1+\bar{g}) - (-\xi^T-\bar{\eta})\right)\cdot y^T, \tag{35}$$

$$rer_1^{opt} = \frac{\theta^N}{\theta^T}\cdot\frac{1+r^*}{2+r^*}\cdot\left(1+\omega+\frac{1+\bar{g}}{1+r^*+\nu}\right)\cdot\frac{y^T}{y^N}. \tag{36}$$

First, we note that initial productivity or wealth of a nation ω only appears in d^{*opt} in a one-to-one relation, but not in $rsrv^{*opt}$. This links to our very first proposition earlier in the paper, which relates external private assets and current productivity. External public savings (reserves) do not need to be adjusted in response to changes in current productivity. It is therefore right here that we find an independent role for private and public external asset holdings.

Next we develop several propositions regarding how the two frictions affect external asset positions and, consequently, the real exchange rate.

Proposition 4. *Fixing all other parameters, if an economy has a higher output loss in a crisis*

[26] Note that the separation depends on the assumption that the probability of crisis and the early liquidation penalty are independent of $rsrv^*$. If these variables depend on policy instruments, it cannot be divided into two independent problems as the government has to weigh utilities in non-crisis and crisis state. Here we make a first cut and keep the problem as simple as possible.

[27] That is, once a crisis hits, today's consumption is determined by reserve accumulation, which is piled up to be liquidated and prevents severe consumption drops. Again, recall that the probability of crisis is a constant, so both decisions are independently made.

(ξ^T), optimal reserve accumulation increases while the real exchange rate is not affected. That is,

$$\begin{aligned}\frac{\partial rsrv^{*opt}}{\partial \xi^T} &= \frac{1}{2+r^*}y^T > 0,\\ \frac{\partial rer_1^{opt}}{\partial \xi^T} &= 0.\end{aligned}$$

Proposition 5. *Fixing all other parameters, if an economy has a higher growth externality (ν), optimal reserve accumulation increases while the real exchange rate is depreciated. That is,*

$$\begin{aligned}\frac{\partial rsrv^{*opt}}{\partial \nu} &= \frac{1}{2+r^*}y^T \cdot \frac{(1+r^*)(1+g)}{(1+r^*+\nu)^2} > 0,\\ \frac{\partial rer_1^{opt}}{\partial \nu} &= \frac{\theta^N}{\theta^T}\frac{1+r^*}{2+r^*}\frac{1+\bar{g}}{(1+r^*+\nu)^2}\frac{y^T}{y^N} < 0.\end{aligned}$$

The proofs are immediate and the intuition is as follows. In the former case, there is a higher output loss in a crisis: the precautionary motive strengthens, and the policymaker wants to hold more reserves. The exchange of assets increases so the gross position expands. However, since there is no change in the size of the growth externality, there is no desire to manipulate the trade balance. Net external saving does not change, hence the real exchange rate is not affected. In the closed-form solution, that is, the partial derivatives with respect to ξ^T are the same for external (official) assets $rsrv^*$ and external (private) debts d^*. The two offset each other completely. By contrast, in the latter case, there is a higher growth externality: the mercantilist motive strengthens, and the policymaker wants to induce a larger export surplus and thus, more net savings. In this case, it will be optimal to increase external savings via reserve accumulation, while maintaining the level of debt. The current real exchange rate consequently depreciates as prices adjust to accommodate the larger trade surplus.

Now with the closed-form solution of the real exchange rate available, we can set out a theoretical rationale for our statistically insignificant association between the external asset position and the real exchange rate. From (36), we can see that the real exchange rate is composed of current and future tradable goods, and current nontradable goods. We suggest the following argument:

Proposition 6. *Assume that $(1+\omega)$ and y^N are two independent random variables. Given a fixed variance of the inverse of y^N, the correlation between rer_1^{opt} and $1+\omega$ increases as the variance of $1+\omega$ increases.*

Proof. The correlation between rer_1^{opt} and $1+\omega$ has the following closed form solution

$$\text{corr}\left(rer_1^{opt}, 1+\omega\right)$$
$$= \left(\left(\frac{1+\bar{g}}{1+r^*+\nu} \right)^2 \left(\frac{\theta^N}{\theta^T} \frac{1+r^*}{2+r^*} y^T \right) \frac{1}{(E(1/y^N))^2} \frac{Var(1/y^N)}{Var((1+\omega))} + \frac{2(1+\bar{g})}{1+r^*+\nu} \frac{1}{E(1/y^N)} \right)^{-\frac{1}{2}}$$

□

We conjecture that the volatility of the tradable endowment in a typical developing country is larger than in an advanced country, while that of the nontradable endowment is more similar across developing and advanced countries. If so, then the statistical association between the real exchange rate and the tradable endowment will be relatively weaker in advanced countries compared to developing countries, as the relatively higher volatility of the nontradable endowment will blur the association between tradable consumption and the real exchange rate. And again, since the private external position $(-d^*)$ is a linear multiple of the current tradable endowment as in (34), there is only a weak association between private external positions and real exchange rates. We believe this to be an explanation for statistically non-significant results in advanced economies.

Optimal Capital Account Policies In the previous section, we showed how two underlying friction parameters mapped into external asset and liability positions. Here we derive the optimal capital account policy: the reserves and capital controls needed to implement the constrained social planner's allocation. The government can implement the allocation by its choice of reserves $rsrv^*$, transfer schedule $\{T_1, T_2, \hat{T}_1, \hat{T}_2\}$, and an appropriate degree of capital controls κ to offset private capital inflows. That is, after setting the optimal reserve accumulation $rsrv^{*opt}$ and finding the optimal external debt d^{*opt}, the government can induce the latter by an appropriate tax schedule with degree of capital control κ.[28]

It can be shown that the government's choice of optimal capital control κ satisfies

$$1 - \tau_1(d^{*opt}, \kappa) = \frac{(1-\pi)\lambda_2^{*opt} + \pi\hat{\lambda}_2^{*opt}}{(1-\pi)\lambda_1^{*opt} + \pi\hat{\lambda}_1^{*opt}}. \tag{37}$$

This leads to our main theorem.

[28]We abstract from the domestic bond market. Basically, there are infinitely many solutions for optimal levels of domestic bonds and domestic interest rates, along with tax schemes, which implement the same optimal allocation. Full illustration of the decentralized economy is provided in the appendix.

Theorem. *(Precaution Versus Mercantilism) All else equal, if an economy has a higher output loss in a crisis (ξ^T), the optimal degree of capital control decreases. And if an economy has a higher growth externality (ν), the optimal degree of capital control increases. That is,*

$$\frac{\partial \kappa^{opt}}{\partial \xi^T} \leq 0, \quad \textit{and} \quad \frac{\partial \kappa^{opt}}{\partial \nu} \geq 0.$$

Proof. See Appendix. □

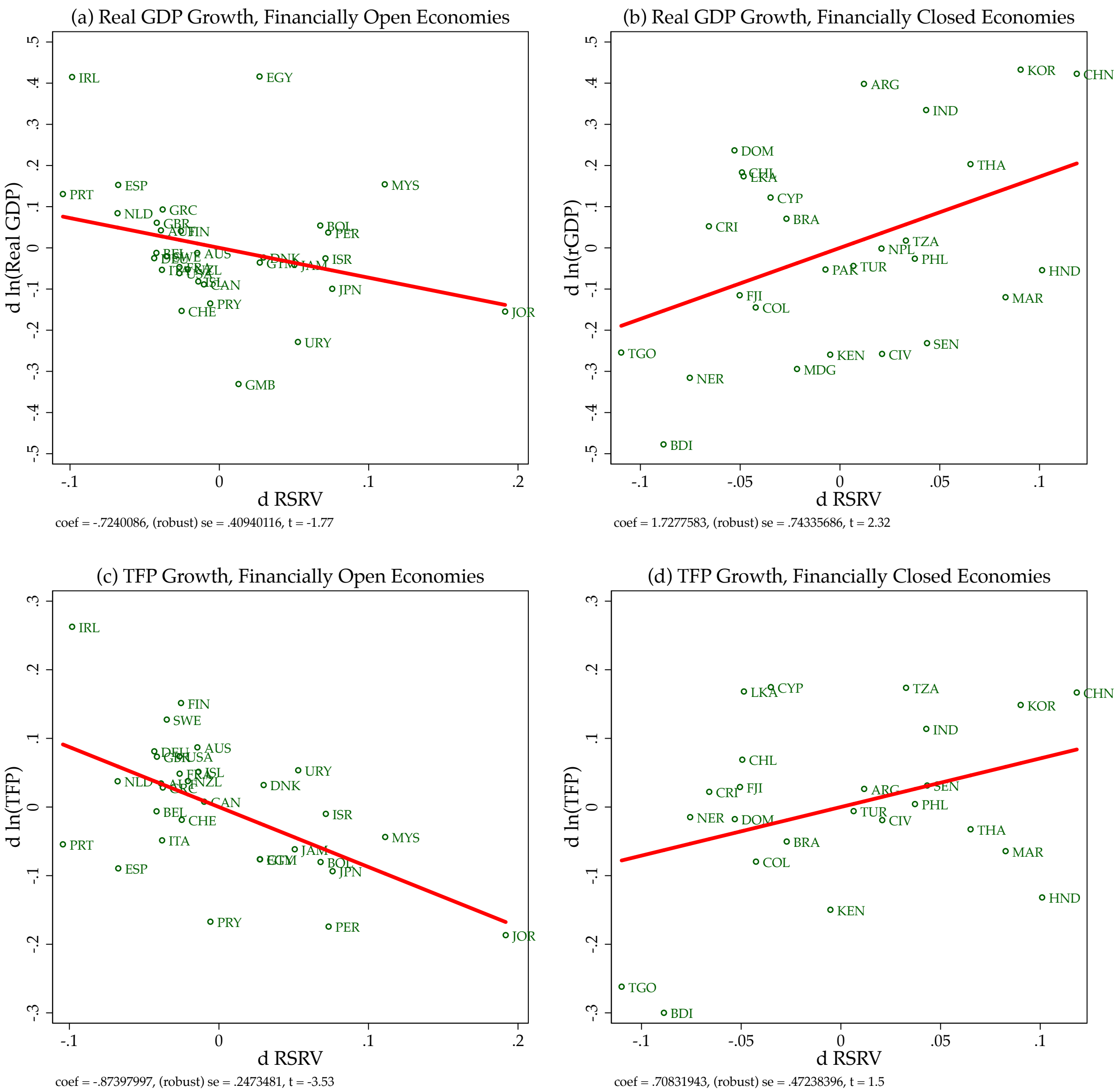
Intuitively, it is clear that the optimal degree of capital control increases with higher growth externality (ν); since the benevolent planner wishes to encourage more aggregate exports, she needs to both increase international reserves and boost controls for offsetting private capital inflows at the same time. On the other hand, if the economy were to have a higher output loss during a crisis (ξ^T), the planner wants to engage in more asset transactions and will hold more reserves; however, as she does not want to increase aggregate exports, she will also relax the degree of capital controls. (We should note that the extent to which capital controls relax will critically depend on the convexity of the tax schedule.)

4.2. Evidence on Capital Account Policies and Economic Growth

Finally, to examine the empirical validity of the above newly proposed model mechanisms, we document the bilateral relationship between capital account policies and economic growth in Figure 2 and Tables 17, 18, 19. Our new model mechanisms presented in this section would suggest that the effect of reserves on real exchange rates and the trade balance is different in different groups of countries because each economy has a different motivation: *mercantilist* exploitation of growth through exports versus *precautionary* efforts to buffer a crisis via reserves. To try to assess the empirical validity of this argument, we document whether capital account policies which potentially exploit the proposed growth externality are, indeed, related to realized economic growth.

We focus on period23, since "mercantilist" motivations seem to have emerged in the 1990s, as argued by Ghosh, Ostry and Tsangarides (2016) and Aizenman and Lee (2008). We first document the bilateral association of reserve growth and real GDP per capita or TFP growth for groups of financially open or closed economies. We take the average level of reserves to GDP (RSRV) and log real GDP per capita or TFP for periods 2 and 3, and take the differences. We present scatterplots in Figure 2. While there are negative relations between reserve growth and real GDP per capita (or TFP) growth in financially open economies, those in financially closed economies are clearly positive. The patterns

Figure 2: *Capital Account Policies and Growth of Real GDP per Capita and TFP: Bivariate Scatters, All Countries*



Notes: Simple bivariate relationship between reserve growth and real GDP per capita growth between period 2 (1986–1996) and 3 (1997–2007). Oil exporting countries are excluded. Constant is included in bivariate regression. Real GDP per capita and TFP are from PWT9.

Table 17: *Cross Section: Capital Account Policy and Growth of Real GDP and TFP*

	Period 2 and 3 (1986–2007)			
Dependent variable:	Real GDP per Capita Growth		TFP Growth	
	All	w/o Oil	All	w/o Oil
	(1)	(2)	(3)	(4)
Δ RSRV	-0.65**	-0.54	-0.47**	-0.61**
	(-2.02)	(-1.01)	(-2.37)	(-2.48)
Δ (RSRV × KAClosed)	1.66***	1.33*	0.59**	0.66**
	(2.77)	(1.80)	(2.49)	(2.37)
Initial Real GDP per capita or TFP	0.06	0.03	-0.54***	-0.57***
	(1.30)	(0.59)	(-7.28)	(-6.04)
Schooling	0.03**	0.03*	0.01	0.01
	(2.24)	(1.90)	(1.43)	(1.13)
Inst. Quality	-0.06	-0.03	0.03***	0.03*
	(-1.66)	(-0.87)	(2.98)	(1.80)
Trade Openness	0.15***	0.05	0.01	0.01
	(3.01)	(0.57)	(0.56)	(0.27)
Credit to GDP	-0.00	-0.00	-0.00	-0.00
	(-0.33)	(-0.09)	(-0.77)	(-0.32)
Terms of Trade (% change)	0.09	0.06	0.03	-0.01
	(0.97)	(0.63)	(0.52)	(-0.17)
Observations	64	54	61	52
Countries	64	54	61	52
R^2	0.39	0.29	0.70	0.69

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. *t*-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

are notably driven by South Korea, China, and several other East Asian countries: the dramatic increase in reserves in period 23 is associated with a high real GDP per capita growth, and TFP growth, all of which is consistent with our model's predictions.

For a full growth analysis, we provide cross-sectional and panel analysis. We regress the growth of real GDP per capita or TFP on the increases of reserves to GDP and its interaction with capital controls,

$$\begin{aligned} \Delta log(y_i) \quad &= \quad \alpha + \beta^{RSRV} \Delta RSRV_i + \beta^{R\&KAClosed} \Delta RSRV_i \times KAClosed_i \\ &\quad + \beta^{InitialGDP} log(y_{i,0}) + \gamma' Z_i + \epsilon_i, \end{aligned} \tag{38}$$

where y is the average real GDP per capita or TFP for period 2 or 3. The initial value of real GDP per capita or TFP comes from the the last year of the period 1. Z stands for all other controls chosen based on Estevadeordal and Taylor (2013) or Kose, Prasad, and Terrones (2009).[29] The results for the cross-sectional analysis are reported in Table 17:

[29]Data for real GDP and TFP come from PWT9. Real GDP per capita is constructed using real GDP

Table 18: *Annual Panel: Capital Account Policy and Growth of Real GDP per Capita*

	Period 2 & Period 3 (1986-2007)											
Dependent variable:	All Sample						w/o Oil Exporters					
Real GDP per Capita Growth	All	Fin.Opn.	Fin.Cl.	Adv.	EM	Dev.	All	Fin.Opn.	Fin.Cl.	Adv.	EM	Dev.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lagged Δ RSRV	0.07	0.04	0.23**	0.01	0.19**	0.02	0.03	-0.05	0.23**	-0.06	0.27***	-0.03
	(1.18)	(0.56)	(2.56)	(0.06)	(2.60)	(0.31)	(0.38)	(-0.49)	(2.51)	(-0.57)	(3.18)	(-0.26)
Initial Real GDP per Capita	-0.05**	-0.09***	-0.02	-0.08***	-0.10***	-0.02	-0.09***	-0.11***	-0.08***	-0.09***	-0.10***	-0.08***
	(-2.54)	(-4.62)	(-0.69)	(-3.10)	(-3.62)	(-0.91)	(-6.72)	(-4.86)	(-5.28)	(-3.41)	(-3.39)	(-3.69)
Schooling	0.01	0.01*	0.00	0.00	0.04**	0.01	0.01**	0.01**	0.02*	0.00	0.04**	0.01
	(1.65)	(2.00)	(0.03)	(1.19)	(2.90)	(1.02)	(2.30)	(2.11)	(1.84)	(0.89)	(2.54)	(1.33)
Inst. Quality	0.01***	0.01***	0.00	0.00*	0.01**	0.01*	0.01***	0.00***	0.01**	0.00*	0.00	0.01*
	(2.93)	(3.90)	(0.81)	(1.82)	(2.60)	(1.90)	(3.30)	(2.81)	(2.52)	(1.99)	(1.38)	(1.98)
Trade Openness	0.03*	0.03***	0.04	0.02***	-0.04	0.05	0.01*	0.03***	-0.03	0.02***	-0.06*	-0.02
	(1.69)	(3.51)	(1.28)	(3.51)	(-1.31)	(1.62)	(1.75)	(3.08)	(-0.91)	(2.88)	(-1.85)	(-0.63)
Credit to GDP	-0.00***	-0.00***	-0.00**	-0.00	0.00	-0.00**	-0.00***	-0.00**	-0.00	-0.00	-0.00	-0.00
	(-3.80)	(-3.08)	(-2.16)	(-1.09)	(0.03)	(-2.26)	(-3.20)	(-2.49)	(-1.60)	(-0.57)	(-0.11)	(-1.35)
Terms of Trade	-0.01	0.04	-0.04*	0.03	-0.11***	0.04*	-0.04	-0.02	-0.05*	-0.03	-0.11***	0.01
(% change)	(-0.42)	(1.36)	(-2.05)	(0.55)	(-10.11)	(1.85)	(-1.67)	(-0.67)	(-1.90)	(-0.99)	(-10.45)	(0.51)
Observations	1231	724	507	424	248	559	1037	609	428	405	208	424
Countries	64	38	26	22	13	29	54	32	22	21	11	22
R^2	0.18	0.26	0.22	0.44	0.63	0.20	0.24	0.27	0.32	0.48	0.66	0.23

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors.

Table 19: *Annual Panel: Capital Account Policy and Growth of TFP*

Dependent variable:	Period 2 & Period 3 (1986-2007)											
	All Sample						w/o Oil Exporters					
TFP Growth	All	Fin.Opn.	Fin.Cl.	Adv.	EM	Dev.	All	Fin.Opn.	Fin.Cl.	Adv.	EM	Dev.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lagged Δ RSRV	0.03	-0.02	0.20^{***}	0.06	0.14^{**}	-0.01	0.07^{*}	0.03	0.17^{***}	0.05	0.20^{**}	0.04
	(0.47)	(-0.31)	(3.19)	(0.96)	(2.60)	(-0.14)	(1.79)	(0.64)	(2.92)	(0.71)	(2.86)	(0.92)
Initial TFP	-0.11^{***}	-0.11^{**}	-0.09^{***}	-0.06^{***}	-0.17^{***}	-0.10^{**}	-0.11^{***}	-0.15^{***}	-0.07^{**}	-0.06^{***}	-0.20^{***}	-0.10^{***}
	(-3.95)	(-2.63)	(-3.41)	(-3.77)	(-3.19)	(-2.31)	(-4.57)	(-4.21)	(-2.63)	(-3.28)	(-3.38)	(-3.01)
Schooling	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(-0.50)	(-0.61)	(0.41)	(-1.35)	(-0.40)	(-0.07)	(-0.84)	(-0.93)	(-0.44)	(-1.35)	(-0.22)	(-0.56)
Inst. Quality	0.00^{***}	0.00^{***}	0.00^{***}	0.00	0.00	0.00^{**}	0.00^{***}	0.00^{**}	0.00^{***}	0.00	0.00	0.00^{**}
	(3.40)	(2.74)	(3.10)	(0.98)	(1.56)	(2.25)	(3.02)	(2.68)	(2.92)	(0.59)	(0.53)	(2.43)
Trade Openness	0.02^{***}	0.02^{***}	0.02^{***}	0.01^{***}	-0.01	0.02^{***}	0.01^{***}	0.02^{***}	0.03	0.01^{***}	-0.00	0.02
	(6.13)	(3.37)	(7.78)	(4.05)	(-0.41)	(4.10)	(4.17)	(3.27)	(1.17)	(4.15)	(-0.27)	(0.86)
Credit to GDP	-0.00^{*}	-0.00	-0.00^{*}	-0.00	-0.00	-0.00	-0.00^{**}	-0.00	-0.00^{**}	-0.00	-0.00	-0.00
	(-1.95)	(-1.43)	(-1.75)	(-0.99)	(-0.55)	(-1.08)	(-2.20)	(-1.46)	(-2.17)	(-1.07)	(-1.28)	(-1.14)
Terms of Trade	-0.03^{**}	-0.01	-0.05^{**}	-0.02	-0.10^{***}	-0.00	-0.03^{*}	-0.01	-0.05^{*}	-0.02	-0.10^{***}	0.01
(% change)	(-2.37)	(-0.74)	(-2.75)	(-1.30)	(-7.62)	(-0.03)	(-1.93)	(-0.67)	(-2.07)	(-1.52)	(-6.75)	(0.67)
Observations	1187	720	467	424	248	515	1013	605	408	405	208	400
Countries	61	37	24	22	13	26	52	31	21	21	11	20
R^2	0.18	0.15	0.30	0.18	0.56	0.19	0.21	0.24	0.27	0.19	0.65	0.21

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. *t*-statistics in parentheses based on heteroskedasticity consistent standard errors.

reserves are positively associated with economic growth in the financially closed group.

For the corresponding analysis using annual panel data, we regress the growth of real GDP per capita or TFP on the *lagged* increases of reserves to GDP for different groups,

$$
\begin{aligned}
log(y_{i,t}) - log(y_{i,t-1}) &= \alpha_i + D_t + \beta^{RSRV} \left(RSRV_{i,t-1} - RSRV_{i,t-2} \right) \\
&\quad + \beta^{Initial} log(y_{i,t-1}) + \gamma' Z_{i,t} + \epsilon_{i,t}. \qquad (39)
\end{aligned}
$$

The results reported in Table 18 and 19 are notable for a group of emerging economies. These are consistent with our model prediction, where economies with high reserves and high capital controls are exploiting "mercantilist" export-driven growth.[30]

5. Conclusion

We have documented new stylized facts regarding real exchange rates. Economists have argued for decades, if not centuries, that the real exchange rate is positively associated with an economy's net external asset position: the real exchange rate appreciates when external wealth increases. This view has long been central to our understanding of the international payment mechanism and relative price adjustment.

On the contrary, we claim that the real exchange rate implications of external assets held by the public sector differs from those of external assets held by private agents. Our empirical results show that for 1975–2007, controlling for GDP and the terms of trade, a one percentage point increase in net external assets to GDP (net of reserves) is associated with an 0.24 percent real exchange rate appreciation. Yet, a one percentage point increase in reserve accumulation to GDP has little effect on the real exchange rate in financially open countries (countries with low capital controls), and is associated with a 1.77 percent real exchange rate depreciation in financially closed countries (countries with high capital controls). Our results are robust when confronted with a battery of specification checks, sample changes, and to alternative measures of controls, real exchange rates. Our results are strongest in developing countries in the most recent period.

To account for these findings, we present a theoretical framework. Our model of *precautionary* and *mercantilist* motives explains the result due to two competing forces: the desire, on the one hand, to hold reserves as insurance against crisis losses and capital

(expenditure side) in PWT, divided by population. For TFP, we use TFP at constant prices (2011). Schooling data is from Barro and Lee (2013), and quality of institutions comes from the *International Country Risk Guide (ICRG)* of the PFS group. We linearly interpolate schooling to annual frequency. Other controls are from IMF IFS or WDI. Trade Openness is constructed by Export plus Import divided by GDP. Initial real GDP per capita or TFP is the log value for 1985.

[30] For additional sectoral evidence on these mechanisms, see **?**.

market exclusion; and another desire to use real exchange rate and capital account policies to force external saving through a trade surplus when there is an export-led growth externality. We provide further empirical evidence on growth and TFP outcomes consistent with these model mechanisms.

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Appendices

A. Proof of Propositions 1–3

We note that Lagrangian multipliers λ_1, λ_2 are function of $\omega, rsrv^*, \tau, d^*$,

$$\begin{aligned}\lambda_1(\omega, rsrv^*, \kappa, d^*) &= u'(c_1)\frac{\partial c_1}{\partial c_1^T} = u'(c_1)c_1^{\frac{1}{\sigma}}\theta^{T\frac{1}{\sigma}}(c_1^T)^{-\frac{1}{\sigma}},\\ \lambda_2(\omega, rsrv^*, \kappa, d^*) &= \frac{1}{1+r^*}u'(c_2)\frac{\partial c_2}{\partial c_2^T} = \frac{1}{1+r^*}u'(c_2)c_2^{\frac{1}{\sigma}}\theta^{T\frac{1}{\sigma}}(c_2^T)^{-\frac{1}{\sigma}},\end{aligned}$$

given a composite consumption by (1), and a feasible consumption set by (6) and (7). We can then obtain the following partial derivates,

$$\begin{array}{llllll}\frac{\partial\lambda_1}{\partial\omega} & \leq & 0, & \frac{\partial\lambda_2}{\partial\omega} & = & 0,\\ \frac{\partial\lambda_1}{\partial rsrv^*} & \geq & 0, & \frac{\partial\lambda_2}{\partial rsrv^*} & \leq & 0,\\ \frac{\partial\lambda_1}{\partial d^*} & \leq & 0, & \frac{\partial\lambda_2}{\partial d^*} & \geq & 0.\end{array} \tag{40}$$

And also,

$$\frac{\partial\lambda_t}{\partial\kappa} = 0 \quad \text{for } t=1,2, \quad \frac{\partial\lambda_t}{\partial rsrv^*} = -\frac{\partial\lambda_t}{\partial d^*} \quad \text{for } t=1,2, \quad \frac{\partial\lambda_1}{\partial\omega} = \frac{1}{y^T}\frac{\partial\lambda_1}{\partial d^*}. \tag{41}$$

Define the function $\Phi(\omega, rsrv^*, \kappa, d^*)$ as,

$$\Phi(\omega, rsrv^*, \kappa, d^*) \equiv (1-\tau_1(d^*,\kappa))\,\lambda_1(\omega, rsrv^*, \kappa, d^*) - \lambda_2(\omega, rsrv^*, \kappa, d^*). \tag{42}$$

And let $d^{*opt}(\omega, rsrv^*, \kappa)$ be a solution to consumer's maximization problem. We note that

$$\Phi\left(\omega, rsrv^*, \kappa, d^{*opt}(\omega, rsrv^*, \kappa)\right) \equiv 0. \tag{43}$$

Partial derivatives of Φ yields,

$$\Phi_1 \equiv \frac{\partial\Phi(\cdot)}{\partial\omega} = (1-\tau_1(\cdot))\frac{\partial\lambda_1}{\partial\omega} \leq 0, \tag{44}$$

$$\Phi_2 \equiv \frac{\partial\Phi(\cdot)}{\partial rsrv^*} = (1-\tau_1(\cdot))\frac{\partial\lambda_1}{\partial rsrv^*} - \frac{\partial\lambda_2}{\partial rsrv^*} \geq 0, \tag{45}$$

$$\Phi_3 \equiv \frac{\partial\Phi(\cdot)}{\partial\kappa} = -\tau_{12}\lambda_1 \leq 0, \tag{46}$$

$$\Phi_4 \equiv \frac{\partial\Phi(\cdot)}{\partial d^*} = (1-\tau_1(\cdot))\frac{\partial\lambda_1}{\partial d^*} - \frac{\partial\lambda_2}{\partial d^*} - \tau_{11}\lambda_1 \leq 0. \tag{47}$$

By the implicit function theorem combined with (40), (41), and (44)–(47), we have

$$-y^T < \left.\frac{\partial d^*}{\partial\omega}\right|_{d^*=d^{*opt}} = -\frac{\Phi_1}{\Phi_4} \leq 0, \tag{48}$$

$$0 < \left.\frac{\partial d^*}{\partial rsrv^*}\right|_{d^*=d^{*opt}} = -\frac{\Phi_2}{\Phi_4} \leq 1, \tag{49}$$

$$\left.\frac{\partial d^*}{\partial\kappa}\right|_{d^*=d^{*opt}} = -\frac{\Phi_3}{\Phi_4} \leq 0. \tag{50}$$

We can rewrite the equilibrium condition (9),

$$rer_1 = \left(\frac{\theta^N}{\theta^T} \frac{1}{y^N} \left((1+\omega) y^T - \left(rsrv^* - d^{*opt}(\cdot) \right) \right) \right)^{\frac{1}{\sigma}}. \tag{51}$$

Taking a derivative of (51), we have

$$\begin{aligned}
\frac{\partial rer_1}{\partial \omega} &= \frac{1}{\sigma} \left(\frac{\theta^N}{\theta^T} \frac{1}{y^N} \right)^{\frac{1}{\sigma}} {c_1^T}^{\frac{1}{\sigma}-1} \left(y^T + \frac{\partial d^{*opt}}{\partial \omega} \right) &\geq 0, \\
\frac{\partial rer_1}{\partial rsrv^*} &= \frac{1}{\sigma} \left(\frac{\theta^N}{\theta^T} \frac{1}{y^N} \right)^{\frac{1}{\sigma}} {c_1^T}^{\frac{1}{\sigma}-1} \left(-1 + \frac{\partial d^{*opt}}{\partial rsrv^*} \right) &\leq 0, \\
\frac{\partial rer_1}{\partial \kappa} &= \frac{1}{\sigma} \left(\frac{\theta^N}{\theta^T} \frac{1}{y^N} \right)^{\frac{1}{\sigma}} {c_1^T}^{\frac{1}{\sigma}-1} \left(\frac{\partial d^{*opt}}{\partial \kappa} \right) &\leq 0.
\end{aligned}$$

Q.E.D.

B. The Model with Endogenous Policies : Full Illustration

Private agent's problem is given as follows. Given prices, $\{p_{1,2}, \hat{p}_{1,2}\}$, a set of government policies, $\{\kappa, T_{1,2}, \hat{T}_{1,2}, r\}$, and growth rates $g, \hat{g}$, private agent maximizes the utility,

$$U^{private} \equiv max_{\{c_{1,2}^T, c_{1,2}^N, \hat{c}_{1,2}^T, \hat{c}_{1,2}^N, d^*, a\}} \; (1-\pi) \left[u(c_1) + \frac{1}{1+r^*} u(c_2) \right] + \pi \left[u(\hat{c}_1) + \frac{1}{1+r^*} u(\hat{c}_2) \right], \tag{52}$$

subject to

$$\begin{aligned}
c_1^T + p_1 c_1^N + a + \tau(d^*, \kappa) &\leq (1+\omega) y^T + p_1 y^N + d^* + T_1, & (53)\\
c_2^T + p_2 c_2^N + (1+r^*) d^* &\leq (1+g) y^T + p_2 y^N + (1+r) a + T_2, & (54)\\
\hat{c}_1^T + \hat{p}_1 \hat{c}_1^N + a + \tau(d^*, \kappa) &\leq (1+\omega - \xi^T) y^T + \hat{p}_1 (1-\xi^N) y^N + d^* + \hat{T}_1, & (55)\\
\hat{c}_2^T + \hat{p}_2 \hat{c}_2^N + (1+r^*) d^* &\leq (1+\hat{g}) y^T + \hat{p}_2 y^N + (1+r) a + \hat{T}_2, & (56)
\end{aligned}$$

where $\hat{c}_t^T, \hat{c}_t^N$ represents consumptions of period t with crisis, $\hat{p}_t$ is the price of nontradable goods for period t with crisis, $\hat{T}_t$ is the transfer (negative tax) of period t with crisis. Note that non-crisis budget constraints are exactly the same as in the previous section. And the level of debt (d^*) and asset (a) contract cannot be renegotiated so they are the same in each state.[31]

We can define solutions of private agent's problem as,

$$\begin{aligned}
&\{c_{1,2}^{Tp}, c_{1,2}^{Np}, \hat{c}_{1,2}^{Tp}, \hat{c}_{1,2}^{Np}, d^{*p}, a^p\} \equiv argmax_{\{c_{1,2}^T, c_{1,2}^N, \hat{c}_{1,2}^T, \hat{c}_{1,2}^N, d^*, a\}} \; U^{private}, \\
&\text{given } \{p_{1,2}, \hat{p}_{1,2}\}, \{\kappa, T_{1,2}, \hat{T}_{1,2}, r\}, \text{ and } \{g, \hat{g}\}.
\end{aligned} \tag{57}$$

The government budget constraints in the non-crisis state are the same as in (4), (5). In the

[31] Note that r is a government determined interest rate since foreign investors cannot participate in domestic financial market. And thus the government is the only participant and behave as a monopolitic provider of domestic asset. Again, although it is an important issue in general, we abstract from it throughout the anlaysis; tax and bond financing are equivalent.

crisis state, the government budget constraints are

$$rsrv^* + \hat{T}_1 \leq a + \tau(d^*, \kappa) + \left(rsrv^* - \eta(rsrv^*, y^T)\right), \tag{58}$$
$$\hat{T}_2 + (1+r)a \leq 0, \tag{59}$$

where $\eta(rsrv^*, y^T)$ is the liquidation penalty.

Now we can write the government's problem as

$$U^{govt} \equiv max_{\{rsrv^*, \kappa, T_{1,2}, \hat{T}_{1,2}, r\}} (1-\pi)\left[u(c_1^p) + \frac{1}{1+r^*}u(c_2^p)\right] + \pi\left[u(\hat{c}_1^p) + \frac{1}{1+r^*}u(\hat{c}_2^p)\right], \tag{60}$$

subject to the government budget constraints, (4), (5), (58), (59), growth rates (18) and (19), aggregate exports (28), and the set of private agent's solutions (57), with resource conditions (20), (21), (22), (23), (24), (25), (26), (27), and prices such that

$$\frac{\theta^N}{\theta^T}\frac{c_t^{Tp}}{c_t^{Np}} = p_t^\sigma, \quad \text{and} \quad \frac{\theta^N}{\theta^T}\frac{\hat{c}_t^{Tp}}{\hat{c}_t^{Np}} = \hat{p}_t^\sigma, \quad \text{for} \quad t = 1, 2.$$

Intuitively, we note that the government's problem is to replicate the solution of the constrained social planner's problem (29). Indeed, there are infinitely many policies that solve the government's problem. Instead of documenting all of them, we propose one set of policies. First, set r strictly smaller than r^*. This will guarantee a to be zero in $U^{private}$. Then set $rsrv^* = rsrv^{*opt}$. And set κ^{opt} to satisfy the following condition

$$1 - \tau_1(d^{*opt}, \kappa) = \frac{(1-\pi)\lambda_2^{opt} + \pi\hat{\lambda}_2^{opt}}{(1-\pi)\lambda_1^{opt} + \pi\hat{\lambda}_1^{opt}} \tag{61}$$

where $(1-\pi)\lambda_1^{opt}$, $\frac{(1-\pi)}{1+r^*}\lambda_2^{opt}$, $\pi\hat{\lambda}_1^{opt}$, and $\frac{\pi}{1+r^*}\hat{\lambda}_1^{opt}$ are the Lagrangian multipliers of (53), (54), (55), and (56), respectively. Finally set the transfer scheme: $T_1^{opt} = -rsrv^{*opt} + \tau(d^{*opt}, \kappa^{opt})$, $T_2^{opt} = (1+r^*)rsrv^{*opt}$, $\hat{T}_1^{opt} = \tau(d^{*opt}, \kappa^{opt}) - \eta(rsrv^{*opt}, y^T)$, and $\hat{T}_2^{opt} = 0$. These define one of solutions to the government's problem and attain U^{govt}.

If we assume a form of log utility (relative risk aversion $\gamma = 1$) and unit elasticity between tradable and nontradable goods ($\sigma = 1$), closed form solutions are given by (34),(35), and

$$c_1^{opt} = \left(\lambda_1^{opt}\right)^{-1} = \frac{1+r^*}{2+r^*}\left((1+\omega) + \frac{1}{1+r^*+\nu}(1+\bar{g})\right), \tag{62}$$
$$c_2^{opt} = \left(\lambda_2^{opt}\right)^{-1} = \frac{1+r^*+\nu}{2+r^*}\left((1+\omega) + \frac{1}{1+r^*+\nu}(1+\bar{g})\right), \tag{63}$$
$$\hat{c}_1^{opt} = \hat{c}_2^{opt} = \left(\hat{\lambda}_1^{opt}\right)^{-1} = \left(\hat{\lambda}_2^{opt}\right)^{-1} = \frac{1+r^*}{2+r^*}\left((1+\omega-\xi-\bar{\eta}) + \frac{1}{1+r^*}(1+\bar{g})\right). \tag{64}$$

C. Proof of Theorem

Let κ^{opt} be a optimal capital control which satisfies the condition (37). Then we can rewrite the equilibrium condition as an identity,

$$\frac{1}{\tau_1\left(d^{*opt},\kappa^{opt}\right)} \equiv \left(1+\frac{1+r^*}{\nu}\right)\left(1+\frac{\pi}{1-\pi}\frac{c_1^{opt}}{\hat{c}_1^{opt}}\right).$$

Taking derivatives on each side with respect to ξ^T yields

$$\frac{\partial\kappa^{opt}}{\partial\xi^T} = \left(\left(1+\frac{1+r^*}{\nu}\right)\frac{\pi}{1-\pi}\frac{c_1^{opt}}{\left(\hat{c}_1^{opt}\right)^2}\frac{\partial\hat{c}_1^{opt}}{\partial\xi^T}\tau_1(\cdot)^2-\tau_{11}\frac{\partial d^{*opt}}{\partial\xi^T}\right)\tau_{12}(\cdot)^{-1}\leq 0.$$

Taking derivatives on each side with respect to ν yields

$$\frac{\partial\kappa^{opt}}{\partial\nu} = \left(\tau_1(\cdot)\right)^{-2}\left(\tau_{12}(\cdot)\right)^{-1}\left(\left(1+\frac{\pi}{1-\pi}\frac{c_1^{opt}}{\hat{c}_1^{opt}}\right)\frac{1}{\nu^2}-\left(1+\frac{1+r^*}{\nu}\right)\frac{\pi}{1-\pi}\frac{1}{\hat{c}_1}\frac{\partial c_1^{opt}}{\partial\nu}\right)\geq 0.$$

Q.E.D.

D. Robustness Checks: Cross-Sectional Analysis

In this section, we check the validity of the robustness checks using cross-sectional analysis rather than annual panel data. In Table A.1, we report the results of the specification,

$$\begin{aligned}\Delta log\left(REER_{i,T_1T_2}\right) \quad = \quad & \alpha + D_T + \beta^{NFAxR}\Delta NFAXR_{i,T_1T_2} + \beta^{RSRV}\Delta RSRV_{i,T_1T_2} \\ & +\beta^{R\&KAControl}\Delta\left(RSRV_{i,T_1T_2}\right)\cdot KAControl_{i,T_1T_2} \\ & +\beta^{KAControl}KAControl_{i,T_1T_2} \\ & +\beta^{YD}\Delta\log(YD_{i,T_1T_2}) + \beta^{T_1T_2}\Delta\log(TT_{i,T_1T_2}) + \epsilon_i. \qquad (65)\end{aligned}$$

Table A.2 reports the results with the binary interaction term constructed using other capital control measures from Edwards (2007) and Fernández et al. (2015), and capital account openness measure from Quinn and Toyoda (2008). In Table A.3, we analyze period 3 and 4, to include real exchange rate determination during the crisis period; interestingly, the negative association between reserve accumulation and the real exchange rate still holds. In Table A.4, we document the result without oil exporting countries. And in Table A.5, we incorporate the real effective exchange rate index from the IMF. All results are broadly robust and consistent with previous results in the main text.

E. List of Countries

The list of sample countries and their binary financial openness indicator $(1 - KAClosed)$ by period is shown in Table A.6.

Table A.1: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis, Continuous Capital Control Measures*

Dependent variable: Δ log(REER)	Periods 12 (Average 86–96 minus Average 75–85) Periods 23 (Average 97–07 minus Average 86–96), Pooled Sample					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.18*	0.25**	-0.11	-0.11	0.20	0.31**
	(1.67)	(2.41)	(-1.47)	(-1.44)	(1.65)	(2.60)
Δ RSRV	-0.66*	-0.70***	-0.09	0.05	-0.96**	-0.79***
	(-1.92)	(-2.82)	(-0.22)	(0.09)	(-2.45)	(-3.24)
Δ RSRV × KAControl		-0.57***		0.09		-0.84***
		(-2.82)		(0.21)		(-3.90)
KAControl	-0.04**	-0.02	0.01	0.01	-0.00	0.03
	(-2.21)	(-1.23)	(0.35)	(0.27)	(-0.16)	(1.35)
Δ ln YD	0.05	0.07	0.02	-0.00	0.03	0.01
	(0.49)	(0.68)	(0.09)	(-0.01)	(0.24)	(0.07)
Δ ln TT	0.09	0.10	0.35***	0.35***	0.04	0.04
	(0.82)	(1.01)	(3.02)	(2.93)	(0.36)	(0.40)
Time Dummy	0.07	0.08*	-0.03	-0.03	0.19***	0.19***
	(1.55)	(1.74)	(-0.54)	(-0.53)	(3.21)	(3.23)
Observations	150	150	44	44	106	106
Countries	75	75	22	22	53	53
R^2	0.13	0.17	0.20	0.20	0.13	0.20
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.03	0.00	0.96	0.77	0.01	0.00
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.00		0.62		0.00

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

Table A.2: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis, Other Capital Control Measures*

Dependent variable:	Edwards	Quinn and Toyoda	Fernández et al.
Δ log(REER)	Period 123	Period123	Period23
	(1)	(2)	(3)
Δ NFAxR	0.22**	0.23**	0.12**
	(2.09)	(1.99)	(2.15)
Δ RSRV	0.11	0.43	-0.47
	(0.21)	(0.79)	(-0.84)
Δ RSRV × KAClosed	-1.36**	-1.81***	-0.57
	(-2.15)	(-2.75)	(-0.87)
Δ ln YD	0.11	-0.00	-0.05
	(0.99)	(-0.01)	(-0.34)
Δ ln TT	0.10	0.06	-0.38**
	(0.92)	(0.38)	(-2.40)
Time Dummy	0.11**	0.12***	
	(2.40)	(2.66)	
Observations	144	130	60
Countries	72	65	60
R^2	0.12	0.13	0.29
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.84	0.73	0.30
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$	0.02	0.00	0.30

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

Table A.3: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis With Crisis Period*

Dependent variable: Δ log(REER)	Period 34 (Average 08–11 minus Average 97–07)					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.02	0.02	0.04^{*}	-0.04	-0.01	0.04
	(1.24)	(1.44)	(1.78)	(-1.16)	(-0.07)	(0.62)
Δ RSRV	-0.52^{***}	-0.11	-0.45	-0.19	-0.52^{**}	-0.07
	(-2.70)	(-0.87)	(-1.53)	(-0.93)	(-2.64)	(-0.47)
Δ RSRV × KAClosed		-0.52^{***}		-1.63^{**}		-0.58^{***}
		(-2.80)		(-2.49)		(-2.75)
Δ ln YD	0.05	0.04	0.01	0.19	0.01	0.01
	(0.34)	(0.27)	(0.02)	(0.41)	(0.07)	(0.06)
Δ ln TT	0.00	-0.01	0.27^{***}	0.24^{**}	-0.02	-0.05
	(0.03)	(-0.16)	(3.11)	(2.44)	(-0.23)	(-0.53)
Observations	75	75	22		53	53
Countries	75	75	22		53	53
R^2	0.26	0.31	0.44	0.48	0.26	0.32
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.00	0.33	0.09	0.48	0.02	0.49
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.00		0.02		0.01

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. We take the average over 11 or 4 years for each variable (in differences) and perform a cross-sectional analysis. *t*-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

Table A.4: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis Without Oil Exporting Countries*

Dependent variable: Δ log(REER)	Period 12 & 23 Pooled Sample					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.21^{***}	0.22^{***}	-0.10	NA	0.24^{**}	0.24^{**}
	(2.64)	(2.79)	(-1.07)		(2.43)	(2.50)
Δ RSRV	-0.32	0.32	0.05		-0.11	0.34
	(-0.99)	(0.81)	(0.11)		(-0.25)	(0.70)
Δ RSRV × KAClosed		-1.23^{**}				-0.75
		(-2.19)				(-1.33)
Δ ln YD	0.05	0.09	0.05		-0.04	-0.02
	(0.49)	(0.85)	(0.29)		(-0.34)	(-0.16)
Δ ln TT	0.07	0.08	0.37^{***}		0.01	0.01
	(0.86)	(0.95)	(2.76)		(0.09)	(0.17)
Time Dummy	0.10^{**}	0.11^{**}	-0.03		0.18^{***}	0.18^{***}
	(2.24)	(2.45)	(-0.79)		(3.10)	(3.08)
Obs	122	122	42		80	80
Countries	61	61	21		40	40
R^2	0.12	0.14	0.20		0.21	0.22
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.12	0.81	0.76		0.48	0.85
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.01				0.10

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. *t*-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

Table A.5: *Determinants of the Real Effective Exchange Rate: Cross-Sectional Analysis, IMF REER Index*

Dependent variable: Δ log(REER)	Period 23					
	Full Sample		Advanced Countries		Developing Countries	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ NFAxR	0.09	0.10^{*}	-0.20^{*}	-0.20^{*}	0.19^{**}	0.23^{**}
	(1.47)	(1.74)	(-2.07)	(-2.07)	(2.21)	(2.32)
Δ RSRV	-0.88^{**}	-0.33	-0.18	-0.18	-1.32^{***}	-0.63
	(-2.37)	(-0.81)	(-0.28)	(-0.28)	(-2.77)	(-1.01)
Δ RSRV × KAClosed		-0.92^{*}		0.00		-0.97
		(-1.85)		(.)		(-1.64)
Δ ln YD	0.21^{**}	0.21^{**}	-0.17	-0.17	0.30^{***}	0.27^{***}
	(2.40)	(2.55)	(-0.96)	(-0.96)	(3.35)	(3.60)
Δ ln TT	0.02	0.04	0.41^{*}	0.41^{*}	0.06	0.07
	(0.17)	(0.48)	(2.06)	(2.06)	(0.66)	(0.94)
Observations	54	54	22		32	32
Countries	54	54	22		32	32
R^2	0.27	0.32	0.29	0.29	0.40	0.45
p-value: $\beta^{NFAxR} \neq \beta^{RSRV}$	0.02	0.31	0.97	0.97	0.01	0.18
p-value: $\beta^{NFAxR} \neq \beta^{RSRV \times KAClosed}$		0.05		0.05		0.07

Notes: *,**,*** indicate significance at 10%, 5%, 1% levels. The REER increases when it appreciates. We take the average over 11 years for each variable (in differences) and perform a cross-sectional analysis. t-statistics in parentheses based on heteroskedasticity consistent standard errors. Constant terms not reported.

Table A.6: *List of Countries*

Advanced Countries 22 counries				Developing Countries 53 counries							
	Financial Openness Index				Financial Openness Index				Financial Openness Index		
	1975–2007	1975–1996	1986–2007		1975–2007	1975–1996	1986–2007		1975–2007	1975–1996	1986–2007
Australia	1	1	1	Algeria	0	0	0	Korea, Republic of	0	0	0
Austria	1	1	1	Argentina	0	0	0	Libya	0	0	0
Belgium	1	1	1	Bahrain, Kingdom of	1	1	1	Madagascar	0	0	0
Canada	1	1	1	Bolivia	1	1	1	Malaysia	1	1	1
Denmark	1	1	1	Brazil	0	0	0	Mexico	1	1	1
Finland	1	1	1	Burundi	0	0	0	Morocco	0	0	0
France	1	1	1	Cameroon	0	0	0	Nepal	0	0	0
Germany	1	1	1	Chile	0	0	0	Niger	0	0	0
Greece	1	0	1	China, P.R.: Mainland	0	0	0	Nigeria	0	0	0
Iceland	1	0	1	Colombia	0	0	0	Pakistan	0	0	0
Ireland	1	1	1	Costa Rica	0	0	0	Papua New Guinea	0	1	0
Italy	1	1	1	Cote d'Ivoire	0	0	0	Paraguay	0	0	1
Japan	1	1	1	Cyprus	0	0	0	Peru	1	0	1
Netherlands	1	1	1	Dominican Rep.	0	0	0	Philippines	0	0	0
New Zealand	1	1	1	Ecuador	1	1	0	Saudi Arabia	1	1	1
Norway	1	1	1	Egypt	0	0	1	Senegal	0	1	0
Portugal	1	1	1	Fiji	0	1	0	Solomon Islands	0	1	0
Spain	1	1	1	Gambia, The	1	1	1	Sri Lanka	0	0	0
Sweden	1	1	1	Guatemala	1	1	1	Syrian Arab Rep.	0	0	0
Switzerland	1	1	1	Honduras	0	1	0	Tanzania	0	0	0
United Kingdom	1	1	1	India	0	0	0	Thailand	0	1	0
United States	1	1	1	Indonesia	1	1	1	Togo	0	0	0
				Iran, Islamic Rep. of	0	0	0	Trinidad and Tobago	1	1	1
				Israel	1	0	1	Turkey	0	0	0
				Jamaica	1	0	1	Uruguay	1	1	1
				Jordan	1	0	1	Venezuela, Rep. Bol.	1	1	0
				Kenya	0	0	0				

Notes: Countries with IMF IFS code less than 199 are classified as advanced, except for Turkey. For financial openness indexes, we calculate the average of capital account openness measure from Chinn and Ito (2008) over the given period, and dichotomize into a binary code.