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## **Rounding the Corners of the Trilemma: A Simple Framework**

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## Abstract

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# Rounding the Corners of the Trilemma: A Simple Framework

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October 26, 2021

## Abstract

Many emerging market economies use foreign exchange interventions capital controls or at the same time as they float their currencies, a policy mix that is not explained by Mundell's policy trilemma. This paper presents a simple model that accounts for this fact. In the model, changes in foreign appetite for domestic assets lead to a trade-off between stabilizing the tradable sector and stabilizing the nontradable sector. The model is consistent with a number of stylized facts about the impact of the global financial cycle on emerging market economies, and on the policies used by emerging markets to mitigate this impact. Consistent with Rey's dilemma thesis, the benefits of using countercyclical capital flow taxes may be substantially larger than the benefits of floating. The paper also discusses the reasons that capital flow taxes are not more popular in practice.

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# 1 Introduction

The phrase “rounding the corners of the trilemma” in the title refers to the way emerging market economies manage their currencies.<sup>1</sup> Most of these countries have a floating currency but use policy instruments such as foreign exchange interventions or capital controls to manage their exchange rate. This policy mix is not in the menu offered by traditional textbook analysis—according to Mundell’s trilemma, capital controls should be used only by countries with a fixed peg that wish to maintain monetary autonomy. The international community used to ignore—or frown on—these unconventional policy instruments but has become more open to their use in the last ten years. The international monetary fund (IMF) developed a new “institutional view” on capital controls in the wake of the global financial crisis (IMF, 2012), and more recently started to develop an “integrated policy framework” to support a coherent doctrine about the conditions under which foreign exchange interventions and capital controls should be used (Gopinath, 2019).

This paper proposes a simple framework to analyze the tradeoffs involved in rounding the corners of the trilemma. The framework is used to organize a discussion of recent research on how emerging markets and developing economies manage their currencies. The model has microfoundations and lends itself to a welfare-based comparison of various policies, but remains simple enough in reduced form to allow an intuitive presentation of the main issues.

The analysis focuses on a small open economy. The model’s situation in the literature is best described by highlighting two of its features, the nature of the shock and the macroeconomic tradeoff that the policymaker is faced with. I will consider shocks to the interest parity condition<sup>2</sup>

$$i_t = i_t^* + E_t(e_{t+1} - e_t) + \rho_t \tag{1}$$

where  $i_t$  is the home currency interest rate,  $i_t^*$  is the dollar interest rate and  $\rho_t$  is the “UIP wedge.” For emerging markets most of the external financial volatility comes from the UIP wedge rather than foreign interest rates. Figure

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<sup>1</sup>I borrow the phrase from Klein and Shambaugh (2015).

<sup>2</sup>UIP shocks have been assumed in the literature trying to explain the disconnect between exchange rates and economic fundamentals, including Devereux and Engel (2002), Kollmann (2005), or Itskhoki and Mukhin (2021). Itskhoki and Mukhin (2021) show that UIP shocks can account for the major exchange rate puzzles in a dynamic general equilibrium model.

1 illustrates this fact by reporting the US dollar interest rate as well as the average UIP wedge in a sample of emerging markets over the period 2010-2021.<sup>3</sup> The volatility in the UIP wedge is much larger than the fluctuations in the US interest rate, especially after the Great Recession. Thus it makes sense to focus on the UIP wedge as the main source of shocks if one wants to understand how emerging market economies adjust their policies to the global financial cycle.

The second distinctive feature of the model is the macroeconomic tradeoff that the policymaker is faced with. Because labor is not perfectly mobile between sectors, there are two welfare-relevant output gaps, the output gap in the tradable sector and the output gap in the nontradable sector. Closing the output gap in the tradable sector requires a certain level of the exchange rate level and closing the output gap in the nontradable sector requires a certain level of the interest rate. In general, those levels are not consistent with the parity condition (1), i.e., there is no “divine coincidence” under free capital mobility. Hence, the home policymaker must trade off stabilizing the nontradable sector against stabilizing the tradable sector. This tradeoff is especially acute for economies that are hit by large UIP shocks.

It is natural, in this context, to augment the standard policy instruments with a tax on capital inflows. The tax introduces an additional wedge in the parity condition that can be used to offset the fluctuations in the UIP wedge. This is a second-best instrument, however, because the tax distorts capital flows. As will be discussed later in more detail, the welfare cost of the capital flow distortion depends on how the capital controls are designed. For plausible calibrations of the model, the welfare gain from optimally designed capital controls can far exceed the welfare gains from exchange rate flexibility, vindicating Rey’s (2015) point that the most salient decision for emerging markets dealing with the global financial cycle is not whether to fix or to float, but whether to use capital controls.

The model can be used to analyze foreign exchange interventions. Foreign exchange interventions achieve the same allocations as taxes if the cap-

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<sup>3</sup>The UIP wedge is constructed following the same approach as in Kalemli-Özcan and Varela (2021). The data are quarterly. The interest rates have a one-year maturity and the expected exchange rate is measured at a one-year horizon. The expected exchange rate is the median forecast reported by Bloomberg. The country sample is composed of China, Colombia, the Czech Republic, Greece, Hungary, India, Korea, Malaysia, Mexico, Poland, Russia, South Africa and Thailand. I thank Jeongwon Son for constructing and sharing his estimate of the UIP wedge with me.

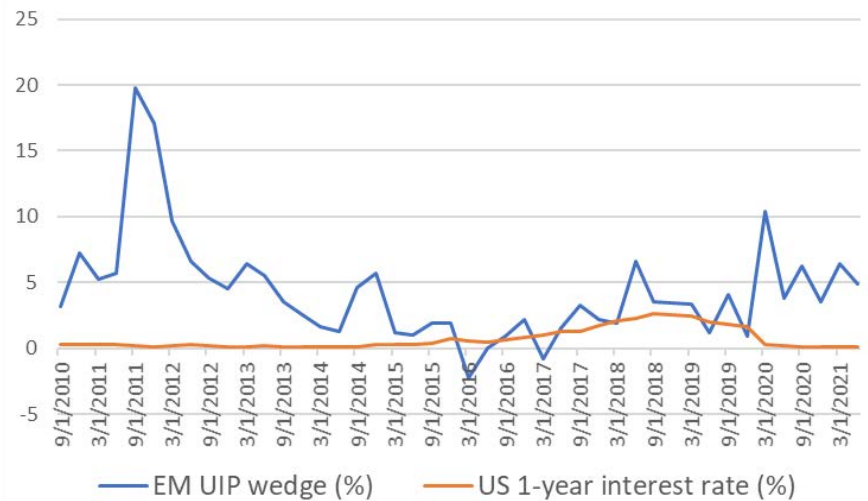


Figure 1: UIP wedge in emerging market economies (2010Q2-2021Q2)

ital account is closed. Foreign exchange interventions tend to work better than capital flow taxes in less financially integrated economies whereas the opposite is true for economies that are more integrated to global financial markets. Thus, we should observe that less financially integrated economies tend to use foreign exchange interventions whereas more financially developed economies use capital flow taxes. The former is true but not the latter. The use of capital flow taxes in the real world seems limited by a range of problems (circumvention, governance and stigma) that are largely left outside of the theoretical literature.

**Literature.** The literature of the last ten years has put a lot emphasis on risks to financial stability as a justification for using new policy instruments. We see in capital flows the same boom-bust dynamics as in domestic credit, suggesting that the macroprudential instruments used to curb booms in domestic credit should have their counterparts for capital flows. Thus, one recurrent critique of the traditional Mundellian trilemma analysis since the global financial crisis is that it does not recognize the financial stability objectives of policymakers (Obstfeld, 2021; Aizenman, 2019). On the theoretical side, a wave of literature emphasized how excessive volatility in capital flows should be curbed by policy interventions (Jeanne and Korinek, 2010; Benigno et al., 2013; Bianchi, 2011). This literature was reviewed elsewhere

(Erten, Korinek and Ocampo, 2021; Rebucci and Ma, 2020).

However, the evidence suggests that financial stability is not the only reason that policymakers round the corners of the trilemma in the real world. For example, in his 2010 “currency war” speech, Brazil’s finance minister Guido Mantega declared that the currency appreciation caused by the capital inflow pressure “*threatens us because it takes away our competitiveness.*”<sup>45</sup> This is the motive captured by the model in this paper. When faced with capital inflow pressure, countries navigate a tradeoff between overheating their nontradable sector and depressing their tradable sector.

This paper can be viewed as one more illustration of the Tinbergen principle. There is scope of extra policy instruments if the number of targets exceeds the number of instruments. This is the case here under a pure float because there is one interest rate for two output gaps. Ghosh, Ostry and Chamon (2016) and Alla, Espinoza and Ghosh (2016) have made the same point in models that have less micro-foundations than the one presented here but are quite close to it in reduced form. In the micro-founded literature, extra policy instruments are needed if the number of frictions exceeds the number of instruments. Liu and Spiegel (2015) explore the case for capital controls and foreign exchange interventions in a one-sector model with nominal stickiness. In Farhi and Werning (2014) the policymaker manipulates the terms of trade with a tax on capital flows while stabilizing the home economy with monetary policy. Several recent papers have assumed both nominal and financial frictions (see, e.g. Davis and Presno, 2017; Coulibaly, 2020) and the recent IMF work on the integrated policy framework belongs to that category. Basu et al. (2020) consider the role of monetary policy, capital controls, foreign exchange intervention, and macroprudential regulation in a small open economy affected by several frictions, including two collateral based financial frictions. Adrian et al. (2020) look at how capital controls and foreign exchange interventions can smooth the impact of currency premium shocks in a DSGE model with a rich menu of frictions. They emphasize that these instruments may be more valuable for emerging markets because they have less anti-inflationary credibility than advanced economies.

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<sup>4</sup>In BBC News, September 28 2010, “Currency ‘war’ warning from Brazil’s finance minister,” <https://www.bbc.com/news/business-11424864>.

<sup>5</sup>Foreign exchange interventions and capital controls tend to be frowned upon in international official circles if they are used to keep currencies competitive. This may explain why the macroprudential label sometimes seems to be used to justify policies whose real motives are not primarily about financial stability.



The paper is structured as follows. Section 2 presents the model. Sections 3 and 4 then look at a free float and a managed float, where the latter is defined as a regime where a social planner determines capital flows. Sections 5 and 6 respectively consider how the managed float allocation can be implemented with taxes on capital flows and foreign exchange interventions. Section 7 concludes.

## 2 Model

The model features a small open economy, which will be called home. The home economy has two sectors, the tradable sector and the non-tradable sector. Home residents sell home currency bonds to foreigners and accumulate foreign currency bonds that yield some utility. Home residents pay a premium on their home currency borrowing. To add some local color we will call the home and foreign currencies “peso” and “dollar” respectively.

**Preferences and technology.** The home economy is populated by identical infinitely-lived consumers. Time is discrete. The model is deterministic and we will consider unexpected deviations from steady state. In period 1 the representative consumer maximizes

$$U_1 = \sum_{t=1}^{+\infty} \beta^{t-1} [u_N(C_{Nt}) - L_{Nt} + u_T(C_{Tt} - L_{Tt}) + u_{B^*}(B_t^*)] \quad (2)$$

where  $u_N(\cdot)$  and  $u_T(\cdot)$  are the utility of nontradable and tradable consumption and  $u_{B^*}(\cdot)$  is the utility of dollar bonds. Like in models with money in the utility function, the last term may be interpreted as the utility brought by dollar balances for international transactions or in terms of liquidity. This utility is reflected in the convenience yield on dollar liquid assets that has been analyzed in the recent literature (see, e.g. Jiang, Krishnamurthy and Lustig, 2021).

The representative consumer issues peso bonds and invest in dollar bonds. Foreign investors demand an excess dollar return  $\rho_t$  for holding peso bonds. As a result interest parity is given by

$$(1 + i_t) \frac{E_t}{E_{t+1}} = (1 + i_t^*) (1 + \rho_t), \quad (3)$$

where  $i_t$  and  $i_t^*$  are the peso and dollar interest rates respectively, and  $E_t$  is the exchange rate (peso per dollar). The model is agnostic about the nature of the excess return  $\rho_t$ , which could be an exchange rate risk premium or a wedge due to a financial friction on the side of foreign investors like in Gabaix and Maggiori (2015). Because  $\rho_t$  is not necessarily due to risk, we will call it the UIP wedge.

In spite of the UIP wedge, residents borrow in peso in order to hold dollar liquidity because of the convenience yield. Dollar liquidity is financed through the financial account (by borrowing in peso) and through the current account (with a trade surplus).

I assume that  $\rho_t$  is exogenous. Throughout this paper we consider how the home economy responds to disturbances in  $\rho_t$ . Periods with low (high) levels of  $\rho_t$  are episodes of high (low) global appetite for emerging markets bonds.

The nontradable and tradable goods are produced with home labor by perfectly competitive firms. There are constant returns to scale in the nontradable sector and decreasing returns to scale in the tradable sector. The production functions are  $Y_{Nt} = L_{Nt}$  and  $Y_{Tt} = f(L_{Tt})$  where  $f(\cdot)$  is increasing and concave. The utility and production functions are given by

$$u_N(\bullet) = \frac{\bullet^{1-\sigma_N}}{1-\sigma_N}, u_T(\bullet) = \theta \frac{(\bullet + \kappa)^{1-\sigma_T}}{1-\sigma_T}, u_{B^*}(\bullet) = \theta \mu \frac{\bullet^{1-\sigma_{B^*}}}{1-\sigma_{B^*}}, f(\bullet) = \left( \frac{\bullet}{1-\alpha} \right)^{1-\alpha}. \quad (4)$$

Parameter  $\kappa$  is set in such a way that  $\theta$  is the ratio of the value of tradable output to the value of nontradable output.

**Keynesian short run.** To keep things simple I distinguish between the Keynesian short run, which takes place in period 1, and the classical long run, which takes place in the following periods. The economy enters period 1 with zero net foreign assets and reaches a new steady state from period 2 onwards (the long run). To alleviate notations the short-run variables are denoted without time index and the long-run variables are denoted with an upper bar. I describe each regime in turn, starting with the long run. Both regimes are characterized in more detail in the appendix and their main properties are summarized here.

The long run consists of a steady state in which nominal prices and wages are flexible and the risk premium  $\bar{\rho}$  is constant. Because there is no nominal friction, production is at its natural level in the long run. In both sectors the marginal disutility of labor is equal to the marginal utility of the consumption produced by this labor,  $u'_N(Y_N) = 1$  and  $f'(L_T) = 1$ . Using the specifications

in (4), these conditions imply that the natural level of output is equal to one in both sectors,  $\bar{Y}_N = \bar{Y}_T = 1$ .<sup>6</sup>

The short run differs from the long run in two ways. First, the currency premium is in general not the same in the short run as in the long run,  $\rho \neq \bar{\rho}$ . Second, the nominal wage is sticky in both sectors in period 1. To capture the notion that the short run is a deviation from steady state, I assume that in both sector the period-1 nominal wage is such that the natural allocation obtains in period 1 if the currency premium is at the long-run level,  $\rho = \bar{\rho}$ . The home monetary authorities peg the nominal price in the nontradable sector at a constant level.

### 3 Free float

This section considers the case of a free float as it is defined in the traditional Mundellian analysis. The home authorities use one policy instrument, the interest rate  $i$ , under free capital mobility. I first describe the trade-off facing the home policymakers, before solving the optimal policy. Section 3.3 discusses the related empirical literature.

#### 3.1 Tradeoffs

The first-order approximation to the equilibrium is derived in the appendix and the main results are summarized here. The trade balance  $Y_T - C_T$  is denoted by  $X$ . The dollar value of the gross capital inflows (peso bonds) and capital outflows (dollar bonds) are denoted by  $B$  and  $B^*$  respectively. The short-run deviations from steady state are denoted with lower case variables, e.g.,  $Y_T = \bar{Y}_T + y_T$ ,  $B^* = \bar{B}^* + b^*$ ,  $X = \bar{X} + x$ . The balance of payments equation implies that the trade balance is accumulated in net foreign assets,  $x = b^* - b$ .<sup>7</sup>

The equilibrium conditions can be organized into a capital flow block and a production block. The capital flow block describes how capital flows

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<sup>6</sup>The natural level of tradable output is independent of the country's net foreign asset position because preferences are GHH in the tradable sector (Greenwood, Hercowitz and Huffman, 1988).

<sup>7</sup>Variable  $x$  will be indifferently called the trade balance or the current account balance. The net factor income from abroad being given in period 1, the deviation in the trade balance is equal to the deviation in the current account balance.

are determined by the UIP wedge. The production block describes how the output gaps are affected by the UIP wedge and by monetary policy.

**Capital flows.** The first order conditions for bonds imply the following expressions for capital flows,

$$x = \frac{1}{\sigma_T} (\rho - \bar{\rho}), \quad (5)$$

$$b^* = -\frac{\phi}{\sigma_T} (\rho - \bar{\rho}), \quad (6)$$

$$b = -\frac{1 + \phi}{\sigma_T} (\rho - \bar{\rho}), \quad (7)$$

where  $\phi = \frac{\sigma_T \bar{B}^*}{\sigma_B^* \bar{\rho}}$ . The intuition behind these equations is straightforward. An increase in the UIP wedge raises the cost of external borrowing. This induces home residents to save, which increases the trade balance (equation (5)), and to reduce their holdings of dollar liquidity (equation (6)). Equation (7) reflects that gross inflows finance the current account deficit plus gross outflows. Thus, a lower UIP wedge leads to an expansion in gross capital flows (both in and out) and in the current account deficit. I will sometimes call the case  $\rho < \bar{\rho}$  a situation with high capital inflow pressure and the case  $\rho > \bar{\rho}$  a situation with low capital inflow pressure.

**Output gaps.** On the side of production, the linearized model is

$$y_N = -\frac{i - \bar{i}}{\sigma_N}, \quad (8)$$

$$y_T = \frac{e}{\gamma}, \quad (9)$$

$$i - \bar{i} + e = \rho - \bar{\rho}, \quad (10)$$

where  $\gamma \equiv \alpha / (1 - \alpha)$  is the inverse elasticity of the supply of tradable good with respect to the exchange rate and  $\bar{i} \equiv i^* + \bar{\rho}$  is the long-run peso interest rate. Equation (8) is the Euler equation for nontradable consumption. An increase in the interest rate contracts the demand for the nontradable good. Equation (9) reflects that a currency depreciation cheapens the dollar cost of home labor and stimulates home production of tradable good. The third equation is a linearized version of interest parity (3).

Equations (8)-(9)-(10) show that it is not possible to set the output gaps to zero in both sectors in general. Setting the tradable output gap to zero

requires  $e = 0$  and setting the nontradable output gap to zero requires  $i = \bar{i}$ .<sup>8</sup> These requirements are not consistent with interest parity (3) except in the special case where the UIP wedge is at the long-run level ( $\rho = \bar{\rho}$ ). In general, the home policymaker has to trade off stabilizing output in the tradable sector against stabilizing output in the nontradable sector.

For example, if  $\rho$  falls below  $\bar{\rho}$  (high capital inflow pressure) the peso appreciates against the dollar for an unchanged monetary policy by (10). This depresses the tradable sector. The home policymaker can resist appreciation by lowering the nominal interest rate, but this leads to over-heating in the nontradable sector. Conversely, low capital inflow pressure leads to a trade-off between a negative output gap in the nontradable sector and a positive output gap in the tradable sector.

## 3.2 Optimal policy

The home policymaker optimally trades off the output gaps in the two sectors. As shown in the appendix, the policymaker minimizes a loss that can be written as a quadratic function of the output gaps or the policy instruments,

$$\begin{aligned} \mathcal{L}_y &= \frac{1}{2} (\omega_N y_N^2 + \omega_T y_T^2), \\ &= \frac{1}{2} [\omega_i (i - \bar{i})^2 + \omega_e e^2], \end{aligned} \tag{11}$$

where the second line comes from substituting out the output gaps using (8) and (9), and the weights on interest rate and exchange rate stabilization are simple functions of the underlying parameters:  $\omega_i = 1/\sigma_N$  and  $\omega_e = \theta/\gamma$ . Intuitively, a large  $\sigma_N$  implies a low weight on interest rate stabilization because the demand for the nontradable good is not very sensitive to the interest rate. Similarly, a large  $\gamma$  implies a low weight on exchange rate stabilization because the supply of tradable good is not very sensitive to the exchange rate. The weight on exchange rate stabilization increases with  $\theta$ , which reflects the importance of the tradable sector in the home economy.

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<sup>8</sup>The essential point here is not that  $e$  and  $i$  should be set at their long-run levels in order to have zero output gaps. For example, the required levels of the interest rate and exchange rate would depend on the state of productivity if we introduced productivity shocks in both sectors. The essential point is that the desirable levels of  $i$  and  $e$  are determined independently of the UIP wedge and do not satisfy the interest parity condition (10) in general.

Under a free float, the home policymaker allocates the capital inflow pressure between the interest rate and the exchange rate by minimizing the loss function (11) subject to (10). The solution is

$$i - \bar{i} = \frac{\omega_i^{-1}}{\omega_i^{-1} + \omega_e^{-1}} (\rho - \bar{\rho}), \quad e = \frac{\omega_e^{-1}}{\omega_i^{-1} + \omega_e^{-1}} (\rho - \bar{\rho}). \quad (12)$$

The policymaker lets the capital inflow pressure affect the exchange rate but leans against the wind with the interest rate.

### 3.3 Evidence

The model captures in a parsimonious way a number of facts that have been documented in the literature on exchange rate regimes, capital flows, and the global financial cycle.

First, the trade-off between stabilizing the tradable sector and the non-tradable sector in response to changes in capital flow pressure resonates well with the policy dilemmas described by policymakers. As noted in the introduction, the main reason that Brazil raised its tax on capital inflows in 2009 was to resist the appreciation of the *real* and the resulting damage to the export sector. A survey of emerging markets central banks reveals that the most important intermediate goal of foreign exchange interventions is to stabilize the exchange rate, especially in response to fluctuations in foreign investors' risk aversion (Patel and Cavallino, 2019). The primary concern of policymakers, during episodes of capital inflow surges, seems to be the appreciation of the domestic currency and its negative impact on the domestic economy.

Moving to more systematic evidence, Benigno, Converse and Fornaro (2015) find that during episodes of large capital inflows the currency appreciate in real terms and capital and labor shift out of tradable sectors. The reason that policymakers do not feel comfortable leaning against the currency appreciation by lowering the interest rate, according to the model, is the risk of overheating the nontradable sector. This is consistent with the other complaint that policymakers have about capital inflow surges, which is that they tend to finance booms in nontradable sectors of the economy such as real estate. Cesa-Bianchi, Cespedes and Rebucci (2015) indeed find that bank inflow surges are correlated with real estate booms in emerging market economies.

Second, the model is consistent with a large literature testing the predictions of the trilemma analysis in the data. One important question in that literature is the extent of the monetary independence offered by a floating exchange rate. That literature typically tests whether the coefficient in a panel regression of  $i$  on  $i^*$  is lower for countries with a floating exchange rate than for countries with a fixed pegs (Aizenman, Chinn and Ito, 2010; Han and Wei, 2018; Bekaert and Mehler, 2019; Obstfeld, 2021). The typical finding is that the coefficient is positive for floating exchange rates but lower than for fixed exchange rates.<sup>9</sup>

Coming back to the model, if the disturbance is in the US interest rate rather than the UIP wedge the equation for the peso interest rate becomes

$$i - \bar{i} = \frac{\omega_i^{-1}}{\omega_i^{-1} + \omega_e^{-1}} (i^* - \bar{i}^*).$$

The model thus predicts that with a floating exchange rate, the peso interest rate moves in the same direction as the US interest rate although less than one for one as it would do under a fixed peg. The *formal* independence offered by a floating exchange rate translates into limited *effective* independence. With a floating exchange rate the home policymaker can set the interest rate at any level that she wants, but she chooses not to fully insulate the home interest rate from the dollar interest rate. Full insulation would be the optimal policy from the perspective of the nontradable sector, but stabilizing the tradable sector requires leaning against the wind with the interest rate. The point of exchange rate management policies is to increase the effective monetary independence offered by a floating exchange rate by using policy instruments other than the interest rate.<sup>10</sup>

Third, the model can reproduce the correlation between gross capital inflows and outflows that has been documented in the literature (Forbes and Warnock, 2012; Broner et al., 2013; Avdjiev et al., 2017; Davis and Van Wincoop, 2018). Forbes and Warnock (2012) observe that capital inflow surges tend to be associated with increases in capital outflows (which they call *flights*) and that stops in capital inflows are associated with decreases in capital outflows (*retrenchments*). The model predicts a positive correlation

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<sup>9</sup>For example, in their baseline regression Han and Wei (2018) find that a floating exchange rate lowers the coefficient from 0.65 to 0.45. The size of the difference (0.2) is what the model predicts for the baseline calibration introduced in section 5.2.

<sup>10</sup>To use a weather-related metaphor, I am *formally* free to wear a raincoat whenever I want but my *effective* freedom to wear a raincoat is increased if I can also use an umbrella.

between gross inflows and outflows in response to external financial shocks, as shown by equations (6) and (7). When there is capital inflow pressure home agents use a fraction of the additional inflows to finance outflows.

The exogenous driving variable in my model is the UIP wedge  $\rho$ . There are different ways of measuring the appetite of foreign investors for emerging market risk but a proxy that is commonly used in the literature is the VIX. Avdjiev et al. (2017) find that both capital inflows and outflows respond negatively to an increase in the VIX, that is periods of low risk perception are associated with an expansion of gross capital flows. This is consistent with equations (6) and (7). A decrease in the UIP wedge leads to both a surge and a flight in capital flows, whereas an increase in the UIP wedge leads to both a stop and a retrenchment. In a recent contribution Kalemli-Özcan and Varela (2021) provide a direct measure of the UIP wedge  $\rho$  using survey-based measures of exchange rate expectations. These authors find that, consistent with my model, the UIP wedge is negatively correlated with gross capital inflows and positively correlated with the local currency interest rate in emerging markets.<sup>11</sup>

## 4 Managed float

In a managed float the policymaker uses policy instruments other than the interest rate to influence the exchange rate. Different policy instruments can be used for that purpose but the basic rationale for intervention can be best understood by considering a social planner who sets the levels of capital flows directly. Thus, in line with the public finance approach that is increasingly used in macroeconomic theory, I consider separately the social planner allocation and the policy instruments that implement it. This section looks at the social planner allocation and the following sections will discuss implementation.

Giving the social planner control over  $B$  and  $B^*$  is equivalent to assuming that the capital account is closed and the financial transactions with the rest of the world are monopolized by the government. In this case the representative consumer is cut off from international financial markets and the first-order conditions (5), (6), (7) and (8) no longer apply. As shown in the

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<sup>11</sup>However they do not find a significant correlation between the UIP wedge and the exchange rate.



appendix, nontradable output is instead given by

$$y_N = \frac{1}{\sigma_N} (e - \sigma_T x), \quad (13)$$

where the trade balance  $x = b^* - b$  is directly determined by the social planner's decisions about  $b$  and  $b^*$ . The intuition behind equation (13) is that increasing net exports reduces the home consumption of tradable good and, given the relative price  $e$ , the demand for nontradable good. Depreciating the currency raises the demand for the nontradable good through the expenditure-switching effect.

Using (9) to substitute out  $e$  in (13) gives

$$\gamma y_T - \sigma_N y_N = \sigma_T x. \quad (14)$$

This equation describes the trade-off between the sectoral output gaps faced by the social planner. It is not very different from the trade-off under a pure float, which using (8)-(9)-(10) can be written like (14) with  $\rho - \bar{\rho}$  on the right-hand side. The difference between a free float and a managed float is that under a managed float, the trade balance is determined by the social planner rather than by the UIP wedge.

The social planner still minimizes the loss  $\mathcal{L}_y = (\omega_N y_N^2 + \omega_T y_T^2) / 2$  subject to (14). Hence, conditional on the trade balance the social planner chooses the same exchange rate as under a free float. The question is how the social planner sets capital flows. On one hand, a welfare-maximizing social planner should make capital flows responsive to changes in the cost of external borrowing, as private agents do in the decentralized equilibrium. On the other hand, the social planner is also mindful that capital flows affect the macroeconomic stabilization tradeoff, something that private agents ignore in the decentralized equilibrium. In other words, capital flows have demand externalities that private agents do not take into account. How the social planner takes this into account is described in the following proposition.

**Proposition 1** (*Managed float*) *In a managed float the social planner mitigates the responsiveness of the trade balance  $x = b^* - b$  to external financial conditions and keeps dollar liquidity  $b^*$  the same as under a free float. Denoting by  $MF$  and  $FF$  the levels of variables under a managed float and a free float respectively, we have*

$$x_{MF} = \chi x_{FF}, \quad (15)$$

$$b_{MF}^* = b_{FF}^*, \quad (16)$$

where the mitigating factor

$$\chi = \left(1 + \frac{\sigma_T}{\theta\sigma_N + \gamma}\right)^{-1}$$

is between 0 and 1. A managed float reduces the welfare loss under a free float by  $1 - \chi$ ,

$$\frac{\mathcal{L}_{FF} - \mathcal{L}_{MF}}{\mathcal{L}_{FF}} = 1 - \chi. \quad (17)$$

**Proof.** See Appendix. ■

The social planner moderates the fluctuations in gross and net capital inflows because the trade imbalances worsen the tradeoff between the sectoral output gaps. The social planner has no reason to change the accumulation of dollar liquidity because borrowing in peso to finance dollar liquidity does not affect the macroeconomic stabilization tradeoff.

**Remark.** Capital flow management is second best. An example of first-best policy instrument in this model would be a tax or subsidy on employment in the tradable sector that disconnects tradable production from the exchange rate. This illustrates the general principle that the first-best instruments are taxes targeted at the underlying friction rather than at the disturbance. Here the friction is nominal stickiness in the labor market and the first-best production allocation can be achieved with a tax or subsidy on employment in one of the two sectors. In the real world, however, exchange rate management policies tend to target the disturbance, which is in the UIP wedge.

## 5 Capital flow taxes

This section explores how the social planner allocation described in the previous section can be implemented with taxes on capital flows. These taxes are adjusted to the capital inflow pressure, and thus belong to the capital controls that Klein (2012) calls “gates” by opposition to “walls” (capital account restrictions that are not episodic but long-standing and pervasive).

## 5.1 Optimal taxes

Consider a tax  $\tau$  on the purchase of peso bonds by foreign investors. Foreign investors must pay  $(1 + \tau)$  pesos in period 1 for a bond that yields  $(1 + i)$  pesos in period 2. The net proceeds from the tax are rebated in a lump-sum way to the home residents. Foreign investors still demand an after-tax excess dollar return  $\rho$  on peso bonds, implying

$$\frac{E}{1 + \tau} \frac{1 + i}{\bar{E}} = (1 + i^*) (1 + \rho). \quad (18)$$

The linearized interest parity condition now reflects the presence of capital controls

$$i - \bar{i} + e = \rho - \bar{\rho} + \tau. \quad (19)$$

The capital flow block and the production block are still given by (5)-(6)-(7) and (8)-(9)-(10) except that  $\rho$  is replaced by  $\rho + \tau$ . Disturbances in  $\rho$  can thus be neutralized by offsetting movements in  $\tau$ .

In order to implement the social planner allocation the capital flow tax must satisfy

$$x_{MF} = \frac{1}{\sigma_T} (\rho + \tau - \bar{\rho}),$$

where by (15)  $x_{MF} = \chi x_{FF} = \frac{\chi}{\sigma_T} (\rho - \bar{\rho})$ . This implies

$$\tau = - (1 - \chi) (\rho - \bar{\rho}). \quad (20)$$

The tax on inflows is positively correlated with the foreign appetite for domestic bonds.

Our results about the optimal capital flow taxes are summarized in the following proposition.

**Proposition 2** (*Optimal capital flow taxes*) *The social planner allocation can be implemented by a tax on capital inflows associated with an equivalent subsidy on capital outflows. The optimal tax on capital flows is given by (20) where  $\chi$  is the smoothing factor defined in Proposition 1.*

**Proof.** See Appendix. ■

The tax must be associated with a subsidy on capital outflows to avoid a distortion in the accumulation of dollar bonds. What matters for the output gaps is not the gross level but the net level of capital inflows .

## 5.2 Rey’s dilemma

In her contribution to the 2013 Jackson Hole conference Rey (2015) argued that when dealing with the global financial cycle, emerging market economies effectively face a dilemma between free capital mobility and capital controls rather than the textbook trilemma. To quote the abstract of her paper, “*whenever capital is freely mobile, the global financial cycle constrains national monetary policies regardless of the exchange rate regime*” so that “*independent monetary policies are possible if and only if the capital account is managed.*” Rey based her claims on empirical facts that were further documented in Miranda-Agrippino and Rey (2020), who find that countries are equally exposed to U.S. monetary policy shocks independently of their exchange rate regimes.<sup>12</sup>

For a theoretical account of Rey’s thesis it may be useful to come back to the distinction between the formal independence and the effective independence offered by a floating exchange rate. A floating exchange rate regime relaxes a constraint on the home policymaker’s optimization problem, which in my model (like in most models) must yield a positive welfare gain. The question though is how much of this independence policymakers effectively use, and how valuable it is relative to the independence offered by capital controls. Rey’s dilemma thesis could be interpreted as a claim that the autonomy given to emerging markets by floating is of little value relative to the autonomy that they gain from capital controls. Understood in this way, her point is essentially quantitative.

The model presented in this paper is illustrative and obviously too simple for quantitative exercises. However, it may be interesting to see how the dilemma thesis fares in a calibrated version of the model. The only parameters that one needs to calibrate are those that appear in the expression for  $\chi$ , that is  $\sigma_N$ ,  $\sigma_T$ ,  $\alpha$  and  $\theta$ . I adopt a conventional calibration in the literature for the first three parameters:  $\sigma_N = \sigma_T = 2$ , and  $\alpha = 1/3$  (based on the fact that labor income amounts to about two thirds of value added). Furthermore I assume that the two sectors have the same value added, i.e.,  $\theta = 1$ .

Figure 2 compares the welfare losses relative to the first best for four

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<sup>12</sup>On the other hand, Obstfeld, Ostry and Qureshi (2019) find that the transmission of global financial shocks (as measured by the VIX) to a range of domestic variables is lower for countries with a flexible exchange rate regime.

different policy regimes.<sup>13</sup> The two policy regimes on the left-hand side are a fixed peg and a floating exchange rate regime under perfect capital mobility. The second regime, thus, is the free float analyzed in section 3. The third and fourth policy regimes are again fixed and floating, but assuming optimal taxes on capital flows. The first three regimes correspond to the three angles of Mundell’s trilemma and the fourth regime (the managed float) is the one that is omitted by the traditional trilemma analysis.

One part of Figure 2 is unsurprising: the more policy instruments, the better. Going from a fixed peg to a floating exchange rate regime, or from full capital mobility to capital controls, lowers the welfare loss. The more interesting part of Figure 2 is about which instruments yields the largest welfare gain. Going from a fixed peg to a freely floating exchange rate reduces the welfare loss by 20 percent.<sup>14</sup> This is not very large because under my baseline calibration, the welfare loss puts four times more weight on exchange rate stabilization than on interest rate stabilization ( $\omega_i = 1/2$  and  $\omega_e = 2$ ), implying that floating is not very valuable per se. By contrast, going from a freely floating exchange rate to a managed floating exchange rate reduces the welfare loss by a fraction  $1 - \chi = 0.44$ . That is, optimal capital flow taxes eliminate 44 percent of the welfare loss under a free float.

This simple exercise is somewhat supportive of Rey’s view that the most salient choice is not between fixing and floating but between free capital mobility and capital controls. Starting from a fixed exchange rate with capital mobility, the country derives significantly larger welfare gains from using capital controls than from floating its currency. Conditional on capital controls, the welfare gains from floating are minimal.

These results are relatively robust to the parameter values. The following proposition states the condition under which using capital controls yields larger welfare gains than floating—i.e., like in Figure 2, an economy in regime 1 gains more from switching to regime 3 than to regime 2.

**Proposition 3** *Starting from a fixed peg with free capital mobility, using capital controls yields larger welfare gains than floating if and only if  $\gamma < \sigma_T$ .*

**Proof.** See appendix. ■

This condition is satisfied for our benchmark calibration, for which  $\gamma = 0.5$  and  $\sigma_T = 2$ . Intuitively, a lower value of  $\gamma$  makes the tradable output

<sup>13</sup>The welfare losses are expressed in terms of the variance in  $\rho$ .

<sup>14</sup>The welfare loss is multiplied by a factor  $1/(1 + \omega_i/\omega_e) = 0.8$ .

gap more sensitive to the exchange rate, which reduces the extent to which the policymaker uses the freedom to float. A larger value of  $\sigma_T$  increases the sensitivity of the output gaps to the trade balance—as shown by equation (14)—so that stabilizing the output gaps can be achieved at a smaller cost in terms of capital flow distortions.

It would be interesting to explore the robustness of those results to different model assumptions, something that is beyond the scope of this paper and left for future research. I conclude this section by showing that the primacy of capital controls over floating is not robust to deviating from the optimal capital flow taxes described in Proposition 2.

In practice, the countries that have used a countercyclical tax on capital inflows (for example Brazil in 2009-14) have not used at the same time an offsetting subsidy on capital outflows. This must reduce the welfare gains from capital controls. As shown in the appendix, the welfare gain from the optimal tax on inflows if there is no subsidy on outflows is

$$\frac{\mathcal{L}_{FF} - \mathcal{L}_{MF}}{\mathcal{L}_{FF}} = \frac{1 - \chi}{1 + \chi\phi}, \quad (21)$$

where  $\phi$  is the ratio of the capital outflow response to the trade deficit response to the UIP wedge—see equations (5) and (6). The welfare gain from capital flow taxes is lower than when a subsidy on outflows was used, as shown by a comparison with (17). The welfare gain from a single tax on inflows is decreasing with  $\phi$ , which is a measure of the extent to which the tax on inflows distorts outflows if it is not offset by a subsidy.

A calibration of  $\phi$  can be obtained by using the empirical relationship between capital inflows and outflows. The calibration is based on the following two panel regressions

$$\Delta x = -\eta_x \Delta b + \varepsilon_x, \quad (22)$$

$$\Delta b^* = \eta_{b^*} \Delta b + \varepsilon_{b^*}, \quad (23)$$

in which the regressor  $\Delta b$  is the quarterly change in the ratio of gross capital inflows to GDP. The regressands are the quarterly change in the ratio of the current account balance to GDP in regression (22) and the quarterly change in the ratio of gross capital outflows to GDP in regression (23). The regressions are estimated with quarterly data for a sample of emerging market economies<sup>15</sup> and the results are reported in Table 1.

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<sup>15</sup>The source of the data is the IMF IFS. The sample period is 2000Q1-2019Q3 and the

**Table 1. Regressions (22) and (23)**

|              | $\Delta x$           | $\Delta b^*$        |
|--------------|----------------------|---------------------|
| $\Delta b$   | -0.061***<br>(0.009) | 0.904***<br>(0.010) |
| constant     | 0.016<br>(0.133)     | 0.028<br>(0.148)    |
| Observations | 2, 224               | 2, 219              |
| R-squared    | 0.019                | 0.777               |

\*\*\* indicates significance at the 1 % level

One can derive estimates for  $\phi$  using equations (5), (7) and (6), which imply  $\eta_x = -1/(1 + \phi)$  and  $\eta_{b^*} = \phi/(1 + \phi)$ . The first regression implies  $\phi = 14.9$  and the second regression implies  $\phi = 9.42$ .<sup>16</sup> That  $\phi$  takes large values is not surprising and reflects the fact that gross capital flows are larger and more volatile as a share of GDP than the current account.

If one assumes  $\phi = 10$ , equations (17) and (21) imply that the welfare loss reduction from capital flow taxes decreases from 44 percent if outflows are undistorted to 7 percent if they are. Hence, capital flow taxes lose most of their benefits if they are applied only to inflows. In the calibrated model, it is crucial to use a subsidy on outflows to validate Rey's view that the welfare gains from capital controls dominate those from floating.

## 6 From theory to policy: Capital controls vs. foreign exchange interventions

In practice, the countries using countercyclical tax on capital flows are few and far between. The Central Bank of Chile used a countercyclical Unremunerated Reserve Requirement (URR) policy in the 1990s but later abandoned that policy tool.<sup>17</sup> Brazil became the poster boy for countercyclical capital controls in the 2000s with the tax on capital inflows that it implemented in

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country sample is composed of 36 emerging market economies. I thank Julien Acalin for sharing the results of this regression with me.

<sup>16</sup>There is a difference between the two regressions because errors and omissions introduce a wedge in the balance of payments equation  $b = -x + b^*$ .

<sup>17</sup>For discussions of the Chilean capital flow management policies see De Gregorio, Edwards and Valdés (2000) and Williamson (2005).

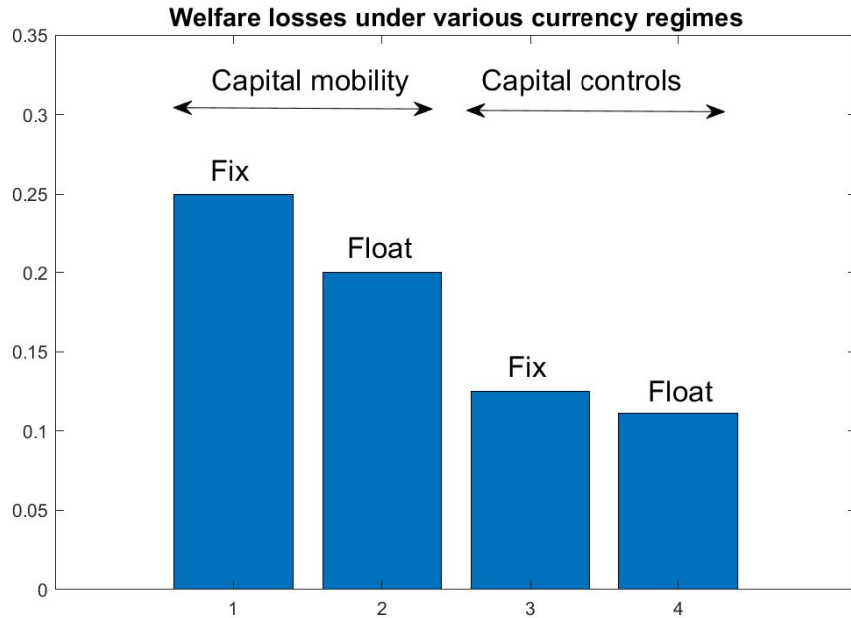


Figure 2: Welfare losses under different policy regimes

2009-14. By contrast, many more countries use foreign exchange interventions than taxes on capital flows.

From a theoretical perspective this is surprising because explaining how foreign exchange interventions work has been an uphill battle for macroeconomic theorists. This section discusses the gap between theory and practice by offering some observations first on what it would take to make foreign exchange interventions work in my model, and on the reasons behind the unpopularity of capital flow taxes.

## 6.1 Foreign exchange interventions in theory

One can represent foreign exchange interventions in the model by assuming that the consolidated government (including the central bank) issues peso bonds  $B_g$  to accumulate dollar reserves  $B_g^*$ . The government makes profits or losses from its balance sheet operations, which it rebates to the representative consumer in a lump-sum way. Sterilized interventions are open market operations that change  $B_g$  and  $B_g^*$  while keeping the nominal interest rate constant. By using its own balance sheet the government might indirectly af-



fect the country's total balance sheet and bring it closer to the social planner allocation described in section 4.

This is not going to happen, however, if the private sector has the same free access to bond markets as the government. Denoting by  $B_h^*$  and  $B_h$  the dollar assets and peso liabilities of the households, it is easy to see that the first-order conditions and budget constraints determine the country *total* assets and liabilities  $B = B_g + B_h$  and  $B = B_g + B_h$  and not the public and private components separately. Hence there is Ricardian equivalence—any change in the government balance sheet is undone by an offsetting change in the balance sheet of the private sector. To prevent Ricardian equivalence, the literature on foreign exchange interventions has assumed various forms of financial friction limiting the ability of the private sector to lend or borrow abroad (Chang, 2019).

An extreme version of this approach is to assume that the capital account is completely closed, i.e., that the private sector cannot issue peso bonds or hold dollar bonds. This is for example the assumption made by Gabaix and Maggiori (2015) in their discussion of foreign exchange reserves interventions. Then the model is the same as in section 4 where capital flows are set by a benevolent social planner. The government buys or sells peso bonds depending on the foreign appetite for peso bonds but at the same time reduces the volatility in the trade balance relative to *laissez-faire*, as stated in Proposition 1. It follows from Proposition 2 that foreign exchange interventions implement the same allocation as capital flow taxes. The intuition behind the equivalence between foreign exchange interventions and capital controls is straightforward. The same allocation can be achieved by setting the appropriate wedges in the first-order conditions or by directly setting the quantities

A less extreme form of financial friction would be to assume that some private agents are less internationally financially integrated than others. For example, Fanelli and Straub (2020) assume that a fraction of private agents are hand-to-mouth and do not have access to financial markets while the other (Ricardian) agents have perfect access to those markets. If one makes the same assumption in our model, the government can implement the social planner allocation by using a combination of foreign exchange interventions and capital flow taxes, each instrument being targeted to the type of households for which it has leverage. The government can reproduce the social planner allocation for the hand-to-mouth consumers using foreign exchange interventions combined with lump-sum transfers, while the capital flow taxes

can be used to implement the optimal allocation for the Ricardian consumers. Such a model would predict that as countries become more financially integrated with the rest of the world, they should switch from foreign exchange interventions to capital flow taxes as the preferred policy instrument to manage the exchange rate.

## 6.2 Capital controls in practice

We do not observe in the real world that countries switch from foreign exchange interventions to capital flow taxes as they become more integrated to global financial markets. There is evidence that foreign exchange interventions tend to be used by less financially integrated countries (Jeanne and Sandri, 2020) but more financially integrated countries seldom use capital flow taxes. Why is this policy instrument unpopular? To answer this question one must acknowledge several issues with capital flow taxes that seem to be first order for policymakers but are typically ignored in the theoretical literature.<sup>18</sup> Those issues point to frictions with the policy instrument itself rather than the economic frictions targeted by policy—what might be called “instrument frictions.”

The first issue is **circumvention**. One reason that the Chilean authorities grew dissatisfied with their capital flow management measures in the 1990s is that the private sector became increasingly adept at circumventing the controls. The resulting rat race between circumvention and regulation led to an increasingly complex and unwieldy system. Similarly, the Brazilian capital flow taxes have been circumvented by disguising investment in short-term bonds as foreign direct investment or investment in long-term bonds (de M. Carvalho and Garcia, 2008). Circumvention can explain Klein and Shambaugh (2015)’s finding that capital controls do not generally allow for greater monetary independence unless they are quite extensive, i.e., they are “walls” rather than “gates.”

The second issue is **governance**. To be effective as a countercyclical tool, a tax on capital flows should be insulated from short-run political influences. Ideally, like banking regulation it should be delegated to an independent agency such as the central bank. Indeed, one reason that countries such as Chile used unremunerated reserve requirement instead of a tax to discourage

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<sup>18</sup>There are exceptions such as Bartolini and Drazen (1997) for stigma or Bengui and Bianchi (2018) for circumvention.

inflows is because the latter would have required congressional approval. As noted by Chamon and Garcia (2016), Brazil’s governance is uniquely adapted to the operation of a countercyclical tax on capital flows because Brazil has a general tax on financial transactions whose rate can be set by decree and without congressional approval. Most countries do not have such a governance in place. This may explain why the evidence that capital controls are used countercyclically is mixed at best. For example, Fernández et al. (2016) find that capital controls are not generally used in a countercyclical way.<sup>19</sup>

The third issue is **stigma**. As noted by Erten, Korinek and Ocampo (2021), the traditional stigma associated with the term “capital controls” was one of the key reasons for why the IMF preferred to use the phrase “capital flow management measures.” One important reason that emerging markets policymakers are reluctant to use capital controls is that this might be interpreted by market participants as a move away from investor-friendly policies and an increase in the risk of future expropriation. The introduction of a tax on capital inflows might thus scare away investors and lead to overreaction in the form of a capital flight. This means that the kind of fine-tuning that capital flow taxes implement in the model might be impossible to achieve in practice.

For these reasons, capital flow taxes may have not been an attractive policy option for financially integrated economies. However, the experience with capital flow taxes is not uniformly negative<sup>20</sup> and the instrument frictions mentioned above might be reduced through appropriate reforms at the domestic and international levels. For example, governance problems could be mitigated by delegating capital flow taxes to independent central banks, and stigma could be reduced by an international agreement codifying good practice in the use of market-based capital controls (Jeanne, Subramanian and Williamson, 2012).

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<sup>19</sup>The evidence in Ghosh, Ostry and Qureshi (2017) is more supportive of the countercyclical use of capital controls.

<sup>20</sup>Circumvention does not make capital flow taxes completely ineffective. For example, Chamon and Garcia (2016) find that the cumulative effect of measures used by Brazil in depreciated the Brazilian real by about 10%.

## 7 Conclusions

Let me conclude by summarizing the main take-away messages from this paper and discussing possible directions for further research.

First, the theoretical case for rounding the corners of the trilemma is perhaps more straightforward than it has been made in the literature. It can be made in a simple macroeconomic model with a basic tradeoff between stabilizing the tradable sector and stabilizing the nontradable sector. This is not to mean that the frictions that I have abstracted from, for example those related to foreign currency debt, are not important in practice. But from a methodological perspective, it might be desirable to understand better the simple macroeconomic case for managing exchange rates before considering models with a richer menu of frictions.

Second, going from theory to policy prescriptions is difficult. Macroeconomic theorists should consider a wider range of policy instruments than in the textbook trilemma analysis because these instruments are used in the real world. One would like to know more about the conditions under which specific policy tools should and should not be used. One limitation of existing models, though, is that they tend to ignore “instrument frictions” that seem very important for policymaking in practice. Hopefully, ongoing research can tell us more about the size of the welfare gains that could be expected from using those policies in an ideal world without instrument friction. Those welfare gains, if they are found to be large, may then motivate more efforts to overcome instrument frictions.

I have illustrated this approach with back-of-the-envelope calculations comparing the welfare gains of taxes on capital flows with the welfare gains from a floating exchange rate. It would be interesting to generalize this kind of exercise to more realistic and richer models. My model was based on assumptions that were made for the sake of simplicity and clarity of exposition rather than realism. Even if one restricts the attention to basic Keynesian frictions, one would like to consider more general preferences, production functions and forms of price and wage stickiness.

Finally, the paper focused on a small open economy and did not consider the multilateral perspective. Clearly, capital controls and foreign exchange interventions have international spillovers, which are the primary concern of those who castigate such policies as “currency manipulation.” However, spillovers may be efficient and do not necessarily call for international coordination (Korinek, 2016). More work is needed on this issue too.

## APPENDIX

**1) Equilibrium conditions.** The dollar price of the tradable good is normalized to one so that by the law of one price the peso price of the tradable good is equal to the exchange rate,  $P_{Tt} = E_t$ . The consumer's budget constraint is

$$E_t B_t^* + (1 + i_{t-1}) B_{Pt-1} + E_t C_{Tt} + P_{Nt} C_{Nt} = W_{Tt} L_{Tt} + W_{Nt} L_{Nt} + \Pi_{Tt} + \Pi_{Nt} + E_t (1 + i_{t-1}^*) B_{t-1}^* + B_{Pt}, \quad (24)$$

where  $B_t^*$  is the consumer's investment in dollar bonds;  $B_{Pt}$  is the consumer's issuance of peso bonds;  $i_t^*$  and  $i_t$  are the dollar and peso interest rates;  $W_{Tt}$  and  $W_{Nt}$  are the peso wages and  $\Pi_{Tt}$  and  $\Pi_{Nt}$  are the firms' profits in the two sectors (in equilibrium  $\Pi_{Nt} = 0$  because of the linearity of production function). The dollar value of the peso bonds is denoted by  $B_t = B_{Pt}/E_t$ .

In the decentralized equilibrium, the representative consumer maximizes (2) over  $C_{Tt}$ ,  $C_{Nt}$ ,  $L_{Tt}$ ,  $L_{Nt}$  subject to the budget constraint (24). The first-order conditions for labor supply are  $W_{Tt} = E_t$  and  $u'_N(C_{Nt}) W_{Nt}/P_{Nt} = 1$  if wages are flexible (if wages are sticky labor supply is demand determined and those conditions do not apply). The firms' profit-maximizing conditions (which hold irrespective of wage stickiness) are  $f'(L_{Tt}) = W_{Tt}/E_t$  and  $P_{Nt} = W_{Nt}$ . Using  $Y_{Nt} = C_{Nt}$ , these conditions imply  $f'(L_T) = 1$  and  $u'_N(Y_N) = 1$  in the natural allocation. For specification (4) this implies  $\bar{L}_T = 1 - \alpha$  and  $\bar{Y}_T = \bar{Y}_N = 1$  as stated in the text.

The first-order conditions for  $B_t^*$  and  $B_t$  are

$$u'_{Tt} = u'_{B^*t} + \beta (1 + i_t^*) u'_{Tt+1}, \quad (25)$$

$$u'_{Tt} = \beta (1 + i_t) \frac{E_t}{E_{t+1}} u'_{Tt+1}, \quad (26)$$

where  $u'_{Tt}$  and  $u'_{B^*t}$  are shorthands for  $u'_T(C_{Tt} - L_{Tt})$  and  $u'_{B^*}(B_t^*)$ . Using (3) to substitute out  $1 + i_t$  in (26) gives

$$u'_{Tt} = \beta (1 + i_t^*) (1 + \rho_t) u'_{Tt+1}. \quad (27)$$

Equations (25) and (27) imply,

$$u'_{B^*t} = \beta (1 + i_t^*) \rho_t u'_{Tt+1}. \quad (28)$$

**2) Steady states.** Let us consider the steady state with flexible wages, a constant UIP wedge  $\bar{\rho} \geq 0$  and a constant level of end-of-period net foreign assets  $\bar{A} = \bar{B}^* - \bar{B}$ . Equation (27) implies  $\beta(1+i^*)(1+\bar{\rho}) = 1$ . Hence I assume that  $\beta(1+i^*) \leq 1$  and

$$1 + \bar{\rho} = \frac{1}{\beta(1+i^*)}. \quad (29)$$

Eliminating the terms related to the nontradable sector in equation (24), the budget constraint of the representative consumer can be rewritten

$$B_t^* + (1 + i_{t-1}^*)(1 + \rho_{t-1})B_{t-1} + C_{Tt} = Y_{Tt} + (1 + i_{t-1}^*)B_{t-1}^* + B_t. \quad (30)$$

Using (29), steady state tradable consumption is then given by

$$\begin{aligned} \bar{C}_T &= \bar{Y}_T + i^*\bar{B}^* - \frac{1-\beta}{\beta}\bar{B} \\ &= \bar{Y}_T + \frac{1-\beta}{\beta}\bar{A} - (1+i^*)\bar{\rho}\bar{B}^*, \end{aligned} \quad (31)$$

where  $\bar{Y}_T = 1$  is the natural level of tradable output. The consumption of tradable good is equal to the production of tradable good plus the return on net foreign assets minus the carry cost of dollar liquidity.

In a steady state with zero net foreign assets the trade balance must pay for the carry cost of dollar liquidity

$$\bar{X} = \bar{Y}_T - \bar{C}_T = (1+i^*)\bar{\rho}\bar{B}^*,$$

where by (28) and  $u'_T = \theta$ ,  $\bar{B}^*$  satisfies

$$u'_{B^*}(\bar{B}^*) = \frac{\bar{\rho}\theta}{1+\bar{\rho}}. \quad (32)$$

Parameter  $\kappa$  is set to a value such that the marginal utility of tradable consumption is equal to  $\theta$  if  $\bar{A} = 0$ . The marginal utility of tradable consumption is given by

$$\begin{aligned} u'_T(\bar{C}_T - \bar{L}_T) &= \theta(\bar{C}_T - \bar{L}_T + \kappa)^{-\sigma_T}, \\ &= \theta(1 - \bar{X} - \bar{L}_T + \kappa)^{-\sigma_T}. \end{aligned}$$

It follows that  $\kappa = \bar{L}_T + \bar{X}$ .

The ratio of the value of tradable output to the value of nontradable output is

$$\frac{E\bar{Y}_T}{P_N\bar{Y}_N} = \frac{u'_T(\bar{C}_T - \bar{L}_T)}{u'_N(\bar{Y}_N)} \frac{\bar{Y}_T}{\bar{Y}_N} = \theta.$$

**3) Linearization.** The period-1 variables are denoted without time index and the deviations from the zero-NFA steady state are denoted with lower case variables, that is

$$\begin{aligned} Y_T &= 1 + y_T, \\ Y_N &= 1 + y_N, \\ B^* &= \bar{B}^* + b^*, \\ B &= \bar{B} + b, \\ X &= \bar{X} + x. \end{aligned}$$

The Euler equation for the period-1 consumption of nontradable good is

$$\frac{u'_N(Y_N)}{P_N} = \beta(1+i) \frac{u'_N(\bar{Y}_N)}{\bar{P}_N}.$$

By assumption the home policymaker pegs the price of the nontradable good,  $P_N = \bar{P}_N$ . Hence using  $\bar{Y}_N = 1$  and  $\beta(1+\bar{l}) = 1$  where  $\bar{l}$  is the long-run peso interest rate, one obtains

$$(1 + y_N)^{-\sigma_N} = \frac{1 + i}{1 + \bar{l}}.$$

Linearizing this equation gives (8).

The first-order condition for firms' profit maximization in the tradable sector is

$$\begin{aligned} \frac{W_T}{E} &= f'(L_T), \\ &= Y_T^{-\alpha/(1-\alpha)}. \end{aligned}$$

By assumption the nominal wage  $W_T$  is fixed at a level such that  $Y_T = \bar{Y}_T = 1$  if the nominal exchange rate is at its long-run level  $\bar{E}$ . If one assumes w.l.o.g. that  $\bar{E} = 1$  so that  $E = 1 + e$ , linearizing this equation gives (9).

The economy in a steady state with net foreign assets  $\bar{A}$  from period 2 onwards (the long term). If  $\bar{A}$  and  $1 - \beta$  are first order, equation (31) shows

that  $\bar{C}_T$  differs from the level that prevails with zero net foreign assets by a second order term. Thus the marginal utility of tradable consumption is equal to  $\theta$  in the long run to a first order of approximation. Furthermore, since in period 1  $Y_T - L_T$  is close to its maximum it deviates from  $\bar{Y}_T - \bar{L}_T$  by a second order term. It follows that

$$\begin{aligned} C_T - L_T + \kappa &= Y_T - X - L_T + \kappa, \\ &\simeq \bar{Y}_T - \bar{X} - \bar{L}_T + \kappa - x, \\ &= 1 - x. \end{aligned}$$

Thus to a first order condition (27) can be written in period 1

$$\begin{aligned} \theta (1 - x)^{-\sigma_T} &= \beta (1 + i^*) (1 + \rho) \theta, \\ &= \theta \frac{1 + \rho}{1 + \bar{\rho}}, \end{aligned}$$

which after linearization gives (5).

The first order condition for  $B^*$  in period 1 is

$$u'_{B^*} (\bar{B}^* + b^*) = \theta \mu (\bar{B}^* + b^*)^{-\sigma_{B^*}} = \frac{\rho \theta}{1 + \bar{\rho}}. \quad (33)$$

Linearizing this equation using (32) and the fact that  $\bar{\rho}$  is first order gives (6).

**4) Welfare.** Welfare is computed by taking the second-order Taylor expansion of

$$\begin{aligned} U_1 &= u_T (C_T - L_T) + u_{B^*} (B^*) + u_N (C_N) - L_N \\ &\quad + \frac{\beta}{1 - \beta} \left[ u_T (\bar{C}_T - \bar{L}_T) + u_{B^*} (\bar{B}^*) + u_N (\bar{C}_N) - \bar{L}_N \right]. \end{aligned}$$

To alleviate notations, irrelevant constant terms are omitted and regrouped under the notation  $K(\dots)$ . For example, since  $\bar{B}^*$ ,  $\bar{C}_N$  and  $\bar{L}_N$  are exogenous to period-1 policies we can rewrite welfare as

$$U_1 = u_T (C_T - L_T) + u_{B^*} (B^*) + u_N (C_N) - L_N + \frac{\beta}{1 - \beta} u_T (\bar{C}_T - \bar{L}_T) + K(\dots). \quad (34)$$



For the utility coming from the nontradable sector, a second-order Taylor expansion give

$$\begin{aligned} u_N(C_N) - L_N &= u_N(1 + y_N) - (1 + y_N), \\ &= -\frac{\sigma_N}{2}y_N^2 + O(y_N^3), \end{aligned}$$

where  $O(y_N^3)$  is a shorthand for terms of order 3 or higher. For the tradable sector

$$\begin{aligned} Y_T - L_T &= 1 + y_T - (1 - \alpha)(1 + y_T)^{1/(1-\alpha)}, \\ &= \alpha - \frac{1}{2}\frac{\alpha}{1-\alpha}y_T^2 + O(y_T^3). \end{aligned}$$

Using these expressions as well as  $C_T = Y_T - X$ ,  $u'_T \simeq \theta$  and  $\gamma = \alpha/(1 - \alpha)$ , expression (34) can be rewritten,

$$\begin{aligned} U_1 &= \frac{\theta}{1 - \sigma_T} (1 - x)^{1 - \sigma_T} + u_{B^*}(\bar{B}^* + b^*) + \frac{\beta}{1 - \beta} u_T(\bar{C}_T - \bar{L}_T) \\ &\quad - \underbrace{\frac{1}{2}(\sigma_N y_N^2 + \theta \gamma y_T^2)}_{\mathcal{L}_y} + O(y_N^3, y_T^3) + K(\dots). \end{aligned}$$

The welfare loss due to the output gaps can be written like in the text,  $\mathcal{L}_y = (\omega_N y_N^2 + \omega_T y_T^2)/2$  with  $\omega_N = \sigma_N$  and  $\omega_T = \theta \gamma$ .

Next we take a second-order Taylor expansion of the terms involving capital flows. The UIP wedge is assumed to be at the long-run level,  $\rho = \bar{\rho}$ , which does not affect the weights in the loss function to a first order of approximation. In period 2, the budget constraint (30) is

$$\begin{aligned} \bar{B}^* - \bar{B} + \bar{C}_T &= \bar{Y}_T + (1 + i^*)(\bar{B}^* + b^*) - (1 + i^*)(1 + \bar{\rho})(-\bar{B}^* + b), \\ &= \bar{Y}_T - (1 + i^*)\bar{\rho}\bar{B}^* + (1 + i^*)[b^* - (1 + \bar{\rho})b], \end{aligned}$$

and after period 2 it is

$$\bar{C}_T = \bar{Y}_T + i^*\bar{B}^* - \frac{1 - \beta}{\beta}\bar{B}.$$

Eliminating  $\bar{B}$  between the previous two equations gives,

$$\bar{C}_T = \bar{Y}_T - (1 + i^*)\bar{\rho}\bar{B}^* + \frac{1 - \beta}{\beta} \left( \frac{b^*}{1 + \bar{\rho}} - b \right) = \bar{Y}_T + \bar{L}_T - \kappa + \frac{1 - \beta}{\beta} \left( x - \frac{\bar{\rho}}{1 + \bar{\rho}} b^* \right),$$

where we have used  $x = b^* - b$  and  $\kappa = \bar{L}_T + (1 + i^*)\bar{\rho}\bar{B}^*$ . The Taylor expansion of welfare  $U_1$  is

$$\begin{aligned}
U_1 &= \frac{\theta}{1 - \sigma_T} (1 - x)^{1 - \sigma_T} + \frac{\theta\mu}{1 - \sigma_{B^*}} (\bar{B}^* + b^*)^{1 - \sigma_{B^*}} + \\
&\quad \frac{\beta}{1 - \beta} \frac{\theta}{1 - \sigma_T} \left[ 1 + \frac{1 - \beta}{\beta} \left( x - \frac{\bar{\rho}}{1 + \bar{\rho}} b^* \right) \right]^{1 - \sigma_T} - \frac{1}{2} \mathcal{L}_y + O(y_N^3, y_T^3) + K(\dots), \\
&= -\frac{1}{2} \left[ \theta\sigma_T x^2 + \frac{\theta\sigma_T}{\phi} b^{*2} + \theta\sigma_T \frac{1 - \beta}{\beta} \left( x - \frac{\bar{\rho}}{1 + \bar{\rho}} b^* \right)^2 + \mathcal{L}_y \right] + O(x^3, b^{*3}, y_N^3, y_T^3) + K(\dots), \\
&= \underbrace{-\frac{1}{2} \theta\sigma_T \left( x^2 + \frac{b^{*2}}{\phi} \right)}_{\mathcal{L}_f} - \frac{1}{2} \mathcal{L}_y + O(x^3, b^{*3}, y_N^3, y_T^3) + K(\dots).
\end{aligned}$$

The first-order terms cancel out because the Taylor expansion is taken in the vicinity of the maximum. To derive the third equality we eliminated the term in  $(1 - \beta) \left( x - \frac{\bar{\rho}}{1 + \bar{\rho}} b^* \right)^2$  on the r.h.s. of the second equality because it is third order if  $1 - \beta$  is first order.

**5) Managed float.** The first-order condition for the intratemporal substitution between the tradable good and the nontradable good is

$$\frac{u'_T(C_T - L_T)}{E} = \frac{u'_N(Y_N)}{W_N},$$

or

$$\theta \frac{(1 - x)^{-\sigma_T}}{1 + e} = \frac{(1 + y_N)^{-\sigma_N}}{W_N}.$$

Linearizing this equation gives (13).

**Proof of Proposition 1.** The social planner minimizes the loss  $\mathcal{L}_y = (\omega_N y_N^2 + \omega_T y_T^2) / 2 = (\sigma_N y_N^2 + \theta \gamma y_T^2) / 2$  subject to (14). The minimized loss is

$$\mathcal{L}_y = \frac{1}{2} \frac{\sigma_T^2}{\sigma_N + \gamma/\theta} x^2.$$

The loss due to capital flow distortions is given by

$$\mathcal{L}_f = \frac{\theta\sigma_T}{2} (x - x_{FF})^2 + \frac{\theta\sigma_T}{2\phi} (b^* - b_{FF}^*)^2,$$

where  $x_{FF}$  and  $b_{FF}^*$  are the trade balance and dollar liquidity under a free float given by (5) and (6). Since capital flows are undistorted under a free float the welfare loss from distorting capital flows is a function of the deviations relative to a free float.

The social planner minimizes  $\mathcal{L}_f + \mathcal{L}_y$  over  $x$  and  $b^*$ . The solution is given by the expressions in Proposition 1. The resulting welfare loss  $\mathcal{L}_{MF} = \mathcal{L}_f + \mathcal{L}_y$  is given by

$$\mathcal{L}_{MF} = \frac{\theta}{2\sigma_T} (1 - \chi) (\rho - \bar{\rho})^2.$$

Using (8) and (9), the welfare loss under a free float  $\mathcal{L}_{FF} = \mathcal{L}_y$  is given by

$$\mathcal{L}_{FF} = \frac{\theta}{2\sigma_T} \frac{1 - \chi}{\chi} (\rho - \bar{\rho})^2, \quad (35)$$

so that  $\mathcal{L}_{MF} = \chi \mathcal{L}_{FF}$ , which implies equation (17).

## 6) Capital flow taxes.

**Proof of Proposition 2.** That the optimal tax on capital inflows must satisfy (20) has been established in the text before the proposition. With a tax  $\tau^*$  on dollar bonds the budget constraint becomes

$$(1 + \tau_t^*) B_t^* + (1 + i_{t-1}^*) (1 + \rho_{t-1}) (1 + \tau_{t-1}) B_{t-1} + C_{Tt} = Y_{Tt} + (1 + i_{t-1}^*) B_{t-1}^* + B_t + Z_t, \quad (36)$$

where the nontradable sector was omitted and  $Z_t$  is the lump-sum rebate of the tax proceeds. The first-order conditions for  $B^*$  and  $B$  in period 1 are

$$(1 + \tau^*) u'_T = u'_{B^*} + \beta (1 + i^*) \bar{u}'_T, \quad (37)$$

$$u'_T = \beta (1 + i^*) (1 + \rho) (1 + \tau) \bar{u}'_T. \quad (38)$$

Thus using  $\bar{u}'_T = \theta$  the first-order condition (28) is replaced by

$$u'_{B^*} = \beta (1 + i^*) [(1 + \rho) (1 + \tau) (1 + \tau^*) - 1] \theta.$$

For the accumulation of dollar liquidity to be undistorted one must have  $(1 + \tau) (1 + \tau^*) = 1$ . The tax on capital inflows must be offset by an equivalent subsidy on outflows.

**Proof of Proposition 3.** Using equation (35) the welfare loss under a free float can be re-written

$$\mathcal{L}_{FF} = \frac{1}{2} \frac{1}{\sigma_N + \gamma/\theta} (\rho - \bar{\rho})^2.$$

Under a fixed exchange rate with capital controls,  $y_T = 0$  and equation (14) imply

$$\mathcal{L}_y = \frac{\omega_N}{2} y_N^2 = \frac{1}{2} \frac{\sigma_T^2}{\sigma_N} x^2.$$

The total loss under a fixed exchange rate with capital controls is

$$\begin{aligned} \mathcal{L}_{FIXCC} &= \min_x \frac{1}{2} \theta \sigma_T (x - x_{FF})^2 + \frac{1}{2} \frac{\sigma_T^2}{\sigma_N} x^2 \\ &= \frac{1}{2} \frac{1}{\sigma_N + \sigma_T/\theta} (\rho - \bar{\rho})^2. \end{aligned}$$

Hence  $\mathcal{L}_{FIXCC} < \mathcal{L}_{FF}$  if and only if  $\gamma < \sigma_T$  as stated in the proposition.

**Proof of equation (21).** Consider the case where there is no tax or subsidy on capital outflows. Then equations (5) and (6) apply with  $\rho$  replaced by  $\rho + \tau$ , which implies  $b^* = -\phi x$  for any allocation implemented by the tax on inflows. It follows that the welfare loss under a managed float is given by

$$\begin{aligned} \mathcal{L}_{MF} &= \frac{\theta \sigma_T}{2} (x - x_{FF})^2 + \frac{\theta \sigma_T}{2\phi} (b^* - b_{FF}^*)^2 + \frac{1}{2} \frac{\sigma_T^2}{\sigma_N + \gamma/\theta} x^2, \\ &= \frac{\theta \sigma_T}{2} (1 + \phi) (x - x_{FF})^2 + \frac{1}{2} \frac{\sigma_T^2}{\sigma_N + \gamma/\theta} x^2. \end{aligned}$$

Minimizing this loss over  $x$  with  $x_{FF}$  given by (5) gives

$$\mathcal{L}_{MF} = \frac{\theta}{2\sigma_T} \frac{1}{\frac{1}{1+\phi} + \frac{\chi}{1-\chi}} (\rho - \bar{\rho})^2,$$

which with (35) implies (21).

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