Revisiting the Trilemma: Sectoral Trade-offs and Exchange Rate Management in Emerging Markets

Jeongwon (John) Son*

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Abstract

Many emerging market economies (EMEs) float the exchange rate and simultaneously manage it by using capital controls or foreign exchange intervention. We rationalize this with a model featuring a sectoral trade-off of monetary policy. Monetary policy can stabilize the tradable sector, but only at the cost of destabilizing the non-tradable sector. Managing the exchange rate to stabilize the tradable sector alleviates this trade-off. We characterize the differences between EMEs and advanced economies that explain why the former need to manage the exchange rate more than the latter and find that higher volatility of shocks and lower inter-sectoral labor mobility in EMEs are the main drivers. Additionally, we find that the welfare gains from exchange rate flexibility dominate the welfare gains from capital controls even for EMEs. However, if we only consider shocks to external financial conditions the opposite holds.

Keywords: Capital controls, foreign exchange intervention, monetary policy, exchange rate regime, exchange rate management, Trilemma, Impossible Trinity, Mundell-Fleming Trilemma, labor mobility

JEL: E32, E43, E44, E52, E58, F31, F32, F38, F41, F44

*Johns Hopkins University, Department of Economics, 3100 Wyman Park Drive, Baltimore, MD 21211. E-mail: **json8@jhu.edu**. For invaluable support and guidance, I thank Olivier Jeanne, Alessandro Rebucci, Jonathan Wright and Paolo Cavallino. I also thank Stelios Fourakis, Francesco Bianchi, Annie Lee and seminar participants at the JHU macro-seminar, JHU macro-finance brownbag seminar, Yonsei Macro Meeting, the Midwest Macro Meetings, Economics Graduate Student Conference, and the KAEA job market conference for helpful comments and discussions.

1 Introduction

Many emerging markets have a managed floating exchange rate regime: they simultaneously float the exchange rate and use capital controls or foreign exchange intervention to manage it. Figure 1 shows the distribution of countries that have a managed floating exchange rate regime, fixed exchange rate regime, and a pure floating exchange rate regime across quintiles of GDP-per-capita.[1] A significant proportion of countries in the first three quintiles, including emerging market economies, have a managed floating exchange rate regime. This stands at odds with the textbook Trilemma, which argues that economies should float the exchange rate or use capital controls or foreign exchange intervention, but not both. Why then do emerging markets choose to have a managed floating exchange rate regime?

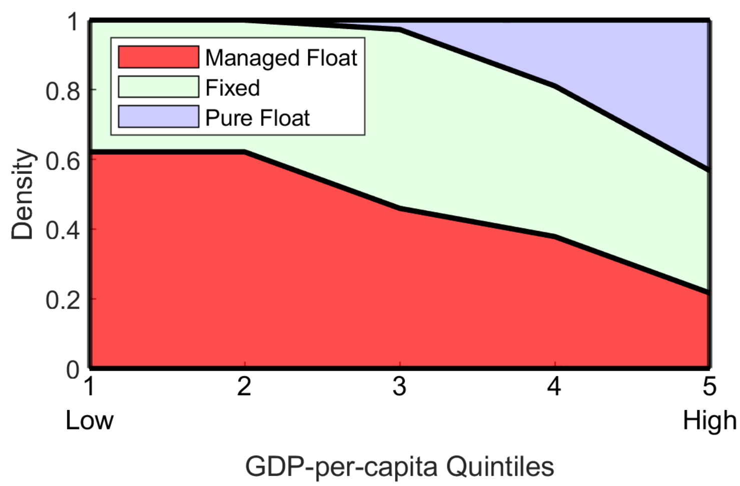


Figure 1: Distribution of exchange rate regimes across GDP-per-capita

We explore an answer that focuses on the trade-off between stabilizing the tradable and non-tradable sectors. We consider a model where there are two separate output gaps for the tradable and non-tradable sectors because of limited inter-sectoral labor mobility and nominal wage rigidities. Monetary policy can be used to stabilize the tradable sector by managing the exchange rate, but this has consequences on the non-tradable sector through its effect on demand. To stabilize one sector, the other must be destabilized, giving rise to what we call the *sectoral trade-off* of monetary policy. Following the Tinbergen

[1] GDP-per-capita is calculated by averaging the real GDP-per-capita from the WB World Development Indicators (WDI) database over 2000-2019. We classify a country's exchange rate regime based on the criteria set forth by Ilzetzki et al. (2019). Specifically, countries classified as 1 under the coarse classification of Ilzetzki et al. (2019) are considered to have a fixed exchange rate regime, those classified as 2 or 3 are considered to have a managed floating exchange rate regime and those classified as 4 are considered to have a pure floating exchange rate regime. Additionally, we classify Euro area countries as having a pure float.

principle that states that there has to be at least as many policy instruments as there are targets, there is an incentive to use additional policy instruments such as capital controls or foreign exchange intervention to manage the exchange rate and stabilize both sectors.

There is evidence that real-world policymakers perceive this sectoral trade-off to be relevant. For example, following the recovery of the global economy from the 2008 Global Financial Crisis, there was heightened demand for Brazilian assets by foreign investors. This created large inflows of foreign capital into Brazil, appreciating the Brazilian real by around 15% in real terms from 2009 to 2011. This appreciation diminished the competitiveness of the manufacturing sector.[2] The Brazilian central bank attempted to offset the appreciation by lowering the policy rate. However, as this approach could further overheat other sectors of the economy, there were limits to relying solely on monetary policy. In the end, Brazil's policymakers resorted to using capital controls, taxing foreign investors on their purchases of Brazilian assets, to curb the appreciation and stabilize the manufacturing sector.[3]

We develop a model with the sectoral trade-off of monetary policy at its core and solve for the policies that maximize the welfare of the representative agent. In the baseline model we focus on the use of capital controls and in later sections extend the model to analyze sterilized foreign exchange interventions. We show how capital controls should be used in response to a range of shocks. When shocks excessively lower labor demand in the tradable sector relative to the non-tradable sector, the policymaker should depreciate the currency (or offset the appreciation) with taxes on domestic asset purchases by foreign investors. In response to shocks that excessively increase labor demand in the tradable sector relative to the non-tradable sector, the opposite should be done. The optimal use of capital controls generates a welfare gain equivalent to a 0.8% increase in permanent consumption.

Using this model, we address two questions. First, we ask why managed floating exchange rate regimes are more common among emerging markets than advanced economies. Using two separately calibrated models for emerging markets and advanced economies, we find that this divergence primarily arises from differences in the volatility of shocks. As emerging markets face higher volatility of shocks, they benefit more from managing exchange rates than advanced economies. Furthermore, we find that the lower inter-

[2]In its 2012 Article IV for Brazil, the IMF claimed "[i]ncreases in relative unit labor costs and nominal exchange rate appreciation are among the factors behind this sub-par performance [of the manufacturing sector]." Post 2009 through its peak in mid 2011, the Brazilian real appreciated by around 15% in terms of CPI-based real effective exchange rate and 20% in terms of unit labor costs.

[3]For example, in 2009 Brazilian authorities implemented a 2% transaction tax on foreign fixed income and equity investments. Subsequently, in 2010, the rate was increased to 6% for fixed-income instruments.

sectoral labor mobility in emerging markets contributes to explaining why managed floating exchange rate regimes are more common among emerging market economies than advanced economies. Lower inter-sectoral labor mobility worsens the sectoral trade-off of monetary policy and therefore increases the benefit of exchange rate management in emerging market economies.

Next, we ask whether the welfare gains from exchange rate flexibility or those from capital controls are larger. This comparison is relevant as these are two different ways of gaining monetary autonomy as implied by the textbook Trilemma. We show that the nature of shocks is important for this analysis. Exchange rate flexibility is more valuable in response to terms of trade shocks since it smooths the fluctuations in labor demand in the tradable sector. On the other hand, capital controls are more valuable in response to shocks to external financial conditions. Shocks to external financial conditions create excessive movements in the domestic interest rate if the economy does not have any monetary autonomy. Capital controls and exchange rate flexibility provide monetary autonomy, allowing the domestic interest rate to respond less, with the former being more effective due to imperfect inter-sectoral labor mobility. When considering all shocks, because of the large volatility of terms of trade shocks in emerging market economies, exchange rate flexibility is more welfare improving.

This comparison of welfare gains across exchange rate flexibility and capital controls allows us to address the Dilemma hypothesis by Rey (2013). Rey states that the gains in monetary autonomy from capital controls are larger than those from exchange rate flexibility due to the Global Financial Cycle, a phenomenon where worldwide risky asset prices move together due to US monetary policy. Therefore, the relevant policy choice is whether or not to use capital controls, resulting in a "Dilemma." This view challenges the textbook Trilemma that states both exchange rate flexibility and capital controls provide monetary autonomy and has instigated a debate on whether the Dilemma or Trilemma holds.

We interpret the Dilemma hypothesis as implying that the welfare gains from capital controls are larger than those from exchange rate flexibility and the Trilemma as the opposite. Interpreted this way, we show that the nature of shocks is important in addressing the Trilemma versus Dilemma debate. Our results imply the Trilemma holds when considering all shocks, but the Dilemma holds if we only focus the Global Financial Cycle which is captured by shocks to global financial conditions in the model.

Finally, we extend the analysis of the model in several ways. First, we add nominal price rigidities to the model and second, solve the model under discretion and find that the baseline results are robust to these changes. Lastly, we capture the policy response of emerging markets during the COVID-19 pandemic by introducing a COVID shock that takes the form of a shift in demand from non-tradable to tradable goods.

Literature review

This paper is related to several strands of literature. First and foremost, this paper is related to the extensive literature on externalities that emerge from having multiple frictions. Bianchi and Coulibaly (2023a), Farhi and Werning (2016), Korinek and Simsek (2016) and Schmitt-Grohé and Uribe (2016) explore environments where externalities arise as a result of nominal rigidities and frictions in the use of monetary policy. Alternatively, Bianchi and Coulibaly (2023b), Costinot et al. (2014), Coulibaly (2023), Devereux et al. (2019), Farhi and Werning (2014a) and Itskhoki and Muhkin (2023) analyze environments with nominal rigidity and financial frictions such as credit constraints or incomplete financial markets. Basu et al. (2020) study a multitude of policy instruments in an environment with a wide range of frictions and shocks. All of these papers advocate the use of capital controls as a way to deal with externalities. We contribute to this literature by quantitatively analyzing an environment where aggregate demand externalities arise as a result of nominal wage rigidities in an environment with imperfect inter-sectoral labor mobility as explored in a stylized model in Jeanne (2022) and Farhi and Werning (2014b). These aggregate demand externalities result in a sectoral trade-off of monetary policy.

Contrary to Jeanne (2022) and Farhi and Werning (2014b), we quantitatively analyze the welfare implications of capital controls as well as foreign exchange intervention using a dynamic setup while accounting for shocks to the terms of trade and sectoral total factor productivity. We find that considering shocks to the terms of trade is important as it emphasizes the value of exchange rate flexibility over capital controls, flipping the result found in Jeanne (2022). We also address the question of why most emerging markets manage the exchange rate but not advanced economies. We find that the differences in the volatility of shocks and inter-sectoral labor mobility are key.

This paper is also related to the wide literature that studies the sectoral impact of shocks. Benigno and Fornaro (2014), Benigno et al. (2015) and Benigno et al. (2022) study the impact of capital inflow shocks on the sectoral reallocation of labor while Alberola and Benigno (2017) analyze the sectoral impact of commodity price shocks on the sectoral reallocation of labor. Fornaro and Romei (2023) study the sectoral impact of the COVID-19 pandemic. We contribute to this literature by deriving the optimal policy response to all these shocks that create excessive labor reallocation across sectors in our model.

In addition, we borrow the modeling assumptions from the literature that studies how imperfect inter-sectoral labor mobility affects the macro economy. Utilizing a model with imperfect labor mobility, Horvath (2000) analyzes how sectoral shocks give rise to aggregate fluctuations. Cardi and Restout (2015) show how imperfect labor mobility can explain why sectoral productivity shocks do not affect the real exchange rate in the same quantitative manner as implied by the Balassa-Samuelson model. Cantelmo and Melina (2023), Petrella et al. (2019) and Shi (2011) solve for the optimal monetary policy in a variety of environments with multiple sectors and imperfect inter-sectoral labor mobility.

Lastly this paper is related to the recent literature that studies the Trilemma versus Dilemma debate. Miranda-Agrippino and Rey (2020) show that the impact of the Global Financial Cycle on credit and financial conditions does not depend on a country's exchange rate regime, providing support for the Dilemma hypothesis. In contrast, Farhi and Werning (2014a) and Obstfeld et al. (2018) argue that the exchange rate regime matters. We show that the relative importance of exchange rate flexibility and usage of capital controls depends on the nature of shocks. Exchange rate flexibility is more valuable in responding to terms of trade shocks but capital controls are more valuable in dealing with the Global Financial Cycle. This highlights the finding from Miranda-Agrippino and Rey (2022) that there are two global cycles that explain capital flows, the Global Financial Cycle and the Global Trade and Commodity Cycle where the latter refers to the comovement of global trade flows and commodity prices. Our results show that the policy choices that are relevant differ across these two cycles, and emphasize the importance of exchange rate flexibility once we consider both.

The paper is organized as follows. In Section 2, we set up the model and define the policymaker's problem. In Section 3 we discuss the implication of policy instruments using a tractable version of the model. In Section 4 we calibrate the model and provide a quantitative analysis of the model. We explain why emerging markets manage exchange rates more than advanced economies in Section 5. Section 6 compares the welfare gains from exchange rate flexibility and capital controls and addresses the Dilemma hypothesis. We extend the model to incorporate sterilized foreign exchange intervention in Section 7. We further explore alterations of the model in Section 8 by analyzing optimal policies under discretion, considering nominal price rigidities and replicating the policy response of emerging markets to the COVID-19 pandemic in the context of our model. Lastly, we conclude in Section 9.

2 Model

We consider a small open economy model with two sectors: a tradable sector and a non-tradable sector. Households consume three types of goods: Home tradables (H), Foreign tradables (F) and non-tradables (N). There are four sources of shocks to the economy: shocks to the uncovered interest parity (UIP) wedge, shocks to the terms of trade, and shocks to the two sector specific total factor productivity. We consider four different policy regimes, three that correspond to the textbook Mundell-Fleming model of the Trilemma and a fourth that resembles the managed floating exchange rate regime of most emerging market economies. There is imperfect inter-sectoral labor mobility and the economy features nominal wage rigidities.

Firms

Firms in the Home tradable good and non-tradable good sectors use production technologies given by

$$Y_{S,t} = A_{S,t} L_{S,t}^{\alpha_S}, \quad \forall S \in \{H, N\} \tag{1}$$

where $Y_{S,t}$ is output, $L_{S,t}$ is labor, $0 < \alpha_S < 1$ is the labor share and $A_{S,t}$ is the total factor productivity in sector S. We assume the sectoral TFPs follow an AR(1) process given by

$$A_{S,t} = \zeta_{AS} A_{S,t-1} + \varepsilon_{AS,t}, \quad \varepsilon_{AS,t} \sim N(0, \sigma_{AS}^2), \quad \forall S \in \{H, N\}.$$

Firms aggregate individual types of labor using a CES function:

$$L_{S,t} = \left[\int_0^1 L_{S,t}(j)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} dj \right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}}, \quad \forall S \in \{H, N\}$$

where $L_{S,t}(j)$ denotes the quantity of type-j labor employed by firms in sector S. ε_w is the elasticity of substitution across varieties in labor. This results in the following labor demand condition for type-j labor:

$$L_{S,t}(j) = (\frac{W_{S,t}(j)}{W_{S,t}})^{-\epsilon_w} L_{S,t}, \quad \forall S \in \{H, N\} \tag{2}$$

where $W_{S,t}(j)$ denotes the Home currency wage for type-j labor and $W_{S,t}$ is the aggregate Home currency wage for labor in sector S.

Firms face perfect competition so that in both sectors the marginal productivity of labor is equal to the real wage:

$$\frac{W_{S,t}}{P_{S,t}} = \alpha_S A_{S,t} L_{S,t}^{\alpha_S - 1}, \quad \forall S \in \{H, N\} \tag{3}$$

where $P_{H,t}$ and $P_{N,t}$ denote the Home currency price of Home tradables and non-tradables. We assume the law of one price such that $P_{H,t} = E_t P_{H,t}^*$ where E_t is the bilateral exchange rate between the Home currency and the US dollar denoted such that an increase represents a depreciation of the home currency and $P_{H,t}^*$ is the dollar price of Home tradables. The dollar price of imports is assumed to be fixed at 1 so that fluctuations in $P_{H,t}^*$ capture the movement of terms of trade in the model which we assume to be exogenous. We assume $P_{H,t}^*$ follows an AR (1) process given by

$$\log P_{H,t}^* = \zeta_{pH*} \log P_{H,t-1}^* + \varepsilon_{pH*,t}, \quad \varepsilon_{pH*,t} \sim N(0, \sigma_{pH*}^2).$$

Households

Households have preferences of the form

$$\sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \left[u\left(C_t\right) - v\left(L_t\right) \right],$$

where β is the discount factor. We assume the following functional forms for utility:

$$u(C_t) = \frac{C_t^{1-\sigma} - 1}{1-\sigma}, \quad v\left(L_t\right) = \xi \frac{L_t^{1+\psi}}{1+\psi}.$$

C_t is a composite of tradable consumption $C_{T,t}$ and non-tradable consumption $C_{N,t}$ according to a CES aggregator:

$$C_t = \left[\omega_c^{\frac{1}{\theta_c}} C_{T,t}^{\frac{\theta_c - 1}{\theta_c}} + (1-\omega_c)^{\frac{1}{\theta_c}} C_{N,t}^{\frac{\theta_c - 1}{\theta_c}} \right]^{\frac{\theta_c}{\theta_c - 1}}. \tag{4}$$

$C_{T,t}$ is also a CES index of Home tradable consumption $C_{H,t}$ and Foreign tradable consumption $C_{F,t}$ given by

$$C_{T,t} = \left[\gamma^{\frac{1}{\phi}} C_{H,t}^{\frac{\phi - 1}{\phi}} + (1-\gamma)^{\frac{1}{\phi}} C_{F,t}^{\frac{\phi - 1}{\phi}} \right]^{\frac{\phi}{\phi - 1}}. \tag{5}$$

L_t represents aggregate labor and is a CES index of tradable sector labor $L_{H,t}$ and non-tradable sector labor $L_{N,t}$:

$$L_t = \left[\omega_\ell^{-\frac{1}{\theta_\ell}} L_{H,t}^{\frac{\theta_\ell + 1}{\theta_\ell}} + (1-\omega_\ell)^{-\frac{1}{\theta_\ell}} L_{N,t}^{\frac{\theta_\ell + 1}{\theta_\ell}} \right]^{\frac{\theta_\ell}{\theta_\ell + 1}} . \tag{6}$$

By assuming that labor across sectors are imperfect substitutes we allow the model to capture imperfect inter-sectoral labor mobility in a representative agent model setting.[4] This specification results in a marginal rate of substitution of labor across sectors that is not always equal to one, implying that when reallocating labor from one sector to another there is some loss in efficiency. We interpret the elasticity of substitution of sectoral labor, θ_ℓ, as the level of inter-sectoral labor mobility. In the limit where there is full mobility ($\theta_\ell \to \infty$) the CES function converges to a simple additive function such that the marginal rate of substitution of sectoral labor is equal to one.

Households have access to two bonds: a Home currency bond and a dollar bond. We denote the Home currency value of Home currency bonds held by households at the end of period t with B_t and denote the dollar value of dollar bonds held by households at the end of period t with B_t^*. We assume only the dollar bonds are traded in international markets so that $B_t = 0$ in equilibrium.[5]

The household budget constraint is

$$\begin{aligned} \sum_{S \in \{H,F,N\}} P_{S,t} C_{S,t} + B_t + B_t^* = & \sum_{S \in \{H,N\}} (1+\tau_w) W_{S,t} L_{S,t} + (1+i_{t-1}) B_{t-1} + E_t (1+i_{t-1}^*) B_{t-1}^* \\ & - \frac{\kappa_w}{2} \sum_{S \in \{H,N\}} P_{S,t} Y_{S,t} {\pi_{S,t}^w}^2 - P_{F,t} \frac{\kappa_B}{2} \left(\frac{B_t}{E_t} + B_t^* \right)^2 + \Pi_t \end{aligned}$$

where $\pi_{S,t}^w(j) = \frac{W_{S,t}(j)}{W_{S,t-1}(j)} - 1$ for $\forall S \in \{H, N\}$, τ_w is a wage subsidy that is financed by a

[4]We follow Horvath (2000), Iacoviello and Neri (2010) and Cardi and Restout (2022) to model imperfect inter-sectoral labor mobility with a CES aggregator. An alternative way to model it in a representative agent model is to introduce a quadratic cost of sectoral labor adjustment as in Ju et al. (2014) and Shi (2011). A key distinction between these two assumptions is how the marginal disutility of labor in one sector is affected by labor in the other sector. With the CES aggregator there is a negative relationship under $\psi < \frac{1}{\theta_\ell}$ while with the quadratic costs there is always a positive relationship. This difference is however quantitatively minimal and the results are robust to modeling imperfect labor mobility with quadratic costs. Another way to model imperfect inter-sectoral labor mobility is to introduce heterogeneity in households and a cost for switching sectors.

[5]This is for two reasons. First, by allowing only dollar denominated assets to be traded internationally, we are able to disregard the insurance aspect of exchange rate management as discussed in Fanelli (2023). If Home currency bonds are traded, the exchange rate can be managed to influence ex-post dollar returns on Home currency bonds which is not the motivation that we want to focus on. Second, it is realistic. Many emerging markets are better able to borrow internationally by issuing dollar debt, a phenomenon called the "Original Sin". Although the prevalence of the Original Sin has diminished (Onen et al. (2023)), it is still present especially in the private issuance of debt.

lumpsum tax on households and Π_t is a lumpsum transfer of profits from firms and tax revenue from the government. Following Schmitt-Grohè and Uribe (2003), we introduce a quadratic cost in adjusting the net foreign asset position away from its steady state to provide stationarity. i_t and i_t^* are the interest rates on Home currency bonds and dollar bonds respectively.

To introduce nominal wage rigidities, we assume monopolistic competition of labor and quadratic wage adjustment costs á la Rotemberg (1982). Households supply homogeneous sector specific labor, $L_{S,t}$, to a unit mass of labor unions where each labor union $j \in [0,1]$ supplies type-j labor, $L_{S,t}(j)$, to firms. Each union optimally chooses the nominal wage of type j labor supplied to sector S, $W_{S,t}(j)$, while internalizing the firms' demand for that particular type of labor given by Equation (2). Since the problem is identical across all unions, $L_{S,t}(j) = L_{S,t}$ and $W_{S,t}(j) = W_{S,t}$ in equilibrium for $\forall j \in [0,1]$ and $\forall S \in \{N, H\}$.

The first-order conditions with respect to wages result in New Keynesian wage Phillips Curves:

$$\pi_{S,t}^w = \beta \mathbb{E}_t \left[\pi_{S,t+1}^w \right] + \frac{\varepsilon_w \alpha_S}{\kappa_w} \left(\frac{v_{S,t}/u_{S,t}}{W_{S,t}/P_{S,t}} - 1 \right), \quad \forall S \in \{H, N\} \tag{7}$$

where $v_{s,t} \equiv \frac{\partial v(L_t)}{\partial L_{s,t}}$ and $u_{s,t} \equiv \frac{\partial u(C_t)}{\partial C_{s,t}}$. The wage subsidy given to households is set such that $\tau_w = \frac{1}{\varepsilon_w - 1}$ so as to offset the constant markup from monopolistic competition.

The first-order conditions for consumption goods imply

$$\frac{u_{N,t}}{P_{N,t}} = \frac{u_{H,t}}{P_{H,t}} = \frac{u_{F,t}}{P_{F,t}}. \tag{8}$$

The dollar price of Foreign tradable goods is set to 1 so that under the law of one price for Foreign tradables, the Home currency price of Foreign tradables satisfies $P_{F,t} = E_t$.[6]

Lastly, we have two Euler equations which are derived by using the first-order conditions with respect to B_t and B_t^*.

$$u_{N,t} \left[1 + \kappa_B nfa_t \right] = \beta (1 + i_t) \mathbb{E}_t \left[\frac{P_{N,t}}{P_{N,t+1}} u_{N,t+1} \right] \tag{9}$$

$$u_{F,t} \left[1 + \kappa_B nfa_t \right] = \beta (1 + i_t^*) \mathbb{E}_t \left[u_{F,t+1} \right] \tag{10}$$

where the net foreign asset position, nfa_t, is given by $nfa_t \equiv \frac{B_t}{E_t} + B_t^*$.

[6] Although we could let the dollar price of Foreign tradables be stochastic, this would have minimal impact on welfare and the optimal policies. The main inefficiencies in the model stem from fluctuations in labor demand. The price of Foreign tradables affects labor demand only indirectly through the substitution effects which are calibrated to be small.

Equations (9) and (10) connect interest rates with the demand for goods. In particular, Equation (9) allows monetary policy to influence the demand for non-tradable goods. By linearizing the two Euler equations and Equation (8), we can derive the following uncovered interest parity (UIP) condition.

$$i_t - \mathbb{E}_t \left[\Delta e_{t+1}\right] = i_t^* \tag{11}$$

where $\Delta e_{t+1} \equiv \frac{E_{t+1}}{E_t} - 1$. Since households are able to hold two bonds the expected returns on these bonds must be equal in a linearized model. The UIP condition shows that conditional on expected future exchange rates, a tightening of monetary policy appreciates the home currency creating a second channel through which monetary policy can affect the economy. These two channels of monetary policy provide the basis for the sectoral trade-off of monetary policy discussed in the next section.

Foreign investors

Foreign investors require a time-varying excess return, ρ_t, on the dollar bond over US treasuries representing fluctuations in external financing conditions. High values of ρ_t represent times of global financial stress and low appetite for dollar bonds while low values of ρ_t represent times of global financial exuberance and high appetite for dollar bonds.[7]

As a way to manage capital inflows, the Home central bank can implement capital controls in the form of a tax (τ_t) on purchases of dollar bonds by foreign investors. The net return on dollar bonds ($i_t^* - \tau_t$) must equal the US treasury interest rate plus the excess return ($i_t^{US} + \rho_t$) so that

$$i_t^* = i^{US} + \rho_t + \tau_t. \tag{12}$$

The timing of the tax is such that foreign investors pay one dollar for a Home dollar bond in period t that pays $1 + i_t^* - \tau_t$ in period $t+1$. The tax revenue is rebated as a lump sum to Home households.

By utilizing equations (11) and (12), we derive the adjusted UIP condition:

$$i_t - i^{US} - \mathbb{E}_t \left[\Delta e_{t+1}\right] = \rho_t + \tau_t. \tag{13}$$

[7]The excess return, ρ_t, can be interpreted as representing levels of financial friction that the foreign investors are exposed to. These foreign investors are investors who are specialized in trading dollar bonds with the Home economy, and therefore operate in a segmented market. As a result, US treasuries and Home dollar bonds differ in their liquidity and are not perfect substitutes, giving rise to different returns.

This says that expected returns on Home currency bonds and US treasuries can differ due to the excess returns required by foreign investors and capital controls. Equation (13) shows how fluctuations in external financial conditions and capital controls can affect the exchange rate. Conditional on the expected future exchange rate an increase (decrease) in ρ_t, higher (lower) capital taxes will depreciate (appreciate) the currency in period t. Therefore, capital controls can be used as a substitute for monetary policy to manage the exchange rate. Since ρ_t acts as a wedge in the UIP condition between US treasuries and Home currency bonds, we call it the UIP wedge. Alternatively, we can interpret ρ_t to represent the Global Financial Cycle stated by Rey (2013). We assume ρ_t follows an AR(1) process given by

$$\rho_t = \zeta_\rho \rho_{t-1} + \varepsilon_{\rho,t}, \quad \varepsilon_{\rho,t} \sim N(0, \sigma_\rho^2).$$

Market clearing

Market clearing in the non-tradable sector implies

$$C_{N,t} = (1 - \frac{\kappa_w}{2} {\pi^w_{N,t}}^2) Y_{N,t} \tag{14}$$

and market clearing in the Home tradable sector implies

$$Y_{H,t} = C_{H,t} + C^*_{H,t} \tag{15}$$

where foreign demand for the Home tradable good ($C^*_{H,t}$) is perfectly elastic at the given dollar price of the Home tradable good and absorbs the output of Home tradable goods net of Home demand for Home tradable goods.[8]

The lump sum transfer to households is the sum of profits by firms, taxes to subsidize labor subsidies to households and net tax revenue from capital controls.

$$\Pi_t = P_{H,t} Y_{H,t} - W_{H,t} L_{H,t} + P_{N,t} Y_{N,t} - W_{N,t} L_{N,t} - \tau_w (W_{H,t} L_{H,t} + W_{N,t} L_{N,t}) - \tau_t B^*_{t-1}$$

Using these market clearing conditions and the lump sum transfer to households, we can

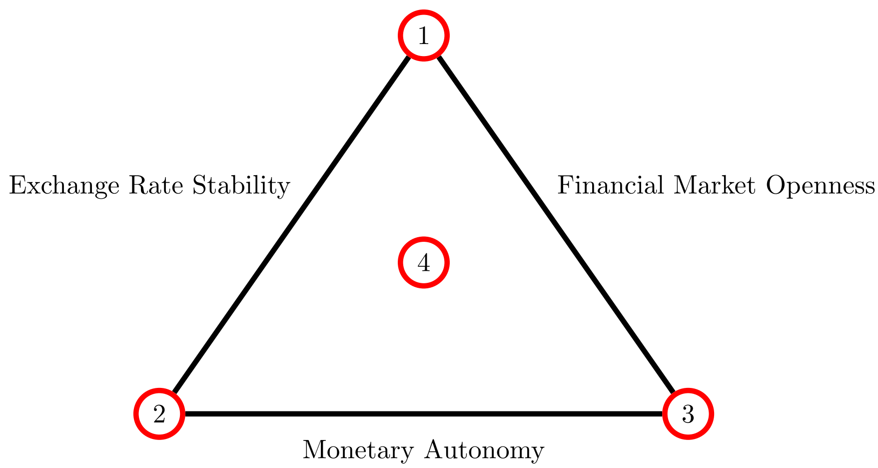
[8]Note that the terms of trade are exogenous in this model and not influenced by exchange rates. This is assumed for two reasons. First, this allows the policy maker to disregard the motive to manipulate the terms of trade for intertemporal consumption smoothing as studied in Costinot et al. (2014). Second, the assumption is realistic for small open economies which have small pricing power in international goods markets.

derive the aggregate budget constraint:

$$C_{F,t} + P^*_{H,t}C_{H,t} + B^*_t = \left(1 - \frac{\kappa_w}{2}{\pi^w_{H,t}}^2\right) P^*_{H,t}Y_{H,t} + (1 + i^{US} + \rho_{t-1})B^*_{t-1} - \frac{\kappa_B}{2}{B^*_t}^2. \quad (16)$$

Policy regimes

We consider the four policy regimes in Figure 2. The three policy regimes located at the three vertices of the Trilemma are those described in the textbook Mundell-Fleming framework. They emphasize that economies should achieve two of the three policy objectives by completely forgoing the third. In addition, countries can choose to float the exchange rate and manage it by regulating the capital account which we interpret as being in the middle of the triangle, labeled as policy regime #4 in Figure 2.



1: Fixed exchange rate regime

2: Fixed exchange rate regime with capital controls

3: Pure float

4: Managed float

Figure 2: The Trilemma and policy regimes

The four policy regimes can be implemented in the model by imposing restrictions on whether or not capital controls are used and whether or not the exchange rate is fixed. If capital controls are not used, then $\tau_t = 0$. If the exchange rate is fixed, then $\Delta e_t = 0$. Fixed exchange rates without capital controls corresponds to policy regime #1 and pursues exchange rate stability and financial market openness. A fixed exchange rate with capital controls corresponds to policy regime #2 and the case under flexible exchange rates without capital controls corresponds to policy regime #3 which we refer to as the pure float. Lastly, the case with flexible exchange rates and capital controls corresponds to policy regime # 4 which we refer to as the managed float from here on.

First-best allocation

In order to define the equilibrium under optimal policies, we need to first define the first-best allocation. We define the first-best allocation as the social planner's allocation that maximizes household lifetime utility taking as given the resource constraints, the imperfect inter-sectoral labor mobility and the financial market structure.[9]

Definition. (First-best allocation) The first-best allocation is the allocation of $\{C_t,\ C_{T,t},\ C_{H,t},\ C_{F,t},\ C_{N,t},\ L_t,\ L_{H,t},\ L_{N,t},\ B_t^*\ \}_{t=0}^{\infty}$ given an initial condition $\{B_{-1}^*\}$ and exogenous processes $\{\rho_t,\ P_{H,t}^*,\ A_{H,t},\ A_{N,t}\ \}_{t=0}^{\infty}$ that solves the following problem.

$$\begin{aligned}
\max \quad & \sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \left[u(C_t) - v(L_t) \right] \\
s.t. \quad & \text{Equations (4) - (6)} \\
& C_{N,t} = A_{N,t} L_{N,t}^{\alpha_N} \\
& C_{F,t} + P_{H,t}^* C_{H,t} + B_t^* = P_{H,t}^* A_{H,t} L_{H,t}^{\alpha_H} + (1 + i^{US} + \rho_{t-1}) B_{t-1}^* - \frac{\kappa_B}{2} B_t^{*2}
\end{aligned}$$

Since the only friction in the model is nominal rigidity in wages, the natural allocation where there is a constant wage subsidy to offset the markup from monopolistic competition is identical to the first-best allocation. We define the steady state equilibrium as the natural allocation where there are no shocks to the economy and where net exports are 0. The latter implies that the net foreign asset position is zero.

From here on, we use variables without a time subscript to denote the steady state values and lower case variables to denote the log-deviation from the steady state (e.g. $y_{N,t} = \log Y_{N,t} - \log Y_N$). We use the superscript "n" to denote the value of the variable under the natural allocation and "hats" to denote gaps between the equilibrium value and the natural allocation value (e.g. $\hat{y}_{N,t} = y_{N,t} - y_{N,t}^n$).

Optimal policy equilibrium

We are now ready to define the policymaker's problem and the equilibrium under optimal policy. We use a linear-quadratic approach to solve for the equilibrium under op-

[9]We assume the social planner takes into account the incompleteness of financial markets.

timal policy. Equilibrium conditions are linearized around the steady state and we derive a second-order Taylor expansion of the period-by-period household welfare function around the first-best allocation to derive a welfare loss function, $\mathscr{W}(\cdot)$.[10] The policymaker's problem is defined such that the policymaker directly chooses the allocations to minimize the welfare loss function subject to the equilibrium conditions. The policy instruments that implement the optimal allocations are derived afterwards. Before proceeding, we rearrange and simplify the equilibrium conditions given by Equations (1) - (16). The equilibrium under optimal policy is given by the allocation achieved by a policymaker that solves the following problem assuming the policymaker is able to commit and does so under a timeless perspective,[11]

$$\min \quad \sum_{t=0}^{\infty} \beta^t \mathbb{E}_0 \left[\mathscr{W}(\hat{y}_{H,t}, \hat{y}_{N,t}, \hat{c}_{T,t}, \pi^w_{H,t}, \pi^w_{N,t}, \hat{nfa}_t) \right]$$

$$s.t. \quad \hat{w}_{H,t} - \hat{w}_{N,t} = \left(\frac{1}{\theta_c} + \frac{1-\alpha_N}{\alpha_N} \right) \hat{y}_{N,t} - \frac{1-\alpha_H}{\alpha_H} \hat{y}_{H,t} - \frac{1}{\theta_c} \hat{c}_{T,t} \tag{17}$$

$$\pi^w_{H,t} = \beta \mathbb{E}_t \left[\pi^w_{H,t+1} \right] + \frac{\varepsilon_w \alpha_H}{\kappa_w} \left(\hat{v}_{H,t} - \hat{u}_{H,t} + \frac{1-\alpha_H}{\alpha_H} \hat{y}_{H,t} \right) \tag{18}$$

$$\pi^w_{N,t} = \beta \mathbb{E}_t \left[\pi^w_{N,t+1} \right] + \frac{\varepsilon_w \alpha_N}{\kappa_w} \left(\hat{v}_{N,t} - \hat{u}_{N,t} + \frac{1-\alpha_N}{\alpha_N} \hat{y}_{N,t} \right) \tag{19}$$

$$\pi^w_{H,t} - \pi^w_{N,t} = {\pi^w_{H,t}}^n - {\pi^w_{N,t}}^n + \hat{w}_{H,t} - \hat{w}_{N,t} - (\hat{w}_{H,t-1} - \hat{w}_{N,t-1}) \tag{20}$$

$$\omega_c \hat{c}_{T,t} + \hat{nfa}_t = \omega_c \hat{y}_{H,t} + \frac{1}{\beta} \hat{nfa}_{t-1} \tag{21}$$

and subject to

$$\Delta \hat{y}_{H,t} = -\frac{\alpha_H}{1-\alpha_H} \pi^w_{H,t} + \frac{\alpha_H}{1-\alpha_H} ({\pi^w_{H,t}}^n - \Delta e^n_t) \tag{22}$$

if the exchange rate is fixed and

$$\hat{u}_{T,t} + \kappa_B \hat{nfa}_t = \mathbb{E}_t \left[\hat{u}_{T,t+1} \right] \tag{23}$$

[10] A derivation of the welfare loss function is shown in Appendix A.

[11] The timeless perspective approach assumes the policymaker implements policy actions that would have been fully optimal to adopt in the distant past. For example, in period 0 the policymaker chooses $\pi^w_{H,0}$ internalizing the impact it has on $\pi^w_{H,-1}$ despite period -1 having already passed. Otherwise, there will be time inconsistency. Without adopting a timeless perspective the first-order conditions for period $t > 0$ derived in period 0 will become suboptimal in period t since the policymaker's problem defined in period t does not take into consideration its impact on variables in period $t-1$. Therefore in subsequent periods the policymaker would like to deviate away from the policy actions promised in period 0 implying time inconsistency.

if capital controls are not allowed. Note that $\hat{v}_{S,t}$ and $\hat{u}_{S,t}$ are used to denote the gap in marginal disutility with respect to sector S labor, and the gap in marginal utility of consuming S goods, respectively. They are linear functions of the two output gaps and tradable consumption gap.

Equation (17) represents the linearized combination of Equations (1), (3) and (8). The relative wage gap on the left-hand-side represents the inability of wages to respond as they should under the natural allocation due to nominal wage rigidities. They become a wedge that must be absorbed by the two output gaps and the tradable consumption gap. Equations (18) - (21) represent the two wage Phillips Curves, the definition of wage inflation and the aggregate budget constraint. Equation (22) shows that under fixed exchange rates, the supply of Home tradable goods is exogenous since the real wage is exogenous. Lastly, Equation (23) represents the "gap" version of Equation (10) in terms of tradable goods. If capital controls are available, the policymaker can freely manage the demand for tradable goods, relieving itself from the constraint.

This gives us four sets of different constraints that correspond to the four policy regimes depicted in Figure 2. The policies that implement the allocations can be solved for with

$$\begin{aligned}
\tau_t &= \hat{u}_{T,t} + \kappa_B n\hat{f}a_t - \mathbb{E}_t\left[\hat{u}_{T,t+1}\right], \\
i_t &= \tau_t + \mathbb{E}_t\left[\pi^w_{H,t+1}\right] + \frac{1-\alpha_H}{\alpha_H}\mathbb{E}_t\left[\Delta\hat{y}_{H,t+1}\right] + r^n_{H,t}
\end{aligned}$$

where $r^n_{H,t}$ is the natural real interest rate in terms of the tradable sector wage.[12]

In theory, we would expect the fixed exchange rate regime (policy regime #1) to exhibit the highest level of welfare loss and the managed float (policy regime #4) to show the lowest. This is because in a New-Keynesian framework having less constraints will always weakly increase welfare under commitment. On the other hand, it is unclear a priori whether the policy regime with fixed exchange rates and capital controls (policy regime #2) or the pure float (policy regime #3) should exhibit higher or lower levels of welfare loss. This is important as it determines whether the choice of the exchange rate regime or the choice of using capital controls matters more for welfare, as we explore in Section 6.

Welfare loss

In the following sections, we express the level of the unconditional expected welfare loss, $\mathbb{E}\left[\mathscr{W}(\cdot)\right]$, in terms of permanent consumption lost per period relative to the first-best.

[12]The natural real interest rate in terms of the tradable sector wage is given by $r^n_{H,t} = i^n_t - \mathbb{E}_t\left[{\pi^w_{H,t+1}}^n\right]$.

More specifically, the welfare loss can be represented by Δc such that

$$\mathbb{E}\left[u(C_t^n - \Delta c)\right] = \mathbb{E}\left[u(C_t^n) - \mathscr{W}(\hat{y}_{H,t}, \hat{y}_{N,t}, \hat{c}_{T,t}, \pi^w_{H,t}, \pi^w_{N,t}, n\hat{f}a_t)\right]. \tag{24}$$

We quantify the welfare gains from moving from one policy regime to another as the change in Δc.

3 A tractable case

In this section we analyze a tractable case of the model in Section 2 to better understand the working of the policy tools and the trade-offs associated with using them. We first analyze the optimal monetary policy under a pure float in response to a negative UIP wedge shock to showcase the sectoral trade-off of monetary policy faced by Brazil in 2009-2012. Then, we show how capital controls can be used under a managed float to alleviate this sectoral trade-off.

3.1 Setup

We assume that wages are constant in period 0, representing the Keynesian short run where labor is demand determined and the wage Phillips Curves in Equation (7) do not apply. Subsequently, from period 1 onwards, wages are flexible, representing the classical long run. Additionally, we assume that there are only shocks in period 0, all exogenous state variables return to the steady state in period 1 and there is perfect foresight. These assumptions imply there is inefficiency only in period 0, making the optimal policy problem static and tractable. We also assume the intertemporal and intratemporal elasticities are equal for both consumption ($\frac{1}{\sigma} = \theta_c$) and labor ($\frac{1}{\psi} = \theta_\ell$) to eliminate substitution effects. We also let the portfolio adjustment cost parameter $\kappa_B = 0$ to simplify the analytical solution. Lastly, we set $W_{N,t} = 1$ so that wages in the non-tradable sector serve as a numeraire for nominal variables.

Under the tractable case, the policymaker minimizes the welfare loss function which takes the form

$$\sum_{t=0}^{\infty} \beta^t \mathbb{E}_t\left[\mathscr{W}(\hat{y}_{H,t}, \hat{y}_{N,t}, \hat{c}_{T,t})\right] = \gamma_H \hat{y}_{H,0}^2 + \gamma_N \hat{y}_{N,0}^2 + \gamma_T \hat{c}_{T,0}^2 \tag{25}$$

such that there are only three relevant variables, $\hat{y}_{H,0}$, $\hat{y}_{N,0}$ and $\hat{c}_{T,0}$ in the welfare loss function. The derivation of the welfare loss function and the weights (γ_H, γ_N and γ_T) is reported in Appendix B.

The policymaker is constrained by the equilibrium conditions which can be simplified to

$$\hat{w}_{H,0} - \hat{w}_{N,0} = \chi_H \hat{y}_{H,0} - \chi_N \hat{y}_{N,0} + \chi_T \hat{c}_{T,0} \tag{26}$$

where the relative wage gap, $\hat{w}_{H,0} - \hat{w}_{N,0}$, is exogenous due to constant wages and $\hat{w}_{H,0} - \hat{w}_{N,0} \equiv \frac{\psi}{\psi+1-\alpha_H}(\rho_0 + p^*_{H,0} + a_{H,0}) + \frac{\psi(\sigma-1)}{\sigma\alpha_N+\psi+1-\alpha_N} a_{N,0}$. Equation (26) corresponds to Equation (17) in the full model. The relative wage gap acts as a wedge since if it is non-zero it is not possible to set all of the gap variables to zero simultaneously. At the core, it reflects the inability of relative wages to respond to shocks due to nominal wage rigidities resulting in a distortion of the labor market. The policymaker's job is to choose how much of this wedge is absorbed by each welfare relevant gap variable so as to minimize the welfare loss function. Under a pure float capital controls are not used so that the dollar interest rate, i^*_t, is not distorted. This implies that

$$\hat{c}_{T,0} = 0. \tag{27}$$

This constraint disappears under a managed float.

3.2 The sectoral trade-off of monetary policy

We solve for the optimal policy under a pure float. The policymaker minimizes the welfare loss function given by Equation (25) subject to Equations (26) and (27).

The constraint given by Equation (26) illustrates the sectoral trade-off of monetary policy. Under a pure float, when there is a shock to the economy, distortions in the labor market that create a non-zero relative wage gap, $\hat{w}_{H,0} - \hat{w}_{N,0}$, must be absorbed by the two output gaps. This implies that to stabilize one sector, the other sector must be destabilized to absorb the wedge.

This sectoral trade-off of monetary policy can be seen in Figure 3 which shows the relationship between $\hat{y}_{H,0}$ and $\hat{y}_{N,0}$ implied by Equation (26). At the steady state, the policymaker is able to choose the combination of the two output gaps along the dotted line that crosses the origin. When there is a negative UIP wedge shock that appreciates the Home currency, the relationship between the two output gaps is shifted downward to the dashed line. A negative UIP wedge shock pushes the relationship down since it creates excessively low relative labor demand in the tradable sector through its impact on the real wage. The policymaker chooses the combination of output gaps along this line that minimizes the welfare loss function. Note that there is a positive relationship between the two output gaps. This is due to the fact that when the policymaker lowers interest rates, it both depreciates the currency and stimulates demand which push up the two output gaps. To stabilize one sector, the policymaker must destabilize the other. Considering this trade-off, the policymaker optimally uses monetary policy and chooses the combination of output gaps represented by point A.

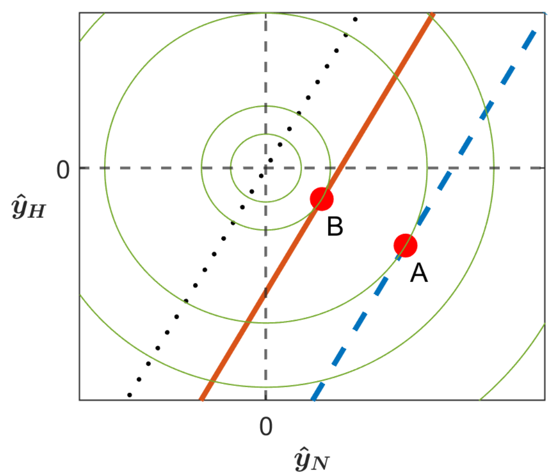


Figure 3: The sectoral trade-off of monetary policy

We now consider the optimal policy problem under a managed float. In this case, $\hat{c}_{T,0}$ can now be used to absorb some of the wedge in Equation (26) at the cost of increasing welfare loss. As a result, the amount of the wedge absorbed by the output gaps is reduced, alleviating the sectoral trade-off of monetary policy. This shifts the relationship between the two output gaps upwards to the solid line in Figure 3 and the policymaker chooses point B. In response to a negative UIP wedge shock, the optimal response is to impose taxes on foreign investors ($\tau_0 > 0$) so that the appreciation of the exchange rate is offset using capital control, reducing the tradable output gap. It also reduces the need to use monetary policy to offset the appreciation, reducing the non-tradable output gap.

The framework provides a qualitative explanation for what happened in Brazil. Heightened foreign demand for Brazilian assets can be interpreted as a negative UIP wedge shock that appreciated the currency, reducing output in the manufacturing sector, a tradable sector. Brazilian policymakers had difficulty managing this with only monetary policy since it would overheat the non-tradable sector so they resorted to using capital controls.

3.2.1 Labor mobility and divine coincidence

Note that with full labor mobility, there is no need for capital controls. When labor is fully mobile ($\theta_\ell \to \infty$) and labor across sectors become perfect substitutes, wages are equalized across sectors making the relative wage ratio always equal to one. Therefore, there is no longer a distortion in relative labor demand allowing the policymaker to close all gaps with just monetary policy. In other words, with full labor mobility there is divine coincidence. This result also holds in the general model. As $\theta_\ell \to \infty$, the two wage Phillips Curves will converge to one. As in Gali (2015), with only one nominal rigidity and without cost push shocks, monetary policy can be used to fully stabilize the economy and close all gaps.

4 Quantitative analysis

In this section we quantitatively analyze the implications of the model. We first explain the baseline calibration and explain the implications of using capital controls by deriving the welfare gains in switching from a pure float to a managed float and showing impulse response functions.

4.1 Calibration

We calibrate the model to a set of 8 emerging market economies for 2000 Q1 - 2014 Q4.[13] Table 1 shows the parameter values used to calibrate the baseline model and we explain the model's ability to match untargeted moments in Appendix E. There are three sets of parameters. The first set consists of parameters that we calibrate to values used in the literature. β is set so that the real annual interest rate is 4%. The coefficient of relative risk aversion (σ) and the inverse of the Frisch elasticity of labor supply (ψ) are set to 2. The elasticity of labor demand across varieties (ε_W) is set to 11 following Born and Johannes (2020). The elasticity of substitution between tradable and non-tradable goods (θ_c) is set to 0.44 following Stockman and Tesar (1995), and that between Home and Foreign tradables (ϕ) is set to 2 following Feenstra et al. (2018). The wage inflation cost parameter (κ_w) is set so that the first order dynamics are equivalent to a Calvo model where households

[13] The set of emerging market economies that we calibrate the model to is Brazil, Chile, Colombia, Hungary, India, Indonesia, Mexico and Peru. This is the subset of emerging market economies that have sector level labor and output data from the World Input Output Database and LA KLEMS database as well as observations of the terms of trade, sectoral TFP and UIP wedge.

update their wages once per year.[14]

Table 1: Parameter calibration

Parameter		Value	Reference
From the literature			
β	Discount factor	0.99	4% annual real interest rate
σ	Relative risk aversion	2	Standard
ψ	Inverse of Frisch elasticity	2	Standard
ε_W	Elasticity of substitution across labor	11	Born and Johannes (2020)
ϕ	Elasticity of consumption substitution (HF)	2	Feenstra et al. (2018)
θ_c	Elasticity of consumption substitution (NT)	0.44	Stockman and Tesar (1995)
κ_w	Wage adjustment cost parameter	66.6985	Match Calvo model
Normalization			
ξ	Labor disutility weight	0.5282	Let $C = 1, L = 1, C_T = \omega_c C$
A_H	TFP of H sector	0.6900	Let $C = 1, L = 1, C_T = \omega_c C$
A_N	TFP of N sector	0.7356	Let $C = 1, L = 1, C_T = \omega_c C$
Estimated parameters			
α_N	Labor share in N sector	0.5854	Match $\frac{W_N L_N}{P_N Y_N} = 0.5854$
α_H	Labor share in H sector	0.4555	Match $\frac{W_H L_H}{P_H Y_H} = 0.4555$
ω_C	Weight of C_T	0.4407	Match $\frac{P_H Y_H}{P_N Y_N} = 0.7878$
γ	Weight of C_H	0.8972	Match $\frac{P_F C_F}{P_H Y_H + P_N Y_N} = 0.0453$
ω_ℓ	Weight of L_T	0.3726	Match $\frac{L_H}{L_N} = 0.5968$
θ_ℓ	Intersectoral elasticity of labor supply	0.1735	Estimated from sample
κ_B	Portfolio adjustment cost	0.0010	Match $Var(\frac{CA}{GDP}), Var(\frac{NFA}{GDP})$
ζ_ρ	Persistence of ρ_t	0.7359	Estimated from sample
σ_ρ	SD of innovation to ρ_t	0.0111	Estimated from sample
ζ_{pH*}	Persistence of $p^*_{H,t}$	0.7702	Estimated from sample
σ_{pH*}	SD of innovation to $p^*_{H,t}$	0.0601	Estimated from sample
ζ_{AH}	Persistence of $a_{H,t}$	0.8248	Estimated from sample
σ_H	SD of innovation to $a_{H,t}$	0.0183	Estimated from sample
ζ_{AN}	Persistence of $a_{N,t}$	0.8309	Estimated from sample
σ_N	SD of innovation to $a_{N,t}$	0.0202	Estimated from sample

A second set of parameters is calibrated to normalize the model such that the steady state values of aggregate consumption and labor are one (i.e., $C = 1$ and $L = 1$) and

[14]In a model with Calvo-type wage stickiness as in Schmitt-Grohè and Uribe (2005), where households supply homogeneous sectoral labor to labor unions that supply differentiated sectoral labor input to firms, the wage Phillips Curves are given by

$$\pi^w_{S,t} = \beta \mathbb{E}_t \left[\pi^w_{S,t+1}\right] + \frac{(1-\beta\tilde{\kappa}_W)(1-\tilde{\kappa}_W)}{\tilde{\kappa}_W}\left(\frac{v_{S,t}/W_{S,t}}{u_{S,t}/P_{S,t}} - 1\right), \quad \forall S \in \{N, H\}$$

where $\tilde{\kappa}_W$ is the fraction of households that cannot set the wage. We calibrate κ_w such that the average slopes of the two sectoral Phillips Curves are equal to that under a model with Calvo-type wage stickiness. This results in

$$\kappa_w = \frac{\tilde{\kappa}_w \varepsilon_w (\alpha_N + \alpha_H)/2}{(1-\beta\tilde{\kappa}_w)(1-\tilde{\kappa}_w)}.$$

We set $\tilde{\kappa}_w = 0.75$ to match the Calvo-type wage stickiness model where wages are updated once a year on average.

tradable consumption is equal to its weight in aggregate consumption ($C_T = \omega_c$). This includes the weight of labor disutility (ξ) and the steady state of TFPs (A_H and A_N).

The last set of parameters is comprised of parameters estimated from the data. We use the IMF International Financial Statistics (IFS) database to derive the current account (% of GDP) and net foreign asset (% of GDP) at the quarterly frequency and the World Input Output Database Socio Economic Accounts (WIOD SEA) and LA KLEMS database for sector specific data on hours worked, labor compensation, capital input and value added at an annual frequency for 2000-2014. The datasets that we use are described in Appendix C.1. We classify agricultural, mining, manufacturing and tradable services (e.g. transportation) as tradable and non-tradable services (e.g. wholesale) as non-tradable. These are sectors that have a high export to output ratio. An explanation of how sectors are classified is provided in Appendix C.2.

Using these data, we compute the mean labor share in the non-tradable and tradable sectors and derive $\alpha_N = 0.585$ and $\alpha_H = 0.456$. We obtain $\omega_c = 0.441$ by estimating the ratio of tradable sector value added to non-tradable sector value added ($\frac{P_H Y_H}{P_N Y_N} = 0.788$). Lastly, we estimate the ratio of tradable sector hours worked to non-tradable sector hours worked ($\frac{L_H}{L_N} = 0.597$) to obtain $\omega_\ell = 0.373$.

To estimate γ, which represents the weight of home tradables in tradable good consumption, we use the World Input Output Tables (WIOT) from the WIOD to derive the consumption of imports in final goods as a fraction of value added. We find this to be 4.5% on average which translates into a value of 0.897 for γ.

We follow Horvath (2000) and Cardi and Restout (2022) and directly estimate θ_ℓ, the degree of inter-sectoral labor mobility. We utilize the labor demand and supply conditions to derive a general equilibrium relationship between labor and value added across sectors that depends on θ_ℓ.[15] We find a value of 0.174.[16] Appendix C.3 provides details on the method used and the robustness of the results.

The portfolio adjustment cost is estimated via generalized method of moments (GMM). Following Schmitt-Grohè and Uribe (2003) we match the variance of the current account and the net foreign asset position as a percentage of GDP, with those observed in the data to estimate κ_B and get a statistically significant value of 0.001.

[15]We are able to identify the elasticity of labor supply since we assume perfect competition in the goods market so that the elasticity of labor demand is a function of the labor share.

[16]Using the same method, Horvath (2000) find an estimate of 1 for the US, and Cardi and Restout (2022) find significant values that range from 0.219 to 1.664 for 17 advanced economies. Using Bayesian estimation, Katayama and Kim (2018) estimate a value of 0.32 for the US economy. The estimates for advanced economies found in the literature are higher than what we estimate for emerging markets. As shown in section 5, we estimate θ_ℓ to be 0.539 for advanced economies which is similar to the median value of 0.6055 found in Cardi and Restout (2022).

Lastly, we estimate the AR(1) processes of the exogenous state variables (ρ_t, $p^*_{H,t}$, $a_{H,t}$ and $a_{N,t}$) individually. Since ρ_t is not observed directly, we use a forecasting regression following Koijen and Yogo (2020) and Jiang et al. (2023) to directly estimate the quarterly observations of ρ_t. A detailed explanation of the method used and the results are provided in Appendix C.4. We detrend the UIP wedge using a linear time trend and estimate an AR(1) process for the cyclical term. We find that the persistence is 0.736 and the standard deviation of the innovations is 1.1%.

Next, we estimate an AR(1) process for the terms of trade. The terms of trade that account for all goods and services and not just commodities is available at the annual frequency from the World Bank World Development Indicators database. We first detrend this annual series by country using a linear time trend and derive the variance of the cyclical component and the covariance with the lag. We use these two statistics to estimate an AR(1) process of the terms of trade at the quarterly frequency. Appendix C.5 explains the method in detail. Using this method, we derive the persistence to be 0.770 and the standard deviation of the innovations to be 6.0%.

Next, we derive the AR(1) process for sector specific total factor productivity. Using sector level hours worked, capital input and real value added, we regress the log of real value added on the log of hours worked and log of capital input over a panel of countries for the tradable and non-tradable sectors. We treat the residuals of this regression as the sector specific TFP. Similar to how we derive the quarterly AR(1) for the terms of trade, we detrend this with a linear time trend and use the variance of the cyclical component and covariance of the cyclical component with its lag to derive the quarterly AR(1) processes for sector specific TFPs. The persistence is estimated to be 0.825 for the tradable sector and 0.831 for the non-tradable sector. The standard deviation of the innovations is estimated to be 1.8% for the tradable sector and 2.0% for the non-tradable sector.

4.2 Optimal policy

Here we explain the dynamics of the model under a pure float and a managed float. To simplify the analysis, we focus on the dynamics of the model following a shock to the UIP wedge and leave the analysis on other shocks in Appendix D. We also derive the welfare gains from introducing capital controls and switching from a pure float to a managed float.

4.2.1 Impulse response function analysis

The impact of a negative UIP wedge shock is similar to the tractable case and can be seen with impulse response functions shown in Figure 4. A fall in ρ_t appreciates the currency, excessively lowering the demand for labor in the tradable sector resulting in a negative tradable output gap. The policymaker partially offsets this impact by lowering interest rates under a pure float. Although this partially stabilizes the tradable output gap, the non-tradable output gap increases substantially as the lower interest rates boost demand for non-tradable goods. These output gaps create pressure in wages as well. The negative tradable output gap creates deflationary pressure on tradable sector wages while the positive non-tradable output gap creates inflationary pressure on non-tradable sector wages. Overall, there is a fall in tradable good production, an increase in non-tradable good production relative to the steady state and a large net inflow of capital that is captured by the fall in the net foreign asset position.

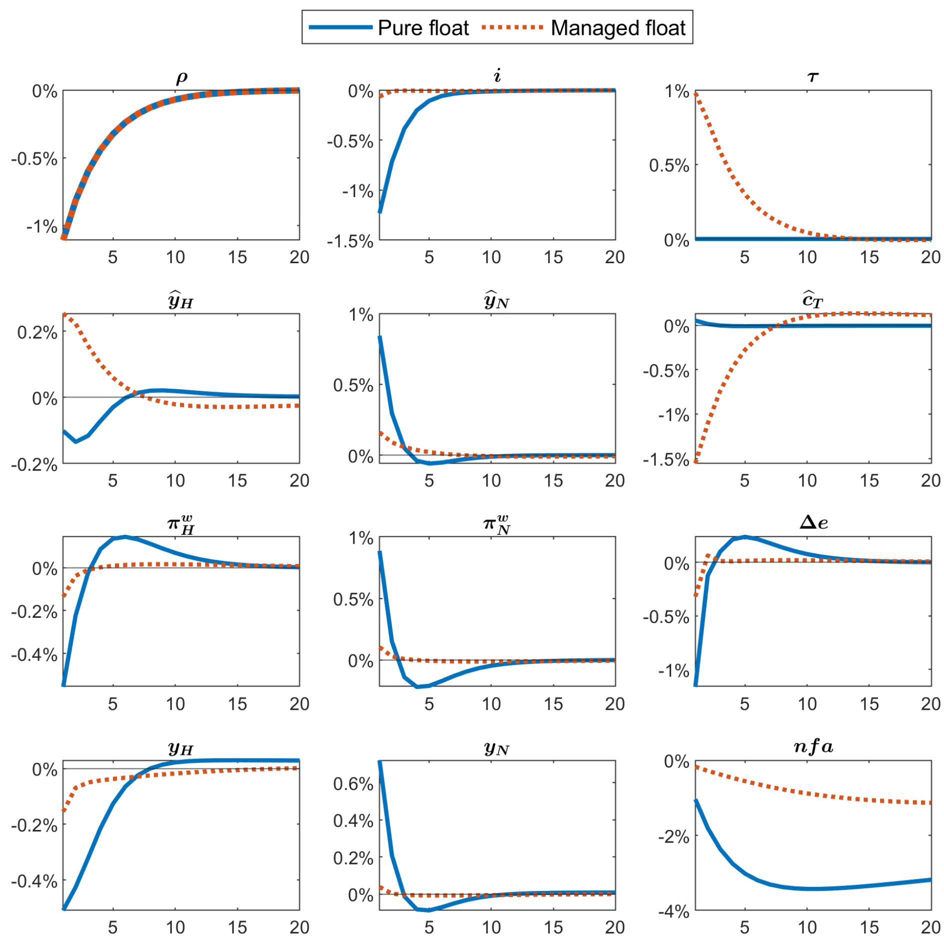


Figure 4: Impulse response functions with respect to a negative UIP wedge shock

Under a managed float, the policymaker is better able to smooth the impact of the negative UIP wedge shock. The impulse response functions under a managed float are shown in Figure 4 with a dotted red line. In response to the shock, monetary policy is used less to stabilize the exchange rate. This results in a smaller non-tradable output gap. Taxes are imposed on foreign investors, resulting in a larger offset of the appreciation. The exchange rate does not appreciate as much in response to the negative UIP wedge shock. This increases the tradable output gap. Interestingly, the tradable output gap is now positive which is qualitatively different from the tractable case. This is because in the full model, the fall in the tradable consumption gap due to capital controls creates deflationary pressure in tradable sector wages through the wage Phillips Curve. To offset this, the policymaker pushes the tradable output gap above zero. Despite this, the level of production in the tradable sector is still below the steady state level following a negative UIP wedge shock. Also, due to capital controls the net inflow of capital is reduced significantly as can be seen from the smaller fall in the net foreign asset position.

The implication of other shocks are similar. They create distortions in labor demand that are stabilized by the policymaker with monetary policy under a pure float. Distortions in the non-tradable sector are stabilized by managing the demand for non-tradable goods with monetary policy, while distortions in the tradable sector are stabilized by managing exchange rates with monetary policy. Since monetary policy works through these two separate channels, there is a sectoral trade-off. Under a managed float this sectoral trade-off is alleviated by the usage of capital controls allowing monetary policy to be used mostly for distortions in the non-tradable sector and capital controls to be used mostly for distortions in the tradable sector.

4.2.2 Welfare gains

We assess the welfare gains from switching from a pure float to a managed float by comparing the welfare loss in terms of permanent consumption lost per period relative to the first-best allocation as shown in Equation (24). Overall, switching from a pure float to a managed float improves welfare equivalent to a permanent increase in consumption by 0.8%. This represents a sizable improvement in welfare and is slightly larger than estimates typically found in the literature that study capital controls under sudden stops.[17]

[17]For example, welfare gains from optimal macroprudential policy in Bianchi and Mendoza (2018) are 0.3%. See Rebucci and Ma (2020) for a review.

5 Emerging markets versus advanced economies

So far, we have explored why emerging markets have a managed float. In this section we explore why most advanced economies do not have a managed float and instead have a pure float. We address this question by calibrating the model to a sample of advanced economies and comparing the gains from exchange rate management across emerging market economies and advanced economies. We find that advanced economies benefit less from using capital controls when the exchange rate is flexible and two main factors that drive this result are the differences in the volatility of shocks and inter-sectoral labor mobility in order of importance.

We calibrate the parameters that we estimated with data (α_N, α_H, ω_c, γ, ω_ℓ, θ_ℓ and the AR(1) process of the exogenous state variables) and those used to normalize variables (ξ, A_H, A_N) separately for advanced economies.[18] We find that except for the persistence of the UIP wedge (ζ_ρ), all parameters are significantly different from their emerging market counterparts at the 1% level. The calibrations for advanced economies are shown in Table 2 alongside the emerging market counterpart. The most notable difference is that advanced economies exhibit lower volatility for all exogenous state variables. Advanced economies have less persistent UIP wedges, terms of trade and sectoral TFP as well as less volatile innovations to these variables. Additionally, labor mobility in advanced economies is more than thrice that of emerging market economies.

We compare welfare loss under a pure float and a managed float in Figure 5. We can see that the welfare loss for advanced economies are lower than those for emerging market economies for both policy regimes. In addition, we see the welfare gains from capital controls are smaller for advanced economies. Emerging market economies gain around 0.8% of permanent consumption by using capital controls under a flexble exchange rate regime while advanced economies gain less than 0.1%. This implies that by extending the model to incorporate a cost from using capital controls that is higher than 0.1% but lower than 0.8% of consumption, the model can explain the fact that emerging markets use capital controls while advanced economies do not under flexible exchange rates.[19]

[18]The sample of advanced economies consist of countries categorized as "advanced" by the IMF's World Economic Outlook in 2023 that have sector level labor and output data from the WIOD and LA KLEMS database as well as observations of the terms of trade, sectoral TFP and UIP wedges. These are Australia, Canada, Switzerland, Czech Republic, United Kingdom, Japan, South Korea, Norway, Sweden, Denmark, Austria, Belgium, Croatia, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Slovakia, Slovenia and Spain.

[19]For example, suppose the economy has to pay a "reputation" cost in the international financial market if it decides to use capital controls. If these costs are larger than the welfare gains from using capital controls for advanced economies but lower than that for emerging markets, then only emerging market economies will use capital controls.

Table 2: Parameter calibration for Advanced Economies

Parameter		Value (AE)	Value (EME)	Reference
Normalization				
ξ	Labor disutility weight	0.6031	0.5282	Let $C=1$, $L=1$, $C_T=\omega_c C$
A_H	TFP of H sector	0.6662	0.6900	Let $C=1$, $L=1$, $C_T=\omega_c C$
A_N	TFP of N sector	0.8312	0.7356	Let $C=1$, $L=1$, $C_T=\omega_c C$
Estimated parameters				
α_N	Labor share in N sector	0.6195	0.5854	Match $\frac{W_N L_N}{P_N Y_N}$
α_H	Labor share in H sector	0.5673	0.4555	Match $\frac{W_H L_H}{P_H Y_H}$
ω_C	Weight of C_T	0.3149	0.4407	Match $\frac{P_H Y_H}{P_N Y_N}$
γ	Weight of C_H	0.7225	0.8972	Match $\frac{P_F C_F}{P_H Y_H + P_N Y_N}$
ω_ℓ	Weight of L_T	0.2524	0.3726	Match $\frac{L_H}{L_N}$
θ_ℓ	Inter-sectoral labor mobility	0.5386	0.1735	Estimated from sample
κ_B	Portfolio adjustment cost	0.0002	0.0010	Match $Var(\frac{CA}{GDP})$, $Var(\frac{NFA}{GDP})$
ζ_ρ	Persistence of ρ_t	0.7359	0.7359	Estimated from sample
σ_ρ	SD of innovation to ρ_t	0.0046	0.0111	Estimated from sample
ζ_{pH*}	Persistence of $p^*_{H,t}$	0.6441	0.7702	Estimated from sample
σ_{pH*}	SD of innovation to $p^*_{H,t}$	0.0378	0.0601	Estimated from sample
ζ_{AH}	Persistence of $a_{H,t}$	0.7660	0.8248	Estimated from sample
σ_H	SD of innovation to $a_{H,t}$	0.0180	0.0183	Estimated from sample
ζ_{AN}	Persistence of $a_{N,t}$	0.7678	0.8309	Estimated from sample
σ_N	SD of innovation to $a_{N,t}$	0.0121	0.0202	Estimated from sample

Why are the gains from using capital controls so small for advanced economies? We analyze which differences in the calibration drive this difference by comparing the different moments used to estimate the parameters, the different value of θ_ℓ, and the different AR (1) processes of exogenous state variables. We compare the moments ($\frac{W_N L_N}{P_N Y_N}$, $\frac{W_H L_H}{P_H Y_H}$, $\frac{P_H Y_H}{P_N Y_N}$, $\frac{P_F C_F}{P_H Y_H + P_N Y_N}$ and $\frac{L_H}{L_N}$) instead of the parameters (α_N, α_H, ω_c, γ and ω_ℓ) because these parameters as well as the parameters used for normalization are endogenous to these moments.

We first compare how the different calibrations improve the gains from capital controls individually by deriving the welfare gains from capital controls after only changing one component to the emerging market counterpart. We find that changing the AR (1) processes of exogenous state variables matters the most. Then, keeping the AR (1) processes of exogenous state variables fixed, we do this exercise again and find that the next component that improves the welfare gains from capital controls the most. We find that the labor mobility parameter, θ_ℓ, matters the most. Then, we keep the values of θ_ℓ and the AR(1) processes of exogenous state variables fixed to their emerging market values and continue this process until all components have been changed to the emerging market counterpart.

We find that the components that create the largest increases in welfare gains in capital controls are the AR (1) processes of exogenous state variables and θ_ℓ in order of magni-

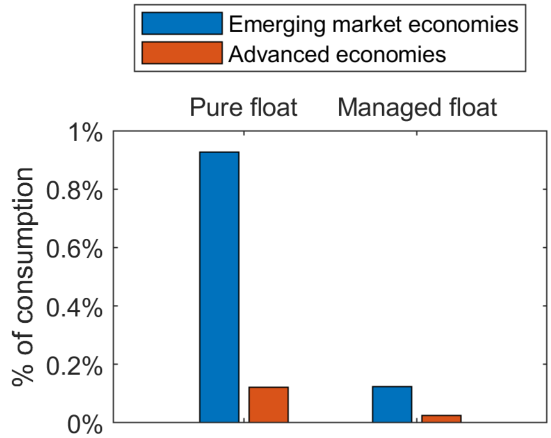


Figure 5: Welfare loss comparison across EMEs and AEs

tude. If we just change these two components to their emerging market counterparts, the welfare gains from capital controls under a flexible exchange rate regime increase to around 1.0% from 0.1%. After these two, other components increase the welfare gains only slightly or even reduce them.

It is surprising that inter-sectoral labor mobility matters so much. Advanced economies have on average higher inter-sectoral labor mobility, so if this is reduced to the level of emerging market economies it increases the weight placed on $\hat{y}_{H,t}$ and $\hat{y}_{N,t}$ in the welfare loss function making it more valuable to trade-off $\hat{y}_{N,t}$ with $\hat{c}_{T,t}$ through the use of capital controls. The robustness of the result that advanced economies have more mobile labor is discussed in Appendix C.3.[20]

6 Exchange rate flexibility versus capital controls

In this section we compare the welfare gains from exchange rate flexibility and capital controls. This exercise is relevant as these are two different ways of gaining monetary autonomy as implied by the textbook Trilemma. We measure the welfare gains from exchange rate flexibility as the reduction in the welfare loss when switching from a fixed exchange rate regime (policy regime #1) to a pure float (policy regime #3) and measure the welfare gains from capital controls as the decrease in the welfare loss when switching from a fixed exchange rate regime (policy regime #1) to a fixed exchange rate regime with capital controls (policy regime #2). Simply put, we compare the welfare gains from switching from a fixed exchange rate regime to the two other vertices of the Trilemma in

[20]There is evidence in the literature that labor mobility may be higher in emerging markets than advanced economies. For example, Bryan and Morten (2019) estimate higher internal migration frictions in Indonesia than in the US.

Figure 2. A priori, we know that there will be gains in welfare when we switch to either of these vertices from a fixed exchange rate regime, but it is unclear which will exhibit higher gains.

6.1 Baseline result

We show the levels of welfare loss under the four policy regimes (#1 - #4) in Figure 6 denoted in terms of permanent consumption lost per period relative to the first-best level. The first graph shows the baseline case where we consider all of the shocks and we can see that the welfare gains from exchange rate flexibility (the difference in welfare loss between a fixed exchange rate regime and a pure float) are much larger than the welfare gains from capital controls (the difference in welfare loss between a fixed exchange rate regime and a fixed exchange rate regime with capital controls). The welfare gains from exchange rate flexibility are equivalent to a 0.9% increase in permanent consumption while those of capital controls are equivalent to a 0.5% increase in permanent consumption.[21]

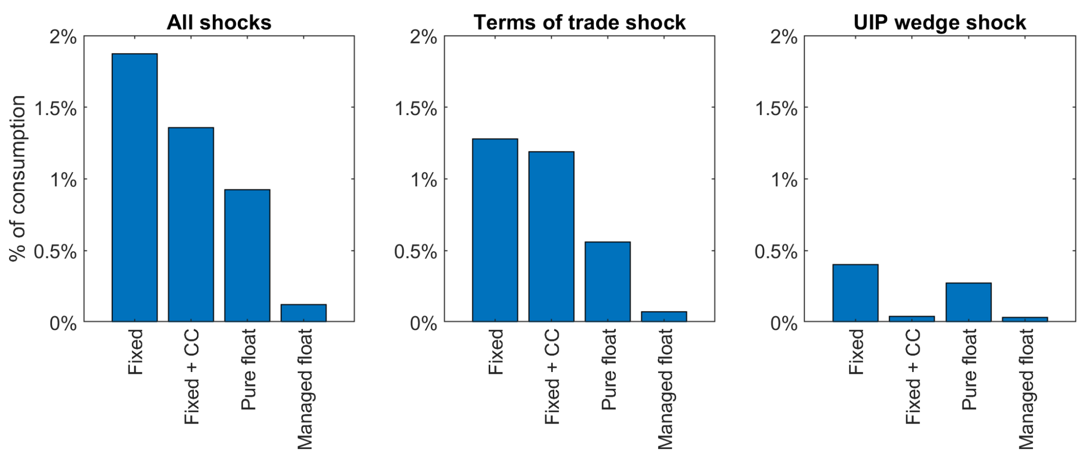


Figure 6: Welfare loss in units of consumption lost per period relative to the first-best

What is driving this result? To answer this question, we look at the welfare gains when there are only shocks to the terms of trade. The second graph in Figure 6 shows the welfare loss under different policy regimes when there are only shocks to the terms of trade. We can see that most of the welfare loss under each policy regime and the low gains from capital controls are driven by terms of trade shocks. This is because under a fixed

[21] Alternatively, we can define the welfare gains from capital controls as the average of the welfare gains from switching from policy regime #1 to #2 and those from switching from policy regime #3 to #4. Similarly, we can define the welfare gains from exchange rate flexibility as the average of the welfare gains from switching from policy regime #1 to #3 and those from switching from policy regime #2 to #4. The qualitative results are consistent with this alternative definition.

exchange rate, the terms of trade creates large distortions in the tradable sector's labor demand and capital controls cannot do much to reduce this distortion. Under a fixed exchange rate, capital controls allow some level of monetary autonomy as the exchange rate can be fixed without having to rely too much on monetary policy. This effectively allows the policymaker to balance the tradable consumption gap ($\hat{c}_{T,t}$) with the non-tradable output gap ($\hat{y}_{N,t}$).[22] However, this is not very useful if most of the distortions are in the tradable sector which is the case with terms of trade shocks.

On the other hand, exchange rate flexibility allows the policymaker to use monetary policy to manage labor demand in the tradable sector. Although this creates distortions in the non-tradable sector (the sectoral trade-off of monetary policy), it is beneficial because it allows the policymaker to directly address the distortion in the economy. In short, exchange rate flexibility allows the policymaker to use monetary policy to balance the two output gaps ($\hat{y}_{N,t}$ and $\hat{y}_{H,t}$) and is useful in responding to terms of trade shocks that create large tradable output gaps.

These differences in welfare gains can also be shown under the tractable case and is summarized in Figure 7. Under a fixed exchange rate regime, the economy will be located at point A following a positive terms of trade shock. There is a positive tradable output gap since the real wage in the tradable sector is excessively low and a zero non-tradable output gap since there is no pressure on the exchange rate that must be offset with monetary policy.[23] Using capital controls allows the policymaker to move along the orange horizontal line, but since it cannot address the distortion in the tradable output gap, the policymaker decides not to use capital controls and keep the economy at point A. With exchange rate flexibility, the policymaker can move along the dashed blue line. This allows the policymaker to address the distortion and thereby move the economy to a more efficient allocation in point B.

6.2 Considering only UIP wedge shocks

An important motivation for using capital controls is to insulate the economy from the Global Financial Cycle (Rey (2013); Farhi and Werning (2014a)). We capture the Global Financial Cycle with shocks to the UIP wedge in our model. Therefore, we compare the welfare gains from exchange rate flexibility and capital controls when there are only shocks to the UIP wedge. We find that the previous results are flipped. As shown in the

[22] Capital controls allow some balancing of the tradable consumption gap ($\hat{c}_{T,t}$) with the tradable output gap ($\hat{y}_{H,t}$), but this is minimal due to the small substitution effect.

[23] In the tractable model, there are no substitution effects so a terms of trade shock has no effect on the non-tradable sector and the exchange rate.

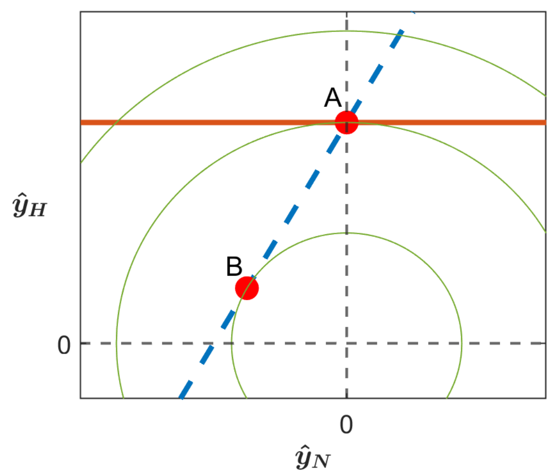


Figure 7: Sectoral output gap trade-offs with a positive terms of trade shock

third graph of Figure 6, with only UIP wedge shocks welfare gains from capital controls (0.36%) are more than twice the gains from exchange rate flexibility (0.13%).

What drives this result? A UIP wedge shock creates distortions in the non-tradable sector under a fixed exchange rate regime since it creates exchange rate pressure. Monetary policy must be used to offset this exchange rate pressure, creating distortions in demand for non-tradable goods. The question of whether capital controls or exchange rate flexibility brings higher welfare gains is then essentially about whether it is more beneficial to balance distortions in the non-tradable output gap ($\hat{y}_{N,t}$) with the tradable consumption gap using capital controls, or with the tradable output gap with exchange rate flexibility. We find that in the calibrated model, balancing $\hat{y}_{N,t}$ with $\hat{c}_{T,t}$ through capital controls is more beneficial. A key parameter that determines this result is the inter-sectoral mobility of labor (θ_ℓ). When inter-sectoral mobility of labor is lower, distortions in labor are more costly in terms of welfare implying that the weights on $\hat{y}_{N,t}$ and $\hat{y}_{H,t}$ in the welfare loss function are larger. On the other hand, the weight on $\hat{c}_{T,t}$ is unaffected by lower labor mobility. Therefore, it is cheaper to trade-off $\hat{y}_{N,t}$ with $\hat{c}_{T,t}$ than with $\hat{y}_{H,t}$ when θ_ℓ is low.

This is shown in Figure 8 which reports the welfare loss for different values of θ_ℓ under the three policy regimes. As θ_ℓ decreases, welfare loss under a pure float becomes higher than welfare loss under a fixed exchange rate regime with capital controls since the weight on $\hat{y}_{H,t}$ increases while the weight on $\hat{c}_{T,t}$ stays constant. In other words, lower labor mobility increases the welfare gains from capital controls relative to exchange rate flexibility.

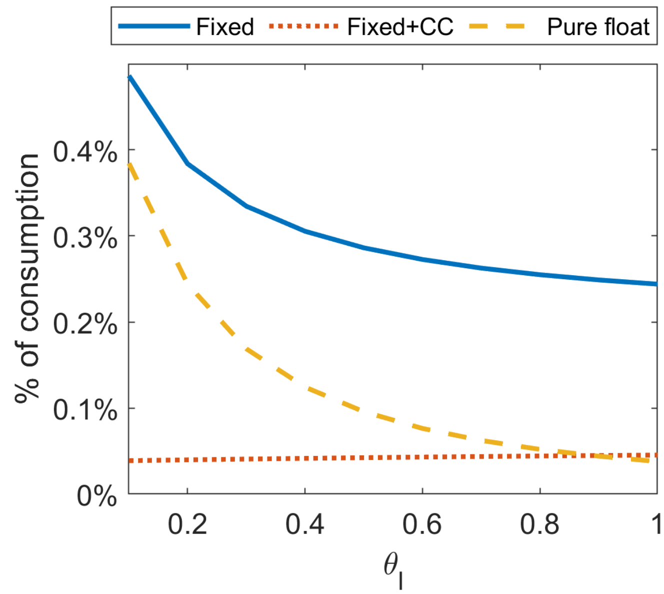


Figure 8: Welfare loss with only UIP wedge shocks for different values of θ_ℓ

6.3 Trilemma versus Dilemma

We can use the results from this section to contribute to the Trilemma versus Dilemma debate. We interpret this debate to be about the comparison between welfare gains from exchange rate flexibility and those from capital controls. Rey (2013) argues that monetary autonomy can only be gained by managing the capital account since the Global Financial Cycle constrains monetary policy if capital is freely mobile even if the exchange rate is flexible.[24] On the other hand, the textbook Trilemma states that monetary autonomy can be gained by either capital controls or exchange rate flexibility. Therefore, the debate on the Trilemma and Dilemma revolves around which of capital controls or exchange rate flexibility offers more monetary autonomy. If there are larger welfare gains from capital controls than exchange rate flexibility, we understand it to mean that the Dilemma hypothesis holds and if not the Trilemma holds.

First, our result that capital controls yield larger welfare gains than exchange rate flexibility when there are only UIP wedge shocks supports the Dilemma hypothesis, which was formulated with a focus on the Global Financial Cycle. In response to fluctuations in the UIP wedge, exchange rate flexibility does little to improve welfare relative to capital controls.

On the other hand, when we expand the range of shocks to include terms of trade

[24] Rey (2013) claims that "*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*."

shocks as in the baseline case, we find that the Dilemma hypothesis no longer holds. Exchange rate flexibility increases welfare more than capital controls. Since most emerging markets in the sample are commodity exporters, this result highlights the importance of exchange rate flexibility in response to what Miranda-Agrippino and Rey (2022) call the Global Trade and Commodity Cycle.

Therefore, our results show that the Trilemma versus Dilemma debate depends on the nature of shocks that the economy is exposed to. Considering only the Global Financial Cycle, the Dilemma holds. On the other hand, focusing on the Global Trade and Commodity Cycle, the Trilemma holds. When both cycles are considered, the Trilemma holds.

6.4 Robustness

From the discussion above, we can see that the driving force behind the result that exchange rate flexibility has larger welfare gains is the large volatility of the terms of trade relative to the UIP wedge. To test out the robustness of this result, we calibrate the standard deviation of UIP wedge shocks using the volatility of the UIP wedge estimated by Kalemli-Ozcan and Varela (2021). These authors find that the unconditional standard deviation of the one year horizon UIP wedge is 6% for emerging market economies. We calibrate the standard deviation of innovations to the UIP wedge (σ_ρ) to match this unconditional standard deviation of the one year horizon UIP wedge assuming the same persistency (ζ_ρ) as in the baseline case.[25] We get a value of 1.8%. This number is higher than our baseline calibration of 1.1%, however it is not enough to flip the baseline result that exchange rate flexibility is more welfare improving than capital controls.

Alternatively, one could question the large volatility of the terms of trade. The unconditional standard deviation of the annual terms of trade used to derive the quarterly AR(1) series is 8.1%. Compared to other estimates used in the literature, this is actually small. In recent work by Schmitt-Grohè and Uribe (2018), the median AR(1) process of the annual terms of trade estimated over a sample of 38 countries during 1980-2011 produces an unconditional standard deviation of 9.4% for the annual terms of trade. Mendoza (1995) finds an unconditional standard deviation of 12.4% using a sample of 23 developing economies for 1965-1990. Additionally, if we used the commodity terms of trade to estimate the terms of trade since most of the emerging market economies in the sample

[25] We assume that the expectation hypothesis holds so that the one-year horizon UIP wedge is equal to the sum of the four one-quarter horizon UIP wedges within that one-year horizon. Then, assuming an AR(1) process of the UIP wedge and given the persistence of the UIP wedge we can derive the volatility of the innovations to the UIP wedge that is needed to match the unconditional volatility of the one-year horizon UIP wedge.

are commodity exporters, the unconditional standard deviation of the annual terms of trade would be 13.8%. Therefore, using other measures of the terms of trade or other estimates from the literature would increase the volatility of the terms of trade and amplify the baseline results.

7 Sterilized foreign exchange intervention

In this section, we extend the model to incorporate sterilized foreign exchange intervention (FXI) that impacts the exchange rate through the portfolio balance channel following Gabaix and Maggiori (2015) and Cavallino (2019). The portfolio balance channel of sterilized FXI assumes the central bank is able to alter the portfolio composition of foreign investors, which affects the UIP wedge and the exchange rate due to the imperfect substitutability of bonds in foreign investors' portfolios.

To model imperfect substitutability of bonds held by foreign investors, we assume the UIP wedge is elastic to debt issued by Home households, or equivalently Home dollar bonds held by foreign investors, such that the adjusted UIP condition is changed from Equation (13) to

$$i_t - i^{US} - \mathbb{E}_t\left[\Delta e_{t+1}\right] = \rho_t + \tau_t - \varsigma B_t^*. \tag{28}$$

An increase in the holdings of Home dollar bonds by foreign investors, which is captured by a fall in B_t^*, increases the expected excess returns on Home bonds relative to US treasuries. Since this also brings stationarity to the model, we no longer assume the portfolio adjustment costs as in the baseline model.

The central bank conducts sterilized FXI by purchasing US treasuries (F_t^{US}) and issuing Home currency bonds to the market (B_t^{CB}), keeping the net value of these transactions equal to zero,

$$E_t F_t^{US} = B_t^{CB}. \tag{29}$$

Home households purchase the issued Home currency bonds so that in equilibrium $B_t + B_t^{CB} = 0$ and the returns on the portfolio position of the central bank are assumed to be transferred as a lump sum to households. Therefore, the aggregate budget constraint is

$$\begin{aligned} C_{F,t} + P_{H,t}^* C_{H,t} + B_t^* + F_t^{US} & \\ = \left(1 - \frac{\kappa_w}{2} {\pi_{H,t}^w}^2\right) P_{H,t}^* Y_{H,t} + (1 + i_{t-1}^*) B_{t-1}^* + (1 + i^{US}) F_{t-1}^{US}. \end{aligned} \tag{30}$$

In order to prevent the central bank from arbitraging the difference in returns from Home dollar bonds and US treasuries infinitely, we also introduce a utility from holding US treasuries as in Jeanne (2022). The period-by-period household utility is given by

$$u(C_t) - v(L_t) + \varkappa(B_t^{US}) \tag{31}$$

where

$$\varkappa(B_t^{US}) = \varpi \frac{(B_t^{US})^{1-\vartheta} - 1}{1-\vartheta} \tag{32}$$

and B_t^{US} is the aggregate holding of US treasuries by the home economy.[26] The central bank balances the gains from holding US treasuries, the convenience yield, against the opportunity cost of holding US treasuries. Under the first-best allocation, the holding of US treasuries is derived by the following first-order condition

$$\varkappa'(B_t^{US}) = \beta \mathbb{E}_t \left[u_{F,t+1}\right] (i^{US} - i_t^* - \varsigma B_t^*). \tag{33}$$

The left-hand-side of Equation (33) represents the marginal utility from holding US treasuries while the right-hand-side represents the marginal opportunity cost of holding US treasuries instead of Home dollar bonds. This is linearized to

$$b_t^{US} = -\frac{B^{US}}{\varsigma\vartheta(-B^*)}(\rho_t - \rho - 2\varsigma b_t^*) \tag{34}$$

where ρ is the steady state value of ρ_t, $b_t^{US} \equiv B_t^{US} - B^{US}$ and $b_t^* \equiv B_t^* - B^*$. We assume at the steady state, $B^{US} > 0$ and $B^* < 0$.

We calibrate the newly introduced parameters, using estimates from the literature. Jeanne (2022) estimates the slope of Equation (34) to be approximately -5 by matching the correlations between gross capital inflows and gross capital outflows and those between gross capital inflows and the current account for a set of emerging market economies. Cavallino (2019) finds an estimate of $\varsigma = 0.2$ by matching the impulse response function of the real exchange rate and net capital flows in response to shocks to the external financial condition for Switzerland. Using these estimates and assuming $i^* = i^{US}$, $B^{US} + B^* = 0$ and the welfare cost of deviations in US treasuries is equal to that in Home dollar bonds, we calibrate ς, ϑ and ϖ as in Table 3.

[26] This is a reduced form way of capturing the convenience yield of US treasuries. This also follows the literature on bond-in-the-utility models such as Rannenberg (2021) and Michaillat and Saez (2021) which originate from money-in-the-utility models that go back to Sidrauski (1967). Assuming a US dollar bond utility allows differences between the returns of Home dollar bonds and US dollar bonds.

Table 3: Parameter calibration for foreign exchange intervention

Parameter	Value	Reference/Target
ς	0.2	Cavallino (2019)
ϑ	0.5	Jeanne (2022)
ϖ	0.009	Match welfare costs from $\widehat{b_t^*}$ and $\widehat{b_t^{US}}$

We solve for the optimal policy mix that minimizes the welfare loss function[27] under a pure floating exchange rate regime, a managed floating exchange rate regime with capital controls, and a managed floating exchange rate regime with sterilized FXI. The impulse response functions in response to a one standard deviation negative UIP wedge shock are shown in Figure 9. The pure floating exchange rate regime is shown in solid blue, the managed exchange rate regime with capital controls is shown in dotted red, and the managed exchange rate regime with sterilized FXI is shown in dashed yellow. The results are qualitatively similar to the baseline impulse response functions in Figure 4. A negative UIP wedge shock appreciates the exchange rate, creating a negative output gap in the tradable sector and a positive one in the non-tradable sector. The optimal capital control leans against the appreciation by imposing taxes on foreign investors as in the baseline model. The optimal sterilized FXI policy also leans against the appreciation by accumulating US treasuries, which can be seen from the elevated F_t^{US}. This partially offsets the appreciation by increasing the UIP wedge and alleviates the sectoral trade-off of monetary policy. Despite the differences in how they are implemented, we see that capital controls and sterilized FXI produce qualitatively and quantitatively similar results.

Although the qualitative implications of exchange rate management in this new setup with debt-elastic UIP wedges is similar to those in the baseline model, there is a difference in the quantitative implications, especially with regards to the welfare benefits of exchange rate management. Using this setup we find that the welfare benefits of using sterilized FXI are equivalent to a 0.18% permanent increase in consumption while those from capital controls are equivalent to a 0.11% permanent increase in consumption. This is in stark contrast to the 0.8% found in the baseline model. The difference is due to the difference in strength of stationarity across the two model specifications. In the baseline model we directly estimate the portfolio adjustment cost by matching the volatility of the current account and net foreign asset position. In the model with debt-elastic UIP wedges, we use values of the elasticity of the UIP wedge to debt that are estimated from the literature. To do a proper comparison, we estimate the debt-elasticity of the UIP wedge by matching the volatility of the current account and net foreign asset position as in the

[27] We derive the welfare loss function in Section A.2.

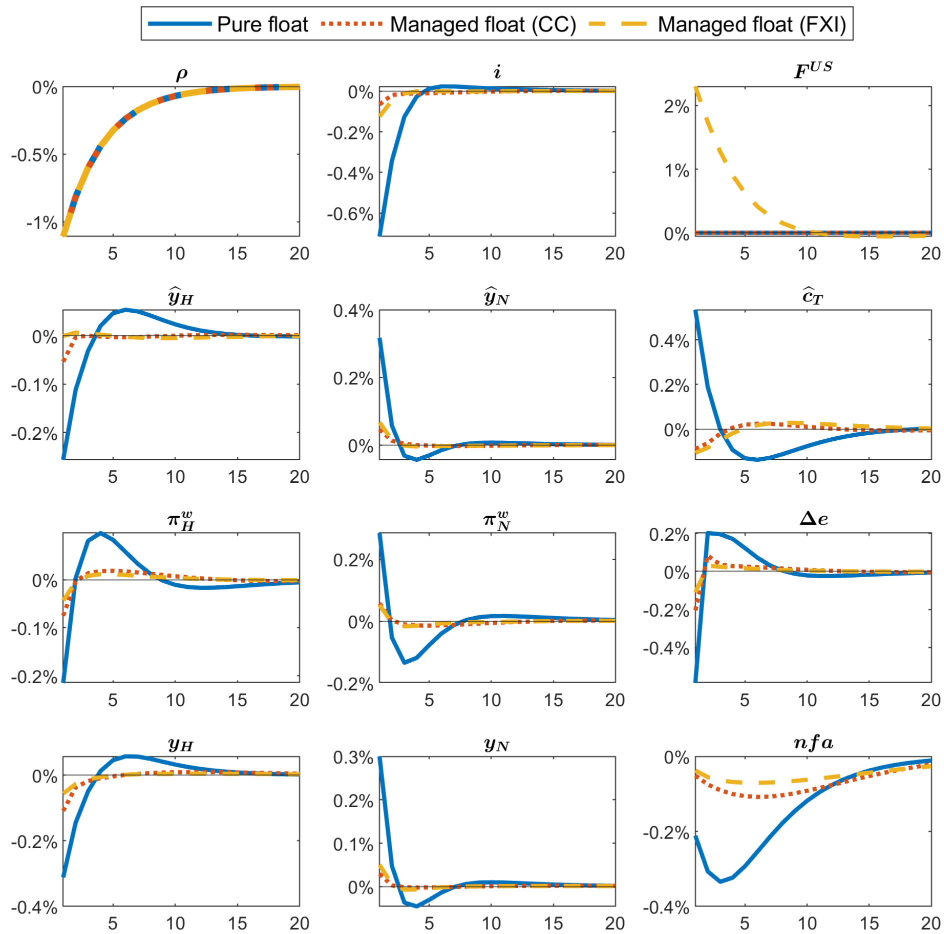


Figure 9: Impulse response functions with respect to a negative UIP wedge shock with sterilized FXI

baseline model, resulting in an estimate of $\varsigma = 0.001$. The welfare benefits of using capital controls and sterilized FXI under the different methods of estimation are shown in Table 4. With $\varsigma = 0.001$, the welfare benefits of sterilized FXI are now equivalent to a 0.07% permanent increase in consumption while those of capital controls are equivalent to a 0.76% permanent increase in consumption. The welfare benefits for capital controls are now approximately the same as those found in the baseline case.

Table 4: Welfare gains from exchange rate management using different policy instruments under debt-elastic UIP wedges in units of permanent consumption increase

	$\varsigma = 0.2$	$\varsigma = 0.001$
Sterilized FXI	0.18%	0.07%
Capital controls	0.11%	0.76%

Therefore, we see that the welfare benefits from exchange rate management are sensitive to how the debt-elasticity is estimated. If we follow Schmitt-Grohè and Uribe (2003) and estimate the parameter governing the stationarity of the model to match the volatility of the current account and net foreign asset position, we find large gains from capital controls but low gains from sterilized FXI. The central bank must accumulate an extremely large amount of reserves to even partially impact the exchange rate with sterilized FXI, which is costly as it distorts the optimal holding of US treasuries. On the other hand, if we use the estimates from Cavallino (2019), a paper that focuses solely on shocks to external financial conditions, then the welfare gains from sterilized FXI are sizable. Higher elasticity of the UIP wedge to debt makes sterilized FXI more effective. This result highlights a tension between the estimates of the elasticity of external financial conditions to debt issued by the Home economy found in the international business cycle literature following Schmitt-Grohè and Uribe (2003) and those found in the literature focusing on sterilized FXI as in Cavallino (2019). The former finds lower values of the elasticity while the latter finds values that are higher.

8 Extensions

In this section we explore different variations of the model and how they impact the baseline results.

8.1 Commitment versus discretion

In the baseline model, we solved for the optimal policies assuming the policymaker is able to commit. In this section we solve for the optimal policies assuming the policymaker is not able to commit and derive the benefits from commitment. We find that there is almost no difference quantitatively. The differences in welfare loss between commitment and discretion for each of the four policy regimes are smaller than 0.1% of permanent consumption per period. As in Gali (2015), under commitment the policymaker is able to internalize the impact expectations of future wage inflation have on today's allocation. This reduces the volatility of wage inflation overall. Under discretion this is not internalized. We quantify and explain the differences in more detail in Appendix F.

We also find that using capital controls is beneficial even under discretion. This is unclear a priori since capital controls may distort expectations and reduce welfare if used under discretion. We find this is not the case and the benefits from using capital controls under discretion are similar to those under commitment. Capital controls alleviate the sectoral trade-off of monetary policy. We show impulse response functions under discretion for both the pure and managed floats in Appendix F.

8.2 Sticky prices

We also consider the case when prices are sticky. We introduce price stickiness by introducing monopolistic competition and Rotemberg price adjustment costs to firms in the non-tradable sector. The labor demand condition in the non-tradable sector is changed from Equation (3) to

$$\pi_{N,t} = \beta \mathbb{E}_t \left[\pi_{N,t+1} \right] + \frac{\varepsilon_p - 1}{\kappa_p} \left(\frac{W_{N,t}/P_{N,t}}{\alpha_N A_{N,t} L_{N,t}^{\alpha_N - 1}} - 1 \right)$$

where ε_p is the elasticity of substitution between varieties of non-tradable goods by households and κ_p is the parameter that governs the cost of inflation.

In models with nominal rigidities it is usually the case that if there are more frictions the welfare gains from policy instruments are larger since they can address more inefficiencies. This is true in our model as well. By going from a pure float to a managed float, welfare loss is reduced by 2.3% of permanent consumption. This is much larger than the reduction in welfare loss of 0.8% of permanent consumption in the baseline case with flexible prices.

In addition, the welfare gains from capital controls are now larger than the gains from exchange rate flexibility. Sticky prices act as an additional friction in the non-tradable sector, allowing shocks to create bigger distortions in the non-tradable sector. This increases the value of capital controls since they allow the policymaker to balance the non-tradable output gap with the tradable consumption gap.

Although there are quantitative differences, qualitatively the model is similar to the baseline case. Shocks in the UIP wedge create labor market distortions incentivizing the use of monetary policy to offset the impact of the UIP wedge on the exchange rate under a pure float, which has consequences on the non-tradable sector. The policymaker now considers the impact it has on non-tradable good price inflation resulting in a smaller output gap in the non-tradable sector compared to the case with flexible prices. Capital controls alleviate this trade-off as in the baseline case and the output gap in the non-tradable sector is reduced further since monetary policy is not used as much.

Additionally, the qualitative result that the nature of shocks is important for the comparison of welfare gains from exchange rate flexibility and capital controls remains robust. Despite sticky prices in the non-tradable sector, in response to terms of trade shocks exchange rate flexibility is more valuable and in response to UIP wedge shocks capital controls are more valuable.

8.3 COVID-19

We extend the analysis of the model by analyzing the implications of the model in response to the COVID-19 pandemic. Following Fornaro and Romei (2023), we model the COVID-19 pandemic shock as a shift in the weights of the households' demand for tradable and non-tradable goods. This is motivated by the fact that during the pandemic there was a reduction in demand for contact-intensive services. We capture this by adding a shock to the weight of tradable good consumption in aggregate consumption:

$$C_t = \left[(\omega_c + \omega_{COVID,t})^{\frac{1}{\theta_c}} C_{T,t}^{\frac{\theta_c - 1}{\theta_c}} + (1 - \omega_c - \omega_{COVID,t})^{\frac{1}{\theta_c}} C_{N,t}^{\frac{\theta_c - 1}{\theta_c}} \right]^{\frac{\theta_c}{\theta_c - 1}}$$

where $\omega_{COVID,t}$ follows an AR(1) process.

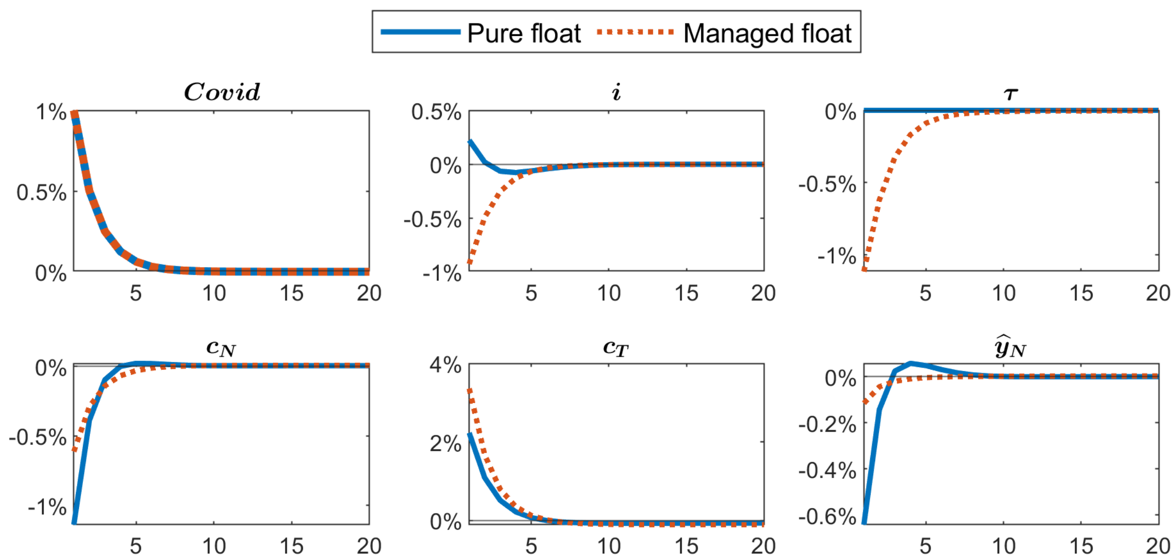


Figure 10: Impulse response functions to a shift in consumption weights

Although the model is not specifically catered to analyzing the effects of the pandemic, the model is able to explain the policy response of many emerging market economies during the pandemic. During the pandemic, many emerging markets lowered the policy rate to boost demand in the economy and at the same time used capital controls or FXI to keep the exchange rate from depreciating too much. This is observed in the model as well. Figure 10 shows the impulse response functions to a 1% shock to the weight in tradables which captures the COVID shock in our model. The shift in consumption demand towards tradable goods and away from non-tradables reduces consumption of non-tradable goods and increases that of tradable goods. The lower demand for non-tradables creates excessively lowers labor demand in the non-tradable sector and ultimately creates a large negative non-tradable output gap. The policymaker would like to offset this by lowering the interest rate, but because of the sectoral trade-offs under a pure float the policymaker does not lower interest rates. Alternatively, under a managed float the policymaker is able to alleviate the sectoral trade-off with capital controls, allowing the policymaker to lower the interest rate and stabilize the non-tradable sector. The lowering of the interest rate minimizes the fall in the non-tradable output gap while tradable consumption rises even more due to capital controls. This is essentially what we observed during the pandemic. Emerging market economies lowered rates and used additional policy tools to contain the impact on the exchange rate.

9 Conclusion

We conclude by summarizing the main takeaways of the paper and discussing possible directions for future research. By developing a model where monetary policy balances stabilizing output across the tradable and non-tradable sectors, we show how managing exchange rates with capital controls or foreign exchange intervention can alleviate this sectoral trade-off. We find that emerging markets manage the exchange rate more than advanced economies due to more volatile shocks and lower inter-sectoral labor mobility. Furthermore, our study finds that the comparison of the welfare gains from exchange rate flexibility and capital controls depends on the nature of shocks. Exchange rate flexibility is more welfare improving in response to terms of trade shocks while capital controls are more welfare beneficial in response to shocks to external financial conditions. When considering all shocks together, the welfare gains from exchange rate flexibility are larger due to the large volatility of the terms of trade.

We extend the analysis of the model in various ways. We introduce sterilized foreign exchange intervention by making the UIP wedge endogenous to the portfolio position of foreign investors. We also introduce nominal price rigidities and solve for the optimal policies under discretion and find that despite these changes the qualitative results of the baseline model remain intact. In addition, we extend the model to explain the exchange rate management policies of emerging market economies during the COVID-19 pandemic by introducing a COVID shock to the model.

An aspect that we do not consider is financial stability, a key motivation for using capital controls in models with financial crises and sudden stops. It would be interesting to extend the comparison between advanced and emerging market economies and the comparison of welfare gains from exchange rate flexibility and capital controls by also incorporating financial stability concerns. Additionally, exploring different ways of modeling imperfect inter-sectoral labor mobility may provide more insight. Having a heterogeneous agent model with costs in switching sectors may yield new implications for the sectoral trade-off of monetary policy. Lastly, we do not consider the reallocation of capital across sectors. Studying the sectoral reallocation of capital and the behavior of investment may provide a new perspective into the sectoral trade-off of monetary policy.

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A Welfare loss function $\mathscr{W}(\cdot)$ derivation

A.1 Baseline model

To derive the welfare loss function we first derive the second-order approximation of the period-by-period welfare function, $u(C_t) - v(L_t)$.

$$\begin{aligned}
u(C_t) - v(L_t) = &\frac{1}{2}u_{HH}(C_t^n)(C_{H,t} - C_{H,t}^n)^2 + \frac{1}{2}u_{FF}(C_t^n)(C_{F,t} - C_{F,t}^n)^2 + \frac{1}{2}u_{NN}(C_t^n)(C_{N,t} - C_{N,t}^n)^2 \\
&+ u_{HN}(C_t^n)(C_{H,t} - C_{H,t}^n)(C_{N,t} - C_{N,t}^n) + u_{FN}(C_t^n)(C_{F,t} - C_{F,t}^n)(C_{N,t} - C_{N,t}^n) \\
&+ u_{HF}(C_t^n)(C_{H,t} - C_{H,t}^n)(C_{F,t} - C_{F,t}^n) \\
&- \frac{1}{2}v_{HH}(L_t^n)(Y_{H,t} - Y_{H,t}^n)^2 - \frac{1}{2}v_{NN}(L_t^n)(Y_{N,t} - Y_{N,t}^n)^2 \\
&- v_{HN}(L_t^n)(Y_{H,t} - Y_{H,t}^n)(Y_{N,t} - Y_{N,t}^n) \\
&+ u_H(C_t^n)(C_{H,t} - C_{H,t}^n) + u_F(C_t^n)(C_{F,t} - C_{F,t}^n) + u_N(C_t^n)(C_{N,t} - C_{N,t}^n) \\
&- v_H(L_t^n)(Y_{H,t} - Y_{H,t}^n) - v_N(L_t^n)(Y_{N,t} - Y_{N,t}^n) \\
&+ t.i.p.
\end{aligned}$$

We use the market clearing condition for non-tradable goods, Equation (14), to get rid of the first-order terms for non-tradables.

$$u_N(C_t^n)(C_{N,t} - C_{N,t}^n) - v_N(L_t^n)(Y_{N,t} - Y_{N,t}^n) = u_N(C_t^n)(-\frac{\phi_w}{2}Y_{N,t}{\pi_{N,t}^w}^2) + t.i.p.$$

Using the following first-order conditions from the natural allocation,

$$\begin{aligned}
v_H(L_t^n) &= u_H(C_t^n) \\
u_F(C_t^n) &= \frac{P_{F,t}^*}{P_{H,t}^*}u_H(C_t^n) \\
\beta(1 + i_t^*)\frac{u_H(C_{t+1}^n)}{u_H(C_t^n)}\frac{P_{H,t}^*}{P_{H,t+1}^*} - 1 &= \kappa_B B_t^{*n}
\end{aligned}$$

the other first-order terms regarding the tradable sector and US treasuries can be simplified to the following.

$$\begin{aligned}
&\sum_{t=-\infty}^{\infty} \beta^t \left[u_H(C_t^n)(C_{H,t} - C_{H,t}^n) + u_F(C_t^n)(C_{F,t} - C_{F,t}^n) - v_H(L_t^n)(Y_{H,t} - Y_{H,t}^n)\right] \\
= &\sum_{t=-\infty}^{\infty} \beta^t \left[-\frac{\kappa_B}{2}\frac{u_H(C_t^n)}{P_{H,t}^*}\left(\hat{B}_t^*\right)^2 - \frac{\kappa_W}{2}\frac{u_H(C_t^n)}{P_{H,t}^*}Y_{H,t}{\pi_{H,t}^w}^2\right] + t.i.p.
\end{aligned}$$

We substitute these into the second-order approximation and use the fact that the first-best allocations differ from the steady state allocation by first-order, giving us the following period-by-period welfare function for households.

$$
\begin{aligned}
& u(C_t) - v(L_t) \\
=& \frac{1}{2}\left(u_{HH}(C)C_H^2 + u_{FF}(C)C_F^2\right)\hat{c}_{T,t}^2 + \frac{1}{2}u_{NN}(C)Y_N^2\hat{y}_{N,t}^2 \\
& + u_{HN}(C)C_H Y_N \hat{c}_{H,t}\hat{y}_{N,t} + u_{FN}(C)C_F Y_N \hat{c}_{T,t}\hat{y}_{N,t} + u_{HF}(C)C_H C_F \hat{c}_{T,t}^2 \\
& - \frac{1}{2}v_{HN}(L)Y_H Y_N \left(\hat{y}_{H,t} + \hat{y}_{N,t}\right)^2 \\
& - \frac{1}{2}\left(v_{HH}(L)Y_H^2 - v_{HN}(L)Y_H Y_N\right)\hat{y}_{H,t}^2 - \frac{1}{2}\left(v_{NN}(L)Y_N^2 - v_{HN}(L)Y_H Y_N\right)\hat{y}_{N,t}^2 \\
& - \frac{\kappa_W}{2}u_H(C)Y_H{\pi_{H,t}^w}^2 - \frac{\kappa_W}{2}u_N(C)Y_N{\pi_{N,t}^w}^2 - \frac{\kappa_B}{2}u_H(C)\left(\hat{B}_t^*\right)^2 \\
& + t.i.p.
\end{aligned}
$$

Therefore, the welfare loss function is given as

$$
\begin{aligned}
& \mathscr{W}\left(\hat{y}_{H,t}, \hat{y}_{N,t}, \hat{c}_{T,t}, \pi_{H,t}^w, \pi_{N,t}^w, \hat{B}_t^*\right) \\
=& -\frac{1}{2}\left(u_{HH}(C)C_H^2 + u_{FF}(C)C_F^2\right)\hat{c}_{T,t}^2 - \frac{1}{2}u_{NN}(C)Y_N^2\hat{y}_{N,t}^2 - u_{HF}(C)C_H C_F \hat{c}_{T,t}^2 \\
& - u_{HN}(C)C_H Y_N \hat{c}_{T,t}\hat{y}_{N,t} - u_{FN}(C)C_F Y_N \hat{c}_{T,t}\hat{y}_{N,t} + \frac{1}{2}v_{HN}(L)Y_H Y_N \left(\hat{y}_{H,t} + \hat{y}_{N,t}\right)^2 \\
& + \frac{1}{2}\left(v_{HH}(L)Y_H^2 - v_{HN}(L)Y_H Y_N\right)\hat{y}_{H,t}^2 + \frac{1}{2}\left(v_{NN}(L)Y_N^2 - v_{HN}(L)Y_H Y_N\right)\hat{y}_{N,t}^2 \\
& + \frac{\kappa_W}{2}u_H(C)Y_H{\pi_{H,t}^w}^2 + \frac{\kappa_W}{2}u_N(C)Y_N{\pi_{N,t}^w}^2 + \frac{\kappa_B}{2}u_H(C)\left(\hat{B}_t^*\right)^2
\end{aligned}
$$

A.2 Debt elastic UIP wedge model

With utility for US treasuries added to households and a debt-elastic UIP wedge, the welfare loss function is given as

$$
\begin{aligned}
& \mathscr{W}\left(\hat{y}_{H,t}, \hat{y}_{N,t}, \hat{c}_{T,t}, \pi_{H,t}^w, \pi_{N,t}^w, \hat{B}_t^*\right) \\
=& -\frac{1}{2}\left(u_{HH}(C)C_H^2 + u_{FF}(C)C_F^2\right)\hat{c}_{T,t}^2 - u_{HF}(C)C_H C_F \hat{c}_{T,t}^2 - \frac{1}{2}u_{NN}(C)Y_N^2\hat{y}_{N,t}^2 \\
& - u_{HN}(C)C_H Y_N \hat{c}_{T,t}\hat{y}_{N,t} - u_{FN}(C)C_F Y_N \hat{c}_{T,t}\hat{y}_{N,t} + \frac{1}{2}v_{HN}(L)Y_H Y_N \left(\hat{y}_{H,t} + \hat{y}_{N,t}\right)^2 \\
& + \frac{1}{2}\left(v_{HH}(L)Y_H^2 - v_{HN}(L)Y_H Y_N\right)\hat{y}_{H,t}^2 + \frac{1}{2}\left(v_{NN}(L)Y_N^2 - v_{HN}(L)Y_H Y_N\right)\hat{y}_{N,t}^2 \\
& + \frac{\kappa_W}{2}u_H(C)Y_H{\pi_{H,t}^w}^2 + \frac{\kappa_W}{2}u_N(C)Y_N{\pi_{N,t}^w}^2 + \beta u_H(C)\varsigma\left(\hat{B}_t^*\right)^2 - \frac{1}{2}\varkappa''(B^{US})\left(\hat{B}_t^{US}\right)^2
\end{aligned}
$$

B Tractable model derivation

Under the tractable model assumptions, the linearized labor demand conditions are

$$\frac{\alpha_N - 1}{\alpha_N} y_N + \frac{1}{\alpha_N} a_N = -p_N \tag{35}$$
$$\frac{\alpha_H - 1}{\alpha_H} y_H + \frac{1}{\alpha_H} a_H = (w_H - e - p_H^*) \tag{36}$$

where we substituted labor with output using the production functions. The Euler equation for non-tradable goods is

$$-\sigma y_N = i + p_N \tag{37}$$

where we substituted non-tradable consumption with non-tradable output using the market clearing condition. The optimal demand for goods is

$$-\sigma y_N - p_N = -\sigma c_T - (e + \gamma p_H^*) \tag{38}$$

The adjusted UIP condition is

$$i = \rho - e + \tau \tag{39}$$

If wages are flexible, households would be able to choose labor, resulting in the following labor supply conditions.

$$\frac{1}{\alpha_H} (y_H - a_H) - \frac{1}{\alpha_N} (y_N - a_N) = \theta_\ell w_H \tag{40}$$
$$-\sigma y_N - p_N = \frac{1}{\theta_\ell} \frac{1}{\alpha_N} y_N \tag{41}$$

The natural allocation can be solved for using Equations (35)-(41). Equations (35)-(39) can be transformed such that they are represented in terms of "gaps" from the natural allocation.

$$\frac{\alpha_N - 1}{\alpha_N}\hat{y}_N = -\hat{p}_N \tag{42}$$

$$\frac{\alpha_H - 1}{\alpha_H}\hat{y}_H = (-w_H^n - \hat{e}) \tag{43}$$

$$-\sigma\hat{y}_N = \hat{i} + \hat{p}_N \tag{44}$$

$$-\sigma\hat{y}_N - \hat{p}_N = -\sigma\hat{c}_T - \hat{e} \tag{45}$$

$$\hat{i} = -\hat{e} + \tau \tag{46}$$

Note that w_H^n enters the system of equations as a wedge since under constant wages, the relative wage cannot fluctuate as it does under the natural allocation. These equations result in the following mapping between gaps and policy instruments.

$$w_{H,0}^n = \chi_H\hat{y}_{H,0} - \chi_N\hat{y}_{N,0} + \chi_T\hat{c}_{T,0}$$

where $\chi_H = \frac{1-\alpha_H}{\alpha_H}$, $\chi_N = (\sigma + \frac{1-\alpha_N}{\alpha_N})$ and $\chi_T = \sigma$. The policymaker takes this into account as a constraint and solves the following problem.

$$\begin{aligned} \min \quad & \gamma_N\hat{y}_{N,0}^2 + \gamma_H\hat{y}_{H,0}^2 + \gamma_T\hat{c}_{T,0}^2 \\ s.t. \quad & w_{H,0}^n = \chi_H\hat{y}_{H,0} - \chi_N\hat{y}_{N,0} + \chi_T\hat{c}_{T,0} \\ & \hat{c}_{T,0} = 0 \quad \text{(if capital controls are not allowed)} \end{aligned}$$

where

$$\begin{aligned} \gamma_N &= (1-\omega_\ell)^{-\frac{1}{\theta_\ell}}\frac{\partial^2 v(L_{N,0})}{\partial Y_{N,0}^2}|_{Y_{N,0}=Y_N} + (1-\omega_c)^{\frac{1}{\theta_c}}\frac{\partial^2 u(C_N)}{\partial C_N^2}|_{C_{N,0}=C_N} \\ \gamma_H &= \omega_\ell^{-\frac{1}{\theta_\ell}}\frac{\partial^2 v(L_H)}{\partial Y_H^2}|_{Y_{H,0}=Y_H} \\ \gamma_T &= \omega_c^{\frac{1}{\theta_c}}\frac{\partial^2 u(C_T)}{\partial C_T^2}|_{C_{T,0}=C_T} \end{aligned}$$

and the natural allocation level of the wage in the tradable sector, $w_{H,0}^n$, is given by

$$w_{H,0}^n \equiv \frac{\psi}{\psi + 1 - \alpha_H}(\rho_0 + p_{H,0}^* + a_{H,0}) + \frac{\psi(\sigma - 1)}{\sigma\alpha_N + \psi + 1 - \alpha_N}a_{N,0}.$$

C Data

In this section we explain the data, how the sectors are classified and how we estimate inter-sectoral labor mobility (θ_ℓ), the UIP wedge (ρ_t) and the AR(1) processes of exogenous state variables.

C.1 Data source

The data used to calibrate the model is from the sources listed in Table 5.

Table 5: Data sources

Variable	Dataset	Frequency
Sector level hours worked	WIOD SEA, LA KLEMS, EU KLEMS	Annual
Sector value added (nominal and real)	WIOD SEA, LA KLEMS, EU KLEMS	Annual
Sector level capital input	WIOD SEA, LA KLEMS, EU KLEMS	Annual
Terms of trade	WB WDI	Annual
Sector level export to GDP ratio	WIOD NIOT	Annual
3M LC sovereign bond interest rate	Bloomberg	Quarterly
Nominal US exchange rate	BIS	Quarterly
CPI	IMF IFS	Quarterly
Current account	IMF IFS	Quarterly
External liabilities	IMF IFS	Quarterly
External assets	IMF IFS	Quarterly
Nominal GDP	IMF IFS	Quarterly

C.2 Classification of sectors

We follow the classification of sectors into tradable and non-tradable sectors used in De Gregario et al. (1994). De Gregario et al. (1994) classify sectors based on export to output ratios. Those with high export to output ratios are defined as tradable and those with low ratios are defined as non-tradable. Since the classification of sectors is more broad in the LA KLEMS than in the WIOD SEA, we use the sectors defined in the LA KLEMS and classify them as tradable or non-tradable. For each sector we derive the average export to output ratio across all countries in the sample using the National Input Output Tables (NIOT) and find that the classification used in De Gregario et al. (1994) holds. The export to output ratios and classification of the sectors is shown in Table 6.

Table 6: Classification of sectors (ISIC rev. 3)

Code	Sector	export/output	Classification
A-B	Agriculture, hunting, forestry and fishing	16.5%	Tradable
C	Mining and extraction	36.8%	Tradable
D	Total manufacturing	45.6%	Tradable
E	Electricity, gas and water supply	8.2%	Non-Tradable
F	Construction	1.6%	Non-Tradable
G-H	Commerce, hotels and restaurants	10.6%	Non-Tradable
I	Transport, storage and communications	18.8%	Tradable
J-K	Finance, insurance, real estate and business services	7.9%	Non-Tradable
L-Q	Social community and personal services	3.1%	Non-Tradable

C.3 Estimating θ_ℓ

Using the labor demand and supply conditions given by Equations (3) and (7) and the definition of aggregate labor, we can derive the following relationship:

$$\frac{L_{H,t}}{L_t} = \omega_\ell^{\frac{1}{1+\theta_\ell}} V_{H,t}^{\frac{\theta_\ell}{1+\theta_\ell}} \tag{47}$$

$$\frac{L_{N,t}}{L_t} = (1-\omega_\ell)^{\frac{1}{1+\theta_\ell}} V_{N,t}^{\frac{\theta_\ell}{1+\theta_\ell}} \tag{48}$$

where

$$V_{S,t} \equiv \frac{\alpha_S VA_{S,t}(1+\Gamma_{S,t})}{\alpha_H VA_{H,t}(1+\Gamma_{H,t}) + \alpha_N VA_{N,t}(1+\Gamma_{N,t})}, \qquad \forall S \in \{N, H\}$$

$$\Gamma_{S,t} \equiv \frac{\kappa_w}{\varepsilon_w \alpha_S}\left(\pi_{S,t}^w - \beta \mathbb{E}_t\left[\pi_{S,t+1}^w\right]\right), \qquad \forall S \in \{N, H\}$$

$$VA_{S,t} \equiv P_{S,t} Y_{S,t}, \qquad \forall S \in \{N, H\}$$

We can take the log-difference of Equations (47) and (48) to derive

$$\Delta \ell_{S,t} - \Delta \ell_t = \frac{\theta_\ell}{1+\theta_\ell} \Delta \nu_{S,t}, \quad \forall S \in \{N, H\} \tag{49}$$

where $\nu_{S,t} \equiv \log V_{S,t}$.

Equation (49) represents the general equilibrium relationship between value added and labor and is used to estimate θ_ℓ. Here θ_ℓ is well-identified because although there are both labor demand and supply equations that link labor and wages, we assume labor demand takes a certain form where the elasticity of labor demand to wage is equal to

1 (since $\frac{W_{S,t}}{P_{S,t}} = \alpha_S \frac{Y_{S,t}}{L_{S,t}}$). Therefore, we can estimate equation (49) without endogeneity issues. Note that we need to find a data equivalent counterpart to $\Delta\ell_t$. We follow the literature and define $\Delta\ell_t$ as

$$\Delta\ell_t = \left(\frac{\alpha_H VA_{H,t-1}(1+\Gamma_{H,t-1})}{\alpha_H VA_{H,t-1}(1+\Gamma_{H,t-1}) + \alpha_N VA_{N,t-1}(1+\Gamma_{N,t-1})}\right)\Delta\ell_{H,t} + \left(\frac{\alpha_N VA_{N,t-1}(1+\Gamma_{N,t-1})}{\alpha_H VA_{H,t-1}(1+\Gamma_{H,t-1}) + \alpha_N VA_{N,t-1}(1+\Gamma_{N,t-1})}\right)\Delta\ell_{N,t}.$$

Finally, we assume that at the annual frequency nominal wage rigidities are of minimal concern so we set $\Gamma_{S,t} = 0$ which holds under flexible wages and estimate equation (49) at the annual frequency. Using annual sector level hours worked and nominal value added data, we run a panel regression with country and year fixed effects. This is the exact same regression used in Horvath (2000) and Cardi and Restout (2022) to estimate inter-sectoral labor mobility. Since the model is at the quarterly frequency unlike the regression we run, we can understand the estimates of θ_ℓ to be an upper bound for what we would find at the quarterly frequency. If the time horizon is longer, one would expect the elasticity to be higher since households have more time to adjust labor supply to changes in wages.

The exact specification of the panel regression we are interested in is

$$\Delta\ell_{k,S,t} - \Delta\ell_{k,t} = \tilde{\theta}\Delta\nu_{k,S,t} + \tilde{\theta}_{EME}(eme_k \times \Delta\nu_{k,S,t}) + FE_k + FE_t + \varepsilon_{k,S,t} \tag{50}$$

where k is the index for country, S is the index for sector, and t represents the year. eme_k is an indicator function that takes the value of 1 if country k is an emerging market economy and 0 otherwise. $\tilde{\theta}$ is a function of labor mobility for AEs and $\tilde{\theta} + \tilde{\theta}_{EME}$ is a function of labor mobility for EMEs. FE_i and FE_t represent fixed effects for country and year. We cluster standard errors by country$\times$sector. For the baseline, we use the sample of countries that have data in 2000-2014 for the terms of trade, UIP wedge, sectoral value added and sectoral hours worked. This results in a total of 31 countries. We classify countries as AEs and EMEs based on the IMF WEO's classification of countries in 2023. This results in 8 EMEs and 23 AEs in the sample.[28]

We report the results in Table 7. Column (1) represents the baseline case. We find that EMEs have significantly lower labor mobility than AEs. The inter-sectoral labor mobility, θ_ℓ, that we get by converting the estimated $\tilde{\theta}_{EME}$ and $\tilde{\theta}$ is 0.1735 for EMEs and 0.5386 for

[28]Our sample of EMEs includes BRA, CHL, COL, HUN, IDN, IND, MEX and PER. AEs include AUS, AUT, BEL, CAN, CHE, CZE, DEU, DNK, ESP, FIN, FRA, GBR, HRV, IRL, ITA, JPN, KOR, NLD, NOR, PRT, SVK, SVN and SWE. During the 21st century, the IMF has changed its classification for CZE, HRV, SVK and SVN from EME to AE. The results are robust to removing these countries from the sample.

AEs.[29]

Table 7: Estimates for $\tilde{\theta}$ and $\tilde{\theta}_{EME}$ in Equation (50)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta\nu_{k,S,t}$	.350***	.350***	.304***	.202***	.315***	.243***	.237***	.233***
	(.039)	(.039)	(.037)	(.035)	(.046)	(.047)	(.045)	(.043)
$eme_k \times \Delta\nu_{k,S,t}$	-.202***	-.233***	-.159**	-.091*	-.167**	-.104	-.126**	-.119**
	(.071)	(.052)	(.069)	(.047)	(.075)	(.064)	(.050)	(.046)
$eu_k \times \Delta\nu_{k,S,t}$						.121**	.127**	-.033
						(.057)	(.055)	(.048)
N	868	982	868	1378	756	868	982	1378
R^2	0.217	0.186	0.169	0.099	0.171	0.22	0.188	0.099

*** p<0.01, ** p<0.05, * p<0.1

To test the robustness of the result, we try modify the regression and sample in various ways. First, we expand the sample such that all of the time periods that are available are used. This expands the time horizon for Mexico, Peru, Chile and Colombia to 1990-2017 as the LA KLEMS provides sector level labor and value added data from 1990 to 2017. This is reported in Column (2) of Table 7. We can see that the results still hold. Second, for countries that also have sectoral data on the EU KLEMS, we switch the data and run the baseline regression.[30] The results are shown in Column (3). The statistical significance of θ_{EME} falls slightly, but it is still significant at the 5% level. Third, we expand the sample size and use the data from EU KLEMS, a combination of the first and second robustness exercises, and report the findings in Column (4). Again, the results show that emerging markets have lower inter-sectoral labor mobility though the significance now falls to the 10% level. Fourth, we drop AEs that were classified as EMEs in 2000, which are CZE, HRV, SVK and SVN. We report the results in Column (5) and find that the result still holds.

[29]For AEs, we can use the following conversion to derive inter-sectoral labor mobility: $\theta_\ell = \frac{\tilde{\theta}}{1-\tilde{\theta}}$. For EMEs, we use the following: $\theta_\ell = \frac{\tilde{\theta}+\tilde{\theta}_{EME}}{1-(\tilde{\theta}+\tilde{\theta}_{EME})}$.

[30]The countries that are in both the WIOD SEA and EU KLEMS dataset are JPN, AUT, BEL, CZE, DEU, DNK, ESP, FIN, FRA, HRV, HUN, IRL, ITA, NLD, PRT, SVK, SVN and SWE.

Next, we consider whether European countries that allow their citizens to freely work in other European countries are different in their inter-sectoral labor mobility. If there is higher international labor mobility, it could be the case that there is higher inter-sectoral labor mobility. Since most of the advanced economies in the sample are European countries and have free mobility of labor across countries within Europe, this may drive the result that AEs have higher inter-sectoral labor mobility than EMEs. To test this, we include another interaction term, $eu_k \times \Delta\nu_{k,S,t}$. eu_k takes the value of 1 if k is a country in the European Union or is CZE, DNK, HUN, NOR, SWE, CHE or GBR which all have no restrictions on labor mobility with each other and the value of 0 otherwise. We report the findins in Column (6) and find that with the baseline sample, the story of European countries having higher labor mobility holds. $\tilde{\theta}_{EME}$ is still negative, but no longer statistically significant at the 10% level. Once we expand the sample though, the statistical significance returns (Column (7)). We also switch the data for countries that also have sectoral data in the EU KLEMS and find that the significance of $\tilde{\theta}_{EME}$ holds, but now the statistical significance of European countries falls.

Overall, the results show that labor mobility is lower in emerging market economies and there is mixed evidence of European countries having higher inter-sectoral labor mobility.

C.4 Estimating ρ_t

To derive quarterly series for ρ_t we first derive the one quarter expected excess dollar returns by forecasting realized excess dollar returns of local currency three month sovereign bonds over the three month US treasury. We follow Jiang et al. (2023) and Koijen and Yogo (2020) and forecast excess dollar returns of local currency sovereign bonds by using the real exchange rate and local currency interest rate of three month local currency sovereign bonds. The local currency sovereign bond interest rates are from Bloomberg and the real exchange rate is derived using the nominal bilateral dollar exchange rate from the BIS and CPI from the IMF IFS database. The tickers for the bonds are shown in Table 8.

Table 8: Bloomberg tickers for 3-month local currency sovereign bonds

Country	Ticker	Country	Ticker	Country	Ticker
Australia	I00103M Index	France	I01403M Index	Norway	I07803M Index
Austria	I06303M Index	Germany	I01603M Index	Peru	I36103M Index
Belgium	I00603M Index	Hungary	I16503M Index	Portugal	I08403M Index
Brazil	I39303M Index	India	I23603M Index	Slovakia	I25603M Index
Canada	I00703M Index	Indonesia	I26603M Index	Slovenia	I25903M Index
Chile	I35103M Index	Ireland	I06203M Index	Spain	I06103M Index
Colombia	I21703M Index	Italy	I04003M Index	Sweden	I02103M Index
Croatia	I36903M Index	Japan	I01803M Index	Switzerland	I08203M Index
Czech Republic	I11203M Index	Korea	I17303M Index	United Kingdom	I02203M Index
Denmark	I01103M Index	Mexico	I25103M Index	United States	USGG3M Index
Finland	I08103M Index	Netherlands	I02003M Index		

We run the following panel regression:

$$\overbrace{i_{k,t} - i_t^{US} - \Delta e_{k,t+1}}^{\text{Realized excess returns}} = \beta_1 i_{k,t} + \beta_2 rer_{k,t} + \alpha_k + \sum_{j \in J} \gamma_j GFC_j + \varepsilon_{k,t} \tag{51}$$

where $i_{k,t}$ is the country k's three-month local currency sovereign bond interest rate from t to $t+1$, i_t^{US} is the three month US treasury rate from t to $t+1$, $\Delta e_{k,t+1}$ is the realized depreciation of currency k with respect to the dollar between t and $t+1$, $rer_{k,t}$ is the real exchange rate in terms of CPI for country k with respect to the US and denoted such that an increase is a real depreciation of currency k, α_k captures the country fixed effects, and GFC_j captures the fixed effects for the Global Financial Crisis from 2008Q1 to 2009Q2. We defined the periods between 2008Q1 and 2009Q2 as the period for the Global Financial Crisis since the NBER defines this period to be a recession for the US economy. We cluster standard errors by countries. Due to data limitations, the time sample is from 2007 Q1 to 2014 Q4.

The results from running the panel regression in Equation (51) is shown in Table 9. Column (1) shows the baseline results. The coefficient for the local currency interest rate is positive, implying that higher interest rates predict higher returns which is consistent with what theory predicts. The coefficient for the real exchange rate is positive, implying that a depreciated currency today predicts higher returns which is consistent with the long-run properties of Purchasing Power Parity (PPP). These coefficients have the same direction as those estimated in Koijen and Yogo (2020) and Jiang et al. (2023).

Table 9: Regression results for Equation (51)

	(1)	(2)	(3)	(4)
$i_{k,t}$	3.063***	1.919***	3.020***	1.630***
	(.401)	(.456)	(.397)	(.457)
$rer_{k,t}$	.086***	.066***	.097***	0.076***
	(.013)	(.016)	(.013)	(.013)
i_t^{US}		1.825***		2.200***
		(.433)		(.449)
VIX_t			.001***	.001***
			(.000)	(.000)
N	975	975	975	975
R^2	0.016	0.024	0.015	0.021

*** p<0.01, ** p<0.05, * p<0.1

We also conduct some robustness checks for the validity of these coefficients. We add the US 3 month interest rate as well as the VIX to Equation (51). We find that these are able to predict excess returns, but do not take away the significance of the baseline results.

We use the fitted values of equation (51) without the Global Financial Crisis controls as the expected excess returns on three month local currency sovereign bonds. We then detrend the expected excess returns using a linear time trend individually for all countries and estimate an AR(1) process together using the cyclical component of the expected excess returns. We find that the persistence is 0.7370 and the standard deviation of the innovations to the expected excess returns is 0.0111 for EMEs and 0.0046 for AEs. The persistence is not significantly different across EMEs and AEs, so we keep the persistence equal. Using an F-test we show that the standard deviation is significantly different.

The estimated UIP wedges for each country are shown in Figure 11. The upper graph shows the UIP wedges for emerging market economies and the lower graph shows the UIP wedges for advanced economies. The thick solid red lines show the median UIP wedge for each group of countries. For emerging markets, the UIP wedge has a mean of 1.2% with a standard deviation of 1.9%. For advanced economies the mean is 0.3% with a standard deviation of 1.1%. Both the level and volatility of the UIP wedge are higher for emerging markets than advanced economies.

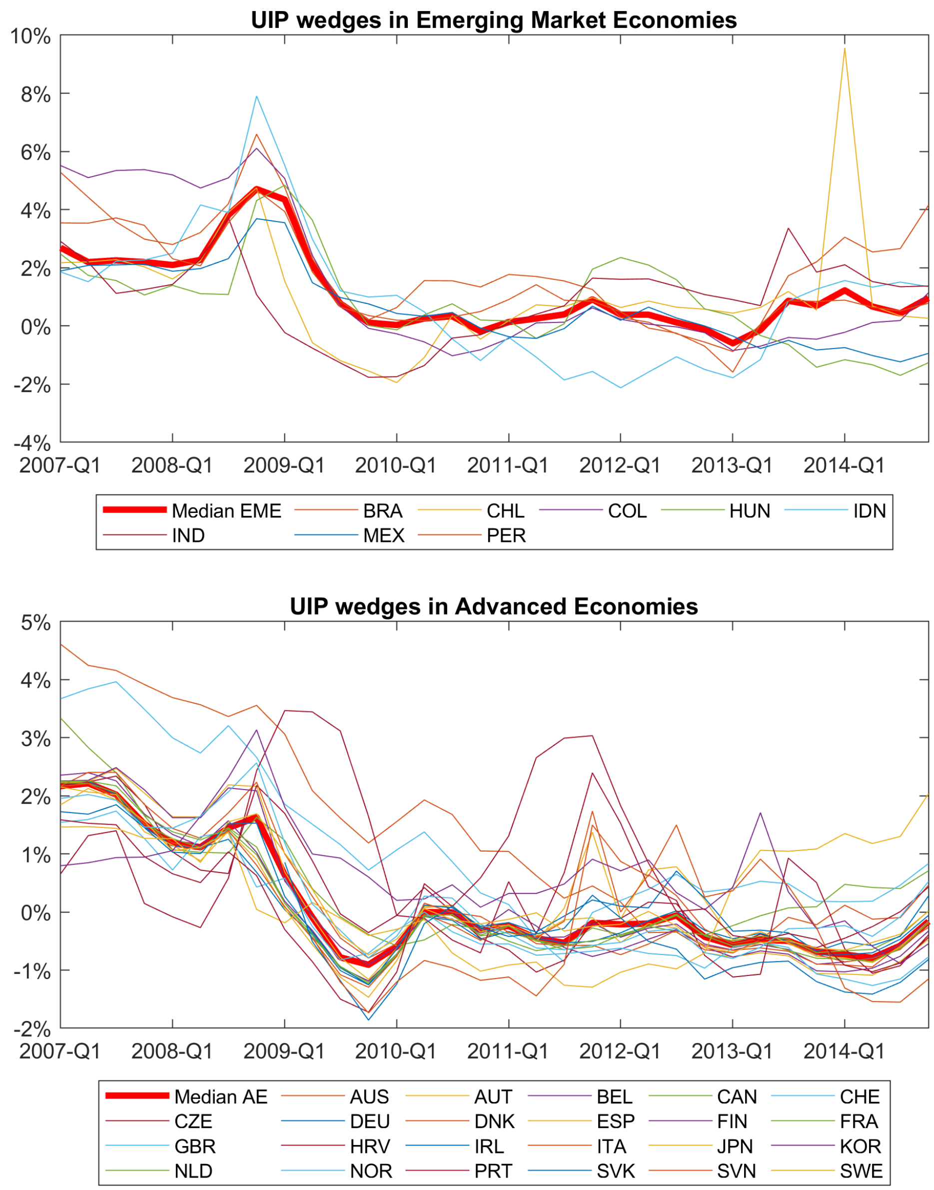

Figure 11: Estimated UIP wedges for emerging market economies and advanced economies

C.5 Estimating a quarterly AR(1) from an annual series

Assume that there is an AR(1) process of the terms of trade at the quarterly frequency such that

$$p^*_{H,t} = \zeta_{pH*} p^*_{H,t-1} + \varepsilon_{pH*,t}, \quad \varepsilon_{pH*,t} \sim i.i.d.N(0, \sigma^2_{pH*}).$$

The variance of the annual average of the terms of trade and the covariance of the annual average of the terms of trade with its lag can be expressed as

$$
\begin{aligned}
&var\left(\frac{p^*_{H,t}+p^*_{H,t-1}+p^*_{H,t-2}+p^*_{H,t-3}}{4}\right)\\
=&\frac{\sigma^2_{pH*}}{16}\left[1+(1+\zeta_{pH*})^2+(1+\zeta_{pH*}+\zeta^2_{pH*})^2+(1+\zeta_{pH*}+\zeta^2_{pH*}+\zeta^3_{pH*})^2/(1-\zeta^2_{pH*})\right]
\end{aligned}
$$

and

$$
\begin{aligned}
&cov\left(\frac{p^*_{H,t}+p^*_{H,t-1}+p^*_{H,t-2}+p^*_{H,t-3}}{4},\frac{p^*_{H,t-4}+p^*_{H,t-5}+p^*_{H,t-6}+p^*_{H,t-7}}{4}\right)\\
=&\frac{\sigma^2_{pH*}}{16}\left[\begin{array}{c}(1+\zeta_{pH*}+\zeta^2_{pH*}+\zeta^3_{pH*})\zeta_{pH*}(1+\zeta_{pH*}(1+\zeta_{pH*})+\zeta^2_{pH*}(1+\zeta_{pH*}+\zeta^2_{pH*}))\\+(1+\zeta_{pH*}+\zeta^2_{pH*}+\zeta^3_{pH*})^2\zeta^4_{pH*}/(1-\zeta^2_{pH*})\end{array}\right].
\end{aligned}
$$

We estimate the variance of the annual average of the terms of trade and the covariance of the annual average and its lag and derive ζ_{pH*} and σ_{pH*}. Using an F-test we find that the variance of the annual terms of trade is significantly different across EMEs and AEs. A t-test shows that the covariance of the annual average with its lag is also significantly different across EMEs and AEs.

For sector level TFP, we run the following regression separately for each sector $S \in \{N, H\}$.

$$\ln VA_{k,S,t} = \beta_{1,S} \ln L_{k,S,t} + \beta_{2,S} \ln K_{k,S,t} + \alpha_{S,t} + \varepsilon_{k,S,t} \tag{52}$$

We take the residual and detrend it using a linear time trend for each country separately. Then using the cyclical components we derive the annual variance and covariance with its lag. Using these two statistics we derive the quarterly AR(1) process for the TFP of tradable and non-tradable sectors across EMEs and AEs.

D IRFs

In this section, we show and explain the impulse response functions under a pure and managed float for the UIP wedge shock, the terms of trade shock and sectoral productivity shocks. Figures 12-15 show the impulse response functions in response to a positive shock to the the UIP wedge, the terms of trade and TFP in the tradable sector and non-tradable sector respectively. The qualitative features of the impulse response functions are all similar. They create a negative non-tradable output gap and a positive tradable output gap under a pure float.

Following a positive UIP wedge shock, a positive terms of trade shock or a positive TFP shock to the tradable sector there is heightened demand for labor in the tradable sector. A positive UIP wedge shock depreciates the currency, making the value of exports higher relative to the wage in terms of Home currency. Similarly, a positive terms of trade shock increases the dollar price of exports again making the value of exports higher relative to the wage. A positive TFP shock to the tradable sector lowers the real wage per unit of output. Since wages are sticky, the real wage per unit of output is lower than under the natural level as a result of the shocks. This stimulates labor demand in the tradable sector, resulting in positive output gaps under a pure float. The policymaker tries stabilizing the tradable sector by raising the interest rate to appreciate (or offset the depreciation of) the currency and increase the real wage. This lowers demand in the non-tradable sector, resulting in a negative non-tradable output gap. The positive tradable output gap and negative non-tradable output gap create wage inflation in the tradable sector and wage disinflation in the non-tradable sector. Capital controls can alleviate the sectoral trade-off, resulting in a smaller non-tradable output gap. The use of capital controls stimulates tradable consumption, resulting in a positive tradable consumption gap. This creates large wage inflation pressure in the tradable sector. To offset this, the policymaker pushes output in the tradable sector down below zero.

The implications of a non-tradable TFP shock is slightly different from those of other shocks. Following a positive TFP shock to the non-tradable sector, the supply of non-tradable goods increases. To increase demand so that the market for non-tradable goods clears, the price of non-tradable goods falls, resulting in a higher real wage in the non-tradable sector. This process is exacerbated under sticky wages since the wage is not able to fall to smooth the increase in real wages. This results in less labor in the non-tradable sector and a negative non-tradable output gap. Under a pure float, the policymaker tries to offset this by lowering the policy rate but is limited from doing so due to the impact this has on the tradable sector. As a result, there is a positive tradable output gap and a negative non-tradable output gap. With capital controls, the policymaker is better able to manage the non-tradable sector since capital controls alleviate the impact that monetary policy has on the exchange rate. The non-tradable output gap is much smaller as a result. Capital controls stimulate consumption of tradable goods, creating wage inflation in the tradable sector. To offset this, the policymaker lowers the tradable output gap below zero.

Overall, the qualitative response of gap variables is similar for all shocks.

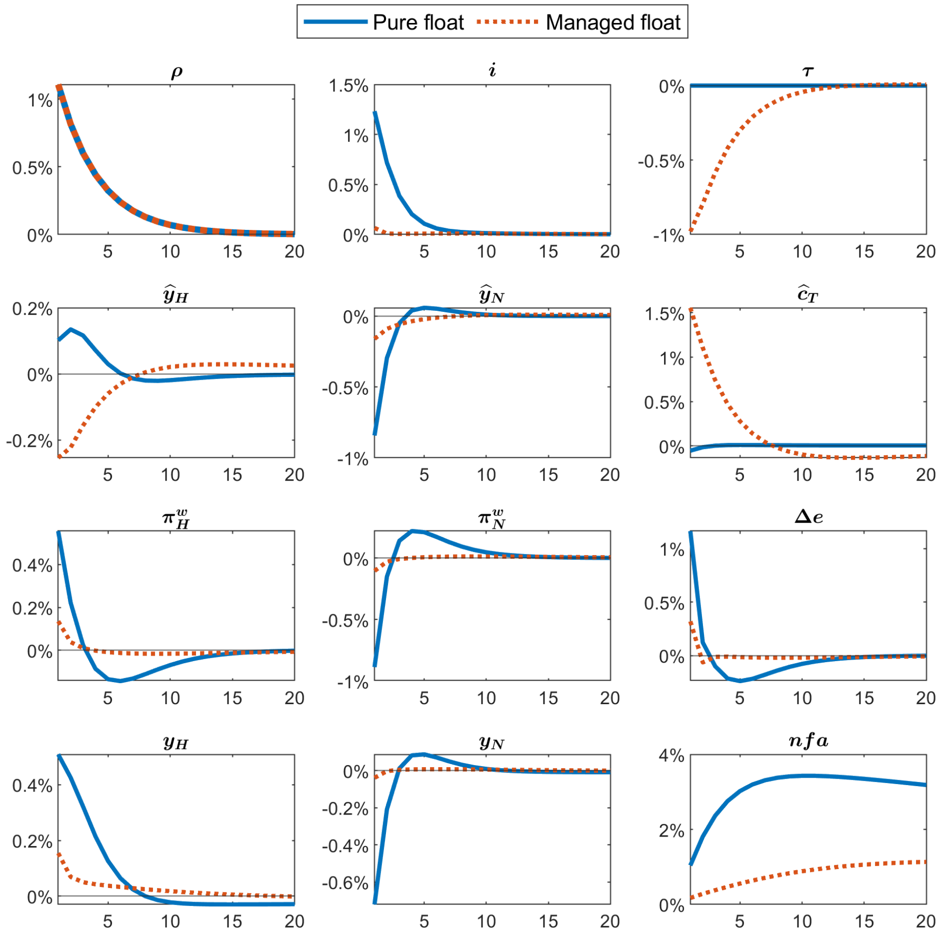

Figure 12: Impulse response function in response to a 1 SD shock to P_H^*

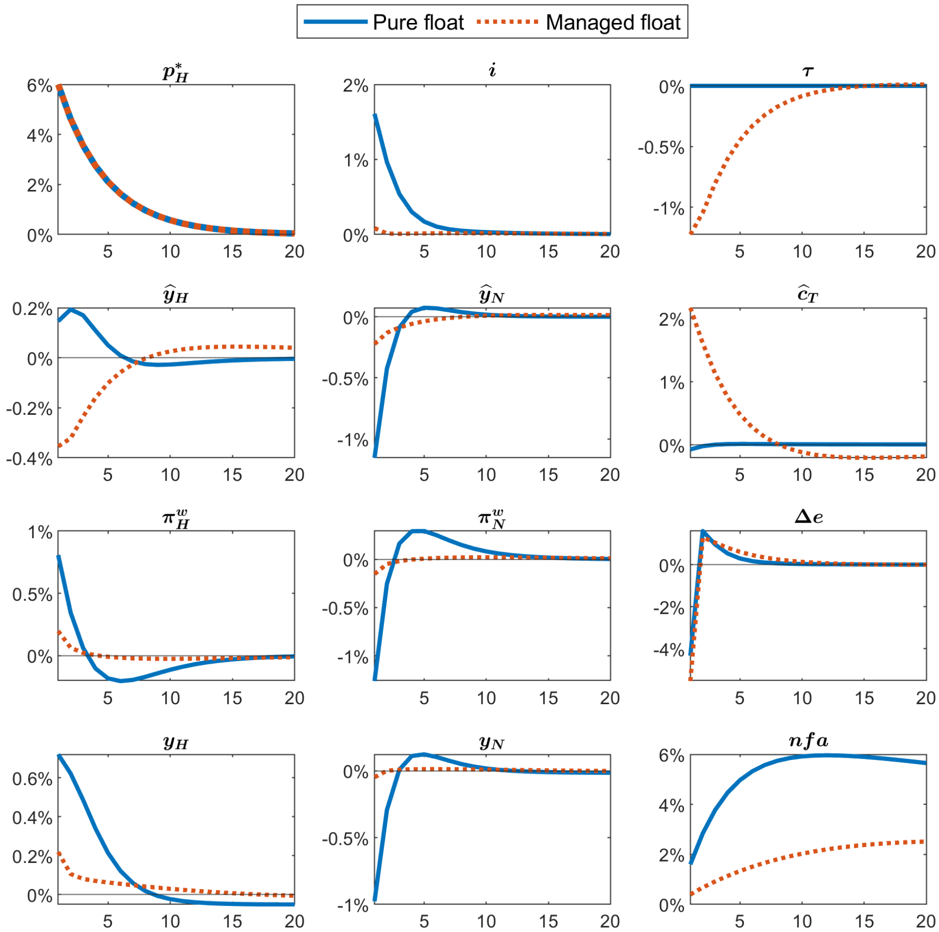

Figure 13: Impulse response function in response to a 1 SD shock to P_H^*

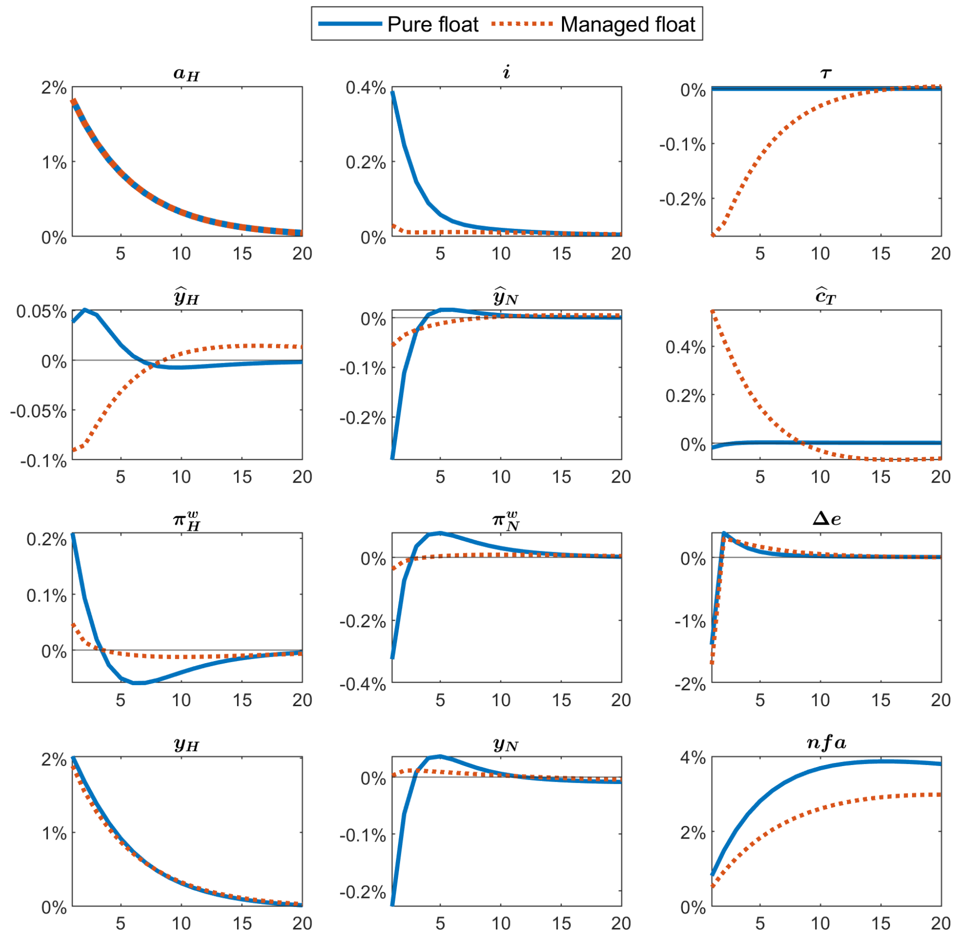

Figure 14: Impulse response function in response to a 1 SD shock to A_H

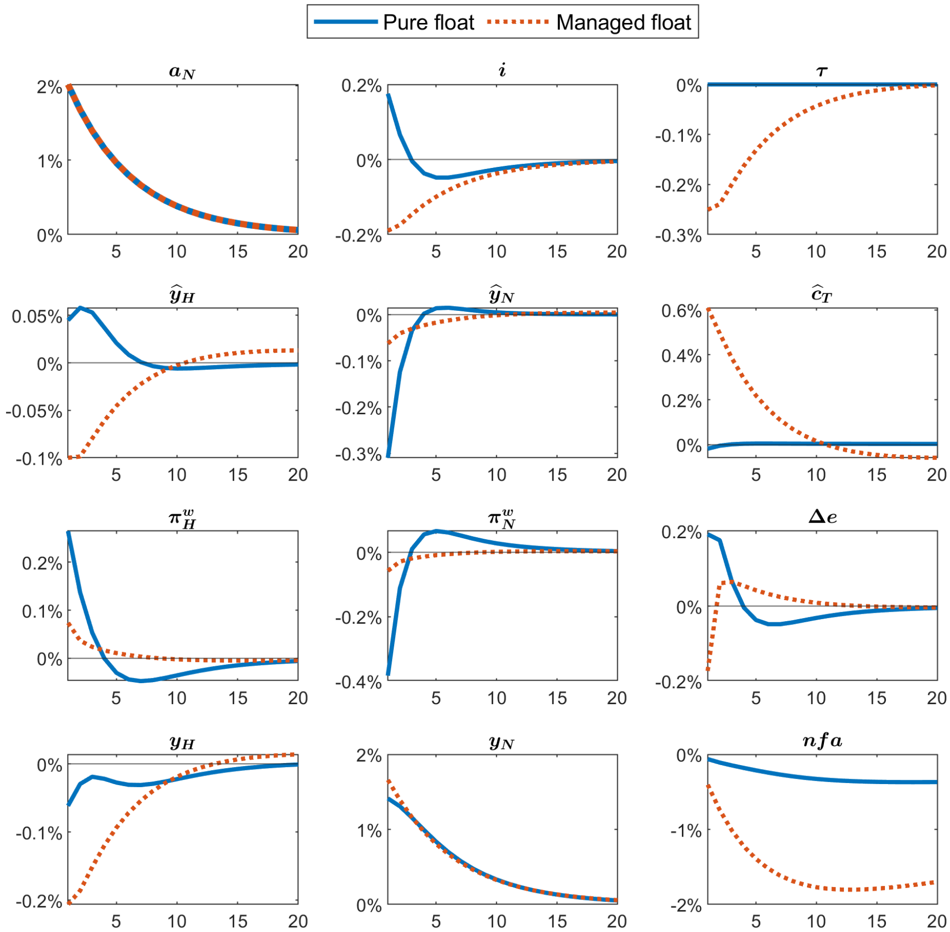

Figure 15: Impulse response function in response to a 1 SD shock to A_N

E Model evaluation

To test the performance of the model, we compare the untargeted moments produced by model simulations and the data. Since most of the sector level data are at the yearly frequency, we compare the standard deviation of annual growth rates. The comparison is shown in Table (10). The first column shows the unconditional standard deviation of the annual growth rates produced by the model and the second and third columns show the unconditional standard deviation of the annual growth rates found in the data after detrending it with a Hodrick-Prescott (HP) Filter and log-linear time trend respectively. The annual growth rate of sectoral output is slightly more volatile than what the data suggests, but it is of the same order of magnitude. The annual growth rate of sectoral labor matches the data quite well. The volatility is slightly higher than the data if we detrend the data with an HP Filter, but slightly lower than the data if we detrend the data using a log-linear time trend. Lastly, annual sectoral wage inflation is less volatile in the model. This can be explained by the fact that in many emerging market economies, especially in Latin American countries, inflation including wage inflation is heavily affected by fiscal spending shocks. This is not included in the model, therefore explaining the relatively low volatility of wage inflation. Overall, the model does a good job at matching the moments of sectoral output and labor which are the variables of importance in the model.

Table 10: Moment comparison

Variable	Model	Data (HP)	Data (log-linear)
$sd(\frac{Y_{H,t}}{Y_{H,t-4}})$	4.2%	2.8%	3.3%
$sd(\frac{Y_{N,t}}{Y_{N,t-4}})$	3.8%	1.4%	2.0%
$sd(\frac{L_{H,t}}{L_{H,t-4}})$	4.0%	2.9%	4.3%
$sd(\frac{L_{N,t}}{L_{N,t-4}})$	3.4%	2.5%	3.7%
$sd(\frac{W_{H,t}}{W_{H,t-4}})$	3.5%	4.2%	6.6%
$sd(\frac{W_{N,t}}{W_{N,t-4}})$	4.3%	3.6%	5.6%

F Commitment versus Discretion

In this section we compare the optimal policy allocations under commitment and discretion. We first derive the benefits from being able to commit and then explain why it is optimal to use capital controls even under discretion.

F.1 Benefits of commitment

We derive the benefits of being able to commit under a pure and managed float. In particular, we explain the gains of being able to commit to a rule under a timeless perspective relative to a discretionary solution.

We first quantitatively compare the welfare loss under commitment and discretion under both a pure float and a managed float. Table 11 shows the level of welfare less for each case in terms of permanent consumption lost relative to the first-best allocation. We can see that for each exchange rate regime, welfare loss is lower with commitment, but not by much. The gains from commitment are less than 0.1% of permanent consumption.

Table 11: Comparison of welfare loss under commitment and discretion

	Pure float	Managed float
Commitment	0.926%	0.122%
Discretion	0.980%	0.127%

The gains from commitment stem from the policymaker being able to internalize the effect of future variables on the expectations today. As in Gali (2015), under commitment the policymaker internalizes the effect of future wage inflation on wage inflation today, reducing the welfare cost from sectoral wage inflation. We show the standard deviation of sectoral wage inflation under commitment and discretion across a pure float and managed float in Table 12. Although the difference is small, commitment lowers the volatility of wage inflation in the non-tradable sector under a pure float and a managed float and the volatility of wage inflation in the tradable sector under a managed float. Alternatively, the volatility of wage inflation in the tradable sector under a pure float is slightly higher with commitment. This is because under commitment, the policymaker also considers how the expectation of future relative wages impacts the current period's relative wage which can increase the volatility of wage inflation.

Table 12: Comparison of wage inflation volatility under commitment and discretion

	$sd(\pi^w_{H,t})$		$sd(\pi^w_{N,t})$	
	Pure float	Managed float	Pure float	Managed float
Commitment	1.27%	0.29%	1.82%	0.23%
Discretion	1.23%	0.38%	1.92%	0.29%

F.2 Benefit of capital controls under discretion

Theoretically, it is not obvious whether it would be beneficial to use capital controls with discretion since future discretionary use of capital controls may create fluctuations in future variables that may reduce welfare today through expectations. It turns out that under the baseline calibration, capital controls are welfare improving even if they are used under discretion. As shown in Table 11, there is a 0.8% increase in permanent consumption following the use of capital controls under discretion.

The gains from using capital controls under discretion work in similar ways as the gains under commitment. Capital controls alleviate the sectoral trade-off faced by monetary policy under flexible exchange rates and allow freedom of monetary policy under fixed exchange rates. Figures 16 - 19 show this. With capital controls, the distortion from using monetary policy is much smaller leading to a much smaller non-tradable output gap. The qualitative features of the impulse response functions are similar to their commitment counterparts discussed in Section D.

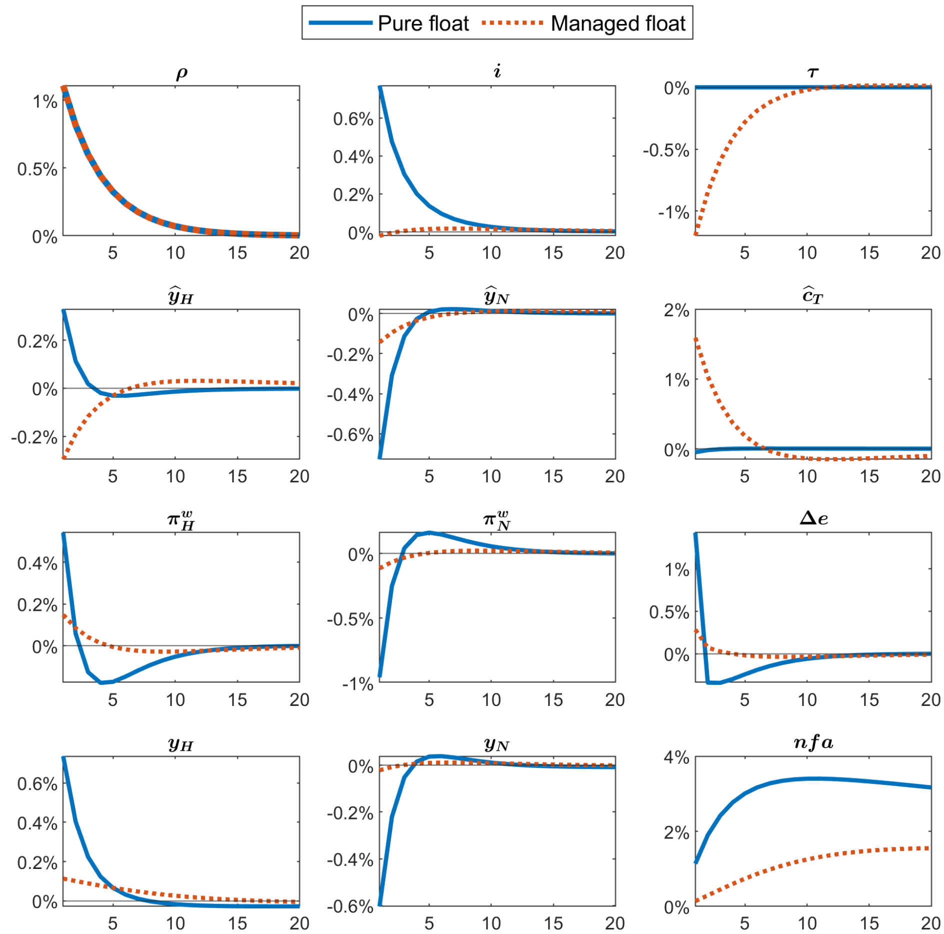

Figure 16: Impulse response function in response to a 1 SD shock to ρ under discretion

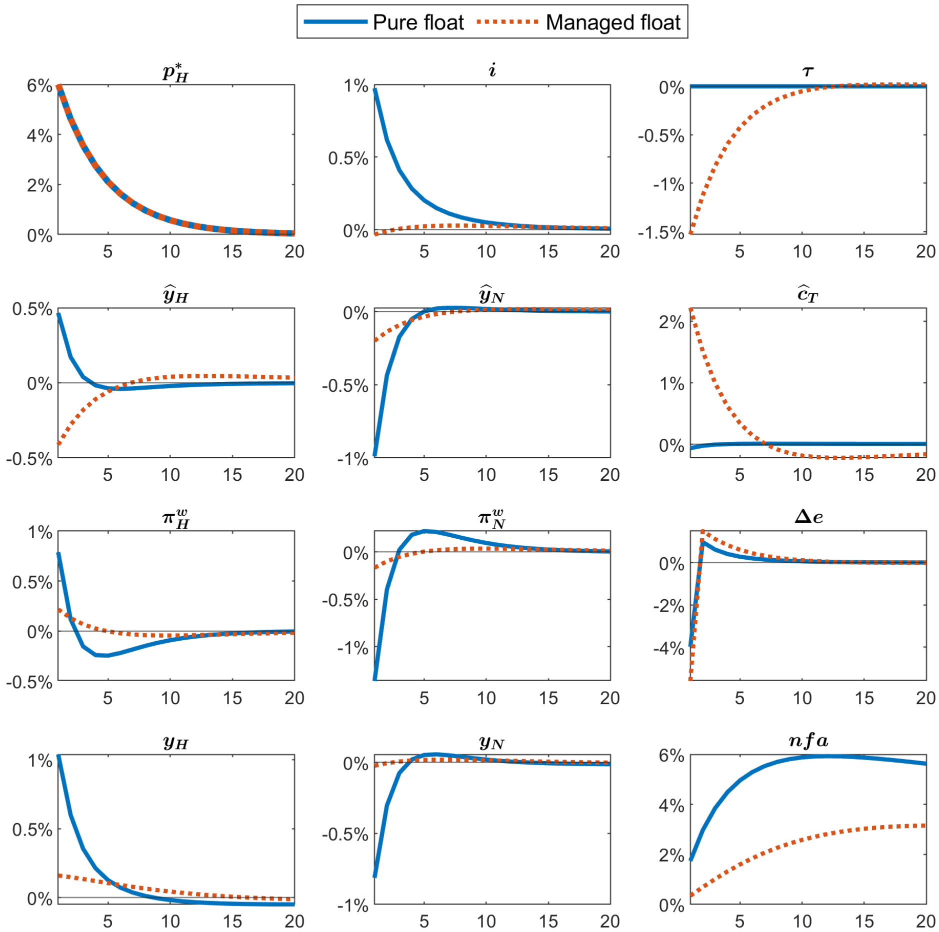

Figure 17: Impulse response function in response to a 1 SD shock to P_H^* under discretion

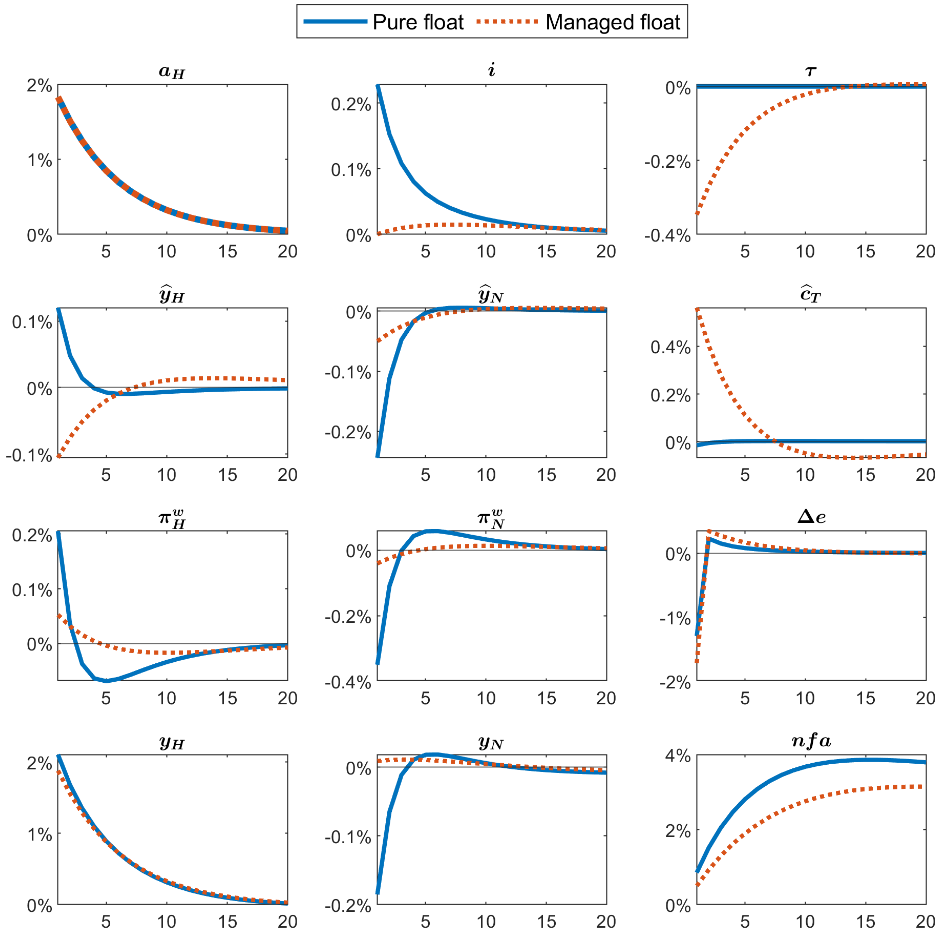

Figure 18: Impulse response function in response to a 1 SD shock to A_H under discretion

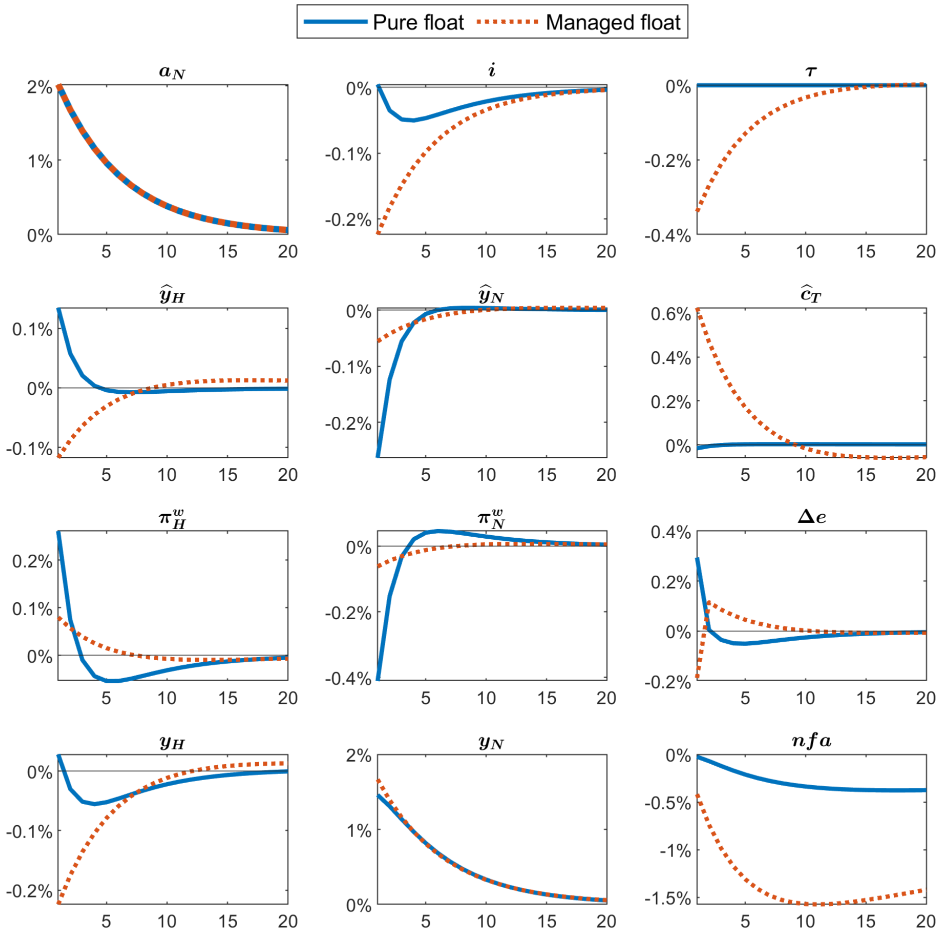

Figure 19: Impulse response function in response to a 1 SD shock to A_N under discretion