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When Is Liquidity Bad?

Husnu C. Dalgic[1]

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[1] University of Mannheim, Email: dalgic@uni-mannheim.de. URL: https://sites.google.com/view/husnucdalgic

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When Is Liquidity Bad? *

Husnu C. Dalgic
University of Mannheim †

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Abstract

Following U.S. monetary policy shocks, exchange rates exhibit two puzzling patterns: they initially depreciate sluggishly (delayed overshooting) before overshooting excessively. I show that incorporating FX speculators with subjective expectations resolves both puzzles by generating short-term momentum and excess volatility in exchange rates. When investors' expectations are sticky and backward-looking, their trading amplifies the initial sluggishness and subsequent overshooting. In contrast, the participation of investors with rational expectations helps to dampen such volatility. This distinction yields sharp policy implications: limiting the market participation of speculators with subjective expectations significantly lowers exchange rate volatility , while their presence also makes FX interventions and local monetary policy more effective by endogenously reinforcing central bank actions.

Key words: foreign financiers, capital controls, subjective expectations
JEL Codes: E44, F32, F41, G15, D84, E71

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†Email: dalgic@uni-mannheim.de. URL: https://sites.google.com/view/husnucdalgic

1 Introduction

Two key puzzles in exchange rate dynamics challenge conventional wisdom: delayed overshooting and excessive overshooting. The delayed overshooting puzzle (Eichenbaum and Evans (1995)) refers to the sluggish response of exchange rates to monetary shocks. In contrast, the excessive overshooting puzzle (Camara et al. (2024)) arises when exchange rates react too sharply to U.S. monetary policy shocks, depreciating so steeply that the subsequent expected appreciation increases local asset returns relative to dollar returns. Engel (2016) highlights a common pattern in both puzzles: exchange rates initially adjust slowly but later exhibit an exaggerated response. I show that subjective beliefs lead to both delayed and excessive overshooting. Furthermore, investors with subjective expectations amplify volatility and generate momentum in exchange rates. Policies limiting their participation in exchange rate markets could significantly reduce this volatility.

Delayed and excessive overshooting puzzles expose a paradox for investors: first, they forgo gains by under investing in dollar assets during delayed overshooting, and then they incur losses by overinvesting in dollar assets during excessive overshooting. Investors take positions in the exchange rate market presumably to make profits. Hence, they aim at buying when the exchange rate is cheap and sell when it is expensive; they provide liquidity to the market and their participation should smooth the exchange rate. However, when foreign investors hold subjective beliefs about future exchange rates (in the spirit of Adam et al. (2017)), these dynamics can instead exacerbate volatility.

Subjective expectations have been shown to explain puzzles in stock markets such as excess and persistent volatility (Adam et al. (2016, 2017)). For the exchange rate markets, deviating from rational expectations has also been shown to explain certain exchange rate puzzles such as forward premium and delayed overshooting puzzles (Gourinchas and Tornell (2004)). Bacchetta et al. (2009) use survey evidence to show that financial professionals make systemic errors; following their methodology, I also show that exchange rate depreciations lead to a positive expectation error, as professional market participants anticipate larger depreciations than those observed in the data. Ilut (2012) shows that ambiguity aversion can explain delayed overshooting, investors react slowly to profit opportunities due to fear of losses. Similarly, Müller et al. (2024) show that informational rigidities can account for delayed overshooting puzzle; investors learn about the state of economy so that they react to shocks slowly. While Bacchetta and van Wincoop (2021) demonstrate that sticky portfolios can explain these puzzles, they do so without specifying the microfoundations. However, Engel (2016) argues that investors reacting slowly is not consistent with excessive overshooting (Camara et al. (2024)) and excess volatility puzzles (Rogoff (1996); Devereux and Engel (2002)) because investors reacting slowly would imply low volatility of exchange rate. In this paper, I show that subjective expectations can account for both delayed and excessive overshooting puzzles. At the same time, it can explain excess volatility puzzle and momentum puzzle (Burnside et al. (2011)). In an extension to infrequent portfolio adjustments, Bacchetta and Van Wincoop (2010) consider investors basing their expectations only on interest rate differential, which increases predictability in the model. This paper relates closely to Kolasa et al. (2025), who demonstrate that introducing cognitive discounting into a New Keynesian open economy model helps resolve key exchange rate puzzles, such as the forward premium and predictability reversal anomalies. However, while their framework assumes a universal bias across all households and firms, I introduce heterogeneity in expectation formation: only foreign FX investors hold subjective beliefs, while domestic households and firms remain rational. This distinction is critical for two reasons. First, it isolates financial speculation as the specific source of excess volatility, enabling the evaluation of targeted policies—such as capital controls or FX interventions—that specifically limit speculative participation without distorting the intertemporal decisions of households. Second, I incorporate dominant currency pricing and balance sheet constraints. These structural features are essential for capturing the contractionary effects of exchange rate depreciations observed in Emerging Markets, allowing for a joint analysis of exchange rate anomalies and their transmission to the real economy

I build a small open economy model with financial frictions. In the model, households and foreign investors can borrow/lend in local currency and the dollar. While domestic agents hold rational expectations, foreign FX investors form subjective expectations à la Adam et al. (2017). Both local and foreigner investors are subject to preferred habitat; they would like to stay close to their target portfolio but can deviate from their targets if the return difference is high enough. Banks collect investments from households and foreigners and invest in non-financial firms which operate capital for goods production. Banks are subject to financial frictions similar to Gertler and Karadi (2011), which limits their borrowing capacity. Banks accept deposits both in local currency and dollars similar to Dalgic and Ozhan (2025), but their revenues (return from capital) is in local currency so that the financial system has a currency mismatch. Currency mismatch in the financial system creates balance sheet effects; exchange rate depreciations lead to losses in the financial system which limit their borrowing capacity in the subsequent periods and lead to investment decline.

Main source of uncertainty in the model is foreign interest rate shock. The idea of Global Financial Cycle shows that global asset prices move together and the US monetary policy is a strong driver of these cycles (Miranda-Agrippino and Rey (2020)). Similarly, two global factors explain more than half of the movements in exchange rates, particularly important for small open economies (Lustig et al. (2011); Dalgic and Ozhan (2025)). An increase in foreign interest rates make dollar assets more attractive for households and demand for dollar assets depreciate the exchange rate. Exchange rate depreciation leads to lower investment through balance sheet effects. Also, for lower elasticity of substitution between domestic and foreign inputs in production, exchange rate depreciations lead to lower production (Auclert et al. (2021)). It is also argued that significant amount of exchange rate fluctuations come from not fundamentals but noise trading (Eichenbaum et al. (2021); Itskhoki and Mukhin (2025)) and intervening against this kind of noise trading increases welfare (Itskhoki and Mukhin (2023)). In these models, excess volatility in exchange rates come from noise shocks. In our model, the behavior of investors create excess volatility; if foreign investors have unbiased expectations, they react only to fundamentals and trade in a way that reduces exchange rate volatility. On the other hand, foreign investors with subjective expectations will trade in a way that increases exchange rate volatility, their trading behavior looks like noise trading. I find that if foreign investors have subjective expectations, excluding them from the FX markets decreases macroeconomic volatility.

This paper also contributes to the literature on FX interventions. When the investors have unbiased expectations, they trade against the central bank and reduce the effectiveness of FX interventions. However, when foreign investors have subjective expectations, they see the initial exchange rate appreciation as a signal of further appreciation so they trade with the central bank by selling dollar assets, which further increases the exchange rate appreciation and makes FX intervention more effective.

The results complement the view that Global Financial Cycle limits domestic monetary policy in small open economies (Kalemli-Ozcan (2019); Miranda-Agrippino and Rey (2020)). In my framework, foreign investors with subjective expectations trade in a way to amplify the effects of foreign shocks. These investors see initial exchange rate depreciation as a signal of future depreciations and sell domestic assets even more, which makes the exchange rate depreciate even more and increases inflation through exchange rate pass through. Monetary policy is constrained because high inflation corresponds to a recession, further interest rate hikes would slow the economy further.

In this paper, I use data on exchange rate expectations to show that, following a depreciation, investors initially underestimate the extent of future declines, leading to a delayed reaction. Instead of fully incorporating the implications of the initial depreciation, investors anchor on prior beliefs or trends, causing them to react sluggishly. However, as they gradually process the new information and update their expectations, they overcompensate, anticipating excessive further depreciation that exceeds what is ultimately realized in the data. This pattern of slow adjustment and subsequent overreaction helps explain two key puzzles in exchange rate dynamics: delayed overshooting, where exchange rates continue to depreciate, and excessive overshooting, where the magnitude of depreciation far exceeds what is implied by interest rate differentials. By incorporating investors with subjective expectations into a small open economy model, I provide a unified framework that reconciles these puzzles and accounts for other well-documented phenomena, such as excess volatility and momentum effects. Importantly, the model predicts that when these investors with subjective expectations are excluded from the market, both exchange rate fluctuations and macroeconomic volatility decline.

2 Delayed and Excessive Overshooting

Figure 1 plots response of emerging market exchange rates following an unexpected 1% (APR) increase in US interest rate [1]. The red line at the bottom represents the hypothetical exchange rate constructed from interest rate responses under the assumption that uncovered interest rate parity (UIP) holds, while the black line depicts the actual exchange rate response.

Two major puzzles emerge from the data. First, the exchange rate continues to depreciate for approximately five months (delayed overshooting). During this period, holding U.S. dollars is profitable, yet investors switch to dollars gradually. The literature attributes this puzzle to frictions that slow investors' reactions to interest rate increases (Ilut (2012); Bacchetta and van Wincoop (2021); Müller et al. (2024)).

However, this slow reaction contradicts the second puzzle: the exchange rate depreciates far more than the UIP-implied level, with the magnitude of depreciation exceedingly large (excessive overshooting, Camara et al. (2024)). Then from its peak around month 5, the exchange rate appreciates so rapidly that holding U.S. dollars becomes unprofitable, raising the question of why investors continued to invest in them.

[1] Data are from Camara et al. (2024), the authors show that the magnitude and shape of the exchange rate response is similar in advanced economies and robust to changing sample.

Despite appearing contradictory, both puzzles share a common feature: first, investors underestimate the extent of future depreciation, and then they fail to anticipate the subsequent rapid appreciation. This paper demonstrates that if investors are slow to adjust their expectations, both anomalies can be reconciled.

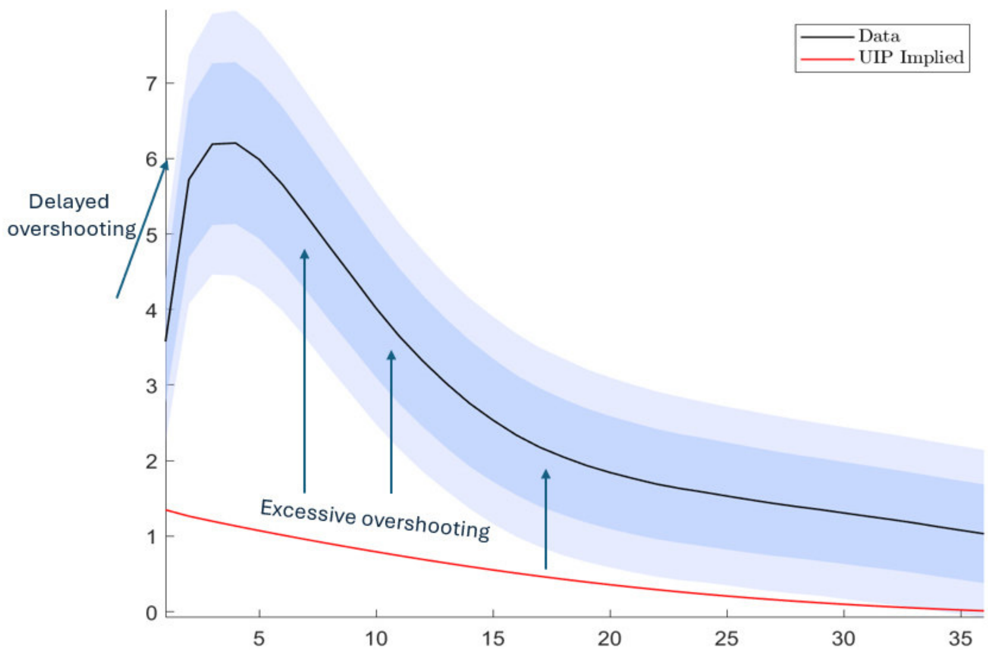


Figure 1: Delayed and Excessive Overshooting

Notes: Data source: Camara et al. (2024). Figure plots the response of the exchange rate following an unexpected 1% (APR) increase in US interest rates. IRF is constructed from Panel Bayesian VAR regressions using identified US monetary policy shocks from Bauer and Swanson (2023)

3 Exchange Rate Expectations

In this Section, I use data on exchange rate expectations to show whether there is systemic difference in expectation errors. Dataset is from FX4Casts from 10/2001 to 10/2018 and covers 26 currencies[2]; exchange rates are defined as LC per USD[3]. Data on exchange rates,

[2]Full set of currencies are Argentine Peso, Australian Dollar, Brazilian Real, Canadian Dollar, Chilean Peso, Colombian Peso, Czech Koruna, Danish Krone, Euro, Hungarian Forint, Indian Rupee, Indonesian Rupiah, Japanese Yen, Mexican Peso, New Zealand Dollar, Norwegian Krone, Philippine Peso, Polish Zloty, Russian Ruble, South African Rand, South Korean Won, Swedish Krona, Swiss Franc, Thai Baht, Turkish Lira, British Pound.

[3]Certain exchange rates (Euro, Pound etc) are reported in the raw data as USD per LC, in these cases I reverse the exchange rate (1/S) to get LC per USD value.

exchange rate expectations, and interest rates are collected at the end of each month. Exchange rate expectations are surveyed among major financial market players and are for 3 months ahead. Therefore, I convert our dataset to a quarterly format, taking only the last month of each quarter. For each currency i, I define realized and expected depreciation as $Depr_{i,t+1} = S_{i,t+1}/S_{i,t}$ and $Depr^e_{i,t+1} = \mathbb{E}^{SUBJ}_t (S_{i,t+1})/S_{i.t}$ respectively, where $\mathbb{E}^{SUBJ}_t$ are subjective expectations reported by financial market professionals. Currency returns are defined [4] as

$$Ret_{i,t+1} = \log(R_{i,t}) - \log(R^*_t) - \log(Depr_{i,t+1})$$

where expectation error is defined, $\left(\log(Depr^e_{i,t+1}) - \log(Depr_{i,t+1})\right)$. Following Bacchetta et al. (2009), I regress expectation error on date $t-1$ observables $\log(Depr_{i,t-1}) = \log(S_{i,t-1}/S_{i,t-2})$ and $Ret_{i,t-1}$[5].

	Dependent variable:					
	Expectation Error					
	OLS	*panel linear*		*OLS*	*panel linear*	
	(1)	(2)	(3)	(4)	(5)	(6)
$S_{i,t-1}/S_{i,t-2}$	0.056**	0.071***	0.028			
	(0.028)	(0.026)	(0.035)			
$Ret_{i,t-1}$				−0.073**	−0.075***	−0.056*
				(0.030)	(0.025)	(0.031)
Constant	−0.057**			−0.001		
	(0.028)			(0.002)		
Currency FE	No	Yes	No	No	Yes	No
Time FE	No	No	Yes	No	No	Yes
Observations	1,710	1,710	1,710	1,710	1,710	1,710
Residual Std. Error (df = 1708)	0.064			0.064		
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 1: Determinants of Exchange Rate Expectation Errors

Notes: Currency and time clustered standard errors in parenthesis. Quarterly data covers 2001Q3-2018Q3. Data source: FX4Casts

The results in Table 1 indicate that exchange rate depreciation leads to a positive expectation error, as investors anticipate larger future depreciations than those observed in the

[4] An alternative strategy to take a position in exchange rate markets is to use forward markets. Christiano et al. (2021) show that trading in the forward market is equivalent to borrowing and lending at risk free rates.

[5] I skip date t because both t and $t+1$ values include S_t

data. This pattern is consistent with two types of errors: (1) investors underreact initially, anchoring on past trends and only gradually adjusting their expectations, and (2) they overreact to recent depreciation, extrapolating past trends excessively into the future. Similarly, when a currency yields low returns, investors expect it to depreciate more than it actually does, further highlighting the role of expectation errors. Notably, this effect loses significance when time fixed effects are included, suggesting that expectation errors are clustered around common exchange rate depreciations across currencies. This reinforces the importance of global shocks in driving these patterns. Importantly, this sluggish expectation adjustment—whether due to underreaction or overreaction—can account for both delayed overshooting and excessive depreciation, suggesting the critical role of expectation formation in shaping exchange rate dynamics. In Appendix Section A, I look at the heterogeneity in exchange rate expectation bias. Results suggests that investors make more mistakes in currencies that are *less* exposed to global shocks.

I further examine the nature of these expectation errors by regressing the expectation error $\left(\log(Depr^e_{i,t+1}) - \log(Depr_{i,t+1})\right)$ on its lag. The results in Table 2 reveal a consistent underreaction and stickiness of expectations among investors. The OLS estimate of 0.15 indicates that a 1% expectation error at time t leads to a 0.15% expectation error at time . This underreaction remains robust when controlling for country-specific heterogeneity. However, when time fixed effects are included to account for global shocks (e.g., the global financial cycle or US monetary policy changes), the coefficient drops to 0.12 and loses significance, indicating that much of the underreaction is driven by common global factors. These findings further emphasize the importance of global shocks in shaping expectation errors and highlight the persistence of underreaction of expectations at the currency level.

Following Froot and Frankel (1989), I also regress the expectation error on expected depreciation and similarly find a positive and significant coefficient (Table 2, column 4). Combined with the first columns, the positive coefficient means that investors have sticky exchange rate expectations and this stickiness creates a bias.

	Dependent variable:				
	Expectation Error				
	OLS	*panel linear*			
	(1)	(2)	(3)	(4)	(5)
Lag Expectation Error	0.151^{***}	0.140^{***}	0.124		
	(0.052)	(0.047)	(0.088)		
Lag Expectations				0.152^{**}	0.053
				(0.061)	(0.080)
Constant	-0.001				
	(0.002)				
Currency FE	No	Yes	No	Yes	No
Time FE	No	No	Yes	No	Yes
Observations	1,736	1,736	1,736	1,736	1,736
Residual Std. Error	0.065 (df = 1734)				
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 2: Exchange Rate Expectation Error Autocorrelation

Notes: Currency and time clustered standard errors in parenthesis. Quarterly data covers 2001Q3-2018Q3. Data source: FX4Casts

In addition, we run forecast revision regressions in the spirit of Coibion and Gorodnichenko (2015). I regress 3 months expectation error ($\log S_{t+2} - \log S^e_{t+2|t+1}$) on the forecast revision ($\log S^e_{t+2|t+1} - \log S^e_{t+2|t}$), where S_{t+2} is the spot exchange rate at quarter $t+2$, $S^e_{t+2|t+1}$ is the 3 month forecast of S_{t+2} at $t+1$ and $S^e_{t+2|t}$ is the 6 months forecast of S_{t+2} at quarter t. In line with the literature, Table 3 shows a positive coefficient. Similar to previous regressions, the effect becomes statistically insignificant if controlled for time fixed effects.

	Dependent variable:		
	Forecast Error		
	OLS	*panel linear*	
	(1)	(2)	(3)
Forecast Revision	0.097*	0.088*	0.063
	(0.050)	(0.047)	(0.081)
Constant	0.001		
	(0.002)		
Currency FE	No	Yes	No
Time FE	No	No	Yes
Observations	1,738	1,738	1,738
Residual Std. Error	0.065 (df = 1736)		
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 3: Exchange Rate Expectation Revision

Notes: Currency and time clustered standard errors in parenthesis. Quarterly data covers 2001Q3-2018Q3. Data source: FX4Casts

Underreaction of exchange rate expectations translate into overreaction of return expectations. For example, initial depreciation and subsequent appreciation of exchange rate following an increase in US interest rates counter high USD returns (in the case of UIP, exchange rate completely offsets interest rate differential). If investors underreact to exchange rate movements, they overreact to interest rate difference and trade more aggressively.

4 Model

I build a small open economy New Keynesian model based on Dalgic and Ozhan (2025) and Camara et al. (2024). The model structure is designed to reflect the empirical observation that US monetary policy shocks trigger sharp contractions in small open economies (Cesa-Bianchi et al. (2024)), primarily driven by declines in investment (Camara et al. (2024)). To capture these dynamics, the model relies on two critical frictions. First, dollar invoicing of exports (Goldberg and Tille (2008) and Gopinath et al. (2020)) dampens the responsiveness of exports to exchange rate movements. Second, dollar-denominated debt (Dalgic and Ozhan (2025)) creates adverse balance sheet effects following exchange rate depreciations. These frictions are necessary to replicate the data; without them, a standard open economy model would counterfactually predict that depreciations stimulate the economy, rendering it unsuitable for analyzing the welfare costs of exchange rate volatility in small open economies.

Crucially, the model also incorporates subjective expectations, which generate exchange rate movements consistent with the data, including delayed and excessive overshooting. These expectation-driven exchange rate dynamics interact with the frictions to amplify the harmful effects of exchange rate depreciations on the real economy, particularly in emerging markets. By integrating both frictions and subjective expectations, the model allows me to study the interaction between exchange rate behavior and macroeconomic outcomes. In the absence of frictions, exchange rate movements could stimulate the economy, making exchange rate volatility less detrimental. However, when frictions are present, exchange rate volatility becomes harmful, as it exacerbates balance sheet effects and dampens export response (Dalgic and Ozhan (2025)) . This highlights the importance of modeling both frictions and subjective expectations to capture the realistic relationship between exchange rate movements and the real economy. For example, I examine how excluding speculators with subjective expectations from the market affects macroeconomic volatility (Section 5.5) and this exercise requires that the model accurately captures the effects of exchange rate depreciations on the real economy. Details of the model are in Appendix Section B. In the model, households maximize discounted sum of life time utility,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(u\left(C_t\right) - \frac{l_t^{1+\varphi}}{1+\varphi} - \frac{1}{2} \overbrace{\gamma\left(\Theta_t - \Upsilon_t\right)^2}^{\text{Disutility of deviating from target portfolio}} \right)$$

where Θ_t is the share of dollar assets in the portfolio and Υ_t is the target portfolio (preferred habitat similar to Camara et al. (2024) and Gourinchas et al. (2022)). Households get disutility if their portfolio deviates from their target. Household budget constraint,

$$D_t + S_t D_t^* + P_t^c C_t = D_{t-1} R_{d,t-1} + S_t R_{d,t-1}^* D_{t-1}^* + W_t l_t + \Pi_t$$

Households can invest in local currency (D_t) and dollar (D_t^*) assets. They get income from these assets as well as labor income and profits and transfers. First order conditions imply in the linearized model,

$$r_t - [r_t^* + \mathbb{E}_t s_{t+1}] = -\gamma(\Theta_t - \Upsilon_t)$$

In the absence of portfolio frictions ($\gamma = 0$), the linearized model will not feature any interest rate spread because any expected return difference will be eliminated by households trading.

4.1 Goods Production

The production side of the economy consists of a continuum of intermediate goods, a domestic homogeneous final good, and three distinct expenditure sectors: consumption (C_t), investment (I_t), and exports (X_t). A key feature of the economy is that all three final sectors combine the domestic homogeneous good with imported inputs.

Intermediate and Homogeneous Goods

Production begins with intermediate goods, $Y_{i,t}$, produced by monopolistically competitive firms using capital and labor via a Cobb-Douglas technology:

$$Y_{i,t} = K_{i,t-1}^{\alpha} \left(l_{i,t}\right)^{1-\alpha}$$

These firms face nominal rigidities à la Calvo. In every period, only a fraction $(1-\theta)$ of firms can reset their domestic currency prices. These intermediate varieties are aggregated into a domestic homogeneous good, Y_t, which serves as the primary domestic input for the final expenditure sectors:

$$Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

Market clearing requires that the supply of the homogeneous good satisfies the domestic input demand derived from the consumption, investment, and export sectors ($Y_t = I_t^d + C_t^d + X_t^d$).

Final Consumption and Investment

Households consume a bundle of domestic goods and imported foreign inputs. The aggregation takes a CES form, where ω_c governs the import share and η_c represents the elasticity of substitution:

$$C_t = \left[(1-\omega_c)^{\frac{1}{\eta_c}} \left(C_t^d \right)^{\frac{\eta_c - 1}{\eta_c}} + \omega_c^{\frac{1}{\eta_c}} \left(C_t^m \right)^{\frac{\eta_c - 1}{\eta_c}} \right]^{\frac{\eta_c}{\eta_c - 1}}$$

Because the consumption basket includes foreign inputs priced in dollars, the consumer price index (P_t^c) is directly exposed to exchange rate fluctuations. Consequently, high exchange rate volatility translates into volatile consumer prices, reducing real incomes (see Auclert et al. (2021)). Similarly, capital is produced by banks combining domestic and foreign inputs. The law of motion for capital includes adjustment costs, $S(\cdot)$, which depend on the change in investment flow:

$$K_t = (1-\delta) K_{t-1} + \left[1 - S\left(\frac{I_t}{I_{t-1}} \right) \right] I_t$$

The Export Sector

The export sector combines domestic inputs with imports to produce a final good for the foreign market. The demand for local exports is downward-sloping and depends on the relative price of exports (P_t^x) to the foreign price level (P_t^f):

$$X_t = \left(\frac{P_t^x}{P_t^f} \right)^{-\eta_f} Y_t^f$$

Following Gopinath et al. (2020), we assume dominant currency pricing (DCP). A fraction $(1-\theta^x)$ of exporters can reset their prices in dollars each period, while the remainder acts conventionally. This price stickiness in dollars dampens the expenditure-switching channel, making exchange rate depreciations potentially recessionary by limiting the quantity response of exports while raising the cost of imported inputs Dalgic and Ozhan (2025).

4.2 Financial System

The financial system consists of banks that intermediate funds between households, foreign investors, and non-financial firms. Figure 2 illustrates this structure. Banks collect deposits from households and foreign investors in both local currency and US dollars, then channel these funds to local firms to finance capital production.

A critical feature of this setup is the currency mismatch on bank balance sheets. While banks lend to firms in local currency (since firm revenues are in local currency), a portion of bank funding is denominated in dollars. Consequently, the financial system is exposed to exchange rate risk; depreciations erode bank net worth, tighten balance sheet constraints, and lead to a contraction in investment.

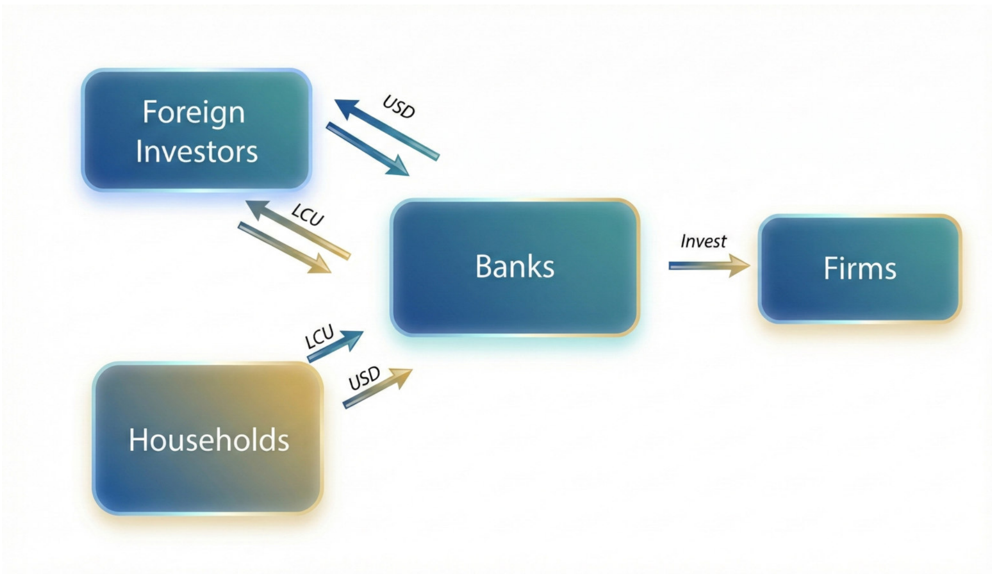


Figure 2: Financial Markets

4.2.1 Banks

Banks borrow from households and foreigners to finance firm investment, but their leverage is limited by financial frictions Gertler and Karadi (2011). Specifically, an incentive constraint ties a bank's borrowing capacity to its net worth (equity).

Banks choose the composition of their liabilities by borrowing in either local currency (LC) or USD. While they prefer the currency with the lower cost of funds, they also face a motive to maintain a balanced portfolio that aligns with a specific target, following the specification in Dalgic and Ozhan (2025). Details of the banker's optimization problem are provided in Appendix Section B.2.

4.3 Foreign Speculators

Foreign investors participate in the local currency market by holding positions in local currency bonds, denoted by B_t^F. Following Gabaix and Maggiori (2015), these investors face leverage constraints that limit their arbitrage capabilities. Investors maintain an initial "preferred habitat" or target portfolio, B^F. They choose their active deviation from this target, $(B_t^F - B^F)$, by maximizing the expected excess return on the position subject to a financial friction. The optimization problem is given by:

$$\max_{B_t^F} V_t = (B_t^F - B^F)\left(\mathbb{E}_t^j\left(\frac{R_t S_t}{S_{t+1}}\right) - R_t^*\right)$$

Subject to the incentive compatibility constraint:

$$V_t \geq \lambda(\mathbb{V}s_{t+1})\left(B_t^F - B^F\right)^2$$

This constraint reflects the cost of deviating from the preferred habitat. As in Gabaix and Maggiori (2015), the constraint tightens when the exchange rate is more volatile, reflecting limited risk-bearing capacity. Assuming the constraint binds, the solution to the foreign investor's problem yields the following demand function:

$$\left(B_t^F - B^F\right) = \frac{\mathbb{E}_t^j\left(\frac{R_t S_t}{S_{t+1}}\right) - R_t^*}{\lambda(\mathbb{V}s_{t+1})}$$

For the incentive-habitat constraint I assume the tightness of the constraint, $\lambda(\cdot)$, takes the following functional form:

$$\lambda(\mathbb{V}s_{t+1}) = \lambda^f + \mu\mathbb{V}s_{t+1} \tag{1}$$

where $\mu\mathbb{V}s_{t+1}$ represents how investors adjust their positions in response to volatility. Importantly, λ^f is the key parameter governing the tightness of the incentive-habitat constraint, which limits investors' willingness to deviate from their preferred portfolios. A higher λ^f implies that investors scale down their positions for any given interest rate spread.

The limiting cases of λ^f offer important economic interpretations. As $\lambda^f \to \infty$, investors remain strictly within their habitat portfolios, refusing to adjust their holdings even when expected profits are substantial. Conversely, as $\lambda^f \to 0$, investors behave like mean-variance optimizers, responding strongly to expected returns. In fact, whenλ^f is sufficiently low, their reactions are so pronounced that they effectively eliminate expected excess returns, driving them to near zero. In Section 5.5, I interpret an increase inλ^f as a policy tool to restrict foreign investors' participation in FX markets.

4.3.1 Expectations

I model foreign investor behavior using two distinct expectation formation frameworks: full information rational expectations (FIRE) and subjective beliefs. First, under the FIRE benchmark, investor expectations coincide with objective probabilities:

$$\mathbb{E}_t^{FIRE}\left(\frac{S_t}{S_{t+1}}\right) = \mathbb{E}_t\left(\frac{S_t}{S_{t+1}}\right) \tag{2}$$

Second, I consider subjective beliefs following the specification in Adam et al. (2017). Here, expectations are formed adaptively:

$$\mathbb{E}_t^{SUBJ}\left(\frac{S_t}{S_{t+1}}\right) = \beta_1 \mathbb{E}_t^{SUBJ}\left(\frac{S_{t-1}}{S_t}\right) + \beta_2 \frac{S_{t-2}}{S_{t-1}} \tag{3}$$

To calibrate this mechanism, I estimate the regression specified in Equation 3 [6]. The results in Table 4, I find $\hat{\beta}_2 \approx 0.05$, which aligns closely with the estimate of 0.0264 Adam et al. (2017).

	Dependent variable:	
	$\mathbb{E}_t^{SUBJ}\left(\frac{S_t}{S_{t+1}}\right)$	
	OLS	*panel linear*
	(1)	(2)
$\mathbb{E}_t^{SUBJ}\left(\frac{S_{t-1}}{S_t}\right)$	0.209***	0.148***
	(0.042)	(0.027)
$\frac{S_{t-2}}{S_{t-1}}$	0.057***	0.050***
	(0.012)	(0.004)
Observations	1,736	1,736
Residual Std. Error	0.016 (df = 1733)	
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 4: Subjective Expectations

[6] Refer to Section 3 for details of the data.

Motivation for Subjective Expectations

The reliance on subjective expectations in FX markets is well-supported by the literature on information frictions. Chakraborty and Evans (2008) argue that while traders understand that a link exists between fundamentals and exchange rates, they lack precise knowledge of the mechanism. Consequently, they engage in a perpetual learning process, refining forecasts using historical data. Similarly, Adam et al. (2017) motivate this functional form within a Bayesian framework where fundamentals are driven by a persistent, latent factor. Because traders cannot observe this factor in real time, they must extract signals from past price movements, leading to expectations that are "sticky" or backward-looking.

This backward-looking behavior is particularly prevalent during periods of high volatility. In the literature, this information friction often leads to cautious behavior. For example, Müller et al. (2024) show that when traders are uncertain about the nature of shocks, they act slowly, creating "delayed overshooting." Similarly, Ilut (2012) argues that ambiguity aversion leads to cautious behavior.

My model generates this empirically relevant "hump-shaped" response via sticky expectations, but the dynamic is driven by a specific pattern of forecast errors. Because agents rely on backward-looking data (Equation 3), their reaction evolves in two phases. First, initial underestimation: When the shock first hits, investors' beliefs are anchored by the previously stable exchange rate. They underestimate the extent to which the currency will continue to depreciate, leading to a delayed reaction. Second, subsequent overestimation: Once the depreciation is fully reflected in their information set, they extrapolate this trend forward. They overestimate how long the depreciation will last and fail to anticipate the exchange rate's eventual mean reversion.

This "underestimate then overestimate" dynamic aligns with the "chartist" behavior described by Froot and Frankel (1989) and Allen and Taylor (1990), where traders rely on heuristics during periods of volatility. It effectively generates momentum in the exchange rate: agents are slow to price in the crash, and then slow to price in the recovery.

These heuristic approaches generate momentum trading (Hong and Stein (1999)). Despite the traditional view that speculators stabilize prices by "leaning against the wind," empirical evidence suggests sophisticated investors often amplify trends. For instance, Brunnermeier and Nagel (2004) show that hedge funds heavily rode the Dot-com bubble rather than correcting it, and Moskowitz et al. (2012) find that speculator positions in futures markets are characterized by net positive momentum. In the context of my model, Equation 3 captures this dynamic. Estimated β_1 close to 1 implies that traders view the exchange rate roughly as a random walk but update their beliefs based on recent data. This "sticky" expectation formation reflects a simplified forecasting process where agents, unable to disentangle complex shocks (e.g., monetary policy or geopolitical shifts) in real time, focus instead on observable price dynamics.

4.4 Foreign Sector

Small open economy takes foreign interest rates (R_t^*) and foreign demand (Y_t^f) as given. Both follow exogenous AR(1) processes. Following Camara et al. (2024) I assume that foreign interest rate shocks adversely affect foreign demand for exports.

$$
\begin{aligned}
R_t^* &= (1-\rho_{R^*})R^* + \rho_{R^*}R_{t-1}^* + \varepsilon_t^R \\
Y_t^f &= (1-\rho_{Y^f})Y^f + \rho_{Y^f}Y_{t-1}^f + \gamma(R_t^* - R^*) + \varepsilon_t^{Yf}
\end{aligned}
$$

4.5 Uncertainty

In the model, I focus on foreign interest rates as the source of uncertainty. Extensive literature talks about how foreign interest rate shocks drive small open economy business cycles (Neumeyer and Perri (2005) and Fernandez-Villaverde et al. (2011)). Similarly, global asset prices follow global financial cycle and US interest rates are found to be an important source of its volatility (Kalemli-Ozcan (2019); Miranda-Agrippino and Rey (2020)). An increase in foreign interest rates makes dollar assets more attractive, driving dollar demand higher among both residents and foreign speculators. This surge in demand for dollar assets causes a depreciation of the local currency, which has several effects on the economy: first, it raises consumer inflation through exchange rate pass-through, leading the central bank to hike interest rates. Second, depreciation weakens bank balance sheets, as many banks have dollar-denominated liabilities but earn revenue in local currency. On the positive side, depreciation can stimulate local production by boosting exports and discouraging imports. However, as discussed in Section 4.4, higher foreign interest rates reduce external demand for exports (see Camara et al. (2024)), sticky export prices limit price adjustment and low short-run import substitution elasticity limits the shift away from imports. Together, these factors weaken the expenditure-switching channel. Overall, unlike the classical Mundell-Fleming framework, an increase in foreign interest rates leads to an economic slowdown in a small open economy.

4.6 Parameters

Table 5 summarizes the model parameterization. I borrow the structural parameters from Camara et al. (2024), who estimate them for a set of Emerging Market Economies. This ensures the model captures standard EME business cycle moments.

Specifically, for the parameter governing subjective expectations, I rely on direct estimation using forecasts from financial market participants (Section 4.3.1). This approach ensures that the key behavioral mechanism is disciplined by the actual expectations of the agents modeled in the paper, yielding a coefficient consistent with estimates in the broader behavioral finance literature.

Elasticities of substitution between domestic and imported inputs for consumption, investment, and exports are set lower than 1. This implies they are complements; when the exchange rate depreciates, replacing imported inputs with domestic production is difficult. The consumption elasticity is particularly low, causing a sharp decline in consumption following depreciations. This captures the real income channel of exchange rates discussed by Auclert et al. (2021)

Variable	Description	Value
β	Discount Factor	0.995
α	Capital Share	0.340
δ	Depreciation	0.020
φ	Inverse Frisch	1.000
r_π	Taylor Inflation Coefficient	1.500
r_y	Taylor Output Coefficient	0.000
r_S	Taylor Exchange Rate Coefficient	0.020
ε	Elasticity of Substitution, intermediate goods	6.000
θ	Calvo Parameter, intermediate goods	0.750
ε^x	Elasticity of Substitution, export goods	6.000
γ	Target Portfolio Cost (UIP Friction)	2.560
θ^x	Export Calvo Stickiness	0.800
κ	Investment Adjustment Cost	5.850
η_c	C, Elasticity of Substitution	0.410
$1-\omega_c$	Home Bias, C	0.830
ω_i	Home Bias, I	0.290
γ_x	Home Bias, X	0.500
η^f	Elasticity of Demand, Exports	1.530
η_i	I, Elasticity of Substitution	0.910
η_x	X, Elasticity of Substitution	0.700
ρ_R	MP Persistence	0.900
ϕ	Target Credit Dollarization	0.500
Υ	Target Deposit Dollarization	0.200
$\frac{d^*}{Y}$	Dollar Deposit/GDP	0.500
γ_R	Export Demand Shifter	0.000
θ	Banker survival	0.972
W_b	Banker startup	0.030
λ	Banker constraint	0.300

Table 5: Parameter Values

5 Results

In this section, I explore the pivotal role that speculators' expectations play in the transmission of external shocks to a small open economy. First, I examine how a foreign interest rate shock impacts the domestic economy, depending on whether foreign currency speculators hold unbiased or subjective expectations.

Following this, I analyze the effects of excluding foreign speculators from the market, again focusing on how the nature of their expectations—whether forward-looking or subjective—influences the overall economic outcome. I find that when foreign investors have unbiased expectations (as in Equation 2), their participation in the financial markets has a positive but small impact, their exclusion makes the exchange rate slightly more volatile. However, when foreign investors have subjective expectations (as in Equation 3), their participation makes the exchange rate much more volatile so that their exclusion smooths the exchange rate.

5.1 Response to Foreign Interest Rate Shock

Figure 3 shows the impulse response to a 1% increase in the foreign interest rate across three different economic scenarios, comparing the effects in economies with foreign currency speculators holding unbiased expectations and those with subjective expectations. In all cases, an increase in foreign interest rates causes an immediate depreciation of the domestic exchange rate. In the economy with speculators holding unbiased expectations, the uncovered interest rate parity (UIP) condition holds, meaning that the interest rate spread remains close to zero and does not move significantly. The behavior of the economy without speculators closely mirrors that of the economy with unbiased speculators. This is because households, though they lack speculative activity, are forward-looking and tend to trade in the same direction as unbiased speculators, albeit with a preference for their own "habitat" in financial markets. In contrast, in the economy with speculators holding subjective expectations, the dynamics are notably different. The initial depreciation in the exchange rate creates an expectation of further depreciation. Speculators respond by selling the domestic currency, leading to a decrease in b^*, which further amplifies the depreciation. This exacerbated depreciation intensifies pass-through inflation, driving up interest rates in response. The large and sustained depreciation also triggers balance sheet effects, particularly for entities holding dollar-denominated debt. The combination of high interest rates and balance sheet stress leads to a sharp decline in investment. However, the significant depreciation also boosts exports, providing a temporary lift to GDP. Despite this, the overall economic impact is negative, as both consumption and investment suffer severe declines, driven by the adverse effects of inflation, higher interest rates, and financial fragility. This highlights how subjective expectations among speculators can create self-reinforcing cycles of currency depreciation and economic instability.

When foreign investors have subjective expectations, the exchange rate displays both delayed (Eichenbaum and Evans (1995)) and excessive (Camara et al. (2024)) overshooting. Following a foreign interest rate shock, the exchange rate depreciates sharply and continues to depreciate further, forming an inverse U shaped response. Following the initial depreciation, the UIP spread turns significantly negative, reducing local asset returns. This prompts speculators to sell local assets; b_t^* goes down for several periods (Panel 2,1 in Figure 3). Households also switch their portfolio towards dollars (Panel 2,2). After several quarters, the exchange rate begins appreciating rapidly, making local assets more attractive. Households reallocate to local assets, reducing dollarization. However, foreign investors remain slow to reinvest despite higher local returns, as they do not anticipate the rapid appreciation. In Section D, I look at how other frictions shape the impact of foreign interest rate shocks. Dollar debt and export price stickiness affect real variables like GDP and investment. However, it is the expectation formation that determines the size and pattern of the exchange rate response.

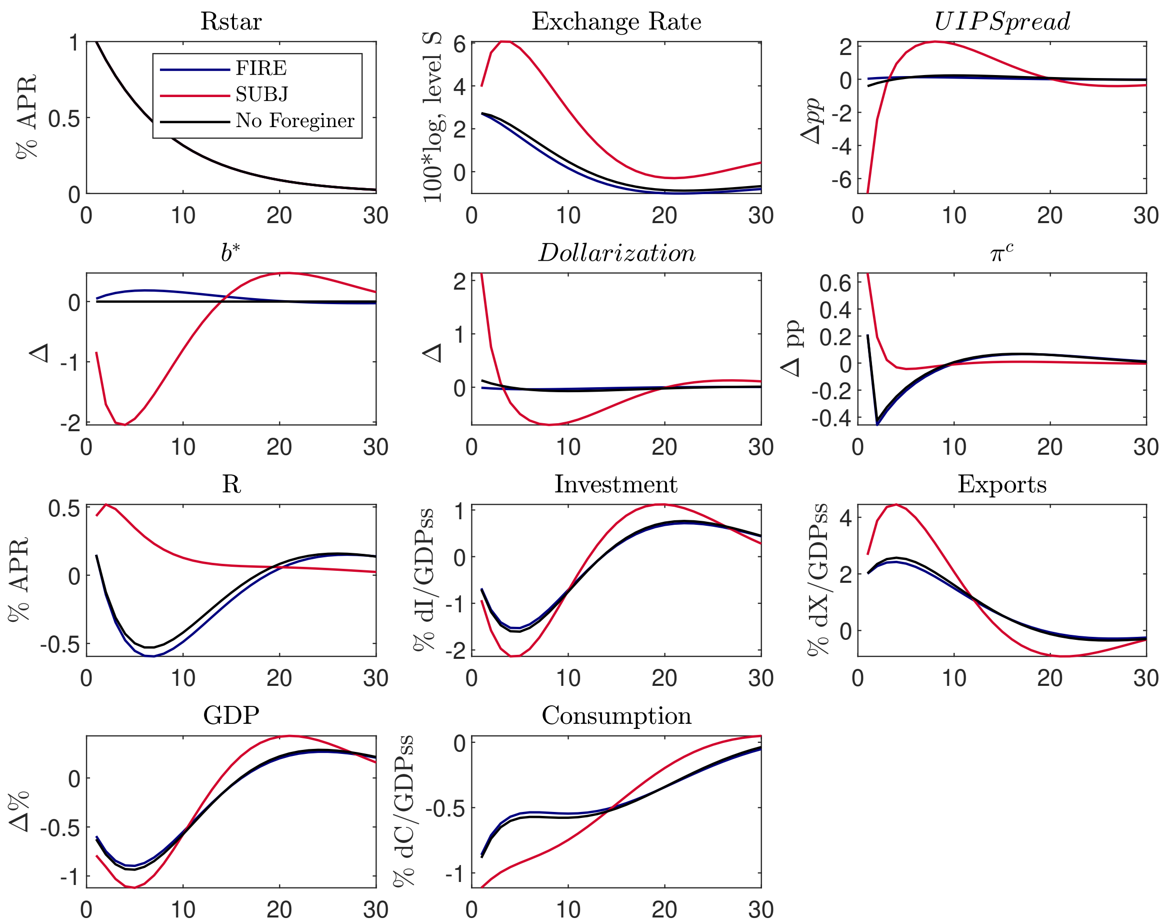


Figure 3: Response to Foreign Interest Rate Shock

5.2 Delayed and Excessive Overshooting

Figure 4 compares subjective exchange rate expectations with the unbiased expectation (the realized path) from Figure 3. Initially, subjective expectations are below rational expectations; investors underestimate the momentum of the exchange rate so that they do not switch to dollar assets as much as they should have. This underestimation in investor expectation creates delayed overshooting. Once the exchange rate reaches its peak, investors underestimate the speed of the appreciation. As a result of this underestimation, they hold on to their dollar assets, which creates excessive overshooting.

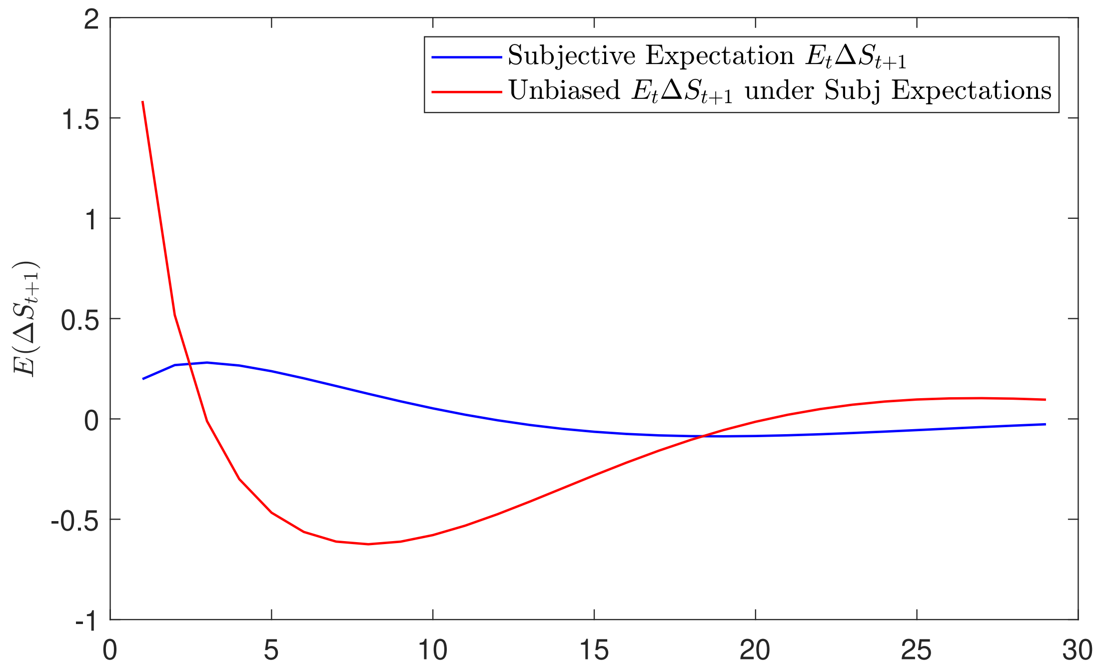


Figure 4: Exchange Rate Depreciation Expectations in response to Foreign Interest Rate Shock

5.3 Fama Regressions and Momentum in FX Markets

Fama (1984) introduced a key empirical framework for testing the Uncovered Interest Parity (UIP) in foreign exchange (FX) markets. His regression examines the relationship between interest rate differentials and subsequent exchange rate changes:

$$\Delta S_{t+1} = \alpha + \beta^{\text{Fama}}(r_t - r_t^*) + \varepsilon_{t+1} \tag{4}$$

Under UIP, the coefficient β should be equal to 1 if risk premia are absent and rational expectations hold. However, empirical findings consistently show $\beta < 1$ often negative, implying a violation of UIP and the presence of currency risk premia. Specifically, $\beta < 1$ implies that exchange rate does not offset the change in interest rates. A related puzzle documented by Burnside et al. (2011) is that the momentum strategy in FX markets—investing in recently outperforming currencies—yields high returns with a Sharpe ratio comparable to that of the US stock market. Momentum regression,

$$\Delta S_{t+1} = \alpha + \beta^{\text{Mom}} \Delta S_t + \varepsilon_{t+1} \tag{5}$$

In this section, I run Fama and momentum regressions and show that subjective expectations can explain both phenomenon. For the three models—investors with subjective expectations, rational expectations, and no foreign investor I simulate the model and run equations 4 and 5. Table 6 plots the regression results from simulations as well as from the data. In the absence of foreign speculators, or when foreign speculators have rational expectations, exchange rate does not have momentum, past depreciations do not help predicting future depreciations. On the other hand, when foreign investors have subjective expectations, exchange rate displays significant momentum. Similarly, under foreign investors with rational expectations, Fama regressions yield coefficient very close to 1. On the other hand, in the economy with investors with subjective expectations, Fama coefficient is significantly below 1 and close to the data.

In addition, I regress exchange rate expectations on their lags as in Table 2. The model with subjective expectations can generate positive regression coefficient as in the data; expectation errors are autocorrelated as investors adjust their expectations slowly. On the other hand, in the presence of investors with FIRE expectations, the regression coefficient is close to zero; investor errors are not correlated.

	Subjective	FIRE	No Foreign Investor	Data
β^{Mom}	0.469	0.037	0.064	0.143 (0.071)
β^{Fama}	0.365	1.136	1.113	0.343 (0.441)
$\beta^{\text{Expectation}}$	0.495	-0.001	-0.001	0.140 (0.047)

Table 6: Fama Regressions Momentum in FX Markets: Model Simulations

These results are in line with Hong and Stein (1999) (proposition 4); if forward looking investors have limited risk capacity, momentum trading (backward looking) creates (i) initial underreaction (delayed overshooting), (ii) subsequent overreaction (excessive overshooting); and (iii) active momentum.

5.4 Role of UIP Frictions

Hong and Stein (1999) show that underreaction and overreaction of asset prices require that there does not exist forward looking and unconstrained investors. In Figure 5 I plot impulse response to foreign interest rate shock in the benchmark economy as well as in the economy with less UIP frictions, where households' portfolio friction parameter (γ) is set close to zero so that UIP holds in the model. Without portfolio frictions, households are able to absorb all the decline in speculator local currency holdings (b^*), which leads to a large decline in dollarization but a small depreciation and no delayed overshooting.

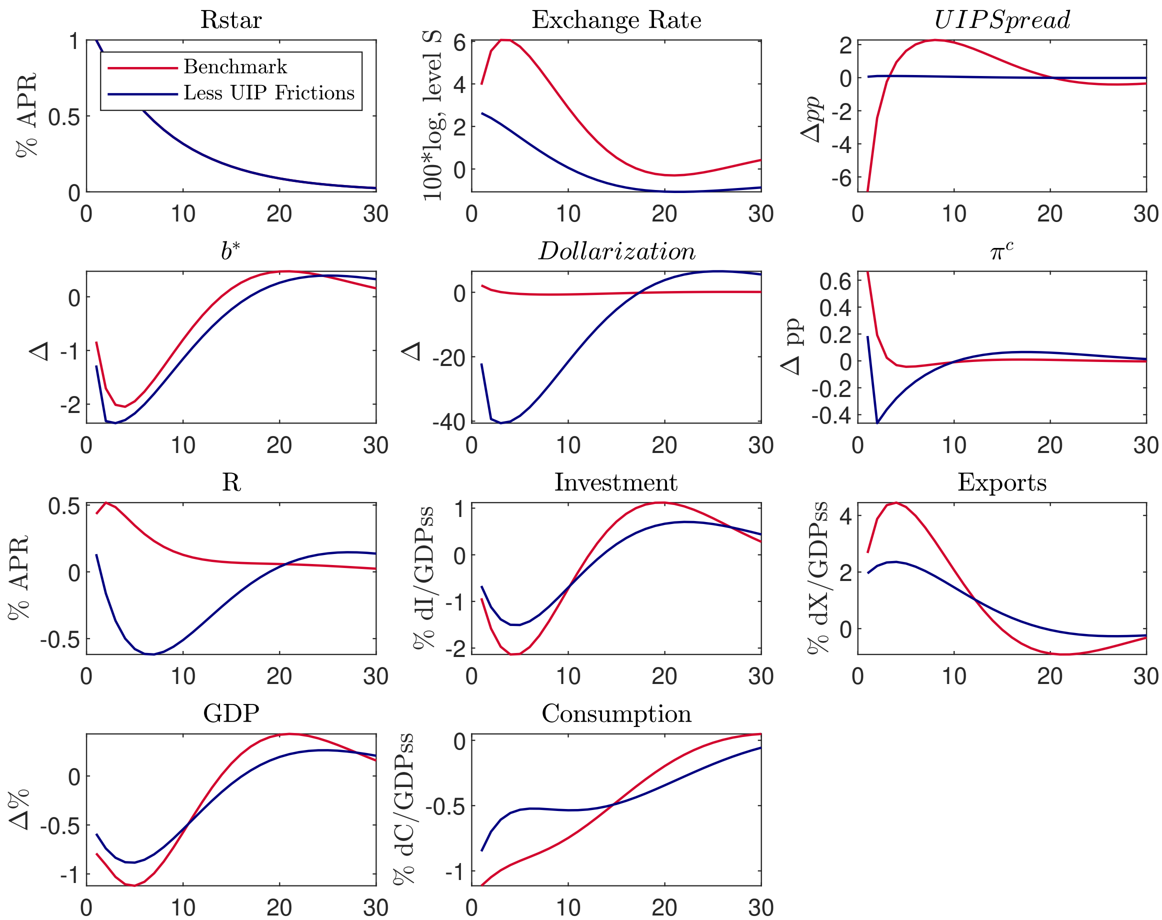


Figure 5: Role of UIP Frictions

5.5 Excluding Foreign speculators

In this section, I examine the economic impacts, particularly on exchange rate volatility, when foreign participants are excluded from the market. To analyze this, I adjust λ^f, the parameter that governs the tightness of the incentive constraint of currency speculators, from 0.01 to 0.15. In the case of financial markets dominated by speculators with unbiased expectations (referred to as FIRE—Full Information Rational Expectations), their exclusion increases exchange rate volatility. Conversely, when speculators hold subjective expectations, their exclusion tends to reduce exchange rate volatility (Figure 6)

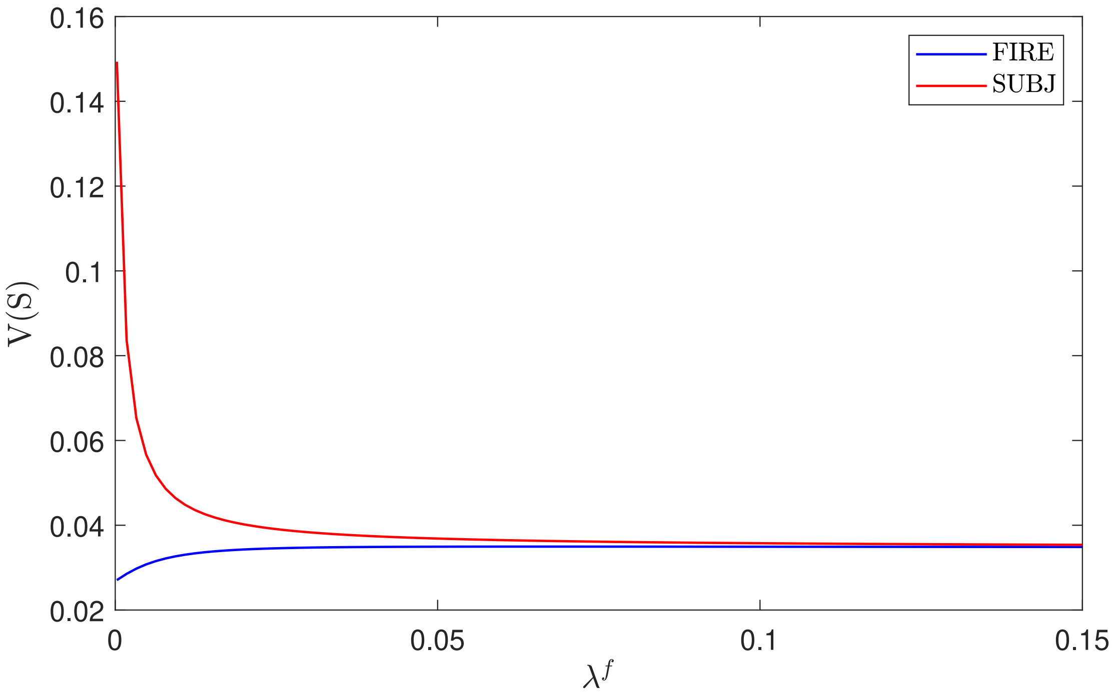
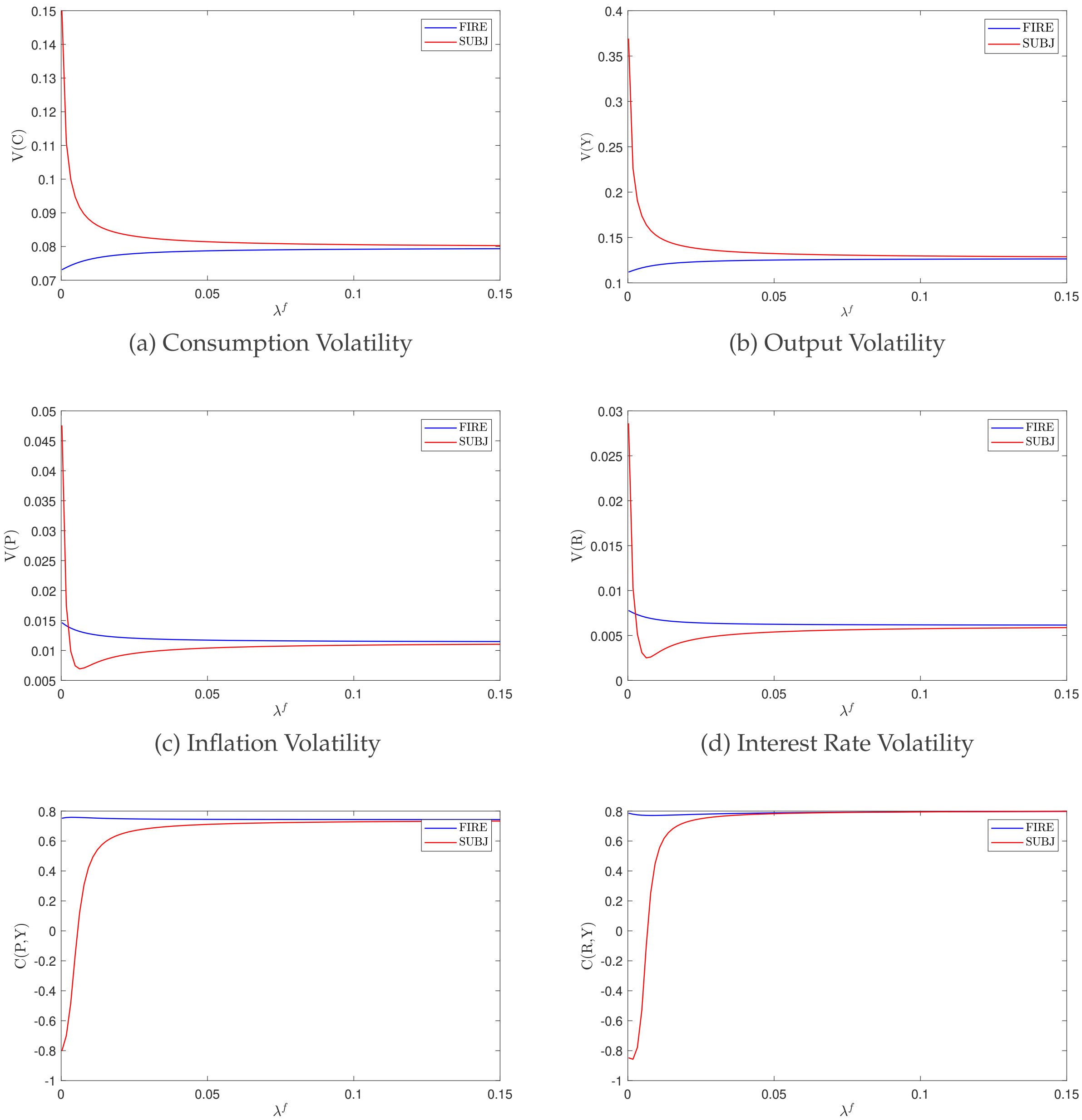


Figure 6: Exchange Rate Volatility vs Foreign Speculator Participation
Notes: The X-axis represents the parameter that governs the foreign investor habitat constraint (see Equation 1). The Y-axis represents exchange rate volatility, measured as the standard deviation of exchange rate depreciations in the model simulation.

When speculators with subjective expectations participate in the market, they tend to contribute to higher exchange rate volatility, which has cascading effects on the broader economy. Therefore, excluding them results in lower volatility across several economic variables—exchange rates, output (Figure 7b) and consumption. On the other hand, when speculators are forward-looking and have unbiased, rational expectations, their exclusion tends to increase exchange rate volatility. This, in turn, raises consumption, and output volatility. However, the impact of tightening the constraint on forward-looking speculators is relatively small. In contrast, when speculators have subjective expectations, excluding them yields significant reductions in volatility across the board.

The effect on inflation and interest rates is more subtle; when investors with subjective expectations are very active in the market (very low levels of λ_f), their presence greatly amplifies inflation and interest rate volatility. This is because high exchange rate volatility translates into inflation volatility because of pass through effect. For moderate levels of λ_f there are two opposing effects on inflation; an exchange rate depreciation increases inflation but GDP slowdown decreases it because of lack of demand. Hence, for very low foreign participation (high values of λ_f), inflation volatility seems to be higher. This is because comovement between inflation and output changes (Figure 7e), for very low values of λ_f, the comovement is negative; inflation goes up when output goes down. This complicates monetary policy because to bring down inflation, the central bank needs to raise interest rates in a recession (Figure 7f). When foreigner participation is low, comovement between output and inflation turns positive so that the central bank can lower interest rates to combat the recession.

When investors have unbiased expectations, the change in macro quantities are minimal. Thus, the nature of speculators' expectations plays a crucial role in determining the effects of their exclusion on economic volatility.



(a) Consumption Volatility

(b) Output Volatility

(c) Inflation Volatility

(d) Interest Rate Volatility

(e) Inflation and Output Correlation

(f) Interest Rates and Output Correlation

Figure 7: Effects of Limiting Foreign Speculator Participation

Notes: The X-axis represents the parameter that governs the foreign investor habitat constraint (see Equation 1). The Y-axis represents (a) standard deviation of consumption (b) standard deviation of output, (c) standard deviation of inflation, (d) standard deviation of interest rates, (e) correlation between inflation and output, (f) correlation between interest rates and output.

5.6 FX Interventions

In this section, I look at the macroeconomic impact of foreign exchange (FX) interventions in the model. Interventions are exogenous AR(1) shocks to the central bank's foreign asset holdings:

$$F_t^* = \rho_{FX} F_{t-1}^* + \sigma_{FX} e_{FXI,t}$$

I consider an FX intervention where the central bank sells dollar assets (F_t^* decreases) to the private sector. Under the preferred habitat assumption, private agents have limited capacity to absorb these additional dollar holdings. Consequently, the transfer of currency risk from the public to the private sector requires an equilibrium adjustment in returns, triggering an immediate appreciation of the local currency (a decrease in S_t).

The macroeconomic transmission of this appreciation operates through two competing channels. First, the balance sheet channel: a stronger local currency reduces the real value of foreign-denominated debt, improving bank balance sheets and stimulating investment (as seen in the "Investment" panel of Figure 8). Second, the trade channel: the appreciation creates a loss in competitiveness, reducing export volumes ("Exports" panel). In the calibration shown, the investment boom dominates, leading to a net increase in GDP.

The Role of Expectations

Figure 8 shows a intervention shock equivalent to 2.5% of GDP. Compared to an economy without FX speculators (black line) the interaction between the intervention and investor expectations produces opposite effects:

FIRE (Dampening): Investors with rational expectations perceive the initial appreciation as temporary. They correctly anticipate that the exchange rate will mean-revert (depreciate) back to steady state. This expectation of future depreciation makes holding dollar assets attractive (high expected returns). Consequently, FIRE investors counter the intervention, buying the dollars the central bank is selling. Their demand absorbs the supply shock, limiting the extent of the initial appreciation (the Blue line in the "Exchange Rate" panel), which lowers the effectiveness of FX interventions.

Subjective Beliefs (Amplification): Investors with subjective expectations view the initial price movement as a momentum signal, predicting further appreciation. Instead of absorbing the central bank's dollar supply, these investors attempt to sell dollars and buy local currency to chase the trend. This exacerbates the supply imbalance: both the central bank and foreign investors are now selling dollars. To clear the market, the domestic household sector must absorb this excess supply, which requires a much larger drop in the exchange rate (a massive appreciation) to induce equilibrium. As shown by the Red line in Figure 8, subjective expectations significantly amplify the impact of FX interventions on the exchange rate and the wider economy.

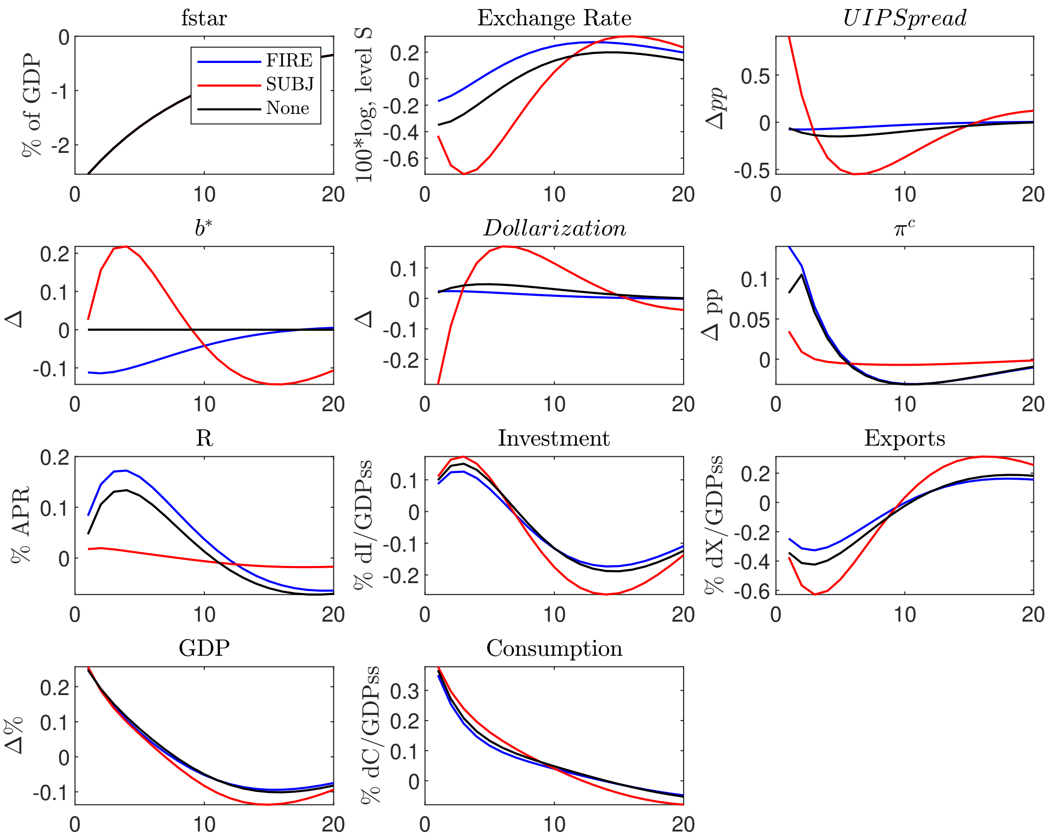


Figure 8: Effects of Foreign Exchange Interventions

5.7 Effectiveness of Tools to Counter External Shocks

In this section, I evaluate the efficacy of policy tools in mitigating the impact of foreign interest rate shocks. I compare the benchmark economy against two alternative policy regimes: FX interventions, where the central bank sells foreign reserves to lean against depreciation (Castillo et al. (2024)), and aggressive interest rate defense, where the central bank raises rates sharply to stabilize the exchange rate (Braggion et al. (2009)).

Figure 9 presents the response to a 1% foreign interest rate shock under rational expectations. FX intervention successfully mitigates the exchange rate depreciation by absorbing the excess supply of local currency. This action dampens the transmission of the external shock to the real economy, resulting in a smaller contraction in GDP and investment compared to the benchmark. In contrast, while an aggressive interest rate defense effectively stabilizes the exchange rate, it induces a severe recession. The sharp increase in domestic borrowing costs crushes consumption and investment, leading to a significantly deeper contraction in GDP than in the benchmark scenario.

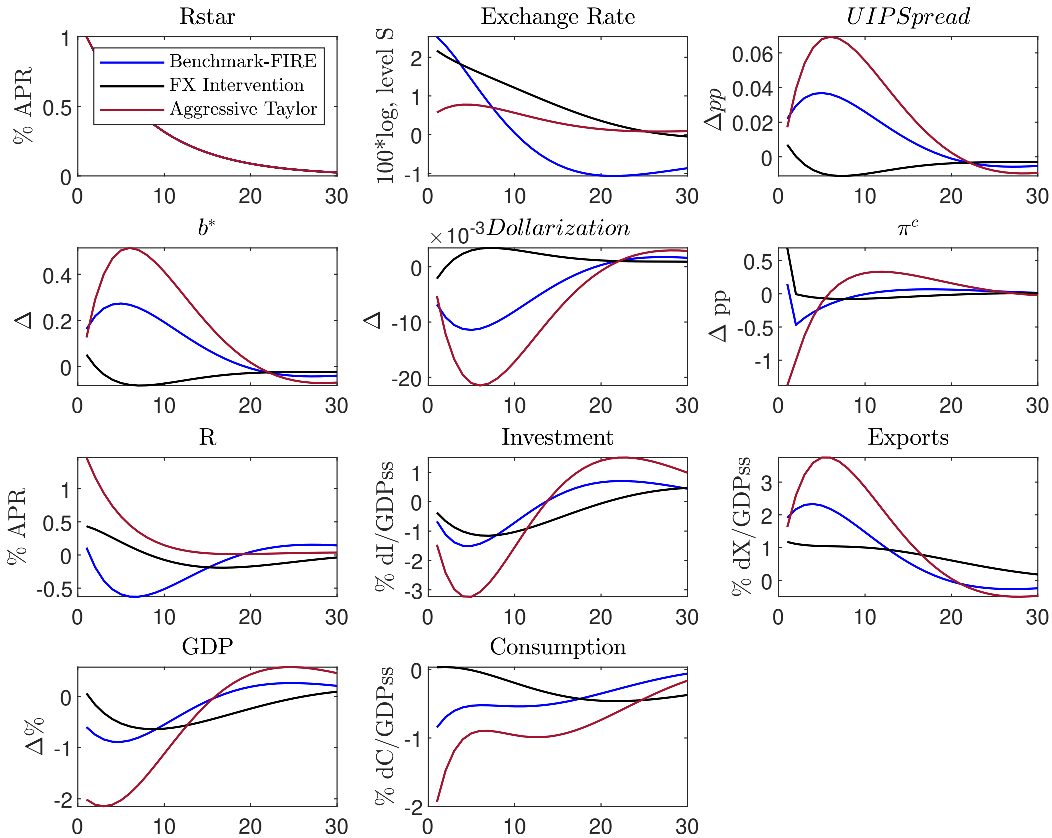


Figure 9: Effect of Policy Tools under FIRE Investors

Figure 10 repeats the exercise under subjective expectations, where the stabilizing role of FX intervention becomes significantly more valuable. In the benchmark subjective economy, the exchange rate overshoots massively due to backward-looking expectations, amplifying the negative impact on the real economy. FX intervention prevents this initial momentum from building up, stabilizing the currency. As shown in the interest rate panel (R), the central bank does not need to raise rates as high as in the benchmark case, resulting in a smoother path for GDP, consumption, and investment. Conversely, to counter the strong momentum driven by subjective beliefs, an aggressive interest rate defense requires the central bank to hike rates sharply. While this successfully pins down the exchange rate, the collateral damage to the real economy is severe, causing a collapse in investment and consumption.

Interestingly, when investors have subjective expectations, the required interest rate hike in the Aggressive Taylor case (Red line) is lower than the eventual peak rate in the Benchmark case (Blue line). This is due to the expectations feedback loop. In the Benchmark, the initial depreciation creates excessive depreciation, which creates pass through inflation and forces central bank to raise interest rates. In the Aggressive case, the immediate defense prevents the initial depreciation from occurring. Consequently, destabilizing expectations never form, and the central bank can maintain equilibrium with a comparatively smaller interest rate increase.

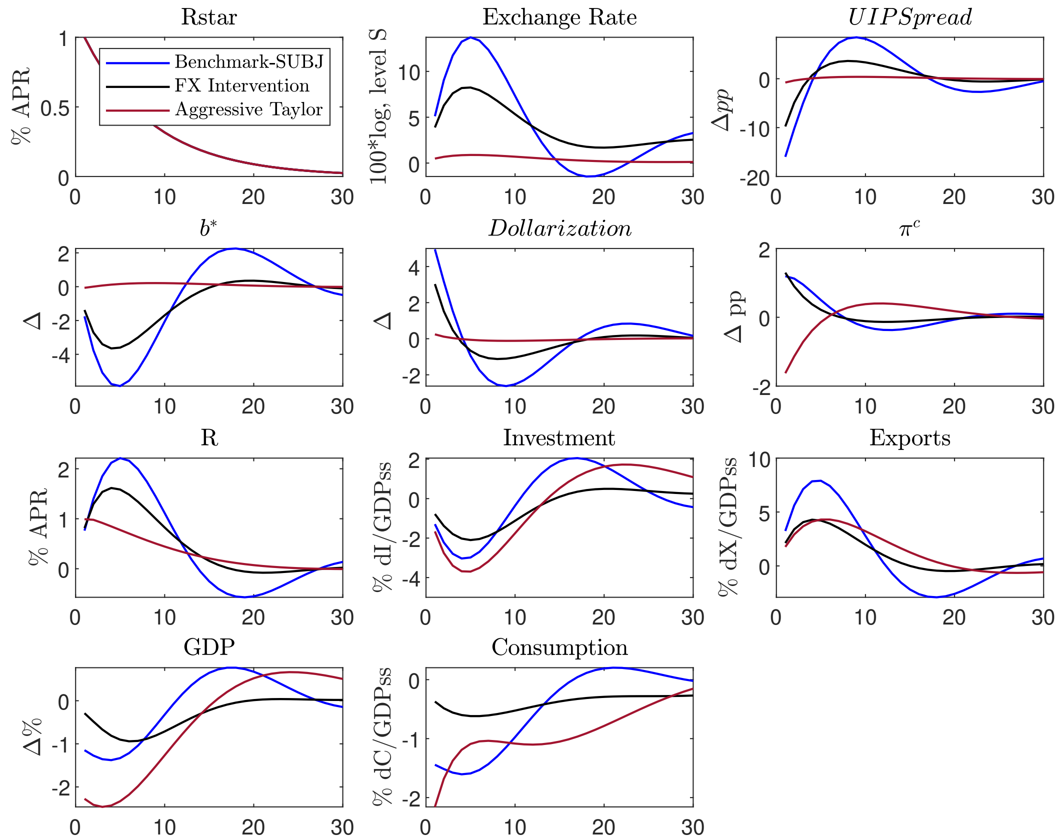


Figure 10: Effect of Policy Tools under SUBJ Investors

Comparing the two regimes reveals a clear hierarchy of policy tools. While aggressive interest rate hikes can stabilize the currency, they do so by aggravating the recessionary impact of the foreign shock. FX interventions, however, address the specific portfolio imbalance friction and allow for exchange rate stability without sacrificing domestic output. This value of this stabilization is highest when investors have subjective expectations because the intervention prevents the destabilizing momentum in the exchange rate.

5.8 Effectiveness of Monetary Policy

In this section, I evaluate the effectiveness of the domestic interest rate as a tool for disinflation. I measure this using the sacrifice ratio, defined as the loss in output required to lower inflation by 1%. To calculate this, I simulate the economy under local monetary policy shocks and estimate the following regression:

$$\Delta log(Y_t) = \alpha + \beta \Delta \log(P_t^c)$$

where β denotes how much a change in CPI translates into changes in GDP following a local monetary policy shock. Similar to Section 5.5, I simulate the model for different levels of foreign currency speculator participation λ^f for FIRE and SUBJ investors. Figure 11 plots sacrifice ratio as a function of FX investor participation constraint. Similar to FX interventions, presence of FX investors with subjective expectations amplify the effect of local monetary policy; presence of biased FX traders makes sacrifice ratio much smaller. The reason is an increase in local interest rates leads to a much larger exchange rate appreciation, which pushes prices down as a result of exchange rate pass through. Similarly, if FX investors have unbiased expectations, their presence limits the appreciation, which limits pass through disinflation.

The slope coefficient β captures the sensitivity of output to changes in the price level. A positive and large β indicates a costly policy trade-off, where significant output losses are required to achieve disinflation. I perform this simulation across varying levels of foreign investor participation, denoted by λ^f. Figure 11 plots the sacrifice ratio against the tightness of the participation constraint. As $\lambda^f \to \infty$, foreign investors are effectively excluded from the market, and the two models converge to a closed-economy limit with identical sacrifice ratios. However, as barriers to entry fall (approaching the left side of the x-axis), the behavior of the two investor types produces a sharp divergence in policy effectiveness.

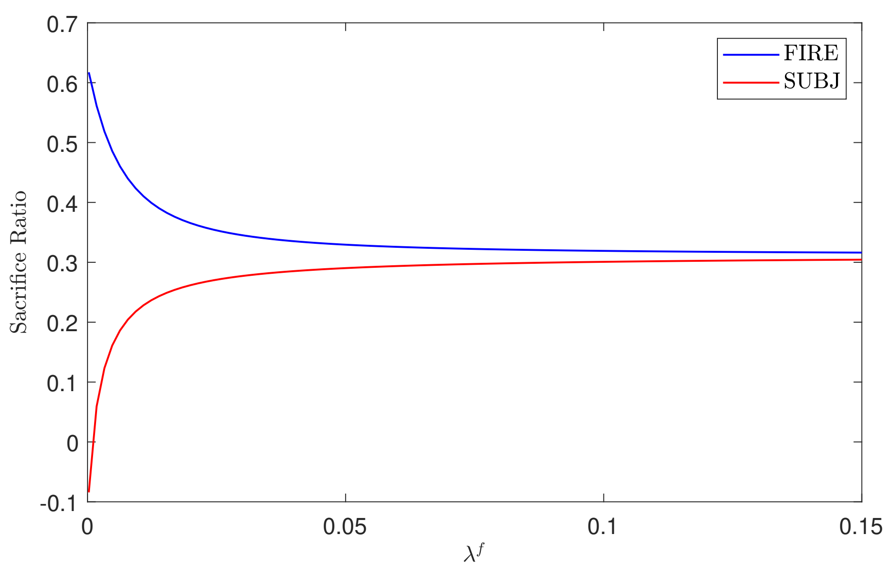


Figure 11: Sacrifice Ratio as a function of FX investor participation constraint (λ^f)

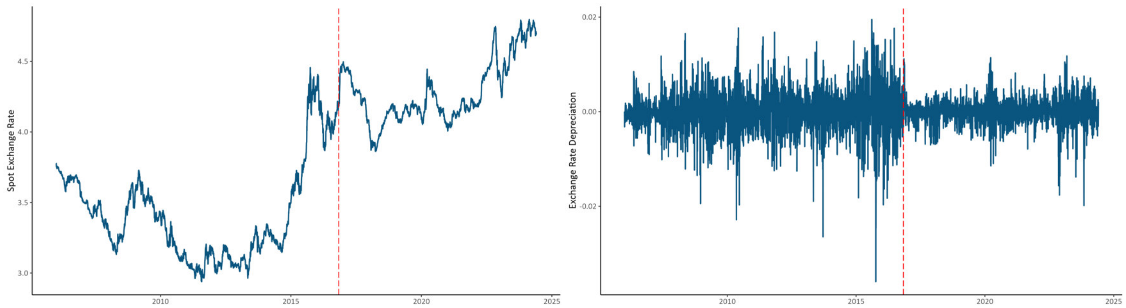
Under rational expectations (FIRE, blue line), higher foreign participation (low λ^f) increases the sacrifice ratio. Rational investors perceive the interest-rate-induced appreciation as temporary and trade against it, dampening the exchange rate movement. Consequently, the central bank cannot rely on the exchange rate channel to lower import prices and must instead depress aggregate demand to control inflation, raising the output cost of disinflation. In contrast, under subjective expectations (SUBJ, red line), the presence of foreign investors drastically reduces the sacrifice ratio. These investors interpret the initial appreciation as a momentum signal and pile into the currency, amplifying the exchange rate response. This triggers a powerful exchange rate pass-through channel where import prices go down, driving down domestic inflation rapidly. As a result, the central bank achieves its inflation target with minimal contraction in real output. In extreme cases of high participation (very low λ^f), the expenditure-switching and balance-sheet benefits of the massive appreciation can even render the sacrifice ratio effectively zero, making monetary policy highly potent for price stability.

6 Empirical Evidence

In November 2016, the Central Bank of Malaysia introduced targeted capital controls prohibiting foreign financial institutions from trading in the offshore ringgit non-deliverable forward (NDF) market. This policy intervention provides a natural experiment to test the model's predictions regarding the exclusion of speculative agents.

Exchange Rate Volatility

Figure 12a illustrates the behavior of the exchange rate around the policy implementation. While the introduction of the rule did not generate a visually discernible break in the level of the exchange rate, the volatility of the exchange rate declined significantly. Figure 12b plots daily exchange rate depreciations, revealing a structural break in variance: following the capital controls, the standard deviation of daily depreciations fell from 0.45% to 0.27%, a reduction of approximately 40%. Similarly, Figure 21 in the Appendix reports time-varying volatility estimated via a GARCH(1,1) process. The results confirm the finding: the mean conditional volatility drops from 0.42% pre-reform to 0.26% post-reform. Furthermore, to rule out global factors, Figure22 compares these dynamics across major Emerging Market Economies (EMEs) as well as the EME USD Index and Broad USD Index. The significant reduction in volatility is unique to the Malaysian ringgit, isolating the effect of the domestic policy.



(a) Exchange Rate

(b) Exchange Rate Depreciations

Figure 12: Malaysia Exchange Rate: Level and depreciations
Note: Daily exchange rate is obtained from DataStream. Data covers between 2006-01-02 and 2024-05-29.

The observed reduction in volatility following the exclusion of foreign speculators contradicts the standard view that speculators provide essential liquidity. Under that view, excluding active traders should thin the market and increase price volatility. The fact that volatility fell suggests that these agents were not stabilizing the price but rather amplifying shocks, consistent with the "subjective expectations" mechanism outlined in Section 5.5.

Central Bank Intervention

An alternative explanation for the stable exchange rate is that the central bank simply intervened more aggressively to enforce stability. However, data on foreign reserves contradict this hypothesis. Figure 13 plots Malaysia's foreign currency reserves (in USD) alongside their HP-filtered trend. Crucially, the volatility of reserves as a proxy for the intensity of FX intervention declined significantly alongside the exchange rate volatility.

The standard deviation of the cyclical component of log reserves fell from 11.5% prior to the policy to 3.5% afterward. If the central bank were fighting market pressure to smooth the exchange rate (Castillo et al. (2024)), we would expect reserve volatility to remain high or increase. Instead, the simultaneous decline in both exchange rate volatility and reserve volatility implies that the market became intrinsically more stable.

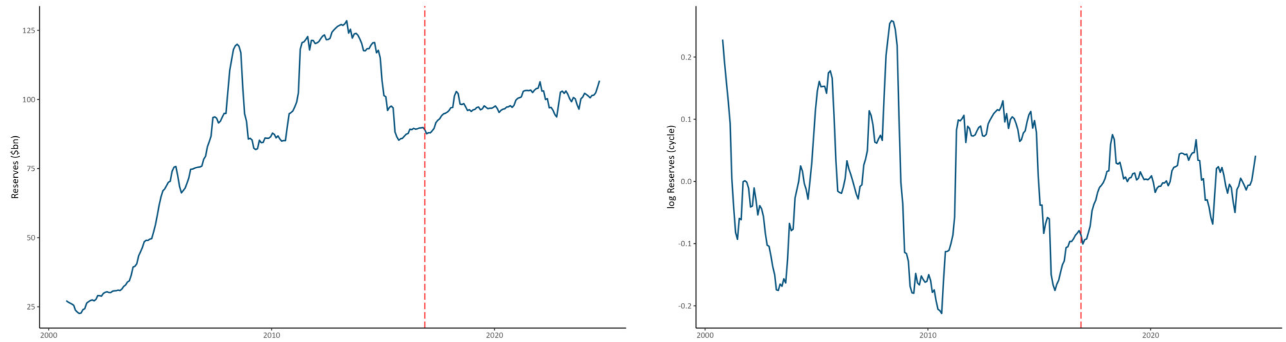


Figure 13: Reserves: Level and the Cycle
Note: Foreign Currency Reserves of Malaysia are obtained from Datastream. Monthly data covers 10/2000-09/2024. Cycle is obtained using HPFilter with $\lambda = 129,600$.

Policy Implications

These findings raise a critical question: why would the central bank need to exclude foreigners if, as standard theory suggests, they smooth the exchange rate? The answer lies in the nature of the expectations. Malaysia remains an open economy classified as "freely floating" (IMF (2023)), where locals can trade foreign currency and foreigners can hedge via onshore forwards. The specific exclusion of the offshore NDF market dominated by speculative players, stabilized the currency and rendered FX intervention unnecessary. This empirical outcome mirrors the model's prediction in Section 5.5: when investors hold subjective, backward-looking expectations, their exclusion reduces volatility and reduces the burden on the central bank.

In Appendix Section F.4, I analyze the volatility of macroeconomic fundamentals—inflation, trade balance, and industrial production—following the policy implementation. I find no significant change in the standard deviation of these variables, a result consistent with the Mussa Puzzle (Itskhoki and Mukhin (2025)). Crucially, this disconnect suggests that the capital controls functioned as an efficient filter: they successfully eliminated the excess volatility without distorting real economic activity. While Itskhoki and Mukhin (2025) attribute such disconnects to exogenous financial noise, my framework identifies a specific amplification mechanism where subjective expectations exacerbate fundamental foreign interest rate shocks that affect export demand. The empirical stability of real variables implies that the policy effectively curbed this behavioral amplification and reduced financial instability without impeding the economy's necessary adjustment to external fundamental shocks. Although the post-policy period includes high-variance events like the

COVID-19 pandemic, the sharp reduction in FX volatility amidst stable real outcomes supports the model's prediction that the liquidity provided by subjective speculators could be destabilizing.

7 Conclusion

Using data on forecasts by professional investors, I document that exchange rate depreciations lead to systematic positive expectation errors: market participants consistently anticipate larger depreciations than those subsequently realized. To analyze the macroeconomic implications of this bias, I build a small open economy model that introduces heterogeneity in expectation formation: while domestic households and firms hold rational expectations, foreign FX speculators hold subjective beliefs calibrated to the forecast data.

By integrating this behavioral friction with dominant currency pricing and balance sheet constraints, the model resolves key exchange rate puzzles including delayed and excessive overshooting, momentum, and the forward premium puzzle within a framework that accurately captures the contractionary effects of depreciations in emerging markets. The results demonstrate that subjective traders do not merely provide liquidity; instead, they amplify fundamental shocks, exacerbating volatility and generating destabilizing momentum.

Consequently, excluding these subjective investors yields significant welfare benefits. The model predicts that limiting their participation reduces the volatility of exchange rates, inflation, and interest rates, thereby improving the trade-offs faced by the central bank.

This theoretical prediction is supported by the empirical evidence from Malaysia's 2016 capital controls. The exclusion of foreign speculators from the offshore ringgit market led to a permanent and significant reduction in exchange rate volatility. Crucially, while FX volatility collapsed, there was no discernible change in the volatility of real macroeconomic variables such as the trade balance or industrial production. Far from suggesting policy irrelevance, this disconnect (reminiscent of the Mussa Puzzle) suggests that the capital controls functioned as an efficient filter. The policy successfully curbed the excess volatility driven by speculative amplification without distorting the economy's fundamental adjustments to external shocks. Future research should further explore the drivers of subjective beliefs to refine the design of such targeted interventions.

References

Adam, K., A. Marcet, and J. Beutel (2017). Stock price booms and expected capital gains. *American Economic Review 107*(8), 2352–2408.

Adam, K., A. Marcet, and J. P. Nicolini (2016, February). Stock Market Volatility and Learning. *The Journal of Finance 71*(1), 33–82.

Allen, H. and M. P. Taylor (1990). Charts, Noise and Fundamentals in the London Foreign Exchange Market. *The Economic Journal 100*(400), 49–59.

Auclert, A., M. Rognlie, M. Souchier, and L. Straub (2021, May). Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel. *NBER Working Papers* (28872).

Bacchetta, P., E. Mertens, and E. van Wincoop (2009, April). Predictability in financial markets: What do survey expectations tell us? *Journal of International Money and Finance 28*(3), 406–426.

Bacchetta, P. and E. Van Wincoop (2010, June). Infrequent Portfolio Decisions: A Solution to the Forward Discount Puzzle. *American Economic Review 100*(3), 870–904.

Bacchetta, P. and E. van Wincoop (2021, July). Puzzling exchange rate dynamics and delayed portfolio adjustment. *Journal of International Economics 131*, 103460.

Bauer, M. D. and E. T. Swanson (2023, March). An Alternative Explanation for the "Fed Information Effect". *American Economic Review 113*(3), 664–700.

Braggion, F., L. J. Christiano, and J. Roldos (2009). Optimal monetary policy in a 'sudden stop'. *Journal of Monetary Economics 56*(4), 582–595.

Brunnermeier, M. and S. Nagel (2004, October). Hedge Funds and the Technology Bubble. *The Journal of Finance 59*(5), 2013–2040.

Burnside, C., M. Eichenbaum, and S. Rebelo (2011, December). Carry Trade and Momentum in Currency Markets. *Annual Review of Financial Economics 3*(Volume 3, 2011), 511–535.

Camara, S., L. Christiano, and H. Dalgic (2024, July). The International Monetary Transmission Mechanism. In *NBER Macroeconomics Annual 2024, Volume 39*. University of Chicago Press.

Castillo, P., R. Lama, and J. Medina (2024, June). Escaping the Financial Dollarization Trap: The Role of Foreign Exchange Intervention. IMF Working Paper 2024/127, International Monetary Fund.

Cesa-Bianchi, A., A. Ferrero, and S. Li (2024, March). Capital Flows and Exchange Rates: A Quantitative Assessment of the Dilemma Hypothesis. *CEPR Discussion Papers* (18943).

Chakraborty, A. and G. W. Evans (2008, April). Can perpetual learning explain the forward-premium puzzle? *Journal of Monetary Economics 55*(3), 477–490.

Christiano, L., H. Dalgic, and A. Nurbekyan (2021, July). Financial Dollarization: Efficient Intranational Risk Sharing or Prescription for Disaster? Technical Report w29034, National Bureau of Economic Research, Cambridge, MA.

Coibion, O. and Y. Gorodnichenko (2015, August). Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts. *American Economic Review 105*(8), 2644–2678.

Dalgic, H. and G. K. Ozhan (2025). Dominant Currency Pricing and Currency Risk Premia. *Working Paper*.

Devereux, M. B. and C. Engel (2002, July). Exchange rate pass-through, exchange rate volatility, and exchange rate disconnect. *Journal of Monetary Economics 49*(5), 913–940.

Eichenbaum, M. and C. L. Evans (1995, November). Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates*. *The Quarterly Journal of Economics 110*(4), 975–1009.

Eichenbaum, M. S., B. K. Johannsen, and S. T. Rebelo (2021, January). Monetary Policy and the Predictability of Nominal Exchange Rates. *The Review of Economic Studies 88*(1), 192–228.

Engel, C. (2016). Exchange rates, interest rates, and the risk premium. *American Economic Review 106*(2), 436–474.

Fama, E. F. (1984, November). Forward and spot exchange rates. *Journal of Monetary Economics 14*(3), 319–338.

Fernandez-Villaverde, J., P. Guerron-Quintana, J. F. Rubio-Ramirez, and M. Uribe (2011, October). Risk Matters: The Real Effects of Volatility Shocks. *American Economic Review 101*(6), 2530–2561.

Froot, K. A. and J. A. Frankel (1989, February). Forward Discount Bias: Is it an Exchange Risk Premium? *The Quarterly Journal of Economics 104*(1), 139.

Gabaix, X. and M. Maggiori (2015, August). International Liquidity and Exchange Rate Dynamics. *The Quarterly Journal of Economics 130*(3), 1369–1420.

Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of Monetary Economics 58*(1), 17–34.

Goldberg, L. S. and C. Tille (2008, December). Vehicle currency use in international trade. *Journal of International Economics 76*(2), 177–192.

Gopinath, G., E. Boz, C. Casas, F. J. Díez, P.-O. Gourinchas, and M. Plagborg-Møller (2020, March). Dominant Currency Paradigm. *American Economic Review 110*(3), 677–719.

Gourinchas, P.-O., W. D. Ray, and D. Vayanos (2022, March). A Preferred-Habitat Model of Term Premia, Exchange Rates, and Monetary Policy Spillovers. NBER Working Papers 29875, National Bureau of Economic Research, Inc.

Gourinchas, P.-O. and A. Tornell (2004, December). Exchange rate puzzles and distorted beliefs. *Journal of International Economics 64*(2), 303–333.

Hong, H. and J. C. Stein (1999, December). A Unified Theory of Underreaction, Momentum Trading, and Overreaction in Asset Markets. *The Journal of Finance 54*(6), 2143–2184.

Ilut, C. (2012, July). Ambiguity Aversion: Implications for the Uncovered Interest Rate Parity Puzzle. *American Economic Journal: Macroeconomics 4*(3), 33–65.

IMF (2023). Annual Report on Exchange Arrangements and Exchange Restrictions 2022. https://www.imf.org/en/Publications/Annual-Report-on-Exchange-Arrangements-and-Exchange-Restrictions/Issues/2023/07/26/Annual-Report-on-Exchange-Arrangements-and-Exchange-Restrictions-2022-530144.

Itskhoki, O. and D. Mukhin (2023, December). Optimal Exchange Rate Policy.

Itskhoki, O. and D. Mukhin (2025). Mussa Puzzle Redux. *Econometrica 93*(1), 1–39.

Kalemli-Ozcan, S. (2019, September). U.S. Monetary Policy and International Risk Spillovers. NBER Working Papers 26297, National Bureau of Economic Research, Inc.

Kayalar, D. E. and F. P. Erdem (2024, March). The effects of non-deliverable forward programs of emerging-market central banks: A synthetic control approach. *Borsa Istanbul Review*.

Kolasa, M., S. Ravgotra, and P. Zabczyk (2025, May). Monetary policy and exchange rate dynamics in a behavioral open economy model. *Journal of International Economics 155*, 104087.

Lustig, H., N. Roussanov, and A. Verdelhan (2011). Common risk factors in currency markets. *Review of Financial Studies 24*(11), 3731–3777.

Miranda-Agrippino, S. and H. Rey (2020). U.S. Monetary Policy and the Global Financial Cycle. *The Review of Economic Studies 87*(6), 2754–2776.

Moskowitz, T. J., Y. H. Ooi, and L. H. Pedersen (2012, May). Time series momentum. *Journal of Financial Economics 104*(2), 228–250.

Müller, G. J., M. Wolf, and T. Hettig (2024, July). Delayed Overshooting: The Case for Information Rigidities. *American Economic Journal: Macroeconomics 16*(3), 310–342.

Neumeyer, P. A. and F. Perri (2005). Business cycles in emerging economies: The role of interest rates. *Journal of Monetary Economics 52*(2), 345–380.

Rogoff, K. (1996). The Purchasing Power Parity Puzzle. *Journal of Economic Literature 34*(2), 647–668.

A Expectation Error Heterogeneity

In this Section, I look at in which currencies the investors make the most expectation errors. The explanatory variable I consider is the riskiness of the currency. I define riskiness based on the exposure of a currency to the 2nd principal component of currency returns. Following Lustig et al. (2011), I call this Carry Trade Risk. Currencies who have higher exposure to carry trade risk tend to give larger average returns (Dalgic and Ozhan (2025)). For each currency in the dataset, I regress expectation errors on lagged returns (see 1). Figure 14 plots regression coefficients obtained on the exposure of each currency to carry trade risk. Similarly, Table 7 shows the statistical relation. Results suggest that investors error is higher in ’safe’ currencies. Camara et al. (2024) note that the exchange rate behavior following US monetary policy shock is not different in AEs and EMEs (both set of countries display delayed and excessive overshooting), so that investors might be underestimating the depreciation in ’safer’ currencies. On the contrary, investors might be more careful and devote more resources to forecast ’risky’ currencies so that the bias in high risk currencies is not statistically significant with the important exceptions of Chile and Brazil. Still, note that the constant term in Table 7 is negative and highly significant indicating that even after taking into account carry trade exposure, investors still have biased expectations on average.

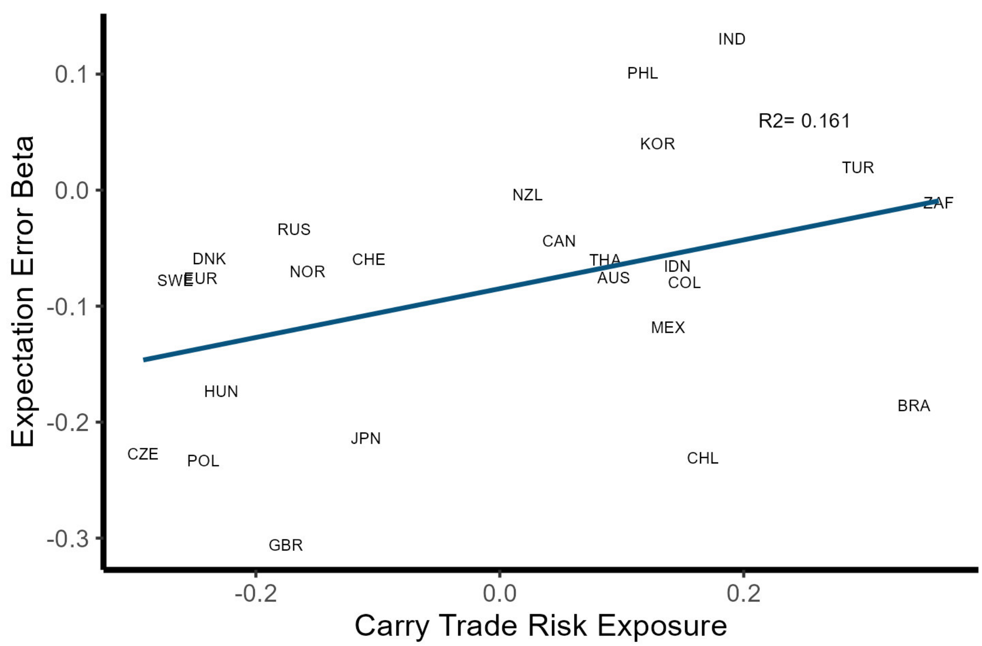


Figure 14: Expectation Error vs Carry Trade Exposure

	Dependent variable:
	Expectation Error Beta
Carry Trade Risk Exposure	0.210**
	(0.103)
Constant	−0.085***
	(0.020)
Currency FE	No
Time FE	No
Observations	25
Residual Std. Error	0.100 (df = 23)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 7: Expectation Error vs Carry Trade Exposure

B Model Equations

B.1 Good Production

- Consumption bundle and price index

$$C_t = \left[(1-\omega_c)^{\frac{1}{\eta_c}} \left(C_t^d\right)^{\frac{\eta_c-1}{\eta_c}} + \omega_c^{\frac{1}{\eta_c}} \left(C_t^m\right)^{\frac{\eta_c-1}{\eta_c}}\right]^{\frac{\eta_c}{\eta_c-1}}$$

$$P_t^c = \left[(1-\omega_c) P_t^{1-\eta_C} + \omega_c \left(P_t^m\right)^{1-\eta_c}\right]^{\frac{1}{1-\eta_c}}$$

- Investment bundle

$$I_t = \left[\gamma_I^{\frac{1}{\nu_I}} I_{d,t}^{\frac{\nu_I-1}{\nu_I}} + (1-\gamma_I)^{\frac{1}{\nu_I}} I_{m,t}^{\frac{\nu_I-1}{\nu_I}}\right]^{\frac{\nu_I}{\nu_I-1}}$$

$$P_{I,t} = \left[\gamma_I P_t^{\nu_t} + (1-\gamma_I)\left(P_t^m\right)^{1-\nu_I}\right]^{\frac{1}{1-\nu_I}}$$

Evolution of capital is subject to capital adjustment costs.

$$K_t = (1-\delta) K_{t-1} + \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t.$$

- Export bundle. Exports are produced from the domestic export good and the imported input, both priced in dollars.

$$X_t = \left[\gamma_x^{\frac{1}{\eta_x}} \left(X_t^d \right)^{\frac{\eta_x - 1}{\eta_x}} + (1 - \gamma_x)^{\frac{1}{\eta_x}} \left(X_t^m \right)^{\frac{\eta_x - 1}{\eta_x}} \right]^{\frac{\eta_x}{\eta_x - 1}}$$

$$P_t^x = \left[\gamma_x \left(P_t^{d,x} \right)^{1-\eta_x} + (1 - \gamma_x) \left(P_t^f \right)^{1-\eta_x} \right]^{\frac{1}{1-\eta_x}}$$

- Domestic export good production

$$X_t^d = \left[\int_0^1 X_{i,t}^{\frac{\varepsilon_x - 1}{\varepsilon_x}} di \right]^{\frac{\varepsilon_x}{\varepsilon_x - 1}}$$

Intermediate export good $X_{i,t}$ is produced by monopolists using domestic homogenous good. Monopolists price intermediate export good in dollars and face Calvo style sticky prices; $(1 - \theta_x)$ share of monopolists are allowed to change their prices.

- Domestic Homogenous good production,

$$Y_t = p_t^* K_{t-1}^{\alpha} \left(A_t l_t \right)^{1-\alpha}$$

where

$$p_t^* = \left[(1 - \theta) \left(\frac{1 - \theta \pi_t^{\varepsilon - 1}}{1 - \theta} \right)^{\frac{\varepsilon}{\varepsilon - 1}} + \frac{\theta \pi_t^{\varepsilon}}{p_{t-1}^*} \right]^{-1}$$

$$Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\varepsilon - 1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon - 1}}, \varepsilon > 1$$

- Market clearing in homogeneous goods

$$Y_t = I_t^d + C_t^d + X_t^d$$

where $\left(I_t^d, C_t^d, X_t^d \right)$ are domestic goods to produce final investment, consumption and export goods respectively.

B.2 Banker Problem

Banker problem follows Dalgic and Ozhan (2025). Bankers are part of the household, with probability θ, they stay bankers and with probability $(1-\theta)$ they retire and become workers. Bankers maximize,

$$V_{j,t} = \max \mathbb{E}_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+i+1} N_{j,t+i+1}$$

I can write $V_{j,t}$ recursively

$$V_{j,t} = \mathbb{E}_t \left[\beta(1-\theta) N_{j,t+1} + \beta\theta\Lambda_{t,t+1} V_{j,t+1} \right]$$

Evolution of net worth,

$$N_{j,t+1} = R^k_{t+1} Q_t S_{jt} - R_t B^{LC}_{j,t} - R^F_t \frac{S_{t+1}}{S_t} B^{FC}_{j,t}$$

I want to scale the above expression by $N_{j,t}$

$$\frac{N_{j,t+1}}{N_{j,t}} = R^k_{t+1} \frac{Q_t S_{jt}}{N_{j,t}} - R_t \frac{B^{LC}_{j,t}}{N_{j,t}} - R^F_t \frac{S_{t+1}}{S_t} \frac{B^{FC}_{j,t}}{N_{j,t}}$$

Define $\phi_t \in [0,1]$ as the share of net worth allocated to borrowing in dollars, which leaves $(1-\phi)$ share to be allocated to local currency borrowing. Define leverage ratios, $\left(L^{LC}_t, L^{FC}_t\right)$ as the ratio of assets that are funded by local currency and dollars respectively

$$B^{FC}_{j,t} = \left(L^{FC}_{j,t} - 1\right) \phi_{j,t} N_{j,t}$$
$$B^{LC}_{j,t} = \left(L^{FC}_{j,t} - 1\right) \left(1 - \phi_{j,t}\right) N_{j,t}$$

Evolution of net worth becomes

$$\frac{N_{j,t+1}}{N_{j,t}} = \left[\left(R^k_{t+1} - R_t\right) L^{LC}_{j,t}\left(1-\phi_{j,t}\right) + \left(R^k_{t+1} - R^F_t \frac{S_{t+1}}{S_t}\right) L^{USD}_{j,t}\phi_{j,t} + R_t(1-\phi_t) + R^F_t \frac{S_{t+1}}{S_t}\phi_{j,t}\right]$$

Bankers can divert λ fraction of the assets. In that case, they run away with the money. Understanding this, bankers lend to banks only if the value of being a banker exceeds the diverted assets. I assume that bankers get two separate loans in local currency and in dollars. The implication is that bankers can independently run away with local currency or dollar loans so that the incentive constraint need to bind for both types of borrowing,

$$V^{LC}_{j,t} \geq \lambda L^{LC}_{j,t} N^{LC}_{j,t}$$
$$V^{FC}_{j,t} \geq \lambda L^{FC}_{j,t} N^{FC}_{j,t}$$

where$N^{LC}_{j,t}$ and $N^{FC}_{j,t}$ are net worth allocated to local currency and dollar borrowing respectively $N^{LC}_{j,t} + N^{FC}_{j,t} = N_{j,t}$ and,

$$V^{LC}_{j,t} = \mathbb{E}_t\left[\beta(1-\theta)\left[L^{FC}_{j,t} N^{LC}_{j,t}\left(R^k_{t+1} - R_t\right) + R_t(1-\phi_{j,t})N^{LC}_{j,t}\right] + \beta\theta\Lambda_{t,t+1}V^{LC}_{j,t+1}\right]$$
$$V^{FC}_{j,t} = \mathbb{E}_t\left[\beta(1-\theta)\left[L^{FC}_{j,t} N^{FC}_{j,t}\left(R^k_{t+1} - R^F_t \frac{S_{t+1}}{S_t}\right) + R^F_t \frac{S_{t+1}}{S_t} N^{FC}_{j,t}\right] + \beta\theta\Lambda_{t,t+1}V^{FC}_{j,t+1}\right]$$

so that $V^{LC}_{j,t} + V^{FC}_{j,t} = V_{j,t}$

Scale recursive net worth for dollar borrowing,

$$\frac{V^{FC}_{j,t}}{N^{FC}_{j,t}} = \mathbb{E}_t\left[\beta(1-\theta)\left[L^{FC}_{j,t}\left(R^k_{t+1} - R^*_t \frac{S_{t+1}}{S_t}\right) + R^*_t \frac{S_{t+1}}{S_t}\right] + \beta\theta\Lambda_{t,t+1}\frac{V^{FC}_{j,t+1}}{N^{FC}_{j,t+1}}\frac{N^{FC}_{j,t+1}}{N^{FC}_{j,t}}\right]$$

where $\frac{N^{FC}_{j,t+1}}{N^{FC}_{j,t}} = \left[L^{FC}_{j,t}\left(R^k_{t+1} - R^*_t \frac{S_{t+1}}{S_t}\right) + R^*_t \frac{S_{t+1}}{S_t}\right]$ is the amount of equity a dollar borrowing bank expect to have at the end of the period. Simplifying,

$$\psi^{FC}_t = \mathbb{E}_t\left[\left[\beta(1-\theta) + \beta\theta\Lambda_{t,t+1}\psi^{FC}_{t+1}\right]\left[L^{FC}_{j,t}\left(R^k_{t+1} - R^*_t \frac{S_{t+1}}{S_t}\right) + R^*_t \frac{S_{t+1}}{S_t}\right]\right]$$

similarly for local currency borrowing

$$\psi_t^{LC} = \mathbb{E}_t\left[\left[\beta(1-\theta) + \beta\theta\Lambda_{t,t+1}\psi_{t+1}^{LC}\right]\left[L_{j,t}^{LC}\left(R_{t+1}^k - R_t\right) + R_t\right]\right]$$

Since the last equations are independent of j, all bankers make the same choice so I can remove j subscript.

Banker Optimization

A banker who borrows in dollars solve,

$$\psi_t^{FC} = \max_{L_t^{FC}} \mathbb{E}_t\left[\beta\left[(1-\theta) + \Lambda_{t,t+1}\theta\psi_{t+1}^{FC}\right]\left[L_t^{FC}\left(R_{t+1}^k - R_t^*\frac{S_{t+1}}{S_t}\right) + R_t^*\frac{S_{t+1}}{S_t}\right]\right]$$

subject to the incentive constraint

$$\psi_t^{FC} \geq \lambda L_t^{FC}$$

Solution satisfies

$$L_t^{FC} = \frac{\nu_t^{FC}}{\lambda - \eta_t^{FC}}$$

$$\begin{aligned}
\eta_t^{FC} &= \mathbb{E}_t\left[\beta\Lambda_{t,t+1}\Omega_{t+1}^{FC}\left(R_{t+1}^k - R_t^*\frac{S_{t+1}}{S_t}\right)\right] \\
\nu_t^{FC} &= \mathbb{E}_t\left[\beta\Lambda_{t,t+1}\Omega_{t+1}^{FC}R_t^*\frac{S_{t+1}}{S_t}\right] \\
\Omega_{t+1}^{FC} &= (1-\theta) + \theta\psi_{t+1}^{FC} \\
\psi_t^{FC} &= \lambda L_t^{FC}
\end{aligned}$$

similarly local currency borrowing satisfies,

$$L_t^{LC} = \frac{\nu_t^{LC}}{\lambda - \eta_t^{LC}}$$

$$\eta_t^{LC} = \mathbb{E}_t \left[\beta \Lambda_{t,t+1} \Omega_{t+1}^{LC} \left(R_{t+1}^k - R_t\right)\right]$$
$$\nu_t^{LC} = \mathbb{E}_t \left[\beta \Lambda_{t,t+1} \Omega_{t+1}^{LC} R_t\right]$$
$$\Omega_{t+1}^{LC} = (1-\theta) + \theta \psi_{t+1}^{LC}$$
$$\psi_t^{LC} = \lambda L_t^{LC}$$

Currency Choice

Bankers allocate net worth according to

$$\max_{\phi_t} \phi_t \psi_t^{LC} + (1-\phi_t)\psi_t^{USD} - \frac{\varepsilon}{2}(\phi_t - \bar{\phi})^2$$

where the last term denotes preferred habitat (or regulation) so that banks do not move their portfolios too much away from the target credit dollarization.

$$\psi_t^{LC} - \varepsilon(\phi_t - \bar{\phi}) = \psi_t^{USD}$$
$$L_t^{LC} - \frac{\varepsilon}{\lambda}(\phi_t - \bar{\phi}) = L_t^{USD}$$
$$\phi_t = \frac{\lambda}{\varepsilon}\left(L_t^{LC} - L_t^{USD}\right) + \bar{\phi}$$

B.3 Market Clearing Conditions

Financial Market Clearing

Local currency financial market clearing condition implies local currency deposits by households (D_t) and local currency investments by foreigners ($S_t B_t^F$) equal to total bank borrowing in local currency (B_t^{LC}). I require $B_t^{LC} \geq 0$, but foreigners or local can also have negative position

$$S_t B_t^F + D_t = B_t^{LC}$$

Similarly dollar market clearing condition implies foreign and local dollar deposits ($S_t B_t^{F,*}$, D_t^*) equal to bank dollar borrowing (B_t^{FC}) in local currency terms. For foreigners, dollar lending/borrowing is riskless and at the exogenous risk free dollar interest rate R_t^* so that their position ($B_t^{F,*}$) is the difference between household and bank positions.

$$S_t B_t^{F,*} + D_t^* = B_t^{FC}$$

Balance of Payments

Net exports ($X_t - M_t$) equal to change in net foreign asset position (which includes interest income earned by foreigners)

$$X_t - M_t = -\left(B_t^{F,*} - B_{t-1}^{F,*} R_{t-1}^* \frac{S_t}{S_{t-1}}\right) - \left(B_t^F - B_t^F R_{t-1}\right)$$

C Response to Foreign Interest Rate Shock

In Figures 15 and 16, I plot impulse response to foreign interest rate shock with different levels of foreign speculator participation in the FX market: High ($\lambda = 0.0003$), moderate ($\lambda = 0.005$) and low ($\lambda = 20$) for unbiased and subjective expectation speculators respectively. . Figure 15 plots the response of the economy with foreign speculators with unbiased expectations. When speculators have unbiased expectations, their participation makes the economy less volatile but the effect is not so strong.

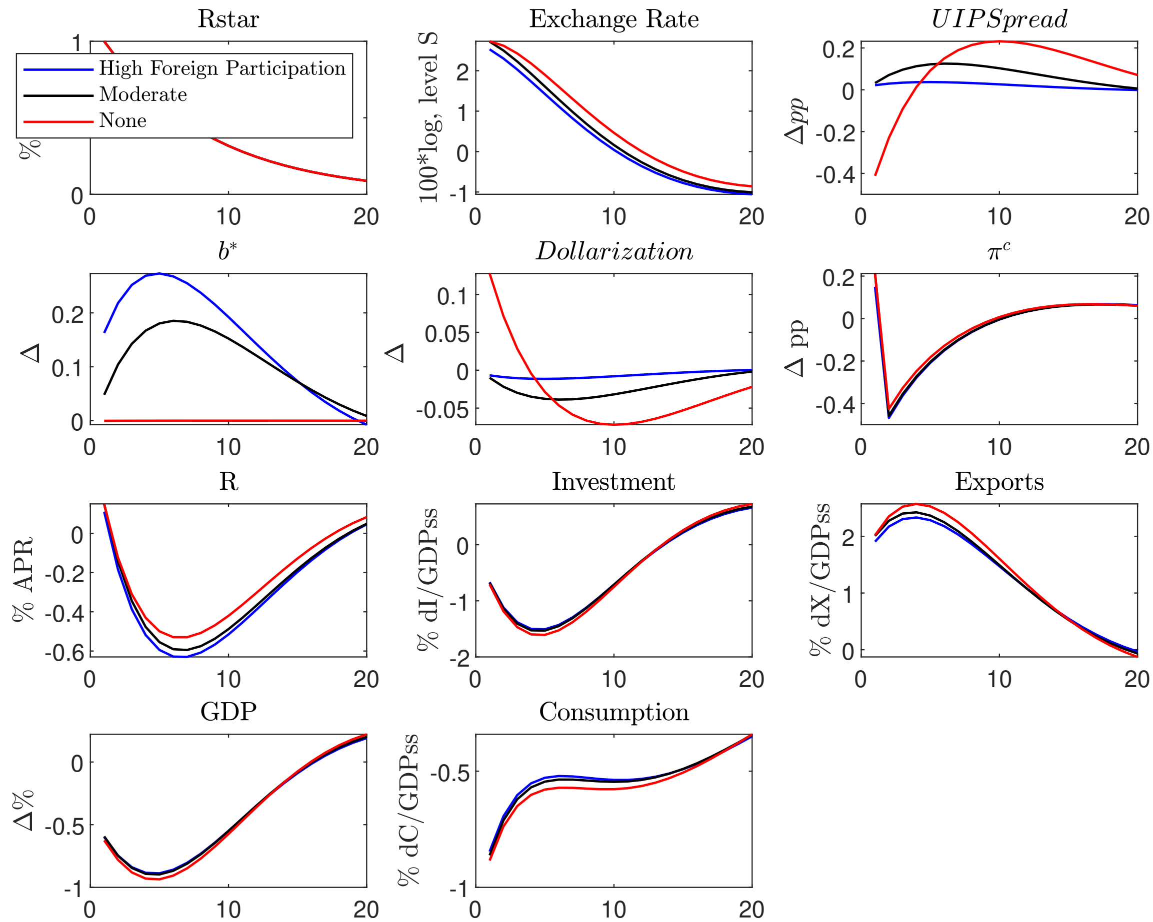


Figure 15: Response to Foreign Interest Rate Shock with FIRE Foreign Speculators

Figure 16 plots the response of the economy with foreign speculators with subjective expectations. When speculators have subjective expectations, their participation makes the economy much more volatile. The effect is non-linear, when λ is very small, their participation is large and their participation makes the exchange rate order of magnitude more volatile.

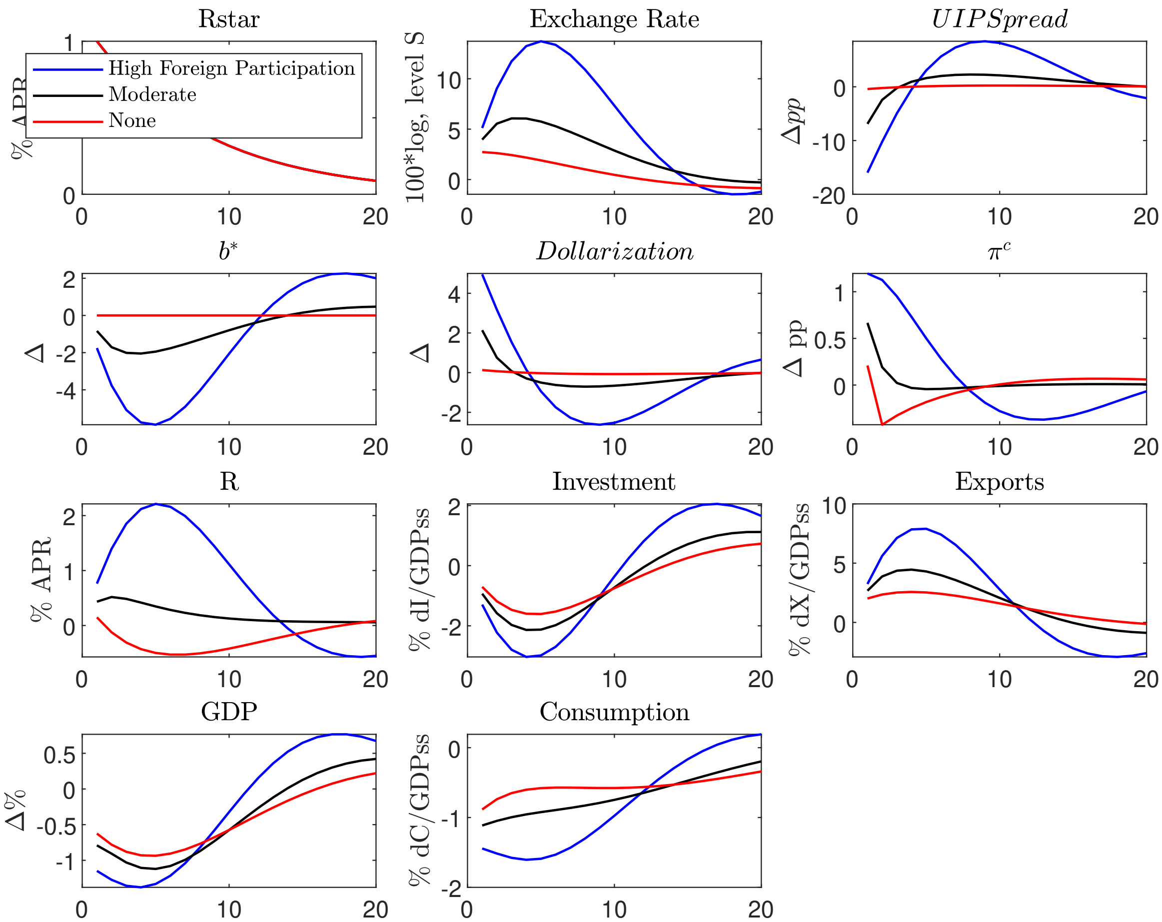


Figure 16: Response to Foreign Interest Rate Shock with SUBJ Foreign Speculators

D Role of Frictions

The model incorporates several key frictions that play a critical role in transmitting foreign interest rate shocks: dollar debt and export price stickiness (Dalgic and Ozhan (2025)). Figure 17 illustrates the economy's response to a foreign interest rate shock in the model with investors who form subjective expectations, comparing models with and without these frictions. While the frictions significantly affect the transmission to GDP and investment, the response of the exchange rate remains largely similar regardless of whether frictions are present. Notably, the exchange rate exhibits both delayed overshooting and excessive depreciation, consistent with the empirical patterns observed in the data.

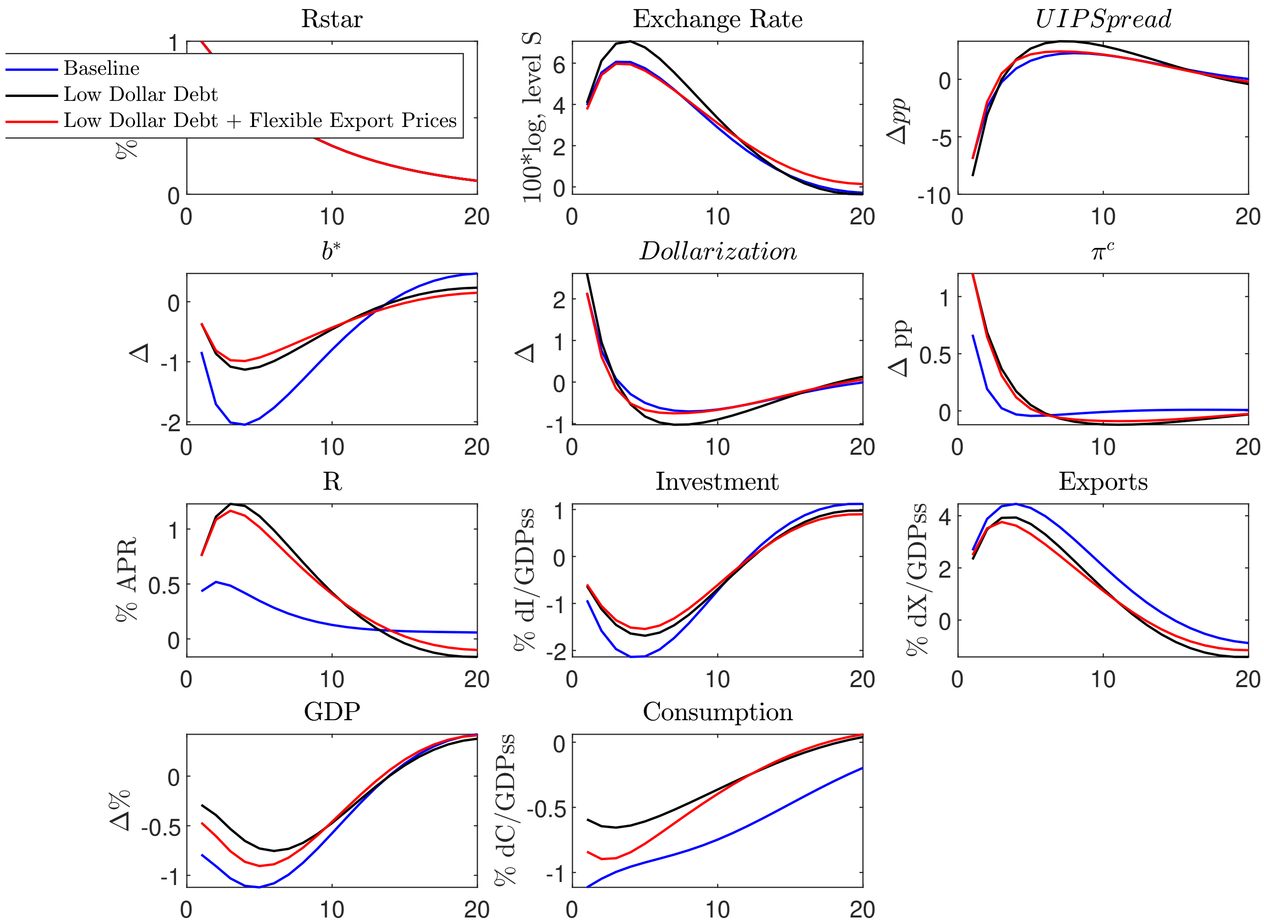


Figure 17: Role of Frictions: Response of Foreign Interest Rate Shock with SUBJ Investors

Figure 18 further examines the response to a foreign interest rate shock under the assumption of fully rational (FIRE) investors. Here, too, the frictions have a substantial impact on the transmission to the real economy, but the exchange rate response remains relatively unchanged. These results highlight that while frictions are crucial for understanding the real economic effects of foreign interest rate shocks, they play a limited role in shaping exchange rate dynamics, which are instead driven primarily by the formation of expectations.

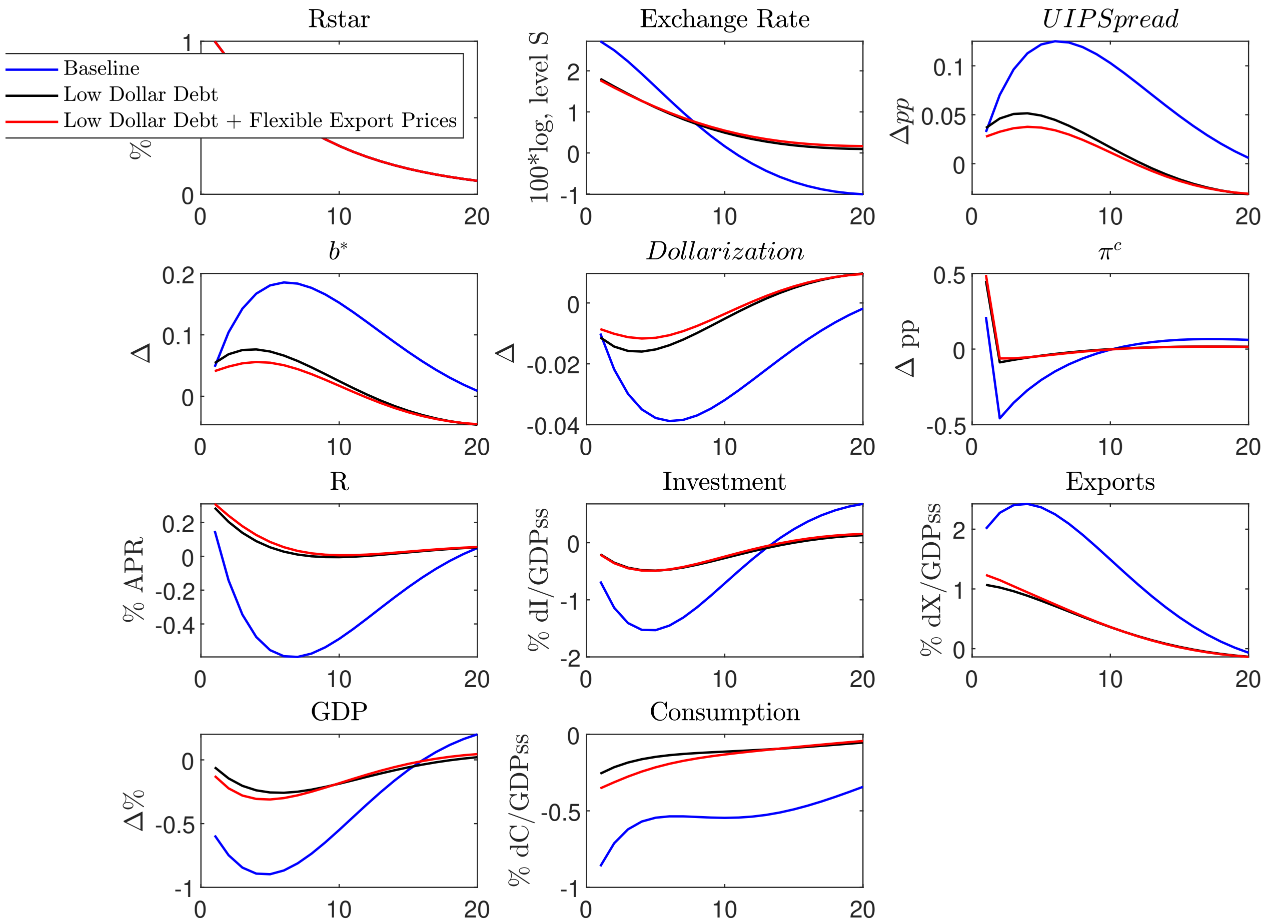


Figure 18: Role of Frictions: Response of Foreign Interest Rate Shock with FIRE Investors

E Response to FX Intervention Shock

Similar to the previous section, in Figures 19 and 20, I plot impulse response to FX intervention shock with different levels of foreign speculator participation in the FX market: High ($\lambda = 0.0003$), moderate ($\lambda = 0.005$) and low ($\lambda = 20$) for unbiased and subjective expectation speculators respectively. Figure 19 plots the response of the economy with foreign speculators with unbiased expectations.

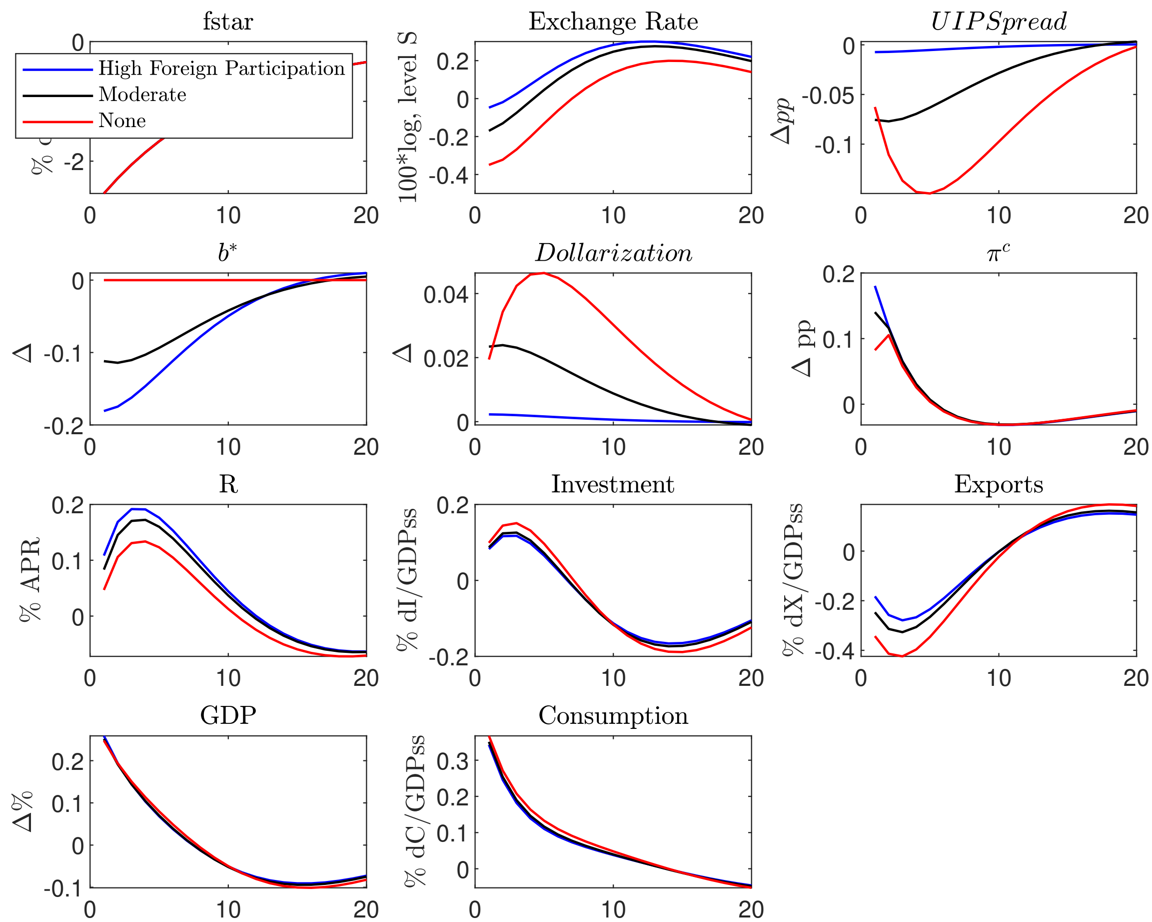


Figure 19: Response to FX Intervention Shock with FIRE Foreign Speculators

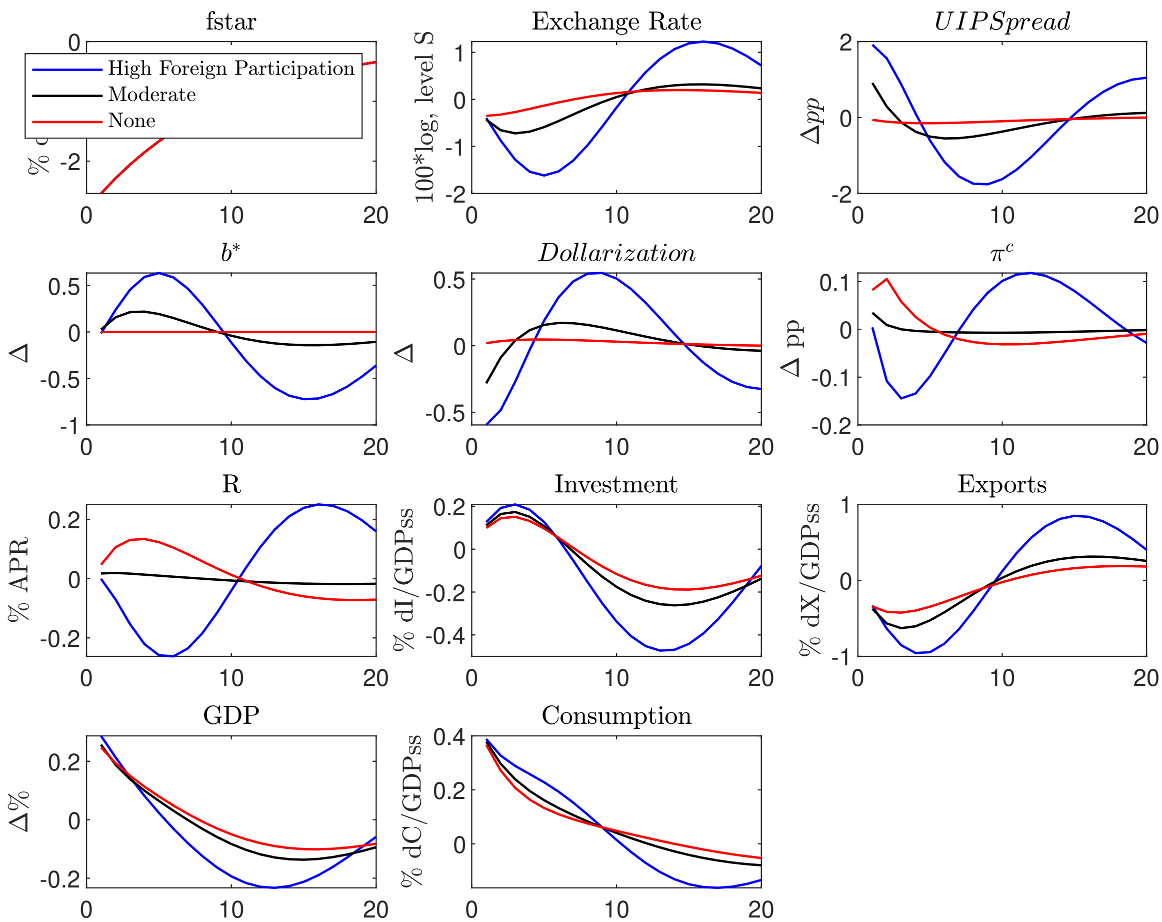


Figure 20: Response to FX Intervention Shock with SUBJ Foreign Speculators

F Capital Controls in Malaysia

The specific capital control in Malaysia prohibits foreign banks from taking position in the non-deliverable FX forward market. Non-deliverable forwards (NDFs) are financial derivatives used for hedging currency risk, particularly in markets where capital controls or regulatory restrictions prevent the free flow of foreign currency. Unlike traditional forwards, NDFs do not involve the physical exchange of currencies; instead, they are settled in a reference currency, typically the US dollar. This makes NDFs attractive in markets where foreign exchange (FX) transactions are tightly regulated or restricted, as they provide a way to hedge against exchange rate fluctuations without the need for actual currency transfers. NDF markets are especially prevalent in emerging market economies (EMEs), where central banks may impose restrictions on the use of their domestic currency in international markets. By allowing investors to hedge against currency risks without engaging in onshore currency transactions, NDFs contribute to the liquidity and stability of FX markets. However, their effectiveness as a tool for managing exchange rate volatility varies across different markets and policy environments. In some cases, central banks actively participate in or regulate the NDF market, while others, such as Malaysia, have chosen to ban offshore NDFs entirely. In the case of central banks in some emerging markets such as Brazil, Mexico, and Turkey, NDFs have become an integral part of their currency risk management toolkit (Kayalar and Erdem (2024)). These central banks have engaged in the NDF market not only to help hedge domestic currency exposure but also to enhance market liquidity and mitigate excessive exchange rate volatility. The Central Bank of Brazil, for instance, has been one of the leading emerging market central banks to utilize NDFs in managing the real's exchange rate volatility. Similarly, the Central Bank of Mexico and the Central Bank of the Republic of Turkey have embraced NDFs as a means to stabilize their currencies in response to external shocks and speculative pressures(Kayalar and Erdem (2024)).

F.1 Exchange Rate Volatility

In Figure 21, I fit a GARCH(1,1) process on exchange rate depreciations and calculated time varying volatility. Similarly, the mean of the time varying volatility before the capital controls is 0.42% and after the controls is 0.26%.

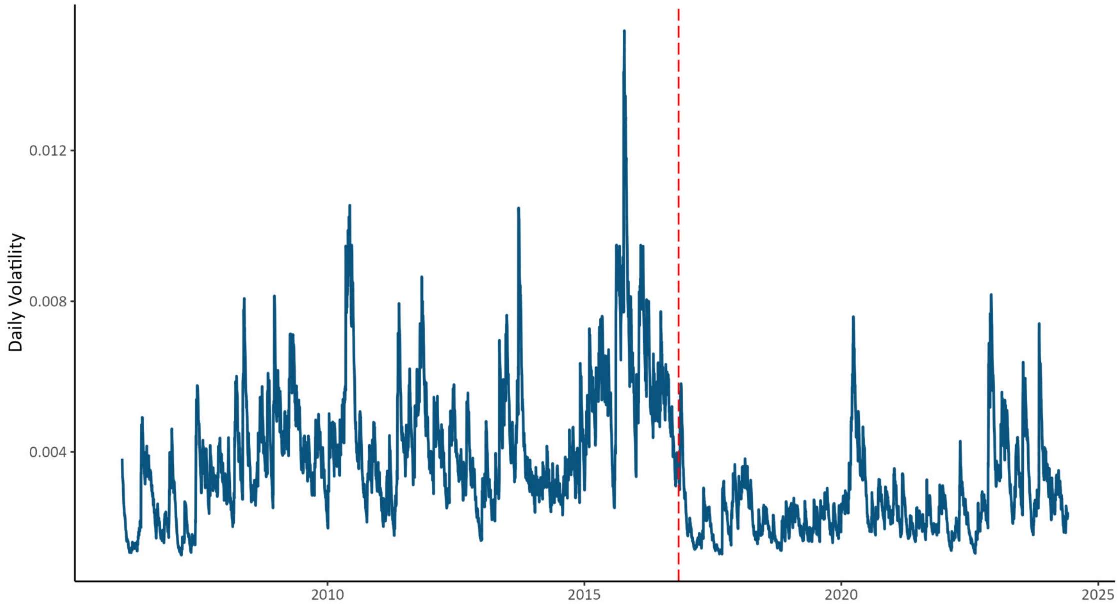


Figure 21: Exchange Rate Volatility

Note: Volatility is measured by fitting a GARCH(1,1) model on exchange rate depreciations. Fitted time varying volatility is plotted. Daily exchange rate is obtained from DataStream. Data covers between 2006-01-02 and 2024-05-29.

F.2 Other Major EMEs

Figure 22 plots the exchange rate volatilities across major EMEs as well as EME USD Index and Broad USD Index. The only significant volatility reduction is in Malaysian exchange rate[7].

[7] I thank Ozer Karagedikli for this graph

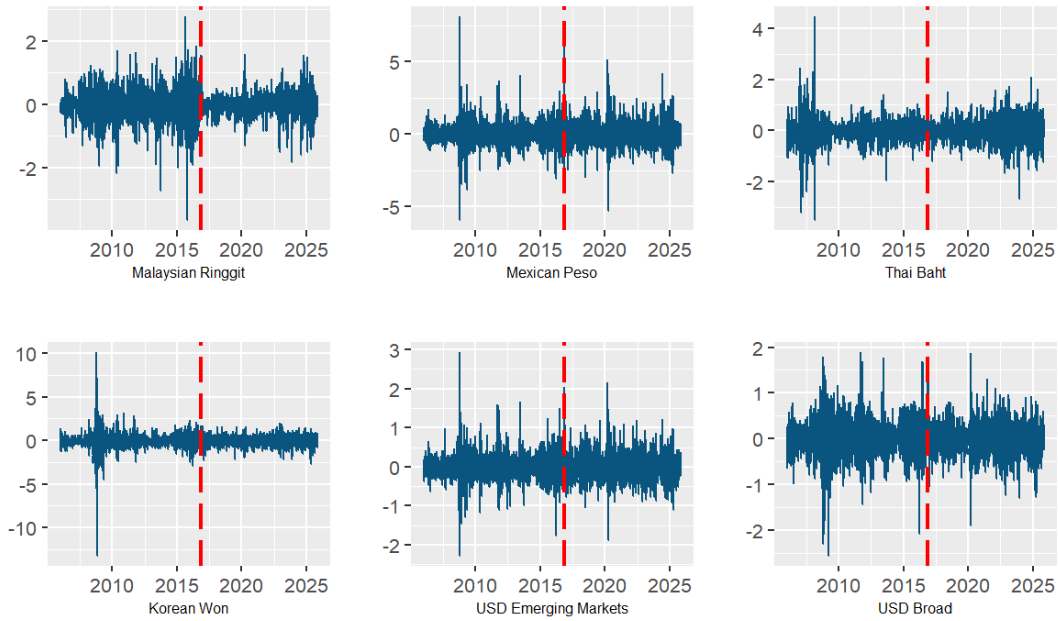


Figure 22: Exchange Rate Depreciations in EMEs

Note: Daily Exchange rate depreciation is plotted. Daily exchanges are obtained from FRED. Data covers between 2006-01-02 and 2024-05-29.

F.3 Interest Rate Volatility

Figure 23 plots 5 year government bond yields obtained from Datastream as well as its time varying volatility estimated using GARCH(1,1). There is some increase in interest rate level and volatility around the policy date but overall there does not seem to be a significant difference between before and after policy.

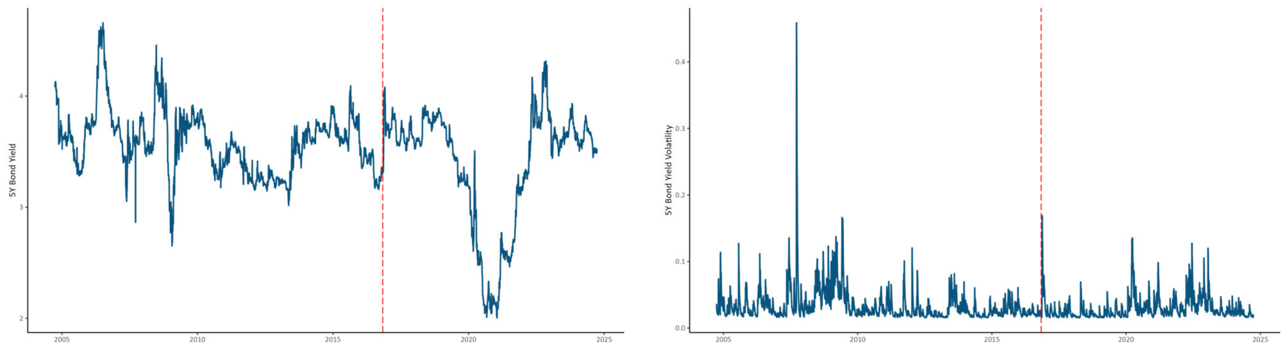
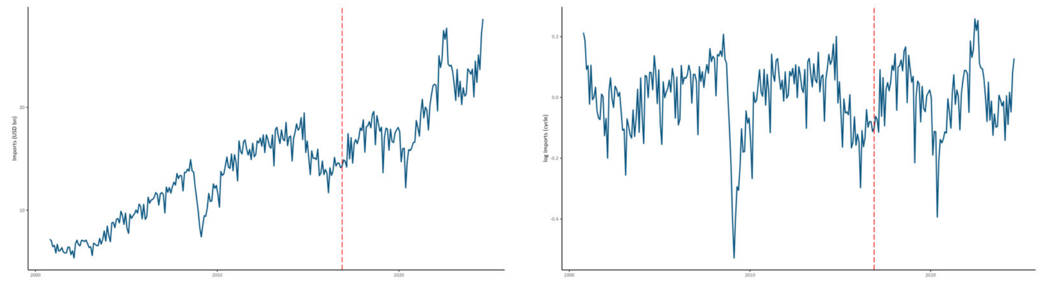


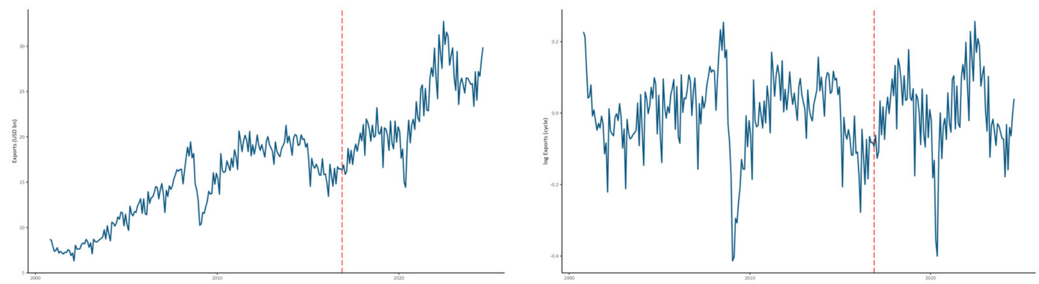
Figure 23: Interests Rates and Volatility
Note: Volatility is measured by fitting a GARCH(1,1) model on 5Y government bond Yield. Fitted time varying volatility is plotted. Government bond yields are obtained from DataStream. Data covers between 2004-09-27 and 2024-09-27.

F.4 Macroeconomic Quantities

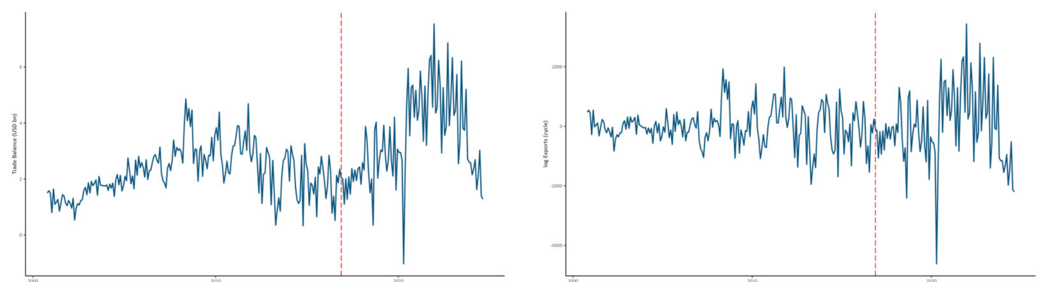
In this Section, I plot various macroeconomic quantities and their HP-Filtered cycles to see whether there is any discernible effect of the policy. Figure 24 plots exports, imports and the trade balance (in USD), there is not a statistically significant difference in the volatility of their cycles before vs after the policy. Similarly, Figure 25 plots consumer price index and industrial production index. Both fall considerably during the COVID period but otherwise there is not statistically meaningful difference. Results are in line with Mussa Puzzle. There is a significant decline in exchange rate volatility but it does not seem to affect the real economy (see Itskhoki and Mukhin (2025)).



(a) Imports



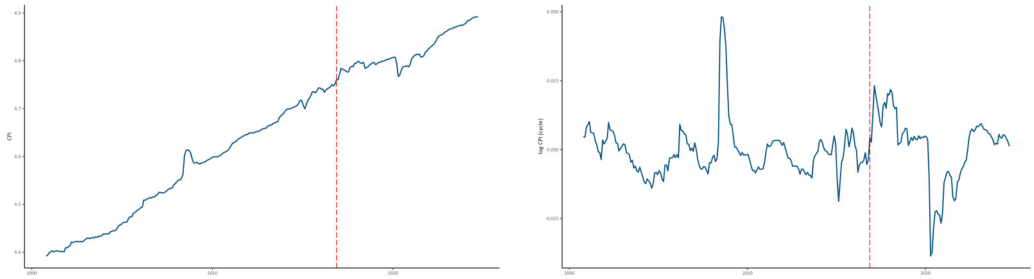
(b) Exports



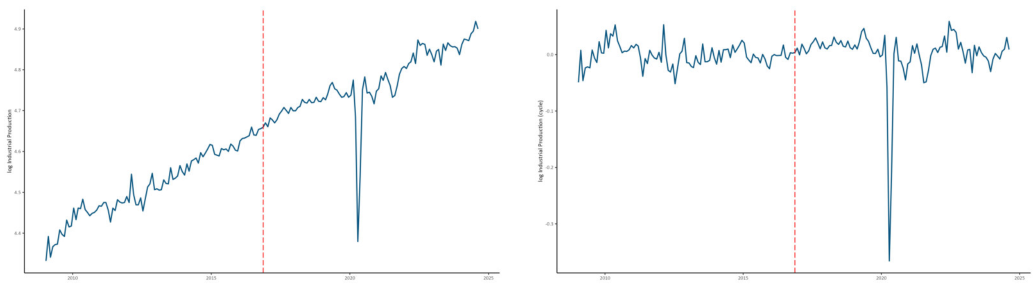
(c) Trade Balance

Figure 24: Foreign Trade and Cycles

Note: Exports and imports of Malaysia are obtained from Datastream. Trade balance is calculated as the difference. Obtained data are in local currency, which is converted to dollars using current exchange rate. Monthly data covers 10/2000-09/2024. Cycle is obtained using HPFilter with $\lambda = 129,600$.



(a) Consumer Price Index



(b) Industrial Production

Figure 25: Inflation, Industrial Production and Their Cycles

Note: CPI and industrial production of Malaysia are obtained from Datastream. Both data are indexes. Monthly data covers 10/2000-09/2024. Cycle is obtained using HPFilter with $\lambda = 129,600$.