External Debt Structure and Vulnerabilities: Implications for Optimal Monetary Policy in Sudden Stop Economies

Hasan Halit Toprak

A Dissertation presented to the Graduate Faculty of the University of Virginia

in Candidacy for the Degree of Doctor of Philosophy

Department of Economics

University of Virginia

July, 2023

Anton Korinek

Eric Young

Eric van Wincoop

Felipe Saffie

Abstract

This dissertation examines the role of external liability structure on the vulnerabilities and the necessary policy design in economies prone to sudden stops. Accounting for different types of capital flows, the first and second chapters study whether monetary policy in emerging market economies should be prudential—i.e., deviate from price stability to induce agents to borrow less and hold more insurance during tranquil times. In the first chapter, I develop a New Keynesian open economy model in which agents can trade a variety of international assets subject to a collateral constraint, then I derive a set of theoretical results. In the second chapter, I calibrate the model and conduct a quantitative analysis. From these analyses, I find that there is no scope for prudential monetary policy if either (1) the government can regulate both the level and composition of capital inflows or (2) commitment is not possible and the government can only regulate the volume but not the composition of flows. Otherwise, monetary policy should be prudential, though it is less effective than capital controls, especially without commitment. Compared with single bond setups, having multiple securities further reduces monetary policy's capability to act in a prudential manner. These results suggest that macroprudential instruments that target both the level and composition of capital inflows are an essential part of an optimal policy mix. When capital controls are not available, committing to a simple inflation targeting rule delivers higher welfare than discretionary prudential monetary policy.

The third chapter explores the transmission of U.S. monetary policy to small open economies, specifically focusing on the role of real debt revaluation channel. The paper presents a tradable-nontradable sectors small open economy model with international financiers who have limited risk-bearing capacity and introduces two channels of monetary transmission - capital flows and debt revaluation. The strength of the debt revaluation channel depends on the dollar's share in both external debt and trade. Using high-frequency data, the paper empirically shows that countries with a larger "exposed debt", a measure of real debt value sensitivity to dollar fluctuations, are more affected by U.S. monetary policy shocks. The findings emphasize that both the level and currency composition of external debt, relative to that of trade, are critical in international monetary policy transmission.

Acknowledgments

I would like to thank my dissertation committee members, Anton Korinek, Eric Young, Eric van Wincoop, and Felipe Saffie. Each one of them has played an instrumental role in guiding, challenging, and refining this research. Anton and Eric van Wincoop provided invaluable feedback and guidance beginning just days after my first year. They always raised the most critical questions, helped me focus on the bigger picture, and pushed my research further. I have immensely benefited from Eric Young's analytical and computational expertise. His inputs were crucial for designing, approaching, and solving the numerical model. Felipe's insightful feedback and suggestions have enriched this research significantly.

Over the years, my interactions with the department's members have profoundly shaped my journey. I owe much to the Macro faculty, including Eric Leeper, Ana Fostel, Zach Bethune, Leland Farmer, and Francis Warnock, for their insightful feedback. I've also gained immensely from my discussions with Kerem Cosar. Lee Lockwood provided valuable feedback on the broader perspective as an outsider to my specific area when it was the most needed.

I would like to thank both the Department of Economics and the Bankard Fund for Political Economy at the University of Virginia for their financial support. Special acknowledgment goes to Sage Bradburn, Debby Stanford, and Ashley Watkins for their invaluable administrative assistance.

I would like to express my gratitude to my friends from the department as well as to those in the UVa and Charlottesville community. My fellow graduate students have been instrumental in both academic discussions and in providing social support. My friends from the broader UVa and Charlottesville communities made my time here truly feel like home, enriching each moment with their kindness and encouragement.

I am eternally grateful to my family. The love and support from my parents and siblings have been a constant presence in my life. I reserve my deepest gratitude for my wife, Vasfiye Betul, whose unconditional love, encouragement, and faith in me have been my guiding light. I have never encountered anyone who embodies the essence of these words as she does. Finally, and most importantly, I am grateful for my son, Ibrahim Tarik. He consistently reminds me what matters in life, and also made me realize that academic challenges are child's play compared to decoding the cryptic art of toddler negotiations.

Chapter 1

The Composition of Capital Inflows and Optimal Monetary Policy in Sudden-Stop Economies

1.1 Introduction

Cross-border capital flows generate substantial benefits for emerging market economies (EMEs) by facilitating more efficient consumption smoothing and risk sharing. However, capital flow surges and their subsequent reversals might undermine domestic financial stability (Forbes and Warnock 2021). Sudden stops of capital inflows are associated with financial crises in EMEs.[1] Further, these crises are preceded by large capital inflows, particularly in the form of debt flows (Reinhart and Rogoff 2011; Schularick and Taylor

[1] See Bianchi and Mendoza (2020) who identify 36 sudden stops in EMEs between 1979 and 2016.

2012). Therefore, how to mitigate the adverse impacts of capital flows is at the core of policy debates.[2] This paper investigates the role of monetary policy in managing capital flows by asking the following questions: Should monetary policy in EMEs depart from its traditional role of price stabilization to target *the volume and composition* of capital flows—that is, be prudential? If so, how effective is prudential monetary policy for reducing the likelihood and severity of financial crises? How do various policy regimes compare in terms of welfare, accounting for both normal and crisis times?

I answer these questions within the framework of a two-sector (tradable and nontradable) small open economy New Keynesian model, in which agents trade a variety of international securities. Domestic agents are subject to an occasionally binding collateral constraint as in Mendoza (2002, 2010), which captures surges and reversals of capital flows in EMEs. Also, some forms of flows are more cyclical than others, making them riskier. The value of collateral depends on the exchange rate; thus, the policymaker can influence borrowing capacity by manipulating the exchange rate. Along with monetary policy, the policymaker might have access to capital controls and reserve accumulation as policy instruments. I theoretically characterize the optimal monetary policy in this environment. Then, in the next chapter, I calibrate the model and conduct a numerical analysis to quantify the differences between alternative policy regimes.

The findings can be summarized as follows. In general, monetary policy is prudential and deviates from macroeconomic stabilization—i.e., stabilizing prices and closing the output gap—during tranquil times. In only two scenarios is monetary policy not prudential and focuses exclusively on macroeconomic stabilization: first, with distinct capital

[2] See, for instance, the recent institutional view of the International Money Fund on capital flow management, IMF (2022).

controls that alter both the volume and the composition of capital inflows; second, with uniform capital controls that only target the level but not the composition of flows under discretion. However, prudential monetary policy alone is less successful than capital controls in reducing the frequency and intensity of sudden stops, especially in the absence of commitment. Commitment is crucial; even sticking to a simple inflation targeting rule (which doesn't include leaning against the wind) delivers higher welfare than prudential monetary policy under discretion. Furthermore, allowing multiple securities as opposed to a single bond in the international asset markets further weakens the effectiveness of prudential monetary policy.

To better understand the intuition behind these results, consider the underlying inefficiencies and how their interactions create policy tradeoffs. First, the nominal rigidities are sources of aggregate demand externalities and lead to inflation and an output gap when monetary policy cannot adjust (Korinek and Simsek 2016; Farhi and Werning 2016; Schmitt-Grohé and Uribe 2016). Second, the presence of a collateral constraint that depends on exchange rates generates pecuniary externalities (Korinek 2010; Bianchi 2011). When the constraint binds, a currency depreciation reduces the borrowing capacity of domestic agents, and therefore leads to capital outflows from the domestic economy. The fall in net capital inflows further depreciates the exchange rate and reduces borrowing capacity even more. This is a manifestation of amplification through the Fisherian debt deflation mechanism. Importantly, lower wealth in bad states exacerbates this negative feedback loop. Because individual agents take the exchange rate as given, they do not internalize how their financial decisions (both the total and composition of liabilities) in good states are contributors to contractionary depreciations in bad states. As a result, private agents overborrow *and* underinsure. All in all, there are four inefficiencies in the model—inflation, output, overborrowing, and underinsurance—that require conflicting monetary policy stances in normal times. Thus, although monetary policy is not constrained (by, e.g., the zero lower bound or by a fixed exchange rate regime), it cannot achieve all of the objectives and must strike a balance between them.

In normal times, in the absence of capital controls, monetary policy must strike a compromise between macroeconomic stabilization and leaning against the wind to mitigate overborrowing and underinsurance. Prudential monetary policy consists of two actions. First, by changing the relative prices of tradable and nontradable goods, monetary policy can influence the demand for tradable goods and therefore the total borrowing of domestic agents. Since this does not require any commitment, it is available to policymakers under both discretion and commitment. However, this action can only impact the total level of borrowing but not the composition directly. In fact, as total borrowing decreases, the probability and severity of financial crises decrease as well. As a result, agents increase their exposure and have less insurance, since insurance is costly. In this way, private agents can undo the benefits of the first form of prudential monetary policy. The second type of prudential action involves a future threat of a more depreciated currency, and thus a more severe financial crisis. An expectation of a more severe and frequent crisis induces agents to limit their exposure by reducing total borrowing and increasing insurance. Since this policy is not, by definition, available to monetary policy under discretion, it cannot directly target underinsurance. To recap, absent capital controls, monetary policy under commitment aims for price stabilization, closing the output gap, addressing overborrowing, and addressing underinsurance; discretionary monetary policy has the same objectives, except for addressing underinsurance.

The existence of capital controls modifies the role of monetary policy. Under distinct capital controls, monetary policy focuses exclusively on macroeconomic stabilization. This is because capital controls can eliminate the financial inefficiencies that result from the pecuniary externalities without directly interacting with inflation and the output gap. Importantly, in this environment, there is a "divine coincidence", so monetary policy can simultaneously close the output gap and stabilize prices. As a result, under distinct capital controls, all of the inefficiencies are addressed in normal times. When only uniform capital controls are available, they restrict the volume of capital inflows and address overborrowing. The remaining financial inefficiency, underinsurance, can only be addressed by monetary policy under commitment. Notably, all the prudential actions, whether they are conducted by macroprudential tools or monetary policy, are in place only if there is a nonzero possibility of a binding constraint in the next period. When total liabilities are low enough, the possibility of a future financial crisis is zero. This means that the negative feedback between the exchange rate and the borrowing limit doesn't exist; thus, there is no financial inefficiency and no scope for prudential action.

Furthermore, during a financial crisis, monetary policy limits currency depreciation to prevent borrowing capacity from collapsing too much. This is a form of "fear of floating" (Calvo and Reinhart 2002). However, containing the exchange rate depreciation leads to expenditure switching from nontradables to tradables, and therefore underproduction and deflation in the nontradable sector. Thus, in a financial crisis, monetary policy sacrifices macroeconomic stabilization in favor of easing the borrowing constraint (Ottonello 2021). This tradeoff between macroeconomic stabilization and increasing capital inflows in bad states is present regardless of the commitment power or existence of capital controls.[3]

To summarize, the extent to which optimal monetary policy leans against the wind depends on commitment power, the nature of additional policy instruments, whether there is a financial crisis in the current period, and whether there is a possibility of a financial crisis in future. Note that without the borrowing constraint, the incentive to increase capital inflows during crisis times, as well as the financial inefficiencies of overborrowing and underinsurance, would disappear. That would leave macroeconomic stabilization as the sole responsibility of monetary policy in all circumstances.

These analyses reveal that an essential part of an optimal policy mix is capital controls that target both the total volume and composition of capital inflows. First, they are more effective for addressing financial inefficiencies than prudential monetary policies. Second, they alleviate the tradeoffs that monetary policy faces, and therefore monetary policy more effectively focuses on its traditional macroeconomic stabilization role. Finally, capital controls help insulate the domestic economy from external financial shocks. In normal times, distinct capital controls can be adjusted accordingly to neutralize the impacts of foreign shocks to capital inflows. In a crisis, since capital controls reduce the strength of financial crises, they also dampen the transmission of financial shocks through credit constraints. These results are in line with Rey (2015) who argues that even without any restriction on the exchange rates, global financial conditions constrain domestic monetary policy under unrestrained capital flows.

This paper contributes to a growing literature on optimal monetary and macroprudential policy mix in financially constrained economies[4] (see, e.g., Fornaro (2015); Ot-

[3]However, having commitment power and/or capital controls alleviates this tradeoff as shown below.

[4]For earlier contributions to optimal contractionary monetary policy in a crisis, see, among others,

tonello (2021); Adrian et al. (2020); Basu et al. (2020); Benigno et al. (2013, 2016, 2019); Schmitt-Grohé and Uribe (2021), Bianchi and Coulibaly (2022)). Within this strand of literature, this paper is closely related to Devereux et al. (2019) and Coulibaly (2022). The borrowing constraint in Devereux et al. (2019) features the expected future value of collateral. Therefore, in contrast to this paper, neither monetary policy nor capital controls are prudential in their setup. In my model, borrowing capacity depends on current prices and monetary policy is prudential if the necessary capital controls are not available. Coulibaly (2022) argues that the relative strength of intra- and intertemporal substitutions explains procyclical monetary policies in EMEs. All of these papers consider homogeneous capital flows by assuming a single bond. By contrast, I focus on the effectiveness of prudential monetary policy in a setup with multiple nonuniform capital inflows and a nontrivial liability choice. Having multiple forms of capital inflows yields new insights into both financial crisis dynamics and optimal policy design in financially fragile economies.

This paper is also related to the financial crisis literature that features pecuniary externalities; for example, Korinek (2010); Bianchi (2011); Bianchi and Mendoza (2018); and Jeanne and Korinek (2019). The papers Erten et al. (2021) and Rebucci and Ma (2020) extensively review the literature on the source and implications of pecuniary externalities. The current paper departs from this literature by studying crisis dynamics under the interaction between financial and nominal frictions.

Finally, this paper also relates to the literature that investigates the role of external capital structures on financial stability. Korinek (2018) shows in a real model that the externalities generated by capital inflows in EMEs depend on the payoff profiles of these

Caballero and Krishnamurthy (2003); Christiano et al. (2004); Caballero and Krishnamurthy (2004); and Braggion et al. (2009).

flows. By contrast, in this paper I consider interactions between nominal and financial frictions as well as optimal monetary policy design in an economy facing different forms of capital inflows. Liu et al. (2021) studies the role of having local currency in sudden stop dynamics, while Ma and Wei (2020) argues that financing current account deficits with more equity and less debt reduces financial risks. Empirical studies, such as Forbes and Warnock (2012a), Catão and Milesi-Ferretti (2014), document the importance of the liability structure of a country for financial stability. This paper complements those studies by focusing on the prudential role of monetary policy, which is not addressed by those papers.

1.2 Baseline Environment

Consider an infinite-horizon small open economy model with a tradable and a nontradable sector. The economy is subject to occasional sudden stops of capital inflows. Time is discrete and indexed by t. In each period, the economy is endowed with a stochastic tradable endowment Y_t^T while nontradable goods Y_t^N must be produced within the country. Households have access to international financial markets. In the baseline model, I assume that domestic agents have access to the full set of state contingent Arrow securities. In Appendix B, I show that the main results do not depend on this assumption. Specifically, the financial inefficiencies of overborrowing and underinsurance exist, and the policy responses are the same under financial markets with both complete Arrow securities and composite securities, such as bonds. Domestic agents are subject to a borrowing limit that depends on the price of tradables relative to nontradables. The exogenous shocks are the ones to the tradable goods endowment and to the pricing kernel of international investors.

1.2.1 Households

A representative household has preferences over tradable goods C_t^T, non tradable goods C_t^N, and labor L_t:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t^T, C_t^N, L_t) \tag{1.1}$$

where $\mathbb{E}_0$ denotes the conditional expectations operator and $\beta < 1$ is a discount factor. The utility function $U(.)$ is such that labor is separable from both consumption goods[5] and satisfies the standard regularity conditions. In the quantitative analysis section below, there will be more restrictions on the preferences.

Nontradable goods are produced and consumed domestically. Households are exogenously endowed with stochastic tradable goods Y_t^T in each period. The tradable good is homogeneous and can be traded internationally at price P_t^* without any friction. As a result, in each period, the small open economy has a net export of $Y_t^T - C_t^T$ expressed in the foreign currency. Assuming that the law of one price holds, the price of the tradable good in Home currency is

$$P_t^T = \mathscr{E}_t P_t^*$$

where $\mathscr{E}_t$ is the nominal exchange rate between home and foreign currency denoting the

[5] This assumption greatly simplifies the notation without directly impacting the qualitative findings below.

value of one unit of foreign currency in units of local currency. A depreciation in home currency corresponds to an increase in $\mathscr{E}_t$. Also, without loss of generality, I assume that the international price of the tradable good remains constant at one for every period, i.e., $P_t^* = 1$, $\forall t$.

Households trade securities with large international investors. As an implication of the small open economy assumption, payoff profiles of international securities expressed in the foreign currency are determined by the international investors' pricing kernel, and therefore they are exogenous to the domestic economy. Let B_{t+1}^s denote the security holdings of households for state $s \in S$ at time $t+1$ that is acquired at time t. $B_{t+1}^s > 0$ denotes domestic agents' savings, whereas $B_{t+1}^s < 0$ denotes their borrowings from the international investors using the security s.

In each state of the world, households are subject to the following sequence of flow budget constraints expressed in local currency:

$$P_t^N C_t^N + P_t^T C_t^T + \mathscr{E}_t \mathbb{E}_t \left[M_{t+1}^s B_{t+1}^s \right] = W_t L_t + P_t^T Y_t^T + \mathscr{E}_t B_t + \Pi_t + T_t, \qquad (1.2)$$

where P_t^N is price of nontradable goods; M_{t+1}^s is the pricing kernel of international investors in state s at time $t+1$; W_t is wage from supplying one unit of labor to production of nontradable goods; Π_t is profit resulted from the ownership of the domestic firms; T_t is lump-sum tax or transfers levied by the government. The total wealth that the agent carries to the next period is given by the term $\mathscr{E}_t \mathbb{E}_t \left[M_{t+1}^s B_{t+1}^s \right]$. Note that all variables are indexed by both time and state. However, to ease the notation, I will only explicitly denote states of $t+1$ variables, as in B_{t+1}^s and M_{t+1}^s.

Additionally, domestic households face a borrowing constraint that limits their total external liabilities in the form of

$$-\mathscr{E}_t \mathbb{E}_t \left[M^s_{t+1} B^s_{t+1} \right] \leq \kappa (P^T_t Y^T_t + P^N_t) \tag{1.3}$$

This borrowing constraint captures the idea that the level of total borrowing in the small open economy positively depends on the realization of tradable endowment, nontradable goods price, and the value of local currency against the foreign currency. Because $P^T_t = \mathscr{E}_t P^*_t$, holding everything else constant, a depreciation of the local currency reduces the borrowing limit expressed in tradable goods.[6] Even though the exact specification might differ, this class of borrowing constraints for small open economies is the backbone of sudden stop dynamics and, therefore they are used extensively in the literature.[7]

Given this environment, the representative household's problem is to choose consumption of tradable and nontradable goods, labor, and asset holdings to maximize the expected discounted utility (1.1) subject to the budget constraint (1.2), and the borrowing constraint (1.3). The resulting optimality conditions are

$$U_{T,t} = p_t U_{N,t}, \tag{1.4}$$

$$-\frac{U_{L,t}}{U_{N,t}} = \frac{W_t}{P^N_t}, \tag{1.5}$$

$$U_{T,t} = \beta U^s_{T,t+1} R^s_{t+1} + \mu_t, \qquad \forall s \in S, \tag{1.6}$$

where $p_t \equiv P^T_t / P^N_t$ is the price of the tradable good relative to the nontradable good. Fol-

[6] To see this more clearly, rewrite the constraint as $-\mathbb{E}_t \left[M^s_{t+1} B^s_{t+1} \right] \leq \kappa (Y^T_t + P^N_t / \mathscr{E}_t)$.

[7] See, for example, Basu et al. (2020), Farhi and Werning (2016), Bianchi (2011). In Farhi and Werning (2016) and Basu et al. (2020) borrowing limit depends only on the domestic currency price, and not the production level or endowment. Further, Korinek (2018) provides an analytic description of how this constraint can be micro-founded in the presence of a moral hazard problem.

lowing convention, I interpret this relative price as the inverse of the real exchange rate. U_T, U_N, U_L are marginal utilities of tradable goods consumption, nontradable goods consumption and labor, respectively; $R^s_{t+1} \equiv 1/M^s_{t+1}$ is the return on the security B^s_{t+1}, and $\mu_t/\mathscr{E}_t$ is the lagrange multiplier on the borrowing constraint. Equations (1.4) and (1.5) are intratemporal optimality conditions: (1.4) relates relative demand between nontradable and tradable goods to their relative price, while (1.5) is the condition for optimal labor supply. (1.6) gives the usual intertemporal Euler equation with a wedge μ_t which is positive when the borrowing constraint binds, and zero otherwise.

The condition for optimal portfolio allocation between any two states s and s' is given by the following expression, which can be obtained by writing Euler equations with respect to both states:

$$U^s_{T,t+1} R^s_{t+1} = U^{s'}_{T,t+1} R^{s'}_{t+1} \tag{1.7}$$

This expression reveals that the extent of insurance across different states of the world depends on the relative cost (or return if households save) of the associated securities. If there is no difference in cost, that is, if international investors are risk neutral, and therefore $M^{s'}_{t+1} = M^s_{t+1}$, domestic households have perfect insurance between the two states, i.e., $U^s_{t+1} = U^{s'}_{t+1}$.

1.2.2 Firms

To introduce price stickiness in the nontradable sector, I assume that production of final nontradable goods Y^N_t requires nontradable intermediate goods that are produced by monopolistically competitive firms. The final nontradable good Y_t^N is produced by competitive firms according to the following technology

$$Y_t^N = \left(\int_0^1 Y_{j,t}^{N\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where $\varepsilon > 1$ is the elasticity of substitution between varieties. Each intermediate variety $Y_{j,t}^N$ is produced by a monopolistically competitive firm j which faces the economy-wide productivity A and uses labor as the only input: $Y_{j,t}^N = AL_{j,t}$. The government provides a wage subsidy ϕ^n to each firm j to remove the inefficiency resulted by the imperfect competition. As a result, each firm has the same marginal cost expressed in nontradable goods: $MC_t = \frac{W_t}{AP_t^N}(1-\phi^n)$.

The intermediate goods producers can adjust their prices in each period but are subject to a convex price-adjustment cost in terms of final nontradable goods as in Rotemberg (1982):

$$\frac{\varphi}{2} \left(\frac{P_{j,t}^N}{P_{j,t-1}^N} - 1 \right)^2$$

where φ captures the severity of the adjustment cost.

In a symmetric equilibrium, this formulation yields the following version of the New Keynesian Philips curve:

$$\varphi \pi_t (1+\pi_t) = \varepsilon \left(MC_t - \frac{\varepsilon - 1}{\varepsilon} \right) + \frac{\varphi}{Y_t^N} \mathbb{E}_t \left[\Theta_{t,t+1} Y_{t+1}^N \pi_{t+1} (1+\pi_{t+1}) \right] \tag{1.8}$$

where $\pi_t \equiv \frac{P_t^N}{P_{t-1}^N} - 1$ is the inflation rate of nontradable goods and $\Theta_{t,t+1} \equiv \frac{\beta U_{N,t+1}}{U_{N,t}}$ is households' stochastic discount factor between t and $t+1$. "The profit for each firm j is computed as the difference between its revenue and the combined wage and price adjustment costs and given by:

$$\Pi_t = P_t^N Y_t^N \left(1 - \frac{\varphi}{2}\pi_t^2\right) - W_t \left(1 - \phi^n\right) L_t$$

1.2.3 Government

The government in the small open economy is an entity that sets monetary policy, macroprudential policies, and the wage subsidy. The monetary policy instrument is the value of the local currency, i.e. the exchange rate between the home and foreign currency. Note that the usual interpretation of monetary policy of setting the domestic interest rate path would be isomorphic to choosing the exchange rate between the home and foreign currency, given exchange rate expectations and foreign interest rates. For this, one can assume that there exists a zero net supply of home currency bonds, which are exclusively traded domestically. Moreover, since for a given nontradable price level P_t^N the policymaker can choose P_t^T, I interpret Home's monetary policy as choosing price of tradable goods relative to nontradable goods p_t.

I examine optimal monetary policy based on (1) the availability of additional prudential instruments that can directly regulate the household's portfolio holdings and (2) whether the policy maker has the commitment capacity. For the additional macroprudential instruments, I consider capital control taxes in the baseline model. I investigate whether monetary policy should lean against the wind and be prudential under three different assumptions about the nature of capital controls. The first one is distinct capital controls, where the policymaker can impose a differential capital control tax on each security. I show in Appendix C that employing these kinds of capital controls yields the same allocations as accumulating international reserves. In this sense, capital controls and reserve accumulation are equivalent to each other in the current setup. Then I consider uniform capital controls, in which the policymaker cannot distinguish between capital control taxes among various securities but rather imposes a uniform tax for all types of securities. The final case is when capital controls are not available to the policymaker. The government runs a balanced budget regardless of the type of policy instruments. This means that the lump sum transfers or taxes T_t to households include the wage subsidy as well as the revenue from macroprudential policies when they are in place.

1.2.4 Equilibrium

In an equilibrium, nontradable good consumption is equal to nontradable production net of price adjustment cost

$$C_t^N = Y_t^N \left(1 - \frac{\varphi}{2}\pi_t^2\right) \tag{1.9}$$

The resource constraint for tradable goods derives from substituting firms' profits, the government budget identity and the market clearing condition for nontradable goods into the household budget constraint:

$$C_t^T = Y_t^T + B_t - \mathbb{E}_t\left[M_{t+1}^s B_{t+1}^s\right] \tag{1.10}$$

Definition 1 *(Competitive Equilibrium) A competitive equilibrium for this economy con-*

sists of allocations $\{C_t^T, C_t^N, L_t, \{B_{t+1}^s\}_{s\in S}\}$ *and prices* $\{P_t^T, \pi_t, W_t\}$ *such that taking as given the monetary policy* $\{p_t\}$*, macroprudential policies, wage subsidy, and prices (including asset prices), households maximize their lifetime utility (1.1) subject to their budget constraint (1.2) and borrowing constraint (1.3); firms maximize profits; markets for labor, tradable and nontradable goods clear.*

In line with the optimal policy literature, I take the primal approach by substituting away the policy instruments using the associated equilibrium conditions. This yields the following implementability result:

Implementability: *An allocation* $\{C_t^T, C_t^N, L_t, \{B_t^s\}_{s\in S}\}$ *and prices* $\{\pi_t, p_t\}$ *form part of an equilibrium if and only if the conditions (1.3), (1.4), (1.8), (1.9), and (1.10) are satisfied.*

Note that the implementability result is obtained by assuming that the government has access to tools that can target both the level and composition of security holdings of households. Without these tools, the relevant household optimality conditions become additional implementability constraints for the policymaker, as shown below.

1.3 Optimal Policy Analysis

In this section, I analyze optimal policy design and whether monetary policy has a prudential role. First, I discuss the externalities and inefficiencies that shape the optimal policy actions. Then, I characterize the optimal monetary policy under commitment and discretion. In each case, I investigate how the tradeoffs that monetary policy faces depend on the availability and nature of additional prudential instruments. In what follows, I assume that the wage subsidy is only used to eliminate the inefficiency resulting from imperfect competition in the production of intermediate nontradable goods. This means that the subsidy is time invariant and set to the inverse of the elasticity of substitution between varieties, $\phi^n = 1/\varepsilon$. Setting an optimal wage subsidy in each period would give another optimality condition and and adds little or no realism to the optimal policy design.

1.3.1 Frictions, Externalities and Inefficiencies

Next, I will discuss nominal and financial frictions in this economy and how they create inefficiencies.

Nominal Frictions and Aggregate Demand Externalities

The first friction in this setup is nominal rigidity due to costly price adjustments in the nontradable sector. Because resetting prices is costly, after the realization of a shock, the prices of nontradables do not adjust as they would under flexible prices. "This leads to either over- or under-production of nontradable goods compared to what would be produced under a flexible price level, resulting in an output gap. Additionally, any price change reduces the amount of nontradable goods available for consumption, which in turn induces welfare losses. Households do not take into account the impact of their demand on these price adjustments. Therefore, there are aggregate demand externalities. These externalities are associated with two inefficiencies: inflation and output gaps.

To ease the notation, instead of using the standard output gap concept in the New Keynesian literature, following Farhi and Werning (2016), I will analyze optimal policies using a closely related equilibrium object, the labor wedge, which indicates the wedge between social marginal cost and benefit of transforming labor into nontradable goods:

$$\tau_t = 1 + \frac{1}{A}\frac{U_{L,t}}{U_{N,t}}.$$

The labor wedge is proportional to the output gap and is zero in the flexible price allocations. A positive wedge indicates an output that is below its efficient level (or a recession). As will be shown below, when the borrowing constraint is binding, monetary policy increases the borrowing capacity of the economy, which requires having an exchange rate not depreciated enough to close the output gap. This results in a positive labor wedge in a financial crisis.

Financial Frictions and Pecuniary Externalities

The second friction is due to the existence of the borrowing constraint that depends on the relative price of tradable goods. As the literature shows, this friction leads to pecuniary externalities because private agents do not internalize how their portfolio decisions impact the relative price of tradables through the absorption of tradable goods. In the states in which the borrowing is constrained, lower absorption of tradables due to lower wealth depreciates the real exchange rate (or equivalently, raises the price of tradables relative to nontradables) in an equilibrium. A depreciation in the real exchange rate makes the borrowing constraint even more stringent and further reduces the tradable goods consumption. This is a version of financial amplification through Fisherian debt deflation: A binding borrowing constraint leads to a reduction in net capital inflows, which results in falling in real exchange rates and adverse balance sheet effects through a tighter borrowing constraint; thus leads to even more reduction in net capital inflows. Because this mechanism operates through relative prices, which is an equilibrium object, private agents do not consider how their actions contribute to it, and they accumulate too little wealth in tranquil times.

Remark 1 *Private agents' security holdings in decentralized equilibrium are generally inefficient and it exhibits inefficiencies in*

(i) total volume: the level of total borrowing is excessive, i.e., private agents overborrow,

(ii) composition: portfolio allocation is not socially desirable, i.e., private agents underinsure.

To better understand how pecuniary externalities lead to portfolio inefficiencies in the current setup, suppose that prices are fully rigid[8] at $P_t^N = 1$ for all t and policymaker has access to a distinct capital controls tax for each security. Then the policymaker's problem becomes maximizing households' life time utility (1.1) subject to the implementability constraints (1.3), (1.6), (1.9), (1.10). Also, suppose that there is no financial crisis in the current period. Under these conditions, the Euler equations of the policymaker becomes:

$$U_{T,t} = \beta U^s_{T,t+1}\left(1+\mu^{*,s}_{t+1}\Phi^s_{t+1}\right)R^s_{t+1}, \qquad \forall s \in S \tag{1.11}$$

where $\mu^{*,s}_{t+1}$ is the policymaker's lagrange multiplier on the borrowing constraint at time $t+1$ in state s, and $\Phi^s_{t+1} \equiv \frac{\kappa(U^s_{NT,t+1}-U^s_{TT,t+1})}{U^{s2}_{T,t+1}p^s_{t+1}} > 0$. Weighting these state dependent Euler equations with their associated probabilities and summing across states yields:

$$U_{T,t} = \beta \mathbb{E}_t\left[U^s_{T,t+1}\left(1+\mu^{*,s}_{t+1}\Phi^s_{t+1}\right)R^s_{t+1}\right]. \tag{1.12}$$

[8]This means resetting price is "too costly"; i.e., $\varphi \to \infty$.

Similarly, applying the same steps to the households' Euler equations 1.6, we have

$$U_{T,t} = \beta \mathbb{E}_t \left[U^s_{T,t+1} R^s_{t+1} \right]. \tag{1.13}$$

Because of the assumptions that the constraint is not currently binding and the nontradable good price is rigid, the marginal benefit of an additional unit of borrowing, given by the left hand side of the equations, are the same for households and the policymaker. However, private and social marginal cost of an additional unit of borrowing (the right hand side of the equations) are different, if there is a nonzero possibility of a binding borrowing constraint in some states $\mu^{*,s}_{t+1} \neq 0$. A higher level of debt, first, directly reduces tradable good in the next period. Second, there is an indirect channel. In the states in which the constraint is binding, this reduction in the absorption of tradable goods further decreases the relative price of tradables and makes the constraint even tighter as explained above, which reduces tradable goods consumption even more. The planner takes into account these secondary general equilibrium impacts of borrowing, summarized by the term $U_{T,t+1}\mu^*_{t+1}\Phi_{t+1}$, while private agents do not. For private agents, the marginal value of the next period tradable consumption is $U_{T,t+1}$, while for the government it is $U_{T,t+1}\left(1+\mu^*_{t+1}\Phi_{t+1}\right)$. Consequently, private debt accumulation is inefficiently high, that is, households overborrow.

In addition to overborrowing (inefficient wealth distribution across time), households' security holdings suffer from underinsurance (inefficient wealth distribution across states) due to the existence of pecuniary externalities. Comparing private agents' and the planner's optimality conditions for portfolio allocation between a crisis state *sc* and a non-crisis state sn at $t+1$ is illustrative for this point:

$$U_{t+1}^{sn} R_{t+1}^{sn} = U_{t+1}^{sc} R_{t+1}^{sc} \tag{1.14}$$

$$U_{t+1}^{sn} R_{t+1}^{sn} = U_{t+1}^{sc} \left(1 + \mu_{t+1}^{*,sc} \Phi_{t+1}^{sc}\right) R_{t+1}^{sc}. \tag{1.15}$$

Equation (1.14) is obtained from the households' optimality condition (1.7), and equation (1.15) is the policymaker's optimality condition for the portfolio shares under the fully rigid nontradable goods price assumption. Whether there is a binding constraint or not, households value the tradable goods consumption by its direct effect U_T. Thus, at the optimum, they allocate their portfolio such that the marginal benefits of tradable consumption is equal to the relative cost of securities. The policymaker also makes this marginal cost-benefit tradeoff. However, in crisis states the value of an additional unit of consumption is not just U_T but also $U_T(1+\mu^*\Phi)$ due to the secondary general equilibrium effects as explained before. That's why although the marginal cost of allocating wealth from the non-crisis state sn to the crisis state sc (the left hand side) is the same for both private agents and the policymaker, marginal benefit (the right hand side) is different. As a result, private agents misallocate their portfolios and take excessive risks. This is the underinsurance problem.

Importantly, having the full set of Arrow securities clearly shows that overborrowing in and itself, is not the main problem but underinsurance is. This is because a low level of wealth is a source of inefficiency in bad states but not in good states. However, consumption smoothing across states induces private agents to have a higher level of borrowing than the policymaker in good states as well. With arbitrary composite securities (such as bonds or equities) one cannot distribute wealth across states however one wishes, thus overborrowing and underinsurance is more tightly connected.

The relationship between the volume and composition of debt securities. In this environment, under some mild assumptions, if the total level of borrowing exogenously increases, private agents also reallocate their portfolio to increase their wealth in bad states. This is because as their total liabilities increase, the consumption risk in a crisis also increase. Therefore, private agents want to contain their exposure by having more insurance. As the quantitative analysis in the next chapter shows, this has important policy implications.

To summarize, there are two relevant frictions in this setup, costly price adjustments and the borrowing constraint that depends on the exchange rates. These two frictions lead to aggregate demand and pecuniary externalities that are associated with four inefficiencies: labor wedge, inflation, overborrowing, and underinsurance. The policymaker takes into account these frictions when designing an optimal policy mix.

Also note that due to the modelling assumptions, other possible motives of monetary policy that are usually present in open economy setups do not exist here. Two such motives are manipulating terms of trade and "completing" financial markets by adjusting asset returns. Both terms of trade and asset returns are exogenous to the policymaker in this study. Therefore, they do not play any role in shaping the optimal policy.

1.3.2 Policy Instruments

The monetary policy instrument in this study is the nominal exchange rate, or equivalently, the local currency price of tradable goods. Due to staggered prices in the nontradable sector, by adjusting the exchange rate, monetary policy impacts the relative price of tradable and nontradable goods. By causing an expenditure switch between the two sectors, the policymaker influences the demand for nontradables, thereby affecting inflation and the labor wedge.

For additional prudential instruments, I consider capital control taxes which the policymaker imposes on international securities transactions. By adjusting these taxes, the policymaker distorts private intertemporal and intratemporal financial decisions. This allows the policymaker to choose allocations without having to respect the relevant households Euler equations given by (1.6). These sets of Euler equations can be rewritten in the forms of (1.13) and (1.7) to study the implications of distinct and uniform capital control taxes. If the policymaker can use distinct capital control taxes differentiated by types of capital inflows, then neither (1.13) nor (1.7) constrain the policymaker.[9] Instead, when uniform taxes are available, so that the policymaker cannot directly adjust portfolio allocations, then although (1.13) is not a constraint, the policymaker has to respect the private equilibrium conditions (1.7). If no capital control tax is available, then both (1.13) and (1.7) enter as constraints to Ramsey problems. I assume that the proceeds from capital control taxes are rebated to households so that the government always has a balanced budget.

Next, I will study how optimal policy mixes should be designed considering the inefficiencies outlined above.

[9]As an alternative to distinct capital controls, the policymaker might also accumulate reserves for prudential purposes, as in Arce et al. (2019). Appendix C shows the reserve accumulation case.

1.3.3 Optimal Policies under Commitment

In this subsection, I will characterize optimal monetary policy with the premise that the policymaker is able to commit. Due to the existence of inefficiencies described above, the policymaker has three separate roles in this economy. The first is the standard role of macroeconomic stabilization, which involves stabilizing prices and closing the output gap. Second, in a financial crisis, i.e., when the borrowing constraint is binding, the policymaker aims to ease the credit conditions by increasing the value of collateral. Finally, in normal times, monetary policy leans against the wind to correct the financial inefficiencies that capital inflows create and to policy reduce the severity and frequency of financial crises. The next proposition explains how these roles interact with each other depending on the availability of additional prudential instruments.

Proposition 1 *Optimal monetary policy under commitment has the following properties:*

1. *without the financial friction (if the borrowing constraint is never binding), it achieves the perfect macroeconomic stabilization by eliminating inflation and closing labor wedge, i.e.,* $\pi_t = \tau_t = 0$.
2. *with the financial friction,*
   (a) *under distinct capital controls*
      i. *in normal times, it is able to fully stabilize the economy (*$\pi_t = \tau_t = 0$*) if the most recent crisis is sufficiently past,*
      ii. *in a financial crisis, it strikes a balance between macroeconomic stabilization and relaxing the borrowing constraint,*

iii. *it is not prudential,*

(b) *under uniform capital controls*

i. *in normal times, it deviates from macroeconomic stabilization to target private agents' portfolio allocations by promising a more severe crisis when the constraint binds,*

ii. *this macroprudential role only exists if there is a nonzero possibility of a financial crisis in the future,*

iii. *in a financial crisis, it aims for increasing capital inflows by relaxing the borrowing constraint,*

(c) *without capital controls*

i. *in normal times, it deviates from macroeconomic stabilization to target both level and composition of households' debt by (1) promising a more severe crisis when the constraint binds (2) increasing private marginal cost of borrowing,*

ii. *this macroprudential role only exists if there is a nonzero possibility of a financial crisis in the future,*

iii. *in a financial crisis, it aims for increasing capital inflows by relaxing the borrowing constraint.*

Proof See Appendix A.1.

One immediate takeaway from these results is that during a financial crisis, to alleviate the severity of the crisis, monetary policy increases domestic agents' borrowing capacity by increasing the value of collateral and relaxing the credit constraint, regardless of the capital controls. This requires appreciating the local currency to decrease the relative price of tradables. However, reducing the relative price of tradables induces an expenditure switch from nontradable goods to tradable goods, which leads to underproduction, deflation, and a recession in the nontradable sector. This tradeoff between easing financial conditions and ensuring macroeconomic stabilization is usually present in open economy models with financial frictions (see Farhi and Werning (2016), Ottonello (2021), Coulibaly (2022), among others). In reality, many EME central banks face a similar dilemma as monetary easing might stimulate demand but also it depreciates the currency and reduces capital inflows to the economy. To see this tension more clearly in this environment, suppose the nontradable goods price is extremely rigid at $P^N = 1$ and policymaker has access to the full set of prudential instruments. Then monetary policy can be characterized by the following simple expression

$$\underbrace{U_{N,t}^2 \tau_t (p_t)^2}_{\text{macroeconomic stabilization}} \quad = \quad \underbrace{\mu_t^* \kappa (U_{TN,t} - p_t U_{NN,t})}_{\text{relaxing the borrowing constraint}}$$

which indicates that in a financial crisis ($\mu_t^* > 0$), monetary policy has to sacrifice macroeconomic stabilization ($\tau \neq 0$) in order to relax the borrowing constraint. Conversely, macroeconomic stabilization is only possible if the constraint is not binding.

Remark 2 *Inflation stabilization is generally not the optimal policy.*

Importantly, considering various types of capital inflows reveals that inflation stabilization is the optimal monetary policy in financially fragile economies only under rare circumstances. The first is the absence of the credit frictions (and therefore financial frictions), that is, when κ is sufficiently large. Since there is no financial crisis, there's also no need to increase capital inflows[10] without an occasionally binding borrowing constraint. Moreover, as a consequence of the absence of the borrowing restriction, there is no pecuniary externality and thus, neither overborrowing nor underinsurance arises. This also eliminates the need for prudential action. As a result, monetary policy can focus entirely on stabilizing prices and closing the labor wedge.

Another case when perfect price stabilization is the optimal policy is when there is a full set of policy instruments that can target both the level and the composition of capital inflows *and* the last financial crisis has occurred a sufficiently long time ago. The prudential instruments considered in this study can perfectly eliminate the financial inefficiencies (overborrowing and underinsurance) without directly interfering with the non-financial inefficiencies of the labor wedge and inflation. Therefore, when they are in place, the only role left for monetary policy is macroeconomic stabilization. The requirement that the last crisis hit the economy sufficiently in the past is due to the commitment assumption. If there was a financial crisis that resulted in a deviation from macroeconomic stabilization recently, then convex price adjustment cost requires to adjust nontradable goods price through time, rather than in just one period. This is only possible under commitment. As a result, if there was a recent crisis, even with perfect instruments and without a financial crisis in this period, monetary policy still deviates from zero inflation to keep previous price adjustment promises.

A key feature of the current model that makes price stabilization optimal under aforementioned conditions is the possibility of simultaneously eliminating inflation and output

[10]In fact, without a borrowing constraint that depends on exchange rate (or any other policy instrument) the policymaker is not able to directly adjust capital inflows other than through changing the demand for tradable goods.

gap; that is, the divine coincidence (Blanchard and Galí 2007) exists. In general, in open economy models, there is a tension between closing output gap and stabilizing prices, as explored by Corsetti et al. (2010). The absence of a compromise between inflation and labor wedge in the current setup is due to a combination of different factors. Importantly, here inflation and labor wedge are defined with respect to only nontradable sector which does not feature any other frictions. Also, terms of trade is exogenous because of the existence of homogeneous tradable goods with an exogenous price in foreign currency. Finally, there are no real or nominal frictions other than staggering nontradable goods prices and credit frictions.[11] Without these assumptions of the model, the divine coincidence would not exist.

Remark 3 *Absent from the relevant full set of capital controls, optimal monetary always policy has a prudential element.*

Without the full set of prudential instruments that can target the size and composition of households' borrowing, monetary policy has a prudential role to correct inefficiencies in private portfolios since they contribute to more frequent and severe financial crises. In order to examine how monetary policy reacts to portfolio inefficiencies, let us suppose that there is no financial crisis in the current period and that the nontradable good price is fully rigid at $P^N = 1$. Assuming that there are no other prudential instruments, monetary policy can be characterized by the following expression in a target form

$$\underbrace{U_{N,t}\tau_t}_{\text{macroeconomic stabilization}} = \underbrace{\lambda_{5,t-1}U_{TN,t}R_t}_{\text{addressing underinsurance}} \quad \underbrace{+\lambda_{6,t}U_{TN,t} - \beta\lambda_{6,t-1}U_{TN,t}R_t}_{\text{addressing overborrowing}} \tag{1.16}$$

[11]The existence of credit frictions worsens the trade off between output gap and consumer price inflation (CPI) but not between output and tradable good inflation. Here, CPI is not inherently a source of inefficiency.

where λ_5 and λ_6 denote the policymaker's lagrange multipliers on the optimality condition for portfolio allocation (1.7) and the households' Euler equation (1.13) respectively. Note that to emphasize the monetary policy actions on addressing overborrowing and underinsurance, I break the households' financing decisions into two steps: deciding how much to save or borrow and allocating this sum across different states. In other words, I break the condition (1.6) into two separate conditions: (1.7) and (1.13).

The prudential actions of monetary policy are given on the right side of the above formulation. These actions involve adjusting the private benefits of tradable goods, U_T. All of the terms on the right hand side has U_{TN} in them, meaning that monetary policy uses expenditure switching between tradable and nontradables to improve financial stability. Depending on the degree of complementarity between tradables and nontradables, the policymaker either creates a boom or recession in the nontradable sector to adjust the private value of tradables U_T.

First, consider the case in which the policymaker has access to uniform capital control tax. Then the households' Euler equation (1.13) is not a constraint to the policymaker and the terms in the last bracket in the above expression drop. In this case, monetary policy tradeoffs between macroeconomic stabilization and keeping a promise from the last period. At time $t-1$, the policymaker promises that in the states of time t where the repayment cost is high (R_t^s is high), it will make marginal cost of not having additional insurance, U_T, also high. This requires departing from macroeconomic stabilization (i.e., $\tau_t \neq 0$). Importantly, this promise is the only policy action available through which monetary policy can address underinsurance. For a given borrowing level, portfolio choice is a forward-looking optimization problem that involves future excess returns and consumption risk. Given the assumption that portfolio returns are exogenous to the policymaker, the only available policy action to adjust portfolio weights is the promise to increase consumption risk in future bad states.

If both the level of capital inflows as well as portfolio shares cannot be targeted by additional prudential instruments, monetary policy aims to reduce overall borrowing as well. Under commitment, this can be done through two policy actions. First, at time t, the policymaker increases the cost of borrowing by reducing private marginal value of tradables, $U_{T,t}$. Second, at time $t-1$, the policymaker increases the value of additional wealth at time t by promising an increase in the private marginal value of tradables $U_{T,t}$. However, once household borrowing decisions are already made at time $t-1$, this promise of increasing $U_{T,t}$ at time t is in contrast with the first action (decreasing $U_{T,t}$). This is a source of the time inconsistency problem.

What is the resulting monetary policy stance in a given state? Is it expansionary or contractionary policy in nontradable sector? This depends, first, on the combined impacts of the three action—one for targeting underinsurance and two for targeting overborrowing—explained above, that is, $\left(\lambda_{5,t-1}R_t - \beta\lambda_{6,t-1}R_t + \lambda_{6,t}\right)$. The sign of this expression reveals whether the policymaker wants to increase or decrease the private marginal utility of tradables, $U_{T,t}$. Second, whether this translates into creating a recession or a boom in the nontradables depends on the substitutability between tradables and nontradables, that is, on the sign of $U_{TN,t}$.

Remark 4 *Having additional prudential instruments help insulate the domestic economy from external shocks.*

The results also speak to the recent global financial cycle (GFC) literature that studies whether and how countries insulate themselves from the GFC (see, e.g., Rey 2015). The external shocks in this setup are the ones to the pricing kernel of international investors and, thus, to asset payoffs. If the economy is in a financial crisis, then any change in the debt repayment cost affects the domestic consumption of tradable goods and the exchange rates. Through these, asset price changes have a direct impact on the tightness of the collateral constraint, inflation, and labor wedge. Also, without distinct capital controls, external shocks translate into changes in inflation and labor wedge, even in normal times. Shocks to the cost of borrowing changes the monetary policy stance, as can be seen from (1.16). With a full set of instruments, on the other hand, monetary policy does not face a trade off between macroeconomic stabilization and financial stabilization, and any external shock can be absorbed through exchange rate movements which then lead to an adjustment of the relative price of tradables. In this case, the external shock does not have an impact on inflation and the labor wedge. In this sense, monetary policy is inward looking.

Remark 5 *The resulting allocation is (constrained) efficient only if distinct capital controls are in place and the last crisis has occurred a sufficiently long time ago.*

Because the policymaker cannot undo the frictions that stem from the existence of the borrowing constraint, the first-best allocations are unattainable in this setup. A closely relevant welfare metric used by the literature is constrained efficiency. Constrained efficient allocations are obtained by the policymaker who faces the same financial constraints as private agents but fully internalizes the impacts of their financial decisions on the equilibrium. Without a proper set of instruments that can fully target households' portfolio size and weights, the pecuniary externalities cannot be eliminated. Only with a full set of instruments and after a long period of tranquil times[12], the constrained efficient allocations in which external liabilities do not feature overborrowing and underinsurance can be achieved. This means monetary policy cannot substitute for prudential policies, and these relevant additional prudential policies are welfare improving.

1.3.4 Optimal Policies under Discretion

What are the features of optimal time consistent policies in this environment? To answer this question, in line with the optimal time consistent policy literature (e.g. Klein et al. 2008), I investigate an equilibrium in which the current planner knows that the future planners will re-maximize in future periods and that those maximizations also depend on today's financial decisions B^s_{t+1}. A Markov-perfect equilibrium is a fixed point in these policy actions. Using this equilibrium concept, the next proposition characterizes the time consistent monetary policy, depending on the nature of macroprudential tools.

Proposition 2 *Optimal time consistent monetary policy has the following properties*

1. *without the financial friction (if the borrowing constraint is never binding), it achieves perfect macroeconomic stabilization by eliminating inflation and closing labor wedge, i.e.,* $\pi_t = \tau_t = 0$*.*

2. *with the financial friction,*

   (a) *both under full instrument and under uniform macroprudential tax*

      i. *in normal times, it can fully stabilize the economy (*$\pi_t = \tau_t = 0$*)*

[12] The long period of tranquil times assumption is necessary to completely eliminate the welfare reducing price adjustment.

    ii. *in a financial crisis, it strikes a balance between macroeconomic stabilization and relaxing the borrowing constraint*
    iii. *it does not play any prudential role*
(b) *without any other prudential instrument*
    i. *in normal times, it diverges from macroeconomic stabilization to target level of households' debt by increasing private marginal cost of borrowing*
    ii. *this macroprudential role exists only if there is a nonzero possibility of a financial crisis in the future*
    iii. *in a crisis, it aims for increasing capital inflows by relaxing the borrowing constraint*

Proof See Appendix A.2.

In a financial crisis, as in the commitment case, monetary policy under discretion has to compromise between macroeconomic stability and easier financial conditions (relaxing the borrowing constraint), regardless of the availability of prudential instruments. In normal times, the nature of the tradeoffs that the policymaker faces is different under discretion than under commitment.

Remark 6 *Discretionary monetary policy cannot directly target underinsurance.*

The last section shows that in normal times, absent a full set of instruments that eliminates overborrowing and underinsurance, monetary policy wants to curtail financial inefficiencies in addition to macroeconomic stabilization. This tradeoff between financial stability (if left unaddressed by capital controls) and macroeconomic stabilization also exists under discretion. However, as the last subsection shows, threatening a more severe crisis is an essential tool of monetary policy for ensuring financial stability. As all future promises are futile under discretion, monetary policy is less potent to tackle the financial inefficiencies. As a result, monetary policy focuses more on macroeconomic stabilization, rendering it more inward-looking under discretion than commitment. Note that although discretionary monetary policy wants to target inefficiencies created by capital inflows if they are not addressed by the relevant capital controls, compared with the commitment case, it has fewer options to do so.

Specifically, in the absence of a commitment regarding future actions, monetary policy alone cannot directly address inefficient portfolio shares. This result is not surprising given that portfolio choice involves comparing future risk and returns of different assets and that monetary policy cannot impact them without a promise. One implication of this result is that discretionary monetary policies under both distinct capital controls and uniform capital controls face the same tradeoffs, since in both cases the only financial inefficiency that discretionary monetary policy can target (underinsurance) is already addressed by capital controls.

Remark 7 *Discretionary monetary policy faces less restrictive conditions for stabilizing inflation than under monetary policy commitment.*

In normal times, macroeconomic stabilization is the optimal discretionary policy, except for the case where there are no capital controls available to the policymaker. Consequently, for inflation targeting to be an optimal policy, it requires fewer conditions to be met than under monetary policy commitment. Note that the reasons why inflation stabilization is the optimal policy are different for the distinct capital control case and the uniform capital control case. In the former, all the financial inefficiencies are already addressed, so the only job left to monetary policy is to ensure macroeconomic stabilization. Under the uniform capital control tax case, although overborrowing is addressed, the underinsurance problem is still present, and monetary policy *would* address it if it had a way to do it (as in the commitment case). However, discretionary monetary policy lacks tools to address underinsurance, thus it focuses only on closing the output gap and eliminating inflation.

Remark 8 *Compared to single bond only setups, having multiple assets hinders the discretionary monetary policy's ability to address financial inefficiencies, as overborrowing and underinsurance are negatively related.*

Importantly, although discretionary monetary policy cannot directly address underinsurance, it can still target overborrowing when capital controls are not available to the policymaker. Through expenditure switching between tradable and nontradable sectors, monetary policy is able to alter the private cost of borrowing $U_{T,t}$ by adjusting $U_{TN,t}$. Therefore, the policymaker can reduce overborrowing to some extent, even without additional prudential instruments. However, as explained before, a lower level of borrowing reduces the probability of a financial crisis in the future, and thus the cost of underinsurance becomes lower. As a result, private agents have less incentive to make socially efficient portfolio choices if they accumulate lower debt, and in effect, undo at least some of the prudential gains of reducing the financial inefficiencies. This reduces the effectiveness of prudential actions of monetary policy. Therefore, the benefit of deviating from macroeconomic stabilization to reduce financial inefficiencies is lower than it would be if reducing overborrowing does not lead agents to increase the riskiness of their portfolio. As the marginal benefit is lower in this case, monetary policy gives more weight to macroeconomic stabilization. Indeed, in the quantitative analysis below, I show that discretionary monetary policy is more effective in prudential roles under a single bond setup than multiple security setup.

The result that time consistent monetary policy cannot directly address underinsurance together with the fact that overborrowing and underinsurance are negatively related to each other highlight the importance of well-crafted prudential tools. Monetary policy under discretion alone has much less ability to tackle financial inefficiencies. As the quantitative section shows, these inefficiencies are associated with large welfare losses if they are left unaddressed.

1.3.5 Summary of Policy Objectives

The previous two sections show that optimal monetary policy targets crucially hinge on the existence of other prudential instruments and commitment ability. Table 1.1 summarizes these findings. In every different configuration, monetary policy always has the traditional macroeconomic stabilization objective, namely stabilizing prices and closing the labor wedge. However, the financial stability role of monetary policy is contingent upon the state of the economy and the nature of policy tools. First, regardless of additional prudential instruments, if the economy is in financial crisis, monetary policy also relaxes the constraint by appreciating the currency. Second, if a financial inefficiency can be addressed by prudential policies such as capital controls or reserve accumulation, then monetary policy does not address it. Otherwise, monetary policy addresses both overborrowing and underinsurance under commitment but only the former under discretion.

Table 1.1: Monetary Policy Actions

	Distinct Tax	Uniform Tax	No Other Instrument
Commitment	MS, (RB)	MS, (RB), AU	MS, (RB), AU, AO
Discretion	MS, (RB)	MS, (RB)	MS, (RB), AO

Note: This table summarizes the monetary policy actions depending on availability of other prudential instruments and commitment mechanism. MS: macroeconomic stabilization; RB: relaxing borrowing constraint; AU: addressing underinsurance; AO: addressing overborrowing.

1.4 Conclusion

The intricate relationship between cross-border capital flows and emerging market economies (EMEs) offers both promising opportunities and daunting challenges. This chapter has delved deep into the role of monetary policy in managing capital flows and the possible repercussions of deviating from traditional stabilization methods. The primary findings underscore the inherent complexities in employing monetary policies to mitigate financial inefficiencies in EMEs. When capital flows are uncontrolled, monetary policy must often strike a delicate balance, navigating between macroeconomic stabilization and the prudential measures needed to address overborrowing and underinsurance. However, the presence of capital controls – particularly those that target both volume and composition – can considerably shift the paradigm. They not only address financial inefficiencies more effectively than prudential monetary policies, but they also enable monetary policy to return its focus to traditional macroeconomic stabilization. Moreover, by buffering the economy from external financial shocks, they ensure greater domestic stability, validating arguments that favor a measured approach to capital inflows.

In essence, while monetary policy in EMEs can play a pivotal role in managing capital flows, its efficacy is contingent upon the policy environment and the presence of supplemental tools such as capital controls. Relying solely on prudential monetary policies may not suffice; a more holistic approach, considering both monetary policies and capital controls, is vital for ensuring the stability and prosperity of EMEs.

Chapter 2

A Quantitative Analysis on Monetary Policy and Composition of Capital Inflows in Sudden-Stop Economies

2.1 Introduction

In the previous section, I characterize the optimal monetary policy in small open economies that are subject to sudden stops of capital flows, taking into account various types of capital flows. The main takeaway from that analysis is that in general, monetary policy leans against the wind, and macroeconomic stabilization is rarely an optimal policy. In this section, I conduct a quantitative analysis to investigate the implications of alternative policy regimes for the frequency and severity of financial crisis, their impact on welfare, and the importance of considering various types of capital inflows in designing the policy mix.

For this, I calibrate the model and use a global solution technique[1] to solve it under optimal time consistent policies as well as under commitment with strict inflation targeting. In the quantitative model, I divide capital flows into debt and equity flows (Meng and van Wincoop 2020). The literature shows that equity inflows provide more insurance in a sudden stop for domestic agents (see, e.g., Forbes and Warnock 2012b). From the international investors' point of view, equity is riskier, and thus they demand a premium over debt. So, for the domestic economy, financing current account deficits via debt flows is cheaper but riskier. Due to the pecuniary externalities, private agents choose to carry an excessive level of liabilities with an excessive proportion of debt into the future.

The numerical analysis demonstrates the relative ineffectiveness of prudential monetary policy in reducing the frequency and intensity of sudden stops. Of the discretionary policy regimes I consider, the economy under prudential monetary policy has the highest crisis probability, followed by the uniform capital control regime. Distinct capital controls yields the lowest crisis probability. Further, in a crisis, the drop in both total consumption and nontradables production, as well as current account reversal are the highest under prudential monetary policy, which is followed by uniform and then distinct capital controls regimes. Notably, the policymaker allows a higher level of capital inflows under distinct than under uniform capital controls. This is because the inefficiency comes from the amplification that occurs only in bad states. To the extent that wealth in bad states is not too low, having a high level of liabilities in good states does not create inefficiencies per se.

[1] Specifically, by including portfolio choice and optimal monetary policy, I extend the endogenous grid points with the endogenous borrowing limits procedure described in Jeanne and Korinek (2019), which builds on Carroll (2006).

This is indeed the case; the frequency and severity of financial crises are lower with distinct than uniform capital controls. The ineffectiveness of prudential monetary policy for improving financial stability leads to the lowest welfare compared with distinct or uniform capital controls.

Given that time consistent monetary policy is ineffective for prudential actions, is there any benefit in deviating from a strict inflation targeting regime when capital controls are not available? The inflation targeting regime focuses exclusively on stabilizing prices, *even in a financial crisis*. Since this means that monetary policy does not increase borrowing capacity under inflation targeting, crises are more severe than under prudential monetary policy. However, because private agents know this, they decrease their exposure by borrowing less in total and issuing proportionally more equity in normal times. The result is less frequent but more severe crises. Overall, committing to inflation targeting yields greater welfare than discretionary monetary policy with a prudential component. This shows the importance of commitment.

One reason for discretionary monetary policy's relative ineffectiveness in prudential actions is that when it reduces total liabilities, the frequency and severity of crises also decrease—and as a result, private agents shift their portfolios toward cheaper but riskier securities. This weakens the prudential benefits of having less liabilities and reduces the marginal benefit of having prudential monetary policy. Therefore, monetary policy places less weight on prudential actions. How important is this channel quantitatively? I create a synthetic security whose weights are the same as the equilibrium of the economy under both debt and equity. This ensures that the combined security has the same risk and return profiles as the portfolio chosen in the original equilibrium, while at the same time it allows the volume of flows to change without impacting the composition. As a result, in this case, discretionary prudential monetary policy reduces total borrowing more than it does under multiple securities. Consequently, financial crises are less frequent and less severe. The experiment suggests that models with a single borrowing instrument present in the literature overstate the effectiveness of prudential monetary policy.

In the remainder of this chapter, first, I introduce the quantitative model, along with its calibration and solution method. Then I present the results from this quantitative analysis. The last subsection concludes.

2.2 Quantitative Model

In this section, I show that the financial inefficiencies of overborrowing and underinsurance have quantitatively important impacts on severity and frequency of sudden stops, and hence on welfare. I also evaluate the welfare implications of alternative policy designs.

2.2.1 Preferences, Financial Markets and Policy Instruments

The household utility function in (1.1) takes the following form

$$U(C_t, L_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\varphi_L}}{1+\varphi_L}$$

Consumption good is a composite of nontradable C_t^N and tradable C_t^T consumption and given by

$$C_t(C_t^N, C_t^T) = \left[a^{\frac{1}{\eta}} \left(C_t^T\right)^{\frac{\eta-1}{\eta}} + (1-a)^{\frac{1}{\eta}} \left(C_t^N\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where $\eta > 1$ is the intratemporal elasticity of substitution.

In the previous sections, I considered the full set of Arrow securities in the financial markets. Using these securities, one can create various forms of composite assets that are differentiated based on their risk and return profiles. In practice, a useful classification of capital flows distinguishes between equity flows and debt flows (Meng and van Wincoop 2020). Moreover, literature has documented that debt flows are usually cyclical and riskier for sudden stop prone economies, while equity flows are more benign (Korinek 2018, Forbes and Warnock 2012a, Razin et al. 1998). Based on this, in the quantitative model, I assume that there are two types of capital flows, debt and equity, with equity being safer for domestic agents. On the flip side, equity is riskier for international investors, so they require an equity premium to compensate for the risk.

Then, period budget constraint in local currency becomes

$$P_t^N C_t^N + P_t^T C_t^T + \mathscr{E}_t \left(B_{t+1}^d + q_{t+1}^e B_{t+1}^e\right) \leq W_t L_t + P_t^T Y_t^T + \mathscr{E}_t \left(B_t^d R_t^* + B_t^e R_t^e\right) + \Pi_t + T_t,$$

where B^d and B^e are bond and equity holdings of households, $q^e < 1$ is the price of equity. This price, and returns R^* and R^e are assumed to be set by the international investor's pricing kernel and are expressed in terms of tradable goods. As in the general model, these prices and returns expressed in tradable goods units are exogenous to the policymaker. I will assume that q^e and R^* are constant over time while R_t^e is stochastic in what follows. The borrowing constraint takes the following form

$$-\mathscr{E}_t\left(B_{t+1}^d + q^e B_{t+1}^e\right) \leq \kappa\left(P_t^T Y_t^T + P_t^N\right).$$

The rest of the model has the same structure as before. Appendix D provides private agents' optimality conditions and the government's problems.

2.2.2 Calibration

I calibrate the model to Argentina. Table 2.1 summarizes the parameter values and corresponding sources or targets. There are two categories of parameters. The first set of parameters are those whose values are fairly standard in the literature (Christiano et al. 2005, Mendoza 2005, Bianchi 2011, Devereux et al. 2019). These include international interest rate $R^* = 1.04$, risk aversion $\sigma = 2$, iverse Frish elasticity $\varphi_L = 1$, weight on tradables $a = 0.38$, elasticity of substitution $\nu = 0.83$, monopoly power $\varepsilon = 10$.

The second type of parameters is the ones used to match the moment of historical Argentine data: $\beta = 0.91$ to have an average net foreign asset to GDP ratio of -29%; $\delta = 0.98$ to have an equity to total liabilities ratio of 48% (Lane and Milesi-Ferretti 2017); $\kappa = 0.304$ to have a frequency of sudden stop of 5.5%. The price adjustment parameter φ is chosen to have a three quarter of price stickiness (Faia and Monacelli 2008). I normalize mean labor and total factor productivity to one by choosing labor disutility coefficient $\chi = 0.65$ and $A = 1$.

The stochastic processes for endowment and equity returns are jointly assumed to have

Table 2.1: Parameter values

Parameter	Description	Value	Source or Target
β	Subjective discount factor	0.91	Average NFA-GDP ratio = -29%
R^*	International interest rate	1.04	Bianchi (2011)
q^e	Price of equity	0.98	Equity to total liabilities = 48%
σ	Risk aversion	2	Standard value
φ_L	Inverse Frisch elasticity	1	Standard value
a	Weight on tradables	0.38	Benigno et al. (2013)
η	Elasticity of substitution	0.83	Mendoza (2005)
ε	Monopoly power	10	11% net markup
φ	Adjustment cost parameter	65	Three quarter of price stickiness
κ	Collateral coefficient	0.30	Frequency of crisis = 5.5 %
χ	Labor disutility coefficient	0.65	Mean labor = 1
A	TFP in non-tradable sector	1	Normalization

a bivariate first-order autoregressive process in log forms:

$$\begin{bmatrix} \ln\left(Y_t^T\right) \\ \ln\left(\frac{R_t^e}{R^e}\right) \end{bmatrix} = \rho_s \begin{bmatrix} \ln\left(Y_{t-1}^T\right) \\ \ln\left(\frac{R_{t-1}^e}{R^e}\right) \end{bmatrix} + \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^R \end{bmatrix}$$

with

$$\left[\varepsilon_t^Y, \varepsilon_t^R\right] \sim \text{ i.i.d. } N\left(0, \begin{bmatrix} \sigma_Y^2 & \sigma_{Y,R^e}^2 \\ \sigma_{Y,R^e}^2 & \sigma_{R^e}^2 \end{bmatrix}\right).$$

For the tradable income data, I use the sectoral outputs from manufacturing, agriculture and total natural sources provided by the World Development Indicators (Bianchi 2011). I calculate the return on equity using the data on the Argentina Stock Market (MERVAL) index (Korinek 2018), then based on Tauchen and Hussey (1991), I discretize this continuous process for the tradable endowment and equity returns. In what follows, following the literature, sudden stops are defined as an event in which the borrowing constraint becomes binding and current account reversal is more than one standard deviation.

2.2.3 Solution Method

In order to solve the model, I use a version of the endogenous grid points method proposed by Carroll (2006). I extend the method to the case where the borrowing constraint is endogenous[2], monetary policy is set optimally, and there is an endogenous portfolio choice. The method uses backwards time iteration on the relevant optimality conditions. To simplify the multidimensional nature of the problem, I follow Carroll (2011) and first solve the optimal portfolio weights using the next period's optimal choices (policy functions), then with them, reconstruct the relevant policy functions. Again, treating these new policy functions as the next period's optimal choices, I solve for the rest of today's choice variables and the endogenous state variable of total debt repayment. In the next step, I follow the same procedure by treating the policy functions as the optimum future choices. I repeat these steps until the policy functions in the consecutive periods converge.

[2]For a similar approach, see Jeanne and Korinek (2019).

2.3 Quantitative Analysis

This section presents the results from the quantitative analysis. First, I show the ineffectiveness of prudential discretionary monetary policy in reducing the likelihood and severity of financial crises. Then, I compare prudential discretionary monetary policy with the inflation targeting regime. Finally, I investigate the impacts of the capital inflows structure on the effectiveness of prudential monetary policy,

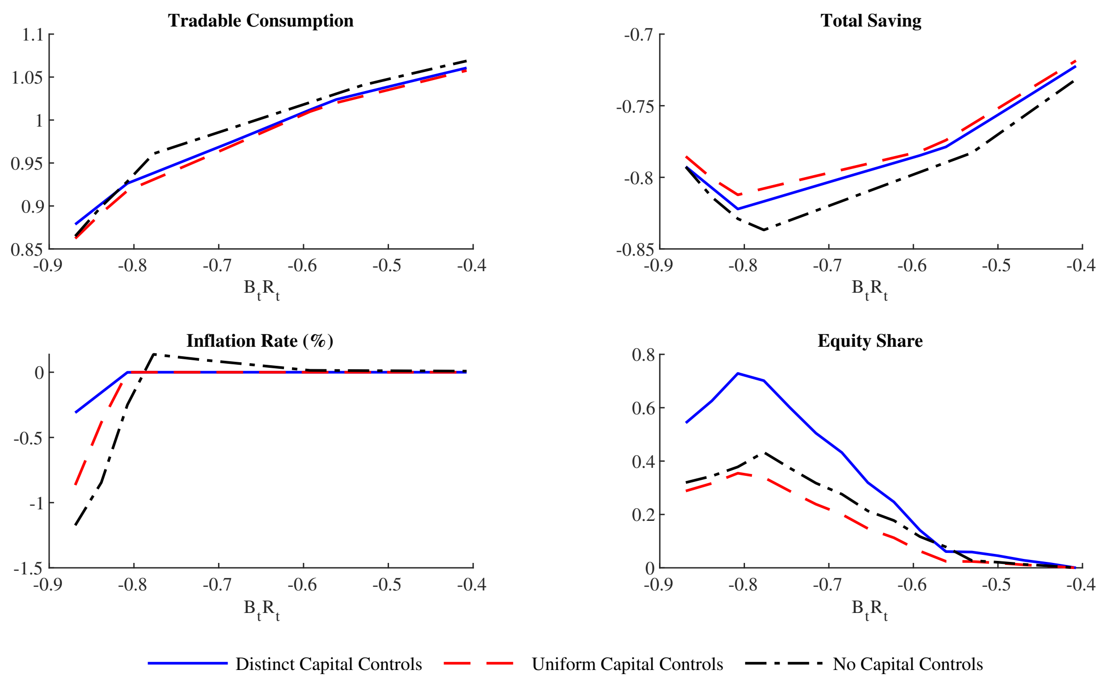
2.3.1 Ineffectiviness of Prudential Monetary Policy

Policy Functions

For a given negative one standard deviation shocks, Figure 2.1 depicts the policy functions that maps the external wealth at the beginning of the period[3] ($B_t R_t$) to endogenous variables, tradable consumption, total savings, equity share in total financing and inflation. In the graphs, the three lines correspond to different policy mixes based on the availability of capital controls. The solid blue line denotes the policy mix with distinct capital controls that can be distinguished for equity and debt flows. The dashed red line corresponds to the uniform capital controls case in which capital controls are the same for both types of flows; and the dashed-dotted line represents no capital controls. In each regime, monetary policy is assumed to be under discretion. Time consistent monetary policy is prudential only in the absence of capital controls. In the other two cases, monetary policy focuses on macroeconomic stabilization in normal times.

[3]With a slight abuse of notation, I will refer $B_t R_t$ as the total debt repayment, including both debt and equity outflows.

Figure 2.1: Policy Functions



Notes: B_tR_t denotes external wealth at the beginning of the period. This figure shows the policy functions under various policy mixes for negative one standard deviation shocks.

As is standard in sudden stop models, the decision rules are nonlinear. Further, the total saving and equity share policy mappings have kinks at the points where the borrowing constraint becomes binding. In the unconstrained region, total saving is increasing (or total financing from abroad is decreasing) in the total external wealth. Due to the existence of externalities, private agents tend to overborrow[4] without capital controls. Indeed, economy under no capital controls borrows the most. Remarkably, when the distinct taxes are available, the policymaker allows more borrowing than the uniform tax. This is because, the policymaker does not want to increase the next period wealth per se but to shift the wealth from bad states to good states and to change the composition of new financing. When this shift is possible, there is no need to reduce the total borrowing as much as in the uniform tax case. On the other hand, in the uniform tax case, the policymaker restricts the total borrowing sharply, since this is the only option to address financial inefficiencies. Tradable consumption follows the patterns of the total financing.

Equity shares are very small at first, then they increase with the total debt repayment in the unconstrained region. When there is no risk of a binding borrowing constraint in next period, the benefit of issuing equity is relatively low, so private agents prefer the cheaper option, issuing debt. As the risk of a binding borrowing constraint becomes positive, agents under all regimes issue more equity. As the solid blue line demonstrates, under the distinct capital controls case, the equity issuance is the largest. Although a higher equity share in liabilities provides more insurance by leading to higher wealth in bad states, private agents do not fully take advantage of it, thus underinsure. By imposing higher capital controls tax on bond issuance, the policymaker is able to induce agents to have

[4]Here overborrowing refers to carrying too little wealth to the next period by raising too much financing (both equity and debt) from abroad in the current period.

a higher equity share. Further, the economy under no capital controls case has a larger proportion in equity than the one under uniform controls. As agents borrow more, they also want to use less risky instrument to contain overall riskiness of their total liabilities in the next period, $B_{t+1}R_{t+1}$.

Discretionary monetary policy focuses on macroeconomic stabilization if uniform or distinct capital control taxes are available in the unconstrained region. When the distinct taxes are available, all the financial inefficiencies are corrected by the capital controls, and monetary policy eliminates the costly price adjustments by stabilizing prices. If only uniform taxes are available, although overborrowing is addressed by the capital controls, underinsurance is not. However, discretionary monetary policy cannot address underinsurance because this requires a credible future promise. As a result, discretionary monetary policy again focuses on macroeconomic stabilization and does not play a prudential role—however, for different reasons than under distinct capital taxes. There is no need for monetary policy to be prudential in the distinct tax case, whereas there is a room to be prudential, but it discretionary monetary policy does not have tools for it, namely a credible threat.

If there is no additional prudential instruments, monetary policy deviates from price stabilisation to be prudential, and thus, there is a spike in the corresponding inflation decision rule in the unconstrained region. Monetary policy creates a boom in the nontradable sector, which then reduces the private value of tradable goods consumption (or increases cost of borrowing); and through this channel contains overborrowing to some extent. Because this entails welfare cost because of nonzero inflation and labor wedge, the policymaker does not fully eliminate overborrowing. Further, reducing total borrowing induces agents to have more risk since low level of total liabilities reduces the probability and severity of financial crises. Thus, in addition to inflation and the labor wedge, containing borrowing has another cost. As a result, capital controls are more effective and less welfare-costly than prudential monetary policy.

In the constrained region, consistent with the Fisherian debt deflation mechanism, as the total wealth decreases, consumption also decreases, and the real exchange rate appreciates, which then further tightens the borrowing constraint and reduces capital inflows (increases total savings). Because this mechanism works through a binding borrowing constraint, we observe a "v-shape" decision rule in total savings (or borrowing). As in the unconstrained region, equity shares follow borrowing patterns; as total borrowing decreases, so do equity shares of all policy regimes. When the borrowing constraint is binding, monetary policy faces a tradeoff: stabilizing prices and closing the output gap requires an expansionary monetary policy; however, relaxing the borrowing constraint requires a contractionary monetary policy to appreciate the currency and relax the constraint. The result is having deflation and a positive labor wedge (underproduction of nontradables). This trade-off is the most severe under a prudential monetary policy regime and the least severe under distinct capital controls. This translates into the highest drop in nontradable production and also in price under prudential monetary policy and the lowest in the distinct tax.

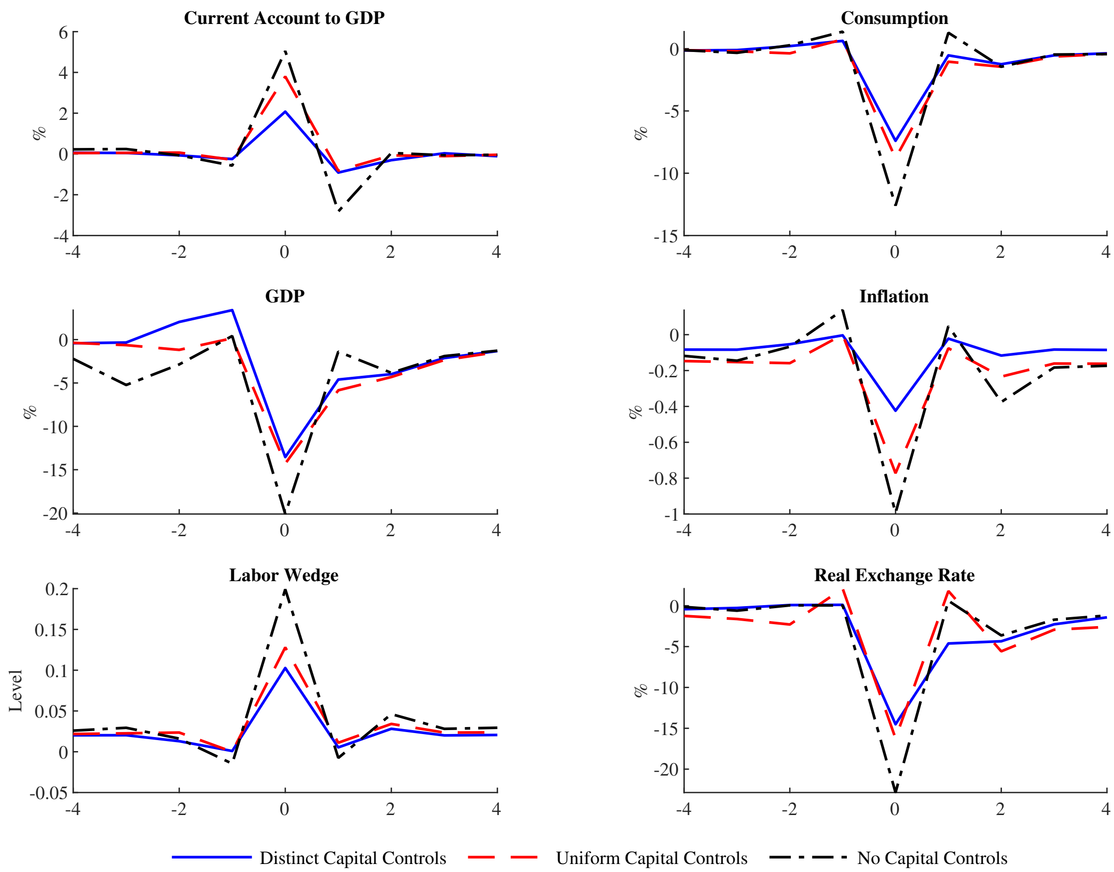
Crisis Dynamics

This section simulates the model and conducts an event window analysis to describe the sudden stop dynamics under different monetary and capital control mixes. A sudden stop is defined as a crisis in which borrowing constraint is binding and the current account is one standard deviation above its ergodic distribution. The model is simulated for 500,000 periods, using the same initial shocks and states for tradable endowment and equity returns for all different regimes. Then, based on the sudden stop definition, I identify crisis episodes and take the averages of the relevant variables around sudden stops. Figure 2.2 presents the results. The x-axes in the figure represent the timing such that time 0 denotes crisis periods and minus and plus numbers represent periods before and after the crisis. As before, the solid blue line, the dashed red line, and the dashed-dotted black line represent distinct capital controls, uniform capital controls, and prudential monetary policy regimes; and in all these regimes, monetary policy is optimally set under discretion.

The first observation from the figure is that sudden stops episodes are painful for the economy. In a sudden stop, current account largely reverses; consumption, production, inflation, real exchange rate sharply fall; labor wedge becomes positive, which represents underproduction of nontradable goods, i.e., recession. These results are consistent with the empirical sudden stop patterns of the corresponding variables in the data, for example, presented by Korinek et al. (2014) and Bianchi and Mendoza (2020).

Importantly, prudential monetary policy is inferior to capital controls in mitigating the severity of financial crises. In every panel of Figure 2.2, the economy in which monetary policy (rather than capital controls) plays a prudential role (dashed-dotted black line) suffers the most. Although monetary policy engineers the highest recession in the nontradable sector and the steepest drop in price level to ease the borrowing constraint, both the current account reversal and the consumption drops are still the highest in this case. This is because discretionary monetary policy is ineffective in playing a prudential role and

Figure 2.2: Event Window Analysis



Notes: This graph shows the averages of variables around the sudden stop events. In the x-axes, 0 denotes the timing of sudden stops, while minus and plus numbers show the before and after crises.

resolving financial inefficiencies. As a result, agents enter into sudden stops with lower wealth and with a higher share of debt.

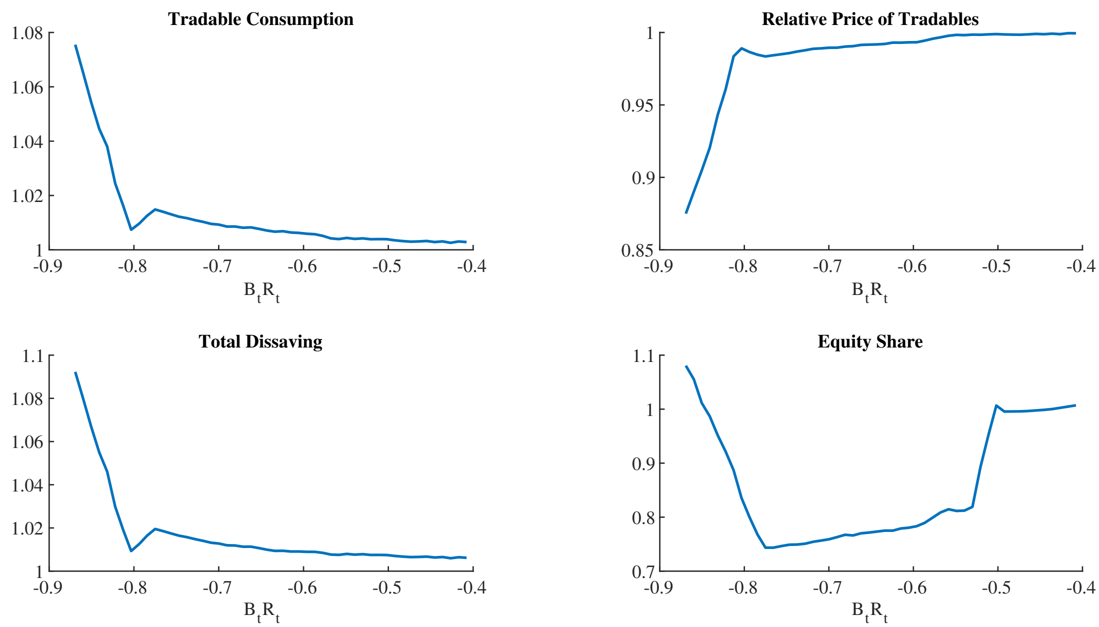
The figure also shows that the composition of liabilities is an important driver of the severity of financial crises, as the comparison of the solid blue line to the others reveals. Since the equity dividend payments decrease in a crisis, the value of existing liabilities also decreases in a sudden stop. Therefore, a higher share of equity in total liabilities makes financial crises less acute. Notably, even though total borrowing is greater in the distinct capital controls case than the uniform tax case, the crisis is less severe under the former. This indicates that for the strength of a financial crisis, not the level of total liabilities per se, but the composition of them matters.

Prudential Monetary Policy under Discretion vs Inflation Targeting

Given that discretionary prudential monetary policy is not effective in addressing the financial inefficiencies of overborrowing and underinsurance, is there a benefit to deviating from the inflation targeting regime in the absence of additional prudential instruments? Next, I will investigate this question.

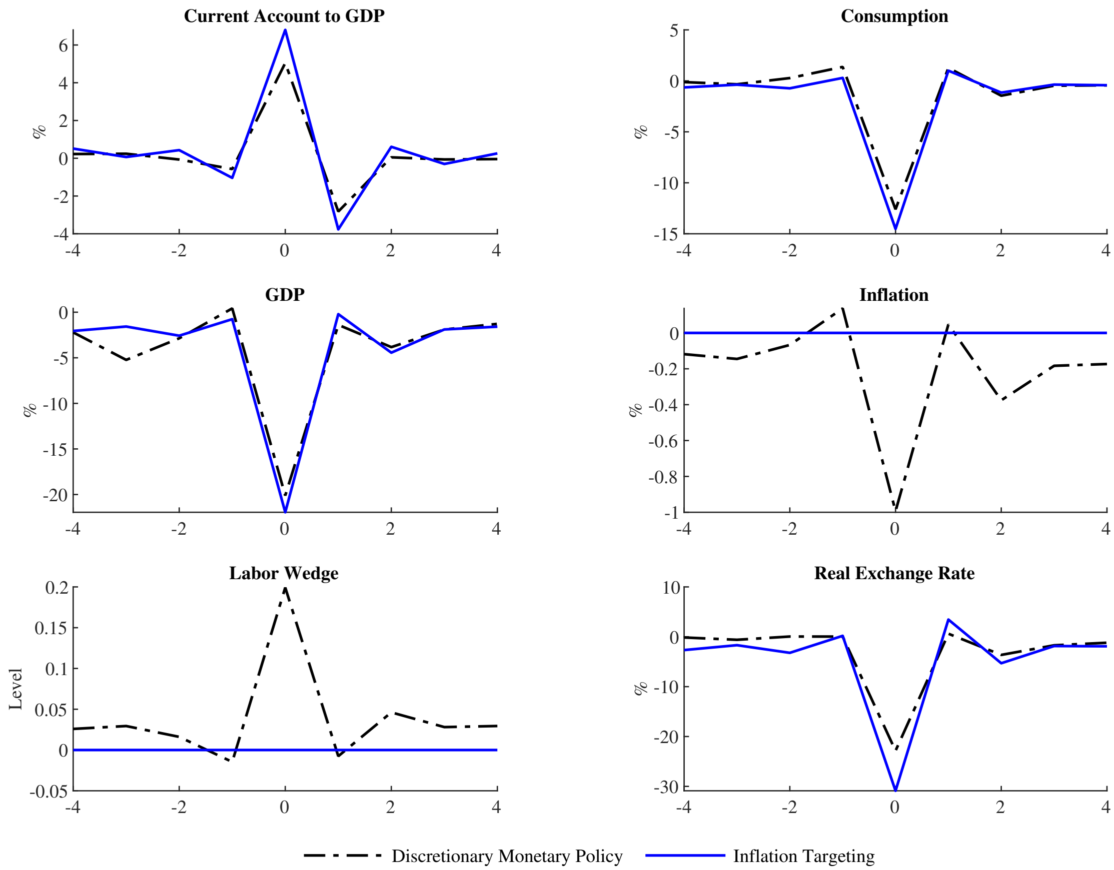
Figure 2.3 displays the ratios of policy functions in the discretionary prudential regime to those in the inflation targeting regime in the absence of capital controls. The only available option for monetary policy under discretion to address financial inefficiencies is to reduce the total financing of private agents from abroad. However, compared to inflation targeting regime (without prudential action), the total borrowing (sum of debt and equity issuance) is still higher under discretionary monetary policy (with prudential action). Under commitment, monetary policy is exclusively focuses on stabilizing inflation,

Figure 2.3: Policy Function Ratios of Prudential Monetary Policy to Inflation Targeting



Notes: This graph shows the ratios of policy functions under prudential monetary policy to those under inflation targeting regime.

Figure 2.4: Event Window Analysis: Prudential Monetary Policy vs Inflation Targeting



Notes: This graph shows the averages of variables around the sudden stop events. In the x-axes, 0 denotes the timing of sudden stops, while minus and plus numbers show the before and after crises.

even during a financial crisis, which makes sudden stops more acute. Thus, agents reduce their exposure by not only lowering their borrowing levels but also by increasing equity shares in total borrowing in the unconstrained region when there is a positive probability of a binding constraint in the future. Higher borrowing levels translate into higher consumption and a lower relative price of tradables under discretionary prudential monetary policy.

Although total debt repayment is higher under discretionary prudential monetary policy than under commitment, crisis episodes are less severe under the former than the latter, as shown in Figure 2.4. This is because, under discretion, monetary policy can forgo price stability in order to increase the borrowing capacity of the economy by appreciating the currency in a crisis. However, the inflation targeting regime exclusively focuses on macroeconomic stabilization, regardless of the state of the economy. Importantly, as domestic agents anticipate this ex-post intervention, they take on too much risk under the prudential discretionary policy regime. This effect is stronger than the ex-ante prudential actions taken by monetary policy to induce agents to have less exposure.

Comparing Simulation Results for Different Regimes

The first panel of Table 2.2 summarizes the severity and frequency of sudden stops under the four different policy mixes considered so far. The first three columns show the results for discretionary monetary policy with distinct capital controls, uniform capital controls, and no capital controls; and the last column shows the outcomes for commitment to inflation targeting without capital controls.

In terms of the incidence of sudden stops, prudential monetary policy under discretion

Table 2.2: Simulation Results

	Optimal Discretionary Monetary Policy			Inflation Targeting
	Distinct Capital Control Tax	Uniform Capital Control Tax	No Capital Control Tax	No Capital Control Tax
1. Crisis Dynamics				
Probability of crises	1.3	2.7	6.6	5.4
Change in				
Consumption(%)	-7.42	-8.81	-12.65	-14.52
CA/GDP	2.07	3.80	5.04	6.83
RER(%)	-14.50	-16.23	-22.86	-30.88
Labor wedge	0.09	0.12	0.19	0
GDP(%)	-13.54	-14.32	-20.11	-21.94
2. Long-run Moments				
Avg(Liability/GDP)	35.09	33.71	38.18	36.67
Avg(Equity Share)	0.46	0.22	0.26	0.29
Std(CA/GDP)	1.03	1.82	2.97	3.28
Std(RER)	5.26	5.31	6.97	7.04

Note: This table shows the simulation results for various policy regimes. CA and RER denote current account and real exchange rate; while Std and Avg denote standard deviation and average.

is the worst in the reducing frequency of financial crisis. Under discretion, having a uniform capital controls decreases the probability of crisis from 6.6% to 2.7% and having a distinct tax further reduces it to 1.3% in the ergodic distribution. Interestingly, even committing to a simple inflation targeting rule is better at reducing the probability of financial crisis. This is because, since private agents expect a more severe crisis under inflation targeting –as monetary policy focuses exclusively on price stabilization and thus does not ease the financial conditions– they insure themselves by accumulating total liability with more equity share.

Comparing in terms of the intensity of crises, no capital controls case is still the worst among the policy regimes under discretion. This shows prudential monetary policy, compared to capital controls, is not only ineffective at reducing the likelihood of a crisis but also the the severity of it. However, without capital controls, the economy under discretionary monetary policy has a milder crisis than the one under inflation targeting. Another observation is that having distinct capital controls that regulate both the level and composition of capital inflows reduces both the frequency and severity of financial crises.

The second panel of Table 2.2 presents the long-run moments resulting from the simulation. Private agents borrow more with a higher share of risky instruments under discretionary prudential monetary policy as opposed to under discretionary monetary policy with distinct capital controls or compared to the inflation targeting regime. This is another evidence of ineffectiveness of prudential monetary policy compared to both the policy regimes with capital controls and to the inflation targeting regime. Capital controls also reduce the long-run volatility of the economy, as evident in the last two rows.

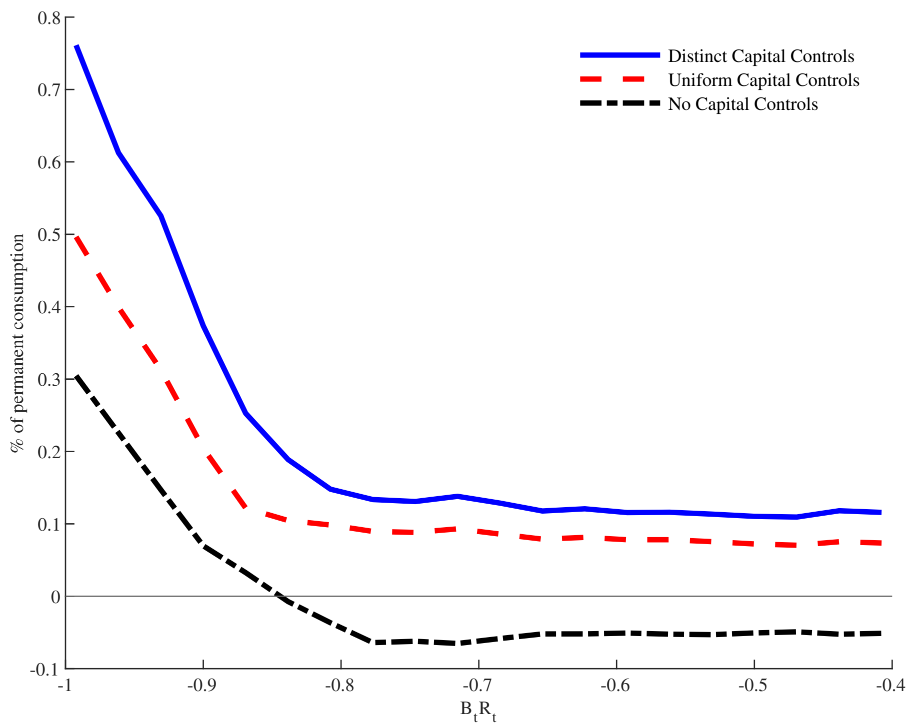
2.3.2 Welfare Implications

Figure 2.5 illustrates the state contingent welfare gains in terms of permanent consumption from discretionary prudential monetary policy (with no capital controls), discretionary monetary policy with uniform capital controls, and discretionary monetary policy with distinct capital controls relative to the inflation targeting regime without capital controls, conditional on a negative one standard deviation shock.

The figure shows that the ineffectiveness of discretionary prudential monetary policy manifests itself in welfare gains. Due to the existence of externalities, private agents tend to have too little wealth and issue too much debt in proportion. Capital controls are better tools than prudential monetary policy under discretion to address these financial inefficiencies. In both constrained and unconstrained regions, discretionary prudential monetary policy yields the lowest welfare compared to discretionary monetary policy regimes with capital controls. Also, there are significant welfare gains in having distinct capital controls that induce agents to borrow less in total with a smaller proportion of the riskier instrument, i.e., debt. Having more insurance and more wealth make sudden stops less frequent and less severe, hence the welfare gains. In the ergodic distribution, discretionary policies with distinct tax and uniform tax yield 0.36% and 0.24% higher welfare (in terms of permanent consumption) compared to the inflation targeting regime.

Importantly, if capital controls are not available, commitment to inflation targeting yields lower welfare than under discretion in the constrained region, since sudden stops are more severe under the latter. However, in the unconstrained region, strict inflation targeting is a better policy than discretionary prudential monetary policy. In the ergodic

Figure 2.5: Welfare Gains Relative to the Inflation Targeting Regime



Note: This figure shows the state contingent welfare gains in terms of permanent consumption from discretionary prudential monetary policy (with no capital controls), discretionary monetary policies with uniform capital controls and with distinct capital controls relative to the inflation targeting regime without capital controls, conditional on a negative one standard deviation shock.

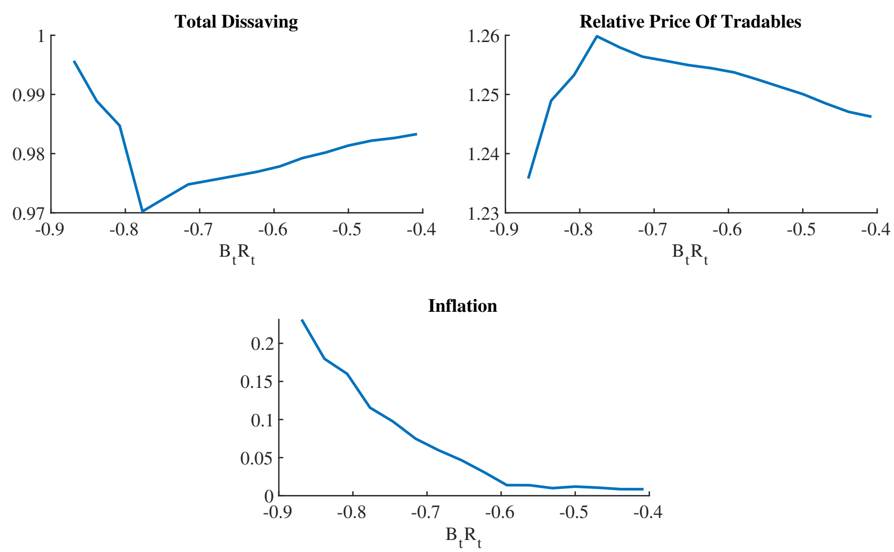
distribution, the inflation targeting regime yields 0.04% higher overall welfare in terms of permanent consumption.

2.3.3 Prudential Monetary Policy under Heterogenous Capital Flows vs Uniform Flows

How does having multiple securities for external financing affect the potency of prudential monetary policy compared to single bond setups? To make this comparison fair, I create a synthetic instrument that is composed of the same bond and equity as before. I take their shares from the equilibrium of the discretionary monetary policy without capital controls case. As previously shown, the lower volume of total borrowing increases the share of the risky instrument, holding everything else constant. This decreases the marginal benefit of reducing total borrowing by having prudential monetary policy. For given marginal cost of deviating from perfect macroeconomic stabilization, this reduces the motivation of the policymaker for financial stabilization. This means that, if the liability shares were to remain constant, we would expect the policymaker to have a more prudential monetary policy, at the expense of macroeconomic stabilization in normal times. As the synthetic instrument allows for changing the volume without impacting the composition, it enables us to test this idea.

The result is given in Figure 2.6. The figure depicts the ratios of policy functions from the synthetic single security setup to those of multiple borrowing instruments, under the assumption of discretionary monetary policy without capital controls. In the single bond case, monetary policy reduces total borrowing more, especially in the regions where the probability of a financial crisis in the next period is higher. This requires more deviation

Figure 2.6: Policy Function Ratios of Prudential Monetary Policy under Single Asset to Multiple Assets



Note: The monetary policy is assumed to be under discretion in both cases.

from price stability, thus higher inflation in normal times. Moreover, the lower level of overall external liabilities reduces the need for appreciation of the local currency to relax the constraint in a crisis and therefore, less drop in the nontradable goods prices.

Having a smaller amount of borrowing translates into fewer and less severe sudden stops. Compared to the multiple bond setup, the single bond setup has a lower risk of financial crises (6.6% vs. 5.7%) and less painful sudden stops (12.65% vs 9.83% consumption drop). Therefore, this exercise shows that bond-only analyses have a tendency to overestimate the effectiveness of prudential monetary policy. Under multiple security setup, monetary policy is more ineffective in addressing financial inefficiencies associated with capital inflows.

2.4 Conclusion

This chapter describes optimal prudential monetary policy in EMEs that face volatile and different forms of capital flows quantitatively. Except for two cases—when there are distinct capital controls or when monetary policy is discretionary and capital controls are uniform for all types of capital inflows—optimal monetary policy always has a prudential element. However, this prudential monetary policy is highly ineffective for reducing the frequency and severity of financial crises, especially without commitment power. Notably, when the total volume of capital flows is restricted without manipulating the composition, private agents realize that the severity and frequency of financial crises decrease, and therefore choose an even higher proportion of riskier financing instruments. In this sense, they undo some of the benefits of a prudential policy. Combining this with the fact that without a credible threat, monetary policy cannot alter the composition of private liabilities, implies that monetary policy (especially under discretion) alone is ineffective for improving financial stability. Committing to a simple objective of inflation targeting yields a higher level of welfare compared with discretionary monetary policy with a prudential component. These results suggest that the primary tool for managing financial inefficiencies created by capital inflows should be prudential instruments, such as capital controls. Importantly, these tools should be employed not only to reduce the total level but also to alter the composition of capital flows.

Chapter 3

Natural Hedge, Real Debt Exposure and International Monetary Policy Transmission

3.1 Introduction

The influence of U.S. monetary policy on global economic dynamics is a critical concern for both scholars and policymakers. Despite its pivotal role, a comprehensive understanding of the transmission channels and factors driving these effects remains somewhat incomplete. This chapter attempts to shed light on these dynamics by examining the role of real debt revaluation, resulting from the differential influence of the dollar on the value of external debt and price of imports, on the transmission of US monetary policy to the domestic economies.

To achieve this, this chapter begins by constructing a model in which I describe the real debt revaluation channel and show that it is a crucial determinant of international US monetary policy transmission. It then employs high-frequency data to provide empirical evidence that countries with greater "exposed debt", a term indicating the sensitivity of real debt revaluation to the dollar, are more responsive to US monetary policy shocks.

The model focuses on a small open economy (SOE) with a tradable and nontradable sectors in a New Keynesian setup. SOE trades both goods and financial instruments with the rest of the world using dollars and euros[1]. It also features international financiers with limited risk-bearing capacity a la Gabaix and Maggiori (2015). Financiers intermediate between SOE and international financial markets. This friction creates the first channel for international transmission of US monetary policy. Holding everything else constant, an increase in the US interest rate increases funding cost of financiers, whereby decreasing their demand for SOE's bonds, and raising the borrowing costs for the households.

The second channel, which concerns real debt revaluation, is the main contribution of this study. Here, a contractionary US monetary policy change appreciates the dollar against the euro[2]. If the dollar's proportion is greater than its share in import invoicing, then this dollar appreciation effectively increases value of external debt in terms of imports. Consequently, the amount of debt, when expressed in terms of tradable goods that the country must repay, increases, impacting the price of tradable goods relative to nontradables in SOE.This leads to a depreciation in the local currency, an increased policy rate, and a heightened currency premium for the country. The effects are stronger for

[1] Bénétrix et al. (2020) and Boz et al. (2020) show that only a handful of currencies are used in international markets.

[2] It has been well documented in the literature that a contractionary US monetary policy appreciates the dollar. See, e.g. Eichenbaum and Evans (1995).

countries with greater "exposed debt" which can be defined as the portion of external debt that is vulnerable to fluctuations in dollar's value and determined by the differential pass through to external debt and imports.

Importantly, the extent of the differential pass through rates to external debt and imports, hence exposed debt, hinges on the comparative weight of the dollar in external debt versus trade. When both external debt and trade are denominated in the same currency, a perfect "natural hedge" is attained, rendering the real value of debt (expressed in terms of tradable goods) independent from fluctuations in the dollar's value. However, when the difference between the dollar's weight in external debt and trade widens, the exposed debt also increases correspondingly. Consider the other extreme. If all external debt is denominated in dollars while all the trade is conducted in euros, then a dollar appreciation against the euro raises the real value of debt one-to-one.

To test the model's predictions regarding the role of exposed debt in transmitting US monetary policy shocks, I conduct an empirical investigation. Employing the identified US monetary policy shocks from Nakamura and Steinsson (2018), I find that countries with more exposed debt are more sensitive to the US monetary policy shocks. Specifically, they experience larger depreciations of their local currencies, higher increases in their currency premia, and larger increases in their domestic policy rates following an unexpected contractionary US monetary policy shock.

Using high frequency measures of US monetary policy shocks, rather than policy rate changes, addresses endogenity issues stemming from the fact that monetary policy reacts to economic news. These shocks are identified by using changes in short-term interest rate instruments in tight windows around policy announcements. The response variables of change in exchange rates and currency premia are measured within the 1-day window bracketing the Federal Open Market Committee (FOMC) meetings to mitigate the risk that they respond to some other news. Domestic policy rates, on the other hand, are in monthly frequency as they are slow moving compared to the other two.

Empirical analyses show that when faced with a 10 bp unexpected contractionary US monetary policy shock, a country with 5% debt exposure (because of having a 50% external debt to GDP ratio and 10% more dollar share in debt than in imports, for example) experiences 5% depreciation in its currency against the dollar and 7.5% increase in its currency premium measured as before and after an FOMC meeting. Similarly, for a 100 bp unexpected contraction in US monetary policy, a country with 5% debt exposure experiences 10 bp increase in its policy rate. These results are stable and robust after controlling for possibly relevant variables including changes in real output and inflation, country size, trade openness, external debt and the volatility index, VIX, as well as other trade and debt related measures.

The theoretical analyses, along with empirical validations, highlight two key points. First, the level of external debt is crucial. Second, the currency composition of this debt, especially when compared to the currency composition of trade, significantly impacts international monetary policy transmission. Therefore, limiting exposed debt requires not only to limit the total level but to adjust the currency composition of debt in accord with currencies that a country trades with.

This chapter's primary contribution is in identifying a crucial channel for the transmission of US monetary policy. There is an extensive literature on the spillover channels from the US monetary policy to the rest of the world. To name a few, Zhang (2018) documents that countries with higher share of dollar in imports exports experience stronger responses in exchange rates, interest rates, and equity returns to changes in US monetary policy. Wiriadinata (2021) shows that the local currency of countries with higher dollar denominated external debt depreciate against dollar more in an event of a contractionary US monetary policy. Among others, Hoek et al. (2022) and Ahmed et al. (2021) show that the extent of spillovers from US monetary policy depend on the source of the shock and the domestic conditions such as foreign currency-denominated debt. Georgiadis (2016) highlights that the magnitude of spillovers determined by domestic country characteristics, such as financial and trade openness, the exchange rate regime, industry and labor market structure, and financial market development. This paper adds to this literature by identifying a new mechanism, exposed debt, for international US monetary policy transmission.

This research adds to the literature on cross sectional variation in currency premia (e.g., Hassan (2013), Richmond (2019), Della Corte et al. (2021), Lustig and Verdelhan (2007)). Similarly, Della Corte et al. (2016) argues external debt while Wiriadinata (2021) argues that dollar denominated debt is important determinant for explaining currency premia across countries. This paper contributes to the existing literature by introducing a distinct channel that impacts currency premium and empirically validating its implications.

An important finding of this research is that having flexible exchange rate regime is not sufficient to insulate an economy from the US monetary policy shocks. This result speaks to trilemma vs dilemma discussions in the literature (Rey (2015), Miranda-Agrippino and Rey (2020), Kalemli-Özcan (2019), Obstfeld et al. (2005), Obstfeld et al. (2019), among others). My contribution here is laying out a specific mechanism that turns trilemma into dilemma.

Finally, this research is related to the literature on dominant currencies in the international monetary system (see, e.g., Gopinath et al. (2020), Maggiori et al. (2019), Chahrour et al. (2017)).

3.2 A Model of International Monetary Policy Transmission

In this section, I present a model that shows the role of the dollar's share in trade and external debt in transmitting U.S. monetary policy to a small open economy (SOE). The model features two sectors: tradable and nontradable. The nontradable sector features sticky prices, allowing us to explore the optimal monetary policy response to U.S. monetary policy changes. Another important friction is that international financiers have limited risk-bearing capacity a la Gabaix and Maggiori (2015). The optimal monetary policy response in the SOE is determined by the level and currency composition of accumulated external debt as well as the currency composition of imports.

The model introduces two channels through which U.S. monetary policy influences the SOE's policy rate, exchange rate, and excess return on its currency. The first channel operates through capital flows: when the U.S. raises interest rates, demand for the SOE's bonds diminishes, leading to capital outflows from the SOE. The second channel, the debt revaluation channel, operates through changes in the dollar's value, affecting the local currency value of the SOE's dollar-denominated external debt, and potentially altering the real value of the debt. The impact of this second channel crucially hinges on the dollar's share in external debt and its share in tradable goods in the economy. Given a specific dollar appreciation and external debt level, a higher share of imports implies a stronger pass-through to import prices, thereby reducing the real value of debt in terms of imported goods.

When the U.S. interest rate increases, the SOE's monetary policy responds by raising the interest rate to counterbalance the capital outflows. The concurrent rise in both domestic and U.S. interest rates leads to lower demand for non-tradable goods, requiring a decline in the relative price of non-tradables. Because nontradable goods have staggered prices, the price of tradable goods increases. This is equivalent to an exchange rate depreciation. Consequently, the interest rate in the SOE increases, the exchange rate depreciates, and the currency premium rises.

3.2.1 Environment

This analysis focuses on a small open economy that accepts international prices as given, referred as the "Home" economy. Time is considered discrete and indexed by $t = 1, 2, 3...$ There are two international currencies, the dollar and the euro, used in the international markets.

Households. In the SOE, a representative household maximizes its utility over the consumption of tradable and nontradable goods, as well as labor. The utility function is represented as:

$$\mathbb{E}_1 \sum_{t=1}^{\infty} \beta^{t-1} U(C_t^T, C_t^N, L_t) \tag{3.1}$$

where

$$U(C_t^T, C_t^N, L_t) = \omega \log C_t^T + (1-\omega) \log C_t^N - L_t \tag{3.2}$$

The composite of tradable goods is given by dollar and euro denominated goods:

$$C_t^T = \left(\frac{C_t^{\$}}{\theta}\right)^{\theta} \left(\frac{C_t^{€}}{\theta}\right)^{1-\theta}. \tag{3.3}$$

Note that dollar-goods and euro-goods can only be traded with their respective currencies. As a result, the price index for C_t^T is defined as:

$$P_t^T = \left(\mathscr{E}_t^{\$} P_t^{\$}\right)^{\theta} \left(\mathscr{E}_t^{€} P_t^{€}\right)^{1-\theta}, \tag{3.4}$$

where $\mathscr{E}_t^j$ is the bilateral exchange rate between Home currency and currency j, and P_t^j is the price of the tradable good C_t^j expressed in currency j. Due to the Cobb-Douglass form, the dollar's expenditure share in tradable goods consumption is θ. Home is endowed with composite traded goods, Y_t^T, in each period. This assumption enables us to focus on the real debt revaluation channel by eliminating the well-understood terms of trade channel. By focusing on the overall net trade balance, there is no need to track bilateral trades between Home and other countries.

Households in SOE are subject to the following budget constraints expressed in the local currency:

$$P_t^N C_t^N + P_t^T C_t^T + B_t^l (1 + i_{t-1}) \leq P_t^T Y_t^T + W_t L_t + B_{t+1}^l + \Pi_t \tag{3.5}$$

where P_t^N is price of nontradable goods; W_t is wage; Π_t is the profit received from the domestic firms, B_t^l denotes the local currency value of debt inherited from the previous period with interest rate i_{t-1}.

As explained below, households borrow from financial intermediaries in local currency who finance themselves by borrowing in foreign currencies from the international markets. Furthermore, small open economy is assumed to have external debt stock at the beginning, some of which is denominated in dollars, $B_1^{\$}$, and the rest is in euros, $B_1^{€}$. Unlike this existing debt stock, households borrow in domestic currency[3].

Households' optimality conditions are given by

$$C_t^N = \alpha p_t C_t^T \tag{3.6}$$

$$-\frac{U_{L,t}}{U_{N,t}} = \frac{W_t}{P_t^N} \tag{3.7}$$

$$U_{T,t} = \beta \mathbb{E}_t \left[U_{T,t+1} (1 + i_t) \frac{P_t^T}{P_{t+1}^T} \right] \tag{3.8}$$

where U_T is the derivative of $U(.)$ with respect to $C_{T,t}$; $\alpha \equiv (1-\omega)/\omega$; and p_t is price of tradable goods relative to nontradables, ie, $p_t \equiv P_t^T / P_t^N$.

Production. Nontradable goods are produced by firms whose only input is labor. The technology that firms use for production is given by

$$Y_t^N = L_t \tag{3.9}$$

[3] This is to simplify the algebra. One can make SOE's external foreign currency borrowing as nonzero by allowing household ownership of the financial intermediaries. However, this would not impact the real debt revaluation mechanism which is the key focus of this paper

where L_t denotes labor at t and A_t is labor productivity. Market clearing condition for nontradables implies:

$$C_t^N = L_t. \tag{3.10}$$

Profits are given by $\Pi_t = Y_t^N P_t^N - W_t L_t$.

Financial Intermediaries. In the financial markets, there is an agency friction a la Gabaix and Maggiori (2015). Households do not have direct access to international financial markets; rather, they must borrow from financial intermediaries. Financial intermediaries buy domestic bonds from Home households and sell dollar denominated bonds in the international markets. Therefore, at time t, they take positions of B_{t+1}^l in domestic bonds and $B_{t+1}^l/\mathscr{E}_1^\$$ in dollar bonds. There is an agency friction such that financial intermediaries can divert $\Gamma(B_{t+1}^l)^{t+1}$ fraction of funds that they borrow from international financial markets. Γ captures the severity of the friction. Therefore, financial intermediaries' demand for domestic bonds is limited by an incentive compatibility condition. Their maximization problem at time t is given by

$$\begin{aligned}
&\max_{B_{t+1}} \quad B_{t+1}^l \left[(1+i_t) - (1+i_t^\$) \frac{\mathbb{E}_t \mathscr{E}_{t+1}^\$}{\mathscr{E}_t^\$} \right] \\
&\text{s.t.} \quad B_{t+1}^l \left[(1+i_t) - (1+i_t^\$) \frac{\mathbb{E}_t \mathscr{E}_{t+1}^\$}{\mathscr{E}_t^\$} \right] \geq \Gamma(B_{t+1}^l)^2.
\end{aligned}$$

where the constraint is the incentive compatibility condition. As the maximand is linear in

B_2^l, the constraint always binds, and the demand for domestic bonds are given by

$$B_{t+1}^l = \frac{1}{\Gamma}\left[(1+i_t) - (1+i_t^{\$})\frac{\mathbb{E}_t \mathscr{E}_{t+1}^{\$}}{\mathscr{E}_t^{\$}}\right]. \tag{3.11}$$

Foreign Economies. The analysis assumes that the aggregate demand in foreign countries is perfectly elastic at constant prices, with $P_t^{\$} = 1$ and $P_t^{€} = 1$. Consequently, the net export of Home varies only in response to changes in domestic demand for tradable goods. Further, the uncovered interest rate parity condition between the dollar and euro holds. This means that an increase in the US interest rate is accompanied by a proportional appreciation of the dollar. Consequently, the returns on dollar and euro-denominated bonds are the same. Based on this, I assume, without loss of generality, that financial intermediaries borrow exclusively in dollars. Other than these, there are no restrictions on the foreign economies and international markets.

Initial External Debt. Home economy starts the first period with initial external debt whose fraction γ is denominated in the dollars and $1-\gamma$ is denominated in the euros.

Competitive Equilibrium. A competitive equilibrium in this economy is given by allocations $\{C_t^T, C_t^N, L_t, B_t^l, Y_t^N\}$, prices $\{P_t^N, P_t^T, P_t^{\$}, P_t^{€}, W_t\}$, interest rates $\{i_t^{\$}, i_t^{€}, i_t\}$, and exchange rates $\{\mathscr{E}_t^{\$}, \mathscr{E}_t^{€}\}$ such that households and firms optimize subject to their respective constraints; goods and labor markets clear.

Resource constraint for tradable goods is given by

$$C_t^T = Y_t^T - \frac{B_t^l(1+i_{t-1})}{P_t^T} + \frac{B_{t+1}^l}{P_t^T} \tag{3.12}$$

Short Run vs Long Run. I assume that in the first period, price of nontradable goods is rigid and given by $P_1^N = 1$. From time $t = 2$ on, the economy reaches the steady state. Our focus is on the short run adjustments in Home to an unexpected change in the US interest rate, $i_t^{\$}$ by considering sufficiently high tradable endowment in the long run so that Home is a net borrower in the first period.

3.2.2 Model Solution

It is important to note that monetary policy can affect the value of local currency in terms of foreign ones, i.e, bilateral exchange rates *simultaneously.* A domestic monetary policy change results in a change in both $\mathscr{E}_t^{\$}$ and $\mathscr{E}_t^{€}$, *at the same time*, therefore, a proportional change in P_t^T. However, monetary policy cannot affect the ratio $\mathscr{E}_t^{\$}/\mathscr{E}_t^{€}$ which is equal to the bilateral exchange rate between dollar and euro. From Home economy's perspective, this ratio changes exogenously which is a key feature for the model. Nor can Home monetary policy affect the ratios $\mathscr{E}_t^{\$}/P_t^T$ or $\mathscr{E}_t^{€}/P_t^T$ since both numerator and denominator change by the same fraction as a result of a domestic monetary policy intervention.

The economy reaches the steady state from the second period onward, where all prices freely adjust, thus, monetary policy does not affect the real allocations.

Further, there is no uncertainty in this version of the model. I analyze the effects of a one-time surprise change in US interest rate as a so called MIT shock on the Home economy.

It is useful to define the labor wedge such that

$$\tau_1 \equiv 1 + \frac{1}{A}\frac{U_{L,t}}{U_{N,t}} \tag{3.13}$$

This labor wedge is proportional to output gap in New Keynesian models. When $\tau > 0$, social cost of producing one more unit of good (given by marginal disutility of labor) is less than social benefit of consuming. This means there is a deviation from potential output, hence an output gap.

Optimal Monetary Policy

To close the model, we must define monetary policy. This is obtained by solving the following problem:

$$\max_{\{p_t, C_t^T, C_t^N, L_t, B_t^l, (1+i_1)\}} \mathbb{E}_1 \sum_{t=1}^{\infty} \beta^{t-1} U(C_t^T, C_t^N, L_t)$$

$$\text{s.t.} \quad C_t^N = \alpha p_t C_t^T, \tag{3.14}$$

$$C_t^N = L_t, \tag{3.15}$$

$$C_t^T = Y_t^T - \frac{B_t^l(1+i_{t-1})}{P_t^T} + \frac{B_{t+1}^l}{P_t^T}, \tag{3.16}$$

$$U_{T,t} = \beta U_{T,t+1}(1+i_t)\frac{P_t^T}{P_{t+1}^T}, \tag{3.17}$$

$$B_{t+1}^l = \frac{1}{\Gamma}\left[(1+i_t) - (1+i_t^{\$})\frac{\mathbb{E}_t \mathscr{E}_{t+1}^{\$}}{\mathscr{E}_t^{\$}}\right]. \tag{3.18}$$

The planner maximizes household utility, subject to the optimality conditions of private agents and resource constraints. In order to simplify the algebra, I consider the limit $\beta \to 1$. Also, without loss of generality, suppose that in the first period we have $\mathscr{E}_1^{\$} = \mathscr{E}_1^{€} = \mathscr{E}_1$ which implies $P_1^T = p_1 = \mathscr{E}_1$; and monetary policy is targeting $\overline{\mathscr{E}^{\$}} = 1$ and $\frac{\overline{U_T}}{\overline{P^T}} = 1$. As prices freely adjust, these nominal assumptions do not have any real implications for the steady state allocations.

As a result, the following expression defines the optimal monetary policy in the first period.

$$\underbrace{\tau_1}_{\text{Demand Stabilization}} = \underbrace{\frac{2B_2C_1^T}{\frac{1}{\Gamma}(1+i_1)^2+\omega-2(1-\omega)B_2C_1^T}}_{\text{Financial Stabilization}}. \tag{3.19}$$

Equation (3.19) characterizes the optimal monetary policy in a target form for Home economy in the first period. It illustrates that monetary policy has to tradeoff between demand stabilization, or closing the output gap, and financial stabilization, or increasing the consumption of tradable goods, given the future (steady state) consumption levels. First, depending on the sign and magnitude of the elasticity of exchange rate to interest rate, increasing tradable goods consumption, which is given by $C_1^T = \omega/[(1+i_1)p_1]$ in an equilibrium, requires either interest rate hike or cut. Second, a contractionary monetary policy reduces the demand for nontradables and increases the output gap and vice versa. This means that monetary policy trades off between increasing the consumption of tradable goods and minimizing the output gap, $|\tau_1|$. The optimal interest rate will balance these two objectives.

As can be seen in (3.19), one implication of this tradeoff is that, in general, the output gap is not zero ($\tau_1 \neq 0$) in this setup, unless either nontradable goods price is flexible (which makes output gap zero by definition) or there is no agency friction in the financial sector ($\Gamma \downarrow 0$). In fact, coexistence of these two frictions lead to the tradeoff between macro stabilization and financial stabilization.

In short, monetary policy can affect the domestic economy through two channels. First, any policy change impacts the economy by shifting the demand for nontradable goods. Second, monetary policy alters the financiers' demand for domestic bonds through (3.11) as well as households' demand for funds. Importantly, these two channels have different effects on the exchange rates, thus, relative price of tradable goods. Next, I discuss the relationship between domestic policy rate and exchange rates.

Relationship between Interest Rate and Exchange Rate In the Short Run

By combining the household optimality conditions (3.6), (3.8); demand for domestic bonds (3.11); resource constraint (3.12); and monetary policy equation (3.19) we obtain the following two expressions that relate the domestic interest rate and exchange rate in the first period:

$$\frac{\omega}{(1+i_1)} = (Y_1 - B_1(1+i_0))p_1 + \frac{1}{\Gamma}\left[(1+i_1) - \frac{(1+i_1^{\$})}{p_1}\right] \tag{3.20}$$

$$p_1 = \frac{2(\omega + i_1)\Lambda_1}{i_1\,(\Gamma\omega + (1+i_1)^2)} \tag{3.21}$$

where B_1 is value of real debt in terms of tradable goods given in the beginning of the first period; $(1+i_0)$ is gross interest rate on the existing debt B_1; and Λ_1 denotes the currency premium given by

$$\Lambda_1 \equiv \left[(1+i_1) - (1+i_1^{\$})\frac{1}{\mathscr{E}_1^{\$}}\right] \tag{3.22}$$

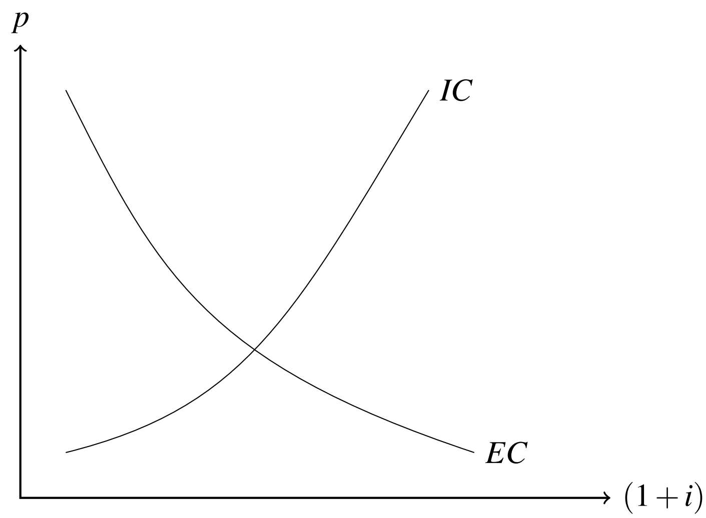
Equation (3.20) defines a familiar relationship between interest rate and exchange rate, where an increase in policy rate rate appreciates the local currency. The Euler equation and the resource constraints for tradable goods yield the supply schedule for domestic bond.

Then imposing bond market clearing condition and equating the supply schedule to bond demand (3.11) results in Equation (3.20). To gain more intuition on this equation, consider an increase in the domestic interest rate. Holding the exchange rate constant, this decreases demand for tradables while financiers' demand for domestic bonds increases (as return on domestic bond increases). To restore the equilibrium, p_1 must decrease (exchange rate must appreciate), which reduces the domestic bond demand (as their return decreases) and facilities expenditure switching from nontradables to tradables.

Equation (3.21) reveals another relationship between interest rate and tradable goods price (i.e. exchange rate). A contractionary monetary policy reduces the demand for non-tradable goods which puts a downward pressure to their prices. This translates into a higher price of tradable goods to reduce relative price of nontradables, because nontradable goods price is sticky. Increase in tradable goods price requires depreciation in exchange rate by its definition (3.4). This channel implies that contractionary monetary policy depreciates the exchange rate, that is, increases p_1.

As a result, we have two loci relating the interest rate and exchange rate, one with negative slope given by (3.20) which I call EC, and one with positive slope given by (3.21) which I call IC. Intersection of IC and EC determines equilibrium levels of exchange rate and interest rate. Importantly, this means that whether an interest rate hike appreciates or depreciates the local currency depends on the shock that monetary policy responds to. A shock that moves IC curve to the right results in an increase in interest rate and appreciation of the local currency, whereas a shock that shifts EC to the right results in increase in interest rate but this time depreciation of the local currency. In this model we consider only an unexpected US monetary policy shock whose effects will be analyzed

Figure 3.1: Exchange Rate Determination



next.

3.2.3 US Monetary Policy Transmission to SOE

An unexpected change in the US policy rate impacts Home economy via two channels. First, it affects the financial intermediaries' demand for Home bonds, therefore, capital flows to the Home economy. Holding everything else constant, an interest rate hike in the US makes Home bonds less attractive for the financial intermediaries, hence reduces financial intermediaries' demand for Home bonds.

Real Debt Revaluation Channel

Debt revaluation is the second channel through which US monetary policy affects the Home economy. Home households have to repay the initial external debt whose real value is given as

$$\frac{\mathscr{E}_1^{\$}B_1^{\$}(1+i_0^{\$})+\mathscr{E}_1^{€}B_1^{€}(1+i_0^{€})}{p_1}=\left[\gamma\mathscr{E}_1^{(1-\theta)}+(1-\gamma)\mathscr{E}_1^{-\theta}\right]B_{1,0}^{l} \tag{3.23}$$

where the equality comes from the definition of p_1 given by (3.4); $B_{1,0}^{l}$ is the local currency value of debt inherited at the beginning of period 1 (including interest rate payments); and $\mathscr{E}$ is the exchange rate between the euro and dollar. Increase in $\mathscr{E}$ denotes appreciation of the dollar against the euro.

As we assumed that UIP between the euro and dollar holds, an increase in the US interest rate appreciates the dollar against the euro by the same proportion. Then change in the real value of debt has to be repaid in response to a US monetary shock is given by

$$\frac{\partial(B_1(1+i_0)/p_1)}{\partial(1+i_1^{\$})}=(\gamma-\theta)B_{1,0}^{l}\equiv D \tag{3.24}$$

where D represents the sensitivity of real debt revaluation to US monetary policy shocks, a concept I will henceforth refer to as “exposed debt”. In response to a US monetary policy tightening, the real value of debt increases with the debt share of dollar, γ, and decreases with the import share of dollar, θ. This means, the impact of US monetary policy on the real value of existing debt depends on dollar’s share in debt as well as its share in trade. When the shares of dollar in debt and trade are equal to each, that is, the debt is naturally hedged, the real value of debt is independent of the US monetary policy. This is the second mechanism by which US monetary policy influences Home economy.

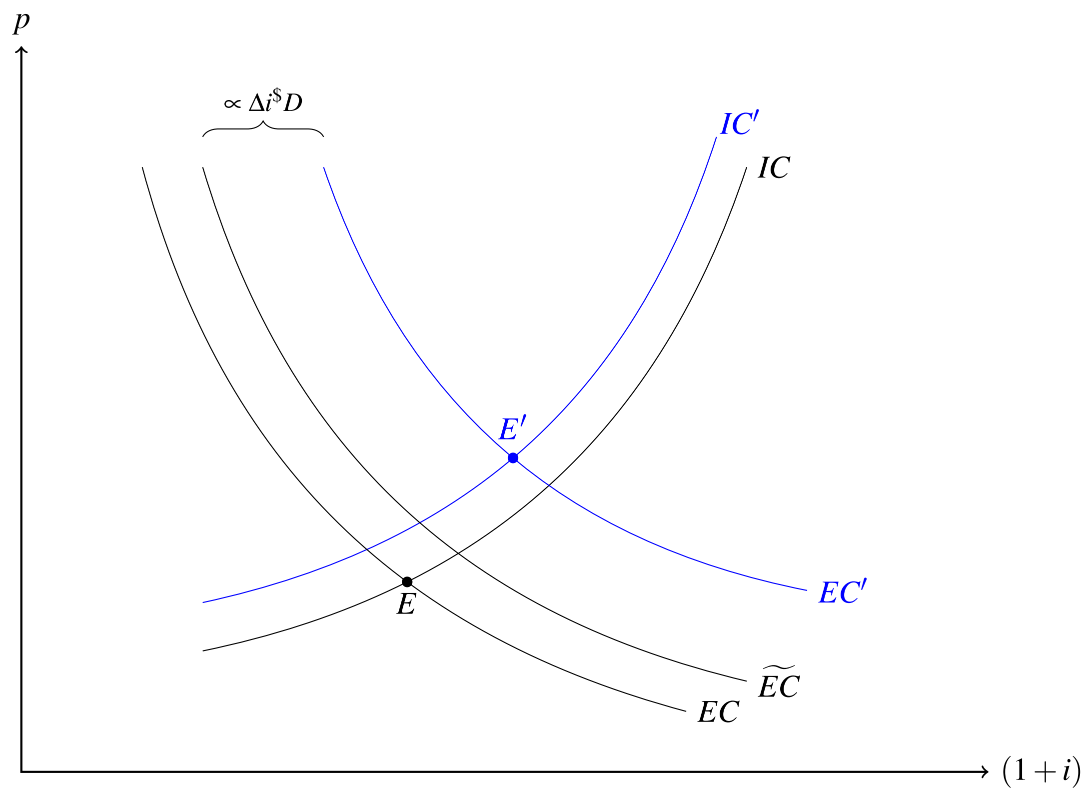
It is well documented that a contractionary US monetary policy appreciates, and expansionary US monetary policy depreciates the dollar. Accordingly, a country with dollar assets experiences change in the local currency value of these assets. Whether these nominal changes translate into real changes depends on the pass through of exchange rates into goods prices. If pass-through is perfect, then asset prices and goods prices move proportionally, and there is no real changes in asset values. However, if the pass-through is imperfect, then exchange rate movements translate into movement in real value of assets.

When assets and goods have different currency composition, pass through to asset prices and good prices differ from each other. Suppose all the assets are denominated in dollars. It is illustrative to consider two polar cases for trade invoicing, first no proportion of consumption good is invoiced in dollars; and second all goods are invoiced in dollars (complete natural hedge). An appreciation of the dollar then has two opposite consequences in the real value of the assets. Real value of assets rises one to one with the dollar appreciation in the first case, but they are constant in the second case. Therefore, dollar's relative shares in assets and goods are important determinants of real asset revaluation.

New Equilibrium

Consider the case where $\gamma - \theta > 0$. Then the two channels described above are in work when there is a contractionary US monetary policy shock. First, it increases the funding cost of financier's, hence reduces their demand for Home bonds. This reduces households' borrowing given domestic interest rate and exchange rates. Second, a contractionary monetary policy in the US appreciates the dollar against the euro, hence, increases the value of debt that must be paid in terms of tradable goods. These two reduce the available tradable goods in the domestic economy. As a result, relative price of tradable goods must increase to constitute a new equilibrium. Due to price stickiness in the nontradable goods, increase in relative price of tradable goods requires nominal exchange rate depreciation.

Figure 3.2: Responses of Interest rate and Exchange rate to U.S. Monetary Policy Contraction



The depreciation of the exchange rate further reduces the inflows of funds (in terms of tradable goods) to Home. Then, to increase the financiers' willingness to lend, monetary policy optimally raises the policy rate. Given the agency friction in the financial sector, higher borrowing necessities higher currency premium. Therefore, in the new equilibrium, Home has a depreciated currency, higher policy rate, higher currency premium. Crucially, these responses of the domestic variables become stronger as the exposed debt, D, increases.

Figure (3.2) depicts the responses of domestic interest rate and exchange rate. The change in financiers' demand for Home bonds due to a higher US interest rate leads IC to shift upwards to IC$'$ and EC to shift right to $\widetilde{\text{EC}}$. The debt revaluation channel shifts EC curve further to EC$'$. It is important to note that for a given US interest rate change, this second shift in the EC curve is proportional to exposed debt, D.

As a result, we have the following predictions from this model:

Model Predictions: *When there is a contractionary US monetary policy, countries with higher exposed debt (D) experience,*

i. greater currency depreciation against the dollar

ii. a higher increase currency premium, and

iii. a higher increase in domestic policy rate.

In addition to external debt and imports, exports might be another channel through which US monetary policy impacts Home. A monetary policy change in the US might change the demand for Home goods in the US and possibly in ROW. This channel is not present in this model given TNT setup and perfectly elastic demand of foreign countries for the tradable goods. This is inline with the empirical findings presented in the next section[4]. Furthermore, even if we focus on differentiated traded goods to allow exports and imports to exist simultaneously, the debt revaluation channel will still exist, which is the main focus of this paper.

Next section tests these model predictions regarding the role of exposed debt in transmitting the US monetary policy internationally.

3.3 Empirical Analysis

This section presents the empirical analysis that shows the importance of exposed debt in transmitting monetary policy shocks internationally. I first describe the data used for the analysis. Then, I regress policy rates, exchange rates, and risk premia on exposed debt and other relevant covariates to investigate the extent to which the impact of US monetary policy shocks on these three response variables varies across countries. The results suggest that for a given external debt, the response variables are more sensitive to the US monetary policy shocks in countries with higher exposed debt.

3.3.1 Data Description

Response Variables. To test the model's prediction regarding the role of exposed debt in transmitting US monetary policy shocks, I consider three response variables in the empirical analysis: domestic exchange rate vis a vis the dollar, premium on domestic currency,

[4] Similarly, Zhang (2018) shows share of exports invoiced in dollars does not play a role for international monetary spillovers from the US. Gopinath et al. (2020) shows in the case of dominant currency pricing, where exports are invoiced in dollar, local currency devaluation does not help export revenues.

and domestic monetary policy rate. I measure the changes in exchange rate and currency premium within a one-day window bracketing FRB announcements. Currency premia is calculated using forward premia and the realized exchange rates. Daily exchange rates and forward rates are from the Bloomberg Market Data.

For changes in monetary policy, I consider monthly difference in policy rates. I obtain monthly monetary policy rates from the IMF's International Financial Statistics (IFS) and Bank of International Settlement (BIS)'s Central Bank Policy Rate data. For a few cases where policy rates are not available in both series, I use short term interest rates, such as treasury bills rate, money market rates or discount rates. These are also from the IMF's IFS.

Main Covariates. There are two key independent variables used in the empirical analysis. The first one is exposed debt variable. To construct this variable, I merge data on currency invoicing of trade with currency denomination and level of external debt. The data on the currency invoicing of trade is from Boz et al. (2020). They provide currency shares of each country's imports and exports between 1990 to 2019. The currencies they consider include the dollar, euro, home currency, and "other", which represents the combined shares of the remaining currencies. I obtain the data on external assets and liabilities and their currency breakdown from Bénétrix et al. (2015) and its updated version from Bénétrix et al. (2020). This dataset covers 50 countries. Observations in both currency shares of trade and external debt data are in yearly frequency, as a result, exposed debt variable is also constructed in yearly frequency.

The second key independent variable is the US monetary policy shocks.For this, I use the US monetary shocks identified by Nakamura and Steinsson (2018) and updated by Bu et al. (2020). Nakamura and Steinsson (2018) construct the US monetary policy shock as the first principal component of change in various interest rate futures in a 30-minute window bracketing FOMC meetings. The main identifying assumption here is that financial markets possess all relevant information regarding monetary policy changes; therefore, any change in those interest rates within this short window reveals monetary policy shocks. This implies that they are also exogenous to the response variables in this study.

Other Covariates. Other macro variables such as GDP, imports, exports, government debt are from the IMF's International Financial Statistics database. In the monetary policy regressions, I include usual Taylor rule variables. However, instead of using realized values of output and inflation, I use revisions in their projections reported in the IMF's World Economic Outlook vintages. Starting from 1990, the WEO has been published twice a year with usually two additional updates. In each publication, the WEO reports the IMF staff's projections for a selected group of variables in addition to their past (realized) values. For each country, the projections are made by desk economists at the IMF who have privileged access to member countries' data. Then these projections are scrutinized by the IMF Research Department in order to ensure global consistency[5]. Using the revisions of projections instead of actual realization of output and inflation addresses some of the endogeneity issues.

[5]See Genberg and Martinez (2014) for a detailed discussion on the WEO projections.

Sample. The final sample is an unbalanced panel dataset spanning 1995 to 2017. In all regressions, I exclude observations with (1) peg exchange rates given by Ilzetzki et al. (2019), (2) closed capital accounts given by Chinn and Ito (2006), (3) observations during global financial crisis of 2008-9, (4) extreme exchange rate volatility (defined as changes in the exchange rate exceeding 10% within two days). I also exclude countries with currencies that are extensively used in international markets, such as the US, UK, Japan, and Switzerland.

3.3.2 Empirical Strategy

Consider the following panel regression:

$$\Delta y_{i,t} = \alpha_0^y + \alpha_1^y \Delta i_t^\$ + \beta^y \left(\Delta i_t^\$ \times D_{i,t}\right) + \alpha_c^y \Xi_{i,t}^y + \varepsilon_{i,t}^y \tag{3.25}$$

where $y_{i,t}$ denotes the change in the response variable of country i at time t. The response variables considered are exchange rate, currency premium, and policy rate. The term $\Delta i_t^\$$ represents the US monetary policy shock, and $D_{i,t}$ denotes the real debt subjected to revaluation (exposed debt), calculated as $D_{i,t} \equiv (\gamma_{i,t} - \theta_{i,t}) \times B_{i,t}$. Here, B denotes the total foreign currency external debt normalized by GDP, while γ and θ denote the dollar's share in external debt and imports, respectively. $\Xi_{i,t}^y$ includes other relevant covariates specific to the regression. In all three regression specifications (exchange rate, currency premium, and policy rate), $\Xi_{i,t}^y$ also covers lower-level interaction terms. It's important to note that changes in the exchange rate and currency premium are obtained within a one-day window bracketing the FOMC meetings. However, for monetary policy rates, monthly changes are used due to the unavailability of higher frequency data.

The coefficient of interest in Equation (3.25) is β^y. This coefficient will inform us about the role of exposed debt on the transmission of unexpected US monetary shocks into domestic variables of exchange rate, currency premium and policy rate. The model in section 3.2 predicts that higher exposed debt results in greater exchange rate depreciation, higher increase in currency premium and policy rate when there is a contractionary monetary policy. Therefore, we expect β^y to be positive and significant in all three regressions.

3.3.3 Main Results

Exchange Rate Response

This subsection presents my empirical findings that provide strong support for the theoretical predictions about the relationship between real debt exposure (D) and the transmission of US monetary policy shocks ($\Delta i^{\$}$) by focusing on the exchange rate movements around the FOMC meetings. Table 3.1 presents the results for the exchange rate regressions for six different specifications. In all specifications, exchange rate response is measured as the percentage change occurring between the day following and the day preceding an FOMC meeting. An higher exchange rate indicates a depreciation of the home currency.

Consistent with the implications of theoretical framework, I find that an increase in the US interest rate ($\Delta i^{\$}$) has a significant positive effect on the exchange rate in all six models. This finding aligns with previous studies and suggests that contractionary US monetary policy is generally associated with a stronger dollar and consequently, depreciated local currencies.

However, the dollar's appreciation against other currencies is not uniform across all observations. In all specifications, the coefficient estimate for $\left(\Delta i^{\$} \times D_i\right)$ is positive and statistically significant. This, in line with the model presented in section 3.2, implies that countries with higher debt exposure experience a greater impact on their exchange rate from changes in the US interest rate. More specifically, on average, a coefficient of 0.1 implies that a country with 2.5% more debt exposure (because of having a 25% foreign currency to GDP ratio and 10% more dollar share in debt than in imports, for example) experiences *2.5% more depreciation* in its currency against the dollar, when there is a 10 bp unexpected contraction in US monetary policy.

Notably, including other possibly relevant variables such as size (the domestic GDP relative the US), openness (imports plus exports relative to GDP), external debt does not change the fact that having more exposed debt is associated with higher fluctuations in exchange rate around FOMC meetings. In all the specifications, the main coefficient of interest is estimated around 0.1. In the last column, where all these variables are considered together, the coefficient is estimate is 0.12 and it's still statistically significant.

A remark on the interaction term on external debt in column (6) is in the order. This coefficient positive and significant, suggesting that external debt is a factor driving the response of domestics exchange rate to US monetary policy shock. This also aligns with the mechanisms laid out in section 3.2. According to the model, a higher level of external debt implies higher borrowing needs, ceteris paribus. When the US interest rate rises, it deters financiers' demand for home bonds, making borrowing more difficult, which in turn, affects the exchange rate. This is also in line with previous findings such as Wiriadinata (2021). Remarkably, after controlling for external debt the explanatory power of the exposed debt (D) remains robust.

In the analyses, not the headline US interest rate changes but the shocks extracted from it is used to eliminate any endogeneity concerns. To make sure that the US monetary policy shocks and the exchange rates do not respond to the same global shocks, in column (5) I control for the VIX index which is considered to capture global financial conditions. The estimate of coefficient on VIX is statistically insignificant while D is still significant.

These results support the model's prediction that countries with higher exposed debt experience a more pronounced depreciation of their currency against the dollar when there is a contractionary US monetary policy change.

Currency Premium

We now turn to the relationship between real debt exposure (D) and the US monetary policy shocks ($\Delta i^{\$}$) on the response of currency premium. The results for the currency premium regressions are presented in Table 3.2 based on six distinct models. Similar to the analysis in the previous section, the response of the currency premium is as the percentage change in one-day windows bracketing FOMC meetings. The dependent variable, change in currency excess return, is calculated according to:

$$curprem_{i,t+1} = log(FP_{t,t+1}) - \Delta log(ER_{t+1}) \tag{3.26}$$

where $log(FP_{t+1})$ is logarithm of forward premium and $log(ER_{t+1})$ is realized exchange rate.

Similar to the findings in the context of exchange rates, an increase in the US interest rate ($\Delta i^{\$}$) exhibits a significant positive effect on the currency premium. Note that although

Table 3.1: Nominal Exchange Rate Response

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta i^{\$}$	8.115***	4.960**	7.905*	6.315*	8.117***	-11.170
	(1.847)	(2.308)	(4.243)	(3.402)	(1.860)	(7.766)
$\Delta i^{\$} \times D$	0.128**	0.114*	0.130**	0.125**	0.132**	0.141**
	(0.062)	(0.064)	(0.061)	(0.063)	(0.063)	(0.069)
$\Delta i^{\$} \times Size$		1.088				2.244**
		(0.821)				(1.027)
$\Delta i^{\$} \times Openness$			0.304			8.587
			(4.589)			(5.294)
$\Delta i^{\$} \times ExternalDebt$				0.034		0.130
				(0.059)		(0.080)
ΔVIX					0.010	0.010
					(0.016)	(0.016)
N	832	832	832	832	823	823
Within R2	0.047	0.052	0.047	0.048	0.052	0.066
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

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

the coefficient on $\delta i^{\$}$ appears negative and significant in column (6), considering all the other interactions, the average impact of $\delta i^{\$}$ is still positive. In the model, an increase in the US interest rate reduces the financiers' demand for Home bonds. To restore financiers' demand, Home currency offers a higher currency premium.

The interaction term $\Delta i^{\$} \times D$ shows a positive and significant impact on the currency premium in all six specifications. This result is in line with the theoretical expectations laid out in section 3.2 and supports the hypothesis that higher debt exposure amplifies the impact of US monetary policy shocks on the currency premium. On average, a coefficient of around 0.15 suggests that a country with a 2.5% more debt exposure (because of having a 25% foreign currency to GDP ratio and 10% more dollar share in debt than in imports, for example) experiences *3.75% more increase in excess return in its currency*, when there is a 10 bp unexpected contraction in US monetary policy. Greater debt exposure result in an amplified increase in the currency premium following a contractionary US monetary policy shock.

As in the exchange rate analysis in the previous part, other macroeconomic such as size, openness, and external debt are considered in this analysis. Interestingly, the interaction terms involving these variables show statistically significant impact only in Model 6, where all variables are considered together. This suggests that while the primary determinant of currency premium response is the country's debt exposure, other macroeconomic factors may also play a role when they are simultaneously accounted for.

Similar to the previous subsection on the exchange rate response, we also observe that external debt is positive and significant in column (4) and (6). This again aligns with the theoretical framework: as higher external debt implies increased borrowing needs, and a rise in the US interest rate reduces financiers' demand for home bonds, the currency of a country with higher external debt needs to offer higher premium. However, the impact of real debt exposure (D) remains robust, even after controlling for external debt. This highlights the argument that not only the total debt level but also the specific composition of the debt (i.e., the extent of dollar-denominated debt relative to dollar-denominated imports) significantly influences a country's currency premium response to US monetary policy shocks.

In contrast, the variable related to global volatility (ΔVIX) does not exhibit a significant impact on the currency premium in columns 5 and 6 where they are included. This suggests that global volatility may not play a significant role in affecting the currency premium response to US monetary policy shocks.

In conclusion, these results indicate that a country's real debt exposure is a crucial determinant of its currency premium response to US monetary policy shocks, as predicted by the model presented in section 3.2.

Policy Rate

The model predicts that monetary policy rates of countries with higher exposed debt (D) are more sensitive to US monetary policy shocks. The regression results, presented in Table 3.3, provide empirical support for this prediction.

To examine this hypothesis, I estimate equation (3.25) with the domestic monetary policy rate as the dependent variable. An important difference in this set of regressions from the previous ones, is the frequency of the dependent variable. While the outcome variables for exchange rate and excess return were measured within a one-day window

Table 3.2: Currency Premium Response

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta i^{\$}$	8.300***	7.068**	7.841	-1.692	8.415***	-28.319***
	(2.236)	(2.780)	(5.580)	(2.116)	(2.286)	(7.899)
$\Delta i^{\$} \times D$	0.163***	0.159***	0.167***	0.111*	0.166***	0.120*
	(0.053)	(0.055)	(0.060)	(0.058)	(0.053)	(0.071)
$\Delta i^{\$} \times Size$		0.447				3.329***
		(0.728)				(1.038)
$\Delta i^{\$} \times Openness$			0.573			11.742**
			(5.361)			(5.574)
$\Delta i^{\$} \times ExternalDebt$				0.194***		0.353***
				(0.043)		(0.072)
ΔVIX					-0.010	-0.009
					(0.015)	(0.014)
N	525	525	525	525	520	520
Within R2	0.059	0.060	0.059	0.079	0.061	0.103
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

around FOMC meetings, the same approach is not feasible for policy rates due to their more infrequent adjustment. Consequently, I employ monthly observations in this analysis as this is the most frequent data available.

Moreover, in this set of regressions, I include usual Taylor rule variables, output and inflation as the policy rates possibly respond to these variables. Note that these are revisions to the projections in the WEO instead of actual realization of real GDP growth and inflation. However, the WEO revisions are published quarterly, although the policy rates are measured monthly.

The coefficient on the interaction term $\Delta i^{\$} \times D$ is positive and significant across all specifications, indicating that an increase in the US interest rate leads to a larger response in the monetary policy rates of countries with higher real debt exposure. On average, a coefficient of around 0.02 suggests that a country with a one standard deviation more debt exposure experiences *30 bp more increase in its policy rate*, when there is a 100 bp unexpected contraction in US monetary policy. This result remains robust after controlling for several macroeconomic variables, including changes in real output and inflation, country size, trade openness, external debt and the volatility index, VIX.

Notably, the effects of these macroeconomic controls on policy rate sensitivity are not significant across the models. This suggests that these factors do not significantly influence the sensitivity of policy rates to US monetary policy shocks. In contrast, the consistent significance of the interaction term $\Delta i^{\$} \times D$ emphasizes the important role of real debt exposure in shaping this sensitivity.

In sum, these findings underscore the importance of accounting for the composition of debt, in addition to its level, when assessing a country's vulnerability to external monetary shocks. High real debt exposure (higher external debt levels and/or higher debt share of dollar than its share in imports) can amplify the impact of US monetary policy on domestic policy rates.

3.3.4 Robustness

In this section, I conduct various types of robustness checks for the analyses presented before. First, I include the lower level interaction terms to the main specifications; then, I control for other possible debt-related variables; and finally, I control for international trade-related variables. In a nutshell, the main coefficient of interest for exposed debt, *D*, remains economically and significant significant across these new specifications.

Table 3.4 presents the results in which I included the lower term interaction terms. Because debt exposure *D* is in fact an interaction term involving the US monetary policy shocks, external debt and the difference between dollar's share in debt denomination and import denomination, one concern would be whether the estimate on the coefficient of *D* represents the combined impacts rather than marginal impacts. To address this issue, I included the lower terms.

The coefficient of the main variable of interest, *D*, is positive and highly significant across all model specifications. In fact, we observe that the estimates for the coefficient of *D* increase with the inclusion of lower level interaction terms, for all three outcome variables. This observation reaffirms the robustness of the main findings that *D* does not merely capture overall international financial exposure but rather captures a specific aspect that is robust to the inclusion of additional lower level interaction terms.

Table 3.4 shows the main results are similar when I control for other possible debt

Table 3.3: Policy Rate Response

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta i^{\$}$	0.925**	0.259	0.296	0.285	0.191	0.064	-0.530
	(0.416)	(0.558)	(0.577)	(0.565)	(0.977)	(0.796)	(1.538)
$\Delta i^{\$} \times D$	0.014**	0.020*	0.020*	0.020**	0.020*	0.017*	0.016*
	(0.006)	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.009)
$\Delta RealOutput$		-0.009	-0.009	-0.009	-0.009	0.003	0.003
		(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)
$\Delta Inflation$		-0.002	-0.001	-0.002	-0.002	0.009	0.012
		(0.021)	(0.022)	(0.022)	(0.021)	(0.018)	(0.019)
$\Delta i^{\$} \times Size$			-1.261				-1.806
			(3.869)				(5.552)
$\Delta i^{\$} \times Openness$				-0.029			-0.034
				(0.197)			(0.260)
$\Delta i^{\$} \times ExternalDebt$					0.001		0.014
					(0.015)		(0.022)
ΔVIX						0.003	0.004
						(0.003)	(0.002)
N	644	405	405	405	405	307	307
Within R2	0.009	0.014	0.014	0.014	0.014	0.015	0.017
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

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

Table 3.4: Specifications with Lower Interaction Terms

	Exchange Rate	Currency Premium	Policy Rate
	(1)	(2)	(3)
$\Delta i^{\$}$	2.876	-4.474*	0.405
	(3.154)	(2.570)	(0.951)
$\Delta i^{\$} \times D$	0.298*	0.499***	0.067*
	(0.154)	(0.133)	(0.036)
$\Delta i^{\$} \times ExternalDebt$	0.065**	0.169***	-0.005
	(0.030)	(0.031)	(0.010)
$\Delta i^{\$} \times (\gamma - \theta)$	-14.230	-30.155***	-3.076
	(11.053)	(9.425)	(2.399)
$ExternalDebt$	-0.013*	-0.009**	0.002
	(0.007)	(0.004)	(0.002)
$\gamma - \theta$	-0.978	-0.363	-0.134
	(0.796)	(1.015)	(0.498)
$ExternalDebt \times (\gamma - \theta)$	-0.014	-0.014	-0.001
	(0.011)	(0.015)	(0.007)
$\Delta RealOutput$			-0.009
			(0.014)
$\Delta Inflation$			-0.006
			(0.024)
N	832	521	405
Within R2	0.090	0.102	0.028
Fixed Effects	Yes	Yes	Yes

Standard errors in parentheses

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

related channels through which the US monetary policy impacts the domestic economies. I control for dollar denominated external debt in column (1); for net dollar denominated external debt where I subtract dollar denominated debt assets from dollar denominated debt liabilities in column (2); for external debt denominated currencies other than dollar in column (3) of each panel. As observed in these columns, the coefficient estimate for D remains significant across all model specifications, even when I include additional controls related to countries' external debt. It is consistently positive and highly significant, suggesting that real debt exposure, D, is an important channel which is robust to inclusion of other debt related variables.

Another possible channel for international monetary policy transmission is international trade. Therefore, it is useful to investigate whether real debt exposure is still relevant after accounting for international trade. Table 3.6 shows that the results remain similar after inclusion of trade related variables. I control for net exports in column (1); net dollar denominated exports in column (2); and net exports denominated in other currencies in column (3) of each panel. Despite the inclusion of these additional trade related controls, the coefficient of D continues to be positive and significant, indicating the robustness of the main findings to these variables.

To summarize, the findings from these robustness exercises provide strong evidence for the robustness of the main findings. The consistent significance of the coefficient D (denoting exposed debt), despite various model specifications and control variables, highlights the unique explanatory power of this variable for exposures to U.S. monetary shocks, providing further support for the main predictions of the model.

Table 3.5: Other Debt Related Controls

	Exchange Rate			Currency Premium			Policy Rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$\Delta i^{\$}$	8.573***	8.984***	0.001	15.997***	17.263***	8.211*	4.214***	3.970***	4.654***
	(2.886)	(2.895)	(4.258)	(3.977)	(5.031)	(4.414)	(1.246)	(1.345)	(1.742)
$\Delta i^{\$} \times D$	0.125**	0.133**	0.130***	0.216***	0.338***	0.261***	0.017**	0.017**	0.016**
	(0.054)	(0.056)	(0.048)	(0.057)	(0.059)	(0.056)	(0.007)	(0.007)	(0.007)
$\Delta i^{\$} \times NetDollarDebt$		-0.040			-0.242			0.028	
		(0.068)			(0.155)			(0.037)	
$\Delta i^{\$} \times NonUSDDebt$			0.155**			0.185***			-0.020
			(0.066)			(0.070)			(0.022)
$\Delta i^{\$} \times DollarDebt$	0.046			0.170			-0.049**		
	(0.054)			(0.109)			(0.024)		
$\gamma - \theta$	0.116	-0.450	-2.021	0.032	-1.113	-0.821	0.044	0.034	0.195
	(0.735)	(0.848)	(1.250)	(1.019)	(1.300)	(1.044)	(0.294)	(0.313)	(0.394)
$ExternalDebt \times (\gamma - \theta)$	-0.006	0.000	-0.009	-0.007	-0.000	-0.023	-0.001	-0.001	-0.001
	(0.009)	(0.010)	(0.010)	(0.015)	(0.017)	(0.016)	(0.004)	(0.004)	(0.004)
$\Delta i^{\$} \times DollarDebtShare$	-0.043	-0.018	0.078	-0.243***	-0.205***	-0.084	-0.031**	-0.052***	-0.058**
	(0.062)	(0.058)	(0.073)	(0.056)	(0.062)	(0.063)	(0.015)	(0.020)	(0.023)
$DollarDebttoGDP$	-0.023*			-0.004			0.002		
	(0.013)			(0.008)			(0.004)		
$NetDollarDebt$		-0.012			0.010*			0.001	
		(0.011)			(0.006)			(0.002)	
$NonUSDDebt$			-0.018*			-0.019***			0.001
			(0.010)			(0.007)			(0.002)
N	832	832	832	521	521	521	644	644	644
Within R2	0.088	0.066	0.073	0.084	0.094	0.108	0.016	0.015	0.014

Standard errors in parentheses

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

Table 3.6: Other Trade Related Controls

	Exchange Rate			Currency Premium			Policy Rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$\Delta i^{\$}$	7.588***	8.404***	8.436***	7.094**	8.579**	8.595**	0.549	1.143	1.150
	(2.551)	(3.114)	(3.112)	(3.002)	(4.152)	(4.163)	(0.669)	(0.830)	(0.827)
$\Delta i^{\$} \times D$	0.130**	0.141*	0.142*	0.184***	0.194***	0.194***	0.014**	0.015**	0.015**
	(0.061)	(0.081)	(0.082)	(0.056)	(0.067)	(0.067)	(0.007)	(0.007)	(0.007)
$Openness$	-1.505	-1.415	-1.417	1.224***	1.119**	1.102**	0.518***	0.501***	0.500***
	(1.146)	(0.927)	(0.925)	(0.464)	(0.527)	(0.531)	(0.154)	(0.150)	(0.150)
$\Delta i^{\$} \times NetExports$	15.975			17.800			4.396		
	(20.940)			(19.432)			(7.571)		
$NetExports$	0.477			4.742**			0.206		
	(1.483)			(2.339)			(0.442)		
$\Delta i^{\$} \times NetDollarExports$		-0.082			-0.078			-0.092	
		(0.412)			(0.537)			(0.138)	
$NetDollarExports$		-0.139			0.052			-0.008	
		(0.096)			(0.048)			(0.019)	
$\Delta i^{\$} \times OtherNetExports$			0.091			0.083			0.095
			(0.417)			(0.548)			(0.139)
$OtherNetExports$			0.141			-0.048			0.008
			(0.097)			(0.049)			(0.020)
N	832	808	808	521	521	521	644	626	626
Within R2	0.064	0.077	0.077	0.083	0.069	0.069	0.017	0.018	0.018

Standard errors in parentheses

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

3.4 Conclusion

This chapter studies the global implications of US monetary policy, particularly by introducing "real debt revaluation" mechanism. Revaluation of existing external debt, resulted from changes in the value of dollar that impacts value of existing debt and price of imports differently is shown to be an important determinant of international transmission of US monetary policy.

In the theoretical framework, the paper identifies two principal channels for the international transmission of U.S. monetary policy. The first is the funding cost of financiers, and the second—the main contribution of this study—is the real debt revaluation. The latter illustrates how an appreciation of the dollar, resulting from a contractionary U.S. monetary policy, increases the effective value of external debt relative to imports. This, in turn, leads to depreciation of local currencies, increased policy rates, and higher currency premiums in countries with greater exposed debt. Exposed debt represents the sensitivity of real debt revaluation to fluctuations in the dollar's value and the currency composition of external debt relative to trade.

Empirically, the paper applies high-frequency data to validate the theoretical model's predictions, demonstrating that countries with more exposed debt are indeed more sensitive to U.S. monetary policy shocks. These economies experience larger depreciations of local currencies, heightened increases in their currency premia, and more significant domestic policy rate increases in response to unexpected contractionary U.S. monetary policy shocks.

Future research can build on these insights, expanding the scope to understand other factors influencing exposed debt and exploring ways to mitigate its adverse effects, particularly in emerging and developing economies.

Bibliography

Adrian, M. T., Erceg, C. J., Lindé, J., Zabczyk, P., and Zhou, M. J. (2020). *A quantitative model for the integrated policy framework*. International Monetary Fund.

Ahmed, S., Akinci, O., and Queralto, A. (2021). Us monetary policy spillovers to emerging markets: both shocks and vulnerabilities matter. *FRB of New York Staff Report*, (972).

Arce, F., Bengui, J., and Bianchi, J. (2019). A macroprudential theory of foreign reserve accumulation. Technical report, National Bureau of Economic Research.

Basu, S. S., Boz, E., Gopinath, G., Roch, F., and Unsal, F. (2020). A conceptual model for the integrated policy framework.

Bénétrix, A. S., Gautam, D., Juvenal, L., and Schmitz, M. (2020). Cross-border currency exposures: new evidence based on an enhanced and updated dataset.

Bénétrix, A. S., Lane, P. R., and Shambaugh, J. C. (2015). International currency exposures, valuation effects and the global financial crisis. *Journal of International Economics*, 96:S98–S109.

Benigno, G., Chen, H., Otrok, C., Rebucci, A., and Young, E. R. (2013). Financial crises and macro-prudential policies. *Journal of International Economics*, 89(2):453–470.

Benigno, G., Chen, H., Otrok, C., Rebucci, A., and Young, E. R. (2016). Optimal capital controls and real exchange rate policies: A pecuniary externality perspective. *Journal of monetary economics*, 84:147–165.

Benigno, G., Chen, H., Otrok, C., Rebucci, A., and Young, E. R. (2019). Optimal policy for macro-financial stability. Technical report, National Bureau of Economic Research.

Bianchi, J. (2011). Overborrowing and systemic externalities in the business cycle. *American Economic Review*, 101(7):3400–3426.

Bianchi, J. and Coulibaly, L. (2022). Liquidity traps, prudential policies, and international spillovers. Technical report, National Bureau of Economic Research.

Bianchi, J. and Mendoza, E. G. (2018). Optimal time-consistent macroprudential policy. *Journal of Political Economy*, 126(2):588–634.

Bianchi, J. and Mendoza, E. G. (2020). A fisherian approach to financial crises: Lessons from the sudden stops literature. *Review of Economic Dynamics*.

Blanchard, O. and Galí, J. (2007). Real wage rigidities and the new keynesian model. *Journal of money, credit and banking*, 39:35–65.

Boz, E., Casas, C., Georgiadis, G., Gopinath, G., Le Mezo, H., Mehl, A., and Nguyen, T. (2020). Patterns in invoicing currency in global trade.

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

Bu, C., Rogers, J., and Wu, W. (2020). A unified measure of fed monetary policy shocks. *Journal of Monetary Economics*.

Caballero, R. J. and Krishnamurthy, A. (2003). Excessive dollar debt: Financial development and underinsurance. *The Journal of Finance*, 58(2):867–893.

Caballero, R. J. and Krishnamurthy, A. (2004). Inflation targeting and sudden stops. In *The inflation-targeting debate*, pages 423–446. University of Chicago Press.

Calvo, G. A. and Reinhart, C. M. (2002). Fear of floating. *The Quarterly journal of economics*, 117(2):379–408.

Carroll, C. D. (2006). The method of endogenous gridpoints for solving dynamic stochastic optimization problems. *Economics letters*, 91(3):312–320.

Carroll, C. D. (2011). Solution methods for microeconomic dynamic stochastic optimization problems. *World Wide Web: http://www. econ. jhu. edu/people/ccarroll/solvingmicrodsops. pdf.(accessed August 30, 2011). Cited on*, page 28.

Catão, L. A. and Milesi-Ferretti, G. M. (2014). External liabilities and crises. *Journal of International Economics*, 94(1):18–32.

Chahrour, R., Valchev, R., et al. (2017). International medium of exchange: Privilege and duty. *Boston College Department of Economics*.

Chinn, M. D. and Ito, H. (2006). What matters for financial development? capital controls, institutions, and interactions. *Journal of development economics*, 81(1):163–192.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of political Economy*, 113(1):1–45.

Christiano, L. J., Gust, C., and Roldos, J. (2004). Monetary policy in a financial crisis. *Journal of Economic theory*, 119(1):64–103.

Corsetti, G., Dedola, L., and Leduc, S. (2010). Optimal monetary policy in open economies. In *Handbook of monetary economics*, volume 3, pages 861–933. Elsevier.

Coulibaly, L. (2022). Monetary policy in sudden stop-prone economies.

Della Corte, P., Jeanneret, A., and Patelli, E. (2021). A credit-based theory of the currency risk premium. *Available at SSRN 3413785*.

Della Corte, P., Riddiough, S. J., and Sarno, L. (2016). Currency premia and global imbalances. *The Review of Financial Studies*, 29(8):2161–2193.

Devereux, M. B., Young, E. R., and Yu, C. (2019). Capital controls and monetary policy in sudden-stop economies. *Journal of Monetary Economics*, 103:52–74.

Eichenbaum, M. and Evans, C. L. (1995). Some empirical evidence on the effects of shocks to monetary policy on exchange rates. *The Quarterly Journal of Economics*, 110(4):975–1009.

Erten, B., Korinek, A., and Ocampo, J. A. (2021). Capital controls: Theory and evidence. *Journal of Economic Literature*, 59(1):45–89.

Faia, E. and Monacelli, T. (2008). Optimal monetary policy in a small open economy with home bias. *Journal of Money, credit and Banking*, 40(4):721–750.

Farhi, E. and Werning, I. (2016). A theory of macroprudential policies in the presence of nominal rigidities. *Econometrica*, 84(5):1645–1704.

Forbes, K. J. and Warnock, F. E. (2012a). Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of international economics*, 88(2):235–251.

Forbes, K. J. and Warnock, F. E. (2012b). Debt-and equity-led capital flow episodes. Technical report, National Bureau of Economic Research.

Forbes, K. J. and Warnock, F. E. (2021). Capital flow waves—or ripples? extreme capital flow movements since the crisis. *Journal of International Money and Finance*, 116:102394.

Fornaro, L. (2015). Financial crises and exchange rate policy. *Journal of International Economics*, 95(2):202–215.

Gabaix, X. and Maggiori, M. (2015). International liquidity and exchange rate dynamics. *The Quarterly Journal of Economics*, 130(3):1369–1420.

Genberg, H. and Martinez, A. (2014). On the accuracy and efficiency of imf forecasts: A survey and some extensions. *IEO Background Paper BP/14/04, Independent Evaluation Office of the International Monetary Fund, Washington, DC, USA*.

Georgiadis, G. (2016). Determinants of global spillovers from us monetary policy. *Journal of international Money and Finance*, 67:41–61.

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

Hassan, T. A. (2013). Country size, currency unions, and international asset returns. *The Journal of Finance*, 68(6):2269–2308.

Hoek, J., Kamin, S., and Yoldas, E. (2022). Are higher us interest rates always bad news for emerging markets? *Journal of International Economics*, 137:103585.

Ilzetzki, E., Reinhart, C. M., and Rogoff, K. S. (2019). Exchange arrangements entering the twenty-first century: Which anchor will hold? *The Quarterly Journal of Economics*, 134(2):599–646.

IMF (2022). Review of the institutional view on the liberalization and management of capital flows. *International Monetary Fund Policy Papers*, 2022(008).

Jeanne, O. and Korinek, A. (2019). Managing credit booms and busts: A pigouvian taxation approach. *Journal of Monetary Economics*, 107:2–17.

Kalemli-Özcan, 2019). Us monetary policy and international risk spillovers. Technical report, National Bureau of Economic Research.

Klein, P., Krusell, P., and Rios-Rull, J.-V. (2008). Time-consistent public policy. *The Review of Economic Studies*, 75(3):789–808.

Korinek, A. (2010). Excessive dollar borrowing in emerging markets: Balance sheet effects and macroeconomic externalities. *Available at SSRN 967524*.

Korinek, A. (2018). Regulating capital flows to emerging markets: An externality view. *Journal of International Economics*, 111:61–80.

Korinek, A., Mendoza, E. G., et al. (2014). From sudden stops to fisherian deflation: Quantitative theory and policy. *Annual Review of Economics*, 6(1):299–332.

Korinek, A. and Simsek, A. (2016). Liquidity trap and excessive leverage. *American Economic Review*, 106(3):699–738.

Lane, M. P. R. and Milesi-Ferretti, M. G. M. (2017). *International financial integration in the aftermath of the global financial crisis*. International Monetary Fund.

Liu, S., Ma, C., and Shen, H. (2021). Sudden stop with local currency debt. *Available at SSRN 3785755*.

Lustig, H. and Verdelhan, A. (2007). The cross section of foreign currency risk premia and consumption growth risk. *American Economic Review*, 97(1):89–117.

Ma, C. and Wei, S.-J. (2020). International equity and debt flows to emerging market economies: Composition, crises, and controls. *Crises, and Controls (December 29, 2020)*.

Maggiori, M., Neiman, B., and Schreger, J. (2019). The rise of the dollar and fall of the euro as international currencies. In *AEA Papers and Proceedings*, volume 109, pages 521–526. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

Mendoza, E. G. (2002). Credit, prices, and crashes: Business cycles with a sudden stop. In *Preventing currency crises in emerging markets*, pages 335–392. University of Chicago Press.

Mendoza, E. G. (2005). Real exchange rate volatility and the price of nontradables in sudden-stop-prone economies.

Mendoza, E. G. (2010). Sudden stops, financial crises, and leverage. *American Economic Review*, 100(5):1941–66.

Meng, G. and van Wincoop, E. (2020). A decomposition of international capital flows. *IMF Economic Review*, 68(2):362–389.

Miranda-Agrippino, S. and Rey, H. (2020). Us monetary policy and the global financial cycle. *The Review of Economic Studies*, 87(6):2754–2776.

Nakamura, E. and Steinsson, J. (2018). High-frequency identification of monetary non-neutrality: the information effect. *The Quarterly Journal of Economics*, 133(3):1283–1330.

Obstfeld, M., Ostry, J. D., and Qureshi, M. S. (2019). A tie that binds: Revisiting the trilemma in emerging market economies. *Review of Economics and Statistics*, 101(2):279–293.

Obstfeld, M., Shambaugh, J. C., and Taylor, A. M. (2005). The trilemma in history: tradeoffs among exchange rates, monetary policies, and capital mobility. *Review of economics and statistics*, 87(3):423–438.

Ottonello, P. (2021). Optimal exchange rate policy under collateral constraints and wage rigidity.

Razin, A., Sadka, E., and Yuen, C.-W. (1998). A pecking order of capital inflows and international tax principles. *Journal of International Economics*, 44(1):45–68.

Rebucci, A. and Ma, C. (2020). Capital controls: A survey of the new literature. *Oxford Research Encyclopedia of Economics and Finance*.

Reinhart, C. M. and Rogoff, K. S. (2011). From financial crash to debt crisis. *American economic review*, 101(5):1676–1706.

Rey, H. (2015). Dilemma not trilemma: the global financial cycle and monetary policy independence. Technical report, National Bureau of Economic Research.

Richmond, R. J. (2019). Trade network centrality and currency risk premia. *The Journal of Finance*, 74(3):1315–1361.

Rotemberg, J. J. (1982). Sticky prices in the united states. *Journal of political economy*, 90(6):1187–1211.

Schmitt-Grohé, S. and Uribe, M. (2016). Downward nominal wage rigidity, currency pegs, and involuntary unemployment. *Journal of Political Economy*, 124(5):1466–1514.

Schmitt-Grohé, S. and Uribe, M. (2021). Multiple equilibria in open economies with collateral constraints. *The Review of Economic Studies*, 88(2):969–1001.

Schularick, M. and Taylor, A. M. (2012). Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870-2008. *American Economic Review*, 102(2):1029–61.

Tauchen, G. and Hussey, R. (1991). Quadrature-based methods for obtaining approximate solutions to nonlinear asset pricing models. *Econometrica: Journal of the Econometric Society*, pages 371–396.

Wiriadinata, U. (2021). *External debt, currency risk, and international monetary policy transmission*. The University of Chicago.

Zhang, W. (2018). *Monetary policy spillovers through invoicing currencies*. The University of Chicago.

Appendix A

Proofs

A.1 Proof of Proposition 1

The policymaker solves the following problem

$$\max_{\{p_t, C_t^T, C_t^N, L_t, B_{t+1}^s, \pi_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t^T, C_t^N, L_t)$$

s.t.

$$\lambda_{1,t}: \qquad U_{T,t} = p_t U_{N,t}, \tag{A.1.1}$$

$$\lambda_{2,t}: \qquad C_t^N = A_t L_t \left(1 - \frac{\varphi}{2}\pi_t^2\right), \tag{A.1.2}$$

$$\lambda_{3,t}: \qquad C_t^T = Y_t^T + B_t - \mathbb{E}_t\left[B_{t+1}^s / R_{t+1}^s\right], \tag{A.1.3}$$

$$\lambda_{4,t}: \qquad \varphi\pi_t(1+\pi_t) = \pi_t^{rhs} \tag{A.1.4}$$

$$\lambda_{5,t}: \qquad U_{T,t+1}^s R_{t+1}^s = U_{T,t+1}^{s'} R_{t+1}^{s'} \quad \forall s, s' \in S \text{ with } s \neq s' \tag{A.1.5}$$

$$\lambda_{6,t}: \qquad U_{T,t} = \beta \mathbb{E}_t \left[U^s_{T,t+1} R^s_{t+1} \right] + \mu_t^{CE} \tag{A.1.6}$$

$$\mu_t^*: \qquad -\mathbb{E}_t \left[B^s_{t+1}/R^s_{t+1} \right] \leq \kappa_t^T Y_t^T + \frac{\kappa_t^N}{p_t}. \tag{A.1.7}$$

where $\pi_t^{rhs} \equiv (1-\varepsilon)\left(1+\frac{U_{L,t}}{AU_{N,t}}\right) + \frac{\varphi}{L_t}\mathbb{E}_t\left[\Theta^s_{t,t+1} L^s_{t+1} \pi^s_{t+1}\left(1+\pi^s_{t+1}\right)\right]$.

The first order conditions are given by

$$\lambda_{1,t} U_{N,t} - \frac{\mu_t^* \kappa_t^N}{p_t^2} = 0 \tag{A.1.8}$$

$$U_{T,t} + \lambda_{1,t}\left(p_t U_{NT,t} - U_{TT,t}\right) - \lambda_{3,t} + \lambda_{4,t}\pi^{rhs}_{T,t} + \lambda_{4,t-1}\pi^{rhs}_{T,t-1} - \lambda_{5,t-1} U_{TT,t} R_t$$
$$+\lambda_{6,t} U_{TT,t} - \beta\lambda_{6,t-1} U_{TT,t} R_t = 0 \tag{A.1.9}$$

$$U_{N,t} + \lambda_{1,t}\left(p_t U_{NN,t} - U_{TN,t}\right) - \lambda_{2,t} + \lambda_{4,t}\pi^{rhs}_{N,t} + \lambda_{4,t-1}\pi^{rhs}_{N,t-1} - \lambda_{5,t-1} U_{TN,t} R_t$$
$$+\lambda_{6,t} U_{TN,t} - \beta\lambda_{6,t-1} U_{TN,t} R_t = 0 \tag{A.1.10}$$

$$U_{L,t} + \lambda_{2,t} A\left(1 - \frac{\varphi}{2}\pi_t^2\right) + \lambda_{4,t}\pi^{rhs}_{L,t} + \lambda_{4,t-1}\pi^{rhs}_{L,t-1} = 0 \tag{A.1.11}$$

$$\lambda_{3,t} + \beta\mathbb{E}\left[\lambda_{3,t+1} R^s_{t+1}\right] + \mu_t^* = 0 \tag{A.1.12}$$

$$-\lambda_{2,t}\varphi\pi_t A L_t + \lambda_{4,t}\varphi(1+2\pi_t) + \lambda_{4,t-1}\pi^{rhs}_{\pi,t} = 0 \tag{A.1.13}$$

where I obtain expression (A.1.12) by integrating all the first order conditions with respect to B^s_{t+1} with $er^s_{t+1} \equiv R^s_{t+1} - R^{s'}_{t+1}$. The terms $\pi^{rhs}_L, \pi^{rhs}_T, \pi^{rhs}_N, \pi^{rhs}_{B_{t+1}}, \pi^{rhs}_\pi$ denote the derivative of π^{rhs} with respect to L, C^T, C^T, B^s_{t+1}, π, respectively.

Combining (A.1.11) and (A.1.13) we have

$$\lambda_{4,t} = \frac{-\pi_t L_t U_{L,t} + \lambda_{4,t-1}\left(\pi_t L_t \pi^{rhs}_{L,t-1} - \pi^{rhs}_{\pi,t}\left(1-\varphi/2\pi_t^2\right)/\varphi\right)}{\left(1+2\pi_t\right)\left(1-\frac{\varphi}{2}\pi_t^2\right) + \pi^{rhs}_{L,t}\pi_t L_t} \tag{A.1.14}$$

Also combining (A.1.10) and (A.1.11) gives

$$\lambda_{1,t} = \frac{U_{N,t}\left(1+\frac{\tau-1}{1-\frac{\varphi}{2}\pi_t^2}\right)+\lambda_{4,t}\left(\frac{\pi_{L,t}^{rhs}}{A(1-\frac{\varphi}{2}\pi_t^2)}+\pi_{N,t}^{rhs}\right)-\lambda_{6,t}U_{TN,t}+\Psi_{N,t-1}^{\pi}+\Psi_{N,t-1}^{B}}{U_{TN,t}-p_t^T U_{NN,t}} \tag{A.1.15}$$

with

$$\Psi_{N,t-1}^{\pi} \equiv \lambda_{4,t-1}\left(\frac{\pi_{L,t-1}^{rhs}}{A(1-\frac{\varphi}{2}\pi_t^2)}+\pi_{N,t-1}^{rhs}\right)$$

$$\Psi_{N,t-1}^{B} \equiv \beta\lambda_{6,t-1}U_{TN,t}R_t - \lambda_{5,t-1}U_{TN,t}R_t^s$$

Using the expression for λ_1 from (A.1.15) together with (A.1.8) yields an expression for monetary policy in a target form:

$$U_{N,t}\left(1+\frac{\tau-1}{1-\frac{\varphi}{2}\pi_t^2}\right)+\lambda_{4,t}\left(\frac{\pi_{L,t}^{rhs}}{A(1-\frac{\varphi}{2}\pi_t^2)}+\pi_{N,t}^{rhs}\right)+\Psi_{N,t-1}^{\pi} = \frac{\mu_t^*\kappa_t^N\left(U_{TN,t}-p_tU_{NN,t}\right)}{U_{N,t}p_t^2}$$
$$+\lambda_{6,t}U_{TN,t}-\beta\lambda_{6,t-1}U_{TN,t}R_t+\lambda_{5,t-1}U_{TN,t}R_t^s \tag{A.1.16}$$

For the proofs for this section, consider a path from $t=0$ with $\lambda_{4,-1}=\lambda_{5,-1}=\lambda_{6,-1}=0$.

- **Proof of part 1.** First, note that without the borrowing constraint $\mu_t^*=0$ for all t. Next, I first consider a relaxed problem by dropping the implementability constraints (A.1.5) and (A.1.6). This means the Lagrange multipliers of the omitted constraints

(λ_5, λ_6) are zero. Then I will argue that $\pi_t = \tau_t = 0$ is the optimal policy, and with this policy the constraints (A.1.5) and (A.1.6) are always satisfied. Starting from $\lambda_{4,t-1} = 0$, by (A.1.14), $\pi_t = 0$ implies that $\lambda_{4,t} = 0$. Then we have $\lambda_{1,t} = 0$. Also, $\pi_t = \pi_{t+1} = 0$ requires that $\tau_t = 0$ by (A.1.4). Thus $\tau_t = \pi_t = \mu_t^* = 0$ satisfies the monetary policy expression (A.1.16). Then the optimality condition (A.1.9) gives $\lambda_{3,t} = U_{T,t}$. Replacing the lagrange multipliers in expression (A.1.12) without integrating we obtain

$$U_{T,t} = \beta U_{T,t+1}^{s} R_{t+1}^{s} \quad \forall s \in S \tag{A.1.17}$$

which can be decomposed in to the constraints (A.1.5) and (A.1.6) as in the main text. Therefore all the constraints, including the omitted implementability conditions are satisfied. This completes the proof.

Note that a similar argument shows that if there is no possibility of a binding constraint in the future, then $\lambda_5 = \lambda_6 = 0$ satisfies all the equilibrium conditions. Then monetary policy expression (A.1.16) does not include λ_5 and λ_6 which shows monetary policy is not prudential.

- **Proof of part 2.(a)**. Under distinct capital controls tax, the household Euler equation as well as the optimality condition for portfolio choice do not constitute a constraint to the policymaker, therefore $\lambda_{5,t} = \lambda_{6,t} = 0 \; \forall t$. Also, if the last crisis is sufficiently past, we have $\lambda_{4,t-1} \approx 0$. Then, A.1.16 becomes

$$U_{N,t}\left(1+\frac{\tau-1}{1-\frac{\varphi}{2}\pi_t^2}\right)+\lambda_{4,t}\left(\frac{\pi_{L,t}^{rhs}}{A(1-\frac{\varphi}{2}\pi_t^2)}+\pi_{N,t}^{rhs}\right)=\frac{\mu_t^*\kappa_t^N\left(U_{TN,t}-p_t^T U_{NN,t}\right)}{U_{N,t}(p_t^T)^2} \tag{A.1.18}$$

If the borrowing constraint is not binding, then we have $\mu^*=0$. Then $\pi_t=\tau_t=0$ satisfies the above expression, and the rest of the first order conditions collapse to those of private agents, showing that $\pi_t=\tau_t=0$ is an optimal policy. This also shows that monetary policy is not prudential. When the borrowing constraint is binding, on the other hand, ($A.1.18$) shows that $\pi_t=\tau_t=0=\lambda_{4,t}=0$ can no longer be an optimal policy, and the policymaker must a strike a balance between macroeconomic stabilization and relaxing the constraint.

- **Proof of part 2.(b)** With uniform capital controls, the policymaker can adjust total borrowing so household's Euler equation is not a constraint, $\lambda_{6,t}=0\ \forall t$. However, households can allocate the total borrowing as they wish. In normal times ($\mu_t=0$), the monetary policy expression ($A.1.16$) implies that $\pi_t=\tau_t=0$ cannot be an optimal policy if $\lambda_{5,t-1}\neq 0\ \forall t$, otherwise the policymaker takes into account the promise from the last period.

- **Proof of part 2.(c)** When there is no other prudential policy is available, both households' Euler and portfolio optimality conditions enter to the policymaker's problem as constraints, $\lambda_{5,t}\neq 0$ and $\lambda_{6,t}\neq 0$. It is obvious that even in normal times $\mu_t=0$, the monetary policy expression ($A.1.16$) implies that $\pi_t=\tau_t=0$ cannot be an optimal policy.

Note that in a sudden stop $\mu_t^* \neq 0$, and therefore the right hand side of the policy expression (A.1.16) includes the first term. This shows another consideration of monetary policy while setting the relative price of tradables.

A.2 Proof of Proposition 2

$$\max_{\{p_t, C_t^T, C_t^N, L_t, B_{t+1}^s, \pi_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t^T, C_t^N, L_t)$$

s.t.

$$\lambda_{1,t}: \qquad U_{T,t} = p_t U_{N,t}, \tag{A.2.19}$$

$$\lambda_{2,t}: \qquad C_t^N = A_t L_t \left(1 - \frac{\varphi}{2}\pi_t^2\right), \tag{A.2.20}$$

$$\lambda_{3,t}: \qquad C_t^T = Y_t^T + B_t - \mathbb{E}_t\left[B_{t+1}^s / R_{t+1}^s\right], \tag{A.2.21}$$

$$\lambda_{4,t}: \qquad \varphi\pi_t(1+\pi_t) = \pi_t^{rhs} \tag{A.2.22}$$

$$\lambda_{5,t}: \qquad U_{T,t+1}^s R_{t+1}^s = U_{T,t+1}^{s'} R_{t+1}^{s'} \quad \forall s, s' \in S \text{ with } s \neq s' \tag{A.2.23}$$

$$\lambda_{6,t}: \qquad U_{T,t} = \beta\mathbb{E}_t\left[U_{T,t+1}^s R_{t+1}^s\right] + \mu_t^{CE} \tag{A.2.24}$$

$$\mu_t^*: \qquad -\mathbb{E}_t\left[B_{t+1}^s / R_{t+1}^s\right] \leq \kappa_t^T Y_t^T + \frac{\kappa_t^N}{p_t}. \tag{A.2.25}$$

where $\pi_t^{rhs} \equiv (1-\varepsilon)\left(1 + \frac{U_{L,t}}{AU_{N,t}}\right) + \frac{\varphi}{L_t}\mathbb{E}_t\left[\Theta_{t,t+1}^s L_{t+1}^s \pi_{t+1}^s \left(1+\pi_{t+1}^s\right)\right]$.

The first order conditions are given by

$$\lambda_{1,t} U_{N,t} - \frac{\mu_t^* \kappa_t^N}{p_t^2} = 0 \tag{A.2.26}$$

$$U_{T,t} + \lambda_{1,t}(p_t U_{NT,t} - U_{TT,t}) - \lambda_{3,t} + \lambda_{4,t}\pi_{T,t}^{rhs} + \lambda_{6,t} U_{TT,t} = 0 \tag{A.2.27}$$

$$U_{N,t} + \lambda_{1,t}(p_t U_{NN,t} - U_{TN,t}) - \lambda_{2,t} + \lambda_{4,t}\pi_{N,t}^{rhs} + \lambda_{6,t} U_{TN,t} = 0 \tag{A.2.28}$$

$$U_{L,t} + \lambda_{2,t} A\left(1 - \frac{\varphi}{2}\pi_t^2\right) + \lambda_{4,t}\pi_{L,t}^{rhs} = 0 \tag{A.2.29}$$

$$\lambda_{3,t} + \beta\mathbb{E}\left[\lambda_{3,t+1} R_{t+1}^s\right] + \mu_t^* = 0 \tag{A.2.30}$$

$$-\lambda_{2,t}\varphi\pi_t AL_t + \lambda_{4,t}\varphi(1+2\pi_t) = 0 \tag{A.2.31}$$

where I obtain expression (A.2.30) by integrating all the first order conditions with respect to B^s_{t+1} with $er^s_{t+1} \equiv R^s_{t+1} - R^{s'}_{t+1}$. The terms $\pi^{rhs}_L, \pi^{rhs}_T, \pi^{rhs}_N, \pi^{rhs}_{B_{t+1}}, \pi^{rhs}_\pi$ denote the derivative of π^{rhs} with respect to L, C^T, C^T, B^s_{t+1}, π, respectively.

Combining (A.2.29) and (A.2.31) we have

$$\lambda_{4,t} = \frac{-\pi_t L_t U_{L,t}}{(1+2\pi_t)\left(1-\frac{\varphi}{2}\pi_t^2\right) + \pi^{rhs}_{L,t}\pi_t L_t} \tag{A.2.32}$$

Also combining (A.2.28) and (A.2.29) gives

$$\lambda_{1,t} = \frac{U_{N,t}\left(1+\frac{\tau-1}{1-\frac{\varphi}{2}\pi_t^2}\right) + \lambda_{4,t}\left(\frac{\pi^{rhs}_{L,t}}{A(1-\frac{\varphi}{2}\pi_t^2)} + \pi^{rhs}_{N,t}\right) - \lambda_{6,t}U_{TN,t}}{U_{TN,t} - p_t^T U_{NN,t}} \tag{A.2.33}$$

Using the expression for λ_1 from (A.2.33) together with (A.2.26) yields an expression for monetary policy in a target form:

$$U_{N,t}\left(1+\frac{\tau-1}{1-\frac{\varphi}{2}\pi_t^2}\right) + \lambda_{4,t}\left(\frac{\pi^{rhs}_{L,t}}{A(1-\frac{\varphi}{2}\pi_t^2)} + \pi^{rhs}_{N,t}\right) = \frac{\mu_t^* \kappa_t^N (U_{TN,t} - p_t U_{NN,t})}{U_{N,t} p_t^2} + \lambda_{6,t}U_{TN,t}$$

- **Proof of part 1.** First, note that without the borrowing constraint $\mu_t^* = 0$ for all t. Next, I first consider a relaxed problem by dropping the implementability constraints (A.2.23) and (A.2.24). This means the Lagrange multipliers of the omitted constraints (λ_5, λ_6) are zero. Then I will argue that $\pi_t = \tau = 0$ is the optimal policy, and with this policy the constraints (A.2.23) and (A.2.24) are always satisfied.By

(A.2.32), $\pi_t = 0$ implies that $\lambda_{4,t} = 0$. Then we have $\lambda_{1,t} = 0$. Also, $\pi_t = \pi_{t+1} = 0$ requires that $\tau_t = 0$ by (A.2.22). Thus $\tau_t = \pi_t = \mu_t^* = 0$ satisfies the monetary policy expression (A.2.34). Then the optimality condition (A.2.27) gives $\lambda_{3,t} = U_{T,t}$. Replacing the lagrange multipliers in expression (A.2.30) without integrating we obtain

$$U_{T,t} = \beta U^s_{T,t+1} R^s_{t+1} \quad \forall s \in S \tag{A.2.34}$$

which can be decomposed in to the constraints (A.2.23) and (A.2.24) as in the main text. Therefore all the constraints, including the omitted implementability conditions are satisfied. This completes the proof.

Note that a similar argument shows that if there is no possibility of a binding constraint in the future, then $\lambda_5 = \lambda_6 = 0$ satisfies all the equilibrium conditions. Then monetary policy expression (A.2.34) does not include λ_5 and λ_6 which shows monetary policy is not prudential.

- **Proof of part 2.(a)**. Under distinct and uniform capital controls tax, the household Euler equation (A.2.23) does not constitute a constraint to the policymaker, therefore $\lambda_{6,t} = 0 \, \forall t$. Then, A.2.34 becomes

$$U_{N,t}\left(1 + \frac{\tau - 1}{1 - \frac{\varphi}{2}\pi_t^2}\right) + \lambda_{4,t}\left(\frac{\pi^{rhs}_{L,t}}{A(1 - \frac{\varphi}{2}\pi_t^2)} + \pi^{rhs}_{N,t}\right) = \frac{\mu_t^* \kappa_t^N \left(U_{TN,t} - p_t^T U_{NN,t}\right)}{U_{N,t}(p_t^T)^2} \tag{A.2.35}$$

If the borrowing constraint is not binding, then we have $\mu^* = 0$. Then $\pi_t = \tau_t = 0$

(and therefore $\lambda_4 = 0$) satisfies the above expression, and the rest of the first order conditions collapse to those of private agents, showing that $\pi_t = \tau_t = 0$ is an optimal policy. This also shows that monetary policy is not prudential. When the borrowing constraint is binding, on the other hand, (A.2.35) shows that $\pi_t = \tau_t = 0 = \lambda_{4,t} = 0$ can no longer be an optimal policy, and the policymaker must a strike a balance between macroeconomic stabilization and relaxing the constraint.

- **Proof of part 2.(b)** When there is no other prudential policy is available, both households' Euler and portfolio optimality conditions enter to the policymaker's problem as constraints, $\lambda_{5,t} \neq 0$ and $\lambda_{6,t} \neq 0$. It is obvious that even in normal times $\mu_t = 0$, the monetary policy expression (A.2.34) implies that $\pi_t = \tau_t = 0$ cannot be an optimal policy.

  Note that in a financial crisis $\mu_t^* \neq 0$, and therefore the right hand side of the policy expression (A.2.34) includes the first term. This shows another consideration of monetary policy while setting the relative price of tradables.

Appendix B

Model With Composite Securities

Suppose instead of a complete Arrow securities, domestic agents can borrow or lend using one-period internationally traded composite securities. Let B^i_{t+1} denote the holding of asset i with $i = 1, ..., I$ whose price is Q^i_t at time t and pays out dividend D^i_{t+1} at time $t+1$. Both price Q^i_t and dividend D^i_t are denominated in units of internationally tradable good. Agents in the small open economy take Q^i_t and D^i_t as given. At time t, let B_{t+1} be the total asset holdings; γ^i_{t+1} be the portfolio share of asset i; and R_t be the real return on the portfolio:

$$B_{t+1} \equiv \sum_{i=1}^{I} Q^i_t B^i_{t+1}$$

$$\gamma^i_{t+1} \equiv \frac{Q^i_t B^i_{t+1}}{B_{t+1}}$$

$$R_t \equiv \sum_{i=1}^{I} \left(\gamma^i_t \frac{Q^i_t + D^i_t}{Q^i_{t-1}} \right)$$

As a result, households are subject to the following sequence of flow budget constraints expressed in local currency

$$P_t^N C_t^N + P_t^T C_t^T + \mathscr{E}_t B_{t+1} \leq W_t L_t + P_t^T Y_t^T + \mathscr{E}_t B_t R_t + \Pi_t + T_t, \tag{B.0.1}$$

Also the borrowing constraint takes the form

$$-\mathscr{E}_t B_{t+1} \leq \kappa^T P_t^T Y_t^T + \kappa^N P_t^N. \tag{B.0.2}$$

Then households optimality conditions become

$$U_{T.t} = p_t^T U_{N.t} \tag{B.0.3}$$

$$-\frac{U_{L,t}}{U_{N,t}} = \frac{W_t}{P_t^N} \tag{B.0.4}$$

$$U_{T,t} = \beta \mathbb{E}_t \left[U_{T,t+1} R_{t+1} \right] + \mu_t \tag{B.0.5}$$

$$\mathbb{E}_t \left[U_{T,t+1}(er_{t+1}^i) \right] = 0 \quad \forall i = 1, ..., I-1, \tag{B.0.6}$$

where p_t^T is price of the tradable good relative to the nontradable good P_t^T / P_t^N; U_T, U_N, U_L are marginal utilities of tradable goods consumption, nontradable goods consumption and work, respectively; μ_t is the lagrange multiplier on the borrowing constraint; er^i is excess return of asset i relative to some reference asset which is labeled as I:

$$er_{t+1}^i \equiv \frac{Q_{t+1}^i + D_{t+1}^i}{Q_t^i} - \frac{Q_{t+1}^I + D_{t+1}^I}{Q_t^I}.$$

The production side remains the same except for the fact that variables are now not indexed by state but time. The policymaker solves the following problem

$$\max_{\{p_t, C_t^T, C_t^N, L_t, B_{t+1}, \gamma_{t+1}^i, \pi_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t^T, C_t^N, L_t)$$

s.t.

$$\lambda_{1,t}: \qquad U_{T,t} = p_t^T U_{N,t}, \tag{B.0.7}$$

$$\lambda_{2,t}: \qquad C_t^N = A_t L_t \left(1 - \frac{\varphi}{2}\pi_t^2\right), \tag{B.0.8}$$

$$\lambda_{3,t}: \qquad C_t^T = Y_t^T + B_t R_t - B_{t+1}, \tag{B.0.9}$$

$$\lambda_{4,t}: \qquad \varphi \pi_t (1 + \pi_t) = \pi_t^{rhs} \tag{B.0.10}$$

$$\lambda_{5,t}^i: \qquad \mathbb{E}_t \left[U_{T,t+1} er_{t+1}^i\right] = 0, \quad \forall i = 1, ..., N-1 \tag{B.0.11}$$

$$\lambda_{6,t}: \qquad U_{T,t} = \beta \mathbb{E}_t \left[U_{T,t+1} R_{t+1}\right] + \mu_t^{CE} \tag{B.0.12}$$

$$\mu_t^*: \qquad -B_{t+1} \leq \kappa_t^T Y_t^T + \frac{\kappa_t^N}{p_t^T}. \tag{B.0.13}$$

where $\pi_t^{rhs} \equiv (1-\varepsilon)\left(1 + \frac{U_{L,t}}{AU_{N,t}}\right) + \frac{\varphi}{L_t}\mathbb{E}_t\left[\Theta_{t,t+1} L_{t+1} \pi_{t+1}(1+\pi_{t+1})\right].$

Depending on the commitment assumption, this problem yields very similar expressions to the ones either in Appendix A.1 or Appendix A.2. Therefore, the proofs of the propositions 1 and 2 follow the same steps.

Appendix C

An Alternative for Distinct Capital Controls: Reserve Accumulation

As an alternative to capital controls, the policymaker might also accumulate reserves for prudential purposes as in Arce et al. (2019). Without a borrowing constraint, as the government accumulates reserves and finances them via lump sum tax expressed in tradables, households also increase their borrowing, hence "undo" the impacts of reserve accumulation, in line with the Ricardian logic. With the borrowing constraint, however, households can do so only until they hit the borrowing constraint. After that point, any additional reserve accumulation reduces the net borrowing of the country. Unlike capital controls, this policy increases the gross flows but improves net flows. The government can also change the composition of overall asset position of the country by adjusting the composition of reserve accumulation. As a result, both the level and composition of net asset position can be set to the socially optimal levels.

I assume that the government has access to the same international financial markets as households and reserve accumulation is not associated with any other cost. Therefore, it can trade the same set of assets by facing the same price as households. Denoting $A^{*^i}_{t+1}$ as the government's accumulation of an asset denominated in i at time t, the government budget identity becomes

$$\mathscr{E}_t \sum_{i=1}^{I} Q^h_t A^{*^i}_{t+1} = \mathscr{E}_t \sum_{i=1}^{I} (Q^i_t + D^i_t) A^{*^i}_t + T_t \tag{C.0.1}$$

In this setup, capital controls and reserve accumulation are perfect substitutes. They both distort households intertemporal decisions and do not incur any cost to the policymaker to implement. In other formulations of reserve accumulation in the literature, reserve accumulation is usually costly to the policymaker and economy. If this was the case here, then capital controls would be superior instruments than reserve accumulation.

Note that while capital controls can be used to target total borrowing without interfering households' optimality decisions for portfolio shares via uniform tax, this is not possible under reserve accumulation. Therefore, if the reserve accumulation is possible and government has access to the same financial instruments as private agents, then both the level and composition of net debt of the country can be adjusted by the policymaker.

Appendix D

Details of the Quantitative Model

The quantitative model is a version of the model with composite securities laid out in Appendix B. The total saving at the end of period t is given by $B_{t+1} = B^d_{t+1} + q^e_{t+1}B^e_{t+1}$, with B^d and B^e debt and security holdings, and q^e is the price of equity in terms of tradable goods. The time consistent policymaker looks for a Markov perfect equilibrium by solving the following problem:

$$\max_{\{p_t, C^T_t, C^N_t, L_t, B_{t+1}, \gamma^i_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C^T_t, C^N_t, L_t)$$

s.t.

$$\lambda_{1,t}: \quad U_{T,t} = p_t U_{N,t}, \tag{D.0.1}$$

$$\lambda_{2,t}: \quad C^N_t = A_t L_t \left(1 - \frac{\varphi}{2}\pi^2_t\right), \tag{D.0.2}$$

$$\lambda_{3,t}: \quad C^T_t = Y^T_t + B_t R_t - B_{t+1}, \tag{D.0.3}$$

$$\lambda_{4,t}: \quad \varphi\pi_t(1+\pi_t) = \pi^{rhs}_t \tag{D.0.4}$$

$$\lambda_{5,t}: \qquad \mathbb{E}_t\left[U_{T,t+1}er_{t+1}\right] = 0 \tag{D.0.5}$$

$$\lambda_{6,t}: \qquad U_{T,t} = \beta\mathbb{E}_t\left[U_{T,t+1}R_{t+1}\right] + \mu_t^{CE} \tag{D.0.6}$$

$$\mu_t^*: \qquad -B_{t+1} \leq \kappa_t^T Y_t^T + \frac{\kappa_t^N}{p_t}. \tag{D.0.7}$$

where $\pi_t^{rhs} \equiv (1-\varepsilon)\left(1+\frac{U_{L,t}}{AU_{N,t}}\right) + \frac{\varphi}{L_t}\mathbb{E}_t\left[\Theta_{t,t+1}L_{t+1}\pi_{t+1}\left(1+\pi_{t+1}\right)\right]$, and er_{t+1} is the expected excess return of equity.