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Sudden stop with local currency debt[☆]

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ABSTRACT

Over the past two decades, emerging market economies have improved their liability structures by increasing the share of their debt denominated in local currency. This paper introduces a local currency debt (i.e., in units of aggregate consumption) into a sudden stop model and explores how this alternative structure sheds new perspectives on financial regulations. Decentralized agents do not internalize the effects of their portfolio decisions on financial amplification and undervalue the insurance benefit of using local currency debt. However, due to debt-deflation incentives and the cost of buying insurance, a discretionary planner is reluctant to issue local currency debts, and capital controls are primarily used to restrict credit volumes. In contrast, a social planner with commitment would promise a higher future payoff to obtain a more favorable bond price. The capital control under commitment encourages borrowing in local currency, mitigates the severity of crises, and improves welfare relative to laissez-faire.

1. Introduction

Financial fragility within emerging markets is closely related to countries' liability structures and their foreign currency exposure. In economic downturns, a country's dollar-denominated debt amplifies the adverse effect of negative shocks, creating a large devaluation of the domestic currency. Under certain financial frictions, the reduction in income further constrains a country's ability to borrow and its real absorption. As in the sudden stop literature, the endogenous feedback between consumption collapse, real depreciation, and amplification through financial constraints leads to a Fisher's debt-deflation mechanism (e.g., Mendoza, 2002; Bianchi, 2011; Benigno et al., 2016; Schmitt-Grohé and Uribe, 2021). Therefore, sudden stops are usually characterized by large current account reversals, currency devaluations, and a sudden freeze in financial intermediation.[1]

The financial instability that arises from currency mismatch also has welfare consequences and calls for appropriate financial regulations. While the existing literature (e.g., Bianchi, 2011) has argued for a restriction on debt volumes, many ignore the composition of credit flows. The capital structures of emerging countries, however, have evolved drastically over the past two

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[1] The problem of excessive reliance on foreign currency debt has been described as the "original sin" by Eichengreen and Hausmann (1999).

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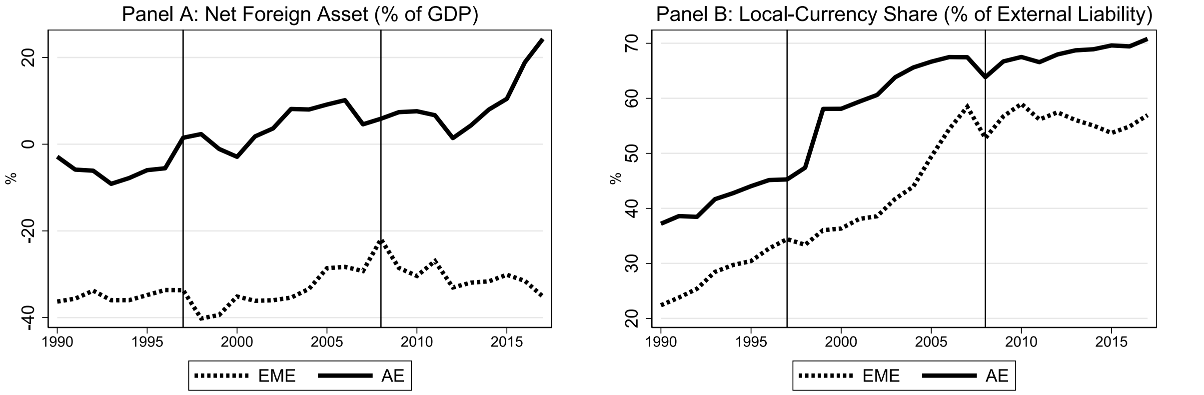

Fig. 1. Net foreign assets and local currency share of external liabilities. NOTE: The vertical lines mark the 1997 Asian Crisis and 2009 Global Financial Crisis. The data comes from Bénétrix et al. (2019). See online appendix A for the list of countries in the sample.

decades. As shown in Fig. 1, although emerging economies' net foreign asset position remains largely negative, their external liability has steadily increased toward local currency. This non-negligible change in capital structures suggests that countries have obtained a safer foreign exchange position and warrants a renewed perspective on financial regulations. How does a country's rising local currency share affect its economic resilience during a financial crisis? Are the existing policy prescriptions still effective in today's environment? What are the optimal capital control policies under the presence of local currency debt?[2]

We answer these questions by embedding the issuance of local currency debt into a sudden stop model with a flow collateral constraint. The model is a two-sector small open economy with limited access to international financial markets. Domestic households can trade two types of financial assets with foreign investors: a one-period bond denominated in the tradable consumption good (referred to as foreign currency debt, or FCD henceforth) and a one-period bond denominated in the domestic consumption bundle (referred to as local currency debt, or LCD henceforth). The LCD invites a state-contingent payment schedule from the foreign investors' perspective, and its price is endogenously determined by the foreign investors' expectation of exchange rate fluctuations.[3] The form of the collateral constraint follows Mendoza (2002), which says that a country's total proceeds of borrowing is restricted by the market value of its income. This constraint has been widely adopted by other works that study the sudden stop phenomenon and associated pecuniary externalities.

Relative to a standard sudden stop economy with only FCD, the introduction of LCD changes the state contingency in the payoff of a country's liability. It improves risk sharing of the indebted economies with the rest of the world and, more importantly, adds economic resilience during a financial crisis. In particular, the local currency bond provides a buffer against large adverse shocks and mitigates the severity of sudden stop crises. However, risk-averse foreign investors perceive procyclical movements in the real exchange rate and charge a risk premium on their holding of local currency bonds. Therefore, in equilibrium, the domestic agent chooses debt denominations based on the hedging benefit of using LCD and the cost of buying this insurance.[4]

We then investigate policy implications in this new environment. Similar to Bianchi (2011), the pecuniary externality arising from the financial constraint leads to an overborrowing phenomenon and an inefficiently high probability of a financial crisis. On top of that, the introduction of LCD adds inefficiencies in the denomination choice. This occurs because private agents do not internalize the effects of their portfolio decisions on the financial amplification and therefore undervalue the insurance benefit of LCD. If allowed to control debt denominations, a social planner would have incentives to issue more debts in local currency because it generates a more favorable payoff schedule. During a financial crisis, the improved capital structure eases a country's debt burden when the real exchange rate depreciates. The reduction in debt burden mitigates the financial amplification caused by a negative shock and improves the country's borrowing opportunity. The relaxed financial constraint also increases the consumption demand and alleviates the real depreciation during the financial crisis. In addition, the smaller depreciation in expectation makes the issuance of LCD less costly ex ante.

[2] The theoretical literature (e.g., Drenik et al., 2022; Engel and Park, 2022; Caballero and Krishnamurthy, 2003) has argued that the trend in the change of debt denomination can be attributed to long-run factors such as more disciplined monetary policies, development in financial institutions and financial markets, or lowered policy risk. The purpose here is not to explain this trend but to consider its implications for capital control policies.

[3] Ottonello and Perez (2019) and Du et al. (2020) have argued that governments that lack the commitment to monetary policy would tilt the composition of debt toward foreign currency. Compared to these papers, we abstract from monetary policy and only consider real bonds that are denominated in consumption goods. The associated time-inconsistency problems are also different.

[4] The insurance role of LCD in financial crises is supported by our empirical analysis using cross-country data. Figures A.1–A.2 in online appendix A compare the crisis event windows between two groups of countries and show that countries with higher local currency shares in their liabilities experienced milder recessions during sudden stops. This result holds in both the advanced and emerging country groups. In addition, panel estimation in online appendix table A.2 shows that an increased share of local currency debt improves a country's economic resilience during a financial crisis. Online appendix table A.1 shows the list of sample countries and the identified sudden stop episodes.

However, we find that the efficient use of LCD requires policy commitment. We analyze the optimal capital control policies by solving two social planning problems: a Markov (discretionary) planner and a social planner under commitment. The discretionary planner solves a recursive problem and has strong incentives to lower the real exchange rate to deflate the debt burden in local currency. This ex post debt-deflating incentive reduces the ex ante bond price and, in equilibrium, makes borrowing in LCD undesirable. On the other hand, the commitment planner can flexibly manipulate the future consumption profile to obtain a more favorable debt payoff schedule. Specifically, she would commit to increasing consumption in good states of the world in order to ensure a better bond price. As a result, the improvement in bond price leads to the greater issuance of LCD. When a sudden stop occurs, the larger debt share in local currency alleviates the country's consumption decline and exchange rate depreciation.

Our model calibration reveals that commitment to capital control policies is quantitatively important. In the absence of commitment power, the Markov planner's primary policy objective is to control total credit volumes. The stringent capital regulation leads to significantly less borrowing, and due to a debt-deflating motive, a lower share of LCD in its capital inflows. The model then becomes similar to a sudden stop economy with only dollar debt. The policy implication under commitment is quite different: the planner aims to change the composition of credit flows by tilting more debts toward the local currency. The improved bond price and capital structure ease the pain of a sudden stop crisis and simultaneously create better borrowing opportunities. Therefore, while both social planners obtain a more stabilized financial market, the commitment planner's policy allows the economy to sustain a higher debt level than the competitive equilibrium and achieves a larger welfare gain.

We also compare our baseline model with an FCD-only economy à la Bianchi (2011) and its constrained-efficient outcome. Our analysis shows that even without any capital control policies, the ability to issue LCD alone improves the economy's risk-sharing and eases the severity of a financial crisis. Meanwhile, as discussed in the sudden stop literature, the main objective of prudential regulations is to target crisis episodes and reduce the probability of crises. The simulation result shows that introducing LCD alone can deliver a sizeable welfare gain that is quantitatively comparable to imposing prudential regulations in an FCD-only economy. This result suggests that financial integration has a strong foothold on welfare consequences and could be a substitute for financial regulations in a dollar-debt economy.

The policy implications from our model suggest that an ideal capital control policy would deliver a less risky liability structure for a country, i.e., encouraging the issuance of LCD relative to FCD. Such policy implication is consistent with Ostry et al. (2012), who suggest using capital controls to alter the composition of capital inflows. Furthermore, our quantitative analysis also highlights the importance of policy commitment to achieve this goal.

Related literature. First, the paper contributes to the sudden stop literature with pecuniary externalities (e.g., Bianchi, 2011; Benigno et al., 2013, 2016, 2019; Schmitt-Grohé and Uribe, 2021; Ma, 2020; Jin and Shen, 2020).[5] The standard sudden stop model assumes that debts are only denominated in hard currency while a significant proportion of collateral income comes from the domestic sector. This currency mismatch generates an inefficient amount of borrowing and results in financial vulnerability. Based on these studies, we introduce the LCD into a sudden stop model and consider the policy adjustments that change countries' debt denomination. In our model, the pecuniary externalities from the collateral and budget constraints lead to an inefficient denomination choice. Moreover, the LCD also creates a time-inconsistency issue. As a result, policy implications are rather different. Our paper demonstrates the importance of a nonuniform capital control tax that changes the composition of capital flows.

Mendoza and Rojas (2017, 2019) introduce the external local currency debt (denominated in the aggregate consumption bundle) into a sudden stop model and consider the new policy implications. They also highlight the time-inconsistency issue in the design of optimal policies, which is due to the endogenous payoff of LCD and its endogenous bond price. Our paper differs from theirs in two important ways. First, we consider the portfolio choice between LCD and FCD. By doing so, we contribute to the recent policy discussion of capital controls in reshaping the composition of capital inflows. Second, we compare the policy assignments involving both commitment and discretionary planners' problems. Mendoza and Rojas (2019), instead, only analyze welfare implications if the government commits to simple policy rules. Mendoza and Rojas (2017), on the other hand, solves for the conditionally efficient allocations, which requires the social planner's commitment to support the pricing function in the competitive equilibrium. Throughout our paper, we follow the method used in Bianchi and Mendoza (2018) to solve for social planners' constrained-efficient allocations and characterize the associated capital control policies.[6]

Our paper relates to the existing studies on countries' currency portfolio of external debts (e.g., Bohn, 1990; Korinek, 2011; Ottonello and Perez, 2019; Drenik et al., 2022; Du et al., 2020). In a pioneer work, Bohn (1990) analyzes the benefits of foreign currency debt relative to domestic currency debt. In particular, FCD is more desirable when domestic inflation is relatively more uncertain and the time-inconsistency problem with LCD is more severe. Korinek (2011) builds a small open economy model with debts denominated in tradable and nontradable goods and studies the mutual feedback between currency denomination, exchange rate risk, and macro-volatility. However, his analysis abstracts from the endogenous collateral constraint and associated pecuniary externalities. In contrast, we build a richer framework to study the interaction between the portfolio choice and the pecuniary externality caused by collateral constraints.

Ottonello and Perez (2019) investigate the government's debt denomination choice when the monetary policy lacks commitment. The incentive to dilute debt payment through currency depreciation induces the government to issue a larger fraction of debt in

[5] See Bianchi and Mendoza (2020), Erten et al. (2021), and Rebucci and Ma (2020) for a comprehensive review on the theoretical framework of capital controls and the empirical evidence.

[6] Bianchi and Mendoza (2018)'s model also features a time-inconsistency problem in the macroprudential regulation. But, different from our paper, their time-inconsistency issue is due to the forward-looking nature of asset price (such as land or capital price) in the collateral constraint.

foreign currency and forgo the hedging benefit of LCD. Consistent with this channel, Du et al. (2020) provide data evidence showing that governments whose LCD provides stronger hedging benefits actually borrow more in foreign currency. In a similar vein, Drenik et al. (2022) set up an optimal contract model to investigate the interaction between the currency choice of private debt and optimal monetary policy. Different from these papers, we abstract from monetary policies and the mechanism in this paper is generated by the real exchange rate risk.

This paper also belongs to the literature that studies externalities associated with risk-sharing and portfolio decisions (e.g., Bocola and Lorenzoni, 2020, 2023). In a generalized model with state-contingent claims, Bocola and Lorenzoni (2023) show that entrepreneurs demand an insufficient amount of risk-sharing because the aggregate risk makes risk-averse consumers charge a high insurance premium. In an analytical setup, Bocola and Lorenzoni (2020) show that liability dollarization is a self-fulfilling equilibrium due to the feedback between denomination choice and the risk premium of LCD. The lending of last resort can eliminate this fragile equilibrium and guide the economy toward a better one without currency mismatch. While these papers focus on the domestic debt, our paper emphasizes external liability dollarization and, therefore, has different policy implications. We study the role of ex ante capital control tax in restoring social efficiency, whereas they study ex post bailout policies.

Another related paper is Farhi and Werning (2016), who study a currency portfolio problem in an environment with aggregate demand externalities. However, their model environment abstracts from the time-inconsistency issue, which is an important aspect of our analysis. Bianchi and Sosa-Padilla (2020) also feature a portfolio problem in the presence of demand externality. They show that the interaction between sovereign default risk and nominal rigidity can account for a macro-stabilization role of international reserves in tranquil times.

Road map. The rest of the paper is organized as follows. Section 2 lays out our benchmark model and builds the environment to study optimal policies. Section 3 considers a simplified environment and characterizes some analytical properties. Section 4 calibrates the quantitative model and presents simulation results. Section 5 compares our framework with an FCD-only economy to discuss the relationship between financial integration and financial regulation. Section 6 concludes the paper.

2. The model

This section builds a small open economy model with a flow collateral constraint. Unlike standard sudden stop models in the literature (e.g., Mendoza, 2002; Bianchi, 2011), we include the local currency debt into the environment and consider agents' debt denomination decisions.

2.1. Economic environment

There are two types of agents in the economy: domestic households and foreign investors. Time is discrete and lasts for infinite horizons: $t = 0, 1, 2, 3 \ldots$. Households are identical infinitely-lived agents that consume both tradable ($c_{T,t}$) and nontradable ($c_{N,t}$) goods to maximize their lifetime utility as follows:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \tag{1}$$

where $\mathbb{E}_t(\cdot)$ is the expectation operator conditional on information at time t. β is the subjective discount factor. The per-period utility takes on the CRRA form: $u(c_t) = c_t^{1-\sigma}/(1-\sigma)$, where the final consumption c_t is a composite product that comes from both tradable and nontradable sectors with a CES aggregator,

$$c_t = \left[\omega c_{T,t}^{\frac{\theta-1}{\theta}} + (1-\omega) c_{N,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}. \tag{2}$$

σ is the coefficient of relative risk aversion, $\omega \in (0,1)$ is the weight on tradable consumption in the composite consumption basket, and $\theta > 0$ is the elasticity of substitution between the two sectors.

Throughout the paper, the tradable good serves as the numeraire, and its price is normalized to 1. We denote p_t^N and p_t^C as the relative prices of the nontradable good and composite consumption, respectively.[7] In each period, the household receives tradable and nontradable endowments. We assume that the supply of nontradable goods is a constant $\{y_{N,t} = \bar{y}_N\}_{t=0}^{\infty}$, and that the tradable endowment follows a log AR(1) process of

$$\log(y_{T,t}) = (1-\rho)\mu + \rho \log(y_{T,t-1}) + \epsilon_t, \tag{3}$$

where $\rho \in (0,1)$ and μ are the persistence and mean of the endowment process, respectively. ϵ_t is an i.i.d. random variable that follows a normal distribution: $\epsilon_t \sim N(0, \sigma_\epsilon^2)$.

The financial market is both incomplete and imperfect. There are two types of financial assets households can trade with foreign investors: b_{t+1}^T denotes the units of one-period bonds denominated in tradable consumption (referred to as FCD), while b_{t+1}^C denotes the units of one-period bonds denominated in aggregate consumption bundles (referred to as LCD). The bond prices (q_t^T and q_t^C) are determined by the international investors' problem, which will be specified below.

[7] As we will show later, p_t^C is monotonically increasing in p_t^N. Throughout the paper, p_t^C is interpreted as the real exchange rate.

The household's sequential budget constraint is given by

$$c_{T,t} + p_t^N c_{N,t} + p_t^C b_t^C + b_t^T = y_{T,t} + p_t^N \overline{y}_N + q_t^C b_{t+1}^C + q_t^T b_{t+1}^T. \tag{4}$$

In period t, the household receives tradable and nontradable incomes, decides consumption allocations, and issues bonds in the international financial market.

As we will discuss later, the portfolio in a country's liability is uniquely pinned down by investors' risk aversion. Presumably, the domestic agents will have incentives to borrow in local currency because its payment structure allows them to enjoy risking-sharing benefits relative to the foreign currency borrowing. However, many countries find it difficult to issue LCDs and excessively rely on foreign currency borrowings in the international market due to some institutional distortions (e.g., a less disciplined monetary policy and incomplete financial integration).[8] While many papers have tackled this issue, we abstract from these institutional costs of using LCD and instead focus on the suboptimality in private agents' portfolio decisions that arises from pecuniary externality.

The household's borrowing capacity is restricted by a collateral constraint, saying that the maximum amount of total borrowings cannot exceed a fraction of the current income:

$$q_t^C b_{t+1}^C + q_t^T b_{t+1}^T \leq \kappa(y_{T,t} + p_t^N \overline{y}_N), \tag{5}$$

with the parameter $\kappa \in (0,1)$. This constraint is similar to what has been used by many papers to capture important aspects of sudden stop episodes (e.g., Mendoza, 2002; Bianchi, 2011; Korinek, 2018), and like many of them, we do not explicitly derive the credit constraint as the outcome of an optimal contract between lenders and borrowers. Instead, this collateral constraint is the reduced form representation of an environment where informational and institutional frictions affect the credit relationship between domestic and foreign agents.

In economic downturns, the depreciating real exchange rate restricts international borrowing and makes private agents reduce their consumption demands. The lower consumption, in turn, reduces the value of the collateral and brings about a Fisher's debt-deflation mechanism. From the quantitative side, the severe economic recession driven by asset price deflation is a desirable feature of the model and provides a good laboratory to study the welfare effect of financial interventions.

In addition to the collateral constraint, we assume that from emerging countries' perspectives, there cannot be any positive net supply of local currency bonds in the international market. In the model, this means that households' issuance of LCDs cannot be negative; that is

$$b_{t+1}^C \geq 0. \tag{6}$$

Generally, this restriction is consistent with the fact that most international reserve assets are denominated in the US dollar or euro rather than any emerging market currencies. In contrast to the restriction on local currency borrowing, we do not make any restriction on the borrowing in foreign currency and assume that $b_{t+1}^T \in \mathbb{R}$.

The household's problem is to choose $\{c_{T,t}, c_{N,t}, b_{t+1}^C, b_{t+1}^T\}_{t=0}^\infty$ so as to maximize lifetime utility (1) subject to constraints (4)–(6) while taking the initial conditions $\{b_0^C, b_0^T\}$, the exogenous process of $\{y_{T,t}\}_{t=0}^\infty$, and the paths of equilibrium prices $\{p_t^N, p_t^C, q_t^C, q_t^T\}_{t=0}^\infty$ as given. The solution is characterized by the following optimality conditions:

$$\lambda_t = u_T(t), \tag{7}$$

$$p_t^N = \frac{1-\omega}{\omega}\left(\frac{c_{T,t}}{c_{N,t}}\right)^{\frac{1}{\theta}}, \tag{8}$$

$$q_t^T(\lambda_t - \mu_t) = \beta \mathbb{E}_t \lambda_{t+1}, \tag{9}$$

$$q_t^C(\lambda_t - \mu_t) + \eta_t = \beta \mathbb{E}_t\left[\lambda_{t+1} p_{t+1}^C\right], \tag{10}$$

where λ_t and μ_t are the Lagrange multipliers associated with the budget and collateral constraints, respectively. η_t is the Lagrange multiplier on non-negativity constraint (6). The relative price of the final consumption good is defined as follows:

$$p_t^C = \left[\omega^\theta + (1-\omega)^\theta \left(p_t^N\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{11}$$

Eq. (7) indicates that the private agents' marginal valuation of wealth equals their marginal utility. Eq. (8) links the price of the nontradable good to the consumption ratio of tradable and nontradable sectors. Eqs. (9) and (10) are the Euler equations for the issuance of FCD and LCD, respectively. In both equations, the left-hand side represents the marginal benefit of borrowing, while the right-hand side represents the expected marginal cost. The presence of a collateral constraint ($\mu_t > 0$) creates a wedge in the two bond Euler equations, implying that the marginal benefit of borrowing declines when the financial constraint binds.

[8] For example, Engel and Park (2022) show that the local government's temptation to deflate the LCD would make the LCD more expensive than the FCD in equilibrium. Ma and Wei (2020) show that poor institutional quality makes international investors suffer more expropriation risk when holding LCD, which also makes it more expensive.

International investors. There is a continuum of deep-pocketed risk-averse international investors (lenders) who purchase bonds issued by domestic agents. Following Bianchi et al. (2018), we assume that the investors' pricing kernel is given by

$$\mathcal{M}_{t,t+1} = e^{-r-\sigma^m(\epsilon_{t+1}+0.5\sigma^m\sigma_\epsilon^2)}, \tag{12}$$

where r is the international risk-free rate and $\sigma^m > 0$ is a parameter that governs the degree of the investors' risk aversion. A strictly positive σ^m implies a negative correlation between the pricing kernel and the tradable endowment shock: $cov(\mathcal{M}_{t,t+1}, \epsilon_{t+1}) < 0$. The economic meaning is that investors would place more weight on the bond's payoff in recessionary states of the local economy than in expansionary states.

The lenders' zero-profit condition leads to the following bond-pricing equations,

$$q_t^T = \mathbb{E}_t\left[\mathcal{M}_{t,t+1}\right] = e^{-r}, \tag{13}$$

$$q_t^C = \mathbb{E}_t\left[\mathcal{M}_{t,t+1}p_{t+1}^C\right] = \mathbb{E}_t[\mathcal{M}_{t,t+1}]\mathbb{E}_t[p_{t+1}^C] + cov(\mathcal{M}_{t,t+1}, p_{t+1}^C), \tag{14}$$

where the second equality in Eq. (13) is due to the log-normality property of the pricing kernel. Let $R_{t+1}^C = p_{t+1}^C/q_t^C$ and $R_t^T = 1/q_t^T$ be the realized returns on LCD and FCD, respectively. Some simple algebra leads to the expression of risk premium on the return of LCD,

$$\rho \equiv \mathbb{E}_t\left[R_{t+1}^C - R_t^T\right] = -\frac{cov(\mathcal{M}_{t,t+1}, R_{t+1}^C)}{\mathbb{E}_t[\mathcal{M}_{t,t+1}]}. \tag{15}$$

The risk premium depends on the covariance between the lenders' pricing kernel and the real exchange rate fluctuations. In our calibration, the lenders' pricing kernel negatively correlates with the economy's tradable endowment shock ($\sigma_m > 0$). It indicates that the price of q_t^C is discounted by a risk premium to compensate lenders' loss in downturns for holding LCD.

2.2. Competitive equilibrium

The market-clearing conditions in the tradable and nontradable sectors are given by

$$c_{T,t} + p_t^C b_t^C + b_t^T = y_{T,t} + q_t^C b_{t+1}^C + q_t^T b_{t+1}^T, \tag{16}$$

$$c_{N,t} = \bar{y}_N, \tag{17}$$

respectively. Then, we define the decentralized equilibrium as follows.

Definition 1 (*Competitive Equilibrium*). Given the initial conditions on the debt position $\{b_0^C, b_0^T\}$ and the sequence of tradable endowments $\{y_{T,t}\}_{t=0}^\infty$, a *competitive equilibrium* is defined as the sequence of allocations $\{c_{T,t}, c_{N,t}, b_{t+1}^C, b_{t+1}^T\}_{t=0}^\infty$ and prices $\{q_t^T, q_t^C, p_t^N, p_t^C\}_{t=0}^\infty$ such that: (i) taking prices as given, the representative household chooses $\{c_{T,t}, c_{N,t}, b_{t+1}^C, b_{t+1}^T\}_{t=0}^\infty$ so as to maximize lifetime utility (1) subject to budget constraint (4), collateral constraint (5), and non-negativity constraint (6); (ii) nontradable good price and real exchange rate $\{p_t^N, p_t^C\}_{t=0}^\infty$ are determined by Eqs. (8) and (11); (iii) bond prices $\{q_t^T, q_t^C\}_{t=0}^\infty$ are determined by the foreign lenders' problem in Eqs. (13) and (14); and (iv) the market-clearing conditions (16)–(17) hold.

2.3. Optimal policy intervention

Similar to the framework used in the sudden stop literature (e.g., Bianchi, 2011; Korinek, 2018; Schmitt-Grohé and Uribe, 2021), models with an endogenous collateral constraint feature a pecuniary externality where atomistic agents fail to consider the effect of their collective borrowing decisions on the nontradable good price and the collateral value. As a result, excessive borrowings in the decentralized market lead to a severe credit contraction when a large negative shock hits and the collateral constraint binds. The externality also creates a role for financial interventions in normal times, such as taxing capital inflows.

We now consider social planning problems: the planners directly choose the issuance of FCD and LCD and let the prices be determined competitively. In the following sections, we consider the problem of a Markov planner who makes discretionary choices, taking future policies as given (denoted as DP), and the problem of a social planner who can commit to her future policy decisions (denoted as CP). The competitive equilibrium is denoted as CE.

2.3.1. Discretionary planner

We describe the discretionary planner's (DP's) problem recursively. Unlike private agents, the social planner internalizes the effect of her time-t decisions on the prices of p_t^N and p_t^C in budget and collateral constraints. However, because the domestic bond price (q_t^C) is determined by the real exchange rate in the future (p_{t+1}^C for all $y_{T,t+1} \in \mathcal{Y}$), a discretionary planner at time t cannot discipline her future decisions to benefit the current-period bond price.

To simplify notation, we omit the time subscript and use a prime to denote variables in the next period. Let $\mathcal{S} = (b^C, b^T, s)$ denote the aggregate state of the economy, where $s = \{y_T\}$ is the exogenous state, and $f(s'|s)$ is the transition density. The DP's recursive problem is given by:

$$V^{DP}(b^C, b^T, s) = \max_{\{b^{C'},\, b^{T'},\, c_T\}} \left\{ c^{1-\sigma}/(1-\sigma) + \beta\mathbb{E}_{s'|s}V^{DP}(b^{C'}, b^{T'}, s') \right\}, \tag{18}$$

$$\text{s.t.} \quad c_T + p^C b^C + b^T = y_T + q^C(b^{C'}, b^{T'}, s)b^{C'} + q^T(s)b^{T'}, \tag{19}$$

$$q^C(b^{C'}, b^{T'}, s)b^{C'} + q^T(s)b^{T'} \leq \kappa(y_T + p^N \bar{y}_N), \tag{20}$$

$$b^{C'} \geq 0, \tag{21}$$

$$q^T(s) = \int_S \mathcal{M}(s, s')f(s'|s)ds', \tag{22}$$

$$q^C(b^{C'}, b^{T'}, s) = \int_S \mathcal{M}(s, s')p^C(b^{C'}, b^{T'}, s')f(s'|s)ds', \tag{23}$$

$$p^N = \frac{1-\omega}{\omega}\left(\frac{c_T}{\bar{y}_N}\right)^{\frac{1}{\theta}}, \tag{24}$$

$$p^C = \left[\omega^\theta + (1-\omega)^\theta \left(p^N\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}, \tag{25}$$

where $c = \left[\omega c_T^{\frac{\theta-1}{\theta}} + (1-\omega)\bar{y}_N^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$. Then, we can define the recursive equilibrium as follows.

Definition 2 (*Recursive Equilibrium for the Discretionary Planner [DP]*)**.** Given the transition matrix of the exogenous state $f(s'|s)$, the *recursive equilibrium for a discretionary planner* is defined as a set of decision rules $\{c_T(\mathcal{S}), b^{C'}(\mathcal{S}), b^{T'}(\mathcal{S})\}_{t=0}^{\infty}$, price functions $\{q^T(s), q^C(b^{C'}, b^{T'}, s), p^N(\mathcal{S}), p^C(\mathcal{S})\}_{t=0}^{\infty}$, and a value function $\{V^{DP}(\mathcal{S})\}$ that solve the problem in Eqs. (18)–(25).

The social planner's problem differs from the CE in three ways. First, since p^N is increasing in c_T, any negative shock that reduces collateral value and tightens the collateral constraint will cause a collapse in tradable consumption and drive a Fisherian debt-deflation spiral. So, the social planner is incentivized to restrict borrowing in states outside the financial crisis to mitigate the future unfavorable effect on the collateral constraint. Second, the social planner also understands that p^C is increasing in c_T. So, she has incentives to lower the consumption to lessen the LCD burdens.

Finally, a time-consistency problem arises because the domestic bond price (q^C) depends on the next-period real exchange rate ($p^{C'}$). The current planner prefers that the next-period planner chooses a higher level of consumption because that will lead to a more favorable bond price and a smaller cost of issuing local currency debts. However, when the next period arrives, the social planner disregards this prior benefit and has strong incentives to deflate the debt by lowering the current consumption. The debt-deflating motive results in unfavorable bond prices and the inefficient use of LCD in equilibrium.

These incentives are illustrated by the following optimality conditions:

$$\lambda_t^{DP}\left(1 + \underbrace{b_t^C \frac{\partial p_t^C}{\partial c_{T,t}}}_{\substack{\text{Additional cost from} \\ \text{higher LCD repayment}}}\right) = \underbrace{u_T^{DP}(t)}_{\text{Direct utility gain}} + \underbrace{\mu_t^{DP}\kappa\bar{y}_N\frac{\partial p_t^N}{\partial c_{T,t}}}_{\substack{\text{Indirect gain from relaxing} \\ \text{the collateral constraint}}}, \tag{26}$$

$$\left(\lambda_t^{DP} - \mu_t^{DP}\right)\left[q_t^T(b_{t+1}^C, b_{t+1}^T, s_t) + \frac{\partial q_t^C(b_{t+1}^C, b_{t+1}^T, s_t)}{\partial b_{t+1}^T}b_{t+1}^C\right] = \beta\mathbb{E}_t\lambda_{t+1}^{DP}, \tag{27}$$

$$\left(\lambda_t^{DP} - \mu_t^{DP}\right)\left[q_t^C(b_{t+1}^C, b_{t+1}^T, s_t) + \frac{\partial q_t^C(b_{t+1}^C, b_{t+1}^T, s_t)}{\partial b_{t+1}^C}b_{t+1}^C\right] + \eta_t^{DP} = \beta\mathbb{E}_t\lambda_{t+1}^{DP}p_{t+1}^C, \tag{28}$$

where λ_t^{DP}, μ_t^{DP}, and η_t^{DP} are the Lagrange multipliers to the budget, collateral, and non-negativity constraints in the DP's problem, respectively. Eq. (26) describes the marginal valuation of wealth from the social planner's perspective (λ_t^{DP}). Compared with the CE, two additional terms show up. First, the social marginal wealth includes an indirect utility gain of increasing consumption that is not present in the private marginal wealth. The term is positive if the collateral constraint binds: $\mu_t^{DP} > 0$. This expression indicates that private agents undervalue the benefit of raising consumption in relaxing the collateral constraint during a financial crisis. Second, the social planner realizes that raising consumption has an additional cost on the debt burden when the existing share of LCD is positive ($b_t^C > 0$). This incentive induces her to lower consumption to reduce debt repayment if LCD exists.

Eqs. (27)–(28) are the Euler equations with respect to bond issuance. Compared to the standard Euler equations (9)–(10) under the CE, the planner now realizes that the domestic bond price is elastic to her debt issuance and portfolio decisions. In particular, the planner, while not being able to commit to future consumption paths, recognizes that today's denomination choices will affect tomorrow's consumption profile and thus impact the bond price schedule in the current period.[9]

[9] In the quantitative analysis, our numerical results verify that the bond price tends to improve when agents denominate a larger fraction of debts in local currency.

2.3.2. Commitment planner

In our model, the presence of LCD offers the hedging benefit to the small open economies, and at the same time, creates a time-inconsistency issue. Since the price of LCD is defined recursively, the social planner would have incentives to manipulate the consumption profile in the next period to obtain a favorable bond price today. As we will show below, this incentive leads to better ex ante portfolio decisions.

Next, we describe the problem of a social planner who can commit to future consumption paths while taking the CE's equilibrium conditions as given. In the quantitative exercise in Section 4, we show that the discretionary and commitment problems necessitate different policy toolkits from financial regulators. Specifically, the commitment planner's problem is described as follows:

$$\max_{\left\{b^C_{t+1},\, b^T_{t+1},\, c_{T,t}\right\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t c_t^{1-\sigma}/(1-\sigma) \tag{29}$$

$$\text{s.t.} \quad c_{T,t} + p_t^C b_t^C + b_t^T = y_{T,t} + q_t^C b_{t+1}^C + q_t^T b_{t+1}^T, \tag{30}$$

$$q_t^C b_{t+1}^C + q_t^T b_{t+1}^T \leq \kappa \left(y_{T,t} + p_t^N \overline{y}_N \right), \tag{31}$$

$$b_{t+1}^C \geq 0, \tag{32}$$

$$q_t^T = \int_S \mathcal{M}(s_t, s_{t+1}) f(s'|s) ds', \tag{33}$$

$$q_t^C = \int_S \mathcal{M}(s_t, s_{t+1}) p_{t+1}^C f(s'|s) ds', \tag{34}$$

$$p_t^N = \frac{1-\omega}{\omega} \left(\frac{c_{T,t}}{\overline{y}_N} \right)^{\frac{1}{\theta}}, \tag{35}$$

$$p_t^C = \left[\omega^\theta + (1-\omega)^\theta \left(p_t^N \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}. \tag{36}$$

We now define the commitment planner's equilibrium as the following.[10]

Definition 3 (*Equilibrium for the Commitment Planner [CP]*). Given the initial debt $\{b_0^C, b_0^T\}$ and the sequence of tradable endowments $\{y_{T,t}\}_{t=0}^{\infty}$, the *equilibrium for a commitment planner* is defined as the sequence of allocations $\{c_{T,t}, b_{t+1}^C, b_{t+1}^T\}_{t=0}^{\infty}$ and prices $\{q_t^T, q_t^C, p_t^N, p_t^C\}_{t=0}^{\infty}$ that maximize the representative agent's lifetime utility (29) subject to budget constraint (30), collateral constraint (31), non-negativity constraint (32), bond-pricing Eqs. (33)–(34), and implementability conditions (35)–(36).

We denote λ_t^{CP}, μ_t^{CP}, and η_t^{CP} as the Lagrange multipliers to the budget, collateral, and non-negativity constraints, respectively. The solution to the CP's problem is characterized by the following optimality conditions,

$$\lambda_t^{CP}\Bigg(1 + \underbrace{\frac{\partial p_t^C}{\partial c_{T,t}} b_t^C}_{\substack{\text{Additional cost from} \\ \text{higher LCD repayment}}}\Bigg) = \underbrace{u_T(t)}_{\text{Direct utility gain}} + \underbrace{\mu_t^{CP} \kappa \overline{y}_N \frac{\partial p_t^N}{\partial c_{T,t}}}_{\substack{\text{Indirect gain from} \\ \text{relaxing the collateral constraint}}} + \underbrace{(\lambda_{t-1}^{CP} - \mu_{t-1}^{CP}) b_t^C \mathcal{M}(s_{t-1}, s_t) \frac{\partial p_t^C}{\partial c_{T,t}} \frac{1}{\beta}}_{\substack{\text{Indirect gain from committing a higher consumption} \\ \text{to improve the previous-period bond price } (h_t)}}, \tag{37}$$

$$\left(\lambda_t^{CP} - \mu_t^{CP} \right) q_t^T = \beta \mathbb{E}_t \lambda_{t+1}^{CP}, \tag{38}$$

$$\left(\lambda_t^{CP} - \mu_t^{CP} \right) q_t^C + \eta_t^{CP} = \beta \mathbb{E}_t \lambda_{t+1}^{CP} p_{t+1}^C. \tag{39}$$

Eq. (37) defines the marginal valuation of wealth (λ_t^{CP}) for the commitment planner. Like the discretionary planner, the commitment planner also considers the indirect utility gain of raising consumption in relaxing the collateral constraint. In addition, she internalizes the positive effect of consumption on debt burdens when the LCD exists.

The last term in Eq. (37) describes how the increased consumption affects the previous-period bond price. This term arises due to the planner's commitment power. Promising a higher tradable consumption in period t can appreciate the current exchange rate (p_t^C) and increase the price of LCD in period $t-1$ (q_{t-1}^C). The higher bond price, in turn, allows agents to issue LCD more easily, which offers additional hedging benefits when an adverse shock hits the economy in period t.

The presence of μ_{t-1}^{DP} and λ_{t-1}^{DP} in the period-t optimality condition confirms that the commitment planner's problem is indeed time inconsistent. During time $t-1$, the planner has the incentive to pledge a higher consumption in period t to inflate its future exchange rate, thus improving the ex ante bond price charged by international lenders. However, once period t arrives, implementing this

[10] Online appendix C describes our solution algorithm. We adopt the method discussed in Marcet and Marimon (2019) and reformulate the commitment planner's problem recursively after introducing an auxiliary state variable. The auxiliary state summarizes the history of commitment made by the social planner in previous periods. Kehoe and Perri (2002) applies a similar method to an open economy environment.

pledge becomes suboptimal because higher consumption leads to a greater debt payment if the share of LCD is positive. Our model simulation (in Section 4.3) shows that this time-inconsistency issue is quantitatively important, so the commitment planner always values wealth more than the discretionary social planner.

In the commitment planner's problem, the bond Euler equations (38)–(39) take on the same form as Eqs. (9)–(10) under the CE. This, however, does not imply that the commitment planner should make the same portfolio decision as the private agents. In both equations, the benefit and cost of issuing bonds are evaluated by the social planner's marginal wealth (λ^{CP}) but not the private agents' (λ^{CE}).

2.3.3. Decentralization

In this section, we consider how a pair of state-contingent debt taxes can implement the social planners' allocations. Let τ_t^T and τ_t^C be the capital control tax rates levied on the issuances of foreign and local currency debts, respectively. We assume that the tax revenue from financial regulation is rebated back to households in a lump-sum fashion. In a tax-regulated economy, the optimality conditions with respect to the bond issuance are

$$(u_T(t) - \mu_t)q_t^T = \beta(1 + \tau_t^T)\mathbb{E}_t u_T(t + 1), \tag{40}$$

$$(u_T(t) - \mu_t)q_t^C + \eta_t = \beta(1 + \tau_t^C)\mathbb{E}_t \left[u_T(t + 1)p_{t+1}^C\right]. \tag{41}$$

The following proposition characterizes the optimal capital control taxes that restore the social planners' allocations.

Proposition 1 (*Decentralization*)**.** *The allocations achieved by the discretionary planner and commitment planner can be implemented with two distinct tax schedules on FCD and LCD, with tax revenues rebated back to the households as a lump-sum transfer.*

Proof. See online appendix B.1. □

The expressions of capital control taxes are displayed in the proof of Proposition 1 in online appendix B.1. We focus on capital control policies in normal times when the collateral constraint does not bind: $\mu_t = 0$. There are two features we notice from the expressions of tax rates. First, in the discretionary planner's problem, the expressions of $\tau^{C,DP}$ and $\tau^{T,DP}$ (in equations B.2–B.3 in online appendix) indicate that the planner understands the effect of her portfolio decisions on the next-period consumption and how the expected consumption affects the current bond price. Second, the expressions of $\tau^{C,CP}$ and $\tau^{T,CP}$ (in equations B.4–B.5 in online appendix) contain a term that represents the commitment made in the previous periods. Such a commitment state increases the social planner's marginal benefit of borrowing and improves the domestic bond prices in equilibrium.

3. A simple model illustration

In this section, we use a simplified model to illustrate the externalities that arise from the introduction of LCD. We assume there is fixed financing need $\bar{I}$ in period 1. The agents' only problem in the first period is to choose the debt denomination of external borrowings. A fraction δ_2 of debt is denominated in local currency while the remaining $1 - \delta_2$ is denominated in foreign currency.[11] Beginning in the second period, the agent only borrows in FCD. Moreover, we assume uncertainty only happens in the second period with the tradable endowment taking a binary distribution: $\mathbb{P}(y_{T,2} = y_{T,2}^H) = 1 - p$ and $\mathbb{P}(y_{T,2} = y_{T,2}^L) = p$. The collateral constraint only binds in the low-income state. There is no financial constraint starting from the third period, and endowments are constant: $y_{T,t} = \bar{y}_T$ for $t \geq 3$. We also assume the consumption aggregator takes on a Cobb–Douglas form; that is $\theta = 1$.

To derive an analytical result, we assume that agents pay the accrued interests of the first-period-issued bonds in the second period. The ex ante interest rates on foreign and local currency bonds are denoted by R_2^* and R_2, respectively. In period 2, the ex post return on FCD is non-contingent, while the return on LCD, $R_2 p_2^N$, is contingent on the income realizations.

From the second period onward, all borrowings are denominated in foreign currencies: $\{b_t\}_{t=3}^{\infty}$. Agents choose the optimal level of borrowing to maximize the lifetime utility: $\mathbb{E}\sum_{t=2}^{\infty} \beta^{t-2} u(c_{T,t}, c_{N,t})$, where $u(c_{T,t}, c_{N,t}) = \left(c_{T,t}^{\omega} c_{N,t}^{1-\omega}\right)^{1-\sigma} / (1 - \sigma)$. The budget and collateral constraints beginning in the second period are given by

$$(\lambda_2) \quad c_{T,2} + p_2^N c_{N,2} + (1 - \delta_2)\bar{I} R_2^* + \delta_2 \bar{I} R_2 p_2^N = \frac{1}{R^*} b_3 + y_{T,2} + p_2^N \bar{y}_N, \tag{42}$$

$$(\mu_2) \quad \frac{1}{R^*} b_3 \leq \kappa(y_{T,2} + p_2^N \bar{y}_N), \tag{43}$$

$$(\lambda_t) \quad c_{T,t} + p_t^N c_{N,t} + b_t = \frac{1}{R^*} b_{t+1} + \bar{y}_T + p_t^N \bar{y}_N, \quad \forall\, t \geq 3, \tag{44}$$

where λ_t and μ_2 are the corresponding Lagrange multipliers. We assume $\beta R^* = 1$ such that the economy can perfectly smooth consumption after the second period: $c_{T,t} = c_{T,3}$ for any $t \geq 3$.

Asset-pricing equations imply that

$$R_2^* = \frac{1}{\mathbb{E}\mathcal{M}_2}, \qquad R_2 = \frac{1}{\mathbb{E}\left[\mathcal{M}_2 p_2^N\right]}, \tag{45}$$

[11] For simplicity, in this section, we assume the payoff of LCD depends on the nontradable price (p^N) rather than the aggregate consumption price (p^C) as in the full model.

where $\mathcal{M}_2$ is the foreign lenders' pricing kernel. We assume the pricing kernel takes the values of $\mathcal{M}_2^H$ and $\mathcal{M}_2^L$ in the high- and low-income states, respectively, and has a relationship $\mathcal{M}_2^H < \mathcal{M}_2^L$. The expected return on LCD is $\mathbb{E}[R_2 p_2^N]$. Then the risk premium on LCD can be expressed as $\rho = \frac{\mathbb{E}[R_2 p_2^N] - R_2^*}{\mathbb{E}[R_2 p_2^N]} = -R_2^* cov(\mathcal{M}_2, \frac{p_2^N}{\mathbb{E}p_2^N})$. The risk premium is positive when the pricing kernel negatively correlates with the nontradable good price.[12]

Hedging benefit of LCD. We begin by solving the competitive equilibrium recursively from the second period. Conditional on a certain local currency share (δ_2), the solution to the second-period problem is characterized by a triplet $\{c_{T,2}^H, c_{T,2}^L, R_2\}$ that solves the following three equations:

$$c_{T,2}^H = C^H(R_2, \delta_2) \equiv \frac{\frac{1}{R^*}\bar{y}_T + (1 - \frac{1}{R^*})y_{T,2}^H - (1 - \frac{1}{R^*})(1 - \delta_2)\bar{I}R_2^*}{1 + (1 - \frac{1}{R^*})\delta_2 \bar{I} R_2 \frac{1-\omega}{\omega}\frac{1}{\bar{y}_N}}, \tag{46}$$

$$c_{T,2}^L = C^L(R_2, \delta_2) \equiv \frac{(1+\kappa)y_{T,2}^L - (1-\delta_2)\bar{I}R_2^*}{1 - (\kappa\bar{y}_N - \delta_2 \bar{I} R_2)\frac{1-\omega}{\omega}\frac{1}{\bar{y}_N}}, \tag{47}$$

$$R_2 = \mathcal{R}(c_{T,2}^H, c_{T,2}^L) \equiv \frac{1}{(1-p)\mathcal{M}_2^H \frac{1-\omega}{\omega}\frac{c_{T,2}^H}{\bar{y}_N} + p\mathcal{M}_2^L \frac{1-\omega}{\omega}\frac{c_{T,2}^L}{\bar{y}_N}}. \tag{48}$$

The first two equations characterize the consumption profiles in the high- and low-income states, while the third equation determines the domestic bond interest rate. From the first two equations, we notice that the consumption is less sensitive to tradable endowment shock if an economy has a larger fraction of LCD, and this is especially true at the low-income state ($\frac{\partial^2 C^L}{\partial y_T^L \partial \delta_2} < 0$). Because the payoff of LCD depends on the nontradable price, it is a better hedging device against the tradable endowment shock compared to FCD.[13] We can also see that a higher interest rate on LCD increases the overall debt burden and reduces second-period consumption in both the high- and low-income states ($\frac{\partial C^H(R_2,\delta_2)}{\partial R_2} < 0$, $\frac{\partial C^L(R_2,\delta_2)}{\partial R_2} < 0$).

In the first period, the optimal portfolio δ_2 is pinned down by the following Euler equation:

$$\frac{R_2\mathbb{E}p_2^N - R_2^*}{R_2\mathbb{E}p_2^N} = \mathbb{E}\left[\frac{\lambda_2^{CE}}{\mathbb{E}\lambda_2^{CE}}\left(1 - \frac{p_2^N}{\mathbb{E}p_2^N}\right)\right]. \tag{49}$$

The left-hand side represents the *insurance cost of using LCD* (relative to FCD) that is equal to the risk premium: $\rho = -R^* cov(\mathcal{M}_2, \frac{p_2^N}{\mathbb{E}p_2^N})$. The right-hand side represents the *hedging benefit of using LCD*, which depends on how people's marginal value of wealth (λ_t^{CE}) covariates with LCD's relative payoff.

3.1. Inefficiency in the LCD issuance

Discretionary planner. We start by analyzing the discretionary planner's choice in the second period. In the low-income state, consumption is uniquely pinned down by the collateral constraint. As a result, the DP 's consumption is the same as in Eq. (47); that is $c_{T,2}^{L,DP}(R_2,\delta_2) = C^L(R_2,\delta_2)$. In the high-income state, the DP has incentives to choose a different consumption function because she realizes that the lower exchange rate will reduce the debt burden if the share of LCD is positive. The DP's high-state consumption function is given by

$$c_{T,2}^{H,DP} = C^{H,DP}(R_2,\delta_2) \equiv \frac{\bar{y}_T + (R^* - 1)y_{T,2}^H - (R^* - 1)(1-\delta_2)\bar{I}R_2^*}{\varphi(R_2,\delta_2) + R^* - 1 + (1 - \frac{1}{R^*})\delta_2 \bar{I} R_2 \frac{1-\omega}{\omega}\frac{1}{\bar{y}_N}}, \tag{50}$$

where $\varphi(R_2,\delta_2) = \left[1 + \phi(R_2,\delta_2)\right]^{\frac{1}{1-(-\sigma+1)\omega}}$ and $\phi(R_2,\delta_2) = \delta_2 \bar{I} R_2 \frac{1-\omega}{\omega}\frac{1}{\bar{y}_N}$. $\varphi(R_2,\delta_2) > 1$ indicates that the DP has an incentive to deflate the LCD burden in states outside the financial crises.

For each value of δ_2, the DP's second-period problem is charactered by a triplet $\{c_{T,2}^{H,DP}, c_{T,2}^{L,DP}, R_2^{DP}\}$ that jointly solves the equations of (47), (48), and (50). The following proposition compares the second-period solutions of the CE and DP.

Proposition 2 (*Ex Post Debt-Reduction Incentive of the DP*). *For each value of $\delta_2 > 0$, the DP's incentive to deflate the LCD in the high-income state results in lower consumption in both states and a higher domestic interest rate than that of the competitive equilibrium. Specifically, we have*

$$c_{T,2}^{H,DP}(\delta_2) < c_{T,2}^H(\delta_2), \quad c_{T,2}^{L,DP}(\delta_2) < c_{T,2}^L(\delta_2), \quad R_2^{DP}(\delta_2) > R_2(\delta_2), \quad \textit{for any} \ \ \delta_2 > 0.$$

Proof. See online appendix B.2. □

[12] Online appendix D provides detailed descriptions of the simplified model and associated optimality conditions.

[13] For relevant parameter values, we find that $\frac{\partial C^H(R_2,\delta_2)}{\partial \delta_2} < 0$ and $\frac{\partial C^L(R_2,\delta_2)}{\partial \delta_2} > 0$. This means that increasing the share of LCD in the first period produces a smaller consumption dispersion in the second period.

Proposition 2 shows that the social planner's debt-reduction incentive in the high-income state also translates into a lower consumption in the low-income state because the endogenous interest rate is determined by the weighted average of consumption, as in Eq. (48).

What does it imply for the planner's first-period portfolio decision? The portfolio Euler equation in the first period is given by

$$\frac{R_2^{DP}\mathbb{E}p_2^{N,DP} - R_2^*}{R_2^{DP}\mathbb{E}p_2^{N,DP}} = \mathbb{E}\left[\frac{\lambda_2^{DP}}{\mathbb{E}\lambda_2^{DP}}\left(1 - \frac{p_2^{N,DP}}{\mathbb{E}p_2^{N,DP}}\right)\right] - \frac{\delta_2}{R_2^{DP}}\frac{\partial R_2^{DP}(\delta_2)}{\partial \delta_2}\mathbb{E}\left[\frac{\lambda_2^{DP}}{\mathbb{E}\lambda_2^{DP}}\frac{p_2^{N,DP}}{\mathbb{E}p_2^{N,DP}}\right], \tag{51}$$

where $\{R_2^{DP}, p_2^{N,DP}, \lambda_2^{DP}\}$ are the DP's equilibrium values in the second period at a certain value of δ_2.[14] Like before, the left-hand side of Eq. (51) represents the *insurance cost* of using LCD from the social planner's perspective, while the right-hand side is the *hedging benefit*. Unlike the CE's condition in Eq. (49), the hedging benefit is evaluated by the social planner's marginal value of wealth λ_2^{DP}, which incorporates pecuniary externalities. Meanwhile, the second term on the right-hand side, arising from the lack-of-commitment issue, represents how the endogenous interest rate varies with the local currency share.

Commitment planner. In the discretionary planner's problem, the debt-reduction incentive prohibits agents from using LCD to hedge downside risk during financial crises. We address this issue by assuming a social planner who commits to future policies. In particular, the planner makes the portfolio decision (δ_2) in period 1, and simultaneously commits to a specific consumption profile in the second period ($c_{T,2}^H$, $c_{T,2}^L$). When the planner enters period 2, she chooses the exact level of borrowing (b_3^H, b_3^L) to implement the pre-committed consumption profile that satisfies the budget and collateral constraints.[15]

The full set of equilibrium conditions are given by equations (B.17)-(B.22) in online appendix B. Since the low-state consumption (c_2^L) is pinned down by the collateral constraint, the planner is only flexible in choosing consumption in the high state (c_2^H). The following proposition shows that the planner would like to commit to a higher level of consumption in the high-income state (relative to the DP) to lower the ex ante interest rate, which allows herself to borrow LCD more easily in the first period. This larger fraction of LCD improves welfare in the crisis state.

Proposition 3 (*Ex Ante Hedging Incentive of the CP*). *Suppose the CP's optimal portfolio is δ_2^{CP*} and there exists a θ^* such that $\theta^* = \frac{\lambda_2^{H,CP}}{\mathcal{M}_2^H} = \frac{\lambda_2^{L,CP}}{\mathcal{M}_2^L}$. Then, the CP's decision satisfies*

$$c_{T,2}^{H,CP} = c_{T,2}^H(\delta_2^{CP*}), \quad c_{T,2}^{L,CP} = c_{T,2}^L(\delta_2^{CP*}), \quad R_2^{CP} = R_2(\delta_2^{CP*}),$$
$$\lambda_2^{H,CP} = \lambda_2^H(\delta_2^{CP*}), \quad \lambda_2^{L,CP} > \lambda_2^L(\delta_2^{CP*}), \quad \mu_2^{L,CP} > \mu_2^L(\delta_2^{CP*}).$$

Furthermore, we assume: (i) the CE's optimal portfolio is denoted as δ_2^{CE*}; and (ii) in the relevant range of δ_2 around δ_2^{CE*}, the CE's policy functions have the property that $\frac{\mathbb{E}[\lambda_2^{CE}(\delta_2)p_2^N(\delta_2)]}{\mathbb{E}\lambda_2^{CE}(\delta_2)} - \frac{R^*}{R_2(\delta_2)}$ is monotonically increasing in δ_2. Then, we have $\delta_2^{CP*} > \delta_2^{CE*}$.[16]

Proof. See online appendix B.3. □

The first part of Proposition 3 says that the commitment planner would prefer to maintain the same consumption allocations as the ones chosen by the decentralized agents at their optimal portfolio share of δ_2^{CP*}. In addition, since the social marginal value of wealth is larger than the private agents' in the low-income state, the planner has a stronger incentive to mitigate the financial risk by issuing more LCDs, as shown by the second half of the proposition.[17]

The Euler equation that determines her portfolio decision is given by

$$\frac{R_2^{CP}\mathbb{E}p_2^{N,CP} - R_2^*}{R_2^{CP}\mathbb{E}p_2^{N,CP}} = \mathbb{E}\left[\frac{\lambda_2^{CP}}{\mathbb{E}\lambda_2^{CP}}\left(1 - \frac{p_2^{N,CP}}{\mathbb{E}p_2^{N,CP}}\right)\right]. \tag{52}$$

Notice that this equation takes exactly the same form as the one under the competitive equilibrium (Eq. (49)) where the social planner chooses a portfolio equalizing the *insurance cost* of using LCD to its *hedging benefit*. The only difference is that the CP's hedging benefit is evaluated by the social marginal value of wealth (λ_2^{CP}) instead of the private one (λ_2).

The welfare implication of the two social planners also differs. Fig. 2 provides a numerical illustration. Compared to the CE, the DP's strong debt-reduction incentive raises up the domestic interest rate and shrinks the resource frontier of the whole economy. In the first period, this incentive makes borrowing in LCD very costly. In the end, the lack of commitment leads to a welfare loss. On the other hand, the CP is cognizant that promising a higher consumption in the good state will benefit the domestic interest rate,

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14 The DP's marginal valuation of wealth in the second period is given by: $\lambda_2^{DP} = \frac{u_T(c_{T,2}) + \mu_2^{DP}\kappa\frac{1-\omega}{\omega}}{1+\phi(R_2,\delta_2)}$.

15 In our simplified model, there is no scope for making commitments beginning in the third period. Therefore, we assume that the social planner in the first period only needs to commit to the second-period allocations. The commitment planner jointly solves the values of $\{c_{T,2}^{L,CP}, c_{T,2}^{H,CP}, \lambda_2^{L,CP}, \lambda_2^{H,CP}, \mu_2^{L,CP}, R_2^{CP}, \delta_2^{CP}\}$ to maximize her lifetime utility.

16 It is usually inappropriate to make assumptions about endogenous objects. However, these assumptions here allow us to characterize portfolio decisions, and we confirm they hold in our numerical example.

17 In online appendix D, we use a numerical example to compare the second-period consumption schedules under the CE and CP. Also, we show their first-period portfolio choices in the two environments.

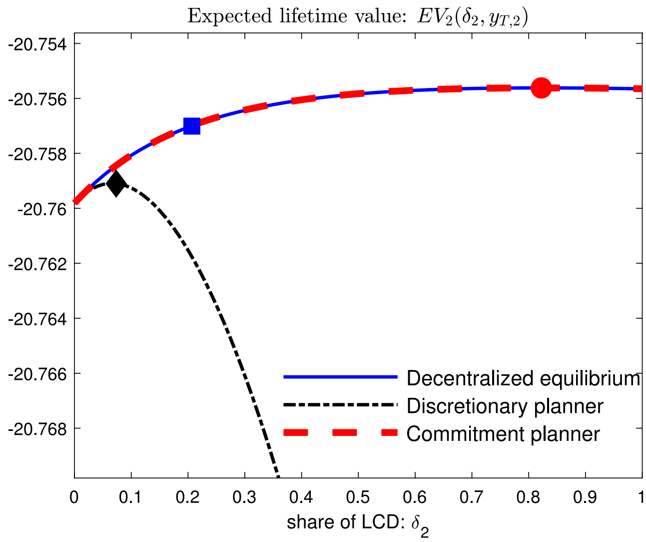

Fig. 2. Lifetime utilities and the optimal portfolio decisions in the simple model. Note: This figure shows the expected lifetime utility functions in the three equilibria. The expected lifetime utility is defined as $\mathbb{E}V_2(\delta_2, y_{T,2}) = (1-p)V_2(\delta_2, y^H_{T,2}) + pV_2(\delta_2, y^L_{T,2})$. The squared/diamond-shaped/round point refers to the optimal portfolio decision in the problem of DE/DP/CP, respectively. We provide details for this illustration in online appendix D.

and she also internalizes the benefit of using LCD in mitigating the exchange rate drop during a financial crisis. As a result, she increases the local currency share to fully utilize its hedging benefit and obtains the maximum welfare among the three equilibria. Proposition 4 in online appendix D provides the expressions of capital control taxes that restore the social planner's allocations. We find that the tax rate that is used to adjust the first-period portfolio is a composite measure that depends on the crisis probability, the crisis severity, and a term representing the relative benefit of using LCD.

4. Quantitative analysis

This section calibrates the full model and analyzes its quantitative implications. In online appendix E, we show that our results are robust to alternative parameter values.

4.1. Calibration and solution method

We use the global solution method with time iteration. Specifically, the solution method involves iterating a set of decision rules based on the first-order conditions until convergence is achieved.[18] For the competitive equilibrium and the discretionary planner's problem, the vector of state variables is $S = (b^C, b^T, s)$. For the commitment planner, we introduce an additional state variable h to capture the history of commitment made in the prior periods (the last term in Eq. (37)). The CP's solution is defined on the extended state vector $\tilde{S} = (b^C, b^T, h, s)$. After including the additional state variable, we formulate the commitment planner's problem in a recursive form that can be solved using the standard Euler equation iteration method. More details on the solution method are provided in online appendix C.

We calibrate the model under the competitive equilibrium using Mexican annual data because Mexico is a standard sudden stop economy frequently used in the literature. Part of the parameters is borrowed from the literature or found by simply matching moments. The risk-free world interest rate is $r = 0.04$. The relative risk aversion σ is set to a standard value of 3.[19] The weight on tradable goods in the aggregate consumption basket ($\omega = 0.39$) is used to target the sectoral consumption ratio $c_N/c_T = 1.643$, as computed by Benigno et al. (2013). The elasticity of substitution (θ) is an important parameter because it governs the real exchange rate fluctuations, which implicitly determines the relative benefits of using LCD. In the baseline calibration, we use a conservative value of 0.83 following Bianchi (2011). The parameters in the income process are estimated by running a regression using the tradable output data between 1970 and 2021. As in Bianchi (2011), we consider the value added of the manufacturing and agriculture industries as tradable output, while the rest of the industrial production is considered nontradable output.

The remaining three parameters (β, κ, σ^m) are jointly calibrated to target data moments: the probability of a crisis, the average net foreign asset (NFA)-to-GDP ratio, and the average share of external debts denominated in local currency. In the model, a sudden stop crisis is defined as the period when (i) the collateral constraint binds; and (ii) the current account exceeds two standard deviations

18 By solving the models using first-order conditions, we implicitly assume that they are both necessary and sufficient for the models' solutions.

19 We also solve a model with $\sigma = 2$ in the sensitivity analysis in online appendix E. All the quantitative results in the baseline calibration remain.

Table 1
Parameter values.

Description	Parameter	Value	Target/Source
From literature or simple moment match:			
Tradable good weight	ω	0.39	Benigno et al. (2013)
Elast. of substitution	θ	0.83	Bianchi (2011)
Risk aversion	σ	3	DSGE literature
International interest rate	r	0.04	Bianchi (2011)
Income process: autocorrelation	ρ	0.81	Mexican tradable income data
Income process: std. dev.	σ_ϵ	0.064	Mexican tradable income data
Income process: mean	μ	$-\frac{1}{2}\sigma_\epsilon^2$	Mean tradable income = 1
Calibrated to fit targets:			
Subjective discount factor	β	0.86	Prob. of crisis $\approx$ 5.5%
Maximum leverage ratio	κ	0.334	Mean NFA-to-GDP = −33.3%
Lenders' risk aversion	σ^m	3.83	Mean LCD share = 13.7%

Note: Mexico's tradable income process comes from the World Development Indicators and covers from 1970 to 2021. The net foreign asset (NFA) is constructed by Lane and Milesi-Ferretti (2018), and the data on the currency denomination of external debt liabilities comes from Bénétrix et al. (2019). To estimate the tradable income process, we linearly detrend the log tradable sector outputs measured in constant U.S. dollars. We include agriculture, manufacturing industries, and natural resources as the tradable outputs.

above its mean.[20] In the model simulation, the crisis happens with a probability of 5.5%, the same as the data counterpart found in Bianchi (2011). The dataset used by Lane and Milesi-Ferretti (2018) suggests that Mexico has an average NFA-to-GDP ratio of −33.3% between 1970 and 2015, while our model predicts an average debt burden-to-GDP ratio of 33.2%. To target the share of LCD, we use the cross-border currency exposure data of Bénétrix et al. (2019). For Mexico, the average share of external debt denominated in local currency between 1990 and 2017 is 13.7%, and that the local currency share has a standard deviation of 7.3%. In the model simulation, the average and standard deviations of local currency share are respectively 13.6% and 10.7%. The parameter values are listed in Table 1.

4.2. CE policy functions

We begin by considering policy functions in the decentralized equilibrium. We define the total debt level as $b_t \equiv b_t^C + b_t^T$ and the share of debt in local currency as $\delta_t \equiv b_t^C/(b_t^C + b_t^T)$. Fig. 3 plots decision rules for a variation of the debt levels (b_t), while keeping the states of δ_t and $y_{T,t}$ at their relative high and low levels. A higher b_t with constant values of δ_t and $y_{T,t}$ means a higher debt burden ($b_t\delta_t p_t^C + b_t(1-\delta_t)$) in the relevant ranges of the state variables. First, we notice that all the decision rules feature strong nonlinearities. For example, in the low-debt state where the collateral constraint does not bind ($\mu_t = 0$), tradable consumption decreases and the debt issuance increases in the debt balance. As b_t gradually approaches the crisis threshold, the probability of hitting a financial constraint in the next period becomes relevant. In response, the private agent starts to issue positive shares of LCD to provide insurance for the upcoming financial crises. This occurs until the collateral constraint becomes binding ($\mu_t > 0$).[21]

In addition, panel E shows that when the financial constraint is nonbinding, the price of LCD decreases in the debt balance. This is because q_t^C is determined by the next-period real exchange rate (p_{t+1}^C), and the greater amount of borrowing lowers the exchange rate in expectation. Panel D shows that the risk premium (for holding LCD) increases when the debt goes up. The reason is that as the higher debt balance drives up the chance of a financial crisis in the next period, the expectation of currency depreciation during a crisis necessitates a larger risk premium for lenders' holding of LCD.

When the debt level is sufficiently high, the collateral constraint starts to bind, triggering the Fisherian debt-deflation channel. In the binding region, tradable consumption sharply declines as the debt increases. The collapse in consumption, in turn, further exacerbates the reduction in the collateral value and borrowing opportunities. Because the reduced borrowing in the current period implies a smaller debt in the next period, the agent has fewer incentives to issue LCD for the insurance benefit. Therefore, as shown by panel C, the share of LCD quickly declines to zero once the constraint binds. Finally, panels D and E show that in the binding region, a higher debt balance results in the lower risk premium and the recovered bond price.

Fig. 3 also compares policy functions for different levels of endowment ($y_{T,t}$) and existing shares of LCD (δ_t). Recall that δ_t is defined as $\delta_t = b_t^C/(b_t^C + b_t^T)$. A higher δ_t indicates (1) a higher fraction of debt denominated in the local currency; and (2) a higher debt burden since the real exchange rate value (p_t^C) is greater than one in our simulations.[22] Therefore, from the upper panel of Fig. 3, we find that a higher δ_t indicates a lower tradable consumption, greater borrowing needs, and stronger incentives to issue LCDs in the nonbinding states. The same logic applies to the comparison between the high- and low-income levels. If the constraint is not binding, the higher income boosts consumption, decreases borrowing, and reduces the agent's incentive to use LCDs. Since

[20] We confirmed that our quantitative evaluation of optimal policies does not depend on alternative definitions of the sudden stop used in the existing studies.

[21] When the economy has a very low debt balance and is far away from the collateral constraint, the private agent borrows exclusively in the form of FCD. The reason is that when b_t is very low, the economy has nearly a zero probability of hitting the financial constraint in the next period. So, the cost of issuing LCD exceeds its hedging benefit. In the long run, the probability that decentralized agents choose a zero share of LCD is 15.3%.

[22] The overall debt balance is $b_t\delta_t p_t^C + b_t(1-\delta_t)$.

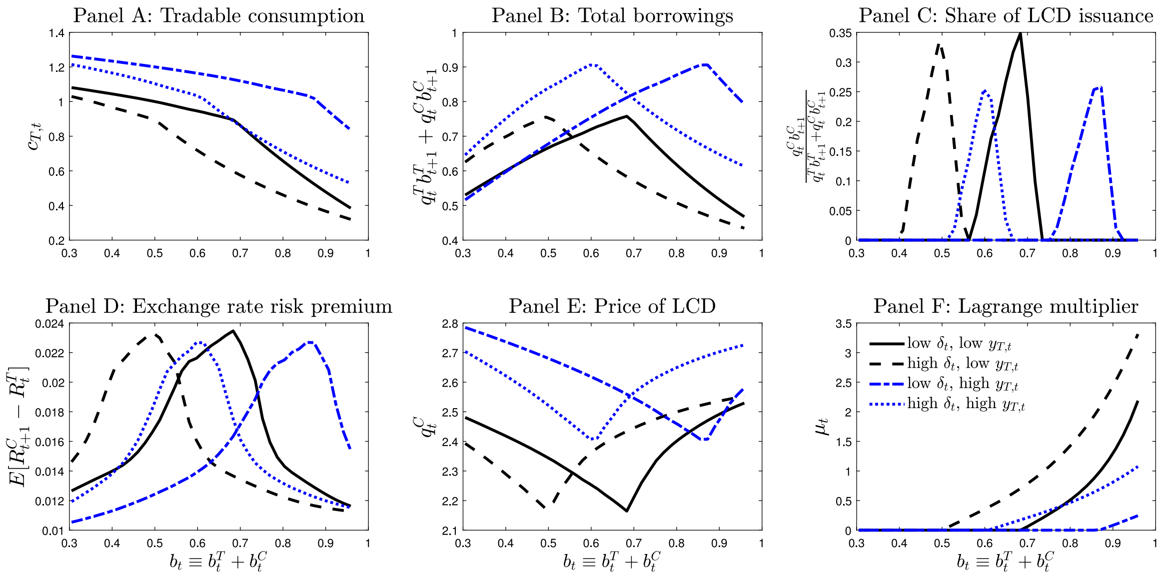

Fig. 3. Policy functions under competitive equilibrium. Note: This figure display decision rules in the decentralized equilibrium. We plot the policy functions for a continuum of debt balance b_t at two different levels of $y_{T,t}$ and $\delta_t \equiv b_t^C/(b_t^C + b_t^T)$. The high-$y_T$ (low-y_T) state is set to one standard deviation above (below) its mean. The high-δ (low-δ) state refers to the CP's (CE's) simulation average. The exchange rate risk premium is defined as $\mathbb{E}_t[R_{t+1}^C - R_t^T]$, where $R_{t+1}^C = p_{t+1}^C/q_t^C$ and $R_t^T = 1/q_t^T$.

the income process is persistent, a higher income also improves the price of LCD and reduces the exchange rate risk premium. More importantly, a positive income shock greatly relaxes the financial constraint and shifts the binding region to the right.

4.3. Analysis of optimal policies

Next, we compare the decentralized equilibrium with the two social planners' allocations.

4.3.1. Comparing policy functions

Fig. 4 compares the policy functions under the CE, DP, and CP. We notice that the two types of social planners improve welfare in different ways. First, compared to the decentralized agents, the discretionary planner internalizes how the restrained borrowing impacts the collateral constraint and real burden of LCD. Lacking commitment power, she also understands that the price of LCD is determined by the next-period consumption, which depends on her borrowing and denomination decisions today. In Fig. 4, we find that in states where the constraint is not binding, the DP borrows less than the decentralized agents so as to preserve liquidity and reduce the probability of hitting a financial constraint. However, in equilibrium, this lower level of borrowing reduces tradable consumption and makes the issuance of LCD less desirable. As a result, the discretionary planner borrows less than the private agents and borrows predominately in FCD.

We then consider the policy functions of a commitment planner who, unlike the discretionary planner, can promise a consumption plan in the next period and will therefore manipulate the debt payoff schedule to influence the endogenous bond price. In particular, the planner has incentives to increase consumption at certain states of nature to obtain a better bond price, which allows her to reap the benefit of issuing LCDs at a lower cost. As shown in panels A2 and B2, the commitment planner borrows more aggressively than the discretionary planner. When the state of prior commitment equals its simulation mean (h_t = mean), the total amount of borrowing is even larger than that in the decentralized market.[23] Panels A3 and B3 show that the commitment planner denominates a larger fraction of local currency debt relative to the CE and DP.

In Fig. 5, we compare the time-t planner's committed consumption profile (the blue solid line) with a consumption profile chosen by a period-t+1 planner who discards her prior commitment (the black dashed line). The difference between these two lines captures the planner's incentive to manipulate the next-period consumption ($\{c_{T,t+1}\}_{y_{T,t+1}\in\mathcal{Y}}$) in order to improve the current utility. At the low-income realizations, the collateral constraint binds, and the consumption is uniquely determined by the collateral value. As a result, the two lines coincide. As tradable income increases and the collateral constraint becomes slack, the blue line rises above the black dashed line, implying that the commitment planner would prefer to choose a higher consumption than without prior

[23] On the one hand, the commitment planner has more precautionary motives, making her borrow less than the decentralized agents. On the other hand, having access to a safer debt portfolio (i.e., one that means lower debt repayments in bad times) allows her to borrow more. Whether the decentralized economy features "underborrowing" or "overborrowing" depends on the state of prior commitment h_t. Note that even if the commitment planner borrows more, this does not mean she would subsidize debts. Our simulation in Section 4.5 shows that the commitment planner always imposes positive tax rates on FCD and LCD issuance, consistent with Arce et al. (2023).

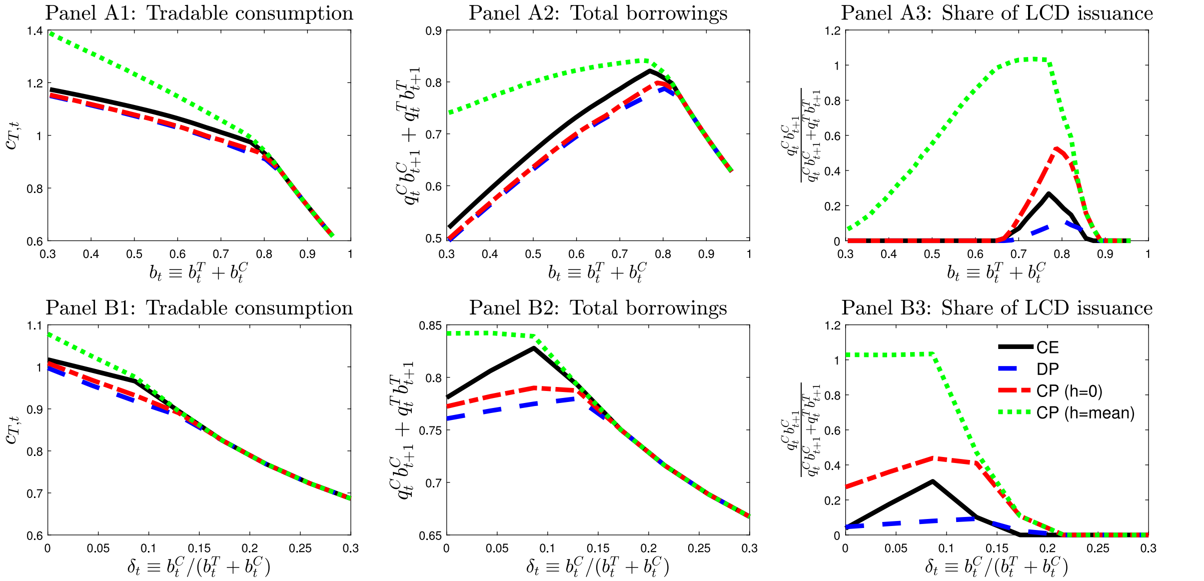

Fig. 4. A comparison of policy functions in three equilibria. Note: This figure compares decision rules under the three equilibria. The tradable endowment is set to its mean. Panels A1–A3 show the decision rules for different b_t while keeping δ_t at the CP's ergodic mean. Panels B1–B3 show the decision rules for different δ_t while keeping b_t at the CP's ergodic mean. To construct the policies for the commitment planner, we set the state of prior commitment (h_t) either to zero or to its long-run mean.

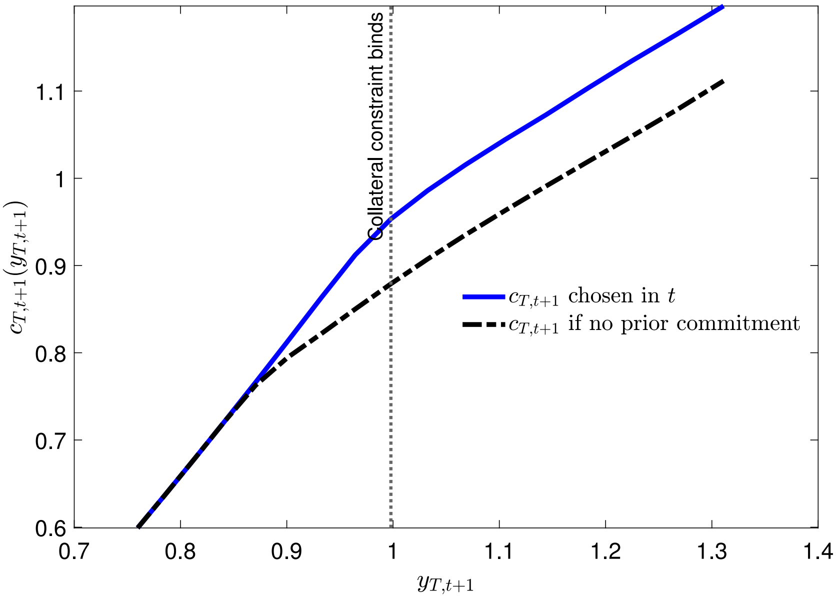

Fig. 5. The next-period consumption profiles w/ and w/o prior commitment. Note: This figure compares the period-t+1 consumption profiles ($c_{T,t+1}(y_{T,t+1})$) chosen by commitment planners with and without prior commitment. The blue solid line plots the period-t+1 consumption schedule that a period-t commitment planner would choose when b_t, δ_t, and the prior commitment state $h_t = \left(\lambda_{t-1}^{CP} - \mu_{t-1}^{CP}\right) b_t^C \frac{\partial p_t^C}{\partial c_{T,t}} \mathcal{M}(s_{t-1}, s_t) \frac{1}{\beta}$ are set to their ergodic means. $y_{T,t}$ is also set to its mean value. The black dashed line plots the consumption schedule if the commitment planner reneges on her previous commitment in period-t+1 (by setting h_{t+1} to 0) and rechooses a $c_{T,t+1}$ after observing the realization of $y_{T,t+1}$.

commitment. Committing to a high consumption in the next period improves the ex ante bond price (q_t^C) and helps the economy mitigate the consumption collapse during sudden stops using a better debt structure.[24]

[24] Figure G.5 in online appendix G shows the histogram of h in the simulation of the commitment planner's problem. We find that the planner tends to promise a high h_{t+1} when the current tradable endowment ($y_{T,t}$) is low to buffer against the upcoming financial crisis.

Table 2
Simulation results.

	Decentralized equilibrium	Discretionary planner	Commitment planner
Avg. debt burden/y	33.2%	31.6%	33.6%
Avg. share of LCD	13.6%	5.8%	53.2%
- Prob. of LCD = 0	15.3%	19.0%	4.5%
- Prob. of positive reserve	0%	0%	0.4%
Std(c_T)/Std(y_T)	1.17	1.12	1.03
Std(ca)/Std(y_T)	0.53	0.31	0.41
Corr(c_T, y_T)	0.92	0.97	0.97
Corr(ca, y_T)	−0.24	−0.32	−0.36
Std(debt burden/y_T)	5.6%	5.5%	4.4%
Std(share of LCD issuance)	10.7%	5.0%	28.9%
Corr(debt burden, y_T)	0.77	0.75	0.85
Corr(share of LCD issuance, y_T)	−0.39	−0.69	−0.63
Avg. spread on LCD	2.03%	1.77%	1.01%
- Avg. $std_t(p^C_{t+1})$	19.2	16.6	14.3
- Avg. $cov_t(\mathcal{M}_{t,t+1}, p^C_{t+1})$	−4.67	−4.02	−3.49
Std(spread)	0.24%	0.16%	1.00%
Corr(spread, y_T)	−0.26	−0.56	0.41
Prob. of crises	5.5%	1.4%	2.8%
Sev. of crises ($\%\Delta c_T$)	−25.2%	−19.0%	−16.5%
Avg. tax on FCD: τ^T	–	6.51%	5.93%
Avg. tax on LCD: τ^C	–	6.19%	5.43%
Avg. tax discrimination: $\tau^T - \tau^C$	–	0.32%	0.50%
Corr($\frac{\tau^T+\tau^C}{2}$, y_T)	–	−0.79	−0.57
Corr($\tau^T - \tau^C$, y_T)	–	−0.51	−0.74
Avg. wel. gain rel. to DE	–	0.019%	0.071%

Note: We simulate each of the three economies for 100,000 periods and discard the first 10,000 periods for burning-in. We repeat the simulation 50 times and then take the average across simulations. A sudden stop is defined as the period when collateral constraint binds and the current account level exceeds two standard deviations above its mean. The spread on LCD is defined as $\mathbb{E}_t[R^C_{t+1} - R^T_t]$, where $R^C_{t+1} = p^C_{t+1}/q^C_t$ and $R^T_t = 1/q^T_t$. The overall debt burden is $p^C_t b^C_t + b^T_t$, while $p^C_t b^C_t/[p^C_t b^C_t + b^T_t]$ is the share of LCD in a country's liability. The share of LCD issuance is defined as $q^C_t b^C_{t+1}/[q^C_t b^C_{t+1} + q^T_t b^T_{t+1}]$. "Prob. of LCD = 0" denotes the frequency of periods without any LCD issuance. "Prob. of positive reserve" denotes the frequency of periods where households borrow only in local currency while holding foreign currency assets as reserves. The average welfare gain represents the percentage of permanent consumption that households would like to sacrifice to move to the social planners' economies. Moments of tax rates are computed based on the periods when the financial constraint does not bind.

4.3.2. Simulation results

Table 2 reports long-run simulation moments in the three equilibria. First, the discretionary planner internalizes the effects of her borrowing decisions on the collapse of collateral value when a future financial crisis hits. That leads her to borrow less in the international market (31.6%) compared to the private equilibrium (33.2%). However, the incentive to deflate debt burdens ex post makes it more costly to issue LCD ex ante. In the long run, the DP only denominates 5.8% of her debts in local currency, even lower than the average share of the CE (13.6%).

Second, because the commitment planner can commit to a better consumption profile and is flexible in using LCD to insure against the downside risk, she denominates 53.2% of the debt in local currency, and her average indebtedness is even larger than that in the CE (33.6% vs. 33.2%). In the decentralized market, the average probability of time that agents issue no LCD is 15.3%. The probability is higher at 19% in the DP's economy but as low as 4.5% in the CP's economy. In the long run, there are even 0.4% of the periods when the CP issues debts only in local currency while holding assets in hard currency as reserves.

By restricting overall debt issuance, the DP reduces the crisis probability to 1.4%, a significant decrease from the 5.5% in a decentralized economy without any policy. The lowered leverage ratio also mitigates the crisis severity. The DP's equilibrium is associated with lower volatilities of consumption and current account. On the other hand, the CP improves consumption-smoothing by issuing more debts in local currency, which is evident by examining the fluctuation of debt burden (std. and its correlation with income). Because the payoff of LCD is contingent on the realizations of real exchange rate, a larger share of LCD reduces the volatility on debt burden (4.4% in the CP vs. 5.6% in the CE).

The middle panel of Table 2 shows the moments on the spread of returns between local and foreign currency debts. The spreads are reduced for both planners because financial regulations always mitigate the consumption collapse during the crises. The spreads decline because the future exchange rate is less volatile and less negatively correlated with the lenders' pricing kernel. By committing to a future consumption plan, the CP enjoys the lowest spread out of the three equilibria. The spreads are weakly countercyclical in the decentralized market and the discretionary economy but become procyclical in the model with commitment.

The CP's flexibility in choosing portfolio can be easily seen from the moments on the local currency share (std. and its correlation with income). Compared with the CE and DP, the CP has the highest standard deviation on the share of LCD issuance (28.9% vs. 10.7% and 5.0%). Also, the negative correlation indicates that the planner prefers to issue a larger fraction of LCD in economic downturns. Figure G.3 in online appendix G shows the scatter plots of portfolio distributions in the three equilibria. Only the CP's

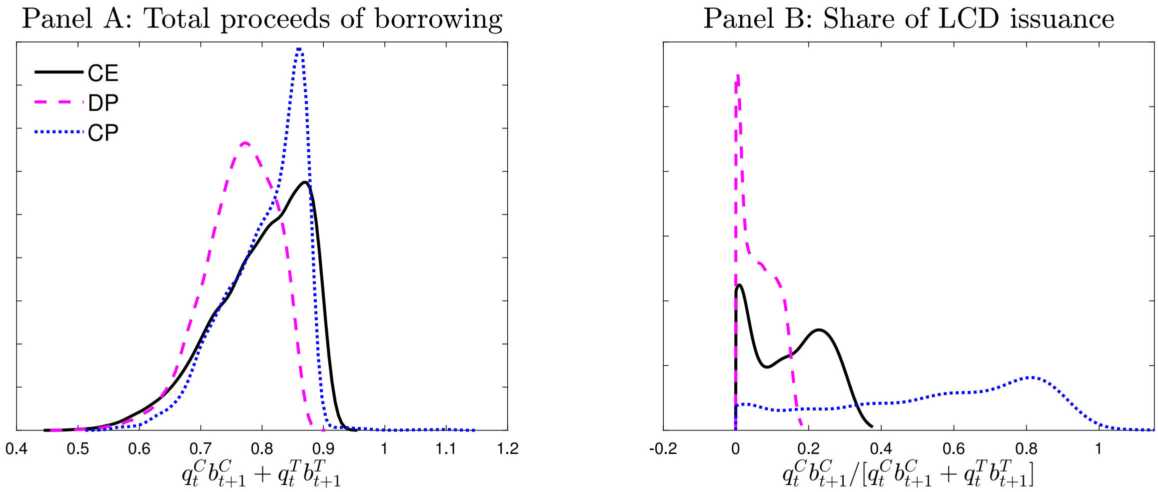

Fig. 6. Ergodic distributions of borrowings and shares of LCD. Note: This figure plots the ergodic distributions of total borrowings and the share of LCD issuance in the three economies.

equilibrium displays a large variation in the local currency share. Online Appendix figure G.4 shows how the debt denomination decisions correlate with the exchange rate volatility and currency risk premium along the equilibrium paths.

Fig. 6 plots the ergodic distributions of total borrowings and the share of debt denominated in local currency.[25] From panel A, we find that the discretionary planner strongly constrains the level of borrowings in the financial market. The commitment planner, on the other hand, borrows a similar level of debt as the private agents. Because the CP can hedge negative income shocks by denominating a large fraction of debt in local currency, at certain economic states, she borrows even more aggressively than the private agents.

Panel B in Fig. 6 compares the distributions of portfolio shares. Due to the lack of commitment, the DP has the lowest local currency share. In contrast, the CP, who enjoys a better domestic bond price by committing to future policies, issues the largest amount of debt in local currency. More importantly, we notice that the share of LCD issuance is widely dispersed in the CP's simulation. In certain states, the share even exceeds 100%, meaning that the home country holds foreign currency assets as international reserves.

4.3.3. Crisis events

This section compares the models' performance during sudden stop crises. We begin by simulating the competitive equilibrium model for 500,000 periods and dropping the first 10,000 periods for burning-in. We then identify 1000 sudden stop episodes from the simulated data and extract a 9-period event window for each identified sudden stop period. Next, we extract the sequences of shocks during the crisis event windows and the initial states before the crises and feed them into the social planners' equilibria.[26] Fig. 7 shows the average simulation paths around a sudden stop event.

The event window under the CE (black solid lines) displays a standard sudden stop phenomenon. Financial crises are often triggered by a sudden collapse in tradable income after a sequence of positive shocks (panel F). The decline in tradable income forces agents to cut consumption, depreciating the real exchange rate. The reduced nontradable price, in turn, tightens the financial constraint and amplifies the collapse in the borrowing limit and consumption demand. Ultimately, the sudden stop event is featured by the drastic drops in consumption and borrowing, large real depreciations, and big current account reversals. We also observe from panel C that the higher income before the crisis induces agents to issue more LCDs because they have a stronger incentive to hedge the upcoming financial risk when their leverage rises.

Compared with the CE, both discretionary and commitment planners experience less severe recessions under the same sequences of shocks. The collapses in consumption, real exchange rate, and borrowings are milder in the planners' equilibria, and the current account reversals are also smaller. However, the two planners achieve financial stability through different strategies. The DP internalizes the pecuniary externality in the collateral constraint and, therefore, preserves liquidity by borrowing less compared to the CE (panel B). This additional liquidity alleviates the amplification effect from the financial constraint when a negative shock hits and allows the planner to achieve a milder fluctuation.

The CP, on the other hand, tends to manipulate the debt payoff by committing to a certain consumption plan in the future. Such a manipulation allows her to reap the insurance benefits of LCD at a lower cost. Panel C shows that the CP issues the largest amount

25 Figure G.1 in online appendix G shows the distributions of debt burden in local and foreign currencies. We find that in the DP's problem, the country's foreign currency exposure is even higher than that under the CE.

26 Our method to conduct crisis event analysis is the same as Bianchi and Mendoza (2018).

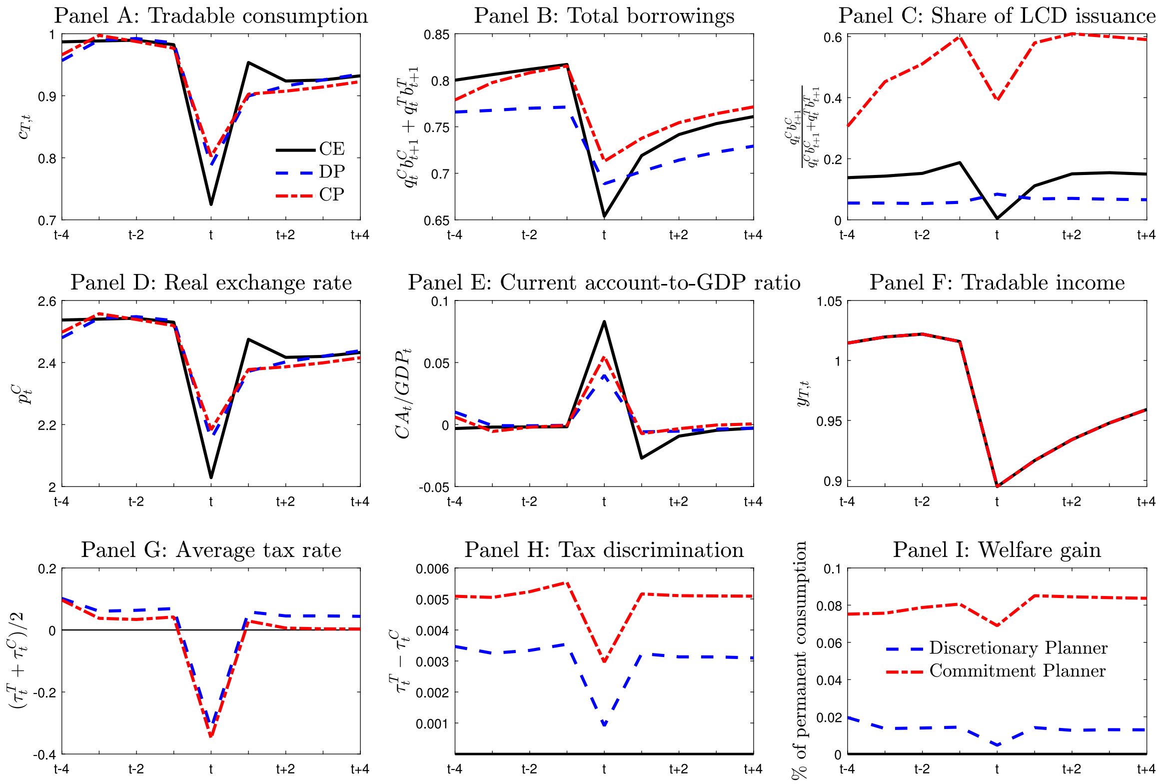

Fig. 7. Event window analysis. Note: The graph compares the sudden stop event windows in the three environments. For comparison, we first identify 1000 sudden stop events from the simulations of the CE and extract the income process during the crises and initial states before the crises. We then feed the series of shocks and initial states into alternative economies. The graph shows the average path of simulations across the event windows. The welfare gain represents the percentage of permanent consumption that households would like to sacrifice to move to the social planners' economies. The initial h state is set to 0 at period $t-4$ in the commitment planner's simulation.

of local currency debts. The extra LCD provides her a buffer to hedge the downward risk and also reduces her need to constrain borrowings. Therefore, the planner still borrows aggressively during the boom periods preceding the financial crisis.

Fig. 8 shows the distributions of crisis severity during sudden stop events in the three equilibria. The crisis severity is measured by the degree of consumption collapse (in percentage deviation from the long-run mean). Both social planners can mitigate the crisis severity by shifting the distribution to the right. By restricting the overall capital inflows, the DP enjoys a smaller consumption collapse when the same sudden stop shock hits the economy. But there is still a significant probability that the consumption drop exceeds 40% in a sudden stop, similar to what we observe under the CE. The CP obtains the mildest consumption drop during sudden stop episodes, even though the restriction on debt issuance is more lenient. Using LCD allows the economy to avoid most of the extreme consumption collapses experienced by private agents. We notice that the distribution displays a thinner left tail compared to the other two economies.

4.4. Welfare implications

To gauge the benefits of policy intervention, we calculate state-contingent welfare gains achieved by the discretionary and commitment planners. The welfare gains are measured as the percentage of permanent consumption that households are willing to sacrifice to live in the world with either a discretionary or commitment planner. We first compute value functions in the three economies. In each economy, the household's value function is defined on the state space as follows:

$$V^i(\mathcal{S}) = \frac{c(\mathcal{S})^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_{s'|s} V^i\left(b^{C'}(\mathcal{S}), b^{T'}(\mathcal{S}), s'\right), \text{ where } i = \{CE, DP, CP\} \tag{53}$$

where $\{c(\mathcal{S}),\ b^{C'}(\mathcal{S}),\ b^{T'}(\mathcal{S})\}$ denote the optimal decisions in the corresponding economy. In the CE's and the DP's problem, the state vector is $\mathcal{S} = \{b^C, b^T, s\}$. In the CP's problem, the value functions and decision rules are defined on the extended state space $\tilde{\mathcal{S}} = \{b^C, b^T, h, s\}$, where the auxiliary state h refers to the prior commitment made by the social planner in previous periods. Iteration of the value functions yields the following objects: $V^{CE}(\mathcal{S})$, $V^{DP}(\mathcal{S})$, $V^{CP}(\tilde{\mathcal{S}})$.

Since the utility is in CRRA form, we can calculate the welfare gains using the following expression:

$$\left[1+\gamma^{DP}(\mathcal{S})\right]^{1-\sigma} V^{CE}(\mathcal{S}) = V^{DP}(\mathcal{S}), \qquad \left[1+\gamma^{CP}(\mathcal{S})\right]^{1-\sigma} V^{CE}(\mathcal{S}) = \hat{V}^{CP}(\mathcal{S}), \tag{54}$$

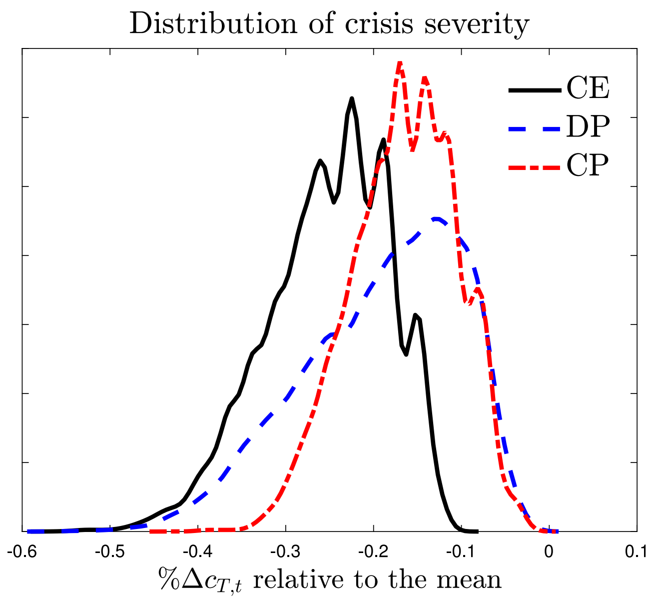

Fig. 8. Distribution of crisis severity. Note: The figure shows the distributions of tradable consumption collapse during the identified sudden stop episodes in the three economies. The crisis severity is measured as the percentage deviation of c_T at the time of a sudden stop from its long-run average.

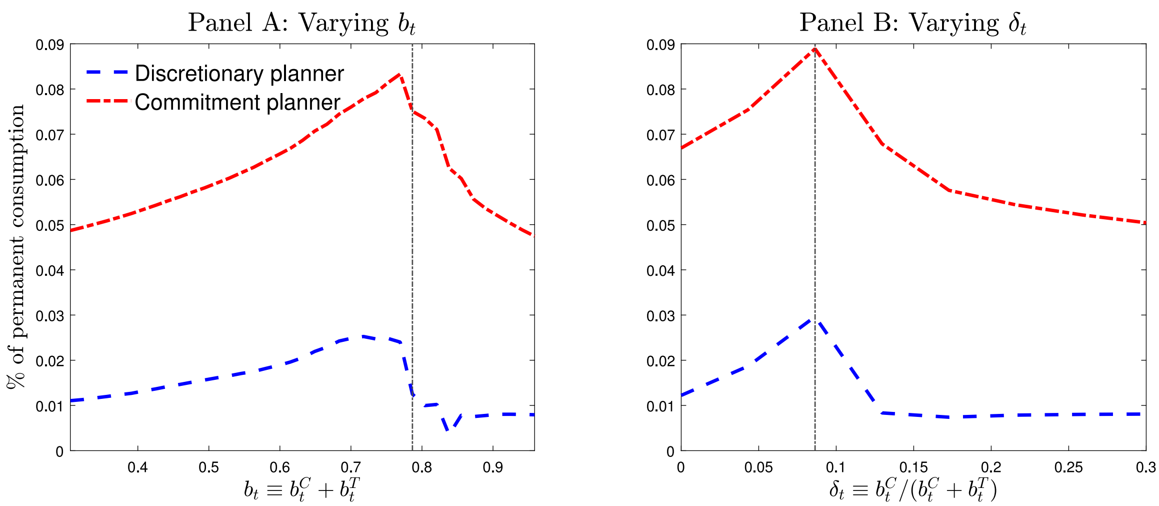

Fig. 9. State-contingent welfare gains: $\gamma^{DP}(S)$ and $\gamma^{CP}(S)$. Note: The figure shows the state-contingent welfare gains for the discretionary and commitment planners. The value represents the percentage of permanent consumption that households are willing to sacrifice to live in an economy with social planners. To compute the welfare gain by the commitment planner, we assume there is no prior commitment by setting $h_t = (\lambda_{t-1}^{CP} - \mu_{t-1}^{CP}) b_t^C \mathcal{M}(s_{t-1}, s_t) \frac{\partial p_t^C}{\partial c_{T,t}} \frac{1}{\beta}$ to zero. In the left panel, we keep the share of LCD ($\delta_t \equiv b_t^C/(b_t^C + b_t^T)$) at the CE's ergodic mean and vary the total debt level ($b_t \equiv b_t^C + b_t^T$). In the right panel, we hold the total debt level b_t at the CE's mean and vary the debt share δ_t. The tradable endowment is always set to its mean.

where $\gamma^{DP}(S)$ and $\gamma^{CP}(S)$ represent the percent of permanent consumption making the household indifferent between living in a competitive equilibrium and in the two social planners' economies. For ease of comparison, we redefine the CP's value function by removing the additional dimension in the state vector. To do so, we set the value of prior commitment to zero: $\hat{V}^{CP}(b^C, b^T, s) = V^{CP}(b^C, b^T, 0, s)$. The attenuated value function $\hat{V}^{CP}(S)$ is then defined on the original state space, which is comparable to the other two cases.[27]

[27] We also use alternative methods to calculate the state-contingent welfare gains of a commitment planner. For example, we simulate the path of the "prior commitment state" ($\{h_t\}_{t=1}^T$) under the CE and compute the CP's welfare gains based on the CE's long-run ergodic distribution over the extended state space $\{\tilde{S}_t = (b_t^C, b_t^T, h_t, s_t)\}_{t=1}^T$. We find that the welfare implication of our model does not depend on the method of calculating welfare gains.

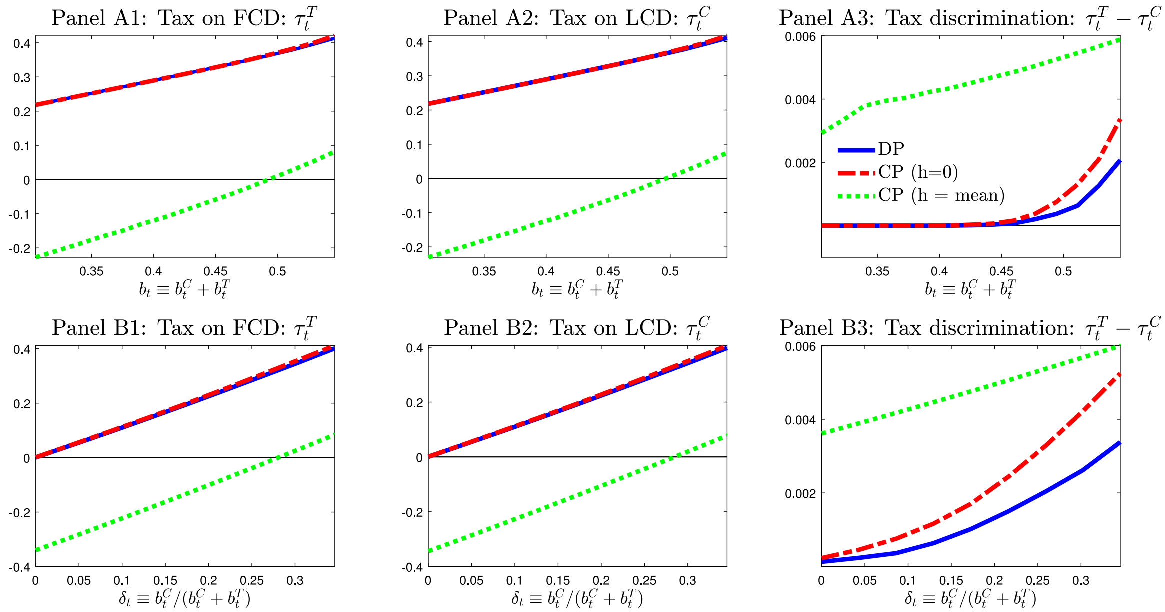

Fig. 10. Tax rate schedules to restore planners' allocations. Note: The figure shows the schedules of state-contingent capital control taxes that restore the social planners' allocations. The tradable endowment is set to its mean. Panels A1–A3 show the tax rates for different $b_t \equiv b_t^C + b_t^T$ while holding the portfolio share $\delta_t \equiv b_t^C/(b_t^C + b_t^T)$ at the CP's ergodic mean. Panels B1–B3 show the tax rates for different δ_t while keeping b_t at the CP's ergodic mean. For the commitment planner, we set the value of prior commitment h_t either to 0 or to the model's long-run simulation mean.

Fig. 9 displays the state-contingent welfare gains in the discretionary and commitment planners' economies. Both planners achieve positive welfare gains across the entire state space, and the gains are larger at the medium debt levels (or medium level of δ_t) where the collateral constraint is currently slack but the probability of hitting the constraint in the next period is relevant. In these financially fragile states, the DP's welfare gain comes from the restriction on capital inflow volumes and the associated decline in financial crisis probability. In contrast, the CP obtains the welfare benefit by managing its portfolio and denominating more debts in local currency. The LCD plays an insurance role by reducing consumption volatility and mitigating financial amplification. Making commitments also allows the economy to enjoy a lower risk premium on LCD.

Lastly, at high-b states (or high-δ) where the constraint is binding, both social planners are trapped in a financial crisis, so their welfare gains are relatively smaller. The bottom row of Table 2 shows that in the long run, the DP and CP obtain the average welfare gains of 0.019% and 0.071% in terms of permanent consumption equivalence, respectively.

4.5. Capital controls taxes

Fig. 10 shows the functions of tax policies that restore the social planners' allocations. For the commitment planner's case, we set the level of prior commitment either to 0 or to its long-run simulation mean. The figure only reports tax rates in states where the financial constraint does not bind. Overall, the DP tends to impose positive capital control taxes on local and foreign currency borrowings across the entire state space, and the difference between the two tax rates is relatively small (right panels). On average, the tax rate on FCD is higher than the tax rate on LCD by 0.32%.

The commitment planner's tax schedule is more complicated. First, the optimal financial regulation highly depends on the level of prior commitment. For any nonzero value of h_t, the CP tends to choose a lower tax rate than the DP at the same economic state. Second, in certain low-b or low-δ states, the CP levies a negative tax to encourage borrowings. In states with low financial risk, the probability of hitting the financial constraint in the next period is minimal. Also, when δ_t is low, the fluctuation of tradable consumption has a minor effect on the overall debt burden. As a result, the planner's incentive to constrain borrowing or to deflate the debt is dominated by her willingness to increase consumption and preserve a better bond price. More importantly, to encourage local currency borrowings, the CP sets nonuniform taxes based on the currency denomination of capital inflows. In our simulations, the average tax on the FCD borrowings is 0.5% higher than the average tax on the LCD. As seen from panels A3 and B3, the tax discrimination is stronger when the economy is more indebted or the level of prior commitment is higher.

Fig. 11 shows the ergodic distributions of capital control taxes. The bottom panel of Table 2 reports the moments on tax rates.[28] Both social planners tend to impose positive capital control taxes on international borrowings, and the tax discrimination is stronger

[28] Figure G.2 in online appendix G shows the scatter plots of capital control taxes against tradable outputs. We find that the cyclicality of capital control tax and tax discrimination is quite different in the two social planning problems.

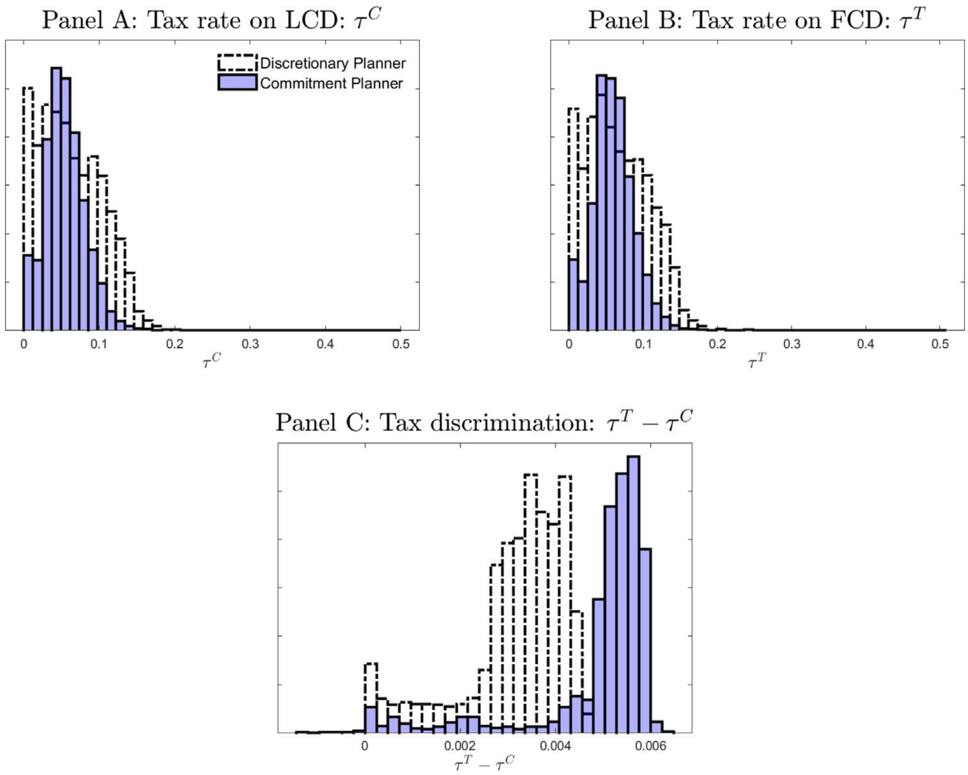

Fig. 11. Distributions of capital control taxes across simulations. Note: The figure shows the histograms of capital control taxes in the models' long-run simulations. We only include the periods when the financial constraint does not bind. Panels A and B show the distributions of tax rates on FCD and LCD, respectively. Panel C displays the tax discrimination that is defined as their difference. A positive number indicates that the planner tends to restrict foreign currency borrowings more heavily than local currency borrowings.

in the CP than in the DP. The discrimination of this size is large enough to incentivize agents in the CP's economy to issue a significantly greater amount of LCD. Table 2 also shows that the average taxes and tax discrimination negatively correlate with the tradable income.

It is worth to mention that the commitment planner never implements a negative tax rate along the equilibrium paths. In this environment, the use of capital control tax is governed by two forces. On the one hand, the CP has incentives to use negative taxes to induce borrowings and tilt up consumption to improve the previous-period bond price. Such an incentive is captured by the region of negative tax policies in Fig. 10. On the other hand, the planner also has an incentive to use positive tax rates to discourage borrowing and reduce the probability of crises. Our simulation result indicates that the second incentive dominates, so the negative tax rates never materialize along the equilibrium path.

5. Discussion: Financial integration vs. Financial regulation

As emerging countries are gradually integrated into the global financial market, they are equipped with a greater ability to issue LCD. This section compares our baseline model with the traditional sudden-stop models with only FCD. We consider the welfare benefits of introducing LCD into a sudden stop economy and its implications for designing macroprudential policies. Table 3 shows the long-run simulation moments, including the results of Bianchi (2011)'s constrained-efficient outcome.

First, introducing LCD delivers a sizeable welfare improvement (0.065% of permanent consumption) even without any capital control policies. The magnitude of this gain is comparable to the one achieved by enforcing financial regulations in the FCD-only economy (0.055%). Compared to the FCD-only environment (CE), the ability to issue LCD reduces the consumption volatility and fluctuation of debt burden. It also reduces the average severity of financial crises (−25.2% vs. −28.3%). The introduction of LCD also changes the design of capital control regulations. As financial markets become more integrated, policymakers should pay special attention to the capital flows' currency denominations when designing capital control policies. Using two state-contingent tax rates, the policymaker under commitment can further reduce the crisis probability (2.8% vs. 5.6%) and lessen the crisis severity (−16.5% vs. −28.3%) while sustaining a relatively high level of debt (33.6% vs. 32.6%). Ultimately, the commitment planner achieves the highest welfare across different economies.

Fig. 12 shows the distributions of crisis severity. We first extract the tradable endowment shocks from the simulation of the baseline CE. The shocks are then fed into alternative models, and we calculate the degree of consumption collapse during sudden

Table 3
A comparison of simulation results with Bianchi (2011).

	FCD Only CE	FCD Only SP	Decentralized equilibrium (FCD + LCD)	Discretionary planner (FCD + LCD)	Commitment planner (FCD + LCD)
Avg. debt burden/y	32.6%	31.6%	33.2%	31.6%	33.6%
Std(c_T)/Std(y_T)	1.24	1.15	1.17	1.12	1.03
Std(ca)/Std(y_T)	0.53	0.35	0.53	0.31	0.41
Avg. $\sigma_t(p^C_{t+1})$	20.5	18.0	19.2	16.6	14.3
Corr(c_T, y_T)	0.91	0.96	0.92	0.97	0.97
Corr(ca, y_T)	−0.23	−0.29	−0.24	−0.32	−0.36
Std(debt burden/y_T)	6.4%	5.8%	5.6%	5.5%	4.4%
Corr(debt burden, y_T)	0.70	0.72	0.77	0.75	0.85
Prob. of crises	5.6%	2.2%	5.5%	1.4%	2.8%
Sev. of crises (%Δc_T)	−28.3%	−21.1%	−25.2%	−19.0%	−16.5%
Avg. tax rate	–	5.71%	–	6.35%	5.68%
Corr(tax rate, y_T)	–	−0.82	–	−0.79	−0.57
Avg. wel. gains rel. to - FCD only (CE)	–	0.055%	0.065%	0.073%	0.133%

Note: We use the same parameters as in our baseline model to simulate the FCD-only economies. The welfare gains are the percentage of permanent consumption that the households living in the FCD-only economy (CE) would like to pay to move to an alternative environment. The average tax rates under "Discretionary Planner" and "Commitment Planner" are $(\tau^{T,DP} + \tau^{C,DP})/2$ and $(\tau^{T,CP} + \tau^{C,CP})/2$, respectively. See the notes under Table 2 for details.

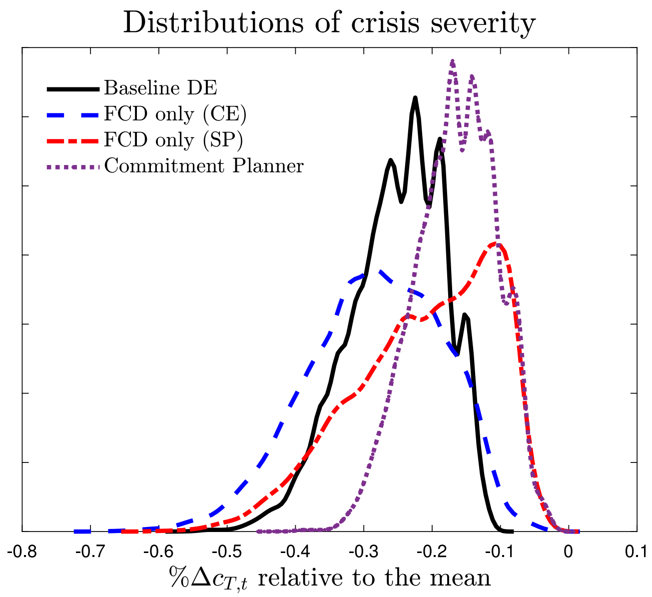

Fig. 12. Distribution of crisis severity: Models w/ and w/o LCD. Note: The figure shows the distributions of crisis severity measured as the percentage of consumption collapse in a sudden stop period from its long-run mean. To construct this figure, we extract shocks from the simulation of the baseline DE and feed them into other economies starting from the DE's initial debt states before the crises. We then take the average across all event windows.

stop crises. We notice that in the model without LCD, the distribution of crisis severity is very dispersed with a fat left tail. Things are different in the social planner's economy with only FCD. In this environment, the policymaker imposes a tough restriction on international borrowings so that it can reduce the crisis severity by a significant amount.

Meanwhile, due to the insurance provided by LCD, our baseline model features a less dispersed crisis severity distribution than the FCD-only economy (CE). Even though the commitment planner borrows a higher amount of debt relative to the baseline, the improvement in capital structure further alleviates the sudden stop crises. In the end, the economy under the CP has the most concentrated distribution of crisis severity in Fig. 12.

Fig. 13 displays the sudden stop event windows in the four economies. Without LCD, an FCD-only economy (CE) is subject to a larger collapse in consumption and a greater trade balance reversal relative to our baseline model. The CP, on the other hand, enjoys the smallest consumption drop during a sudden stop due to the large share of LCD. Panel C in Fig. 13 shows the paths of total borrowings. We notice that the financial regulation in an FCD-only model implies the restriction on credit volumes, resulting in a smaller amount of borrowings in the social planner's economy. On the contrary, in the model with LCD, the CP borrows a similar level of debt as the decentralized market in periods before the financial crises.

The bottom panels of Fig. 13 show the average capital control taxes and welfare improvement relative to an FCD-only economy (CE) around sudden stop periods. The commitment planner's allocation entails the mildest capital control relative to alternative

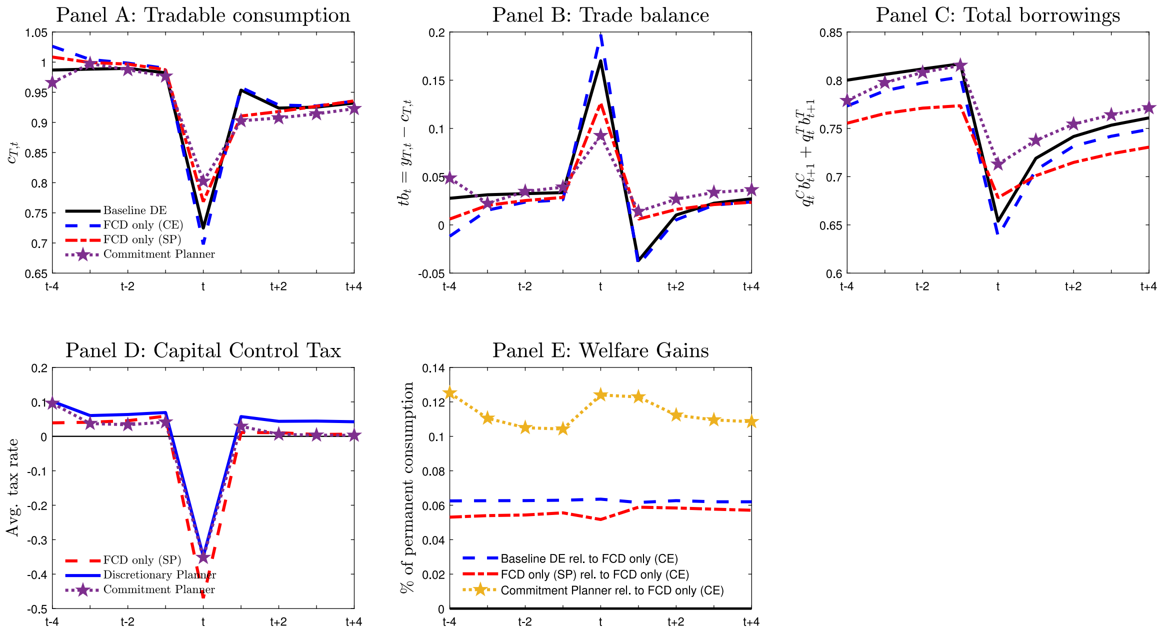

Fig. 13. Event window: Models w/ and w/o LCD. Note: The figure shows the dynamics of endogenous variables and welfare gains around sudden stop episodes. To construct this figure, we extract shocks from the simulation of the baseline DE and feed them into other economies starting from the DE's initial debt states before the crises. We then take the average across all event windows. The welfare gain is measured as the percentage of permanent consumption that households living in an FCD-only economy (CE) would like to sacrifice to move to an alternative environment.

policy environments. The magnitude of welfare gain from introducing LCD is comparable to the one achieved by capital control regulation in an FCD-only model.

It is widely accepted in the literature that prudential regulations are intended to target the crisis episode to limit consumption collapse during a financial crisis. However, the exercise here highlights the welfare benefit of introducing LCD, which is due to the progress of financial integration. This paper sheds a new perspective on the design of capital control policies as emerging economies have been gradually integrated into the global financial market over the past decades. A key takeaway from Table 3 and Figs. 12–13 is that although these two objectives change the financial market in different directions, their welfare benefits have some overlap. For example, the use of LCD can mitigate the crisis severity when a sudden stop hits, similar to Bianchi (2011)'s social planner economy. Meanwhile, the capital control in an FCD-only economy delivers a similar welfare benefit to the one achieved by introducing LCD into a sudden stop model (0.065% vs. 0.055%). This provides a testament that financial integration could be a partial substitute for financial regulation in a dollar-debt economy.

6. Conclusion

Given that the composition of capital inflows to emerging economies has changed over the past two decades, this paper introduced the debt denomination choice into a sudden stop model and investigated its implication on capital control policies. Compared to a dollar-debt economy, the presence of LCD offers risk-sharing opportunities for small open economies, even though the exchange rate risk underlying LCD entails a risk premium. It allows a country to smooth consumption, mitigates crisis severity, and delivers a welfare gain similar to the one achieved by the macroprudential policy in an FCD-only economy. In addition, the introduction of LCD adds new policy implications from pecuniary externalities and a time-inconsistency issue, thus calling for a renewed perspective on financial regulations.

Without the commitment, the Markov planner has an incentive to dilute the payoff of LCD through a real exchange rate depreciation. Such an incentive worsens the ex ante bond price and makes the issuance of LCD undesirable. In contrast, a social planner under commitment can discipline the debt-reduction motive by promising a state-contingent consumption profile in the future. The planner tends to tilt up consumption in good states of nature in order to earn a better bond price of LCD. The improvement in bond price reduces the LCD issuance cost, creates a better debt structure, and delivers a larger welfare gain than the discretionary optimal policy.

One of the key policy implications from our analysis is to use capital controls to change the composition of credit flows, in addition to restricting their aggregate volumes. Ideally, the optimal policy should result in a higher share of LCD and improve the financial stability of the indebted economies. However, such a policy goal can only be achieved with policy commitment.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jinteco.2024.103888.

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