Sudden Stops, Inequality, and Macroprudential Policy

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Abstract

We study how inequality shapes the welfare costs of sudden stops and the design of macroprudential policy. In a small open economy with heterogeneous households and nonhomothetic preferences, borrowing by high-income households generates both a Fisherian debt-deflation externality and a distributional externality through the real exchange rate. Credit expansions appreciate the real exchange rate and benefit low-income hand-to-mouth households, while servicing the resulting debt lowers future tradable consumption and reverses part of this redistribution. Because low-income households devote a larger share of expenditure to tradables, crisis depreciations impose disproportionately larger losses in purchasing power. Quantitatively, a planner who internalizes these externalities reduces leverage and crisis severity, but welfare gains remain modest because the contemporaneous distributional benefits of credit expansions partly offset the future Fisherian and distributional costs of borrowing. Optimal macroprudential policy reflects this trade-off, featuring borrowing subsidies at low debt levels and borrowing taxes when leverage is high.

Keywords: Inequality; Macroprudential policy; Nonhomothetic preference; Sudden Stops
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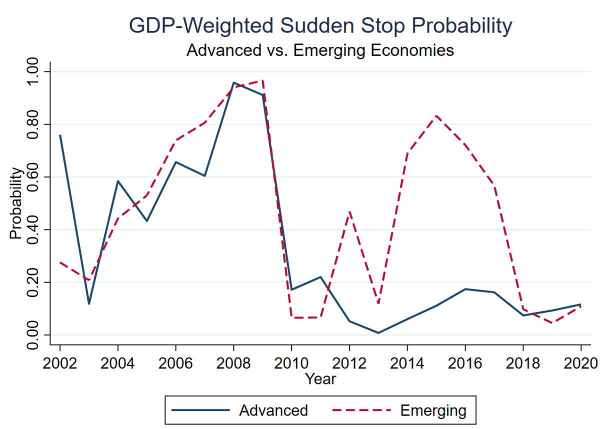
Introduction

Emerging market economies are frequently exposed to sudden stop crises, characterized by abrupt reversals in capital inflows, sharp exchange rate depreciations, and deep contractions in domestic consumption. At the same time, these economies exhibit persistently high levels of income inequality and a large share of households with limited access to financial markets. Despite the prevalence of high inequality among emerging markets, the role of inequality in shaping the dynamics and welfare costs of external financial crises remains relatively underexplored.

Figure 1 illustrates this motivation. Panel (a) shows that the frequency of sudden stops is broadly similar across advanced and emerging economies. Panel (b), however, shows that emerging markets are substantially more unequal, as measured by the income share of the bottom 50 percent.

(a) Sudden Stop Frequency



(b) Inequality

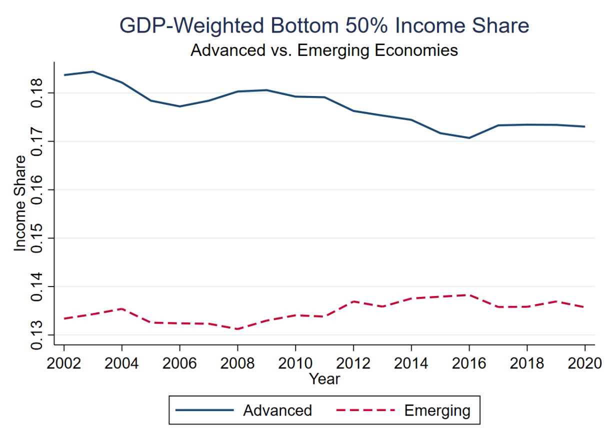


Figure 1: Sudden Stops and Inequality Over Time

Note: Figure 1 plots the GDP-weighted average sudden stop probability and bottom 50 percent income share for advanced economies and emerging markets. Data on sudden stop probabilities are from Forbes and Warnock (2012), while income-share data are from the World Inequality Database.

Motivated by these observations, this paper asks: How does inequality shape the dynamics and welfare costs of sudden stop crises?, and how should macroprudential policy account for income distribution? To answer these questions, we develop a heterogeneous-agent small open economy model with nonhomothetic preferences embedded in a standard sudden-stop framework. The economy consists of high-income borrowing households, who have access to international financial markets subject to occasionally binding collateral constraints, and low-income hand-to-mouth households, who do not participate in financial markets. Nonhomothetic preferences imply that low-income households allocate a larger share of expenditure to tradable goods. We study both the decentralized equilibrium and a constrained-efficient allocation in which a benevolent social planner internalizes the aggregate and distributional consequences of borrowing decisions.

The model features two externalities operating through the real exchange rate. The first is the standard Fisherian debt-deflation externality emphasized in the sudden-stop literature. Private borrowers do not internalize how higher borrowing today leads to future exchange rate depreciations that tighten collateral constraints and amplify crises. The second is a distributional externality. Borrowing by high-income households affects both current and future real exchange rates and changes the purchasing power of hand-to-mouth households. Credit expansions appreciate the real exchange rate and, in our calibrated economy, redistribute purchasing power toward these households. The resulting debt must subsequently be serviced through lower future tradable consumption, which puts downward pressure on the real exchange rate and reverses part of this favorable redistribution. During sudden stops, deleveraging amplifies the associated depreciation. Because low-income households devote a larger share of expenditure to tradables, crisis depreciations impose disproportionately larger losses in purchasing power. Private borrowers do not internalize either the contemporaneous distributional benefit of credit expansion or the future distributional cost associated with servicing the resulting debt when choosing their debt positions.

This mechanism creates a tension between macroprudential stabilization and distributional objectives. Restricting borrowing reduces leverage and mitigates crisis amplification, but it also limits credit expansions that, through real exchange rate appreciation, disproportionately benefit low-income households. At the same time, higher borrowing creates a future distributional cost because servicing the additional debt reduces future tradable consumption and reverses part of the favorable redistribution generated by the initial credit expansion. Moreover, because hand-to-mouth households do not deleverage, their adjustment during crises occurs primarily through intratemporal substitution. They reduce tradable consumption and shift toward relatively cheaper non-tradables. With homothetic preferences, this substitution limits the distributional cost of sudden stops, substantially weakening the planner's incentive to restrain borrowing and, in some cases, overturning the standard macroprudential result. Nonhomotheticity magnifies both sides of the distributional trade-off by making low-income households more exposed to real exchange rate movements. It increases the contemporaneous distributional benefit of appreciations during credit expansions, but also increases the future distributional cost of the depreciations associated with debt repayment and sudden stops. Quantitatively, the latter becomes particularly important in crisis states and partially restores the planner's incentive to reduce financial vulnerability.

The quantitative results reflect this trade-off. Although constrained efficiency reduces leverage and mitigates sudden-stop dynamics in the baseline economy, the correction is modest relative to the standard representative-agent benchmark. The planner internalizes the Fisherian costs of borrowing and the future distributional costs of servicing debt, but also values the contemporaneous distributional benefits of credit expansions. In the baseline, the latter remains sufficiently important to dampen the conventional macroprudential motive. Accordingly, aggregate welfare gains from constrained efficiency are small and unevenly distributed across households. High-income borrowers benefit from lower Fisherian amplification and improved consumption smoothing, while the gains to hand-to-mouth households from less frequent and milder crises are partly offset by the foregone benefits of real appreciation during normal credit expansions.

Comparisons across model specifications clarify the distinct roles of heterogeneity and nonhomotheticity. Introducing hand-to-mouth households into the standard representative-agent homothetic model strongly weakens the planner's incentive to prevent crises. Hand-to-mouth households benefit from credit expansions but are not directly exposed to deleveraging and can adjust to crisis depreciations through intratemporal substitution. As a result, the contemporaneous distributional benefit of credit expansion is large relative to its future distributional cost and substantially offsets the Fisherian motive for restricting borrowing. In contrast, introducing nonhomothetic preferences amplifies real exchange rate depreciation and the associated consumption contraction, consistent with Rojas and Saffie (2022). In the heterogeneous economy, nonhomotheticity has an additional distributional effect because low-income households devote a larger expenditure share to tradables. It magnifies both the contemporaneous distributional benefit of credit-induced appreciations and the future distributional cost of debt-induced depreciations. The latter becomes particularly important during crises, strengthening the macroprudential motive relative to the heterogeneous-homothetic economy.

These forces have important implications for the design of optimal macroprudential policy. Relative to the standard representative-agent model, household heterogeneity shifts policy toward a more accommodative stance because the planner internalizes the distributional gains generated by credit expansions. At the same time, the planner internalizes that the resulting debt must subsequently be serviced through lower future tradable consumption, which creates a future distributional cost in addition to the Fisherian externality. Nonhomotheticity magnifies both the contemporaneous and future distributional effects while also increasing financial amplification. In the baseline, optimal policy therefore features borrowing subsidies at low debt levels but turns into a tax as leverage and crisis risk increase. At low leverage, the contemporaneous distributional benefit of credit expansion is relatively important. As leverage rises, the future Fisherian and distributional costs become increasingly important. Around sudden stops, policy tightens in the run-up to the crisis but becomes accommodative afterward, when leverage is low and renewed credit expansion again benefits hand-to-mouth households through real appreciation.

Our comparative statics further show that income inequality, household composition, and nonhomotheticity operate through distinct channels. A larger income share accruing to high-income borrowers raises debt and the incidence of sudden stops by concentrating resources among households with access to international credit. A larger share of hand-to-mouth households has little effect on aggregate crisis dynamics but strengthens the distributional motive in the planner's problem, lowering the optimal borrowing tax and shifting welfare gains toward low-income households. Changes in nonhomotheticity likewise have limited effects on average debt and crisis frequency, but materially affect welfare and optimal policy. Stronger nonhomotheticity increases the distributional consequences of real exchange rate movements, shifting welfare gains toward high-income borrowers and generating a nonmonotonic response of the optimal borrowing tax as the planner balances the larger contemporaneous distributional benefits of credit expansions against the larger future distributional costs of debt repayment and crisis depreciations. Across these exercises, aggregate welfare gains remain quantitatively small despite substantial changes in their incidence across households.

This paper makes three main contributions. First, we introduce household heterogeneity and nonhomothetic preferences into a standard sudden-stop framework and show that the distributional incidence of real exchange rate movements changes both crisis dynamics and the welfare consequences of macroprudential intervention. Second, we show a new distributional externality operating through the real exchange rate. Credit expansions generate a contemporaneous distributional benefit through real appreciation, while servicing the resulting debt reduces future tradable consumption and can reverse this redistribution. During sudden stops, deleveraging amplifies the associated depreciation and its distributional consequences. This intertemporal distributional externality creates a novel interaction between distributional considerations and Fisherian amplification. Third, we characterize optimal macroprudential policy in this environment and show that the optimal tax can be decomposed into a conventional Fisherian component, a future distributional cost, and a contemporaneous distributional benefit. The contemporaneous benefit dampens the conventional incentive to restrict borrowing, while the future distributional cost strengthens it. Nonhomotheticity magnifies both distributional forces and increases crisis amplification, which changes their relative importance across states. The resulting policy differs from the standard representative-agent prescription and highlights the importance of household-level exposure to real exchange rate movements for the regulation of capital flows in emerging economies.

Related Literature. This paper contributes to the sudden stop literature starting with Mendoza (2002) and Bianchi (2011). Relative to this framework, we introduce household heterogeneity and nonhomothetic preferences. Our model highlights the interaction between private external borrowing, financial crises, and redistributive considerations in the design of macroprudential policy. A growing literature studies the distributional consequences of sudden stop crises, including Villalvazo (2021), Hong (2020), Biljanovska and Vardoulakis (2024), and Guntin et al. (2023). Our contribution is to provide a framework in which movements in the real exchange rate differentially affect households across the income distribution and to study how distributional considerations alter optimal macroprudential policy. We depart from Arce and Tran-Xuan (2022), who assume that all agents have access to international borrowing, to highlight how the borrowing decisions of wealthy households affect poorer households that are permanently credit constrained. Consistent with the presence of offsetting distributional trade-offs, we find that optimal macroprudential policy is quantitatively more muted than in representative-agent environments emphasized in the existing literature.

This paper is also related to the literature on inequality over the business cycle, including Broer (2020), Kumhof et al. (n.d.), Primiceri and Van Rens (2009), and Storesletten et al. (2007). In contrast to this literature, which largely focuses on advanced economies and standard business cycle fluctuations, we study emerging market economies and emphasize the role of sudden stop crises as a key source of macroeconomic risk and distributional dynamics.

Finally, by studying the macroeconomic implications of nonhomothetic preferences, this paper relates to Boppart (2014), Rojas and Saffie (2022), and Comin et al. (2021). As in Rojas and Saffie (2022), we show that nonhomothetic preferences amplify the severity of sudden stop crises. Our additional contribution is to show that nonhomotheticity also shapes the sectoral reallocation of consumption over booms and crises and, through this channel, the distributional effects of real exchange rate movements and macroprudential policy.

Outline. The paper is organized as follows. Section 1 describes the model of sudden stop and inequality and define the decentralized equilibrium and the social planner problem. Section 3 presents the quantatitative analysis. Section **??** examines the optimal macroprudential policy. Section 5 then concludes.

1 Model of Sudden Stops and Inequality

This section presents a heterogeneous-agent dynamic model of a small open economy with non-state contingent bonds subject to an occasionally binding credit constraint. We define and characterize the decentralized equilibrium. We then present the constrained efficient allocation that solves a social planner's problem in which the planner directly chooses the debt level subject to the credit constraint.

1.1 Environment

Time is discrete and indexed by $t = 0, 1, \ldots, \infty$. There are tradable and nontradable goods sectors. Only tradable goods can be traded internationally, and nontradable goods have to be consumed in the domestic economy. The economy is populated by two types of households $i = \{L, H\}$: hand-to mouth ($i = L$) households and borrowing households ($i = H$), with population shares π and $1 - \pi$, respectively.

The two household types differ along two dimensions: their shares of aggregate income and their access to international credit markets. Borrowing households receive a larger share of endowments and have access to international financial markets, whereas hand-to-mouth households receive a smaller endowment share and are financially excluded from international credit markets. This assumption is motivated by the prevalence of financial exclusion in emerging market economies, where a substantial fraction of households lack access to formal borrowing instruments and financial institutions, as reported in Demirguc-Kunt and Klapper (2012).

Endowment. In each period t, household i receives a fraction s^i of endowment of tradable goods Y_t^T and nontradable goods Y_t^N, where $\pi s^L + (1-\pi)s^H = 1$ and $s^H > s^L$, that is the borrowing household is the richer household than the hand-to-mouth household. Both endowments are drawn from first-order Markov processes independent of each other and of all other stochastic shocks in the model. We assume that numeraire is the tradable good.

Assets. Borrowing households have access to one-period, non-state contingent international bonds denominated in units of tradables. The bond is issued in international competitive credit markets at price Q. We assume that the discount factor and the international bond price are such that $\beta/Q < 1$. In each period t, borrowing households face a collaterial credit constraint such that the market value of debt issuances Qb^H_{t+1} cannot exceed a fraction κ of the market value of current income.

In contrast, hand-to-mouth households lack access to international credit markets.

Allocation. Individual household i's allocation on consumption and borrowing is $c^{T,i}_t, c^{N,i}_t, c^i_t, b^i_{t+1}$. The aggregate allocation is denoted in the uppercase: $X = \pi x^L + (1-\pi)x^H$

Preference. Each household maximizes a nested CES utility function similar to Comin et al. (2021), that is,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}, \quad \sigma > 0, \tag{1}$$

where $\mathbb{E}_t(\cdot)$ is the time-t expectation operator, and $0 < \beta < 1$ is the discount factor. The composite consumption $c_t = c(c^T_t, c^N_t)$ is defined by the implicit function

$$\left[\omega \left(c^T_t\right)^{-\eta} (c_t)^{\epsilon_T(1+\eta)-1} + (1-\omega)\left(c^N_t\right)^{-\eta} (c_t)^{\epsilon_N(1+\eta)-1}\right]^{-\frac{1}{\eta}} = 1, \quad \eta > -1,\ \omega \in (0,1),$$

where ω is a weight parameter, $1/(1+\eta)$ is the elasticity of substitution between c^T_t and c^N_t, and ϵ_j is the nonhomotheticity parameter that affects the income elasticity of good $j \in \{T, N\}$, which is $\nu_j = 1/(1+\eta) + \frac{\eta}{1+\eta}\frac{\epsilon_j}{\omega\epsilon_T + (1-\omega)\epsilon_N}$. We assume that $\epsilon_j > \frac{1}{1+\eta}$, for $j \in \{T, N\}$, such that the utility is strictly increasing in both tradable and nontradable consumption. c_t becomes a homothetic CES aggregator with elasticity of substitution $1/(\eta+1)$ between c^T_t and c^N_t when $\epsilon_T = \epsilon_N = 1$.

1.2 Decentralized equilibrium

Borrowing households Given the price of bond q and the of nontradable goods in units of tradables P^N_t, borrowing households $i = H$ choose allocation $\left\{c^{T,H}_t, c^{N,H}_t, b^H_{t+1}\right\}_{t\geq 0}$

that maximizes utility (1) subject to the budget constraint

$$c_t^{T,H} + P_t^N c_t^{N,H} + b_t^H = s^H \left(P_t^N Y_t^N + Y_t^T \right) + Q b_{t+1}^H, \tag{2}$$

and the credit constraint

$$Q b_{t+1}^H \leq \kappa s^H \left(Y_t^T + P_t^N Y^N \right). \tag{3}$$

This credit constraint can be seen as an implication of incentive-compatibility constraints on borrowers if limited enforcement prevents lenders from collecting more than a fraction κ of the value of current endowment owned by defaulting households.

Hand-to-mouth households Hand-to-mouth households ($i = L$) choose consumption $\left\{ c_t^{T,H}, c_t^{N,H} \right\}_{t \geq 0}$ that maximizes utility (1) subject to the budget constraint

$$c_t^{T,L} + P_t^N c_t^{N,L} = s^L \left(P_t^N Y_t^N + Y_t^T \right). \tag{4}$$

Resource constraints The resource constraints in the tradable and nontradable goods sectors are

$$C_t^T + B_t = Y_t^T + Q B_{t+1} \tag{5}$$

$$C_t^N = Y_t^N, \tag{6}$$

where C_t^T, C_t^N, B_t are the aggregate tradable consumption, nontradable consumption, and borrowings.

Recursive formulation We consider the optimization problem of borrowing households in the recursive form. Borrowing households make decisions on current consumption and next-period debt based on the current individual debt b and the current exogenous shock on tradables Y^T. The optimization problem of borrowing households can be written as

$$V^H(b, Y^T) = \max_{c^T, c^N, b'} \quad \frac{c\left(c^T, c^N\right)^{1-\sigma}}{1-\sigma} + \beta \mathbb{E} V^H(b', Y^{T'})$$

subject to

$$c^T + P^N c^N + b = s^H \left(Y^T + P^N Y^N \right) + Q b'$$

$$Q b' \leq \kappa s^H \left(Y^T + P^N Y^N \right).$$

The solution to the household problem gives the individual allocation rule $\left\{c^{T,H}(\cdot), c^{N,H}(\cdot), b'(\cdot)\right\}$.

Hand-to-mouth households do not have access to international borrowing, and therefore their consumption choices depend on the current exogenous tradable endowment Y^T and equilibrium prices. Their recursive problem is

$$V^L(Y^T) = \max_{c^T, c^N} \quad \frac{c\left(c^T, c^N\right)^{1-\sigma}}{1-\sigma} + \beta \mathbb{E} V^L(Y^{T'})$$

subject to

$$c^T + P^N c^N = s^L \left(Y^T + P^N Y^N\right).$$

Since hand-to-mouth households cannot transfer resources across periods, their continuation value does not affect their current consumption choices. The solution to their problem gives the individual allocation rule $c^{T,L}(\cdot), c^{N,L}(\cdot)$.

We have the following definition for a recursive competitive equilibrium.

Definition 1.1. A *recursive competitive equilibrium* is an individual allocation rule $\left\{c^{T,i}, c^{N,i}, b'\right\}$, value function $V^H(b, Y^T)$, aggregate allocation rule $\left\{C^T, C^N, B'\right\}$, a pricing function P^N such that

- Household optimization: given P^N, $\left\{c^{T,H}, c^{N,H}, b'\right\}$ solves borrowing households' problem and V^H is the associated value function. Also, $\left\{c^{T,L}, c^{N,L}\right\}$ solves the hand-to-mouth households' problem, and V^L is the associated value function.
- Aggregation: $C^T = \pi c^{T,L} + (1-\pi)c^{T,H}$, $C^N = \pi c^{N,L} + (1-\pi)c^{N,H}$, and $B' = (1-\pi)b'$
- Market clearance: equations (5)-(6) hold

1.3 Equilibrium real exchange rate

In equilibrium, the intratemporal optimality condition implies that

$$P^N = \frac{1-\omega}{\omega}\left(\frac{c^{T,i}}{c^{N,i}}\right)^{1+\eta} (c^i)^{(\epsilon_N - \epsilon_T)(1+\eta)}, \ \forall i = \{H, L\} \tag{7}$$

Equation (7) states the static optimality condition equating the relative price of nontradables to tradables with the marginal rate of substitution for each household. This implies an equal marginal rate of substitution across households. Under nonhomothetic preferences, the price of nontradables further depends on composite consumption c^i.

We normalize $Y_t^N = 1, \forall t$. The price of nontradables relates to the composite consumption levels across households by the following implicit equation.

$$P^N = (1-\omega)\left\{\pi(E^L)^{\frac{1}{1+\eta}}(c^L)^{\epsilon_N-\frac{1}{1+\eta}} + (1-\pi)(E^H)^{\frac{1}{1+\eta}}(c^H)^{\epsilon_N-\frac{1}{1+\eta}}\right\}^{1+\eta}, \tag{8}$$

where $E^i = c^{T,i} + P^N c^{N,i}$ is the consumption expenditure of household $i = \{H, L\}$.

Equation (8) shows that, due to nonhomothetic preferences, higher-income borrowing households disproportionately shape the relative price of nontradables. Their greater demand for nontradables, reflected in higher consumption expenditure E^H, gives them more weight in determining the price. This implies an unequal influence across households in the equilibrium price of nontradables.

When preferences are homothetic ($\epsilon_T = \epsilon_N = 1$), the price of nontradables becomes

$$P^N = \frac{1-\omega}{\omega}\left(\frac{c^{T,i}}{c^{N,i}}\right)^{1+\eta}, \ \forall i = \{H, L\} \tag{9}$$

and in terms of expenditures and composite consumptions

$$P^N = (1-\omega)\omega^{\frac{1}{\eta}}\left[\left(\pi c^L + (1-\pi)c^H\right)^{-\eta} - (1-\omega)\right]^{-\frac{1+\eta}{\eta}} \tag{10}$$

In contrast, with homothetic preferences, equation (9) shows that the relative price of nontradables is independent of composite consumption, and equation (10) implies no unequal demand effect across households.

1.4 Constrained efficiency

We now formulate the problem of an utilitarian social planner that puts equal weights on households' utilities. The social planner can directly choose the level of borrowing subject to the credit constraints, but allows goods markets to clear competitively. In contrast to the competitive equilibrium households that take prices as given, the social planner internalizes the effect of the borrowing decision on the price of nontradables.

The optimization problem of the social planner is choosing individual allocation to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{\pi \frac{(c_t^L)^{1-\sigma}}{1-\sigma} + (1-\pi)\frac{(c_t^H)^{1-\sigma}}{1-\sigma}\right\}, \tag{11}$$

subject to the households' budget constraints (2) and (4), the credit constraint (3), resource constraints (5)–(6), and the equilibrium price condition (7). We then define this problem in the recursive form as

Recursive social planner's problem

$$
\begin{aligned}
V^{SP}(b,Y^T) = \max_{\{c^{T,i},c^{N,i}\}_{i=\{H,L\}},b'} \quad & \pi\frac{c\left(c^{T,L},c^{N,L}\right)^{1-\sigma}}{1-\sigma} + (1-\pi)\frac{c\left(c^{T,H},c^{N,H}\right)^{1-\sigma}}{1-\sigma} + \beta\mathbb{E}V^{SP}(b',Y^{T'}) \\
\text{subject to} \quad & \\
c^{T,H} + P^N c^{N,H} + b &= s^H\left(Y^T + P^N Y^N\right) + Qb' \\
Qb' &\leq \kappa s^H\left(Y^T + P^N Y^N\right) \\
c^{T,L} + P^N c^{N,L} &= s^L\left(Y^T + P^N Y^N\right) \\
P^N &= \frac{1-\omega}{\omega}\left(\frac{c^{T,i}}{c^{N,i}}\right)^{1+\eta}(c^i)^{(\epsilon_N-\epsilon_T)(1+\eta)}, \quad \forall i = \{H,L\} \\
\pi c^{T,L} + (1-\pi)c^{T,H} + (1-\pi)b &= Y^T + Q(1-\pi)b' \\
\pi c^{N,L} + (1-\pi)c^{N,H} &= Y^N
\end{aligned}
\tag{12}
$$

Definition 1.2. A *recursive constrained efficiency* is the allocation rule $\left\{c_{SP}^{T,i}(Y^T), c_{SP}^{N,i}(Y^T)\right\}_{i=\{H,L\}}, b'_{SP}(Y^T)$ and the value function $V^{SP}(b,Y^T)$ that solve (12).

1.5 Optimal macroprudential policy

We characterize the optimal macroprudential policy that decentralizes the constrained-efficient allocation. An important feature is that the planner faces the same household budget constraints as in the decentralized equilibrium and cannot make direct transfers across household types. Redistribution occurs indirectly through borrowing choices and their effects on equilibrium prices. Therefore, the constrained-efficient allocation can be decentralized with a tax or subsidy on borrowing by high-income households, with the proceeds rebated lump-sum to these households so that the policy does not directly transfer resources across types.

In particular, the recursive problem of a high-income borrowing household under the decentralized equilibrium with taxes is

$$
\begin{aligned}
V^H(b,Y^T) = \max_{c^T,c^N,b'} \quad & \frac{c\left(c^T,c^N\right)^{1-\sigma}}{1-\sigma} + \beta\mathbb{E}V^H(b',Y^{T'}) \\
\text{subject to} \quad & \\
& c^T + P^N c^N + (1+\tau)b = s^H\left(Y^T + P^N Y^N\right) + Qb' + T \\
& Qb' \leq \kappa s^H\left(Y^T + P^N Y^N\right),
\end{aligned}
$$

where τ denotes the predetermined tax on the repayment of current debt b, and T is a lump-sum rebate of tax revenues. In equilibrium, $T = \tau B = \tau(1-\pi)b$.

Let $W \equiv \pi u(c^L) + (1-\pi)u(c^H)$ denote period welfare. Define $\Lambda \equiv \frac{\partial W}{\partial C^T}$ as the social marginal value of aggregate tradable consumption, and let $\mu^{SP}(1-\pi)$ denote the multiplier on the collateral constraint in the planner's problem. The planner's first-order condition for borrowing can be written as

$$\Lambda + \mu^{SP}(1-\pi)\kappa s^H Y^N \frac{\partial P^N}{\partial C^T} = \frac{\beta}{Q}\mathbb{E}\left[\Lambda' + \pi^{SP\prime}(1-\pi)\kappa s^H Y^N \frac{\partial P^{N\prime}}{\partial C^{T\prime}}\right] + \mu^{SP} \tag{13}$$

When the current borrowing constraint of the planner is slack, the planner's first-order condition simplifies to

$$\Lambda = \frac{\beta}{Q}\mathbb{E}\left[\Lambda' + \mu^{SP\prime}(1-\pi)\kappa s^H Y^N \frac{\partial P^{N\prime}}{\partial C^{T\prime}}\right], \tag{14}$$

In the decentralized equilibrium with taxes, the corresponding first-order condition of a borrowing household is

$$U_T^H = \beta R(1+\tau)\mathbb{E}\left[U_T^{H\prime}\right] \tag{15}$$

Combining (14) and (15), we have the following proposition.

Proposition 1.1 (Optimal macroprudential tax)**.** *The constrained-efficient allocation can be decentralized by a state-contingent tax on debt issued by high-income households, with tax revenues rebated to these households through a lump-sum transfer. At states in which the current borrowing constraint is slack at the constrained-efficient allocation, the implementing tax is*

$$\tau = \frac{U_T^H}{\Lambda}\frac{\mathbb{E}\left[\Lambda' + \mu^{SP\prime}(1-\pi)\kappa s^H Y^N \frac{\partial P^{N\prime}}{\partial C^{T\prime}}\right]}{\mathbb{E}\left[U_T^{H\prime}\right]} - 1 \tag{16}$$

2 Model Mechanism

This section explains the model mechanism by presenting the sources of inefficiencies and their implications for optimal macroprudential policy via a decomposition exercise.

2.1 Sources of ineffciencies

The model features two sources of inefficiency that operate through the real exchange rate. The first is the standard Fisherian debt-deflation externality. Borrowing households do not internalize how their borrowing affects future real exchange rate depreciation and collateral constraints, leading to overborrowing, as in Bianchi (2011) and Bianchi and Mendoza (2018). The second is a distributional externality generated by household heterogeneity and amplified by nonhomothetic preferences. Borrowing by high-income households affects the real exchange rate and, through it, the purchasing power of low-income hand-to-mouth households. During credit expansions, higher borrowing raises domestic absorption and appreciates the real exchange rate, benefiting low-income households. Conversely, the subsequent repayment and deleveraging depress absorption and depreciate the real exchange rate, making tradable goods relatively more expensive. High-income borrowers do not internalize these effects on low-income households when choosing their debt positions. Because low-income households allocate a larger share of expenditure to tradable goods, their consumption baskets are more exposed to real exchange rate movements: appreciations during credit expansions benefit them disproportionately, while depreciations during crises impose disproportionately large consumption losses. Nonhomotheticity therefore strengthens the distributional consequences of the same real exchange rate movements that generate Fisherian financial amplification.

Our mechanism differs from Biljanovska and Vardoulakis (2024), where heterogeneity is between entrepreneurs and hand-to-mouth workers and redistribution operates primarily through wages. In their model, the planner uses labor-market policy to shift resources between workers and entrepreneurs, and during sudden stops favors entrepreneurs because their consumption supports collateral prices and mitigates the Fisherian debt deflation. In our model, by contrast, the distributional effect operates directly through the real exchange rate: borrowing by high-income households changes the purchasing power of low-income households. Thus, the same relative price that generates the standard collateral externality also generates a distributional externality.

Our distributional channel is closer to Fanelli and Straub (2017), which also features rich Ricardian and poor hand-to-mouth households with nonhomothetic preferences, so that real exchange rate movements have distributional consequences. The key difference is that their mechanism motivates foreign-exchange intervention to stabilize the real exchange rate in response to capital flows. In our framework, real exchange rate movements are instead endogenous to borrowing and deleveraging and interact directly with an occasionally binding collateral constraint. A credit expansion therefore benefits low-income households through real appreciation, while the associated debt accumulation increases exposure to future deleveraging and amplification. This interaction makes the distributional channel directly relevant for optimal policy.

2.2 Decomposition of optimal macroprudential policy

To understand the effects of the debt-deflation and distributional channels on optimal macroprudential policy, we decompose the optimal tax in Proposition 1.1 into different wedges.

The marginal social value of aggregate tradable consumption can be written as

$$\Lambda = U_T^H + \underbrace{\pi \left(U_T^L - U_T^H \right) (s^L Y^N - c^{N,L}) \frac{\partial P^N}{\partial C^T}}_{\equiv \Psi^D}, \tag{17}$$

where $U_T^i = (c^i)^{-\sigma} \partial c^i / \partial c^{T,i}$. The first term is the private marginal value of tradable consumption for borrowing households, and the second term, Ψ^D, captures the distributional effect of a marginal increase in aggregate tradable consumption operating through the equilibrium relative price of nontradables. This term reflects the redistribution of purchasing power across household types induced by changes in P^N. We next define

$$\Psi^F \equiv \mu^{SP}(1-\pi)\kappa s^H Y^N \frac{\partial P^N}{\partial C^T}, \tag{18}$$

which measures the social value of the relaxation of the collateral constraint induced by a marginal increase in aggregate tradable consumption.

We then have the following decomposition of the optimal macroprudential tax.

Proposition 2.1 (Decomposition of the optimal macroprudential tax)**.** *At any state in which the borrowing constraint is slack at the constrained-efficient allocation, the optimal tax can be decomposed as*

$$\tau = \underbrace{\frac{\mathbb{E}\left[\Psi^{F\prime}\right]}{\mathbb{E}\left[U_T^{H\prime}\right]}}_{\textit{Fisherian}} - \underbrace{\frac{Q}{\beta} \frac{\Psi^D}{\mathbb{E}\left[U_T^{H\prime}\right]}}_{\textit{current distributional}} + \underbrace{\frac{\mathbb{E}\left[\Psi^{D\prime}\right]}{\mathbb{E}\left[U_T^{H\prime}\right]}}_{\textit{future distributional}}. \tag{19}$$

The decomposition highlights the intertemporal trade-off underlying optimal macroprudential policy. Additional borrowing expands current tradable consumption, but must be repaid through lower tradable consumption in the future. The first term captures the conventional Fisherian cost of borrowing and corresponds to the optimal tax in Bianchi (2011). Higher debt increases the economy's exposure to states in which the collateral constraint binds, where a decline in the relative price of nontradables lowers collateral values and amplifies deleveraging. This force therefore raises the optimal tax.

The remaining two terms capture the distributional consequences of shifting tradable consumption across time. The second term reflects the contemporaneous distributional value of credit expansion. When $\Psi^D > 0$, higher current tradable consumption redistributes purchasing power toward households with a higher marginal value of tradable consumption, lowering the optimal tax. The third term captures the corresponding future effect. Higher borrowing today must be serviced through lower future tradable consumption. When $\Psi^{D\prime} > 0$, the resulting decline in $C^{T\prime}$ and $P^{N\prime}$ reverses this favorable redistribution, generating a future distributional cost and raising the optimal tax. Hence, the planner trades off the current distributional benefit of credit expansion against its future distributional cost and the conventional Fisherian cost of greater crisis vulnerability.

The sign of the distributional effect is determined by the term

$$\Psi^D = \pi\left(U_T^L - U_T^H\right)(s^L Y^N - c^{N,L})\frac{\partial P^N}{\partial C^T}.$$

The term $U_T^L - U_T^H$ captures the distributional value arising from differences in the marginal utility of tradable consumption, while $s^L Y^N - c^{N,L}$ is the net quantity of nontradables sold by low-income households. Hence, $(s^L Y^N - c^{N,L})\frac{\partial P^N}{\partial C^T}$ captures the change in the value of their net nontradable sales induced by a marginal increase in aggregate tradable consumption. Under standard parameter values, $U_T^L > U_T^H$, so low-income households have a higher marginal utility of tradable consumption, and $\partial P^N/\partial C^T > 0$, so the relative price of nontradables rises as tradable consumption increases. The sign of Ψ^D is therefore determined by the net nontradable position of low-income households, $s^L Y^N - c^{N,L}$. If low-income households are net sellers of nontradables, so that $s^L Y^N > c^{N,L}$, an increase in tradable consumption raises P^N and increases the value of the nontradables they sell. Resources are therefore redistributed toward low-income households, which have the higher marginal value of tradable consumption, implying $\Psi^D > 0$.

3 Quantitative Analysis

This section presents the quantitative analysis. First, we investigate how income inequality and nonhomothetic preferences shape borrowing decisions and the real exchange rate. Second, we assess the severity of sudden stops and their distributional consequences for consumption inequality. We calibrate the model to match data from Peru and compare decentralized equilibrium outcomes with those under the social planner, examining effects on both aggregates and distributions.

3.1 Parameterization and values

Functional forms and assumptions. The endowment of nontradable goods in every period is normalized to $Y_t^N = 1$. The endowment of tradable goods Y_t^T follows a logged first-order autoregressive process:

$$\log Y_t^T = \rho_y \log Y_{t-1}^T + \epsilon_t^y,\ \epsilon_t^y \sim \mathcal{N}(0, \sigma_y),$$

where ρ_z, σ_z are the auto-correlation and the residual standard deviation, respectively. We discretize the tradable endowment process into a Markov chain using Tauchen's method with 20 evenly-spaced nodes.

Parameter values. Table 1 reports the parameter values used in the analysis. The calibration relies on Peruvian macroeconomic time series and the Peruvian household survey ENAHO to discipline the model targets. Parameters governing the risk-free interest rate, risk aversion, and the elasticity of substitution between tradable and non-tradable consumption are set following Bianchi (2011).

Sectoral income elasticities are calibrated as follows. The tradable elasticity, ϵ_T, is normalized to one, while the non-tradable elasticity, ϵ_N, is estimated to match the household-level non-tradable income elasticity observed in the ENAHO. This estimation follows Arce and Tran-Xuan (2022), which adopts the methodology developed by proposed by Comin et al. (2021). The preference weight on tradable consumption is chosen so that the model replicates an average tradable output share in the data. Tradable output is defined as total output from agriculture, fishing, manufacturing, mining, and energy.

Parameters governing the tradable endowment process are estimated using an AR(1) specification for the log HP-filtered tradable output series for Peru. The persistence parameter is set equal to the empirical persistence of tradable output, and the standard deviation of the tradable shock is calibrated to match the volatility of the tradable output series. The share of borrowing households is chosen to match statistics from the Global Findex Database on financial inclusion, specifically the share of adults who borrow or have access to financial institutions. The endowment shares s^H and s^L are normalized such that $\sum_{i \in H,L} \pi^i s^i = 1$ and are calibrated to match the average relative income share of top and bottom earners in the ENAHO.

Finally, we calibrate the discount factor to match the net foreign asset position of the private sector in Peru, and the credit constraint coeffcient to match the sudden-stop

Table 1: Parameters and Values

Parameter	Description	Value	Target
r^*	Risk-free rate	0.04	Standard literature value
σ	Risk aversion	2	Standard literature value
η	Elasticity of substitution T-NT	0.205	Elasticity of substitution T-NT = 0.83
ϵ_T	Tradable income elasticity	1	Normalized
ϵ_N	Nontradable income elasticity	2.2	Nontradable income elasticity = 1.043
ω	Preference weight of tradables	0.36	Tradable output share = 37%
ρ_y	Tradable endowment persistence	0.59	Tradable output persistence
σ_y	Std. dev. of tradable shock	0.039	Std. dev. of tradable output=0.048
π	Share of hand-to-mouth households	0.6	Share of adults borrowing = 40%
s^H/s^L	Relative endowment share	2.25	Top/bottom income= 1.5
β	Discount factor	0.92	NFA of private sector = -20%
κ	Credit constraint coefficient	0.33	Sudden-stop probability = 5.1%

Note: Table 1 reports the parameter values used in the calibration exercise. The targets for the risk-free rate, the risk aversion, and the elasticity of substitution between tradable and nontradable goods are taken from Bianchi (2011). Income elasticities and preference weights are chosen to replicate sectoral income elasticities measured in the ENAHO household survey and sectoral output shares for Peru. The persistence and volatility of tradable endowments match observed moments of Peruvian tradable output (agriculture, fishing, manufacturing, mining, and energy). Household heterogeneity is computed using ENAHO household survey data, and the household borrowing share is taken from the Global Findex Database. The discount factor targets the private sector net foreign asset position, while the credit constraint parameter is chosen to replicate the observed frequency of sudden-stop episodes in Peru.

probability reported in Bianchi (2011).[1]

3.2 Debt issuance and real exchange rate

We first analyze how the social planner's constrained-efficient debt issuance decisions differ from those of borrowing households and examines their implications for real exchange rate.

Figure 2 reports the policy functions for debt issuance and the real exchange rate as functions of the current level of external debt, comparing the decentralized equilibrium (DE) with the constrained-efficient (CE) allocation. In contrast to the canonical sudden-stop framework where private agents systematically overborrow relative to the social planner, we find state-dependent borrowing distortions. Specifically, borrowing households in the decentralized equilibrium underborrow relative to the social planner

[1] We use the following formula to calculate the net foreign asset position of the private sector: NFA of private sector =NFA of country * private external debt/total external debt. Source: Lane and Milesi-Ferreti (2007)

at low levels of current debt, but overborrow as debt rises and approaches the collateral constraint.

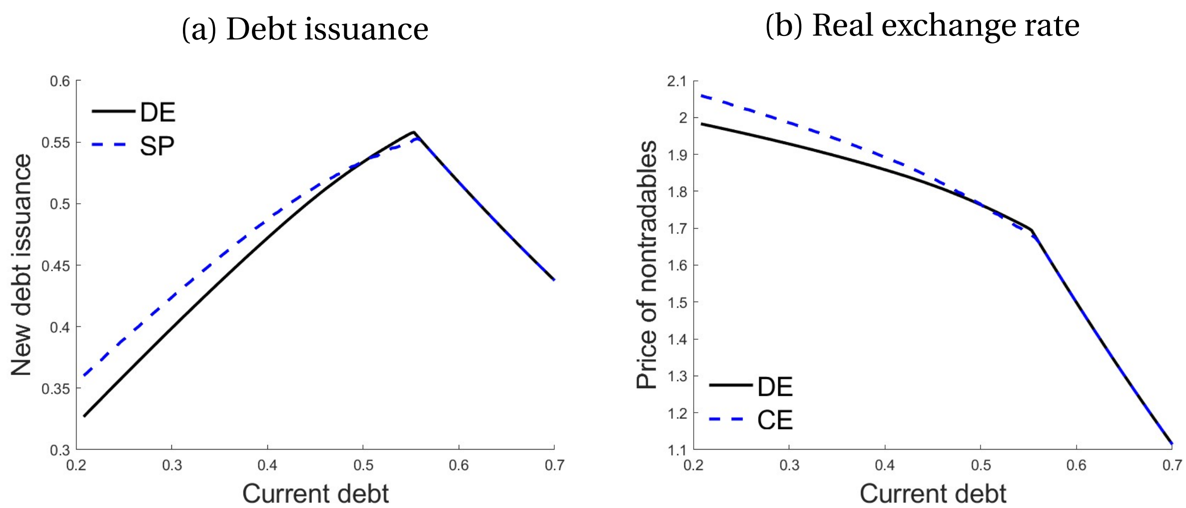


Figure 2: Debt issuance and real exchange rate

Note: Figure 2 shows the policy functions for debt issuance (B') and the real exchange rate (P^N) as functions of current debt (B) under the Decentralized Equilibrium (DE) and Constrained Efficiency (CE).

Panel (a) shows that when the economy is far from the borrowing constraint, decentralized debt issuance lies below its constrained-efficient counterpart. As debt increases and the credit constraint becomes more likely to bind, this ranking reverses, and decentralized borrowing exceeds the planner's allocation. The real exchange rate mirrors this pattern. Relative to the constrained-efficient allocation, the decentralized equilibrium features an undervalued (more depreciated) real exchange rate at low debt levels and an overvalued (more appreciated) real exchange rate when debt is high and the credit constraint is near binding.

These findings differ sharply from the standard results in the sudden-stop literature, in which pecuniary externalities generated by Fisherian debt deflation lead private agents to overborrow in all states, implying an excessively appreciated real exchange rate in the decentralized equilibrium. In our framework, the presence of household heterogeneity introduces an additional externality that alters the incentives of the planner in a state-dependent manner.

When debt is high, borrowing households fail to internalize how additional leverage increases the probability and severity of future binding credit constraints and exchange rate depreciations. Because these depreciations disproportionately reduce the welfare of low-income hand-to-mouth households, the utilitarian social planner prefers lower borrowing than private agents, reproducing the familiar overborrowing result emphasized in the literature. However, when the economy starts from a low level of debt and crisis risk is limited, the planner values exchange rate appreciation as it raises real consumption for hand-to-mouth households with high expenditure shares on tradables. In this region, constrained efficiency calls for larger credit expansions and a stronger real exchange rate than those chosen in the decentralized equilibrium.

3.3 Long-run moments and welfare

We compare the long-run properties and welfare results of the decentralized equilibrium and constrained-efficient economies. We focus on debt, crisis frequency, changes during sudden stops, and welfare gains going from decentralized equilibrium to constrained efficiency. Table 2 reports the results. A sudden stop is defined as a period in which the current account of the economy increases by more than two standard deviations and the credit constraint is binding under decentralized equilibrium. Welfare gains are reported as compensated expenditure variations, defined as the permanent percentage change in expenditure, evaluated at decentralized-equilibrium prices, required to attain the lifetime utility of the constrained-efficient allocation.[2]

We find that borrowing households overborrow in the decentralized equilibrium relative to the constrained-efficient allocation. The constrained-efficient economy therefore features less frequent sudden stops and smaller declines in the real exchange rate and tradable consumption during crisis episodes. These differences, however, are quantitatively modest, reflecting a trade-off between the benefits of reducing crisis risk and the distributional gains from credit expansions, which disproportionately increase the purchasing power of low-income households through real exchange rate appreciation. Accordingly, the welfare gains from constrained efficiency are small.

The welfare effects are unevenly distributed across households. Although hand-to-mouth households benefit from less frequent and milder crisis depreciations, these gains do not offset the foregone benefits from real exchange rate appreciations during credit expansions. High-income borrowers, in contrast, benefit more from reduced

[2] Following Lewis et al. (2022), we use the expenditure-equivalent variation rather than the standard consumption-equivalent variation for welfare. With nonhomothetic preferences, the composite consumption index is a utility aggregator and does not map proportionally into consumption resources. The expenditure-equivalent measure instead expresses welfare changes as a proportional change in the resources required to finance the consumption bundle at fixed prices. In this sense, it is equivalent to scaling tradable and nontradable consumption by the same proportion and coincides wih the welfare measure used by Rojas and Saffie (2022). Under homothetic preferences, this measure coincides with the standard consumption-equivalent variation.

Table 2: Long-Run Moments and Welfare

	Baseline		**Representative-Homothetic** Bianchi (2011)	
	DE	CE	DE	CE
Average (%)				
Debt/income	20.1	19.9	32.6	32.1
Prob. of sudden stop	5.1	3.7	5.1	1.5
Change in sudden stop (%)				
Real exchange rate	-18.8	-17.7	-25.0	-16.4
Tradable consumption	-14.7	-13.7	-21.3	-13.9
Welfare gain (%)	–	0.0005	–	0.025
High type	–	0.0061	–	–
Low type	–	-0.0026	–	–

Note: Table 2 reports long-run moments and welfare gains under the Decentralized Equilibrium (DE) and Constrained Efficiency (CE). The baseline features heterogeneous households and non-homothetic preferences, while the Representative-Homothetic benchmark follows Bianchi (2011). A sudden stop is defined as a period in which the current account of the economy increases by more than two standard deviations and the credit constraint is binding. Welfare gains are reported as expenditure-equivalent variations.

amplification and improved consumption smoothing during crises. As a result, constrained efficiency raises welfare for high-income borrowers while generating small welfare losses for hand-to-mouth households on average.

The contrast with the representative-agent homothetic model highlights the role of these distributional considerations. In the representative-homothetic economy, the planner's intervention is driven primarily by the standard Fisherian externality, leading to a substantially larger reduction in the frequency and severity of sudden stops and larger welfare gains. By contrast, household heterogeneity and nonhomothetic preferences weaken the conventional macroprudential motive by introducing distributional gains from credit expansions.

3.4 Consumption dynamics during sudden stops

To illustrate how the distributional externality operates during crises and how it shapes the planner's incentives, we examine the dynamics of tradable and nontradable consumption across household types around sudden stops. Figure 3 shows that both household types experience a sharp contraction in tradable consumption when the crisis occurs, but their adjustment in nontradable consumption differs significantly. High-income borrowers reduce both tradable and nontradable consumption, reflecting the contraction in resources associated with deleveraging. By contrast, hand-to-mouth households reduce tradable consumption while increasing nontradable consumption during the sudden stop. The crisis affects hand-to-mouth households primarily

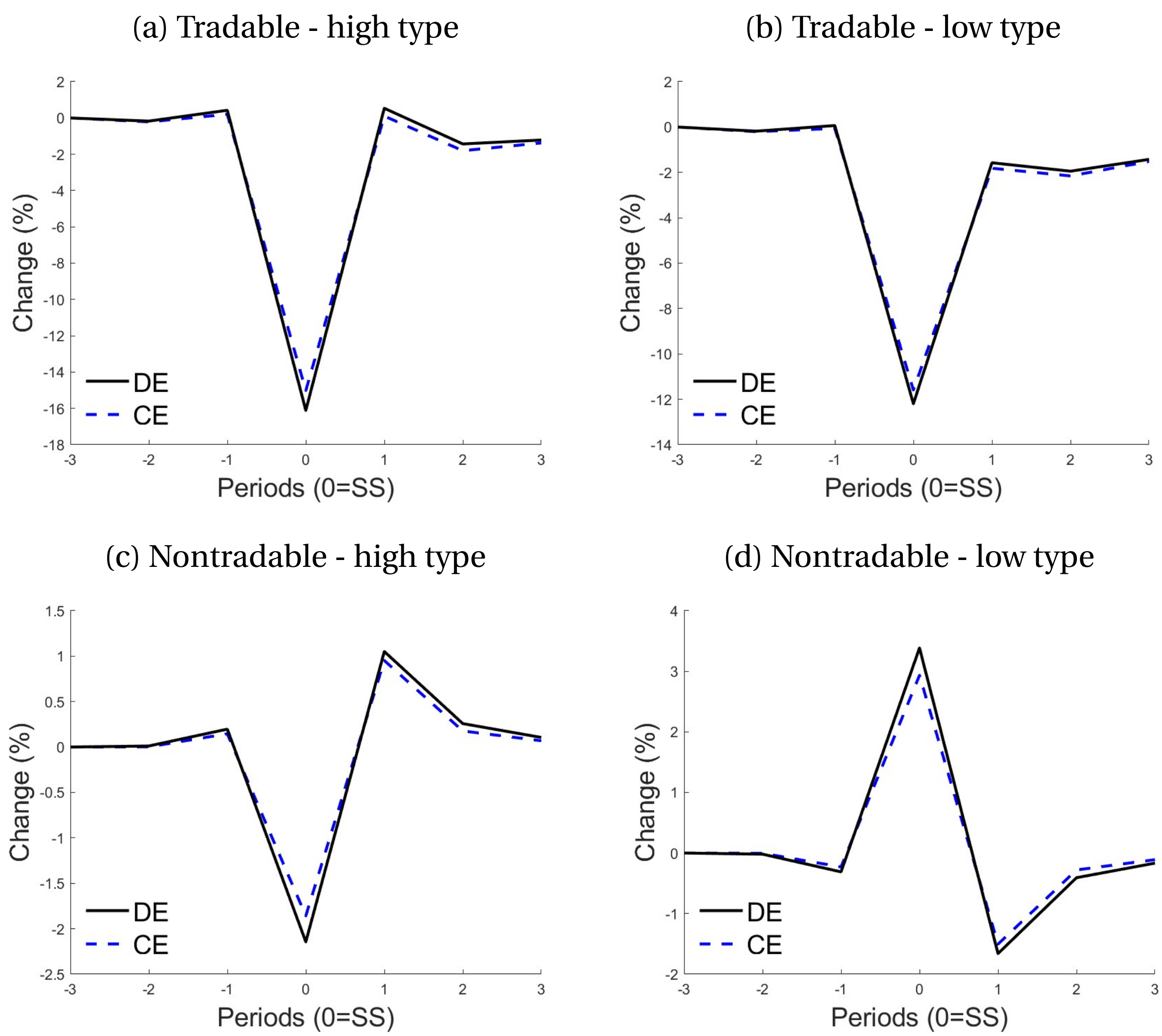


Figure 3: Consumption around sudden stops

Note: Figure 3 plots the tradable and nontradable consumption around a sudden stop, for Decentralized Equilibrium (DE) and Constrained Efficiency (CE) in the simulation of the baseline. A sudden stop (SS) is defined as a period in which the current account of the economy increases by more than two standard deviations and the credit constraint is binding under decentralized equilibrium.

through relative prices rather than deleveraging, as these households do not borrow. A real exchange rate depreciation raises the relative price of tradables and induces substitution toward nontradables, partially offsetting the contraction in their consumption basket. However, because tradables account for a larger share of their expenditure under nonhomothetic preferences, the depreciation still results in a disproportionate loss in their purchasing power.

Under constrained efficiency, the social planner, by reducing the real exchange rate depreciation, mitigates deleveraging for high-income borrowers and the decline in tradable consumption for hand-to-mouth households, while also reducing their need to substitute toward nontradables. The differences remain modest, reflecting the planner's trade-off between the Fisherian benefits of reducing crisis losses and the distributional consequences of shifting tradable consumption across time. In particular, restricting borrowing reduces future crisis and distributional costs, but also forgoes the contemporaneous distributional benefits of credit expansion.

These heterogeneous consumption responses translate directly into changes in consumption inequality. Figure 4 reports the dynamics of tradable and nontradable consumption inequality, measured as the ratio of high- to low-income household consumption. Both measures decline sharply during sudden stops and rebound thereafter. The decline is especially pronounced for nontradable consumption, as hand-to-mouth households substitute toward nontradables while high-income borrowers reduce their consumption through deleveraging. By limiting the real exchange rate depreciation and the associated relative-price adjustment, the social planner mitigates both the decline in consumption inequality during the crisis and its subsequent rebound.

3.5 Roles of heterogeneity and nonhomotheticity

To disentangle the roles of household heterogeneity and nonhomothetic preferences, we compare the baseline economy with two alternative specifications. Table 3 reports long-run moments and welfare gains for a heterogeneous economy with homothetic preferences and a representative-agent economy with nonhomothetic preferences, the latter corresponding to the environment studied in Rojas and Saffie (2022).

Heterogeneity The heterogeneous-homothetic model isolates the role of hand-to-mouth households. Relative to the representative-agent benchmark, their presence substantially weakens the planner's incentive to reduce borrowing. Credit expansions appreciate the real exchange rate and raise the purchasing power of hand-to-mouth

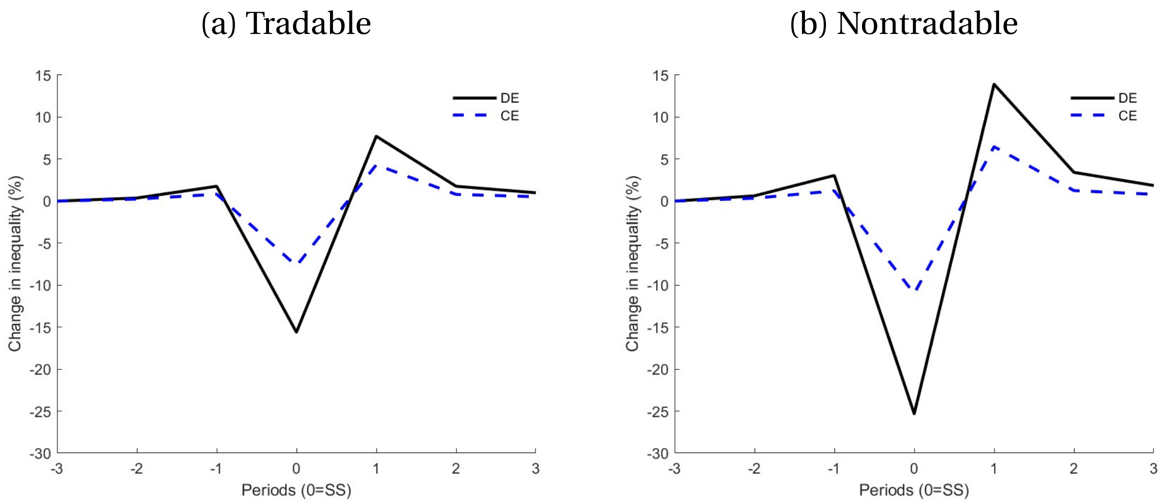


Figure 4: Consumption inequality around sudden stops

Note: Figure 4 plots the consumption inequality around a sudden stop, for Decentralized Equilibrium (DE) and Constrained Efficiency (CE) in the simulation of the baseline. Consumption inequality is the ratio of the consumption of high-income households to that of low-income households. A sudden stop (SS) is defined as a period in which the current account of the economy increases by more than two standard deviations and the credit constraint is binding under decentralized equilibrium.

Table 3: Alternative Model Specifications

	Heterogeneous-Homothetic		**Representative-Nonhomothetic** Rojas and Saffie (2022)	
	DE	CE	DE	CE
Average (%)				
Debt/income	20.1	20.0	32.6	31.9
Prob. of sudden stop	5.3	6.0	4.7	1.2
Change in sudden stop (%)				
Real exchange rate	-16.1	-16.2	-29.8	-18.2
Tradable consumption	-13.5	-13.6	-23.7	-14.3
Welfare gain (%)	–	0.0002	–	0.0335
High type	–	-0.0042	–	–
Low type	–	0.0015	–	–

Note: The table reports long-run moments and welfare gains under the Decentralized Equilibrium (DE) and Constrained Efficiency (CE). A sudden stop is defined as a period in which the current account increases by more than two standard deviations and the credit constraint is binding under decentralized equilibrium. Welfare gains are reported as expenditure-equivalent variations.

households, a benefit that private borrowers do not internalize. This contemporaneous distributional benefit lowers the planner's incentive to restrict borrowing, although it is partly offset by the future distributional cost associated with servicing the additional debt. At the same time, these households are not directly exposed to deleveraging during sudden stops. Their crisis adjustment occurs mainly through intratemporal substitution. Following a depreciation, they reduce tradable consumption but substitute toward relatively cheaper nontradables, which mitigates the contraction in their consumption basket. With homothetic preferences, this relative-price adjustment does not carry the additional welfare cost associated with a disproportionately high expenditure share on tradables. As a result, the net distributional motive—the current benefit of credit expansion relative to its future distributional cost—largely offsets the standard Fisherian motive to restrain borrowing. Constrained efficiency therefore shows slightly lower average debt with higher crisis frequency and severity. The corresponding welfare effects are small and primarily redistributive, with hand-to-mouth households gaining at the expense of high-income borrowers.

Appendix C provides further evidence for this mechanism. Under constrained efficiency, composite consumption of hand-to-mouth households is slightly higher in both crisis and noncrisis states. The planner raises their tradable consumption in normal times, while during sudden stops they substitute further toward relatively cheaper nontradables. With homothetic preferences, this intratemporal adjustment limits the welfare cost of crisis depreciations for hand-to-mouth households. The planner can therefore increase their welfare while tolerating somewhat greater crisis risk, as the contemporaneous distributional benefits of credit expansion are sufficiently strong relative to its future distributional and Fisherian costs. This contrasts with the baseline, where nonhomotheticity makes crisis depreciations disproportionately costly for hand-to-mouth households and restores the planner's incentive to reduce the incidence and severity of sudden stops.

Nonhomotheticity Nonhomothetic preferences amplify the Fisherian mechanism by making expenditure shares respond to changes in consumption. During sudden stops, lower consumption shifts expenditure toward tradables and depresses demand for nontradables, generating a larger real exchange rate depreciation and, through the collateral constraint, a more severe contraction. This amplification is consistent with Rojas and Saffie (2022) and is also reflected in the representative-nonhomothetic specification, where constrained efficiency yields larger welfare gains from mitigating crises.

In the heterogeneous economy, nonhomotheticity also magnifies both sides of the distributional trade-off. Because hand-to-mouth households devote a larger share of expenditure to tradables, changes in the real exchange rate have larger distributional consequences for their purchasing power. Credit expansions therefore generate a larger contemporaneous distributional benefit when they appreciate the real exchange rate and shift purchasing power toward hand-to-mouth households. At the same time, the reduction in tradables associated with future debt repayment, particularly during sudden stops, generates a larger depreciation and a larger future distributional cost. Relative to the heterogeneous-homothetic model, nonhomotheticity thus strengthens both the current distributional benefit of credit expansion and the future distributional cost of servicing debt. Quantitatively, the latter becomes more important in crisis states, strengthening the planner's incentive to reduce the incidence and severity of sudden stops.

3.6 Optimal macroprudential policy

Figure 5 compares the optimal borrowing tax across the four model specifications. The main difference is between heterogeneous- and representative-agent economies. In the representative-agent models shown in Panel (b), the optimal tax is close to zero over most of the debt range and rises sharply only as debt approaches the collateral constraint. Nonhomotheticity strengthens this increase, similar to the results in Rojas and Saffie (2022). By contrast, introducing hand-to-mouth households in Panel (a) shifts optimal policy substantially downward. In the heterogeneous-homothetic economy, borrowing is subsidized throughout almost the entire debt range, with subsidies of about 10 percent at low debt that gradually decline in magnitude as leverage rises. In the baseline nonhomothetic economy, the subsidy is considerably smaller, around 3–4 percent at low debt, and the tax schedule turns positive at sufficiently high leverage. The effect of nonhomotheticity is therefore much stronger in the heterogeneous-agent economy than in the representative-agent economy. With heterogeneous households, nonhomotheticity substantially reduces the borrowing subsidy and shifts the tax schedule upward, while in the representative-agent models it only modestly affects the tax schedule.

Thus, household heterogeneity generates a strong motive to support borrowing at low and moderate debt levels, while nonhomotheticity partially offsets this motive and restores positive macroprudential taxes as financial vulnerability increases. These differences reflect the additional distributional consequences of borrowing in the heterogeneous economies, where credit expansions benefit hand-to-mouth households through real appreciation but future distributional and Fisherian costs become

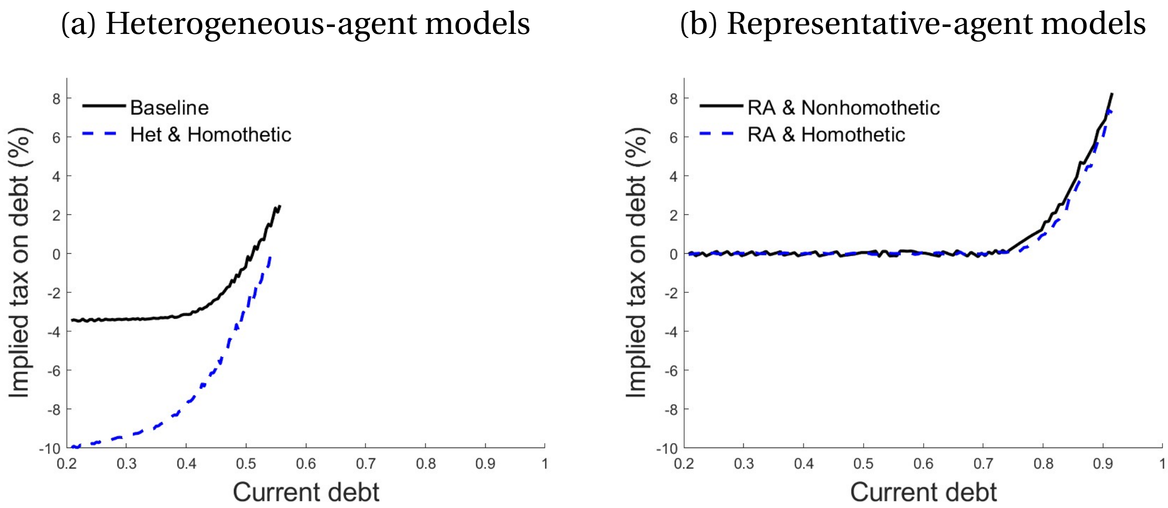


Figure 5: Optimal macroprudential policy across models

Note: Figure 5 reports the optimal borrowing tax as a function of current aggregate debt at the median income shock for different model specifications.

increasingly important as debt rises.

3.7 Determinants of the optimal tax

In this subsection, we quantify the relative importance of the Fisherian and distributional forces underlying the optimal borrowing tax. Figure 6 decomposes the optimal borrowing tax in the two heterogeneous-agent models into a Fisherian component, a current distributional component, and a future distributional component. In both models, the borrowing subsidies at low debt are primarily distributional. The current distributional component is negative and the future distributional component is positive, so the two effects partly offset each other. At low debt, the contemporaneous distributional benefit exceeds the future distributional cost, generating a net subsidy to borrowing. As debt rises, the Fisherian component becomes increasingly important as future states in which the collateral constraint binds become more relevant.

Panel (a) shows the decomposition for the baseline economy. Both distributional components decline in magnitude as debt rises, narrowing the net distributional subsidy. The current distributional component remains negative throughout the relevant debt range, reflecting that low-income households remain net sellers of nontradables. An increase in tradable consumption therefore raises the value of their net nontradable sales and generates a contemporaneous distributional benefit. At the same time, the Fisherian component rises with leverage. At sufficiently high debt, the Fisherian

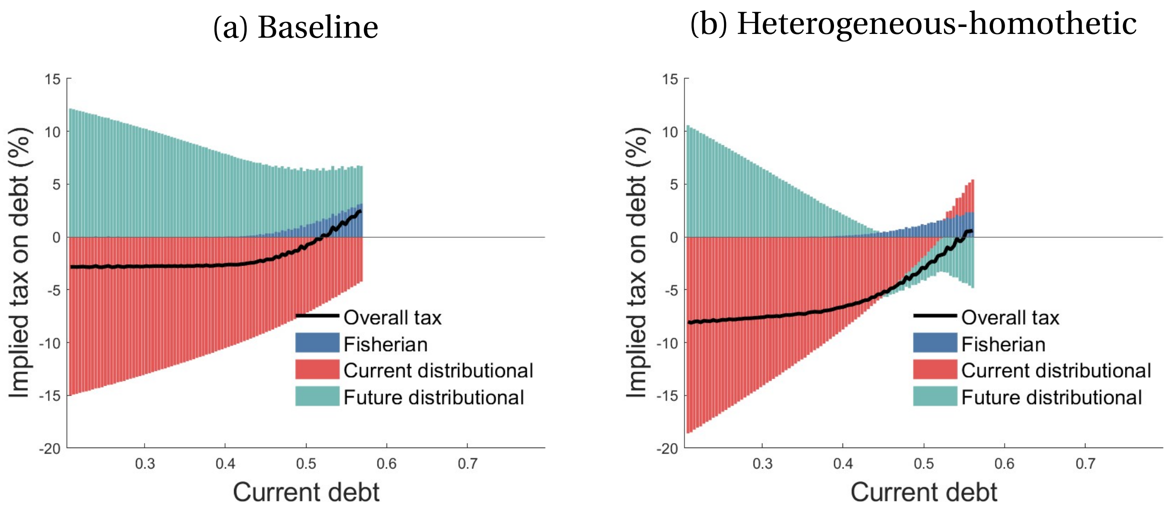


Figure 6: Optimal tax decomposition

Note: Figure 6 decomposes the optimal borrowing tax into the Fisherian, current distributional, and future distributional components for the baseline and heterogeneous-homothetic models.

cost outweighs the remaining net distributional benefit, and the optimal policy switches from a borrowing subsidy to a tax.

Panel (b) shows that the heterogeneous-homothetic economy features substantially larger distributional components, particularly at low debt. The contemporaneous distributional benefit is much larger than in the baseline and produces the substantially larger borrowing subsidies shown in Figure 5. As debt rises, the net nontradable position of low-income households falls and eventually changes sign. Once low-income households become net buyers of nontradables, an increase in P^N raises the cost of their nontradable consumption by more than the value of their nontradable endowment, causing the current distributional component to switch from a subsidy to a tax. The future distributional component also changes sign because a future decline in P^N associated with servicing additional debt benefits low-income households when they are net buyers of nontradables. The two distributional components therefore continue to work in opposite directions, but their signs reverse as the net nontradable position of low-income households changes.

Comparing the two panels shows that nonhomotheticity affects both the distributional and Fisherian components of optimal policy, but its quantitative effect is considerably stronger through the distributional channel. Nonhomotheticity changes households' expenditure patterns, their net positions in nontradables, and the difference in the marginal value of tradable consumption across household types, substantially reducing the large distributional motive for subsidizing borrowing that arises under homothetic preferences. It also increases the Fisherian component by strengthening the response of the relative price of nontradables to changes in tradable consumption and hence the effect of borrowing on collateral values. Quantitatively, however, this increase is smaller than the change in the distributional components, so the large difference in optimal taxes across the two heterogeneous-agent models is driven primarily by the distributional channel.

To understand the differences in the tax components across the two heterogeneous-agent models, Figure 7 compares the underlying distributional and Fisherian wedges. The distributional wedge differs substantially across the two specifications. Under homothetic preferences, Ψ^D is much larger at low debt and declines rapidly with leverage, eventually changing sign. In the nonhomothetic baseline, the distributional wedge is considerably smaller in magnitude and varies less over most of the debt range. By contrast, the Fisherian wedge Ψ^F is larger in the nonhomothetic baseline, consistent with a stronger response of the relative price of nontradables to changes in tradable consumption. Nonhomotheticity therefore strengthens the Fisherian channel, but the cross-model difference in the distributional wedge is quantitatively much larger.

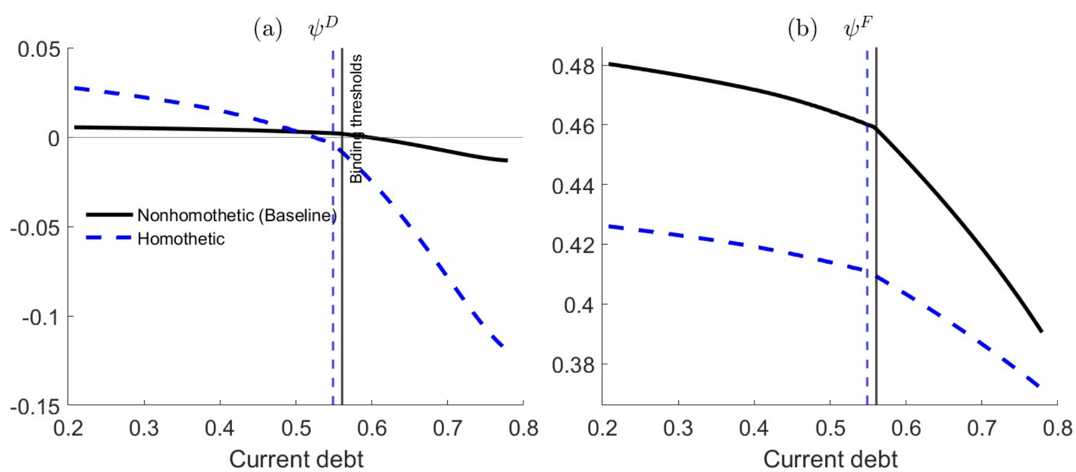


Figure 7: Distributional and Fisherian wedges

Note: Figure 7 compares the distributional wedge Ψ^D and the Fisherian collateral-price sensitivity Ψ^F in the baseline and heterogeneous-homothetic models as functions of current debt for the median income shock. The vertical lines indicate the debt levels at which the collateral constraint binds in the two models.

Figure 8 further decomposes the economic forces underlying these differences. Recall that

$$\Psi^D = \pi \left(U_T^L - U_T^H \right) \left(s^L Y^N - c^{N,L} \right) \frac{\partial P^N}{\partial C^T},$$
$$\Psi^F = (1-\pi)\kappa s^H Y^N \frac{\partial P^N}{\partial C^T}.$$

The large difference in Ψ^D is primarily associated with the marginal-utility gap across households. Panel (a) shows that $U_T^L - U_T^H$ is substantially larger under homothetic preferences. Thus, a given redistribution of resources toward low-income households carries a much larger social value in the heterogeneous-homothetic economy. Panel (b), in contrast, shows that $\partial P^N / \partial C^T$ is larger in the nonhomothetic baseline. This stronger price response explains why nonhomotheticity increases the Fisherian wedge even though it reduces the distributional wedge.

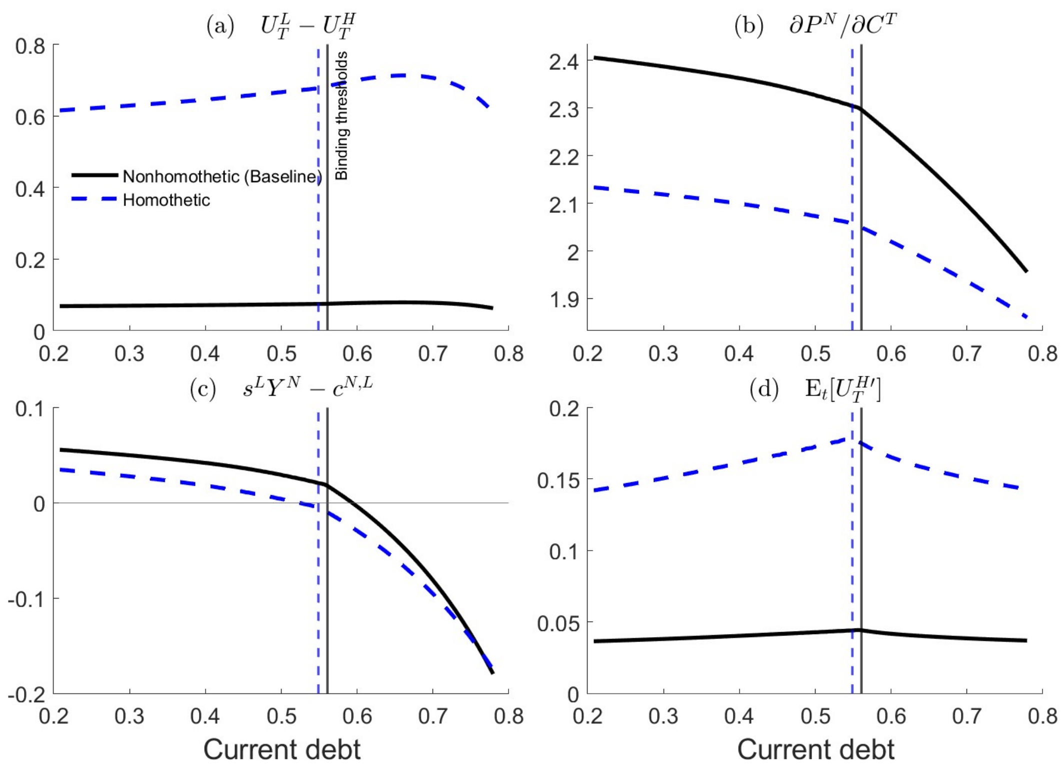


Figure 8: Sources of the distributional and Fisherian wedges

Note: Figure 8 reports the components underlying the distributional and Fisherian wedges in the baseline and heterogeneous-homothetic models. Panel (a) reports the difference in the marginal value of tradable consumption, $U_T^L - U_T^H$. Panel (b) reports the response of the relative price of nontradables to aggregate tradable consumption, $\partial P^N / \partial C^T$. Panel (c) reports the net nontradable position of low-income households, $s^L Y^N - c^{N,L}$. Panel (d) reports the expected future marginal utility of tradable consumption of high-income households, $\mathbb{E}_t[U_T^{H\prime}]$. The vertical lines indicate the debt levels at which the collateral constraint binds in the two models.

Panel (c) shows the second determinant of the distributional wedge, the net nontradable position of low-income households. Low-income households are net sellers of nontradables at low debt in both models, so an increase in P^N raises the value of their net sales and generates a positive distributional effect. Their net nontradable sales decline as debt rises and eventually become negative. This transition occurs at a lower debt level in the homothetic economy and accounts for the earlier sign reversal of Ψ^D in Figure 7. Panel (d) reports $\mathbb{E}_t[U_T^{H\prime}]$, which is the denominator converting the social wedges into the corresponding tax components. Expected marginal utility is substantially higher in the homothetic model, partly offsetting its larger distributional wedge when expressed in tax units. Nevertheless, the much larger marginal-utility gap in Panel (a) generates a substantially stronger distributional motive under homothetic preferences.

Taken together, Figures 7 and 8 show that nonhomotheticity operates through competing forces. It raises the sensitivity of the relative price of nontradables to tradable consumption, strengthening the Fisherian channel. At the same time, it substantially compresses the difference in the marginal value of tradable consumption across household types and changes their net nontradable positions, weakening the distributional channel. Quantitatively, the latter effect is considerably larger, explaining why the optimal borrowing subsidy is much smaller in the nonhomothetic baseline than in the heterogeneous-homothetic economy.

4 Sensitivity Analysis

This section examines how equilibrium outcomes vary with two dimensions of heterogeneity: income inequality and the share of hand-to-mouth households, and nonhomotheticity. In each exercise, we compare the decentralized equilibrium with the constrained-efficient allocation and evaluate the implications for debt accumulation, sudden stop risk, welfare, and borrowing taxes.

4.1 Income Inequality

Figure 9 examines the effects of increasing the income share of high-income households. Greater inequality raises equilibrium debt and, at higher levels, the frequency of sudden stops, as a larger share of income accrues to households with access to external borrowing.

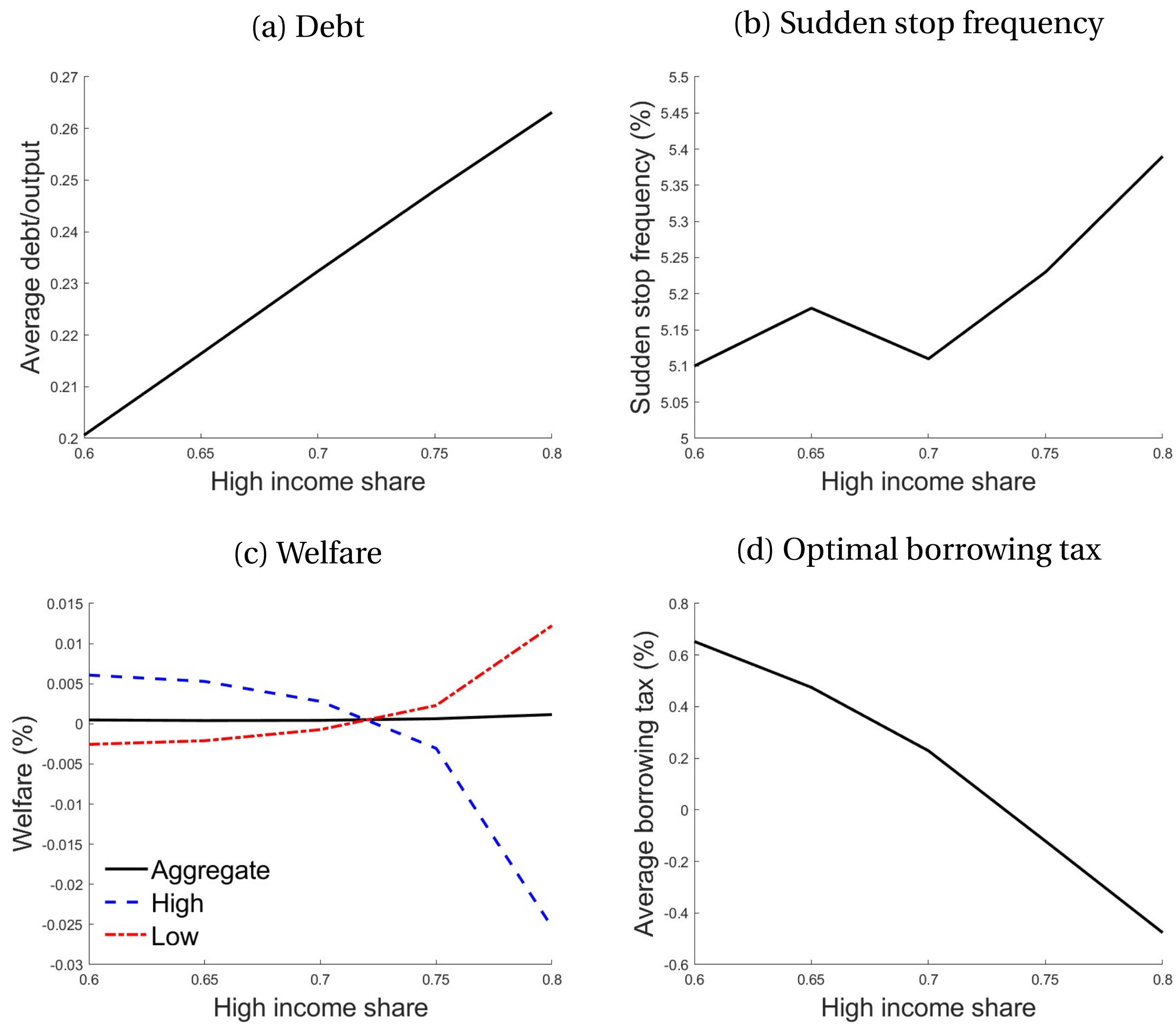


Figure 9: Effects of Income Inequality

Note: Figure 9 reports equilibrium outcomes at the ergodic mean as functions of the income share of high-income households. Panel (a) shows the average debt-to-output ratio, panel (b) the frequency of sudden stops, panel (c) welfare gains in expenditure-equivalent units, and panel (d) average borrowing tax.

Aggregate welfare gains from constrained efficiency remain small, but their incidence changes significantly. At low inequality, gains accrue primarily to high-income borrowers, whereas at higher inequality they shift toward hand-to-mouth households. Greater inequality strengthens the distributional effects of real exchange rate movements because the marginal value of additional consumption is higher for increasingly poorer hand-to-mouth households. This magnifies both the contemporaneous distributional benefit of credit-induced appreciation and the future distributional cost associated with lower tradable consumption and real exchange rate depreciation. Quantitatively, the contemporaneous benefit becomes more important relative to the future distributional and Fisherian costs, so the optimal borrowing tax declines with inequality and eventually becomes a subsidy. Thus, greater inequality weakens the net macroprudential motive despite the associated increase in leverage and crisis risk.

4.2 Share of Hand-to-Mouth Households

Figure 10 examines the effects of varying the share of hand-to-mouth households, π. Changes in household composition have little effect on aggregate financial vulnerability. Average debt remains essentially unchanged, while sudden-stop frequency shows no systematic pattern as π varies.

The main effects are distributional. Aggregate welfare gains from constrained efficiency remain close to zero, but gains shift from high-income borrowers toward hand-to-mouth households as their population share rises. A larger share of hand-to-mouth households strengthens the distributional consequences of real exchange rate movements and therefore magnifies both the contemporaneous distributional benefit of credit expansions and the future distributional cost of servicing debt. Quantitatively, the contemporaneous benefit becomes more important relative to the future distributional and Fisherian costs, so the optimal borrowing tax declines sharply with π and eventually becomes a subsidy. Thus, the prevalence of hand-to-mouth households matters primarily for the incidence of welfare gains and the optimal stance of macroprudential policy rather than for aggregate debt or crisis frequency.

4.3 Nonhomotheticity

Figure 11 examines the effects of varying the degree of nonhomotheticity, governed by ϵ_N. Aggregate debt remains essentially unchanged, while sudden-stop frequency varies only modestly and nonmonotonically. Thus, nonhomotheticity has limited effects on average leverage and crisis incidence, even though it changes the distributional consequences of real exchange rate movements.

The welfare and policy effects are more pronounced. As nonhomotheticity increases, welfare gains shift toward high-income borrowers, while hand-to-mouth households experience larger welfare losses, with aggregate gains remaining close to zero. Nonhomotheticity magnifies both sides of the distributional trade-off. By increasing the exposure of hand-to-mouth households to movements in the relative price of tradables, it raises the contemporaneous distributional benefit generated by real appreciation dur-

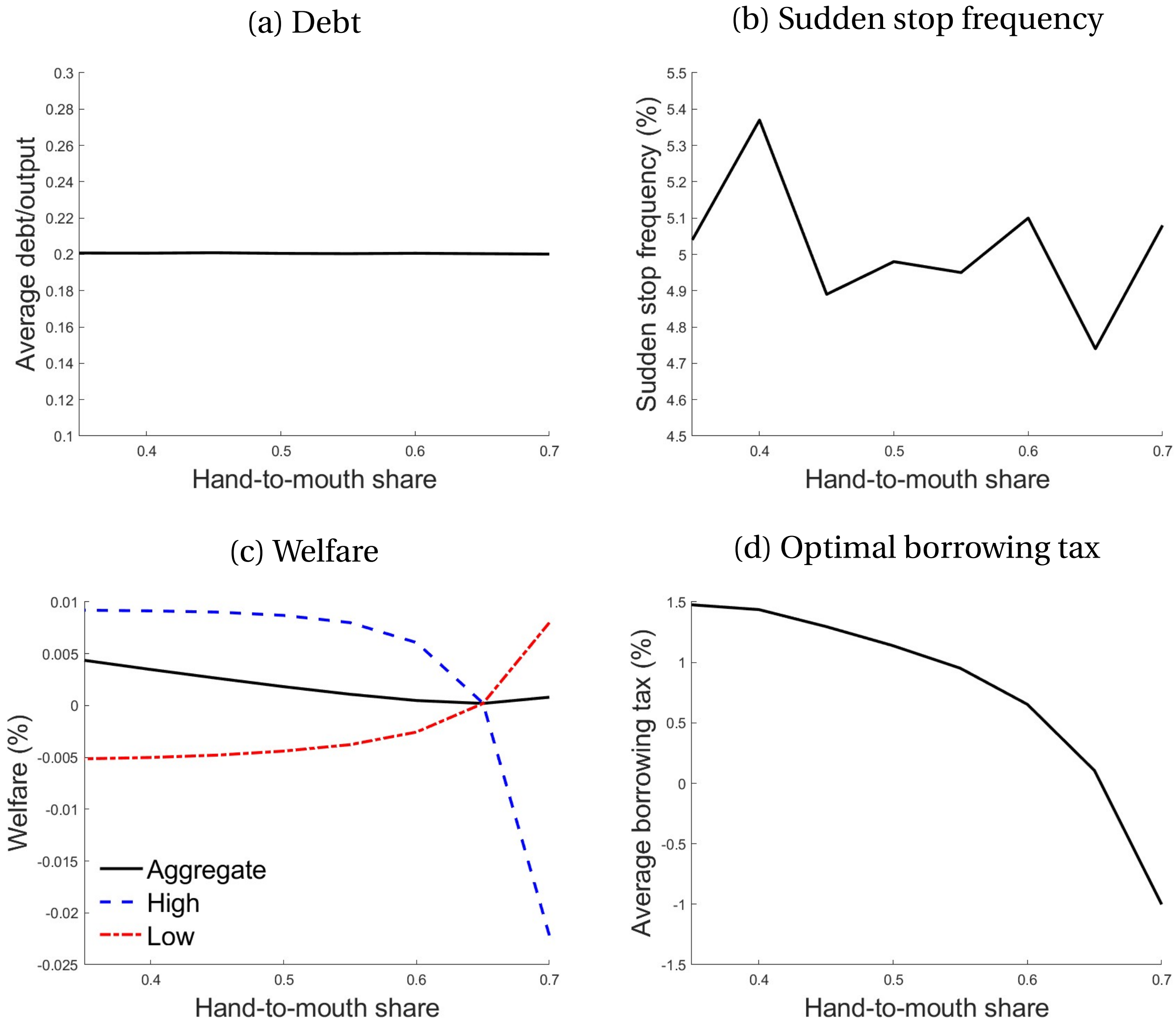


Figure 10: Effects of Hand-to-Mouth Share

Note: Figure 10 reports equilibrium outcomes as functions of the share of hand-to-mouth households. Panel (a) shows the average debt-to-output ratio, panel (b) the frequency of sudden stops, panel (c) welfare gains in expenditure-equivalent units, and panel (d) the average borrowing tax.

ing credit expansions, but also raises the future distributional cost when debt repayment lowers future tradable consumption and depreciates the real exchange rate. At the same time, nonhomotheticity strengthens the Fisherian mechanism by amplifying real exchange rate movements and their effect on collateral values. The optimal borrowing tax therefore reflects the changing balance between the contemporaneous distributional benefit, the future distributional cost, and the Fisherian cost of borrowing. This balance generates the nonmonotonic response of the optimal tax, which rises sharply at intermediate levels of nonhomotheticity before declining.

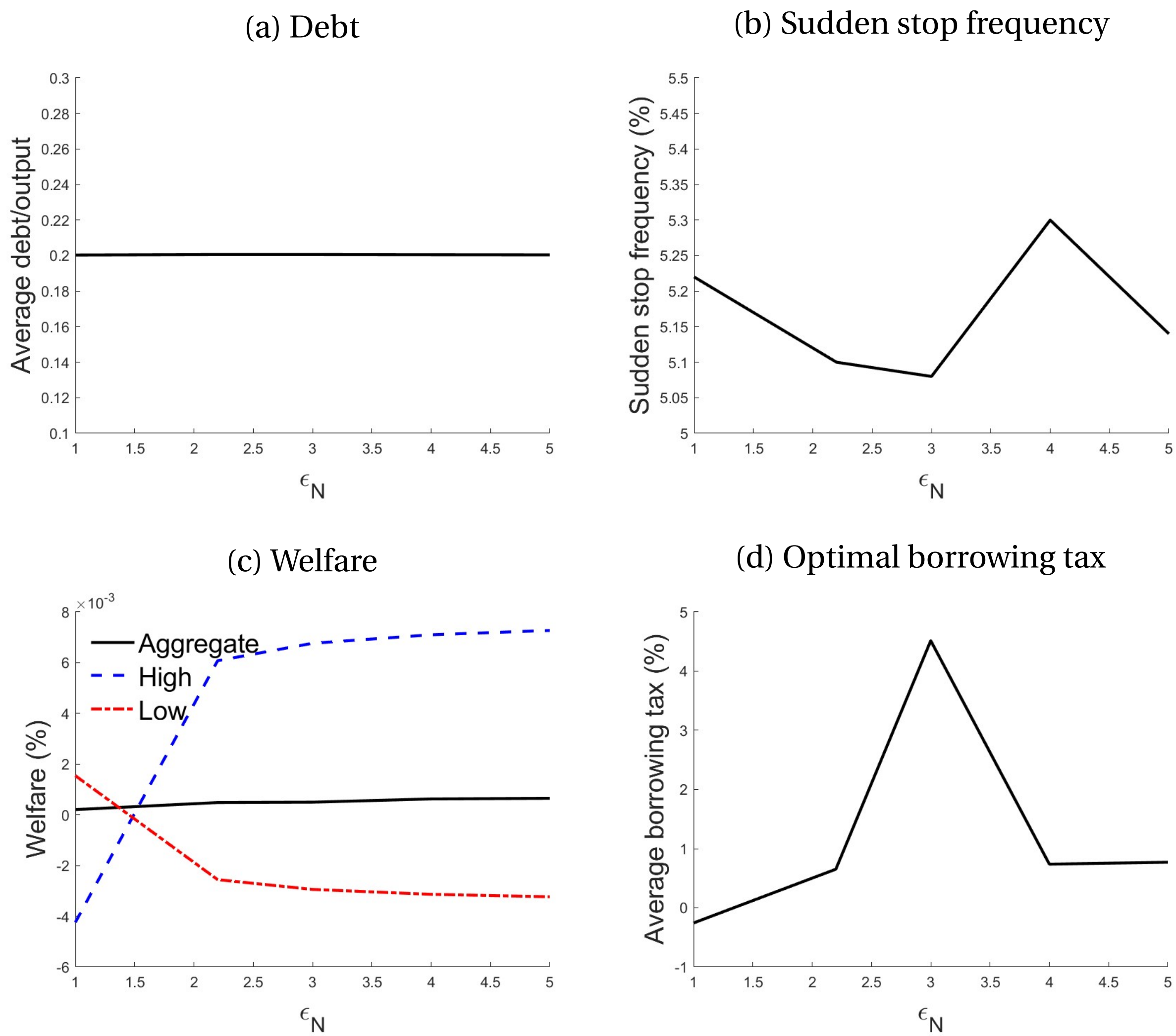


Figure 11: Effects of Nonhomotheticity

Note: Figure 11 reports equilibrium outcomes as functions of the degree of nonhomotheticity, governed by ϵ_N. Panel (a) shows the average debt-to-output ratio, panel (b) the frequency of sudden stops, panel (c) welfare gains in expenditure-equivalent units, and panel (d) the average borrowing tax.

5 Conclusion

This paper studies how household inequality shapes the dynamics and welfare consequences of sudden stops and the design of optimal macroprudential policy in emerging market economies. We develop a heterogeneous-agent small open economy model with nonhomothetic preferences in which high-income households borrow internationally subject to collateral constraints, while low-income households are hand-to-mouth. The framework allows real exchange rate movements to affect households differently across the income distribution and creates an interaction between financial stability and distributional considerations.

The model features two externalities operating through the real exchange rate. In addition to the standard Fisherian debt-deflation externality, borrowing generates a distributional externality by changing the purchasing power of hand-to-mouth households. Credit expansions appreciate the real exchange rate and generate a contemporaneous distributional benefit, while servicing the resulting debt lowers future tradable consumption and reverses part of this redistribution. During sudden stops, deleveraging amplifies the associated depreciation. Because low-income households devote a larger share of expenditure to tradables under nonhomothetic preferences, crisis depreciations impose disproportionately larger losses on them. The planner therefore trades off the contemporaneous distributional benefits of credit expansions against the future distributional and Fisherian costs of borrowing.

Quantitatively, constrained efficiency reduces leverage and crisis severity in the baseline economy, but the adjustment and associated welfare gains are modest relative to the standard representative-agent benchmark. Household heterogeneity weakens the conventional macroprudential motive because hand-to-mouth households benefit from credit expansions and are not directly exposed to deleveraging. With homothetic preferences, their ability to substitute toward nontradables during crises further limits the future distributional cost of borrowing. As a result, the contemporaneous distributional benefit of credit expansion substantially offsets the Fisherian motive to restrict borrowing. Nonhomotheticity magnifies both sides of the distributional trade-off. It increases the contemporaneous benefit generated by real appreciation during credit expansions but also increases the future distributional cost associated with debt repayment and crisis depreciations. At the same time, it amplifies the Fisherian contraction. Quantitatively, the larger future costs become particularly important in crisis states and partially restore the planner's incentive to reduce financial vulnerability.

These forces imply a more accommodative optimal macroprudential policy than in the representative-agent benchmark. The optimal tax can be decomposed into a conventional Fisherian component, a future distributional cost, and a contemporaneous distributional benefit. Borrowing subsidies can be optimal at low levels of debt, when the contemporaneous distributional benefit of credit expansion is relatively important, while borrowing taxes become positive as leverage rises and the future Fisherian and distributional costs of borrowing become more important. Around sudden stops, policy tightens in the run-up to the crisis but remains accommodative afterward, when leverage is low and renewed credit expansion again raises the purchasing power of hand-to-mouth households.

The comparative statics further show that different dimensions of heterogeneity operate through distinct channels. Greater income inequality raises leverage and the incidence of sudden stops by concentrating resources among households with access to international borrowing. It also magnifies the distributional consequences of real exchange rate movements, with the contemporaneous distributional benefit becoming more important relative to the future distributional and Fisherian costs, lowering the optimal borrowing tax. A larger share of hand-to-mouth households has little effect on aggregate crisis dynamics but similarly strengthens the distributional motive, lowering the optimal tax and shifting welfare gains toward low-income households. Nonhomotheticity also has limited effects on average debt and crisis incidence, but magnifies both the contemporaneous and future distributional effects and generates a nonmonotonic response of optimal policy as their relative importance changes. Across these exercises, aggregate welfare gains remain small despite substantial changes in their incidence across households.

Overall, the results show that the distributional incidence of real exchange rate movements is central to the design of macroprudential policy. Policies that reduce financial vulnerability also alter both the contemporaneous gains from credit expansions and the future distributional costs of servicing debt. Accounting for these effects can substantially dampen the conventional case for restricting capital inflows and can even make borrowing subsidies optimal when leverage is low. An important avenue for future research is to extend the framework to incorporate idiosyncratic income risk, fiscal redistribution, and interactions between macroprudential and social insurance policies.

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Appendix

A Data

A.1 Peruvian National Household Survey ENAHO

The Peruvian National Household Survey (Encuesta Nacional de Hogares, ENAHO), conducted annually by the National Institute of Statistics and Informatics (INEI), is a nationally representative survey designed to monitor living conditions and socioeconomic outcomes in Peru. ENAHO collects detailed information on demographics, labor markets, education, health, housing, income, and expenditures. In this paper, we rely specifically on the income and consumption modules. The income module provides granular information on labor earnings, self-employment income, transfers, and other revenue sources, which we use to construct the income distribution and measure inequality between the top 50 percent and bottom 50 percent of households. The consumption module reports detailed household expenditures across a wide range of goods and services, allowing us to aggregate spending into tradable and nontradable categories.

A.2 List of countries

The countries used for Figure 1 are

Advanced economies Australia, Austria, Belgium and Luxembourg, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Kingdom, United States

Emerging economies Argentina, Bangladesh, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Guatamala, Hungary, India, Indonesia, Malaysia, Mexico, Panama, Peru, Philippines, Poland, Romania, Russia, South Africa, Sri Lanka, Thailand, Turkey, Venezuela

B Equilibrium under Hicksian Demand

In this section, we show the derivations of the equilibrium allocation and price under the Hicksian demand. Given $E^i = c^{T,i} + P^N c^{N,i}$ is the expenditure, the Hicksian demands for tradable and nontradable consumption are

$$\begin{aligned} c^{i,T} =& \omega^{\frac{1}{1+\eta}} \left(E^i\right)^{\frac{1}{1+\eta}} \left(c^i\right)^{\epsilon_T - \frac{1}{1+\eta}} \\ c^{i,N} =& (1-\omega)^{\frac{1}{1+\eta}} \left(\frac{E^i}{P^N}\right)^{\frac{1}{1+\eta}} \left(c^i\right)^{\epsilon_N - \frac{1}{1+\eta}}, \end{aligned}$$

which implies that the expenditure can be written in terms of composite consumption and the price of nontradables.

$$E^i = \left[\omega^{\frac{1}{1+\eta}} \left(c^i\right)^{\epsilon_T - \frac{1}{1+\eta}} + (1-\omega)^{\frac{1}{1+\eta}} \left(P^N\right)^{\frac{\eta}{1+\eta}} \left(c^i\right)^{\epsilon_N - \frac{1}{1+\eta}}\right]^{\frac{1+\eta}{\eta}}$$

Using the nontradable resource constraint, one can get the equilibrium price of nontradables to be

$$P^N = (1-\omega)\left[\pi(E^L)^{\frac{1}{1+\eta}}(c^L)^{\epsilon_N - \frac{1}{1+\eta}} + (1-\pi)(E^H)^{\frac{1}{1+\eta}}(c^H)^{\epsilon_N - \frac{1}{1+\eta}}\right]^{1+\eta} \tag{8}$$

C Consumption of hand-to-mouth

Table C.1 provides additional evidence on the mechanism behind the heterogeneous-homothetic model. Under constrained efficiency, hand-to-mouth households consume slightly more tradables in noncrisis states and slightly fewer during sudden stops, while their nontradable consumption moves in the opposite direction. Their composite consumption is marginally higher in both states. Thus, the planner does not primarily improve their welfare by stabilizing crisis consumption. Instead, it reallocates their consumption across goods and states, allowing greater substitution toward relatively cheaper nontradables when the real exchange rate depreciates.

This pattern contrasts with the baseline economy. With nonhomothetic preferences, crisis depreciations are more costly for hand-to-mouth households because tradables account for a larger share of their expenditure. The planner therefore limits the depreciation and the associated relative-price adjustment: tradable consumption falls less during crises, while the increase in nontradable consumption is attenuated. This difference helps explain the contrasting macroprudential outcomes across the two specifications.

Table C.1: Consumption of Hand-to-Mouth Households Across States

	Heterogeneous–Homothetic		Baseline	
	DE	CE	DE	CE
Tradable consumption				
Noncrisis	0.66289	0.66292	0.70646	0.70628
Crisis	0.58478	0.58446	0.61681	0.62125
Change in crisis (%)	-11.782	-11.835	-12.690	-12.040
Nontradable consumption				
Noncrisis	0.67110	0.67109	0.64535	0.64540
Crisis	0.68972	0.68999	0.66816	0.66505
Change in crisis (%)	2.774	2.816	3.535	3.045
Composite consumption				
Noncrisis	0.66783	0.66784	0.92582	0.92581
Crisis	0.64851	0.64853	0.92003	0.92003
Change in crisis (%)	-2.893	-2.892	-0.625	-0.624

Note: The table reports average consumption of low-income hand-to-mouth households in crisis and noncrisis states under the Decentralized Equilibrium (DE) and Constrained Efficiency (CE). "Change in crisis" denotes the percentage change in consumption relative to noncrisis periods.

With homothetic preferences, intratemporal substitution limits the distributional cost of sudden stops, allowing the planner to preserve the gains from credit expansions even at the cost of somewhat greater crisis risk. In the baseline, nonhomotheticity raises the distributional cost of crisis depreciations and restores the planner's incentive to reduce the incidence and severity of sudden stops.

D Proof

D.1 Proof of Proposition 2.1

Proof. When the current borrowing constraint is slack, $\mu^{SP} = 0$, and the planner's Euler equation is

$$\Lambda = \frac{\beta}{Q}\mathbb{E}\left[\Lambda' + \mu^{SP\prime}\Psi^{F\prime}\right]. \tag{C.1}$$

Using $\Lambda = U_T^H + \Psi^D$, this condition can be written as

$$U_T^H + \Psi^D = \frac{\beta}{Q}\mathbb{E}\left[U_T^{H\prime} + \Psi^{D\prime} + \mu^{SP\prime}\Psi^{F\prime}\right]. \tag{C.2}$$

Rearranging gives

$$U_T^H = \frac{\beta}{Q}\mathbb{E}\left[U_T^{H\prime}\right] + \frac{\beta}{Q}\mathbb{E}\left[\Psi^{D\prime}\right] + \frac{\beta}{Q}\mathbb{E}\left[\mu^{SP\prime}\Psi^{F\prime}\right] - \Psi^D. \tag{C.3}$$

The Euler equation of a high-income household facing the macroprudential tax is

$$U_T^H = \frac{\beta}{Q}(1+\tau)\mathbb{E}\left[U_T^{H\prime}\right], \tag{C.4}$$

where the lump-sum rebate of tax revenues is taken as given by the household. Combining equations (C.3) and (C.4) yields

$$\frac{\beta}{Q}\tau\mathbb{E}\left[U_T^{H\prime}\right] = \frac{\beta}{Q}\mathbb{E}\left[\mu^{SP\prime}\Psi^{F\prime}\right] + \frac{\beta}{Q}\mathbb{E}\left[\Psi^{D\prime}\right] - \Psi^D. \tag{C.5}$$

Dividing by $(\beta/Q)\mathbb{E}[U_T^{H\prime}]$ gives

$$\tau = \frac{\mathbb{E}\left[\mu^{SP\prime}\Psi^{F\prime}\right]}{\mathbb{E}\left[U_T^{H\prime}\right]} + \frac{\mathbb{E}\left[\Psi^{D\prime}\right]}{\mathbb{E}\left[U_T^{H\prime}\right]} - \frac{Q}{\beta}\frac{\Psi^D}{\mathbb{E}\left[U_T^{H\prime}\right]}, \tag{C.6}$$

which establishes the decomposition in equation (19). □