Overborrowing, Underborrowing, and Macroprudential Policy*

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Abstract

In this paper, we revisit the scope for macroprudential policy in production economies with pecuniary externalities and collateral constraints. We study competitive equilibria and constrained-efficient equilibria and examine the extent to which the gap between the two depends on the production structure and the policy instruments available to the planner. We argue that macroprudential policy is desirable regardless of whether the competitive equilibrium features more or less borrowing than the constrained-efficient equilibrium. In our quantitative analysis, macroprudential taxes on borrowing turn out to be larger when the government has access to ex-post stabilization policies.

Keywords: Macroprudential policy, over-borrowing, under-borrowing

JEL Classifications: E58, F31, F32, F34

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1 Introduction

After the 2008 global financial crisis, many countries upgraded their policy toolkit with macroprudential tools designed to prevent the buildup of excessive risks and vulnerabilities. A key theoretical foundation for the adoption of these policies is pecuniary externalities. In particular, a body of work has shown that collateral constraints linked to market prices may cause "overborrowing" and therefore call for macroprudential interventions to restrict external borrowing ahead of financial crises (e.g., Bianchi 2011). Other studies, however, have questioned the robustness of this prescription, arguing that, in the context of production economies, agents may instead "underborrow," and suggested that macroprudential policies may be either undesirable or unnecessary (e.g., Benigno, Chen, Otrok, Rebucci and Young 2013).[1]

In this paper, we revisit the foundations for macroprudential policies in a production economy. Using a canonical model with pecuniary externalities, we study constrained-efficient equilibria where we vary the planner's ability to control market allocations and examine the associated decentralization. We show that even in configurations in which the constrained-efficient equilibrium features *higher levels of borrowing* that under laissez-faire, macroprudential policy remains desirable. The logic is that macroprudential taxes are needed ex-ante to make agents internalize the full social costs of debt, regardless of whether the planner is able to alleviate the severity of crises ex-post. Furthermore, we also find that taxes turn out to be larger when the government has access to ex-post stabilization policies.

We analyze a two-sector small open economy model with production and imperfect financial markets, building on the framework developed by Mendoza (2002) and Bianchi (2011). In this economy, households face a credit constraint linked to the market price of non-tradable goods. Standard shocks to income can trigger sharp contractions in borrowing capacity through a feedback loop between consumption and the price of non-tradables. We first consider a scenario in which the planner can control the level of borrowing subject to the credit constraint, letting goods and labor markets clear competitively. We show that a macroprudential tax on debt can decentralize the constrained-efficient allocations, as in Bianchi (2011)'s endowment economy model. We then consider a scenario in which the

[1] Benigno et al. (2013) find that in a production economy, a constrained-efficient planner *borrows more* than private agents in the competitive equilibrium and argue that "...adopting only ex ante interventions such as macro-prudential policies or capital controls may be costly in welfare terms. For example, a small macro-prudential tax on debt that lowers the probability of a crisis to zero is welfare-reducing in our model because it also lowers average consumption." Echoing these findings, in a recent survey, Rebucci and Ma (2020) argue that: "...with a production margin that affects the collateral value in the borrowing constraint, capital controls alone cannot restore constrained efficiency and are generally suboptimal policy instruments."

planner can also reallocate labor across sectors and thus resort to an ex-post stabilization policy. In this case, we find that such interventions lead to an increase in borrowing ex-ante, a result that echoes Benigno et al. (2013) who consider an analogous planning problem but do not examine the question of decentralization. Our analysis demonstrates that a strictly positive tax on debt in normal times remains needed to decentralize the constrained-efficient allocations. Moreover, we find that taxes can actually be larger despite the laissez-faire economy featuring less borrowing.

In addition to the work mentioned above, our paper is complementary to other studies on pecuniary externalities and inefficient borrowing. Dávila and Korinek (2018) find that externalities operating through redistributive effects under incomplete markets can lead to over- or under-borrowing as well as over- or under-investment. Drechsel and Kim (2022) show that with earning-based borrowing constraints, firms may underborrow as higher debt reduces equilibrium factor prices and thereby relaxes borrowing constraints.[2] Benigno et al. (2016) study Ramsey optimal policy in an endowment economy and find that when price support policies require distortionary taxes, the optimal policy also involves a tax on debt.[3] Schmitt-Grohé and Uribe (2021) find that the possibility of self-fulfilling financial crises leads to too little borrowing relative to the constrained planner's allocations. Finally, in the context of different models, several studies have examined interactions between ex-ante and ex-post policies, including Bianchi (2016), Bornstein and Lorenzoni (2018), and Jeanne and Korinek (2020).

2 Model

We consider a dynamic small open economy model with production of tradable and non-tradable goods. The economy is populated by a continuum of identical households that borrow externally, subject to an occasionally binding borrowing constraint.

[2] In a similar vein, Bianchi and Mendoza (2010) point to an attenuation effect of overborrowing through the wage bill and working capital.

[3] Benigno et al. (2023) studies a richer set of policy instruments in a production economy and show how the unconstrained equilibrium can be implemented. Vargas and Parra-Polania (2021) highlight how fiscal constraints can impose limits on price support policies.

2.1 Households' problem

Households' preferences are given by

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

where $\mathbb{E}_0$ is the expectation operator conditional on date 0 information; $0 < \beta < 1$ is a discount factor; $u(\cdot)$ is a standard increasing, concave, and twice continuously differentiable function satisfying the Inada conditions. Consumption c_t is an Armington-type constant elasticity of substitution (CES) aggregator with elasticity of substitution $1/(\eta+1)$ between tradable goods c_t^T and non-tradable goods c_t^N, given by

$$c_t = \left[\omega \left(c_t^T\right)^{-\eta} + (1-\omega)\left(c_t^N\right)^{-\eta}\right]^{-\frac{1}{\eta}}, \qquad \text{with} \quad \eta > -1, \omega \in (0,1).$$

In each period, households are endowed with a fixed number of hours $\bar{h}$, are perfectly mobile across sectors, and do not value leisure. They receive a competitive wage for their labor, as well as profits from firms in the tradable and non-tradable sectors.[4]

Households can borrow (or save) using a one-period non-state-contingent bond b_{t+1} denominated in units of tradables that pays a constant interest rate R exogenously determined in international capital markets.[5] Their budget constraint, in units of tradables, is given by

$$c_t^T + p_t^N c_t^N - \frac{b_{t+1}}{R} = w_t \bar{h} + \pi_t^T + \pi_t^N - b_t, \tag{2}$$

where p_t^N is the price of non-tradables, w_t is the wage, and π_t^T and π_t^N are profits from tradable and non-tradable producing firms. In addition, following Mendoza (2002), Bianchi (2011), and Benigno et al. (2013), households face a credit constraint given by

$$\frac{b_{t+1}}{R} \leq \kappa \left(w_t \bar{h} + \pi_t^T + \pi_t^N\right). \tag{3}$$

The constraint captures in a parsimonious way, the empirical fact that income is critical in determining households' credit-market access (see, e.g., Jappelli, 1990; Lian and Ma, 2021), and from a macro perspective, it has been shown to be important for accounting for the

[4] In a minor departure from Benigno et al. (2013), we do not consider leisure in the utility function. This assumption simplifies the analysis without affecting our theoretical results. For the quantitative analysis, it also helps avoid a counterfactual increase in employment during sudden stops events.

[5] Assuming no foreign inflation, this condition is equivalent to denominating the bonds in foreign currency, capturing the liability dollarization phenomenon.

dynamics of capital flows in emerging markets.[6]

Households choose consumption and borrowing to maximize their utility (1), subject to their budget constraint (2) and credit constraint (3), taking prices and taxes as given. Their optimality conditions are given by

$$p_t^N = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1}, \tag{4}$$

$$\lambda_t = u_T(t), \tag{5}$$

$$\lambda_t = \beta R \mathbb{E}_t \lambda_{t+1} + \mu_t, \tag{6}$$

$$0 = \mu_t \left[\kappa\left(w_t \bar{h} + \pi_t^T + \pi_t^N\right) - \frac{b_{t+1}}{R}\right], \tag{7}$$

where $u_T(t)$ is shorthand notation for $\frac{\partial u}{\partial c}\frac{\partial c}{\partial c^T}$ and μ_t denotes the non-negative Lagrange multiplier on the borrowing constraint. Condition (4) is a static optimality condition equating the marginal rate of substitution between tradable and non-tradable goods to their relative price. Condition (5) equates the marginal utility of tradable consumption to the shadow value of current wealth. Condition (6) is the household's Euler equation for debt, where $\mu_t \geq 0$ is the multiplier on the credit constraint (3). Finally, condition (7) is the household's complementary slackness condition. When $\mu_t > 0$, the credit constraint binds, and the marginal utility benefits from increasing tradable consumption today exceed the expected marginal utility costs from borrowing one unit and repaying next period.

2.2 Firms' problem

The tradable and non-tradable goods are produced by competitive firms that maximize profits and respectively solve

$$\max_{h_t^T} z_t^T (h_t^T)^\alpha - w_t h_t^T, \tag{8}$$

$$\max_{h_t^N} p_t^N z^N (h_t^N)^\alpha - w_t h_t^N, \tag{9}$$

where z_t^T is a stochastic productivity shock, while z^N and α are constant parameters.

[6] The credit constraint can be derived endogenously from a problem of limited enforcement under the assumption that if households default at the end of the period, they lose a fraction κ of the current income, and immediately regain access to credit markets (see Bianchi and Mendoza, 2018, for a derivation of a similar constraint). The ability to borrow could also depend on future income in addition to current income, but as emphasized by Ottonello et al. (2022), what is crucial for the analysis is that borrowing is at least partially leveraged on current income.

The tradable and non-tradable goods firms' optimality conditions are respectively given by

$$w_t = z_t^T \alpha \left(h_t^T\right)^{\alpha-1}, \tag{10}$$

$$w_t = p_t^N z^N \alpha \left(h_t^N\right)^{\alpha-1}. \tag{11}$$

Combining (10) and (11), we obtain

$$1 = \frac{z^N \left(h_t^N\right)^{\alpha-1}}{z_t^T \left(h_t^T\right)^{\alpha-1}} p_t^N. \tag{12}$$

This expression implies that increases in the relative price of non-tradables are associated with a shift in employed hours toward the non-tradable sector.

2.3 Competitive equilibrium

In equilibrium, the market for non-tradable goods must clear domestically and total labor demand by firms must equal $\bar{h}$. That is, we must have

$$c_t^N = z^N (h_t^N)^\alpha, \tag{13}$$

$$\bar{h} = h_t^N + h_t^T. \tag{14}$$

We can now define a competitive equilibrium:

Definition 1. *The competitive equilibrium is given by a sequence of prices* $\left\{p_t^N, w_t\right\}_{t=0}^\infty$ *and allocations* $\left\{c_t^N, c_t^T, h_t^N, h_t^T, b_{t+1}\right\}_{t=0}^\infty$ *such that:*

i) Households optimize. That is, (2)-(7) are satisfied.

ii) Firms optimize. That is, (10)- (11) are satisfied.

iii) Markets clear. That is, (13) and (14) hold.

3 Normative Analysis

We now analyze the normative properties of this economy. We consider two cases. First, we look at the case of a planner that directly controls the level of debt, but lets markets for labor and goods clear competitively. Second, we consider a case in which the planner can also choose the allocation of labor across sectors in addition to choosing the level of debt, and lets only the goods market clear competitively.

3.1 Ex-ante macroprudential intervention

We first assume that the planner directly controls only the level of debt, while the labor and goods markets clear competitively. While the planner cannot directly choose the labor allocations, it internalizes how its borrowing choices affect employment across sectors. In recursive form, the planner's problem can be written as

$$V(b, z^T) = \max_{c^T, c^N, h^T, h^T, b'} u(c^T, c^N) + \beta \mathbb{E} V(b', z^{T\prime}) \tag{15}$$

subject to

$$c^T - \frac{b'}{R} = z^T \left(h^T\right)^\alpha - b, \tag{15a}$$

$$c^N = z^N \left(h^N\right)^\alpha, \tag{15b}$$

$$\bar{h} = h^T + h^N, \tag{15c}$$

$$\frac{b'}{R} \leq \kappa \left[z^T \left(h^T\right)^\alpha + \frac{1-\omega}{\omega} \left(\frac{c^T}{c^N}\right)^{\eta+1} z^N \left(h^N\right)^\alpha \right], \tag{15d}$$

$$\frac{z^T}{z^N} \left(\frac{h^T}{h^N}\right)^{\alpha - 1} = \frac{1-\omega}{\omega} \left(\frac{c^T}{c^N}\right)^{\eta+1}, \tag{15e}$$

where (15a) is the resource constraint for tradable goods, (15b) is the resource constraint for non-tradable goods, (15c) is the time constraint for labor, (15d) is the credit constraint, and (15e) is an implementability constraint associated to firms' and households' optimal intratemporal choices. When both the labor and goods market clear competitively, the marginal rate of substitution is equal to the marginal rate of transformation between goods.

Returning to sequential notation, the planner's Euler equation for debt is given by

$$\lambda_t = \beta R \mathbb{E}_t \lambda_{t+1} + \mu_t, \tag{16}$$

its credit constraint is given by

$$-\frac{b_{t+1}}{R} + \kappa \left[z_t^T \left(h_t^T\right) \alpha + \frac{1-\omega}{\omega} \left(\frac{c_t^T}{c_t^N}\right)^{\eta+1} z^N \left(h_t^N\right) \alpha \right] \geq 0, \tag{17}$$

and its complementary slackness condition is

$$\left\{-\frac{b_{t+1}}{R}+\kappa\left[z_t^T\left(h_t^T\right)\alpha+\frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1}z^N\left(h_t^N\right)\alpha\right]\right\}\mu_t=0. \tag{18}$$

Meanwhile, its remaining optimality conditions for c_t^T, c_t^N, h_t^T and h_t^N are given by

$$\lambda_t=u_T(t)+\left(\mu_t\kappa+\frac{\nu_t}{c_t^N}\right)(1+\eta)\frac{p_t^Nc_t^N}{c_t^T}, \tag{19}$$

$$\delta_t=u_N(t)-\left(\mu_t\kappa+\frac{\nu_t}{c_t^N}\right)(1+\eta)p_t^N, \tag{20}$$

$$\chi_t=\left(\lambda_t+\mu_t\kappa\right)z_t^T\alpha\left(h_t^T\right)^{\alpha-1}-\nu_t\left(\alpha-1\right)p_t^N\frac{1}{h_t^T}, \tag{21}$$

$$\chi_t=\left(\delta_t+\mu_t\kappa p_t^N\right)z^N\alpha\left(h_t^N\right)^{\alpha-1}+\nu_t\left(\alpha-1\right)p_t^N\frac{1}{h_t^N}, \tag{22}$$

where λ_t, δ_t, χ_t, μ_t and ν_t respectively denote the multipliers on constraints (15a), (15b), (15c), (15d) and (15e). Equations (19) and (20) equate the marginal utility benefits of tradable and non-tradable consumption to their marginal utility costs while (21) and (22) are the analogous conditions for tradable and non-tradable employment. Crucially, these conditions incorporate how changes in allocations alter the tightness of the collateral constraint, as captured by the terms featuring μ_t.

Combining (15c) and (19)-(22) to eliminate the multipliers δ_t, χ_t and ν_t leads to the following expression

$$\lambda_t=u_T(t)+\mu_t\widetilde{\Psi}_t, \tag{23}$$

where $\widetilde{\Psi}_t=\Psi_t\Upsilon_t$, with

$$\Psi_t\equiv(1+\eta)\kappa(p_t^Nc_t^N)/c_t^T$$
$$\Upsilon_t\equiv\frac{\frac{1-\alpha}{\alpha}\frac{\bar{h}}{h_t^T}}{\frac{1-\alpha}{\alpha}\frac{\bar{h}}{h_t^T}+(1+\eta)\left[c_t^T/(c_t^T+p_t^Nc_t^N)\right]^{-1}}.$$

Comparing (23) with (5) reveals that the social planner has a higher shadow value of wealth than private agents when the collateral constraint binds. The valuation wedge is the product of the planner's shadow value of the constraint μ_t with the term $\widetilde{\Psi}_t$. This later term, which measures the extent to which the collateral constraint is relaxed by an additional unit of tradable consumption is itself the product of two terms, Ψ_t and Υ_t. The term Ψ_t, also present in Bianchi (2011)'s endowment economy model, captures the elasticity of the collateral value with respect to a change in tradable consumption, *for a given level of non-tradable goods consumption*. The attenuation term Υ_t, which is specific to production economies, accounts for the fact that any rise in tradable consumption, by pushing up the price of non-tradables, reallocates labor towards the non-tradable sector and thereby also raises non-tradable consumption in equilibrium. In turn, this rise in non-tradable consumption mutes some of the increase in the price of non-tradable, so the general equilibrium elasticity of the collateral value is lower in the production economy than in a benchmark endowment economy where non-tradable consumption would be constant.

We obtain the following proposition:

Proposition 1 (Decentralization with ex ante intervention)**.** *Consider the allocations that solve the optimal policy problem* (15)*. These allocations can be decentralized as a competitive equilibrium with a state contingent tax on debt rebated with lump sum transfers. In states in which the borrowing constraint is not binding, the tax on debt is given by:*

$$\tau_t = \frac{\mathbb{E}_t \mu_{t+1} \widetilde{\Psi}_{t+1}}{\mathbb{E}_t u_T(t+1)} \geq 0, \tag{24}$$

Proof. See Appendix A.1. ∎

Thus, the desirability of a strictly positive tax on borrowing in Bianchi (2011) extends to the case with production. Failing to internalize that additional tradable consumption would support the equilibrium price of non-tradable goods and relax credit constraints, private households borrow too much relative to what is socially optimal.[7]

3.2 Ex-ante and ex-post interventions

In the preceding section, we examined a scenario where the planner had the ability to solely control the debt level. We now allow the planner to *also control the allocation of labor across*

[7] When the borrowing constraint is binding, one can show that the tax on borrowing that implements the optimal policy is zero if $\mu_{t+1}\tilde{\Psi}_{t+1} + \mu_t (1 - \Psi_t) \geq 0$.

sectors. In this case, the planner's problem is given by

$$V(b, z^T) = \max_{c^T, c^N, h^T, h^T, b'} u(c^T, c^N) + \beta \mathbb{E} V(b', z^{T\prime}) \tag{25}$$

subject to

$$c^T - \frac{b'}{R} = z^T \left(h^T\right)^{\alpha} - b, \tag{25a}$$

$$c^N = z^N \left(h^N\right)^{\alpha}, \tag{25b}$$

$$\bar{h} = h^T + h^N, \tag{25c}$$

$$\frac{b'}{R} \leq \kappa \left[z^T \left(h^T\right)^{\alpha} + \frac{1-\omega}{\omega} \left(\frac{c^T}{c^N}\right)^{\eta+1} z^N \left(h^N\right)^{\alpha} \right]. \tag{25d}$$

The difference with problem (15) is that the implementability constraint (15e) associated with the intratemporal allocation of labor across sector can now be dropped. The planner can now choose to clear the labor market at a marginal rate of transformation between goods that can be different from the marginal rate of substitution between goods.

Again using the same sequential notation for convenience, we get that the planner's Euler equation for debt, its credit constraint and its complementary slackness condition are still given by (16), (17) and (18), while its remaining optimality conditions for c_t^T, c_t^N, h_t^T and h_t^N are now given by

$$\lambda_t = u_T(t) + \mu_t \Psi_t, \tag{26}$$

$$\delta_t = u_N(t) - \mu_t \kappa (1+\eta) p_t^N, \tag{27}$$

$$\chi_t = (\lambda_t + \mu_t \kappa)\, z_t^T \alpha \left(h_t^T\right)^{\alpha-1}, \tag{28}$$

$$\chi_t = \left(\delta_t + \mu_t \kappa p_t^N\right) z^N \alpha \left(h_t^N\right)^{\alpha-1}, \tag{29}$$

where $\lambda_t, \delta_t, \chi_t$ and μ_t again respectively denote the multipliers on constraints (25a), (25b), (25c) and (25d). In contrast to the regime with only ex-ante intervention, characterized by (23), condition (26) equating the marginal benefits of tradable consumption to its marginal cost is now *identical* to its endowment economy model counterpart (cf. Bianchi 2011, equation 12). The reason is that unlike in the case without ex post intervention, here a higher price of non-tradable does not automatically trigger a labor reallocation toward the non-tradable sector, since the planner is not bound by a private allocation of labor across sectors. As a result, despite non-tradable consumption being endogenous, the elasticity of the collateral value with respect to changes in tradable consumption is given by Ψ_t, and the externality relevant for the planner is the same as in the endowment economy model.

We obtain the following proposition.

Proposition 2 (Decentralization with ex ante and ex post intervention)**.** *Consider the allocations that solve the optimal policy problem* (25)*. These allocations can be decentralized as a competitive equilibrium with a state contingent tax on debt and a payroll tax on non-tradable labor, both rebated lump sum. In states in which the borrowing constraint is not binding, the tax on debt is given by*

$$\tau_t = \frac{\mathbb{E}_t \mu_{t+1} \Psi_{t+1}}{\mathbb{E}_t u_T(t+1)} \geq 0. \tag{30}$$

The payroll tax on non-tradable labor is given by

$$\tau_t^N = \mu_t \kappa c_t^N \left(1+\eta\right) p_t^N \frac{\left(c_t^T\right)^{-1} + \left(c_t^N\right)^{-1} \frac{z^N \left(h_t^N\right)^{\alpha-1}}{z_t^T \left(h_t^T\right)^{\alpha-1}}}{u_T(t) + \mu_t \kappa} \geq 0. \tag{31}$$

Proof. See Appendix A.2. ∎

The proposition shows that a macroprudential debt tax is still warranted in this economy with ex-post government intervention. Irrespective of whether the planner has access to an ex-post stabilization policy or not, the optimal policy thus features a macroprudential tax on debt. The reason is that regardless of the planner's ability to distort the allocation of labor ex-post, private households always undervalue wealth in states of nature in which the credit constraint binds.

In addition, the proposition also shows that implementation requires a payroll tax on non-tradable labor. This tax is positive whenever the credit constraint binds for the planner (i.e., whenever $\mu_t > 0$). The logic is that in such cases, the planner optimally redirects production away from the non-tradable sector so as to support the price of non-tradable goods and relax the credit constraint at the margin.

Underborrowing and macroprudential policy. These results clarify a common misconception in the literature which posits that the case for macroprudential debt taxes is weaker (or absent) in production economies and/or when ex-post stabilization policies are available. This interpretation stems from the fact that in the presence of production and an ex-post policy margin, the optimal policy intervention often results—as we will see below—in higher borrowing than in the laissez-faire economy, a phenomenon referred by Benigno et al. (2013) as *underborrowing*.

Benigno et al. (2013), however, do not formally consider the decentralization of their planner problem. Our results for Propositions 1 and 2 clarify that even when there is underborrowing, restrictions or taxes on borrowing are desirable. That is, regardless of whether ex-post policies are available or whether there is production or not, macroprudential policy is desirable.[8] Intuitively, what is key for the macroprudential policy motive is that households face a private shadow cost of debt lower than the social one. This feature of the model is present irrespective of whether the laissez-faire economy features more or less borrowing compared to the optimal policy outcome.

4 Quantitative Analysis

We next proceed to study quantitatively how the set of instruments available to the planner matters for the levels of borrowing and taxes.[9]

4.1 Calibration

Our model calibration largely follows Bianchi (2011)'s calibration to Argentina. A period in the model represents a year. A first set of parameters is taken from the literature or estimated in the data outside of the model. The preference parameters for risk aversion and the elasticity of substitution are set to $\sigma = 2,\ 1/(1+\eta) = 0.83$. The value for the interest rate is set to 4%. The labor share $\alpha = 0.67$ coincides with the share of aggregate income that goes to labor as a percentage of GDP in household surveys (see Garcıa-Verdú, 2005), a standard value in quantitative sudden stop models with production (see Benigno et al., 2013).

A second set of parameters is calibrated so that the unregulated competitive equilibrium matches a set of moments from the data (following the same targets as in Bianchi, 2011). The relative preference for tradables is set to $\omega = 0.307$ to match the share of tradable GDP in the data. The discount factor $\beta = 0.91$ is set to match the average net foreign asset position to GDP ratio. The collateral constraint parameter is set to $\kappa = 0.32$ to match the observed frequency of sudden stops.[10]

[8] A reader may wonder why Benigno et al. (2013) find numerically that a 1% tax on debt is welfare reducing. Our analysis suggests that this is not a generic result in that even in their environment, a smaller tax on debt or a state-contingent tax would deliver welfare gains.

[9] We solve the model globally, following Bianchi (2011). We use a grid of 500 points for debt and 20 different values of the exogenous shocks. The laissez-faire economy and the economy with an ax-ante intervention are solved using time iteration. The economy with ex-ante ex-post intervention is solved using value function iteration.

[10] These parameters are equal to those used in Bianchi (2011).

To estimate the stochastic process of productivity in the tradable goods sector, we follow Arce et al. (2019). First, we construct a tradable GDP index for Argentina from the World Development Indicators from 1965 to 2007. We assume a first-order autoregressive process for the cyclical component of this series: $\ln y_t^T = \rho^y \ln y_{t-1}^T + \varepsilon_t^y$ with $\varepsilon_t^y \sim N(0, \sigma_y)$. We estimate values of $\rho^y = 0.5$ and $\sigma_y = 0.0502$. We then set the persistence parameter of the productivity shocks in the tradable sector to the persistence of tradable GDP and calibrate the volatility of the productivity shocks in the tradable sector to ensure that the standard deviation of the simulated tradable output at the ergodic distribution of the unregulated economy coincides with the one in the data. This method yields values of $\rho^z = 0.5$ and $\sigma_z = 0.0535$. A summary of parameter values is provided in Table 1.

Table 1: Parameter Values

	Value	Source/Targets
Interest Rate	$r = 0.04$	Standard value
Risk Aversion	$\sigma = 2$	Standard value
Elasticity of Substitution	$1/(1+\eta) = 0.83$	Standard value
Weight on Tradables in CES	$\omega = 0.32$	Share of tradable consumption
Discount Factor	$\beta = 0.91$	Net foreign asset position
Credit coefficient	$\kappa = 0.32$	Frequency of sudden stops
Labor share in production	$\alpha = 0.67$	Share of labor income in GDP
Stochastic structure z^T	$\rho^z = 0.5, \sigma_z = 0.0535$	Persistence and volatility of tradables

4.2 Ex-ante intervention only

Figure 1 plots the policy functions for debt issuance and for employment in the tradable sector as a function of the initial level of assets in the case in which the planner has access only to an ex-ante instrument. Policy functions from the laissez-faire economy are also plotted for comparison. As in Bianchi (2011) and most of the literature on overborrowing, we find that the planner chooses a lower level of borrowing when the credit constraint is not binding (panel a), relative to its level in the laissez-faire economy. We also find that the effect of this lower debt on relative prices leads to a higher level of labor allocated in the tradable sector when the constraint is not binding (panel b). However, for high enough initial levels of debt, the credit constraint binds, and the allocations of the regulated and laissez-faire economies coincide.

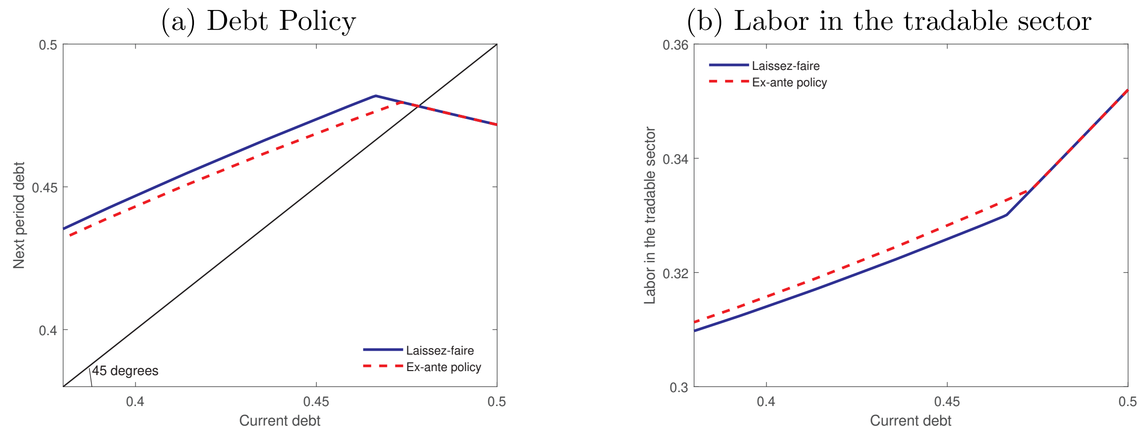

Figure 1: Policy functions: ex ante intervention

Note: In the both panels, the tradable productivity shock is set at the mean value.

4.3 Ex-ante and ex-post interventions

Figure 2 plots the policy functions for debt issuance and employment in the tradable sector as a function of the initial level of assets in the case in which the planner has access to both ex-ante and ex-post policies. Policy functions from the laissez-faire economy are once again plotted as a benchmark. This time, the level of borrowing in the regulated economy is always more than that in the laissez-faire economy (panel a), a phenomenon often referred to as *underborrowing* in the literature (Benigno et al., 2013). While the policy function for debt still exhibits a kink due to the credit constraint, the level of borrowing is always increasing in the current debt level.

The policy function for labor allocated to the tradable sector is helpful for understanding this feature (panel b). When the current level of debt is high enough to lead to a binding credit constraint, the planner seeks to relax the constraint by allocating more labor to the tradable sector. This in turn increases the collateral value and allows the economy to sustain a higher level of debt. Moreover, given that a binding collateral constraint can be alleviated in this way, the incentive to accumulate precautionary savings when the credit constraint is not binding is weaker than in the laissez-faire economy. As a result, the level of borrowing is also higher. This in turn appreciates the real exchange rate, increases wages, and reduces the share of labor employed in the tradable sector relative to their levels in the laissez-faire economy.

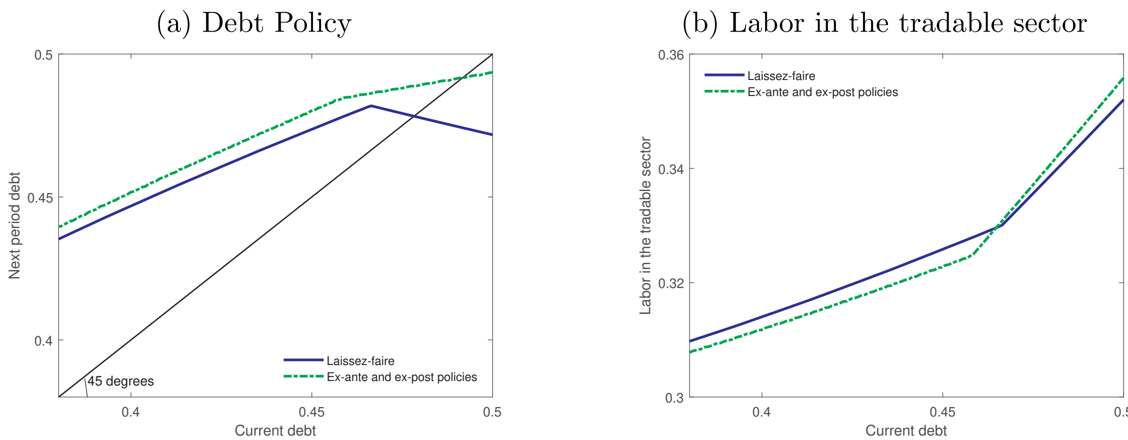

Figure 2: Policy functions: ex ante and ex post intervention

Note: In both panels, the tradable productivity shock is set at the mean value.

4.4 Policy Comparison: Ex-ante vs. Ex-ante and Ex-post

Figure 3 delves deeper into the comparison between the economy with only ex-ante intervention and the economy featuring both ex-ante and ex-post interventions. Panel (a) shows the ergodic distribution of debt for the two regulated economies as well as for the laissez-faire economy (blue). The economy with only ex-ante policies exhibits the least amount of debt, followed by the laissez-faire economy, and then the economy with ex-ante and ex-post policies.

Panel (b) shows the optimal tax on debt that implements the planner's allocations with only ex-ante policies (red) and with ex-ante and ex-post policies (green). In both cases, macroprudential policy is active only when the credit constraint is not binding. Interestingly, taxes on debt are higher in the economy with ex-ante and ex-post policies.

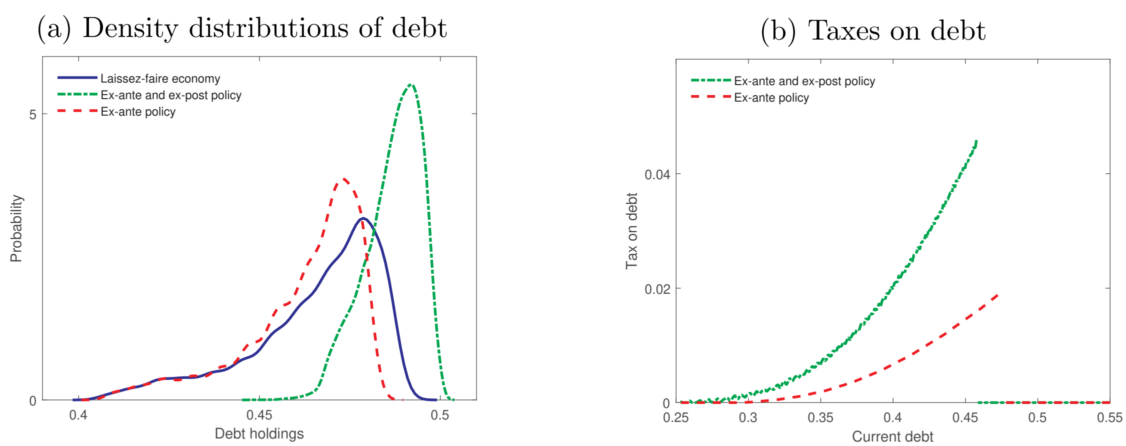

Figure 3: Policy functions for debt and labor in the tradable sector

Note: In panel (b), the tradable productivity shock is set at the mean value.

Why are taxes on debt higher with ex-post policies? The result that the optimal macroprudential tax on debt is higher in the economy where the government also has access to ex-post policy tools may seem surprising. Indeed, the ability to intervene ex-post can in principle mitigate the externality by relaxing a binding credit constraint, suggesting a weaker case for intervening ex-ante for a given level of borrowing. However, the anticipation of laxer future constraints reduces private precautionary savings motive and thereby raises the chosen level of borrowing. This higher level of borrowing in itself strengthens the case for ex-ante intervention.

To compare these two forces, we perturb the allocations around the optimal policy. Specifically, we construct "externality schedules" as a function of the (potentially off-equilibrium) end-of-period debt in two economies. The two schedules are illustrated in Figure 4. In one economy, we assume that the planner will be choosing optimally ex-ante and ex-post policies from $t+1$ onward (green dash-dotted line). In the other economy, we assume that the planner has only access to ex-ante policies at $t+1$ but has access to both ex-ante and ex-post policies from $t+2$ onward (red dashed line). Following the analysis in Sections 3.1 and 3.2, the strength of the externality are given by $\varphi^I(b_{t+1}) \equiv \frac{\mathbb{E}_t \mu_{t+1}(b_{t+1})\Psi_{t+1}(b_{t+1})}{\mathbb{E}_t u_T(b_{t+1})}$ in the first economy, and by $\varphi^{II}(b_{t+1}) \equiv \frac{\mathbb{E}_t \mu_{t+1}(b_{t+1})\tilde{\Psi}_{t+1}(b_{t+1})}{\mathbb{E}_t u_T(c(b_{t+1}))}$ in the second economy.

As one can see in Figure 4, in both economies, the higher the end-of-period debt level (i.e., b_{t+1}), the higher the externality. Furthermore, for every given value of end-of-period borrowing, the externality is stronger in the second economy than in the first economy. However, optimal choices for end-of-period borrowing differ. The green solid dot (C) indicates the optimal debt choice of the planner and the resulting tax required to decentralize this allocation in the first economy, while the red solid dot (A) indicates the optimal debt choice and tax in the second economy.

The difference in the strength of the externality between the economy with ex-post policy at $t+1$ and the economy without ex-post policy at $t+1$ can be expressed as

$$\varphi^I(b^I_{t+1}) - \varphi^{II}(b^{II}_{t+1}) = \underbrace{\varphi^I(b^{II}_{t+1}) - \varphi^{II}(b^{II}_{t+1})}_{\substack{A\to B \\ (-)}} + \underbrace{\varphi^I(b^I_{t+1}) - \varphi^I(b^{II}_{t+1})}_{\substack{B\to C \\ (+)}}$$

where b^I_{t+1} denotes the end-of-period borrowing choice in the economy with ex-post policy at $t+1$ and b^{II}_{t+1} denotes the end-of-period borrowing choice in the economy without ex-post policy at $t+1$. The first term ($A \to B$) represents the difference in the externality between the two economies, given the optimal borrowing choice in the economy without ex-post policy at date $t+1$. This term is negative, as the externality is weaker in the economy with ex-post

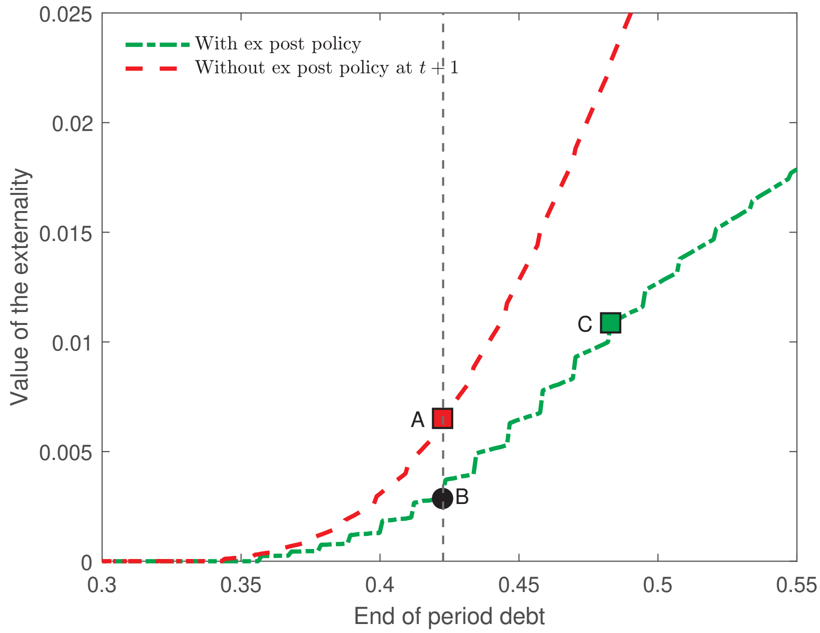

Figure 4: Externality Schedules

Note: In both panels, the tradable productivity shock is set at the mean value and the initial level of debt is set to the mean level observed at the ergodic of the planner with ex ante instruments only. The solid dots A and C represent the optimal level of end-of-period debt chosen by the planner in each experiment. Dot B corresponds to the value of the externality if the planner in the economy with ex-post policies kept the debt issuances of the economy without ex-post policies at $t+1$.

intervention, conditional on a given b_{t+1}. But the second term $(B \to C)$, which accounts for effect of the higher optimal borrowing in the economy with ex-post intervention, is positive and larger than the first term. Overall, the two effects thus yield for a stronger externality in the economy with ex-post intervention, hence the larger debt tax.

These findings indicate that the planner endowed with ex-post policy tools ends up setting higher taxes on borrowing ex-ante because households' expectation of more relaxed borrowing constraints generates larger borrowing—therefore requiring a stronger ex-ante policy to mitigate the externality.

5 Conclusions

Collateral constraints linked to market prices generate a pecuniary externality that leads to inefficient private borrowing. In this paper, we revisit the question of whether this externality leads to overborrowing and the extent to which this depends on the production structure.

Our main findings are threefold. First, configurations where the unregulated competitive equilibrium features less borrowing than the constrained-efficient equilibrium emerge when the planner is endowed with ex-post policy instruments. Second, regardless of whether the unregulated competitive equilibrium features more or less borrowing, optimal taxes on borrowing are always positive, implying that macroprudential policy is always desirable. Finally, macroprudential taxes on borrowing may be larger when the government has access to ex-post stabilization policies.

References

Arce, Fernando, Julien Bengui, and Javier Bianchi, "A macroprudential theory of foreign reserve accumulation," 2019. NBER Working Paper No. 26236.

Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric R Young, "Financial crises and macro-prudential policies," *Journal of International Economics*, 2013, *89* (2), 453–470.

_ , _ , _ , _ , and _ , "Optimal capital controls and real exchange rate policies: A pecuniary externality perspective," *Journal of Monetary Economics*, 2016, *84*, 147–165.

_ , _ , _ , _ , and _ , "Optimal policy for macro-financial stability," 2023. Forthcoming, AEJ Macro.

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

_ , "Efficient Bailouts?," *American Economic Review*, 2016, *106* (12), 3607–3659.

_ and Enrique G Mendoza, "Overborrowing, Financial Crises and 'Macro-prudential'Taxes," 2010. NBER Working Paper 16091.

_ and _ , "Optimal time-consistent macroprudential policy," *Journal of Political Economy*, 2018, *126* (2), 588–634.

Bornstein, Gideon and Guido Lorenzoni, "Moral hazard misconceptions: The case of the Greenspan put," *IMF Economic Review*, 2018, *66* (2), 251–286.

Dávila, Eduardo and Anton Korinek, "Pecuniary externalities in economies with financial frictions," *The Review of Economic Studies*, 2018, *85* (1), 352–395.

Drechsel, Thomas and Seho Kim, "Macroprudential policy with earnings-based borrowing constraints," 2022. Discussion Paper 17561, Centre for Economic Policy Research.

Garcıa-Verdú, Rodrigo, "Factor shares from household survey data," 2005. Working Paper 2005-05, Bank of Mexico, 2005.

Jappelli, Tullio, "Who is credit constrained in the US economy?," *The Quarterly Journal of Economics*, 1990, *105* (1), 219–234.

Jeanne, Olivier and Anton Korinek, "Macroprudential regulation versus mopping up after the crash," *The Review of Economic Studies*, 2020, *87* (3), 1470–1497.

Lian, Chen and Yueran Ma, "Anatomy of corporate borrowing constraints," *The Quarterly Journal of Economics*, 2021, *136* (1), 229–291.

Mendoza, Enrique G., "Credit, prices, and crashes: Business cycles with a sudden stop," in S. Edwards and J. Frankel, eds., *Preventing Currency Crises in Emerging Markets*, 335-392, University of Chicago Press, 2002.

Ottonello, Pablo, Diego J Perez, and Paolo Varraso, "Are collateral-constraint models ready for macroprudential policy design?," *Journal of International Economics*, 2022, *139*, 103650.

Rebucci, Alessandro and Chang Ma, "Capital controls: A survey of the new literature," *Oxford Research Encyclopedia of Economics and Finance*, 2020.

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

Vargas, Carmina O. and Julian A. Parra-Polania, "Analysis of macro-prudential and ex post financial crisis interventions: Relevance of the fiscal-policy setup," *International Journal of Finance and Economics*, 2021, *26* (3), 3759–3769.

A Proofs

A.1 Proof of Proposition 1

Denote by τ_t the tax charged on debt issued at time t, the Euler equation for bonds in the regulated decentralized equilibrium (6) becomes

$$u_T(t) = \beta R(1+\tau_t)\mathbb{E}_t u_T(t+1) + \mu_t. \tag{A.1}$$

Combining the optimality conditions (16) and (23) from the planning problem (15)-(15e) yields

$$u_T(t) = \beta R \mathbb{E}_t \left[u_T(t+1) + \mu_{t+1}\widetilde{\Psi}_{t+1} \right] + \mu_t \left(1 - \widetilde{\Psi}_t \right). \tag{A.2}$$

The optimal policy with ex-ante macroprudential intervention consists of stochastic sequences $\{c_t^T, c_t^N, b_{t+1}, h_t^T, h_t^N, p_t^N, w_t, \mu_t\}_{t\geq 0}$ such that the following conditions hold: (4), (10), (11),(13), (14), (16), (18), (23), (A.2), and $\mu_t \geq 0$.

Meanwhile, the decentralized equilibrium with taxes on debt consists of of stochastic sequences $\{c_t^T, c_t^N, b_{t+1}, h_t^T, h_t^N, p_t^N, w_t, \mu_t, \tau_t, T_t\}_{t\geq 0}$ such that the following conditions hold: (4), (7), (10), (11), (13), (14), (A.1), $T_t = b_t R \tau_{t-1}$ and $\mu_t \geq 0$.

Setting the tax to $\tau_t = \mathbb{E}_t \mu_{t+1}^{\star} \widetilde{\Psi}_{t+1}^{\star} / \mathbb{E}_t u_T^{\star}(t+1)$ yields that the conditions characterizing the decentralized equilibrium with a tax on debt are identical to those characterizing the optimal policy outcome with ex-ante macroprudential intervention. Finally, the result that $\tau_t \geq 0$ is immediate from the fact that $\tilde{\Psi}_t \geq 0$.

A.2 Proof of Proposition 2

With the payroll tax on non-tradable labor, firms maximize $\max_{h_t^N} p_t^N z^N (h_t^N)^{\alpha} - w_t(1+\tau_t)h^N$ and optimality implies

$$w_t(1+\tau_t^N) = p_t^N z^N \alpha \left(h_t^N \right)^{\alpha-1}. \tag{B.1}$$

The proof for the tax on debt follows the same steps as Proposition 1, this time with

$$u_T(t) = \beta R \mathbb{E}_t \left[u_T(t+1) + \mu_{t+1}\Psi_{t+1} \right] + \mu_t \left(1 - \Psi_t \right) \tag{B.2}$$

replacing (A.2), in addition to condition (26) replacing condition (23).

Regarding the payroll tax on non-tradable labor, we can obtain (31) by combining (26)-(28) and (29), together with (B.1).