Optimal Fiscal Policy in Collateral-Constraint Models

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Abstract

I study optimal government spending in a canonical, small-open-economy model where a collateral constraint gives rise to overborrowing. I show quantitatively that excess procyclicality - a pervasive feature of emerging markets - makes the economy more vulnerable to sudden stops. In normal times, pro-cyclical spending encourages borrowing and magnifies the inefficiency; during a sudden stop, it depresses collateral values and exacerbates deleveraging pressures on households. I characterize the optimal time-consistent policy and show that it would significantly reduce both the likelihood and severity of a sudden stop.

1 Introduction

The last decade experienced a dramatic change in paradigm with respect to financial stability. Policymakers have tightened prudential regulation and capital-control policies have become a standard tool for containing financial fragilities, especially in emerging-market economies. Recent empirical work, however, has shown that the outreach of these policy may be limited in practice, as actors in the financial system consistently find ways to bypass regulation. A number of important questions arise against this backdrop: is macroprudential policy enough? Should other policies, too, be an essential part of the macro-financial stability framework?

This paper contributes to this debate, adducing fiscal policy as an example of a policy instrument, alternative to capital controls, with potential to address financial vulnerabilities. The analysis is conducted through the lens of an incomplete market model in the tradition of those typically used to justify macroprudential interventions. Following Mendoza (2002) and Bianchi (2011), I posit an environment with tradable and nontradable goods where households are subject to a collateral constraint that depends on the relative price between the two sectors. Compared to previous work, I innovate by allowing the government to choose how much of nontradable endowment to provide in the form of public consumption.

This departure from an otherwise standard model delivers three main insights. First, expansionary fiscal policy mitigates financial crises by boosting collateral values and facilitating access to credit. Second, not only does fiscal policy reduce the severity of a crisis, but it also make the economy less susceptible to one. Third, the optimal policy appears to be counter-cyclical. Taken together, these three findings provide an argument in favor of the common view that governments should lean against the wind at times of economic expansion and mop up during crises.[1]

The paper begins by laying out a small open economy that lasts for three periods and where households are only allowed to borrow up to a given fraction of their income. Under this formulation a well-known pecuniary externality materializes, generating overborrowing and making the economy more vulnerable to crisis events.[2] Unlike most of the literature, I do not endow the government with access to capital-control policies. Instead, I grant the ability to set public expenditures at will.

When the economy is financially constrained, the optimal policy is to practice stimulus

[1] A line of research suggests that fiscal activities, such as government spending, public debt management or tax policies, affect directly or indirectly the resilience of the economy to adverse financial shocks (e.g. Obstfeld (2013), Gosh et al. (2017), Dumičić (2019)).

[2] Korinek and Mendoza (2014) provide a comprehensive review of the type of inefficiency that arises when the agents' borrowing capacity depends on equilibrium prices. Since households do not internalize the effect of borrowing decisions on collateral values, there is a wedge between private and social marginal utilities of wealth, and the decentralized equilibrium may exhibit overborrowing or underborrowing relative to the constrained efficient benchmark.

as a means to accommodate foreign borrowing and mitigate consumption adjustments. Intuitively, more spending makes nontradables relatively less available and leads to an increase in their relative price. This in turn boosts collateral values and allows the households to assume more debt from abroad.

When financial conditions are loose, by contrast, the objective of the optimal policy is not to sustain, but to limit the build-up of leverage in the private sector. In the model, this can be achieved in two different ways: either by directly tightening the collateral constraint - a quantity-based channel -, or by reducing the household's marginal propensity to consume tradable goods - a price-based channel. This distinction is inconsequential in most of the existing literature, but plays a key role in the following analysis. Under the lens of the optimal fiscal policy, the quantity-based channel always calls for austerity. The intuition is that less spending leads to a lower relative price and depresses collateral values. The price-based channel, instead, only requires austerity under certain conditions on the primitives of the model.

To get a sense of why this is the case, consider a fiscal tightening that makes nontradables relatively more abundant. The increased availability of nontradables has two opposing effects: a substitution effect that discourages borrowing by causing spending to shift away from the tradable sector; and a consumption-smoothing effect that encourages borrowing by making future consumption relatively less attractive. The tightening then helps curb the accumulation of debt only if the substitution effect prevails. In a standard setting with CRRA preferences and a CES aggregation technology this simply amounts to the elasticity of substitution between the two sectors being larger than the inter-temporal elasticity of substitution. Under this condition, it is optimal to practice austerity to mitigate overborrowing and reduce the likelihood of a crisis. This result crucially relies on the assumption that the government lacks access to capital controls. Otherwise there would be no need to practice austerity, as a tax on external debt would be sufficient to fully correct the inefficiency.

The intuition from the three-period model carries over to an infinite-horizon extension where fiscal policy is set optimally at all dates. After calibrating the model to match key moment of Spanish data, I find that a government without commitment chooses to practice austerity in the run-up to the crisis, and then resorts to stimulus when the crisis eventually occurs.

Building on the quantitative model, I then discuss whether the availability of optimal capital controls matters for welfare. First, I show numerically that the unregulated economy features overborrowing, but only to a limited extent. Indeed, the ergodic distribution of debt changes marginally if the government gains the ability to enforce capital controls. Second, I demonstrate by means of a long-run simulation that optimal macroprudential policy is successful in driving the probability of a crisis virtually to zero. This however only results in a modest welfare improvement relative to the unregulated economy, because fiscal stimulus by itself makes crises less costly. Overall, the analysis suggests that gains from macroprudential policies could be overstated in settings that abstract from the availability of alternative policy options, both ex-ante and ex-post.

Relation to the literature. The paper is primarily related to a line of work which studies policy interventions in economies where endogenous collateral constraints give rise to a borrowing inefficiency. Bianchi (2011) is the first to show that in a model with financial frictions the constrained-efficient allocation can be implemented by means of a macroprudential tax on debt.[3] This paper innovates on the environment of Bianchi (2011) by introducing an optimizing fiscal authority that lacks access to capital-control policies but sets government expenditures optimally. In this framework fiscal policy mitigates the severity of crises and partially substitutes for the absence of optimal capital controls.

Ottonello (2015) and Coulibaly (2020) extend the workhorse model of Bianchi (2011) by introducing nominal rigidities. They show that the optimal monetary policy departs from the traditional stabilization policy to mitigate the negative consequence of currency mismatch in the household's balance sheets. Coulibaly (2020) is closest to this paper in that it also characterizes the optimal policy without capital controls. In contrast, this paper studies the role of government expenditures and emphasizes the ability of fiscal policy to act both like a quantity-based and a price-based intervention. I provide a sufficient condition ensuring that prudential austerity is optimal. At the same time, I show that fiscal tightening might be desirable even if that condition is violated.[4]

The approach I follow in this paper is also similar to Korniek and Jeanne (2019), who provide a joint analysis of ex-ante and ex-post policy interventions in a model of financial crises. In contrast, I consider here a single policy instrument, fiscal policy, and show how this tool helps foster financial stability both ex-ante, in the run-up to a crisis, and ex-post, when a crisis hits the economy. Recently, Bengui and Bianchi (2018) consider a similar setting where the planner is only able to enforce capital controls on a subset of agents. They show that even in the presence of leakages macroprudential policy is desirable and improves welfare.

Besides the capital-controls literature, this paper also relates to a strand of research which studies optimal fiscal policy in small open economies. Most of the literature has focused on the role of government spending as a stabilization tool in the presence of nominal rigidities.

[3] A related literature, starting from Bianchi and Mendoza (2018), introduces capital and assumes that the collateral is a stock instead of a flow. Devereux et al (2019), depart from the current-valued collateral of Bianchi and Mendoza (2018), and analyze a model with a borrowing constraint that depends on expected future (resale) prices. Other papers looking at time-consistent macroprudential policies include Benigno et al. (2012, 2013 and 2016), who consider a working capital constraint similar in nature to that in Bianchi (2011). Ottonello et al. (2019) consider a specification where future prices instead of current ones enter the collateral constraint. They show that in this case the competitive equilibrium is in fact constrained-efficient.

[4] The distinction between quantity-based and price-based interventions is inconsequential in most of the literature. Sublet (2019) is a rare exception in this regard.

Examples include Gali and Monacelli (2008), Werning (2011), Farhi and Werning (2017a). Bianchi et al (2018) introduce the possibility of sovereign default in a model with downward wage rigidity. They show that the combination of default risk and limited fiscal capacity may prevent the government from implementing counter-cyclical fiscal policies. In contrast, I focus on the ability of the government to strengthen financial stability by restricting or stimulating households' borrowing in international credit markets.

Finally, this paper speaks to theoretical and empirical work on fiscal multipliers.[5] The closest paper, in this regard, is Liu (2020) who introduces fiscal policy in a two-sector open-economy model with stock collateral constraint à la Bianchi and Mendoza (2018). The model rationalizes the empirical finding that fiscal multipliers seem to increase during sudden stops. Unlike this paper, Liu (2020) does not characterize the optimal policy but only assumes that the government follows an exogenously given fiscal rule.[6]

Layout. The remainder of the paper is organized as follows: Section 2 lays out a three-period model of a small open economy subject to financial frictions. I define the competitive equilibrium and then characterize the welfare-maximizing fiscal policy both with and without capital-control policies. Section 3 extends the model to an infinite horizon setting, which allows me to investigate quantitatively the properties of the optimal time-consistent policy. I describe the implied aggregate dynamics during the typical financial crisis, and discuss welfare gains from optimal macroprudential interventions.

2 Three-Period Model

This section presents a three-period model of a financial crisis to understand the role of fiscal policy and its interaction with the borrowing inefficiency. Section 2.1 lays out the environment. Section 2.2 describes the competitive equilibrium. Finally, Sections 2.3 and 2.4 provide a characterization of the optimal policy.

2.1 Environment

I consider a small open economy that lasts for three periods, $t = 0, 1, 2$. There are two types of goods, tradables and nontradables, and no production. The only source of uncertainty is over the endowment of tradable goods in period $t = 1$.

[5] Empirical studies, which include Farhi and Werning (2017b) and Nakamura and Steinsson (2014), have estimated a wide set of fiscal multipliers.

[6] Woodford (2011) illustrates the stabilization capacity of fiscal policy with nominal rigidities via simple examples for which fiscal multipliers can be analytically characterized.

The economy is populated by a representative household whose preferences are given by

$$U(c_0) + v(G_0^N) + E_0[\beta U(c_1) + \beta^2 U(c_2)] \tag{1}$$

where $\{c_t\}$ denotes private consumption, G_0^N public spending in nontradable goods and $\beta < 1$ the agent's discount factor. I assume that the household has CRRA preferences for private and public consumption with the same elasticity of substitution, i.e.

$$U(c) = (1-\theta)\frac{c^{1-\sigma}}{1-\sigma} \tag{2}$$

$$v(G) = \theta\frac{G^{1-\sigma}}{1-\sigma} \tag{3}$$

with $\sigma > 0$ and $\theta \in (0,1)$. The consumption basket is given by a composite of tradable and non-tradable goods according to a standard CES aggregator

$$c_t = A(c_t^T, c_t^N) = \left[a(c_t^T)^{1-\frac{1}{\xi}} + (1-a)(c_t^N)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}} \tag{4}$$

with $\xi > 0$ and $a \in (0,1)$.

The household receives an exogenous endowment stream, $\{y_t^T, y_t^N\}$, of tradable and non-tradable goods. The endowment of nontradable goods is fixed at some level, y^N, whereas the endowment of tradable goods is time-varying and depends on the realization of one of two possible states, $s \in \{H, L\}$. At time 1, the endowment of tradable goods is higher in state H than in state L, i.e. $y_1^T(H) > y_1^T(L)$, while at time 2 it is the same in both states, i.e. $y_2^T(H) = y_2^T(L) = y_2^T$.

Households borrow from international creditors through a one-period, non-contingent bond denominated in foreign currency. In the following, b_t denotes the amount of debt that must be repaid at the beginning of period t and b_{t+1} denotes the amount of debt issued at t and due at $t+1$. With this notation the household's budget constraints in the three periods are

$$c_0^T + p_0^N c_0^N + b_0 = y_0^T + p_0^N y^N + \frac{b_1}{R} - T_0 \tag{5}$$

$$c_1^T(s) + p_1^N(s) c_1^N(s) + b_1 = y_1^T(s) + p_1^N(s) y^N + \frac{b_2(s)}{R} \tag{6}$$

$$c_2^T(s) + p_2^N(s) c_2^N(s) + b_2(s) = y_2^T + p_2^N(s) y^N \tag{7}$$

where R denotes the world risk-free interest rate, $p_t^N(s)$ the relative price of the nontradable good at time t in state s, and T_0 a lump-sum tax from the government.

In the first two periods, the household is subject to a borrowing constraint, that prevents from borrowing more than a time-varying fraction, κ_t, of his income

$$\frac{b_{t+1}(s)}{R} \leq \kappa_t(y_t^T(s) + p_t^N(s)y^N), \quad \text{for } t = 0, 1 \tag{8}$$

The form of this constraint links collateral values to the relative price of the nontradable good. It follows Mendoza (2002) and is common in the literature on financial crises and macroprudential policies.

To close the model, I assume that the government provides public consumption, G_0^N, in units of the nontradable good, using the proceedings from the lump-sum tax, T_0, to maintain a balanced budget;

$$p_0^N G_0^N = T_0 \tag{9}$$

The household takes government spending as given and chooses private consumption to maximize (1) subject to (5), (6), (7) and (8).

We are now in a position to define the competitive equilibrium of this economy.

Definition 1. *Given government policies, G_0^N and T_0, a competitive equilibrium consists of allocations $\{c_t^T, c_t^N, c_t, b_{t+1}\}_{t=0}^2$ and prices $\{p_t^N\}_{t=0}^2$ such that (1) given prices and government policies households' decisions are optimal, (2) the markets for tradable and nontradable goods clear at all dates, and (3) the government budget constraint holds*

2.2 Equilibrium

We solve for the decentralized equilibrium via backward induction, paying particular attention to the initial period, which is when the government sets fiscal policy optimally. In the following I will use lower-case letters to express individual variables and upper-case letters to express aggregate variables. I will maintain p^N to denote the relative price between sectors.

Date 2 equilibrium. Equilibrium at date 2 is simple. Agents settle their bond positions and consume their holdings of tradable and non-tradable goods.

Date 1 equilibrium. At date 1 the aggregate state of the economy is given by the exogenous state, s, and the debt position, B_1, inherited from the previous period. Equilibrium can then be summarized by a mapping, $C^T(s, B_1)$, from the state variables, s and B_1, to aggregate tradable consumption.

Using this notation allows me to express the relative price of nontradables in the following way

$$p_1^N(s) = \frac{1-a}{a}\left(\frac{C^T(s,B_1)}{y^N}\right)^{\frac{1}{\xi}} \tag{10}$$

This condition links the relative price between the two sectors to the consumption of tradable goods. After plugging in (8), it allows me to derive an equilibrium version of the economy's collateral constraint.

$$\frac{B_2(s)}{R} \leq \kappa_1 \left[y_1(s)^T + \frac{1-a}{a}\left(\frac{C^T(s,B_1)}{y^N}\right)^{\frac{1}{\xi}} y^N \right] \tag{11}$$

This inequality implies that the borrowing limit - the right-hand side of (11) - tightens endogenously when tradable consumption falls. Private agents do not take this effect into account when borrowing at date 0, which gives rise to a well-know overborrowing result.[7]

In order to ensure uniqueness of the time-1 continuation equilibrium, I will assume in the remainder of the section that κ_1 is sufficiently small.[8]

Date 0 unregulated equilibrium. At date 0 the household's problem can be expressed as follows

$$\max_{c_0^T, c_0^N, b_1} U(A(c_0^T, c_0^N)) + v(G_0^N) + \beta E_s V(b_1, s; B_1) \tag{12}$$

s. t.

$$c_0^T + p_0^N c_0^N + b_0 = y_0^T + p_0^N y^N + \frac{b_1}{R} + t_0$$
$$\frac{b_1}{R} \leq \kappa_0 (y_0^T + p_0^N y^N)$$

where $V(b_1, s; B_1)$ denotes the indirect utility function in the time-1 continuation equilibrium. This notation makes explicit the dependence of the indirect utility on the individual state, b_1, as well as the aggregate state, B_1, that the household takes as given.

Solving the optimization problem and using market clearing yields an expression for the relative price similar to (10)

$$p_0^N = \frac{1-a}{a}\left(\frac{C_0^T}{y^N - G_0^N}\right)^{\frac{1}{\xi}} \tag{13}$$

The only difference is that government spending now appears in the denominator, mak-

[7]Unlike the household, the government does internalize the endogenous feedback from consumption plans to equilibrium prices, and this will be a key driver of fiscal policy, as it will become clear shorty.

[8]This is not crucial for the results but allows me to deliver intuition in the clearest possible way.

ing the relative price an increasing function of G_0^N. Intuitively, because the endowment of nontradable goods is fixed, an increase in government spending reduces the supply of nontradables available for private consumption. This creates excess demand, requiring an increase in the relative price for the market to clear.

In addition to (13), the standard condition for inter-temporal optimality must holds. After using market clearing, this condition becomes

$$U_T(C_0^T, y^N - G_0^N) - \beta R E_s U_T(C^T(B_1, s), s) \geq 0 \text{ with equality if } \frac{B_1}{R} \leq \kappa_t(y_0^T + p_0^N y^N) \quad (14)$$

where U_T denotes the marginal utility of tradable consumption.

Finally, market-clearing in the tradable sector requires

$$C_0^T = y_0^T + \frac{B_1}{R} - B_0 \quad (15)$$

Putting everything together, the following proposition formalizes the set of implementability constraints faced by the government.

Proposition 1. *An allocation, $\{C_0^T, C_0^N, C_0, G_0^N, B_1\}$, and a price, p_0^N, form part of an equilibrium if and only if they satisfy (4), (13), (14) and (15).*

2.3 The Samuelson Benchmark

With this characterization of the competitive equilibrium, I now proceed to analyze the role of fiscal policy. I take the perspective of a benevolent government that maximizes the utility of the household subject to implementability constraints. In a first-best world, the policy that achieve highest welfare is one that equalizes the marginal utilities of public and private nontradable consumption. The level of government expenditures that attains this equality plays a key role in the analysis. So, before proceeding, it seems useful to spell it out with a formal definition.

Definition 2. *For given tradable consumption, C^T, define the associated Samuleson level, denoted by $G^*(C^T)$, as the level of government spending that equalizes the marginal utilities of public and private nontradable consumption, i.e.*

$$v_g(G^*(C^T)) = U_N(C^T, y^N - G^*(C^T)) \quad (16)$$

Similarly to Bianchi et al. (2018), I label $G^*(C^T)$ as "Samuelson", but in contrast to them I allow it to be a function of the household's consumption plan.[9] To isolate the role of

[9]Bianchi et al. (2018) focus on a parametrization of the model with $\sigma\xi = 1$. This implies that the

financial frictions, it will later prove convenient to characterize the optimal decision of the government in terms of deviations from this benchmark. To be consistent with terminology, I will then refer to downward deviations from the Samuelson level as fiscal austerity and to upward deviations as fiscal stimulus.

2.4 Optimal Policy

To set a benchmark, I start by describing the constrained-efficient allocation, that is, the welfare-maximizing allocation that can be implemented by a government with the ability to directly control private leverage.[10] I then consider the case where the government lacks this ability but is still able to affect borrowing, though only indirectly through the household's endogenous response.

Constrained efficient allocation. The notion of constrained efficiency is the same as in Bianchi (2011). I assume that the government can directly choose the level of debt subject to the collateral constraint but allows the markets for tradable and non-tradable goods to clear competitively.

Formally, the constrained-efficient allocation solves the following problem

$$\max_{C_0^T, G_0^N, B_1} U(A(C_0^T, y^N - G_0^N)) + v(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{17}$$

s.t.

$$C_0^T = y_0^T + \frac{B_1}{R} - B_0 \tag{18}$$

$$\frac{B_1}{R} \leq \kappa_0 \left(y_0^T + \frac{1-a}{a} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} y^N \right) \tag{19}$$

where (18) is the economy's resource constraint and (19) is the collateral constraint after substituting in the expression for the equilibrium relative price. Unlike private agents, the government internalizes that its consumption choices influence the relative price between the two sectors and consequently affect the economy's borrowing capacity.

The optimal choice of public consumption, G_0^N, is summarized by the following first-order condition

$$U_N(C_0^T, y^N - G_0^N) - v_g(G_0^N) = \mu_0^{sp} \left[\kappa_0 \frac{1-a}{a} \frac{1}{\xi} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} \frac{y^N}{y^N - G_0^N} \right] \tag{20}$$

where μ_0^{sp} denotes the Lagrange multiplier associate to (19).

Samuelson level in their framework is just a deterministic function of the nontradable endowment. As I allow $\sigma\xi$ to be different from 1, the Samuelson level will in general be a function of tradable consumption.

[10]For instance, by means of a tax on external debt.

In good times, when the collateral constraint does not bind, the term on the right-hand side of (20) is equal to zero. Hence, the marginal utilities of private and public consumption are equalized, as in the first-best case. During downturns, by contrast, when the collateral constraint does bind, a strictly positive wedge emerges, requiring the marginal utility of private consumption to be relatively larger. This implies that optimal government expenditures should exceed the Samuelson level, when the economy is financially constrained. The intuition is that fiscal stimulus improves collateral values and facilitates access to credit. This in turn prevents the household from suffering debt deleveraging and costly consumption adjustments. The following proposition summarizes the result.

Proposition 2. *If κ_0 is sufficiently low, the collateral constraint binds in period 0 and the government sets spending above the Samuelson level.*

Optimal fiscal policy without capital controls. So far I have focused on the case where the government has direct control over the households' borrowing decision. Implicit is the assumption that optimal capital controls can be perfectly enforced. In reality this may not be the case, as private agents have often the ability to bypass regulation. If circumvention of capital controls is possible, fiscal policy takes up a prudential role. It in fact provides an alternative channel to discourage borrowing, though only indirectly via the private sector's endogenous response.

To shed light on the optimal policy in the absence of capital controls, I set up the following optimization problem

$$\max_{C_0^T, G_0^N, B_1, \mu_0} U(A(C_0^T, y^N - G_0^N)) + v(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{21}$$

s.t.

$$C_0^T = y_0^T + \frac{B_1}{R} - B_0 \tag{22}$$

$$\frac{B_1}{R} \leq \kappa_0 \left(y_0^T + \frac{1-a}{a} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} y^N \right) \tag{23}$$

$$U_T(C_0^T, y^N - G_0^N) = \beta R E_s U_T(C^T(B_1, s), s) + \mu_0 \tag{24}$$

$$\mu_0 \geq 0 \tag{25}$$

$$\mu_0 \left[\frac{B_1}{R} - \kappa_0 \left(y_0^T + \frac{1-a}{a} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} y^N \right) \right] = 0 \tag{26}$$

where μ_0 denotes the Lagrange multiplier associated to the collateral constraint in the competitive equilibrium.

Relative to the constrained-efficient case, this problem involves three additional constraints: the household's Euler equation, (24); the non-negativity constraint on the Lagrange multiplier, (25); and the complementary slackness condition, (26). These three constraints require government decisions to be consistent with the private sector's equilibrium response. This makes it harder to tackle excessive leverage in the presence of the pecuniary externality. The lack of macroprudential instruments renders the government unable to prevent overborrowing. However, as will become clear shortly, fiscal policy provides an alternative way to partly undo the inefficiency.

Having set up the government problem, I now proceed to characterize its solution. In times of crisis there is not much difference between the present case and the constrained-efficient benchmark. If the collateral constraint binds in period 0, the optimal policy is to stimulate the economy, whether or not the government controls private borrowing. Proposition 1 remains valid, hence stimulus is enacted whenever the credit regime parameter is sufficiently low.[11]

Where the two policies differ is at times where the borrowing constraint is slack but binds with positive probability in the following period. This is exactly when the borrowing inefficiency materializes; households accumulate too much debt as they fail to internalize that higher leverage reduces their absorption capacity when the collateral constraint starts to bind. This gives rise to an interesting policy trade-off. The government would like to curb excessive leverage. However, the only way this can be attained without capital controls is through costly deviations from Samuelson .

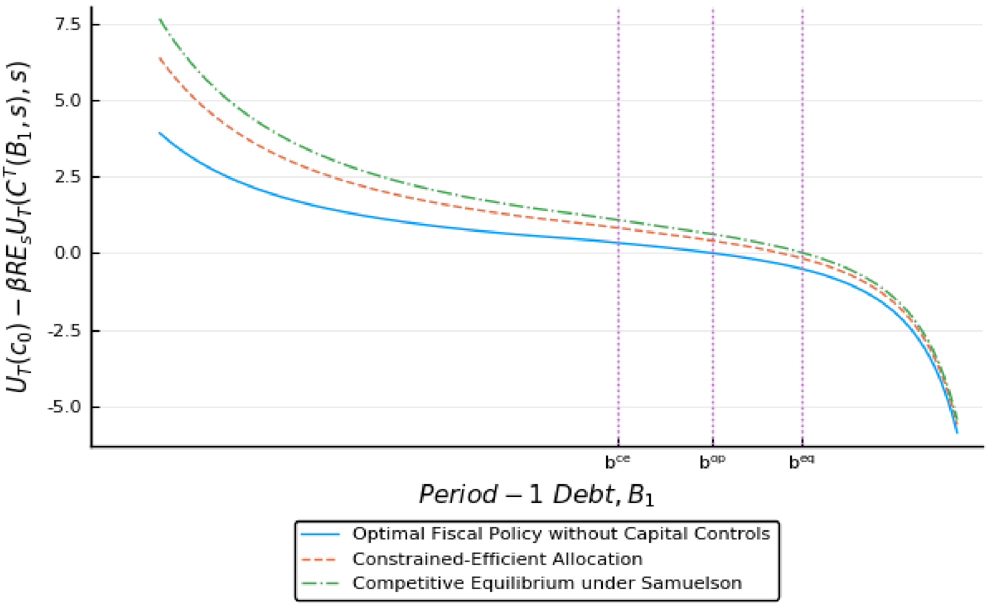
To clarify the key mechanisms, I assume for the time being that in the initial period the economy is unburdened by financial constraints. This implies that leverage is pinned down in equilibrium by the Euler equation of the household.[12] The government here cannot choose directly the level of external debt, but can affect it indirectly through the household's endogenous response. The intuition is that government expenditures influence the shadow value of current consumption - the right-hand side of (24) - and this feeds back into the private sector's borrowing decision. In terms of optimal policy, the implications of this feedback depend on the interaction of two contrasting effects: a substitution effect and a consumption-smoothing effect.

Suppose for instance that the government practices austerity, making nontradable goods relatively more abundant. On the one hand, the increased availability of nontradables induces households to substitute away from the tradable sector. On the other hand, it make them more willing to increase their overall consumption basket. The first channel tends to discourage borrowing, while the second tends to encourage it. Consequently, whether austerity results in higher or lower leverage is ambiguous and depends on the relative strength of these two opposing effects. The following proposition establishes that this comparison

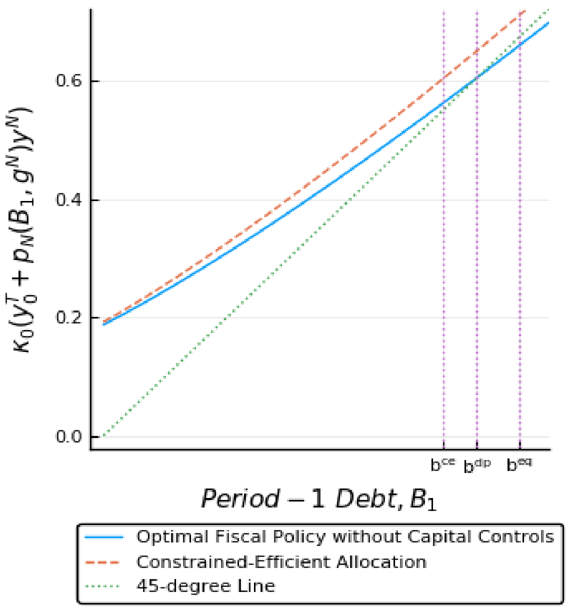
[11] One can show that the threshold for κ, below which stimulus becomes optimal, is in fact the same under the optimal policy and under the constrained-efficient allocation

[12] Think about this case as assuming $\kappa_0 = \infty$. The Euler equation of the household then holds with equality.

Figure 1: Prudential Fiscal Policy



(a) Price-based Channel



(b) Quantity-based Channel

only hinges on the relative magnitude of the elasticity parameters , σ and ξ.[13].

Proposition 3. *Suppose $\kappa_0 \to \infty$. If the collateral constraints binds with positive probability in the competitive equilibrium with $G_0^N = G^*(C_0^T)$, then the government sets spending below (above) the Samuelson level if and only if $\sigma\xi > 1$ (< 1). In the knife-edge case $\sigma\xi = 1$, the governments set spending exactly equal to Samuelson.*

The result provides us with a sufficient and necessary condition, $\sigma\xi > 1$, under which the substitution effect dominates. In this case, a reduction in government expenditures curtails borrowing, by inducing a large enough shift away from the tradable sector. Austerity then emerges as the optimal policy, because it allows the government to curb excessive leverage in a way that is akin to a price-based macroprudential intervention.[14]

The analysis so far has crucially relied on the assumption that the economy is initially unconstrained. To dispense of this restriction, I now allow κ_0 to be arbitrarily small. This makes it possible for the collateral constraint to bind not only at date 1 but also at date 0. To address overborrowing, the government has now the option to tighten the borrowing constraint directly by depressing collateral values to a sufficient extent. This makes austerity potentially desirable regardless of the relative magnitude of the elasticity parameters.[15] The intuition is that the government can always enact a sufficiently large spending cut, to curb at will the maximum level of leverage attainable by the households. Although this quantity-based channel partly invalidates the result in Proposition 3, for the case where $\sigma\xi > 1$ it is still possible to prove that in the run-up to a crisis austerity is unambiguously optimal.

Proposition 4. *Suppose that the following conditions hold*

1. *κ_0 is not too low,*
2. *the collateral constraints binds with positive probability in the competitive equilibrium with $G_0^N = G^*(C_0^T)$; and*
3. *$\sigma\xi > 1$,*

[13]In other words, the following proposition establishes that the nature of the optimal policy depends on the household's preferences over 1) the intra-temporal distribution of consumption between traded and non-traded goods, and 2) the inter-temporal allocation of the aggregate consumption basket.

[14]That is an intervention that alter the relative price of current versus future consumption.

[15]There is a key distinction between the price-based and the quantity-based channel of prudential fiscal policy. If $\sigma\xi > 1$, whenever the economy is subject to overborrowing, an infinitesimal deviation from the Samuelson level affects smoothly the Euler equation and increases welfare. If $\sigma\xi = 1$, this channel is shut down. It is true that the government can still affect the constrain directly. However, the drop in government spending, relative to the Samuleson level, must be large enough so that the constraint actually becomes binding. This implies that with $\sigma\xi = 1$ a marginal deviation from Samuelson is generally not welfare improving. In addition, the are region in the parameter space where the government does not deviate from Samuleson even if the economy is plagued by excessive debt.

Then, the government optimally practices austerity, setting public consumption below the Samuelson level.

Unlike Proposition 3, this is not an if and only if statement.[16] One can easily envisage economies where $\sigma\xi$ =1 or $\sigma\xi < 1$, and yet the government finds it optimal to practice austerity as a remedy for the borrowing inefficiency. The intuition behind the result is that fiscal policy affects both the Euler equation and the collateral constraint. As a consequence, it has potential to act like a price-based interventions or a quantity-based one. Whether it is more effective as one or the other ultimately depends not only on the parameters of the model but also on the state of the economy.[17]

3 Numerical Analysis

In this section, I conduct a quantitative assessment of the mechanisms at play. The goal is to evaluate the ability of fiscal policy to stabilize the economy even in the absence of any macroprudential intervention. To this end, Section 3.1 lays out an infinite-horizon version of the three-period model. Section 3.2 extends the definitions of optimal policy to this more general setting, while Section 3.3 illustrates the calibration strategy. Section 3.4 describes crisis dynamics, and finally Section 3.5 evaluates welfare gains from optimal capital controls.

3.1 Environment

The economy is populated by a unit-continuum of identical, infinitely-lived households, whose preferences are represented by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[U(c_t) + v(g_t^N) \right] \tag{27}$$

As in the Section 2, U and v are of the CRRA type and the consumption basket is a CES aggregator with elasticity $\xi > 0$[18].

The budget and collateral constraints of the household are respectively

$$c_t^T + p_t^N c_t^N + b_t = y_t^T + \frac{b_{t+1}}{R_t} - t_t \tag{28}$$

[16]Interestingly, the optimal fiscal policy is to practice austerity, and this regardless of weather the economy features multiple equilibria that could result in underborrowing, rather than overborrowing.

[17]Figure 1 provides a visual representation of both channels of prudential fiscal policy. A full graphical analysis is presented in Appendix B.

[18]The functional forms are given by equation (2), (3) and (4)

$$\frac{b_{t+1}}{R_t} \leq \kappa(y_t^T + p_t^N y_t^N) \tag{29}$$

where the vector of endowments, $\{y_t^T, y_t^N\}$, is assumed to follow a first-order Markov process.

As before, public consumption, g_t^N, is provided in units of nontradable goods. To finance spending, the government levies lump-sum taxes and maintains a balanced budget;

$$p_t^N g_t = t_t \tag{30}$$

The competitive equilibrium is defined exactly in the same way as in Section 2. The formal definition, together with the full set of equilibrium conditions, is reported in Appendix C.

3.2 Optimal Policy

Having specified the environment, I now extend the definitions of optimal policy to this quantitative framework. Along the lines of Section 2, I make different assumptions about the government's ability to enforce optimal macroprudential interventions.

Constrained efficient allocation. I maintain as a normative benchmark the notion of constrained efficiency.[19] In an infinite-horizon setting, the government's optimization problem can be expressed, recursively, as follows

$$V^{ce}(b,s) = \max_{c^T, b', g^N} (1-\theta)\frac{A(c^T, y^N - g^N)^{1-\sigma}}{1-\sigma} + \theta \frac{{g^N}^{1-\sigma}}{1-\sigma} + \beta E_{s'|s} V^{ce}(b', s') \tag{CE}$$

s.t.

$$c^T = y^T + \frac{b'}{R} - b$$
$$\frac{b'}{R} \leq \kappa\left(y^T + \frac{1-a}{a}\left(\frac{c^T}{y^N - g^N}\right)^{1/\xi} y^N\right)$$

Notice that the household's Euler equation does not appear among the set of implementability constraints. This implies that the Ramsey-policy in this setting is time-consistent.

The formal definition for the constrained-efficient allocation is given below

Definition 3. *The constrained-efficient allocation consists of policy functions $\{b'(b,S)$, $g^N(b,S)\}$ and a value function $V^{ce}(b,S)$ that solve the Bellman equation defined in problem (CE).*

Optimal fiscal policy without capital controls. As a baseline, I postulate an environment

[19] Recall that in this case the government has direct control over the household's borrowing decision.

with no capital control taxes, where the pecuniary externality creates scope for prudential fiscal policy.[20] With an infinite horizon matters are more complicated than in the simple model from Section 2; the government optimizes at all dates and future decisions feed back into the present, giving rise to a time-inconsistency problem.

To understand why, consider the Euler equation of the household when it holds with equality

$$U_T(c^T(b,s), y^N - g^N(b,s)) - E_{s'|s}\left[\beta R U_T(c^T(b',s'), y^N - g^N(b',s'))\right] = 0 \tag{31}$$

In the three-period model, the Euler equation only depended on the government's spending decision in the current period. By contrast, in the quantitative extension the Euler equation, (31), also depends on the decision in the subsequent period. This implies that tomorrow's policy has repercussions on the today's borrowing decision by households.

Future stimulus, for instance, reduces the availability of nontradable goods going forward. This induces the household to substitute towards the nontradable sector in the current period, when this sector's goods are still relatively abundant. If tradable and nontradable consumption are sufficiently substitutable, foreign debt will decrease. This reasoning suggests that future fiscal policy could help alleviate the borrowing inefficiency, in about the same way as current fiscal policy does - by having the household substitute away from the tradable sector. The caveat, however, is that a policy may be optimal from today's viewpoint but not from tomorrow's viewpoint.

With $\sigma\xi > 1$, for instance, future stimulus is desirable under the perspective of the current government, because it mitigates overborrowing and makes a crisis less likely. However, it generally will not be optimal from the perspective of the future government, that only sees it as an inefficient deviation from Samuelson. Not internalizing the benefit over previous periods, a government that lacks commitment would renege on the promise of stimulating the economy, making the Ramsey-policy time-inconsistent.[21]

To circumvent this issue, as standard in the literature, I consider the notion of Markov Perfect Equilibrium, where the government chooses allocations sequentially and without commitment, taking as given future policies. Letting $\mathcal{C}^T(b,S)$ and $\mathcal{G}^N(b,S)$ denote the decision rules of future governments for tradable consumption and public spending, I can write the optimization problem in the current period as follows

$$V^{op}(b,S) = \max_{c^T, b', g^N, \mu} (1-\theta)\frac{A(c^T, y^N - g^N)^{1-\sigma}}{1-\sigma} + \theta\frac{{g^N}^{1-\sigma}}{1-\sigma} + \beta E_{s'|s} V^{op}(b', s') \tag{OP}$$

[20] results in modest improvements relative to the unregulated economy

[21] For instance, if the constraint is not binding, the future government would adhere to the Samuelson principle or practice austerity, depending of whether borrowing is efficient or not. However, under no circumstances will the government find it optimal to keep past promises and practice stimulus.

s.t.

$$c^T = y^T + \frac{b'}{R} - b$$
$$\frac{b'}{R} \leq \kappa\left(y^T + \frac{1-a}{a}\left(\frac{c^T}{y^N - g^N}\right)^{1/\xi} y^N\right)$$
$$\mu = U_T(c^T, y^N - g^N) - E_{S'|S}\left[\beta R U_T(\mathcal{C}^T(b', S'), y^N - \mathcal{G}^N(b', S'))\right]$$
$$\mu \geq 0$$
$$\mu\left[\frac{b'}{R} - \kappa\left(y^T + \frac{1-a}{a}\left(\frac{c^T}{y^N - g^N}\right)^{1/\xi} y^N\right)\right] = 0$$

The Markov-Perfect Equilibrium is then defined as follows

Definition 4. *A Markov-Perfect Equilibrium consists of a value function, $V^{op}(b, S)$, policy functions $\{b'(b, S), g^N(b, S), c^T(b, S), \mu(b, S)\}$ and conjectured future policy rules $\{\mathcal{C}^T(b, S), \mathcal{G}^N(b, S)\}$ such that*

1. *Given the conjectured rules, the value function and the associated policy functions solve the Bellman equation defined in problem (OP).*

2. *The conjectured future policy rules are consistent with the current planner's policies.*

$$\mathcal{C}^T(b, S) = c^T(b, S)$$
$$\mathcal{G}^N(b, S) = g^N(b, S)$$

3.3 Calibration

I calibrate the model at the annual frequency to match key moments of Spanish data between 1980 and 2012. In my calibration strategy I assume that the government chooses fiscal policy optimally but is unable to enforce capital control taxes. The model parameters are divided into three subsets. The first subset is kept fixed according to the values reported in Table 1. The risk aversion coefficient is set to $\sigma = 2$ and the world interest rate to $R = 4\%$, both common values in the DSGE-SOE literature. The intra-temporal elasticity of substitution is fixed at $\xi = 0.74$, following Stockman and Tesar (1995).

The second subset consists of those parameters that govern the law of motion of the exogenous state. Following the literature, I model endowment shocks as a first-order bivariate autoregressive process: $\log y_t = \rho \log y_{t-1} + \epsilon_t$ where $y = [y^T y^N]$, $\rho = \begin{bmatrix} \rho_T & \rho_{TN} \\ \rho_{NT} & \rho_N \end{bmatrix}$ is a 2x2 matrix of autocorrelation coefficients, and $\epsilon_t = [\epsilon_t^T \epsilon_t^N]$ follows a bivariate normal distribution

Table 1: Calibration

Parameter	Description	Value	Source/Target
(a) Fixed Parameters			
R	Interes rate	1.04	Standard value DSGE-SOE
σ	Coefficient of risk aversion	2	Standard value DSGE-SOE
ξ	Intratemporal elasticity of subst.	0.74	Stockman and Tesar (1995)
(b) Calibrated Parameters			
β	Discount rate	0.9	Average NFA/GDP
a	Weight on tradables in CES	0.21	Share of tradable output
θ	Weight of govt. good in utility	0.04	Average govt. spending/GDP
κ	Credit regime	0.37	Frequency of crisis

Notes : This table report values for two subsets of parameters. The upper part shows the parameters that are kept fixed, while the lower part reports the parameters that are calibrated to match key moments of Spanish data.

Table 2: Endowment process

Parameter	Description	Value
σ_{T}	Standard deviation shocks to tradable endowment	0.03
σ_{N}	Standard deviation shocks to non-tradable endowment	0.02
σ_{TN}	Covariance shocks to tradable and nontradable endowment	0.47
ρ_{T}	Autocorrelation of tradable endowment	0.81
ρ_{N}	Autocorrelation of non-tradable endowment	0.65
ρ_{TN}	Cross-correlation of tradable endowment	−0.61
ρ_{NT}	Cross-correlation of non-tradable endowment	0.28

Notes : This table shows the estimated values for the parameters that characterize the exogenous endowment process.

with zero mean and contemporaneous variance-covariance matrix $V = \begin{bmatrix} \sigma_T^2 & \sigma_{TN} \\ \sigma_{TN} & \sigma_N^2 \end{bmatrix}$. The estimates for ρ and V, obtained from data on sectoral value added, are reported in Table 2.

The remaining subset of parameters is chosen to match relevant moments of the Spanish economy. The empirical targets, together with their model counterparts, are reported in Table 3. The first moment is the share of tradable output in GDP (21% in Spanish data), which identifies the preference parameter in the CES aggregator, a. The next empirical target is the average ratio of government expenditures to GDP (17% in Spanish data), which is used to calibrate the weight of public consumption in the household's utility function, θ. The last two moments, which are mostly governed by κ and β, are the average net foreign

Table 3: Targeted Moments

Moment	Descrition	Data	Without CCT	With CCT
$\mathbb{E}[y_T/y]$	Share of tradable output	18.52%	18.12%	18.13%
$\mathbb{E}[p_N g/y]$	Average govt. spending/output	16.70%	16.67%	16.57%
$\mathbb{E}[b/y]$	Average NFA/output	−36.68%	−36.00%	−35.78%
	Frequency of crisis	1.70%	1.77%	0.14%

Notes : This table shows the model counterparts of four targeted moments. It compares the values implied by the model under the optimal fiscal policy without capital control taxes (without CCT), with those implied by the constrained-efficient allocation (with CCT). The set of targeted moments includes the average net financial asset position, the share of tradable output, the government-spending-to-GDP ratio and the frequency of crisis as defined in the main text.

asset (NFA) position (-36% in Spanish data) and the frequency of financial crisis (1.7%, in Bianchi et al. (2020) for a sample of advanced economies).

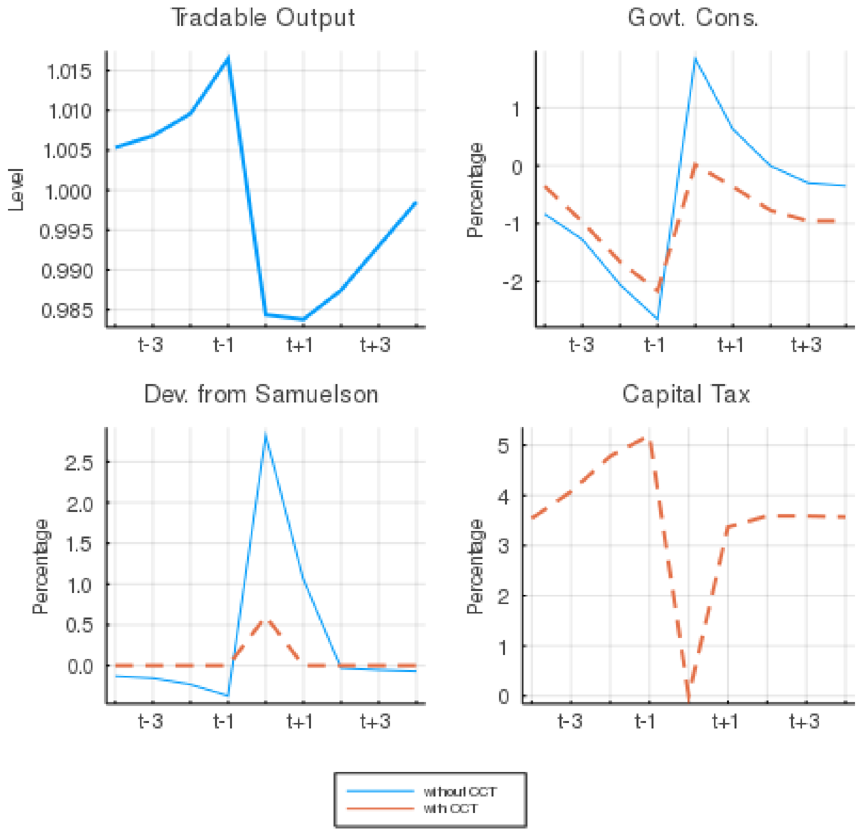
Table 3 shows in its second-to-last column that the calibrated economy - the economy with optimal fiscal policy but without capital control - closely approximates the empirical targets.[22] For comparison, the last column also shows how the moments change if I allow the government to implement optimal capital controls, keeping the same parametrization as in the baseline economy. The values for the first three moments are virtually identical. The only significant discrepancy is in frequency of crises, which is considerably lower under the constrained-efficient allocation as a result of the government being able to fully correct the inefficiency.

3.4 Crisis Dynamics

In this section, I conduct an event study of model-simulated data, by computing averages across crises episodes in a long time-series simulation. The goal is to compare the dynamics of the optimal fiscal policy with and without capital control taxes. To this end, I first simulate the economy under the optimal fiscal policy with no capital controls. I identify financial crisis as the first period where the collateral constraint is binding and I construct a nine-year event window, centered at the year of the crisis. I then recover the corresponding series of exogenous shocks and pass it, together with the initial debt position, through the policy functions of the constrained-efficient equilibrium. Finally, I compute the mean of

[22] The values of calibrated parameters are reported in Table 1.

Figure 2: Typical Financial Crisis



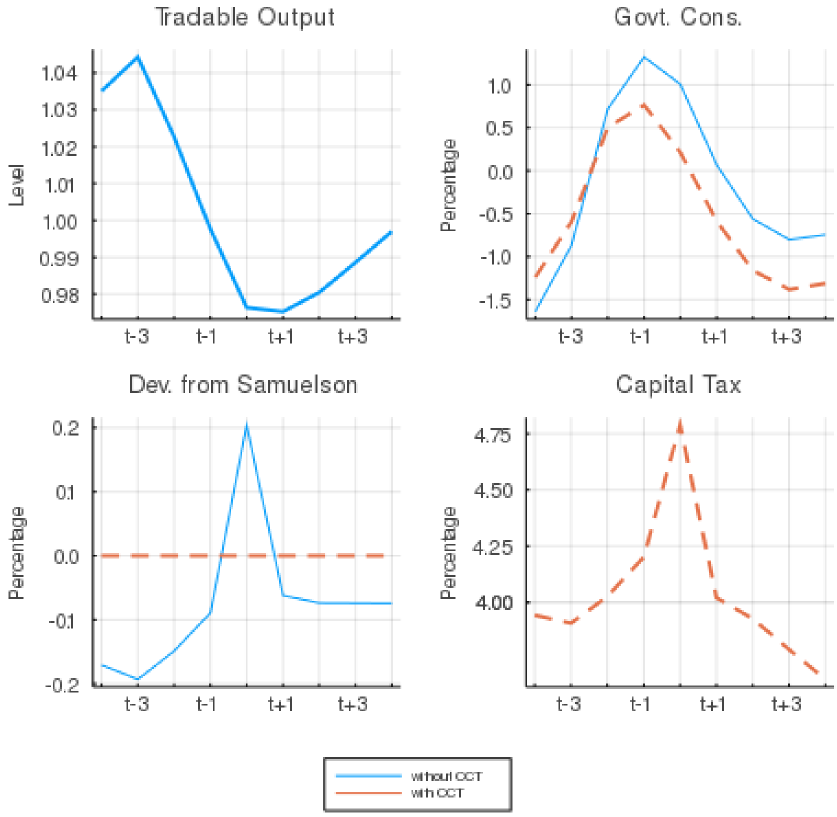
Notes : This figure plots aggregate dynamics during the typical financial crisis. A crisis episode is defined as the first period where the collateral constraint starts to bind. The figure illustrates the dynamics implied by the calibrated model for three aggregate variables: tradable output, goverment consumption and deviation from the Samuelson level. In addition, for the constrained-efficient allocation, it also depicts the implied tax on external debt. The figure compares dynamics without optimal capital controls - the solid line - and with capital controls - the dashed line. Tradable output is in level, while government consumption is expressed in percentage deviations from its average value in the ergodic steady state.

various endogenous variables across crisis episodes.[23]

The results are shown in Figure 1, which depicts average dynamics under the optimal fiscal policy - the solid lines - and under the constrained-efficient allocation - the dashed lines. As expected, the typical financial crisis occurs in periods of weak fundamentals; accordingly, the top-left panel reveals that the tradable endowment falls substantially at the time the constraint becomes binding. The next two panels, at the top-right and bottom-left of the figure, focus on public consumption. One can see that the government practices austerity in the run-up to the crisis, as a means to rein in financial imbalances, consistently with

[23]For two endogenous variables - Deviations from Samuelson and Capital Tax - I plot the median across event windows, rather than the average, as their ergodic distributions tend to be skewed to the right.

Figure 3: Typical Boom-Bust Episode



Notes : This figure plots aggregate dynamics during the typical boom-bust episode. A boom-bust episode is defined as an event windows where the tradable endowments starts above trend but is below trend three periods later. The figure illustrates the dynamics implied by the calibrated model for three aggregate variables: tradable output, goverment consumption and deviation from the Samuelson level. In addition, for the constrained-efficient allocation, it also depicts the implied tax on external debt. The figure compares dynamics without optimal capital controls - the solid line - and with capital controls - the dashed line. Tradable output is in level, while government consumption is expressed in percentage deviations from its average value in the ergodic steady state.

the theoretical analysis. Nevertheless, prudential deviations from the Samuelson level are only modestly negative. By contrast, when the adverse shock hits and the government start resorting to stimulus, spending rises above the Samuelson level by as much as 3 percentage points.

The last panel, at the bottom-right, depicts the capital control tax that implements the constrained-efficient allocation. The typical financial crisis cannot be avoided by means of higher capital controls. Indeed, as soon as the economy enters the recession, the constraint becomes binding and the tax on debt suddenly drops to zero. On the other hand, the constrained-efficient allocation features a lower deviation from the Samuelson level. In addition, government spending remains below the steady-state average even after the negative income shock hits the economy, in stark contrast with the baseline economy.

The analysis so far suggests that the optimal fiscal policy is counter-cyclical. To corroborate this further, I perform a related but different experiment. Following Schmitt-Grohe and Uribe (2018), I identify in the long-run simulation all boom-bust episodes. Specifically, I construct event windows where the tradable endowments starts above trend but falls below trend three periods later. I center each window at the date where the endowment falls below trend, and then plot average dynamics for a subset of aggregates. Figure 3 confirms the counter-cyclical nature of the optimal fiscal policy; government expenditures peak when the downturn hits the economy, and then gradually decline as the endowment shock reverts to its mean. The figure also reveals that the typical boom-and-bust episode results in a crisis only in the absence of capital controls. This confirms that a tax on debt is effective at reducing the likelihood of a crash.

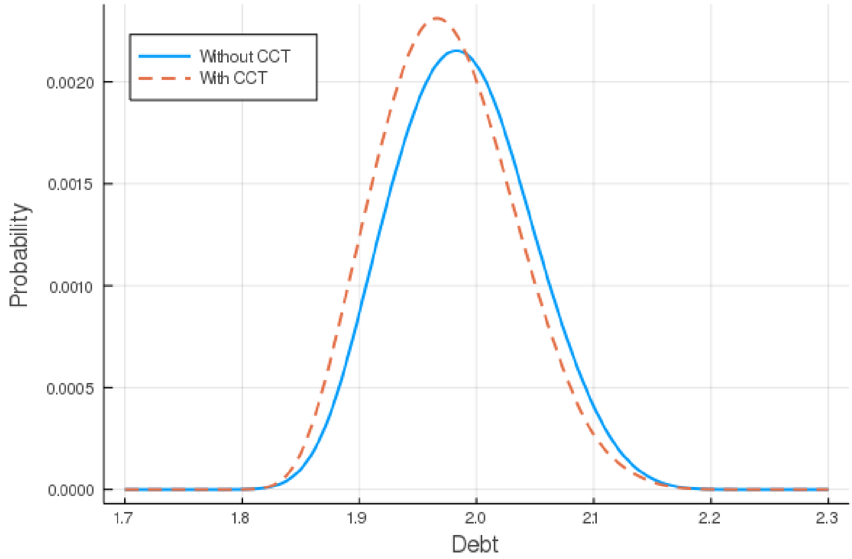
One interesting thing to notice is that the optimal macroprudential policy appears to be pro-cyclical. When the economy enters the recession, in fact, the constrained-efficient allocation calls for an increase in the capital-control tax, not a decrease. The motive for tightening regulation at the onset of a downturn is that this is exactly the time where a financial crisis is most likely. Fiscal policy, in stark contrast, behaves counter-cyclically. The government tightens fiscal policy when tradable income is above trend and then resorts to stimulus as soon as the economy enters the recession. The intuition is that austerity can substitute for capital-control policies only imperfectly. Hence, by the time the economy enters the recession, financial imbalances are too large and the government has no choice but to let the constraint bind.

3.5 Welfare Comparison

To conclude the numerical application, I conduct a welfare analysis of the gains from optimal macroprudential policy. To begin, Figure 2, compares the ergodic debt distribution under the optimal fiscal policy in the unregulated economy - the solid line - and in the economy with optimal capital controls - the dashed line. The figure reveals that the unregulated economy displays overborrowing, as its debt distribution lies to the left of the one associated to the constrained-efficient allocation. Nonetheless, the two distribution are very close to each other, suggesting that the economy is subject to overborrowing only to a limited extent.

Motivated by this evidence, I then quantify welfare gains from implementing optimal macroprudential policies, expressing them as consumption equivalent deviations from the constrained-efficient allocation. More formally, I compute the proportional increase in both private and public consumption that would make households indifferent between remaining in the unregulated economy (with optimal fiscal policy) and moving to the constrained-efficient allocation. Because of the homotheticity of the utility function, the welfare gain in

Figure 4: Ergodic Debt Distribution



Notes : This figure plots the ergodic distribution under the optimal fiscal policy, without optimal capital controls - the solid line - and with optimal capital controls - the dashed line.

Table 4: Welfare Gains from Optimal Capital Controls

	Welfare Gains
Average	0.013%
Standard deviation	0.003%
Correlation with output	0.170%

Notes : This table reports welfare gains from implementing optimal capital controls. Moments are computed based on the ergodic distribution under the optimal fiscal policy in the economy without capital control taxes.

each state, $\gamma(b, y)$, can be computed through the following equation:

$$(1 + \gamma(b, y))^{1-\sigma} V^{op}(b, y) = V^{ce}(b, y) \tag{32}$$

where $V^{op}(b, y)$ denotes the value function in the unregulated economy under the optimal fiscal policy and $V^{ce}(b, y)$ denotes the value function in the constrained-efficient allocation.

I calculate welfare gains for every (b, y)-pair, and then use the ergodic distribution of the aggregate state in the unregulated economy to compute mean, standard deviation and correlation with GDP. Results, which are reported in Table 4, reveal that welfare gains are not negligible, 0.013% on average, but their magnitude appears to be relatively small. This despite of the fact that optimal capital controls are successful in driving the probability of a crisis virtually to zero - see Table 3. The intuition for this is that fiscal stimulus by itself makes crises less costly. As a result a lower frequency only yields modest improvements relative to the unregulated economy.

4 Conclusions

To conclude, this paper studied the design of fiscal policy in economies that are subject to endogenous collateral constraint. The central result is that the optimal policy is counter-cyclical. During boom, the government practices austerity to substitute for capital controls in settings where these cannot be enforced. During downturns, the government resorts to stimulus in order to prevent costly deleveraging episodes.

I find that optimal macroprudential policy is welfare-enhancing but gains are relatively small thanks to the ability of fiscal policy to foster financial stability both ex-ante and ex-post. Overall, the analysis points out that normative studies of open economies with financial frictions should take into account a variety of policy options and be explicit about the constraints that make one alternative or the other more viable to policy-makers.

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Appendices

A Proofs

Proof of Proposition 2. Recall the constrained-efficient problem

$$\max_{C_0^T, C_0^N, G_0^N, B_1} U_c(A(C_0^T, C_0^N)) + U_g(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{33}$$

s.t.

$$C_0^T = y_0^T + B_0 - \frac{B_1}{R} \tag{34}$$

$$\frac{B_1}{R} \leq \kappa_0 \left(y_0^T + \frac{1-a}{a} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} y^N \right) \tag{35}$$

Taking the first-order condition with respect to G_0^N yields

$$U_N(C_0^T, C_0^N) - v_g(G_0^N) = \mu_0^{sp} \left[\kappa_0 \frac{1-a}{a} \frac{1}{\xi} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} \frac{y^N}{y^N - G_0^N} \right] \tag{36}$$

If κ_0 is sufficiently small, the collateral constraint. The result than follows from the fact that in this case $\mu_0^{sp} > 0$ ■

Proof of Proposition 3. If $\kappa_0 \to \infty$, the optimization problem of the government is as follows

$$\max_{C_0^T, G_0^N, B_1} U(A(C_0^T, y^N - G_0^N)) + v(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{OP}$$

s.t.

$$C_0^T = y_0^T + B_0 - \frac{B_1}{R} \tag{37}$$

$$U_T(C_0^T, y^N - G_0^N) = \beta R E_s U_T(C^T(B_1, s), s) \tag{38}$$

I begin by demonstrating that problem (OP) is equivalent to the following

$$\max_{C_0^T, G_0^0, B_1} U(A(C_0^T, y^N - G_0^N)) + v(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{OP1}$$

s.t.

$$C_0^T = y_0^T + B_0 - \frac{B_1}{R} \tag{39}$$

$$U_T(C_0^T, y^N - G_0^N) - \beta R E_s U_T(C^T(B_1, s), s) \leq 0 \tag{40}$$

To show this, suppose we maximize the same objective function as in (OP) but without being subject to constraint (38), i. e.

$$\max_{C_0^T, G_0^N, B_1} U(A(C_0^T, y^N - G_0^N)) + v(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{41}$$

s.t.

$$C_0^T = y_0^T + B_0 - \frac{B_1}{R} \tag{42}$$

Taking the first-order condition of this relaxed problem with respect to B_1, and combining it with the envelop condition for $V(B_1, s; B_1)$ we obtain

$$U_T(C_0^T, y^N - G_0^N) = \beta R E_s \left[U_T(C^T(B_1, s), s) + \mu_1(s)\kappa_1 \frac{1-a}{a}\frac{1}{\xi}\left(\frac{C^T(B_1, s)}{y^N}\right)^{\frac{1}{\xi}-1} \right] \tag{43}$$

From this expression, since the second term on the right-hand side is positive, it follows that the solution to the unconstrained problem satisfies $U_T(C_0^T, y^N - G_0^N) - \beta R E_s U_T(C^T(B_1, s), s) \geq 0$, with strict inequality if and only if $E_s \mu_1(s) > 0$. This directly implies that problem (OP1) and (OP) are equivalent, as the government would never choose an allocation such that $U_T(C_0^T, y^N - G_0^N) - \beta R E_s U_T(C^T(B_1, s), s) < 0$.

From now on I will therefore focus only on problem (OP1). Taking the first-order conditions with respect to g_0^N yields

$$v_g(G_0^N) - U_N(C_0^T, y^N - G_0^N) - \xi U_{TN}(C_0^T, y^N - G_0^N) = 0 \tag{44}$$

where ξ denotes the Lagrange multiplier associated to (40). We now show that $\xi \geq 0$ with strict inequality if and only if $E_s \mu_1(s) > 0$.

From (43), it follows immediately that if $E_s \mu_1(s) = 0$, then (40) does not bind in problem (OP1) and hence $\xi = 0$. Conversely, if $E_s \mu_1(s) > 0$ then the solution to the relaxed problem is such that $U_T(C_0^T, y^N - G_0^N) - \beta R E_s U_T(C^T(B_1, s), s) > 0$. Therefore, (40) is binding and $\xi > 0$.

Let me now focus on $U_{TN}(C_0^T, y^N - G_0^N)$. Using the functional forms (2) and (4), I obtain

$$U_{TN}(C_0^T, y^N - G_0^N) = \theta a(1-a)\frac{1-\sigma\xi}{\xi} C_0^{T-\frac{1}{\xi}} (y^N - G_0^N)^{-\frac{1}{\xi}} C_0^{\frac{1-\sigma\xi}{\xi} - \left(1 - \frac{1}{\xi}\right)} \tag{45}$$

This implies that

$$U_{TN}(C_0^T, y^N - G_0^N) \begin{cases} > 0 & \text{if } \sigma\xi > 1 \\ = 0 & \text{if } \sigma\xi = 1 \\ < 0 & \text{if } \sigma\xi < 1 \end{cases} \tag{46}$$

The result then follows from this and (52). ■

Proof of Proposition 4. The optimization problem of the government is as follows

$$\max_{C_0^T, G_0^N, B_1} U(A(C_0^T, y^N - G_0^N)) + v(G_0^N) + \beta E_s V(B_1, s; B_1) \tag{OP}$$

s.t.

$$C_0^T = y_0^T + B_0 - \frac{B_1}{R} \tag{47}$$

$$\frac{B_1}{R} \leq \kappa_0 \left(y_0^T + \frac{1-a}{a} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} y^N \right) \tag{48}$$

$$U_T(C_0^T, y^N - G_0^N) = \beta R E_s U_T(C^T(B_1, s), s) + \mu_0 \tag{49}$$

$$\mu_0 \geq 0 \tag{50}$$

$$\mu_0 \left[\frac{B_1}{R} - \kappa_0 \left(y_0^T + \frac{1-a}{a} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} y^N \right) \right] = 0 \tag{51}$$

Taking the first-order conditions with respect to G_0^N yields

$$v_g(G_0^N) - U_N(C_0^T, y^N - G_0^N) - \xi U_{TN}(C_0^T, y^N - G_0^N) - \mu_0^{op} \left[\kappa_0 \frac{1-a}{a} \frac{1}{\xi} \left(\frac{C_0^T}{y^N - G_0^N} \right)^{\frac{1}{\xi}} \frac{y^N}{y^N - G_0^N} \right] = 0 \tag{52}$$

where ξ denotes the Lagrange multiplier associated to (40) and μ_0^{op} the multiplier associate to the collateral constraint. The result then follows give that the last term on the right-hand side of the above equation is positive. ■

B Graphical Analysis

Panel (a) of Figure 1 provides a graphical representation of price-based channel for the case where $\sigma\xi > 1$. The figure plots the Euler equation residual as a function of next period's debt. Each curve refers to one of the following cases: (i) the competitive equilibrium with government expenditures equal to the Samuelson level - the dashed and dotted line; (ii) the constrained-efficient allocation - the dashed line; and (iii) the allocation under the optimal fiscal policy with no capital controls - the solid line.

If the government follows Samuelson, the only level of borrowing consistent with the competitive equilibrium is b^{eq}, exactly at the point where the Euler equation holds with equality. The constrained-efficient choice, denoted by b^{ce}, is at its left, as one would expect in the presence of the borrowing inefficiency. Here the government also follows Samuelson, but because the Euler equation residual is strictly positive the borrowing decision is no longer consistent with the competitive equilibrium. The debt level that emerges under the optimal policy, b^{op}, is somewhere in between. Because spending is lower than the Samuelson level, the shadow value of current consumption is also lower and the curve of Euler equation residuals - the solid line - lies uniformly below the other two. Through this channel, austerity allows the government to attain lower leverage without violating the Euler equation of the competitive equilibrium.

Mirroring the previous analysis, Panel (b) of Figure 1 provides a graphical representation of the quantity-based channel, considering a parametrization with $\sigma\xi = 1$. The figure plots the left-hand side of the collateral constraint (23), as function of debt in the next period. As before, each curve refers to a different case: (i) the constrained-efficient allocation - the dashed line; and (ii) the allocation under the optimal fiscal policy with no capital controls - the solid line.[24]

The competitive equilibrium lies at a point, b^{eq}, where the collateral constraint is slack and the Euler equation holds with equality. At the left of it is the constrained-efficient level of debt, b^{ce}. A figure similar to Panel (a) would reveal that at that point the Euler equation features a strictly positive wedge. Because the collateral constraint is slack at b^{ce}, the existence of this wedge constitutes a violation of the slackness condition, making the constrained-efficient choice inconsistent with the competitive equilibrium. Under the optimal policy with no capital controls, the optimal leverage, b^{op}, again lies in between. The government tightens the constraint and this allows to attain a lower level of debt without violating the competitive equilibrium conditions.

[24]Under the assumption that $\sigma\xi = 1$ the Samuelson level of government expenditures is independent of the level of tradable consumption. Therefore, the curve corresponding to the competitive equilibrium with expenditures equal to Samuelson actually coincides with the curve associated to the constrained-efficient allocation.

C Competitive Equilibrium in the Quantitative Model

Definition 5. *A competitive equilibrium consists of allocations and prices* $\{c_t^T, c_t^N, c_t, b_{t+1}, \lambda_t, \mu_t, p_t^N\}_{t=0}^{\infty}$ *satisfying*

$$y_t^N = c_t^N + g_t^N \tag{53}$$

$$c_t^T = y_t^T + \frac{b_{t+1}}{R_t} - b_t \tag{54}$$

$$\frac{b_{t+1}}{R_t} \leq \kappa_t(y_t^T + p_t^N y_t^N) \tag{55}$$

$$\mu_t \left[\kappa_t(y_t^T + p_t^N y_t^N) - \frac{b_{t+1}}{R_t} \right] = 0 \tag{56}$$

$$\lambda_t = U_T(c_t^T, c_t^N) \tag{57}$$

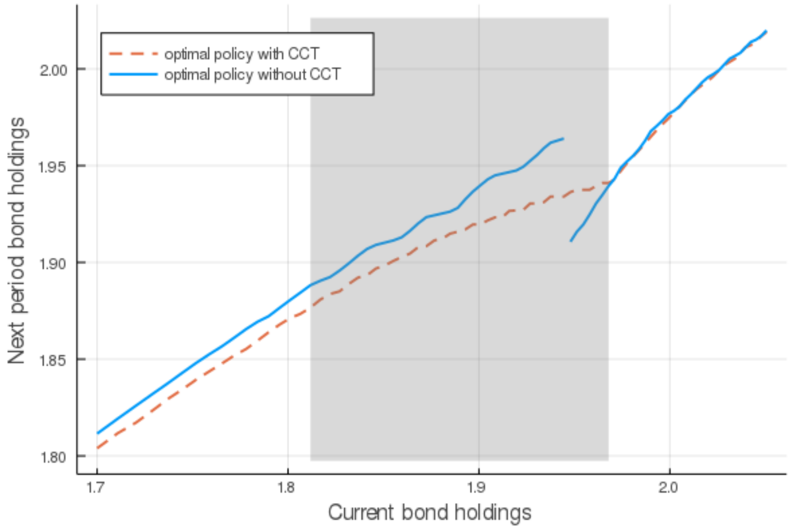
$$\lambda_t = \beta R E_t[\lambda_{t+1}] + \mu_t \tag{58}$$

$$p_t^N = \frac{A_2(c_t^T, c_t^N)}{A_1(c_t^T, c_t^N)} \tag{59}$$

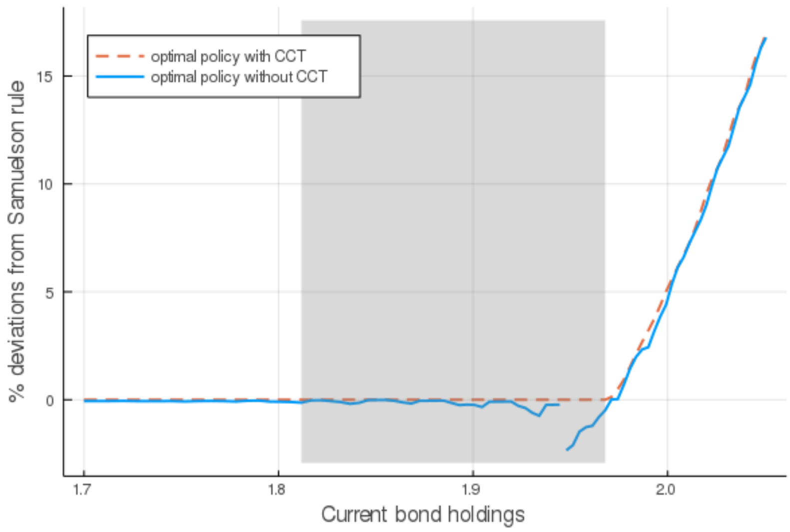
given processes $\{y_t^T, y_t^N, g_t^N\}$ *and initial condition* b_0.

D Additional Plots and Tables

Figure D.1: Policy Functions



(a) Debt



(b) Government Consumption