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Optimal crisis interventions in an open economy
with credit constraint

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Abstract

In an open-economy model with financial constraint, Schmitt-Grohé and Uribe (2017) propose an expression for a capital control policy. From this expression, they argue that the optimal tax, i.e. the one that solves the overborrowing problem, is indeterminate when crises occur (i.e. when the constraint binds) and positive during normal times. In contrast, we show that their capital tax (i) is indeterminate during normal times and, in standard cases, positive during crises, and (ii) does not solve the overborrowing problem, and therefore it is not an optimal capital control policy, as opposed to the capital tax proposed by previous literature (positive during normal times and nil during crisis). We also show that the overborrowing problem can be solved as well by a subsidy on consumption (positive during crises and zero during normal times).

Keywords: credit constraint; financial crisis; capital controls; overborrowing; macroprudential

JEL Classification: F34, F41, G01, H23, D62

1   Introduction

In a recent strand of literature, financial crises have been analyzed by means of open (endowment) economy models in which there is a negative feedback between the presence of an occasionally binding credit constraint and the underestimation of the social cost of debt. This literature gives a welfare foundation to the role of government interventions which intend to prevent and respond to those crises.

Schmitt-Grohé and Uribe (2017) (SGU hereafter) derive an expression for a capital control policy in the abovementioned class of models. From that expression they argue that the Ramsey-optimal tax is indeterminate when crises occur (i.e. when the credit constraint binds) and positive during normal times. In contrast, in the present paper we show that the expression obtained by SGU actually implies a tax that is indeterminate in normal times and, in standard cases, positive during crises. Furthermore, we show that such tax is not optimal as it does not solve the externality problem that results from the underestimation of the social costs of decentralized debt decisions.

The interaction of the credit constraint and the underestimation of the cost of debt has been shown to lead to overborrowing (see, for instance, Bianchi, 2011 and Jeanne and Korinek, 2011), measured as the difference between the level of debt chosen by a social planner (SP) and the one chosen by households in a decentralized economy. Overborrowing is a consequence of the undervaluation of liquidity by private agents during crises. The capital tax proposed by the related literature (positive during normal times and nil during crisis) equalizes the level of decentralized debt (and consumption) to that of the SP during normal times. This is sufficient to implement the SP allocation during crises as well because the level of decentralized debt chosen is equal to that of the SP in those periods since both are equally constrained, given a state of the economy (i.e. the level of past debt and endowments).[1] In contrast, the expression found by SGU turns out to be indeterminate during normal times and positive but ineffective (given the state of the economy, it affects neither the valuation of liquidity nor the allocation) during crises.

In addition, we demonstrate that a subsidy on consumption (positive during crises and zero in normal times) is also a solution to the overborrowing problem because it increases the valuation of liquidity during crises, and therefore implements the SP equilibrium.[2]

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[1]This tax can be considered an indirect solution since it does not directly solve the problem of undervaluation during crises. Instead, it equalizes the allocation during normal times. In contrast the subsidy on consumption that we describe below directly solves the problem, as it equalizes the valuations of liquidity during crises.

[2]Throughout the present paper, the fiscal-policy framework corresponds to a balanced-budget setup: following the standard practice in the related literature, we assume that the specific intervention (tax or subsidy) is financed by means of a lump-sum transfer within the period. In Parra-Polania and Vargas (2016) we analyze countercyclical fiscal-policy frameworks.

2 The Model and Results

Our theoretical framework is the same as that used by SGU and the related literature. We model a small open endowment economy with consumers' preferences of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t) \tag{1}$$

where E_t denotes the expectations operator conditional on information available in period t, β is the discount factor, $U(\cdot)$ is the well-behaved period utility function, and c_t denotes the consumption index which aggregates tradable (T) and nontradable (N) goods.

Every period, each household receives an exogenous bundle of tradable and nontradable goods, y_t^T and y_t^N, and has access to international financial markets through one-period loans d_{t+1} ($d_{t+1} < 0$ implies savings) at an exogenously given interest rate r_t. The household's budget constraint is given by

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t}, \tag{2}$$

where p_t is the price of nontradables and the price of tradables has been normalized to one. We use a standard financial constraint in which there is access to credit up to a fraction $\kappa > 0$ of current total income:

$$d_{t+1} \le \kappa \left(y_t^T + p_t y_t^N \right). \tag{3}$$

The market-clearing conditions for nontradables and tradables, respectively, are:

$$c_t^N = y_t^N, \tag{4}$$

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t}. \tag{5}$$

Let $\beta^t \lambda_t$ be the Lagrange multiplier associated to the budget constraint and $\beta^t \lambda_t \mu_t$ the one associated to the credit constraint. Given $\{r_t, d_t, y_t^T, y_t^N\}$ and $c_t^N = y_t^N$, the solutions for c_t^T, μ_t, λ_t, d_{t+1} and p_t can be obtained from:[3]

$$U'(c_t) \frac{\partial c_t}{\partial c_t^T} = \lambda_t, \tag{6}$$

$$\frac{\lambda_t}{1+r_t} = \beta E_t \lambda_{t+1} + \lambda_t \mu_t, \tag{7}$$

$$\frac{d_{t+1}}{1+r_t} = c_t^T + d_t - y_t^T, \tag{8}$$

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[3]This equation system is equal to the one formed by equations (5)-(7), (9) and (11) in SGU (pp.501-502), except for the fact that they use an explicit function (CES) for the consumption index aggregator. It is also equal to the one formed by equations (17)-(22) in SGU (p. 504) before including any capital control tax ($\tau_t = 0$).

$$p_t = \frac{\partial c_t / \partial c_t^N}{\partial c_t / \partial c_t^T}, \tag{9}$$

$$\mu_t \left[\kappa \left(y_t^T + p_t y_t^N \right) - d_{t+1} \right] = 0. \tag{10}$$

If in period t the economy is unconstrained, $d_{t+1} < \kappa \left(y_t^T + p_t y_t^N \right)$ and hence from Equation (10) $\mu_t = 0$. If, instead, the economy is constrained, $\mu_t \geq 0$ and $d_{t+1} = \kappa \left(y_t^T + p_t y_t^N \right)$.

Since private agents have an insignificant impact on the market, they take prices as given. Instead, a benevolent Social Planner (SP), subject to the same financial constraint, internalizes the effect of borrowing decisions on prices. By following the constrained-efficiency criterion[4], we assume that the SP is constrained by the same pricing rule of the competitive equilibrium. The SP acknowledges the effects that consumption decisions have on price determination given by Equation (9).

Given $\left\{ r_t, d_t, y_t^T, y_t^N \right\}$ and $c_t^N = y_t^N$, the first order conditions for the SP problem are:[5]

$$U' \left(c_t^{SP} \right) \frac{\partial c_t^{SP}}{\partial c_t^{T,SP}} + \lambda_t^{SP} \mu_t^{SP} \psi_t^{SP} = \lambda_t^{SP}, \tag{11}$$

$$\frac{\lambda_t^{SP}}{1 + r_t} = \beta E_t \lambda_{t+1}^{SP} + \lambda_t^{SP} \mu_t^{SP}, \tag{12}$$

$$\mu_t^{SP} \left[\kappa \left(y_t^T + \frac{\partial c_t^{SP} / \partial c_t^N}{\partial c_t^{SP} / \partial c_t^{T,SP}} y_t^N \right) - d_{t+1}^{SP} \right] = 0, \tag{13}$$

$$\frac{d_{t+1}^{SP}}{1 + r_t} = c_t^{T,SP} + d_t^{SP} - y_t^T, \tag{14}$$

where $\psi_t^{SP} \equiv \frac{\partial \left(\frac{\partial c_t^{SP} / \partial c_t^N}{\partial c_t^{SP} / \partial c_t^{T,SP}} \right)}{\partial c_t^{T,SP}} \kappa y_t^N$.

2.1 Macroprudential tax

We replicate in this subsection some important elements from the related literature (e.g. Bianchi, 2011; Jeanne and Korinek, 2011) which has shown that the SP allocation (i.e. consumption and debt) can be implemented in a decentralized economy using a macroprudential tax on debt (triggered during normal times only). In the next subsection we analyze the tax derived by SGU.

Suppose that in the decentralized economy the government imposes a tax τ_t on debt during normal times (i.e. when the economy is constrained, $\tau_t = 0$), which is returned to the household in the same period through a lump-sum transfer l_t. The budget constraint is

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + (1 - \tau_t) \frac{d_{t+1}}{1 + r_t} + l_t \tag{15}$$

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[4]See Kehoe and Levine (1993) and Lorenzoni (2008).

[5]This equation system is equal to the one formed by equations (31)-(33) plus the budget-constraint equation in SGU (pp.524-525), except for the fact that they use an explicit function (CES) for the consumption index aggregator.

There is a balanced-budget fiscal policy every period:

$$l_t = \tau_t \frac{d_{t+1}}{1 + r_t} \tag{16}$$

Notice that with the incorporation of the tax, the system formed by Equations (6)-(10) remains the same except for Equation (7) which turns into

$$\frac{1 - \tau_t}{1 + r_t} \lambda_t = \beta E_t \lambda_{t+1} + \lambda_t \mu_t. \tag{17}$$

Proposition 1 *In the economy described by Equations (1), (3), (15) and (16) there is a value of τ_t such that the SP allocation (FOC: Equations (11)-(14)) is implemented in the decentralized economy, in any period t.*

Proof. When the economy is financially constrained ($\mu_t \geq 0$, $\tau_t = 0$), we solve for $c_t^{T,SP}$ and d_{t+1}^{SP} from Equations (14) and (13). Solutions are exactly equal to those values of c_t^T and d_{t+1} that solve the system (8)-(10), for a given state $\{r_t, d_t, y_t^T, y_t^N\}$. In other words, the SP allocation coincides with the decentralized-economy allocation ($c_t^{T,SP} = c_t^T$ and $d_{t+1}^{SP} = d_{t+1}$), for a given state. However, the valuations of liquidity differ: by comparing Equations (11) and (6):

$$\lambda_t = \lambda_t^{SP} - \lambda_t^{SP} \mu_t^{SP} \psi_t^{SP}, \tag{18}$$

and hence the SP valuation of liquidity under crisis is greater, $\lambda_t^{SP} \geq \lambda_t$.

In unconstrained periods ($\mu_t = 0$), if there were no tax, although Equations (11)-(14) for the SP are of the same form as those for the decentralized economy, (6)-(8), they would not result in the same equilibrium, due to the difference in the valuation of liquidity during crisis, specifically $E_t \lambda_{t+1}^{SP} \neq E_t \lambda_{t+1}$. To implement the SP allocation in the decentralized economy, we introduce a tax τ_t on debt such that (from (6) and (17), with $\mu_t = 0$):

$$\frac{1 - \tau_t}{1 + r_t} U'(c_t) \frac{\partial c_t}{\partial c_t^T} = \beta E_t \left[U'(c_{t+1}) \frac{\partial c_{t+1}}{\partial c_{t+1}^T} \right] \tag{19}$$

becomes equal to (from (11) and (12), with $\mu_t^{SP} = 0$)[6]

$$\frac{1}{1 + r_t} U'(c_t^{SP}) \frac{\partial c_t^{SP}}{\partial c_t^{T,SP}} = \beta E_t \left[\frac{U'(c_{t+1}^{SP})}{1 - \mu_{t+1}^{SP} \psi_{t+1}^{SP}} \frac{\partial c_{t+1}^{SP}}{\partial c_{t+1}^{T,SP}} \right]. \tag{20}$$

Dividing (19) by (20) and taking into account that $c_t^{SP} = c_t$ and $\psi_{t+1}^{SP} = \psi_{t+1}$ (since the tax equalizes the allocations), the optimal tax can be expressed as follows:

$$\tau_t = 1 - \frac{E_t \left[U'(c_{t+1}) \frac{\partial c_{t+1}}{\partial c_{t+1}^T} \right]}{E_t \left[\frac{U'(c_{t+1})}{1 - \mu_{t+1}^{SP} \psi_{t+1}} \frac{\partial c_{t+1}}{\partial c_{t+1}^T} \right]}, \tag{21}$$

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[6]Notice from (11) that $\lambda_t^{SP} = \frac{U'(c_t^{SP})}{1 - \mu_t^{SP} \psi_t^{SP}} \frac{\partial c_t^{SP}}{\partial c_t^{T,SP}}$

which is lower than one and positive. ∎

Summarizing, the macroprudential tax policy that implements the SP allocation in the decentralized economy is such that $\tau_t = 0$ when the economy is financially constrained, and follows (21) in normal times.

2.2 SGU tax

SGU derive their tax directly from Equation (19) (Equations (19) and (20) in their paper) and by imposing $\mu_t = 0$ for all t. In this way, we obtain the following expression for the SGU tax:

$$\tau_t = 1 - \beta \left(1 + r_t\right) \frac{E_t \left[U'\left(c_{t+1}\right) \frac{\partial c_{t+1}}{\partial c_{t+1}^T}\right]}{U'\left(c_t\right) \frac{\partial c_t}{\partial c_t^T}}, \tag{22}$$

which is equal to their equation (26).

Proposition 2 *A tax on debt described by Equation (22) (i.e. the SGU tax) does not implement the SP allocation in the decentralized economy.*

Proof. (i) When the economy is not financially constrained, the SGU tax makes the system indeterminate:

Since $\mu_t = 0$, without a tax, the solutions for c_t^T, λ_t, d_{t+1} and p_t can be obtained from Equations (6)-(9), given $\left\{r_t, d_t, y_t^T, y_t^N\right\}$. Incorporating the SGU tax modifies one equation ((7) turns into (17)) and adds one variable to the system (τ_t). It does not add any further equation since (22) is just a combination of two other equations already present in the system, (6) and (17). There are infinite possible combinations of c_t^T, λ_t, d_{t+1}, p_t and the SGU tax τ_t that solve the corresponding equation system. Only the one that coincides with that derived in the previous subsection (Equation (21)) would implement the SP allocation.

(ii) When the economy is financially constrained, the SGU tax does not affect the decentralized allocation, given $\left\{r_t, d_t, y_t^T, y_t^N\right\}$:

In this case, incorporating the SGU tax adds one equation to the system because (22) is no longer a combination of (6) and (17) (and the specific value of μ_t is determined within the system). Given $\left\{r_t, d_t, y_t^T, y_t^N\right\}$, the solution for c_t^T, μ_t, λ_t, d_{t+1}, p_t and the SGU tax τ_t can be obtained from Equations (6), (8), (9), (17), (22) and the binding constraint

$$d_{t+1} = \kappa \left(y_t^T + p_t y_t^N\right). \tag{23}$$

Solutions for c_t^T, d_{t+1} and p_t are obtained from the subsystem of Equations (8), (9) and (23), independently from the other equations of the whole system. With a solution for c_t^T we can solve for λ_t, from (6), and for τ_t, from (22). Therefore, from (17), τ_t only affects the value of μ_t.[7] It neither solves the problem of the undervaluation of liquidity nor affects the decentralized allocation. ∎

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[7]Since, for the derivation of (22), SGU impose $\mu_t = 0$ for all t, then by construction τ_t implies an equilibrium with $\mu_t = 0$ during crises.

SGU argue that their tax is indeterminate during crises because they assume that only one equation (Equation (17)) is the relevant one for the determination of both τ_t and μ_t; however, as explained in the proof of Proposition 2, these two variables are determined by two independent equations: (17) and (22).

The SGU tax fails to implement the SP allocation in the decentralized economy because it satisfies just condition (19) and disregards condition (20). During crises, the SGU tax is, for pretty standard cases, positive: for the case of the explicit functions and parameter values considered by SGU and the related literature, $U'\left(c_t\right)\left(\partial c_t/\partial c_t^T\right)$ is decreasing in the levels of consumption and hence when the expected level of future consumption is higher than the current one -as usual during crises- the SGU tax, from (22), is positive.[8]

SGU conduct some numerical simulations that seem to confirm their theoretical conclusions about the optimal tax being indeterminate during crises and positive during normal times. It is worth explaining why this occurs. For periods where the constraint binds (i.e crises), they set τ_t to "Not a number" (NaN) by construction (and according to their theoretical result). Regarding periods where the economy is not constrained, SGU are able to determine τ_t because they numerically solve the problem for the SP and then they use those results to assign a value, from Equation (22).

As shown in Proposition 2, Equation (22) does not implement the SP allocation in the decentralized economy. However, it can be shown that Equation (21) is equivalent to

$$\tau_t = 1 - \beta\left(1+r_t\right)\frac{E_t\left[U'\left(c_{t+1}\right)\frac{\partial c_{t+1}}{\partial c_{t+1}^T}\right]}{U'\left(c_t^{SP}\right)\frac{\partial c_t^{SP}}{\partial c_t^{T,SP}}}.$$

Since this, the appropriate tax, equalizes the allocations of the decentralized and the SP cases (and hence $c_t^{SP}=c_t$ and $c_t^{T,SP}=c_t^T$), its value and the ex-post value assigned to the SGU tax (i.e. based on the SP solutions) shall be equal.[9]

2.3   Ex-post subsidy on consumption

In this subsection we show that the SP equilibrium can be implemented in a decentralized economy by means of an alternative policy: a subsidy on consumption that applies in crisis periods only (i.e. an ex-post subsidy).

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[8]Assuming a CES function for the consumption index aggregator -with intratemporal elasticity of substitution ξ and weight a on tradables- and a CRRA function for utility -with intertemporal elasticity of substitution $1/\sigma$- we have that $U'\left(c_t\right)\left(\partial c_t/\partial c_t^T\right)=ac_t^{1/\xi-\sigma}\left(c_t^T\right)^{-1/\xi}$. It is usually assumed that $1/\sigma<\xi$, which is a sufficient condition for $U'\left(c_t\right)\left(\partial c_t/\partial c_t^T\right)$ to be decreasing in the levels of consumption.

[9]This preserves the most important numerical result of the paper by SGU which is showing that for standard functions and parameter values the optimal capital tax is procyclical during normal times (leaving crises aside). Of course this is not true for the SGU tax since, as we have shown, it is indeterminate during normal times, but it is true for the optimal tax (Equation (21)): for standard functions and parameter values the optimal tax is higher when the probability of being financially constrained in the next period increases. With output persistence, such event is more likely during a low-income period than during a high-income one, and hence the optimal tax should be higher during the former and lower during the latter. This procyclical relation is only broken during crises when the optimal tax is the lowest (zero).

Suppose the government, in the decentralized economy, imposes a subsidy $\omega_t > 0$ on both tradable and nontradable consumption which is triggered in crisis periods only ($\omega_t = 0$ in normal times) and it is financed through a lump-sum tax l_t. The budget constraint is

$$\left(c_t^T + p_t c_t^N\right)(1 - \omega_t) + d_t = y_t^T + p_t y_t^N + (1 - \tau_t)\frac{d_{t+1}}{1 + r_t} - l_t \tag{24}$$

There is a balanced-budget fiscal policy every period such that

$$l_t = \omega_t \left(c_t^T + p_t c_t^N\right) \tag{25}$$

Proposition 3 *In the economy described by Equations (1), (3), (24) and (25) there is a value of ω_t, such that the SP allocation is implemented in the decentralized economy, in any period t.*

Proof. As explained in the proof of Proposition 1, in unconstrained periods the decentralized equation system is of the same form as that of the SP. Also explained in that proof, during crises both allocations coincide ($c_t^{T,SP} = c_t^T$ and $d_{t+1}^{SP} = d_{t+1}$, for a given state $\{r_t, d_t, y_t^T, y_t^N\}$) but the SP valuation of liquidity is greater, $\lambda_t^{SP} \geq \lambda_t$. The subsidy on consumption can then be used to equalize them. In this case, the first order conditions with respect to c_t^T and c_t^N, respectively, are:

$$U'(c_t)\frac{\partial c_t}{\partial c_t^T} = \lambda_t (1 - \omega_t), \tag{26}$$

$$U'(c_t)\frac{\partial c_t}{\partial c_t^N} = p_t \lambda_t (1 - \omega_t), \tag{27}$$

which implies that Equation (9) remains the same. Since Equations (7) and (12) are of the same form, then it will be enough to equalize (26) to (11), which implies that the optimal subsidy is

$$\omega_t = \mu_t \psi_t, \tag{28}$$

where we have taken into account that $c_t^{SP} = c_t$, $\lambda_t^{SP} = \lambda_t$ and $\mu_t^{SP} = \mu_t$, because ω_t is equalizing the equilibria. Multiplying and dividing by λ_t the subsidy can be expressed as

$$\omega_t = \frac{\lambda_t \mu_t \psi_t}{U'(c_t)\frac{\partial c_t}{\partial c_t^T} + \lambda_t \mu_t \psi_t},$$

which is positive and less than one. ■

It is important to point out that, unlike the macroprudential tax, the ex-post subsidy (28) is no longer a solution if we remove the assumption that lenders overlook the effect of lump-sum taxes on borrowing capacity. As mentioned by Parra-Polania and Vargas (2015, pp. 5-6), the standard financial constraint (3) implicitly assumes that international lenders suffer from a sort of fiscal illusion since they do not take into account that at

the moment of debt repayment households have to pay taxes, which reduces their income available for debt repayments. In that paper, we remove this assumption and propose the following financial constraint:

$$d_{t+1} \leq \kappa \left(y_t^T + p_t y_t^N - l_t \right). \tag{29}$$

It is easy to see that, under this alternative constraint, the ex-post subsidy on consumption (28) is not able to implement the SP equilibrium because the lump-sum tax that finances the subsidy affects borrowing capacity. As a result, the equation system that solves for c_t^T and d_{t+1} during crises, in the decentralized economy, is different from the one for the case of the SP.[10] Parra-Polania and Vargas (2015, Proposition 4) also show that the macroprudential tax (21), under the alternative constraint (29), preserves its ability to implement the SP allocation because the lump-sum transfer is nonzero during normal times only, when the financial constraint is not relevant for the equation system.

3   Conclusion

Financial crises have been recently analyzed by means of open-economy models with credit constraint in which an externality problem arises from the underestimation of the social cost of decentralized debt decisions.

Schmitt-Grohé and Uribe (2017) derive an expression for a capital control policy in the abovementioned class of models. From that expression they argue that the Ramsey-optimal tax is indeterminate when crises occur (i.e. when the credit constraint binds) and positive during normal times. In contrast, we show that their capital tax (i) is indeterminate during normal times and, in standard cases, positive during crises, and (ii) does not solve the overborrowing problem, and therefore it is not an optimal capital control policy, as opposed to the capital tax proposed by previous literature (positive during normal times and nil during crisis).

We show that the overborrowing problem can be solved as well by an ex-post subsidy on consumption (positive during crises and zero during normal times). We also point out that, unlike the macroprudential tax, this ex-post subsidy is no longer a solution if we remove the assumption that lenders overlook the effect of lump-sum taxes on borrowing capacity.

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[10]The consumption subsidy described in this section is able to solve the externality problem under the standard financial constraint. The government could, however, take better action: Benigno et al. (2016) show that a subsidy only on nontradable consumption could completely avoid crises. Nevertheless, as shown by Parra-Polania and Vargas (2015) and acknowledged by Benigno et al. (2016) afterwards, such policy is completely ineffective under the alternative financial constraint.

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