Macroprudential Regulation Versus Mopping Up After the Crash*

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Abstract

A growing literature has investigated optimal policy responses to the externalities that arise from financial crises. Some have argued in favor of macroprudential regulation to mitigate crisis risk ex-ante, whereas others propose that ex-post stimulus measures are more desirable. As both forms of intervention impose costs that are second-order (i.e. negligible for small amounts but increasing in a convex fashion), we show that the optimal policy mix consists of a combination of ex-ante macro-prudential and ex-post stimulus measures.

1 Introduction

A growing literature has argued in favor of macroprudential regulation based on models that interpret financial crises as episodes of financial amplification, i.e. in which the economy experiences a feedback loop of adverse price movements (in exchange rates or other asset prices) and tightening financial constraints. As pointed out in Lorenzoni (2008) and Korinek (2007), financial amplification effects involve pecuniary externalities because atomistic agents do not internalize that their individual actions lead to relative prive movements in the aggregate.

However, there has been an intense policy debate about the relative desirability of prudential measures that attempt to curb indebtedness before crises materialize and ex-post policy measures that are only taken once a crisis has hit. This is probably best exemplified by the so-called "Greenspan doctrine" (see Greenspan, 2002; Blinder and

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Reis, 2005), according to which ex-ante intervention to prevent booms are too costly compared to "mopping up" measures after a financial crisis has materialized.

This paper studies the desirability of ex-ante versus ex-post interventions in a stylized but general Ramsey setup in which policymakers can both impose an ex-ante "macro-prudential" measure and engage in an ex-post "stimulus" or "mopping up" measure that reduces the severity of financial crises. Both ex-ante and ex-post measures in such a setting relax binding constraints while imposing a second-order distortion (i.e. a distortion that is negligible for small amounts but increasing in a convex fashion) on the economy. We find that the optimal policy mix consists of a combination of both ex-ante prudential measures and ex-post interventions. The point of optimality is determined such that the marginal cost/benefit ratio of ex-ante intervention equals the expected marginal cost/benefit ratio of the ex-post intervention.

1.1 Discussion of the Literature

Pecuniary externalities are sometimes viewed as esoteric, but they actually capture a type of financial amplification mechanism that has been perceived to be quite important in the most recent financial crisis: falling asset prices and the resulting balance sheet effects have played a crucial role (see e.g. Adrian and Shin, 2010). In the same fashion, falling exchange rates and adverse balance sheet effects where the major problem in many of the emerging market crises over the past two decades (see e.g. Krugman, 1999; Mendoza 2002).

Under complete markets, the welfare theorems imply that pecuniary externalities do not matter. The reason is that under complete markets, the relative marginal valuation of all goods by all agents in the economy are equated so that pecuniary externalities and the resulting redistributions do not affect Pareto efficiency. However, during episodes of financial amplification, some agents face binding financial constraints and therefore value resources relatively more than unconstrained agents. A relative price movement that redistributes resources from unconstrained to constrained agents can therefore achieve a Pareto improvement, as shown in Korinek (2007) and Lorenzoni (2008). In fact, the observation that there are "balance sheet effects" during financial crises precisely captures that the redistributions that result from relative price movements matter.

This observation implies that policymakers can improve welfare by instructing private agents to reduce the probability or severity of experiencing binding constraints. For example, Korinek (2007, 2009, 2010) shows that it is desirable to induce borrowers in emerging markets to use more contingent financial instruments, such as local currency debt or equity, and less dollar-denominated debt. If debt is the only source of finance, Jeanne and Korinek (2010) and Bianchi (2011) observe that emerging market borrowers should reduce the total amount of debt they take on. In the closed economy context, Lorenzoni (2008) shows that there is excessive investment and Korinek (2010) finds that agents will not engage in sufficient insurance against adverse shocks that trigger financial amplification, even if state-contingent financial instruments are available.

Jeanne and Korinek (2010ab, 2011) and Bianchi and Mendoza (2010) argue that total borrowing should be reduced if uncontingent debt is the only financial instrument. All these papers have in common that they focus on ex-ante or "macro-prudential" measures to reduce the risk of experiencing financial amplification effects.

In a series of papers, Benigno, Chen, Otrok, Rebucci and Young (2009, 2010a, 2010b) study the desirability of ex-post intervention in emerging economies that experience financial crises in the form of financial amplification effects. Benigno et al. (2009) investigate a setting in which policymakers have a tool to support the exchange rate. They find it optimal to use this tool only when financial constraints in the economy bind, since appreciating the exchange rate then relaxes the constraints. Benigno et al. (2010b) study an economy in which tradable goods are obtained from an endowment process but non-tradable goods are produced using labor. When financial constraints in the economy are binding, they propose that a policymaker should massively reduce labor supply in order to make non-tradable goods more scarce, which would appreciate the real exchange rate and relax the binding constraint. Since this ex-post intervention mitigates the severity of financial crises, the authors find that the economy can in equilibrium sustain a higher quantity of borrowing. However, as we point out in this note, it would still be welfare-improving in their setting to impose an ex-ante tax on borrowing. Benigno et al. (2010a) generalize the finding of their 2010b paper to allow for endogenous production in both the tradable and non-tradable sector. When financial constraints in this setting are binding, they propose that a planner should increase labor allocated to the tradable sector and reduce labor allocated to the non-tradable sector so as to make non-tradable goods relatively scarcer. This would appreciate the real exchange rate and thereby relax the financial constraint.

All three papers share the characteristic that a policymaker can relax binding constraints by engaging in an intervention that introduces a second-order distortion in the economy. Since the benefit of relaxing a binding constraint is first-order and the cost of the intervention is second-order, it is always optimal for policymakers to engage in a positive amount of such measures.

The authors also compare the total amount of debt taken on in a competitive equilibrium in the absence of policy intervention and in the planner's optimal allocation. The planner has a means of relaxing binding financial constraints, which reduces the cost of taking on debt in the planner's equilibrium. This may imply that the equilibrium quantity of debt in the planner's equilibrium is more than in the competitive equilibrium without intervention. Benigno et al. term this phenomenon "underborrowing" and suggest that it may not be desirable to impose macro-prudential policy measures that reduce indebtedness in such a setting. As we show in this note, it is not sufficient to compare the equilibrium quantities of debt in different economic settings in order to infer optimal ex-ante policy measures. Instead, making such normative statements requires a Ramsey analysis that studies optimal interventions in an integrated framework of ex-ante versus ex-post intervention.[1]

[1] A simple comparison captures the basic intuition of our result on prudential measures versus ex

In our paper, we find that it is optimal to use both ex-ante prudential measures and ex-post interventions, and the optimal policy mix is such that the marginal cost/benefit ratio of ex-ante intervention equals the expected marginal cost/benefit ratio of ex-post intervention. Even though we show that it is always optimal to engage in ex-ante measures, we also replicate the result of Benigno et al. that the equilibrium quantity of debt may be higher in an economy where policymakers have access to ex-post interventions. While this may be an important finding, it does *not* provide insights into the desirability of ex-ante prudential policy measures.

Lastly, our paper discusses the implications of our findings for the calibration of models of ex-ante macro-prudential policy measures. We find that if such models do not specifically account for ex-post measures but are calibrated to data that is generated in economies in which policymakers have optimally employed ex-post measures, then the optimal magnitude of ex-ante measures is still a good approximation. This validates the modeling approach of Jeanne and Korinek (2010) and Mendoza and Bianchi (2010).

2 A Simple Model

Our benchmark model is based on the simple setup in Jeanne and Korinek (2010a), augmented by an analysis of an ex-post policy measure that affects labor supply. We describe a small open economy in a one-good world with three time periods $t = 0, 1, 2$.

2.1 Consumers

The economy is populated by a continuum of atomistic identical consumers who consume c_t every period and provide labor l_1 in period 1. We denote their utility as

$$u(c_0) + u(c_1) - d\left(l_1\right) + c_2. \tag{1}$$

where $u\left(c_t\right)$ is a standard neoclassical utility function and $d\left(l_1\right)$ captures the disutility of labor in period 1, which satisfies $d\left(0\right) = d'\left(0\right) = 0 < d''\left(l_1\right)$. Domestic income involves two components: in period 1 consumers obtain labor income Al, which is not pledgeable to foreign creditors. The productivity parameter A may be subject to a stochastic productivity shock. In period 2, consumers obtain a return y_2 on an asset that can be pledged as collateral on loans from foreign investors. (The asset is not acquired by foreign investors because domestic residents have a strong comparative advantage in managing it). For simplicity, we assume that the asset return y_2 is deterministic. Initially, each domestic consumer owns $\theta_0 = 1$ unit of the asset, and the price of the asset at time t is denoted by p_t. Domestic consumers can buy or sell

post intervention: If the introduction of airbags has reduced the expected death toll of car accidents (which is an ex-post device to reduce the cost of crashes), it may—at the margin—be optimal for drivers to be less careful ex-ante and drive at higher speeds. However, this comparison across two different regimes does not imply that it is optimal to subsidize reckless driving.

the asset in a perfectly competitive domestic market in period 1, but in a symmetric equilibrium we must have $\theta_1 = 1$.

The consumer issues one period bonds in periods 0 and 1 and repays in periods 1 and 2. We denote by b_t the amount of bonds to be repaid at the beginning of period t. The riskless world interest rate is normalized to zero. Since there is no default in equilibrium, domestic consumers can borrow at that interest rate.

In period 1, borrowing by the consumer is subject to a collateral constraint of the form

$$b_2 \leq \phi \theta_1 p_1 \tag{2}$$

The micro-foundation for this constraint is that a consumer could walk away from his debt, following which foreign creditors could seize a fraction $\phi < 1$ of his asset holdings and sell them to other consumers in the domestic market in period 1. As discussed in Jeanne and Korinek (2010ab), this setup leads to financial amplification effects when the constraint becomes binding, as reduced consumption, falling asset prices and declining borrowing capacity mutually reinforce each other. Since decentralized agents do not internalize the pecuniary externalities that lead to financial amplification, they engage in what we termed "excessive borrowing" in that paper.

In order to study optimal ex-ante and ex-post policy measures, we introduce two policy instruments that a planner may use. First, the planner can impose macro-prudential taxes in period 0 to discourage excessive indebtedness. Specifically, the planner can impose a tax τ on borrowing b_1 in period 0, which is rebated as a lump sum $T = \tau b_1$. Secondly, the can stimulate the economy ex post in the event of binding constraints by subsidizing labor at rate s. This instrument is similar to the ones that a planner has available in Benigno et al. (2010ab). For simplicity, the government revenue $R = sAl_1$ necessary to finance the subsidy is raised via a lump-sum tax. We summarize the resulting budget constraints as

$$\begin{cases} c_0 = (1-\tau)\, b_1 + T, \\ c_1 + b_1 = (1+s)\, A l_1 + b_2 + (\theta_0 - \theta_1)\, p_1 - R, \\ c_2 + b_2 = \theta_1 y_2. \end{cases} \tag{3}$$

The optimization problem of a representative consumer can be described as maximizing the expectation of utility (1) subject to the budget constraints and the borrowing constraint (2) and (3), where we denote the Lagrange multiplier to the borrowing constraint as λ. The detailed problem is described in the appendix. The consumer's optimality conditions with respect to b_1, b_2, l_1 and θ_1 are

$$u'(c_0)(1-\tau) = E[u'(c_1)] \tag{4}$$

$$u'(c_1) = 1 + \lambda \tag{5}$$

$$u'(c_1)(1+s)\, A = d'(l_1) \tag{6}$$

$$p_1 = \frac{y_2}{(1-\phi)\, u'(c_1) + \phi} \tag{7}$$

The last equation represents the asset pricing condition for the economy. If the asset could not be used as collateral, the price would just be the ratio of marginal products times the asset payoff y_2. However, the denominator in equation (7) captures the additional benefit of owning the asset in providing collateral.

2.2 Ramsey Planner

The optimization problem of a Ramsey planner in our setting is to choose his optimal ex-ante and ex-post policy instruments τ and s so as to maximize expected utility of domestic consumers, while respecting their optimality conditions (4) to (7), their budget constraints (3) – which equal the resource constraints in our setup – and the borrowing constraint (2). See the appendix for details.

This Ramsey problem can be simplified by making the following observations: the two policy instruments τ and s allow the planner to implement any desired level of period 0 borrowing and period 1 labor supply. The planner can therefore pick the allocations b_1 and l_1 directly, and we infer the optimal levels of τ and s from equations (4) and (6), which we drop from the optimization problem. Imposing market clearing implies $\theta_t \equiv 1$. Denoting the asset price obtained from the optimality condition (7) of consumers as $p(c_1)$, we formulate the planner's problem as

$$\max_{b_1,l_1,b_2} u(b_1) + E\{u(Al_1 - b_1 + b_2) - d(l_1) + y_2 - b_2\} - \lambda[b_2 - \phi p(Al_1 - b_1 + b_2)]$$

The planner's optimality conditions are

$$\begin{aligned} u'(c_0) &= E[u'(c_1) + \phi\lambda p'(c_1)] && (8) \\ d'(l_1) &= A[u'(c_1) + \phi\lambda p'(c_1)] \\ u'(c_1) &= 1 + \lambda[1 - \phi p'(c_1)] && (9) \end{aligned}$$

where we note that $p'(c_1) > 0$ by equation (7). We combine the first optimality condition of the planner with the period 0 Euler equation of decentralized consumers (4) to find that the optimal ex-ante tax rate τ satisfies

$$1 - \tau = \frac{E[u'(c_1)]}{u'(c_0)} = 1 - \frac{\phi E[\lambda p'(c_1)]}{u'(c_0)} \quad \text{or} \quad \tau = \frac{\phi E[\lambda p'(c_1)]}{u'(c_0)} \tag{10}$$

This leads us to the following result on ex-ante macro-prudential measures:

Proposition 1 *The planner chooses a positive ex-ante macro-prudential tax in period* 0 *whenever there is a risk of binding constraints in period* 1*, i.e. whenever* $\lambda > 0$ *in some states of nature of period* 1*.*

Similarly, we combine the second optimality condition of the planner with the optimality condition for labor (6) of decentralized consumers to find

$$s = \frac{\phi\lambda p'(c_1)}{u'(c_1)}$$

which is positive whenever $\lambda > 0$.

Proposition 2 *The planner stimulates the economy ex post with $s > 0$ whenever the financial constraint is binding in period* 1.

The relationship between optimal ex-ante and ex-post interventions can be interpreted as follows: The variable λ reflects the value of marginally relaxing the financial constraint. Reducing borrowing by one unit ex-ante will relax binding constraints by $\phi p'(c_1)$, which increases utility by $\phi E[\lambda p'(c_1)]$ and therefore justifies a period 0 tax on borrowing of $\frac{\phi E[\lambda p'(c_1)]}{u'(c_0)}$. Similarly, stimulating labor supply ex-post to produce one additional unit in period 1 relaxes the borrowing constraint by $\phi p'(c_1)$ and increases utility by $\phi \lambda p'(c_1)$, which calls for a wage subsidy of $\frac{\phi \lambda p'(c_1)}{u'(c_1)}$.

An optimizing policymaker chooses the level of both the ex-ante prudential tax and the ex-post stimulus subsidy such that the magnitude of the policy measure equals the marginal benefit in relaxing the financial constraint.

2.3 Model Solution

We solve the consumer's problem for given policy instruments by backward induction: first we take the borrowing level b_1 as given and solve for the optimal period 1 and 2 equilibrium. We also observe that domestic market clearing implies that $\theta_1 = 1$ in a symmetric equilibrium. For simplicity we assume that utility is logarithmic and that the disutility of labor is given by the function $d(l_1) = e l_1^{1+\omega} / (1+\omega)$ with a Frisch elasticity of labor supply of $\frac{1}{\omega}$, where e is a constant parameter.

If the borrowing constraint in period 1 is loose so $\lambda = 0$, the first-best level of consumption c^* satisfying $u'(c^*) = 1$ can be implemented and labor supply is determined by the optimality condition (6), which yields a strictly increasing function $l_1(s; c_1) = \left[\frac{(1+s)A}{ec_1}\right]^{\frac{1}{\omega}}$. We denote the first-best level of labor supply as $l_1^* = l_1(0; c_1^*)$. Under non-binding constraints, the asset price satisfies $p_1 = y_2$, and the optimal level of new borrowing is $b_2 = b_1 + c_1^* - A l_1(s; c_1^*)$. For a given stimulus measure s, the borrowing constraint is indeed loose if $b_2 \leq \phi p_1$, or if the initial debt level satisfies

$$b_1 \leq A l_1(s; c_1^*) + \phi y_2 - 1 \tag{11}$$

If this inequality is violated, the borrowing constraint determines the level of new borrowing $b_2 = \frac{\phi y_2}{(1-\phi)/c_1 + \phi}$ and the optimal level of labor supply is $l_1(s; c_1)$. The constrained level of consumption c_1^{con} is the solution to the implicit equation

$$c_1 = A l_1(s; c_1) + b_2 - b_1 = A\left[\frac{(1+s)A}{ec_1}\right]^{\frac{1}{\omega}} - b_1 + \frac{\phi y_2}{(1-\phi)/c_1 + \phi}$$

Let us focus on the slope of the right-hand side of this equation,

$$\begin{aligned} \frac{\partial rhs}{\partial c_1} &= A\frac{\partial l_1}{\partial c_1} + \frac{\partial b_2}{\partial c_1} = \\ &= -\frac{1}{\omega}\left(\frac{A}{c_1}\right)^{\frac{1+\omega}{\omega}}\left(\frac{1+s}{e}\right)^{\frac{1}{\omega}} + \frac{\phi(1-\phi)y_2}{[1-\phi+\phi c_1]^2} \end{aligned}$$

The equation has a unique solution if $\frac{\partial rhs}{\partial c_1} < 1$. Furthermore, if this condition is satisfied, we observe that

$$\frac{dc_1}{db_1} = \frac{1}{1 - A\frac{\partial l_1}{\partial c_1} - \frac{\partial b_2}{\partial c_1}}$$

The economy exhibits amplification effects if $\frac{dc_1}{db_1} > 1$, i.e. if changes in initial debt have more than proportional effects on consumption because they reduce next period-borrowing. This is the case if and only if $\frac{\partial rhs}{\partial c_1} \in (0,1)$. On the other hand, for $\frac{\partial rhs}{\partial c_1} < 0$, the economic system mitigates shocks to initial debt by increasing labor supply sufficiently to offset the reduction in borrowing capacity.

We observe that $\lim_{c_1 \to 0} rhs = \infty$ and $\lim_{c_1 \to \infty} rhs = y_2 - b_1$. The function is first declining and convex and reaches a minimum when $\frac{1}{\omega}\left(\frac{A}{c_1}\right)^{\frac{1+\omega}{\omega}}\left(\frac{1+s}{e}\right)^{\frac{1}{\omega}} = \frac{\phi(1-\phi)y_2}{[1-\phi+\phi c_1]^2}$, then it is increasing and turns concave, tending towards $y_2 - b_1$ in the limit.

[to complete: conditions such that the equation has a unique solution...]

All in all, consumption c_1 is determined by the condition

$$c_1 = \min\left\{c_1^{con}; c_1^*\right\}$$

Finally, we solve for the level of period 0 consumption, which equals period 0 borrowing, by using the planner's Euler equation (8).

2.4 Calibration

[incomplete]

In our calibration, we set the parameter for the Frisch wlasticity of labor supply to $\frac{1}{\omega} = .5$ so as match the estimated effects of the fiscal stimulus that was passed in the US in 2009 on labor supply.[2] This value is also within the range (albeit towards the high end) of microeconomic estimates for the elasticity of labor supply. In an unconstrained equilibrium, these functional forms imply that $c_1^* = 1$ and $l_1^*(A) = \frac{A^{1/\omega}}{e}$ for a given level of productivity A. We set $y_2 = 4$ to replicate an asset price level $p_1 = 4$ that equals four times aggregate absorption in the unconstrained equilibrium and we set $\phi = 1/8$ to obtain an unconstrained level of collateral $\phi p_1 = 0.5$, which is in the range where many indebted economies run into financial constraints (Reinhart, Rogoff and Savastano, 2003).

[2] According to the non-partisan CBO (2010), the American Recovery and Reinvestment Act of 2009 cost $814bn, which represents about 1.8% of GDP over the period of 2009 – 2011, while resulting in an average increase in full-time employment of 0.9% over that period.

We assume that there are two states of nature corresponding to the levels of productivity A_g and A_b, which describe good times and bad (crisis) times. We set the probability of a crisis $\pi = .05$. We calibrate our model such that the collateral constraint is binding in crisis times and loose in good times. We define the productivity level in the deterministic case at which the collateral constraint is marginally binding as $\hat{A}$ (see appendix) and we set $A_g = \hat{A} + \epsilon$ and $A_b = \hat{A} - \epsilon$, where ϵ is calibrated to match the consumption gap between good and crisis states. In the benchmark case we set $\epsilon = 0.025$, so that $A_g = 1.325$ and $A_b = 1.275$, which yields around a 2% decrease in consumption in the bad state.

The choice of parameters for our benchmark calibration is summarized in table 1.

parameter	value	target
$\hat{A}$	1.3	
ϵ	0.025	consumption gap
π	0.05	average incidence of crisis
y_2	4	level of asset prices
ω	2	Frisch elasticity of .5
ϕ	1/8	maximum debt level $\phi p_1 = .5$

3 Discussion

3.1 Equilibrium Quantity of Debt

In the existing literature, Benigno et al. (2009, 2010ab) have pointed out that the equilibrium quantity of debt may be higher in an economy in which ex-post stimulative policy interventions are available than in the free market equilibrium without intervention. They term this phenomenon "underborrowing." This section replicates their results and discusses the interpretation.

We observed above that a stimulus policy s increases labor supply in our framework and therefore raises period 1 consumption, i.e. $\frac{dc_1}{ds} > 0$ when the financial constraint is binding. Given the period 0 Euler equation (4) of decentralized agents, higher period 1 consumption makes it optimal for consumers to also raise period 0 consumption, i.e. to borrow more for a given tax rate τ. Denoting the planner's optimal ex-post intervention in a given state of nature as s^*, and assuming that there are binding constraints so that $s^* > 0$ in at least some states of nature, we find unambiguously that

$$c_0|_{s=s^*} > c_0|_{s=0} \qquad \text{and} \qquad b_1|_{s=s^*} > b_1|_{s=0}$$

If the planner is expected to intervene ex post, financial crises will be less severe for a given amount of initial debt b_1; therefore it is optimal for the economy to borrow more and raise b_1. This replicates the results that occur under some conditions in Benigno et al. (2009, 2010ab).

By the same token, for given levels of ex-post intervention s^*, an increase in the macroprudential tax τ reduces the amount of period 0 consumption c_0 and borrowing

b_1. Moving from a decentralized equilibrium with no policy intervention $\tau, s = 0$ to a Ramsey equilibrium where $\tau = \tau^*$, $s = s^*$ are chosen optimally, the equilibrium amount of debt may rise or fall, depending on whether the effects of the ex-ante policy or of the ex-post policy are stronger. However, to determine the sign of optimal policy measures, it is irrelevant whether the debt level under a Ramsey planner is higher or lower than in the decentralized equilibrium with no intervention: A Ramsey planner finds it desirable to intervene both ex-ante through macroprudential intervention and ex-post through stimulus measures, as we captured in propositions 1 and 2.

The broader point of the debate is the following: if our interest is to infer optimal policy measures in a model where a Ramsey planner sets multiple policy instruments (or a social planner picks multiple policy variables), then it can be misleading to simply compare equilibrium quantities between the free market equilibrium and the planner's allocation. The planner in our setup finds it optimal to reduce borrowing ex-ante by imposing macroprudential taxes, but there is also a second policy instrument – a wage subsidy – that has the general equilibrium effect of increasing the quantity borrowed. The total effect on the equilibrium quantity borrowed consists of both the tax-induced reduction in borrowing and the stimulus-induced increase in borrowing and is of ambiguous sign. Nonetheless, the optimal policy measure of the planner is unambiguously to impose a macroprudential tax that reduces borrowing.

3.2 Calibration of Ex-Ante Measure

[to be completed or omitted]

4 Alternative Ex-Post Policy Measures

In this section we introduce an alternative ex-post policy intervention than the labor supply policy of the previous section. It is often argued that labor supply policies are not very effective in alleviating financial crises since the problem stems from the demand side in the economy. Here we assume instead that the planner has access to an ex-post policy instrument that can be used to mitigate the financial constraint once the economy experiences an episode of binding constraints, but at a second-order cost. For simplicity, we captures this as a generic policy instrument α that directly relaxes the constraint in period 1 so that b_2 has to satisfy

$$b_2 \leq \phi\theta_1 p_1 + \alpha \tag{12}$$

The cost on consumers of using the instrument α arises in period 2 and is captured by a twice continuously differentiable convex loss function $L(\alpha)$ that satisfies $L(0) = L'(0) = 0$ and $L'' > 0$. A straightforward interpretation of this setup would be that policymakers provide direct loans in the amount α to the private sector sector, but since government is less efficient at screening and monitoring there is a deadweight loss $L(\alpha)$. There are a number of alternative interpretations. One would be that the policymaker buys up assets in period 1 to support the market price and mitigate amplification effects, but that government is less efficient at managing financial asset than the private sector, which imposes a loss $L(\alpha)$. More generally, any government intervention that relaxes financial constaints – be it of fiscal or monetary nature – is likely to also impose costs. Otherwise the intervention would take place in unlimited amounts and on a permanent basis; therefore financial constraints would be irrelevant, and financial crises would never occur. For simplicity, we also replace the period 1 income of consumers with an exogenous endowment e_1.

We derive the resulting optimization problem for both consumers and the Ramsey planner in the appendix. The planner's intertemporal optimality conditions replicate conditions (8) and (9) in our earlier specification. In addition, the planner finds it optimal to employ the ex-post intervention α such that

$$L'(\alpha) = \lambda \tag{13}$$

As observed above in equation (10), the planner finds it optimal to impose an ex-ante tax rate $\tau = \frac{\phi E[\lambda p'(c_1)]}{u'(c_0)}$ in period 0, which is positive whenever there is a risk of binding constraints in period 1.

The planner's optimality condition (13) implies the optimal magnitude of the ex-post financial intervention $\alpha = (L')^{-1}(\lambda)$, which is positive whenever λ is positive.

Proposition 3 *The planner intervenes in financial markets ex post with $\alpha > 0$ whenever financial constraints are binding in period* 1.

A policymaker finds it optimal to engage in ex-post intervention until the marginal cost $L'(\alpha)$ equals the marginal benefit λ of relaxing the constraint.

5 Conclusions

This note provided a simple Ramsey framework of optimal ex-ante macro-prudential and ex-post stimulus measures in an economy that is prone to financial amplification effects and therefore exhibits pecuniary externalities. The ex-ante and ex-post measures that are commonly proposed in the literature both introduce second-order distortions in the economy, i.e. their welfare costs are negligible for small amounts but increase in a convex fashion. We find that in such a setting, it is optimal for policymakers to employ both strictly positive amounts of ex-ante prudential and ex-post stimulus measures, up to the point where the expected marginal benefit of each measure in relaxing binding financial constraints equals its expected marginal cost.

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A Mathematical Appendix

A.1 Consumers' Problem

By substituting the budget constraints, the optimization problem of a representative consumer can be denoted as

$$\max_{d_1,d_2,\theta_1} u\left(\left(1-\tau\right)b_1+T\right)+E\left\{u\left(Al_1\left(1+s\right)+b_2+\left(\theta_0-\theta_1\right)p_1-R\right)-d\left(l_1\right)+\theta_1 y_2-b_2\right\}- \\ -\lambda\left[b_2-\phi\theta_1 p_1\right]$$

A.2 Ramsey Planner's Problem

The full problem of the Ramsey planner is to choose $(b_1, l_1, b_2, p_{1,}\tau, s)$ so as to maximize expected consumer utility subject to the the borrowing constraint (2), the resource constraints in the economy and the optimality conditions (4) to (7). The resource constraints are obtained by from the budget constraints (3) by substituting for $T = \tau b_1$ and $R = sAl_1$,

$$\begin{cases} c_0 = b_1, \\ c_1 + b_1 = Al_1 + b_2, \\ c_2 + b_2 = y_2. \end{cases}$$

This Ramsey problem can be simplified in the following way: the two policy instruments τ and s allow the planner to implement any desired level of period 0 borrowing and period 1 labor supply. We can therefore formulate the problem such that the planner directly picks the allocations b_1 and l_1, and we infer the optimal levels of τ and s from equations (4) and (6), which we can drop from the optimization problem.

Imposing market clearing implies $\theta_t \equiv 1$. Denoting the asset price obtained from the optimality condition (7) of consumers as $p(c_1)$, we formulate the planner's problem as

$$\max_{b_1,l_1,b_2} u(b_1) + E\{u(Al_1 - b_1 + b_2) - d(l_1) + y_2 - b_2\} - \lambda[b_2 - \phi p(Al_1 - b_1 + b_2)]$$

It can easily be verified that the allocation (b_1, l_1, b_2) that result from this optimization problem allows us to derive a triple (τ, s, p_1) from equations (4), (6) and (7) such that the triple supports a competitive equilibrium with the chosen allocations. The solution to the simplified problem above therefore represent the solutions to the initial Ramsey planner's problem.

A.3 Solution to Consumers' Period 1 Problem

Here we establish that the consumer's period 1 problem has a unique solution under the assumptions that we have made.

[to be completed]

Note that $\partial b_2/\partial c_1 = \frac{-\phi y_2(1-\phi)u''(c_1)}{[(1-\phi)u'(c_1)+\phi]^2} > 0$ (remember $u''(c_1) < 0$) being less than 1. In the case of log utility $\partial b_2/\partial c_1 = \frac{\phi y_2(1-\phi)}{[(1-\phi)+\phi c_1]^2} < 1$ if and only if $\frac{\phi y_2(1-\phi)}{c_1{}^2} < \left[\frac{(1-\phi)}{c_1} + \phi\right]^2$.

A.4 Consumers' Problem Under Alternative Ex-Post Policies

If we introduce the alternative ex-post measures discussed in section 4, the budget constraints of a representative consumer are

$$\begin{cases} c_0 = (1-\tau)b_1 + T, \\ c_1 + b_1 = y_1 + b_2 + (\theta_1 - \theta_0)p_1, \\ c_2 + b_2 = \theta_1 y_2 - L(\alpha), \end{cases}$$

and the consumer optimization problem can be denoted

$$\max_{d_1,d_2,\theta_1} u((1-\tau)b_1 + T) + E\{u(e_1 + b_2 - b_1 + (\theta_0 - \theta_1)p_1) + \theta_1 y_2 - b_2 - L(\alpha)\} - \\ - \lambda[b_2 - \phi\theta_1 p_1 - \alpha]$$

The consumer's optimality conditions (4), (5) and (7) remain unaffected.

After conducting the steps discussed above in A.2, the problem of a Ramsey planner can be formulated as

$$\max_{b_1,b_2,\alpha} u(b_1) + E\{u(e_1 + b_2 - b_1) + y_2 - b_2 - L(\alpha)\} - \lambda[b_2 - \phi p(e_1 + b_2 - b_1) - \alpha]$$

B Calibration

In a deterministic world, the competitive equilibrium (without τ and s) satisfies $u'(c_0) = u'(c_1)$ which yields $c_0 = c_1$. If the collateral constraint is non-binding we find $c_0 = c_1 = b_1 = 1$ and $l_1 = \frac{\hat{A}^{\frac{1}{\omega}}}{e}$. Thus, $\hat{A}$ satisfying $1 = \frac{\hat{A}^{\frac{1}{\omega}}}{e} - 1 + \phi y_2$ is the threshold productivity level at which the constraint binds.