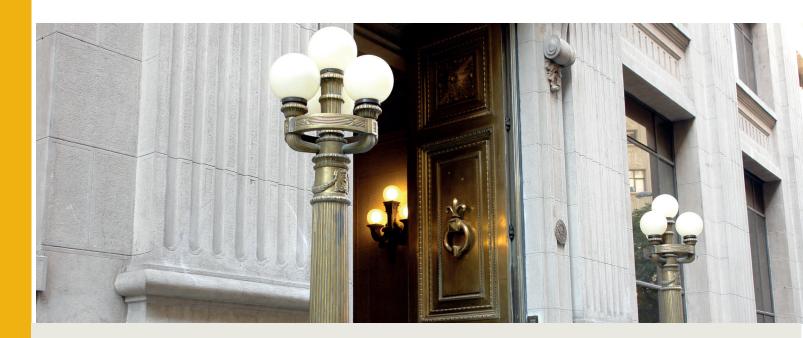# DOCUMENTOS DE TRABAJO

Prudential Policies and Bailouts - A Delicate Interaction

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Abstract

This paper calls attention to the non-trivial (and sometimes pervasive) effects of ex- ante policies, such as prudential policies, on banks' risk taking through their effects on the ex-post incentives to bailouts when the authority lacks commitment. In particular, liquidity requirements, a crisis resolution fund and prudential taxes are examples of policies that may backfire. Conversely, public debt is an example of an ex-ante policy usually with no prudential motivation that may play such a role.

Resumen

Este artículo destaca los efectos no triviales (y a veces perjudiciales) de políticas que se llevan a cabo en tiempos normales, como las políticas prudenciales, sobre los incentivos de la autoridad de realizar un salvataje financiero en tiempos de crisis. Estos efectos a su vez pueden implicar que políticas prudenciales diseñadas en mitigar la toma de riesgo de bancos e intermediarios financieros podrían terminar exacerbándolo. Políticas como requerimientos mínimos de liquidez, fondos de resolución de crisis, e impuestos prudenciales son ejemplos de políticas que podrían terminar siendo perjudiciales. Por otra parte, el manejo de la deuda pública es un ejemplo de una política aplicada en tiempos normales que puede cumplir un rol prudencial al mitigar los incentivos de la autoridad a realizar un salvataje financiero en tiempos de crisis.

1   Introduction

After the 2007-2009 financial crisis there has been a surge of "prudential" regulatory and policy proposals. A common premise behind these proposals is that financial intermediaries (in short, banks) misbehave by taking too much risk which leads to financial crises. Prudential policies are then called to correct such a misbehavior and limit its effects on households' welfare. From a different angle, one reason for banks' excessive risk taking is lack of commitment of bailout policy which fuels expectations of large bailouts if a crisis hits.[1] This paper studies the interplay between prudential policies and this lack of commitment problem to make a cautionary point on the design and implementation of prudential policies.

In brief, prudential policies work as predetermined variables at the time of crises affecting the benefits and costs involved in a bailout sometimes in various, opposite ways. Thus, prudential policies may backfire on inducing banks' risk taking or reinforce their effectiveness depending on their net effect on the authority's incentives to bailout. In particular, a crisis resolution fund, a prudential tax and liquidity requirements are examples of well-intended prudential policies that may backfire. In turn, public debt may play a prudential role when used as a "burning the bridges" policy to raise the welfare cost of bailouts at the time of crises. Beyond these examples, similar mechanism applies for any other prudential policy or, for what matters, any policy before crises affecting the bailout incentives of the authority.

This paper makes this point in an infinitely repeated version of the model of Farhi and Tirole (2012). In the stage game, a non-overlapping generation of bankers borrow from a non-overlapping generation of households to invest in riskless assets and partially pledge-able risky assets. If a crisis hits, confronted with bankers' need of refinancing risky assets, an infinitely lived benevolent authority must decide to reduce the riskfree interest rate by balancing momentary and intertemporal trade-offs. The momentary trade-off arises because the interest rate reduction acts as a bailout that benefits bankers at the cost of distorting households' consumption schemes. The intertemporal trade-off steams from the reputational cost of fueling expectations of larger bailouts in the future.

No bailouts is the optimal policy with commitment as it gives incentives to bankers to hold enough riskless assets to ensure refinancing with no need of a costly bailout. For the case without commitment, for expositional purposes I first focus on the stage game – or equivalently, when the authority fully discounts reputational effects. Any bailout below a certain cap is an equilibrium policy in the stage game. This is because the authority always implements the needed bailout to avoid the loss of bankers' risky assets while households'

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[1]See, for example, the empirical work of Kelly, Lustig and Van Niewerburgh (2016).

welfare loss is not too high. As households' utility is concave, their welfare loss is convex on the size of bailouts. This imposes a cap on the maximum bailout in equilibrium.

This equilibrium multiplicity implies a *fragility problem* instead of the standard time-inconsistency. In standard contexts, such as taxation or monetary policy, lack of commitment yields time-inconsistency as the optimal policy under commitment is not an equilibrium policy. In contrast, for bailouts, the optimal no-bailouts policy is indeed an equilibrium policy, so it is time-consistent. The problem, then, is that the no-bailouts policy is not the *only* equilibrium policy, so it is fragile to the realization of inferior equilibria with bankers taking too much risk ex-ante and the authority doing large distortionary bailouts ex-post.[2]

I show that prudential policies affect the severity of this fragility problem measured as the size of the largest time-consistent bailout. This is the worst the fragility problem can get. I start with a crisis resolution fund policy motivated by those implemented in the U.S. and Europe after the 2007-2009 financial crisis and the Euro crisis. Consider a tax on bankers' risky investment before crises to finance transfers during crises to avoid the need of costly bailouts. In addition to encouraging bankers to increase their exposure to liquidity risk, this policy has two effects: It reduces bankers' financing capacity of risky investment before crises and reduces the burden on households of avoiding the loss of risky assets during crises. The former reduces the benefit of a bailout while the latter reduces its cost. The net effect on the severity of the fragility problem is ambiguous and it may be detrimental depending on the probability of a crisis and how much of risky investment is pledgeable.

The second example is a prudential tax as proposed by Kocherlakota (2010) and Bianchi (2011) among many others to discourage bankers' risk taking. This prudential policy prescribes a tax on bankers' risky investment before crises and a rebate after risky assets return is realized. In the model, the only effect of this policy is to tilt bankers' portfolios more to risk as they completely undo the effect of the tax on the scale of their risky investment. This is because, from a contracting perspective, the riskless asset return and the rebate are equally pledgeable as both are certain future income. Thus, the rebate acts as perfect substitute of riskless assets to raise funds for reinvestment in a crisis. As a result, the trade-offs involved in a bailout decision remain unaffected by this prudential policy.

The third example is the use of public debt with a prudential motivation. Although there are alternative ways to get this effect, the key is that more public debt means more taxes. If taxes have wealth and distortive effects on households, the welfare cost of bailouts increases. This in turn implies that the fragility problem becomes less severe as the largest

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[2]This fragility problem is not a feature of this model only; it is quite prevalent in financial models. See the literature review below.

time-consistent bailout becomes smaller.

Once established the basic mechanism, the paper turns to add the intertemporal trade-off in the bailout decision. This forces to introduce a technical discussion. The standard approach to capture these intertemporal trade-offs in a repeated game is Sustainable Plans (Chari and Kehoe, 1990). In particular, the focus is on the best time-consistent policy from a welfare perspective, which varies from the time-consistent policy in the stage game when the authority fully discards the future to the optimal policy under commitment when the authority is patient enough. However, in the context of bailouts, the optimal no-bailouts policy under commitment is time-consistent in the stage game, so this is the best sustainable plan regardless the authority's discounting. Thus, the effect of prudential policies on the intertemporal trade-off involved in a bailout is not captured by the size of the best sustainable bailout plan because this plan is invariant to such intertemporal trade-off.

To fix this issue, I propose a refinement where a bailout policy, in addition to be time-consistent, must be *resistant* to the threat of all bankers taking more risk than what is optimal given such a bailout policy. The smallest time-consistent bailout that satisfies this condition varies from the largest time-consistent bailout in the stage game when the authority fully discards the future to the optimal no-bailouts policy when the authority is patient enough. Hence, the smallest resistant bailout plan is affected by prudential policy through its effect on the intertemporal trade-off involved in a bailout. In addition, the largest time-consistent bailout used in the analysis abstracting from intertemporal trade-offs is a special case here.

Sustainable plans and the resistance refinement both rely on the quantification of the reputational cost of the authority's deviation from a policy plan as the difference in discounted sum of expected welfare in an equilibrium where the plan is carried out versus the worst equilibrium in the stage game. Prudential policies may affect this reputational cost. Take for instance liquidity requirements. This is an example of many regulations that impose cap restrictions on banks' choices. Although this policy may attain the first best, I show that it backfires when its enforceability is limited. In particular, when the authority ignores reputational costs, this policy monotonically alleviates the fragility problem as it approaches to the first best. However, this monotonicity may be broken when reputational costs are introduced. This happens when the liquidity requirement is more binding when banks take more risk, so it is more welfare improving in the worst equilibrium than in equilibria with smaller bailouts. Thus, the reputational cost becomes smaller and the fragility problem worsens. In general, this result holds for any policy that is more welfare improving (less detrimental) in the worst equilibrium than on the path of the smallest resistant bailout.

Finally, I revisit results in the stage game for a crisis resolution fund, prudential taxes

and public debt. For the first, by decreasing bankers' risky investment, the crisis resolution fund is more detrimental on welfare as bailouts are larger. Thus, the crisis fund increases the reputational cost of a bailout. If the authority puts enough weight on this cost, this effect dominates its pervasive effect on the momentary cost of bailouts, so the crisis fund may both discourage bankers' excessive risk and reduce the burden on households of bailouts. For the second, as prudential taxes are innocuous on the momentary trade-off involved in a bailout, the same applies for the reputational cost. Thus, the result that this prudential policy only tilt bankers' portfolios more to risk also holds here. At last, public debt increases the cost of bailouts by more as bailouts are larger; this reinforces its prudential role as a "burning the bridges" policy that increases the welfare cost of bailouts.

The rest of the paper is organized as follows. Section 2 discusses the contribution of this paper relative to different strands of literature. Section 3 studies prudential policy in the stage game. Section 4 introduces the infinitely repeated game and Section 5 does the prudential policy analysis. Section 6 concludes.

2   Literature review

Although the topic is very different, the title of this paper gets inspiration from Angeletos, Lorenzoni and Pavan (2018). I borrow the baseline model from Farhi and Tirole (2012),[3] but the point is different and complementary. In their paper, lack of commitment of bailouts gives banks incentives to correlate risk exposure, so prudential policies designed to make banks smaller are ineffective and a subsidy on liquidity increases bankers' exposure to crises. Part of this point is also in Acharya and Yorulmazer (2007). This is a type of banks' misbehavior I take as granted, so I use their model with only aggregate risk. Then I study the effect of prudential policy on the lack of commitment problem of bailouts in an infinitely repeated version of this model to capture momentary and intertemporal trade-offs of bailouts.

In the best of my knowledge, all papers studying the lack of commitment problem of bailouts propose prudential policies solving this problem, e.g., Farhi and Tirole (2012) with liquidity requirements, Chari and Kehoe (2016) with loan-to-value limits and Keister (2016) with taxes on banks' liabilities. I take a different perspective by focusing on suboptimal prudential policy under the presumption that first-best policy is in practice difficult to implement and showing that deviating from first-best prudential policy has not trivial effects on bank's behavior. Although I study few examples of prudential policies, results can be generalized to others by their effects on the benefits and costs associated with a bailout at

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[3]To be precise, I use the model in a previous version of their paper (Farhi and Tirole, 2009).

the time of implementation. For instance, Nosal and Ordonez (2016) show that uncertainty in the nature of shocks alleviates the lack of commitment problem of bailouts. This result may be seen as a "prudential opacity policy" that decreases the expected welfare benefit of a bailout. This paper also speaks to the large bulk of literature proposing prudential policies without considering their interaction with bailouts.

In this regard, a couple of specific results deserve special mention. First, prudential taxes have emerged as a popular proposal to control banks' risk taking.[4] In this paper taxes that respond to this motivation are ineffective because the role played by liquid assets on banks' credit constraint. In contrast, in many macro-finance models there is no such a role for liquid assets (for instance, Bianchi, 2011; Bianchi and Mendoza, 2018). Second, in this paper a prudential motive arises for the management of public debt when it works as a substitute of commitment in line with Persson, Persson and Svenson (2006) for monetary policy and Dominguez (2007) for capital taxation. This result complements those of Woodford (1990) who sees a prudential role for public debt by creating supply of liquid assets.

From a different angle, the paper gives great attention to intertemporal considerations in bailout policy. In brief, this paper stresses that these considerations add delicacy to the interaction of bailouts and prudential policies. Regarding literature, most papers studying bailouts without commitment focus on static environments (Acharya and Yorulmazer, 2007; Farhi and Tirole, 2012; and Nosal and Ordonez, 2016). The only exception is Chari and Kehoe (2016). They study bailouts without commitment in a repeated game where bankruptcy is efficient ex-ante to encourage firms' managers to exert high effort, but the authority has incentives to prevent bankruptcies ex-post. Their focus is quite different than mine besides in their model there is no role for liquidity which is quite important in my results.

This paper builds on an economy where lack of commitment of bailouts creates equilibrium multiplicity – a fragility problem. This source of multiplicity is mentioned in Kydland and Prescott (1977)'s seminal paper on time-inconsistency[5] and it is prevalent in many financial applications. Some examples are Schneider and Tornell (2004), Diamond and Rajan (2009), Ennis and Keister (2009), Keister (2016) and Mengus (2018).

In turn, the resistance refinement follows a long tradition of refinements in cooperative games, but it has its differences. Two examples of this kind in static games are "resilient equilibrium" (Aumann, 1959) and "strong-perfect equilibrium" (Rubinstein, 1980). These

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[4]See Lorenzoni (2008), Bianchi and Mendoza (2010), Kocherlakota (2010) and Jeanne and Korinek (2011).

[5]They use an example on flood control: If agents expect no dams (no bailouts) to be built (implemented) on a flood plain (distressed economy), no houses are constructed there (banks keep enough liquidity), so dams (bailouts) are not necessary. But if houses are built on the flood plain (banks do not keep enough liquidity), the authority will be forced to build the dams (to bail out).

refinements are so strong in terms of what deviations are admissible and who could form a coalition that usually rule out all equilibria. In contrast, the resistance refinement is designed for a repeated game and it is weaker than those above, which allows for meaningful results. Refinements in repeated games usually focus on ruling some equilibria out for requiring penalties that are not self-enforcing; examples are "coalition-proof equilibrium" (Berheim, Peleg and Whinston, 1987) and "dynamically consistent equilibrium" (Berheim and Ray, 1989). The resistance refinement also relies on self-enforcing penalties, but its focuses on a particular equilibrium in the stage game.

Finally, Bianchi (2016) and Keister (2016) argue in different frameworks that positive bailouts are desirable even under commitment. In this paper, no bailout is desirable under commitment. I see this results not as a fundamental feature; what is important is that the severity of the lack of commitment of bailout policy is affected by prudential policies.

3   The stage game

This section displays a game between households, bankers and an authority where lack of commitment of bailouts creates a fragility problem. Based on Holmstrom and Tirole (1998) and Farhi and Tirole (2012), this game is static in the sense that the authority has a single opportunity to implementing a bailout. The next section infinitely repeats this game to allow for intertemporal trade-offs in the authority's bailout decision.

3.1   Setup

Consider an economy with three stages, $s = 0, 1, 2$.[6] There are two types of atomistic agents each with total mass one, *households* and *bankers*, and an *authority* to be introduced below.

Households have exogenous endowments e_0 and e_1 in stages $s = 0, 1$ and utility

$$V = c_0^h + u(c_1^h) + c_2^h, \tag{1}$$

where $u(c_1) = c_1^{1-\gamma}/(1-\gamma)$, $\gamma > 1$ and c_s^h is households' consumption in stages $s = 0, 1, 2$.

Bankers have exogenous endowment A only in the initial stage $s = 0$ and utility

$$U = c_0^b + c_1^b + c_2^b \tag{2}$$

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[6]Notation t is reserved for each repetition of this game in Section 4.

where c_s^b denotes *bankers'* consumption in stages $s = 0, 1, 2$.

Households invest in riskless assets while bankers invest in risky and riskless assets denoted by i and xi, so x is bankers' riskless-to-risky investment ratio. Riskless assets simply transfer consumption from $s = 0$ or $s = 1$ to $s = 2$ with zero net return. Risky investment is made in $s = 0$ and pays in $s = 2$ with gross return $\rho_1 > 1$ if there is "no distress" in $s = 1$. Distress has probability $1 - \alpha$ and implies that risky investment needs refinancing in $s = 1$; otherwise it is lost. The scale of risky investment that survives distress is denoted j and pays gross return ρ_1 in $s = 2$. Bankers are financially constrained since they can only pledge up to a fraction $\rho_0 < 1$ of the expected gross return of their risky investment.[7]

The *authority* (for instance, a central bank) can change the return of riskless investment in $s = 1$ by levying a contingent tax to be rebated lump-sum in $s = 2$. The after-tax return of riskless assets in $s = 2$ is denoted by $R \leq 1$. A policy $R < 1$ is interpreted as a "bailout" of size $1 - R$ since this is a policy-driven reduction in the cost of funding for bankers in the distress state. The authority's objective is composed by households' and banks' welfare (the latter weighted β):

$$V + \beta U \tag{3}$$

Timing. *Initial stage, $s = 0$:* Households receive endowment e_0 and decide consumption c_0^h, their riskless investment and loans to bankers. Bankers receive A and decide consumption c_0^b, their risky and riskless investments, i and xi.

Interim stage, $s = 1$: Households receive e_1 and the state is revealed: "no distress" (with probability α) or "distress" (with probability $1 - \alpha$). In the distress state, households decide consumption c_1^h, their riskless investment and their new loans to bankers; bankers receive no endowment and decide consumption c_0^b and the surviving scale j of their risky investment. Taxes on riskless assets are collected. In the no-distress state there is no need of reinvestment, so households only consume and invest in riskless assets.

Last stage, $s = 2$: Riskless and risky investment pays, taxes are rebated, and households and bankers respectively consume c_2^h and c_2^b.

3.2   Interaction between households and bankers

I start the analysis by solving for the allocation resulting from the competitive interaction between households and bankers taking actual and expected bailout policy R and R^e as

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[7]Limited pledgeability ρ_0 is treated as exogenous but it may be justified by an optimal lending contract that induces bankers to exert high effort (Holmstrom and Tirole, 1998).

exogenous variables. This is an artifact that respects sequential rationality of private agents and allows to represent allocations in a way that facilitates the subsequent policy analysis.

The total loan that bankers receive in stage $s = 0$ is $i + xi - A$ if $1 + (1 - \alpha) < \rho_1$. This assumption ensures that bankers set $c_0^b = 0$. Households' endowment e_0 is assumed large enough, so there is no shortage of supply of funds and bankers' risky investment i is pinned down by households' break-even condition in $s = 0$:

$$i + xi - A = \alpha (\rho_0 + x) i. \tag{4}$$

In words, households are willing to lend to bankers up to the expected return of their loan, $\alpha (\rho_0 + x) i$. The lending contract prescribes that bankers only repay to households if there is no distress (which has probability α) in which case they receive the pledgeable part ρ_0 of bankers' risky investment i and all proceedings of bankers' riskless investment, xi.

Bankers must raise new funds in $s = 1$ in the distress state to preserve a scale $j \leq i$ of their risky investment. Only households receive new endowment in $s = 1$. The break-even condition for new loans from households to bankers in $s = 1$ is

$$Rj = \rho_0 j + xi \tag{5}$$

after also assuming that households' endowment e_1 in $s = 1$ is high enough such that there is no shortage of supply of funding. Once the distress state is realized there is no more uncertainty, so households' return for these new loans is the pledgeable part ρ_0 of bankers' surviving scale j of their risky investment and all proceedings of bankers' riskless investment, xi. Opportunity cost for these loans is R, which is the bailout policy instrument. Solving for j yields

$$j (x, R, i) = \min \left\{ \frac{x}{R - \rho_0}, 1 \right\} i.$$

Since bankers' utility is linear and $\alpha \in (0, 1)$, bankers choose in $s = 0$ a level of x that ensures the full continuation of their risky investment if there is distress,

$$x (R^e) = R^e - \rho_0, \tag{6}$$

where R^e denotes bankers' expectations in $s = 0$ of the bailout policy to be implemented in $s = 1$ if there is distress.

Combining $x(R^e)$ with (4) and (5) solves

$$i(R^e) = \frac{A}{1 + (1 - \alpha)R^e - \rho_0},$$ (7)

$$j(R, R^e) = \min\left\{\frac{R^e - \rho_0}{R - \rho_0}, 1\right\} i(R^e).$$ (8)

Equations (6), (7) and (8) characterize allocations only as functions of actual and expected bailout policy R and R^e. These expressions are obtained after imposing competitive and sequentially rational behavior of households and bankers.

3.3 Static trade-offs and time-consistent bailouts

A useful exercise for the subsequent analysis on prudential policies is to establish in this static game the momentary benefits and costs involved in a bailout, i.e., decreasing $R < 1$ if there is distress in $s = 1$. The benefit is given by bankers' increased capacity to finance reinvestment. To see this, note that bankers' utility if there is distress is

$$U(j) = (\rho_1 - \rho_0) j$$ (9)

since bankers' linear utility implies they concentrate all their consumption in $s = 2$. Their consumption is the non-pledgeable part of the gross return of surviving scale j of risky investment. Equation (8) captures the dependence of j on the bailout policy rate R and implictly on expected bailout policy R^e through bankers' choice in $s = 0$ of their portfolio of riskless and risky investment, respectively in (6) and (7). $R > R^e$ implies that $x(R^e) < R - \rho_0$, i.e. bankers' choice in $s = 0$ of x is too low to ensure the continuation of risky investment at full scale if there is distress, so $j < i$. By decreasing R bankers achieve higher j and thus higher welfare. This argument reaches its limit when $R = R^e$, i.e. when x is high enough to ensure that $j = i$. The authority has no incentives to decrease R below ρ_0, so ρ_0 is the lower bound for both R and R^e.

In turn, the cost of a bailout is borne by households. To see this, households' welfare in $s = 1$ and $s = 2$ if there is distress is

$$V(e_1, R, j) = \max_{S^d}\left\{u\left(e_1 - S^d\right) + RS^d + (1 - R)\left[S^d - j\right]\right\},$$

which depends on households' endowment in $s = 1$, e_1, the bailout policy R and the surviving scale j of risky investment. Households' utility in $s = 1$ is given by $u\left(e_1 - S^d\right)$ while their

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utility in $s = 2$ is linear and sums the return on savings (which pays R regardless whether it is invested in riskless assets or lent to bankers) and households' rebate received in $s = 2$ only for the tax levied from their riskless investment return.

Households' savings solve $S^d(R) = e_1 - R^{-1/\gamma}$, so

$$V(R, R^e) = cons + \left\{\frac{R^{1-1/\gamma}}{1-\gamma} - R^{-1/\gamma}\right\} - (1-R)j(R, R^e). \tag{10}$$

Abstracting from a constant, the first term on the right hand side is increasing in $R \leq 1$ as the lower R, the larger the loss of households welfare due to the distortion induced by the bailout on households' consumption scheme. The second term represents the effect of the bailout on the rebate that households receive and is affected by R in two ways. Decreasing $R \in [\rho_0, 1]$ implies higher loss of the rebate given the loan j that bankers receive in $s = 1$ if there is distress (which equal the surviving scale of their risky investment). Decreasing R also implies more loans j to bankers according to (8) provided that $R^e \leq R \leq 1$.

Overall, from equations (3), (6), (7) and (8), the authority's objective from the standing point of distress in $s = 1$ is

$$W(R, R^e) = cons + \frac{R^{1-1/\gamma}}{1-\gamma} - R^{-1/\gamma} + [\beta(\rho_1 - \rho_0) - (1-R)]\min\left\{\frac{R^e - \rho_0}{R - \rho_0}, 1\right\}i(R^e). \tag{11}$$

The next proposition states the set of time-consistent bailout policies or, in other words, the set of equilibrium bailouts when the authority has no commitment technology.

Proposition 1 *A policy $R \in \Re_d = [\underline{R}, 1]$, the set of equilibrium bailouts without commitment in the static game, if*

$$W(R, R^e = R) \geq W\left(\widetilde{R}, R^e = R\right) \quad \forall \widetilde{R} \in [R, 1]$$

or equivalently

$$(1-\gamma)^{-1}\left[\widetilde{R}^{1-1/\gamma} - R^{1-1/\gamma}\right] + \left(R^{-1/\gamma} - \widetilde{R}^{-1/\gamma}\right) \leq \omega\frac{\widetilde{R} - R}{R - \rho_0}i(R) \quad \forall \widetilde{R} \in [R, 1]. \tag{12}$$

with $\omega = \beta(\rho_1 - \rho_0) - (1-\rho_0) > 0$. The largest bailout in equilibrium satisfies $\underline{R} \geq \rho_0$.

Proof. The first equation is simply the definition of an equilibrium. The second equation states its closed form solution. Any policy $\widetilde{R} > 1$ is suboptimal when $R^e = R \leq 1$ because $\widetilde{R} > R^e$ implies downsizing risky investment, $j < i$, and a distortion of households'

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consumption scheme. Besides, any policy $\widetilde{R} < R^e = R$ is also suboptimal because $\widetilde{R} < R$ implies more distortion of households than R but not more j due to $j \leq i$. Hence, candidate policy deviations are $\widetilde{R} \in [\underline{R}, 1]$. If $R^e = R < 1$ but close to one, R is an equilibrium bailout without commitment. This is because households' utility is concave, so the welfare cost of the distortion of households is small relative to avoiding $j < i$. The cost of the distortion for households is increasing and convex as R decreases. Hence for the condition in (12) is met by all $R^e \in [\underline{R}, 1]$ and it is violated by any $R^e \notin [\underline{R}, 1]$. $\blacksquare$

Proposition 1 dictates that for a bailout policy R to be time-consistent, it must be optimal for the authority to implement it if private agents take decisions in $s = 0$ optimal given such a policy, i.e., equations (6), (7) and (8) hold for $R^e = R$. This means that, given bankers' portfolio of riskless and risky assetst, the cost of the bailout on households' welfare is less than its benefit on bankers' welfare. The welfare cost of this distortion is increasing in the size of bailouts, which sets a minimum $\underline{R}$ that is time-consistent.

For comparison, the next proposition states the optimal bailout policy under commitment.

Proposition 2 *There are no bailouts in equilibrium under commitment, $R_c^* = 1$, if*

$$\beta (\rho_1 - \rho_0) \leq (1 - \alpha) + (1 - \rho_0). \tag{13}$$

I do not provide a proof for this proposition as this section follows closely Farhi and Tirole (2012) and the commitment bailout policy only serves as reference with no active role in the analysis of prudential policies hereafter. The main result of Proposition 2 is that, under assumption (13), the government implements a no-bailouts policy if it has a commitment technology. The intuition goes as follows. Under commitment, households and bankers observe R before taking their decisions in $s = 0$. Thus, equations (6), (7) and (8) hold for $R^e = R$. Importantly, $j = i$ for any $R \in [\rho_0, 1]$, so bankers get no direct benefit of a bailout in $s = 1$ if there is distress, but the cost of a bailout on households still applies. From the perspective of $s = 0$, decreasing R increases risky investment i, which has high expected return. But under assumption (13) this incentive is not enough to induce a deviation from the no-bailouts policy. For the rest of this paper I assume (13) holds.

Comparing propositions 1 and 2 highlights the nature of the lack of commitment problem of bailouts policy. Note that $R_c^* \in \Re_d$, so the ex-ante optimal no-bailouts policy under commitment is time-consistent. This is because the authority does not deviate from a commitment of no bailouts if households and bankers behave in $s = 0$ optimally as if such a policy would be carried out, i.e., when $R^e = R_c^*$ in equations (6), (7) and (8).

This result sharply contrasts with standard time-inconsistency due to lack of commitment. In standard policy contexts, such as taxation or monetary policy, the authority wants to deviate from its commitment policy when agents optimally take their decisions as if such policies would be carried out. For bailouts, the lack of commitment problem materializes as equilibrium multiplicity – a *fragility* problem: R_c^* is not the *only* time-consistent policy. A continuum of policies $R \in [\underline{R}, 1]$ are time-consistent such that inferior equilibria with large bailouts (low R) are as likely as the optimal no-bailouts policy. In those inferior equilibria, bankers take excessive risk ex-ante (choose small x) and force large bailouts ex-post that harm households. This *fragility* problem is not specific result of this model; it also arises in other financial environments such as Diamond and Dyvbig (1983), Schneider and Tornell (2004), Diamond and Rajan (2009), Ennis and Keister (2009), Keister (2016) and Mengus (2018). The nature of this fragility problem has some implications when intertemporal trade-off involved in a bailout decision are introduced in the analysis in Section 4.

3.4   Prudential policy

This paper highlights a sometimes pervasive mechanism of prudential policies to affect bankers' risk taking behavior before crises through their effect on the ex-post incentives to bailout during a crisis. Although there is a intertemporal dimension in the authority's incentives to bailout that are not captured in the static game studied so far, it suffices to make the basic point. For concreteness, I study here three examples of prudential policies: A crises resolution fund, prudential taxes, and public debt. The first two are meant as examples of policies that may backfire by this mechanism. Public debt is meant as an example of the converse case: a policy with no prudential motivation that may curb bankers' risk taking by alleviating the fragility problem arising from lack of commitment problem of bailouts.

To capture the severity of this fragility problem, I simply focus here on the size of the largest time-consistent bailout policy, $\underline{R}$.[8] The analysis makes use of the steps followed above to solve for the equilibrium: First, study the effect of a particular prudential policy on competitive allocations given actual and expected bailout policy, then focus on its effect on the trade-offs involved in a bailout, to finish with its impact on the actual set of equilibrium bailouts without commitment. This structure of analysis has general application beyond the three particular examples of prudential policies studied here.

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[8]Next section rationalizes this criterion in the context of the infinitely repeated game.

3.4.1 Crises resolution funds

In Europe and in the United States crises resolution funds created after the 2007-2009 financial crisis and the Euro crisis have been implemented to prevent bailouts financed by tax-payers. The European Union has implemented the "Single Resolution Fund" which collects resources levied from banks and financial institutions to be used in episodes of financial distress.[9] In the United States, the Dodd-Frank Act created the "Orderly Liquidation Fund" financially supporting an alternative mechanism to bankruptcy to deal with companies in distress seen as a treat to financial stability.

Motivated by these policies, consider a tax τ on bankers' risky investment i in $s = 0$ to finance a transfer T to bankers in $s = 1$ to help refinancing risky investment without the need of a bailout. If there is no distress, bankers invest T on riskless assets. Households' break-even condition in $s = 0$ is now

$$(1 + \tau) i + xi - A = \alpha \left[(\rho_0 + x) i + T \right], \tag{14}$$

In words, bankers must raise $(1 + \tau) i$ in stage $s = 0$ to obtain a scale of risky investment i. If there is no distress (with probability α), bankers pay to households the pledgeable part of their risky investment plus all the proceedings of their riskless investment: xi made in the initial period and T made in the interim period. Solving for i yields

$$i(x, \tau, T) = \frac{A + \alpha T}{1 - \alpha \rho_0 + (1 - \alpha) x + \tau}.$$

In turn, households' break-even condition in $s = 1$ in the distress state now is

$$R(j - T) = \rho_0 j + xi, \tag{15}$$

making clear that the transfer T to bankers helps refinancing risky investment in the distress state. Solving for j yields

$$j(x, T) = \min \left\{ \frac{xi + RT}{R - \rho_0}, i \right\}.$$

Taking into account that the authority sets $T = \tau i$ and that bankers choose their riskless investment x to continue their risky investment at full scale given their expectations R^e of

the bailout policy,

$$x\left(R^e; \tau\right) = \left(1 - \tau\right) R^e - \rho_0, \tag{16}$$

$$i\left(R^e; \tau\right) = \frac{A}{1 + \left(1 - \alpha\right)\left[R^e + \left(1 - R^e\right)\tau\right] - \rho_0}, \tag{17}$$

$$j\left(R, R^e; \tau\right) = \min\left\{\frac{R^e - \rho_0}{R - \rho_0}, 1\right\} i\left(R^e; \tau\right). \tag{18}$$

These expressions must be compared to (6), (7), and (8). Bankers anticipate the transfer in $s = 1$ by choosing the ratio x in $s = 0$ to be decreasing in τ, so they tilt their portfolios more to risky assets as the crisis resolution fund becomes larger. As a result, conditioning on R and R^e, the ratio j/i between the scale of risky investment after and before distress in equation (18) is unaffected by the crisis resolution fund. However, equation (17) shows the scale of bankers' risky investment in $s = 0$ is decreasing on the tax τ provided that $R^e < 1$. This is because the reduction in x due to banks' response to the transfer T they get is not enough to fully compensate the lower financing capacity of banks imposed by the tax.

Turning to the effect of this prudential policy on the tradeoffs involved in a bailout, bankers' welfare if there is distress remains as in equation (9). However, the surviving scale j of risky investment if there is distress in (18) is decreasing in the tax τ since the initial scale of risky investment i is decreasing in τ in (17). The crises resolution fund thus decreases bankers' welfare if the size of the bailout is taken as given. The smaller i due to the crises resolution fund also reduces the benefit of a bailout, i.e., the positive effect of a decrease in R when $R^e \leq R$ on bankers' welfare. This effect reduces the authority's incentives to implementing a bailout.

Regarding the cost of the bailout, households' welfare in $s = 1$ and $s = 2$ if there is distress is

$$V\left(e_1, R, j\right) = \max_{S^d}\left\{u\left(e_1 - S^d\right) + RS^d + \left(1 - R\right)\left[S^d - \left(j - T\right)\right]\right\}.$$

The crises resolution fund has two effects on households' wefare relevant for the bailout decision. First, the transfer T bankers receive in $s = 1$ reduces their dependence on households to finance reinvestment in the distress state. This increases households' welfare. This effect is reinforced by the smaller j due to the tax in (18). Importantly, these two effects reduce the detrimental effect of a bailout on households' welfare, increasing the authority incentives to implement a bailout.

Summing up, the next proposition establishes that the crisis resolution fund may increase the size of the largest time-consistent bailouts that can get realized in equilibrium.

Proposition 3 *A crisis resolution fund may worsen the lack of commitment of bailout policy.*

Proof. The condition for a policy R to be an equilibrium bailout policy when there is a crisis resolution fund $T = \tau i$ is

$$(1-\gamma)^{-1}\left[\widetilde{R}^{1-1/\gamma} - R^{1-1/\gamma}\right] + \left(R^{-1/\gamma} - \widetilde{R}^{-1/\gamma}\right) \leq \left[\frac{\omega}{\widetilde{R}-\rho_0} + \tau\right]\left(\widetilde{R}-R\right)i\left(R;\tau\right) \quad \forall \widetilde{R} \in [R,1].$$

The right-hand side of this inequality is increasing in τ f

$$\widetilde{R} \geq \frac{(1-\alpha)(1-R)\omega}{1+(1-\alpha)R-\rho_0} + \rho_0$$

Thus, a policy $R < \underline{R}$ may satisfy the equilibrium condition for $\tau > 0$. ∎

This proposition states that a crisis resolution fund may backfire by worsening the lack of commitment problem of bailouts, in the sense that lower interest rate (i.e, larger bailouts) may become time-consistent policies. This happens when the crises resolution fund policy (τ, T) has stronger effect on reducing the negative effect of a bailout on households' welfare than on reducing the positive effect of a bailout on bankers' welfare. As bankers foresee this effect, they tilt their portfolios more to risky assets and force the authority to introduce even larger distorting bailouts on households' consumption schemes in financial distress.

3.5 Prudential taxes

I now turn to another example of a prudential policy that may backfire. This policy captures a "Pigouvian" motivation in proposals of using taxes to curb bankers' risk taking, for instance, because of a systemic externality (Bianchi, 2011) or expectations of bailouts (Kocherlakota, 2010).

Consider a tax τ on bankers' risky investment in $s = 0$ and a rebate T in $s = 2$, when there is not further uncertainty to be resolved (distress is revealed in $s = 1$). Households' break-even condition in $s = 0$ is

$$(1+\tau)i + xi - A = \alpha\left[(\rho_0 + x)i + T\right],$$

which is identical to the crises resolution funds in (14). However, the interpretation is different. The transfer T to bankers shows up on the right-hand side of (14) because the transfer,

which takes place in $s = 1$, is invested by bankers in riskless assets if there is no distress. Here, bankers receive this transfer as a tax rebate T only in $s = 2$, but such a rebate is fully pledgeable, exactly as riskless investment. This is because the rebate represents a future inflow of resources for bankers that is not affected by moral hazard considerations. Implicit in the limited pledgeability of risky investment is the incentive compatibility constraint that the lending contract must satisfy.[10] In short, the rebate is perfect substitute of riskless investment from the standing point of bankers in $s = 0$.

In turn, if there is distress in $s = 1$, households' break-even condition at the time of refinancing risky investment is

$$Rj = \rho_0 j + xi + T,$$

which is now different than the one obtained for the crises resolution fund case in (15). This is because the rebate in $s = 2$ is still a perfect substitute of riskless investment from the standing point of bankers in $s = 1$ as its financing capacity is not affected by the bailout. As a result, bankers' optimal choice of riskless assets in $s = 0$ once the equilibrium condition $T = \tau i$ is imposed is

$$x\left(R^e; \tau\right) = R^e - \rho_0 - \tau.$$

Thus, bankers choose portfolios more tilt to risky investment such that completely undo the effect of the tax on both the original scale of their risky investment i and its surviving scale j after distress for a given bailout policy R in $s = 1$ and its expected level in $s = 0$. This can be seen from the solution of i and j which are identical to equations (7) and (8) obtained when there is no prudential tax implemented. As a result, the benefits and costs of a bailout also remain identical to the case with no prudential taxes, and so does the equilibrium set of time-consistent bailouts policy. The next proposition states this result.

Proposition 4 *A prudential tax designed to reduce bankers' risk taking induces bankers to tilt more their portfolios to risky assets so the tax is innocuous on their total holding of risky assets.*

This proposition requires no proof as the solution of the equilibrium is identical to Proposition 1. Thus, this prudential tax policy becomes ineffective as bankers choose more risky portfolios in a way that risky investment exposed to inefficient downsizing if there is distress remains the same and the worst equilibrium bailout size also remains the same. The

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[10]See Holmstrom and Tirole (1998). For self-containedness, I sketch the argument here: Assume that the success probability of risky investment is p_H (p_L) if bankers exert high (low) effort. Bankers enjoy the a non-pecuniary benefit Bi when exerting low effort. ρ_0 is thus implictly defined by a binding incentive compatibility constraint, $(\rho_1 - \rho_0) i = Bi/(p_H - p_L)$.

underlying reason is the role played by liquid assets (here, riskless assets) in bankers' credit constraint and the full pledgeability of the tax rebate that works as perfect substitute of liquid assets. In the literature proposing prudential taxes (e.g., Bianchi, 2011; Bianchi and Mendoza, 2013; Kocherlakota, 2010) there is no role for liquid assets, so it abstracts from this effect that ends up undermining the effectiveness of the prudential policy – in fact, in the setup studied in this paper, making it completely ineffective.

3.6 Public debt as prudential policy

I now turn to public debt as an example of a policy that may have a prudential role even though it usually has no such motivation. The key is that public debt enters as a state variable increasing the cost of bailouts at the time of implementation, and thus eliminate equilibria with the largest bailouts. In short, the stock of public debt may serve as a "burning the bridges" strategy to limit bankers' excessive risk taking by curbing expectations of large bailouts.

A simple mechanism to generate such a prudential role is by assuming that the service of an exogenous stock of public debt must be financed with a distortionary tax rate ζ on households' consumption in $s = 1$. For simplicity assume the stock of public debt has no other effect in the problem, for instance, because this debt has been issued abroad to finance some public good which utility is additive separable from households' consumption. Thus, the original investment scale i, the risky-to-riskless investment ratio x and the surviving scale j of risky investment after distress still solve as in equations (6), (7) and (8) when the bailout policy R in $s = 1$ and its expected level in $s = 0$ are taken as given.

Beside a specific motivation, this example illustrates the prudential role of public debt through its effect on incentives to bailouts abstracting from other channels, such as the provision of outside liquidity (Woodford, 1990; Holmstrom and Tirole, 1998). Such liquidity provision role is irrelevant here as riskless assets are exogenously supplied.

Under all these simplifying assumption, bankers' welfare is unaffected by public debt. Households' welfare in $s = 1$ in the distress state is

$$V(R, \zeta) = cons + u\left[(1 - \zeta) c_1^h\right] + R S^D + (1 - R)\left(S^D - j\right)$$

so the public debt service equals $\zeta \left(e_1 - S^D\right)$ where S^D now solves

$$S^D = e_1 - \left[R(1 - \zeta)^{\gamma-1}\right]^{-1/\gamma}.$$

This way to finance the public debt service has no effect on the rebate households receive from the implementation of a bailout, $(1 - R)\left(S^D - j\right)$, but it distorts their consumption schemes. The main result in this subsection follows:

Proposition 5 *The service of public debt alleviates the lack of commitment problem of bailout policy.*

Proof. This result follows from noticing that a give bailout policy R is equilibrium iff

$$(1 - \zeta)^{\frac{1}{\gamma} - 1} \left[(1 - \gamma)^{-1} \left[\widetilde{R}^{1 - 1/\gamma} - R^{1 - 1/\gamma} \right] + \left(R^{-1/\gamma} - \widetilde{R}^{-1/\gamma} \right) \right] \leq \omega \frac{\widetilde{R} - R}{\widetilde{R} - \rho_0} i\left(R\right) \quad \forall \widetilde{R} \in [R, 1].$$

which left-hand side is increasing in ζ for $\gamma > 1$, so the largest equilibrium policy $\underline{R}$ is increasing in ζ. ∎

This proposition states that the severity of the lack of commitment problem of bailout policy is milder because of the service of debt. Thus, in the worst equilibrium outcome bankers' risk-taking ex-ante and the size of bailouts ex-post both become smaller. In general, any type of policy that increases households' marginal utility at the time of financial distress would have similar effect, but public debt has a special feature: it is a state variable for the authority's bailout problem in $s = 1$. Thus, public debt serves as substitute of commitment, as it works in other contexts such as capital taxation (Dominguez, 2007) and monetary policy (Persson, Persson and Svensson, 2006).

Of course an important implicit assumption in this argument is that the authority cannot repudiate the service of its debt in the distress state. One may rationalize this assumption by introducing a cost on the authority for defaulting its debt. Then results in this section would apply in the parameter subspace where the authority does not default. However, when reputational costs of bailouts are introduced in the analysis that comes next, public debt may still have a prudential role even if its service is repudiated.

4   An infinitely repeated game

I now extend the game to allow for an infinite sequence of non-overlapping generations. This game preserves the three-stages structure of the static game but introduces an infinitely lived authority that internalizes the intertemporal effects of its bailout decisions. This, in turn, introduces new channels for prudential policies to affect the severity of the lack of

commitment problem of bailouts. The analysis is structured in a way that results in the previous section are embedded here as special cases.

4.1 Setup

Consider an economy populated by generations of households and bankers. Each generation lives for only one period $t = 0, 1, ..., \infty$. Each period is broken into three stages $s = 0, 1, 2$ which are identical to those in Section 3. Endowments remain exogenous and there are no inter-generational transfers or state variables, so there is no interaction among generations. This ensures that the static game in Section 3 coincides with the stage game here. Thus, allocations given actual and expected policy at t, (R_t, R_t^e), may be represented as in Section 3 by only adding subindex t:

$$x\left(R_t^e\right) = R_t^e - \rho_0, \tag{19}$$

$$i\left(R_t^e\right) = \frac{A}{1 + (1 - \alpha) R_t^e - \rho_0}, \tag{20}$$

$$j\left(R_t, R_t^e\right) = \min\left\{\frac{R_t^e - \rho_0}{R_t - \rho_0}, 1\right\} i\left(R_t^e\right). \tag{21}$$

The only twist of this economy with respect to Section 3 is that the authority, unlike households and bankers, lives infinite periods. Its objective in t is given by

$$\mathbb{E}_t\left\{\sum_{k=0}^{\infty} \delta^k \left[V_{t+k} + \beta U_{t+k}\right]\right\}. \tag{22}$$

where V_{t+k} and U_{t+k} respectively are welfare of households and bankers in generation $t + k$, β is a weight on bankers' welfare within a generation and δ is the discount factor across generations.

Overlapping generations. If generations were overlapped, a bailout at t would simultaneously affect the risky investment scale i_t of the 'young' generation of bankers and the reinvestment scale j_t of the 'old' generations of bankers. This paper abstracts from this effect since it is not central for results.

4.2 Intertemporal trade-offs and resistant bailouts

This section studies the intertemporal tradeoffs involved in a bailout decision and introduces a criterion to evaluate the way that prudential policies affect the severity of the lack of commitment problem of bailouts. To ease exposition I start with the latter.

4.2.1 Evaluation criterion

Section 3 above shows that, in a static setup, lack of commitment of bailout policy creates equilibrium multiplicity – a fragility problem. This multiplicity imposes a technical challenge for the purposes of this paper. The standard approach to introduce intertemporal tradeoffs in policy without commitment is to focus on the "best sustainable plan" (Chari and Kehoe, 1990): the time-consistent policy in the infinitely repeated game that yields the highest welfare. This approach usually produces intuitive polar extremes in which, if the authority fully discounts (gives high weight to) future outcomes, the best-sustainable plan coincides with the equilibrium policy without commitment (with commitment) in the static game.

However, due to the fragility problem, the equilibrium no-bailouts policy with commitment is one of many equilibrium bailout policies without commitment in the static game. A standard property of infinitely repeated games is that any equilibrium in the static game is also an equilibrium in the repeated game (Abreu, 1988). As any equilibrium policy without commitment is time-consistent, the best-sustainable plan is simply the no-bailouts policy regardless the authority's discount. This means that this approach is not suitable for the study of the effect of prudential policies on the authority's intertemporal tradeoffs involved in a bailout decision simply because the best sustainable plan is invariant to the weight that the authority gives to these intertemporal trade-off. Neither does the criterion used in Section 3 of focusing on the largest time-consistent bailout in the static game as it is also invariant to the weight given by the authority to intertemporal trade-offs.

To deal with this issue, I propose to focus on a different bailout policy among the set of time-consistent bailout policies in the infinitely repeated policy game: The *best resistant bailout plan*, which is defined as follows. I argue that this policy recovers the logic behind the criterion of focusing on the best sustainable plan in a context where lack of commitment creates a fragility problem instead of a time-inconsistency problem.

Definition 1 *The best resistant bailout plan R_r^* is such that*

$$R_r^* = \arg\max \left\{ W^{ex-ante}(R_r) \right\}$$

subject to R_r^* to satisfy Condition (1):

$$W_t(R_r^*, R_t^e = R_r^*) \geq W_t(\widetilde{R}_t, R_t^e = R_r^*) - \delta_{\wp}(R_r^*, \underline{R}) \quad \forall \widetilde{R}_t \in [R_r^*, 1] \ \text{and} \ \forall t \qquad (23)$$

or equivalently

$$(1-\gamma)^{-1}\left[\widetilde{R}_t^{1-1/\gamma} - R_r^{*1-1/\gamma}\right] + \left(R_r^{*-1/\gamma} - \widetilde{R}_t^{-1/\gamma}\right) \leq \omega \frac{\widetilde{R}_t - R_r^*}{\widetilde{R}_t - \rho_0} i_t\left(R_r^*\right) + \delta\wp\left(R_r^*, \underline{R}\right), \quad (24)$$

$\forall \widetilde{R}_t \in [R_r^*, 1]$ *and* $\forall t$, *and* R_r^* *to satisfy Condition (2):*

$$W\left(R_r^*, R_t^e\right) \geq W\left(R_t^e, R_t^e\right) - \delta\wp\left(R_r^*, \underline{R}\right) \quad \forall R_t^e \in [\underline{R}, R_r^*] \ \ and \ \forall t \qquad (25)$$

or equivalently,

$$(1-\gamma)^{-1}\left[R_t^{e1-1/\gamma} - R_r^{*1-1/\gamma}\right] + \left(R_r^{*-1/\gamma} - \widetilde{R}^{-1/\gamma}\right) \geq \omega \frac{R_r^* - R_t^e}{R_r^* - \rho_0} i\left(R_t^e\right) + \delta\wp\left(R_r^*, \underline{R}\right) \quad (26)$$

$\forall R_t^e \in [\underline{R}, R_r^*]$ *and* $\forall t$, *where*

$$\wp\left(R_r^*, \underline{R}\right) = \frac{1}{1-\delta}\left[W^{ex-ante}(R_r^*) - W^{ex-ante}(\underline{R})\right], \qquad (27)$$

δ *is the authority discount across generations,* $W_t(R, R_t^e)$ *is welfare of generation* t *relevant for a bailout decision at* t *as in equation (11),* $W^{ex-ante}(R)$ *is generation* t *welfare in an equilibrium where* R *is the bailout policy is carried out if there is distress (to be specified below), and* ω *is a constant defined in Proposition 1.*

The best resistant bailout plan R_r^* is the one that yields the highest welfare for a given generation t (denoted by $W^{ex-ante}(\cdot)$ and specified shortly below) that additionally satisfies two conditions:

Condition I: It is *sustainable*, so it is a time-consistent bailout policy in the infinitely repeated policy game. The inequality in (23) is the mathematical expression for this condition, which establishes that if households and bankers in generation t take decisions in stage $s = 0$ as if the bailout policy R_r^* would be carried out if there is distress, i.e., $R_t^e = R_r^*$, then it is optimal for the authority to carry out R_r^* provided that a deviation from R_r^* implies a "penalty" $\wp\left(R_r^*, R_r^*\right)$ defined in (27). This is not strictly speaking a penalty to the authority imposed by future generations of households and bankers. Following Abreu (1988) and (Chari and Kehoe, 1990), this penalty is an artifact that captures the reputational cost of a policy deviation that allows to check whether a candidate policy is time-consistent in an infinitely repeated game. This penalty is constructed as the largest loss for the authority on future generations' welfare if it deviates from the bailout plan R_r^*, which equals the discounted sum of the difference in all future generations' welfare in equilibria where bailouts

R_r^* and the worst equilibrium in the static game $\underline{R}$ are carried out. Thus, if the bailout policy R_r^* does not satisfy the condition in (23), there may not exist an equilibrium that "sustains" such a policy as time-consistent in the infinitely repeated policy game.

The inequality in (24) casts (23) in closed form using the assumption that all households and bankers are identical, implying that I can focus on pure symmetric strategies for all players and time-invariant bailout policies, so the closed form of one generation's welfare relevant for the bailout decision in distress equals equation (11) in the static game.

Condition II: The best resistant bailout plan R_r^* must be *resistant* to collective deviations of bankers. The inequality in (25) is the mathematical expression for this condition, which establishes that the authority would not deviate from R_r^* even if carrying it out implies that the surviving scale risky investment after distress in the current generation is smaller than its original scale chosen in stage $s = 0$, i.e., if $R_t^e \in [\underline{R}, R_r^*]$. Rational expectations are bounded below by the largest time-consistent bailout $\underline{R}$.

This "resistance" requirement may not be satisfied by all sustainable equilibria; in game theory language, it is a refinement. Following a similar logic than sustainable plans, collective deviations of bankers and the penalty are used here as artifacts to capture the authority's reputational cost that in this case allow to check the severity of the fragility problem. To see this, assume that a given bailout policy $\widehat{R}$ is sustainable but it does not satisfy inequality (25). Then $\widehat{R}$ is a time-consistent policy but nothing prevents inferior equilibria with larger bailout to take place if risky investment can be lost if there is distress. Thus, the situation is akin to the static game where an equilibrium with the non-bailouts policy coexists with inferior equilibria with large bailouts. As in sustainable plans, the penalty represents the highest reputational cost for the authority of a deviation of its policy from a given equilibrium path. Similarly, although bankers are assumed atomistic, so they do not have strategic power to coordinate collective deviations, a deviation of all bankers is the largest possible threat to the authority in a given equilibrium path.

Although this is not the first refinement that focuses on "coordination-proof" equilibria, I use the label "resistant" to distinguish it from other refinements in the literature. Examples are "resilient equilibria" (Aumann, 1959), "strong-perfect equilibria" (Rubinstein, 1980), "coalition-proof equilibria" (Berheim, Peleg and Whinston, 1987) and "dynamically consistent equilibria" (Berheim and Ray, 1989). These refinements are variations of the requirement that on a given equilibrium path no subset of players have either incentives to coordinate their strategies or to deviate from the prescribed penalty at the time of implementing it. However, these refinements are either defined for static games or give so much freedom to whom could form a coalition and what coalition strategies are admissible that

usually rule out all equilibria. Besides the focus on the best equilibrium from a welfare perspective, the critical distinctions of the proposed "resistant" bailout plans relative to existing refinements are the atomistic nature of private agents and the impossibility that unborn generations can coordinate with the current generation, so bankers cannot commit on future strategic behavior.

These two assumptions allow for meaningful results to incorporate intertemporal considerations in the prudential policy analysis when the fragility problem is prevalent in the spirit of sustainable plans. For instance, the simple inspection of Definition 1 shows three important properties: R_r^* is unique, $R_r^* = \underline{R}$ (the largest time-consistent bailout policy in the static game) when the authority's discounting is $\delta = 0$, and $R_r^* = 1$ (the optimal no-bailouts policy with commitment) when the authority's discount $\delta < 1$ is high enough. Hence, the static analysis in Section 3 may be seen as a particular case when $\delta = 0$.

4.2.2 Intertemporal tradeoffs

A convenient feature of the criterion in Definition 1 is that the implications for future generations of a bailout decision are contained in the "penalty" $\wp(R_r^*, \underline{R})$ defined in (27). Thus, to study the intertemporal tradeoffs of a bailout, it suffices to focus on given generation welfare $W^{ex-ante}(R)$ in an equilibrium where the bailout policy R is carried out. This one generation welfare is the sum of welfare of households and bankers (weighted by β) living in that generation:

$$W^{ex-ante}(R) = V_t^{ex-ante}(R) + \beta U_t^{ex-ante}(R).$$

Bankers' welfare of bankers in generation t is

$$U_t^{ex-ante}(R) = (\rho_1 - \rho_0) i_t(R)$$

where $i_t(R)$ solves as in equation (20) for $R_t^e = R$, which ensures that $i_t(R)$ is an equilibrium outcome. As in the static game, bankers concentrate all their consumption in stage $s = 2$ which equals the non-pledgeable part of their risky investment. In equilibrium there is no downsizing of risky investment due to distress, so $j = i$. Equilibria with larger bailouts, i.e., smaller $R \in [\rho_0, 1]$, yield higher welfare for bankers as they can reach higher risky investment scale.

Households' welfare in generation t must take into account consumption in all three stages:

$$
\begin{aligned}
V_t^{ex-ante}(R) \; = \; & \{e_{0,t} - i_t(R) - x_t(R, R) \, i_t(R) + A\} \\
& + \alpha \left\{ u\left(e_{1,t} - S_t^{nd}\right) + S_t^{nd} + (\rho_0 + x_t(R, R)) \, i_t(R) \right\} \\
& + (1 - \alpha) \left\{ u\left(e_{1,t} - S_t^d\right) + R S_t^d + (1 - R)\left[S_t^d - i_t(R)\right] \right\}.
\end{aligned}
$$

The first term in parenthesis is households' linear utility in stage $s = 0$ which equals their consumption of their endowment $e_{0,t}$ minus what they lend to bankers, $i_t + x_t i_t - A$. The second term in parenthesis is households' utility in stages $s = 1, 2$ if there is no distress (with probability α). Households' consumption in $s = 1$ is their endowment $e_{1,t}$ minus their savings S_t^{nd} in riskless assets (bankers do not borrow in $s = 1$ when there is no distress). Their consumption in $s = 2$ is the proceeds of their savings S_t^{nd} which pay no net return (as the authority has no reason to bailout) and the payment from bankers for loans made in $s = 0$, which is the pledgeable part of risky investment, $\rho_0 i_t$, and the whole proceeds of bankers' riskless investment in $s = 0$, $x_t i_t$. The third parenthesis is households' utility in stages $s = 1, 2$ if there is distress (with probability $1 - \alpha$). Their consumption in $s = 1$ is their endowment $e_{1,t}$ minus their savings S_t^d in riskless assets (loans to bankers in $s = 1$ are part of S_t^d as they pay the same return than riskless assets). Their consumption in $s = 2$ is the proceeds of their savings S_t^{nd} given the distorted return R imposed by the bailout policy. The last term is the rebate from the authority prescribed in the bailout for households' investment in riskless assets made in $s = 1$.

Including households' optimal savings given an equilibrium bailout policy R and equilibrium conditions from the competitive interaction between households and bankers,

$$
\begin{aligned}
W_t^{ex-ante}(R) \; = \; & cons + (1 - \alpha)\left[(1 - \gamma)^{-1} R^{1 - 1/\gamma} - R^{-1/\gamma}\right] \qquad (28) \\
& + \left[\beta(\rho_1 - \rho_0) - (1 - \alpha)(1 - R)\right] i(R).
\end{aligned}
$$

From an ex-ante perspective all generations are identical, so we can drop subindex t from $W_t^{ex-ante}(R)$. One generation welfare is increasing in $R \in [\rho_0, 1]$; this is the reason why the equilibrium policy with commitment in the static game is no bailouts, $R_c^* = 1$ in Proposition 2. As households' utility is concave, $W_t^{ex-ante}(R)$ is also concave, so the loss in ex-ante welfare is increasing in the size of the bailout $1 - R$. An important distinction with the authority's objective in (11) in that here expectations of a bailout R_t^e is not free variable as $W_t^{ex-ante}(R)$ refers to equilibrium welfare.

5 Resistant bailouts and prudential policies

I now use the concept of best resistant bailout plans introduced above to study the effect of prudential policies on banks' risk taking through their effect on the momentary and intertemporal tradeoffs involved for the authority in a bailout. I restrict attention to the case in which the authority's discount factor is δ in a mid range such that best resistant sustainable plan $R_r^* \in (\underline{R}, 1)$. In a nutshell, history-dependent strategies add delicacy to the relationship between prudential policies and bailouts that may aggravate or alleviate the fragility problem. The case of liquidity requirements is specially illustrative in this regard.

5.1 Liquidity requirements

Liquidity requirements that imposes $x_t \geq \underline{x}$ is studied here as an example of the variety of regulations proposed after the 2007-2009 financial crisis that take the form of caps on banks' actions. Other examples would be capital requirements or limits on leverage.

As in Farhi and Tirole (2012), this prudential policy attains the first best if it can effectively impose a minimum riskless-to-risky investment ratio, in the current setup, $\underline{x} = 1 - \rho_0$. I instead focus on the case where the success of regulation is limited, so the effective minimum requirement is less than the first best. The motivation relies on the idea that implementation of the first best may be impractical either because regulation may be partially circumvented or the authority lacks of necessary information in real time. This would probably be less of an issue if the effectiveness of the policy is monotonically increasing as it approaches to its first best. This is the case when the analysis abstract from reputational costs of bailouts but not they are added in.

To be specific, assume bankers' ratio of riskless to risky investment must be $x_t \geq \underline{x} < 1 - \rho_0$ such that

$$x\left(R_t^e; \underline{x}\right) = \max\left\{R_t^e - \rho_0, \underline{x}\right\}$$

so the regulation is binding only for $R_t^e \leq \underline{x} + \rho_0$.

Risky investment $i\left(R_t^e; \underline{x}\right)$ is strictly smaller than $i\left(R_t^e\right)$ in (20) and the surviving scale of risky investment if distress $j\left(R_t, R_t^e; \underline{x}\right)$ is strictly larger than $j\left(R_t, R_t^e\right)$ in (21) for $R_t^e \leq \underline{x} + \rho_0$. This is because bankers' riskless investment is increasing in the liquidity requirement $\underline{x}$ when they expect large bailouts. In the static game (or, equivalently, when $\delta = 0$), this implies that outcomes monotonically improve as $\underline{x}$ gets closer to the first best $1 - \rho_0$ as large bailouts become not necessary to save risky investment, so such large bailouts cannot be equilibrium policy. Thus, the severity of the fragility problem in the static game (the size of the largest

time-consistent bailout $1 - \underline{R}$) is decreasing in $\underline{x} \leq 1 - \rho_0$.

However, the next proposition shows that a very different result arises when the authority's $\delta > 0$ but not high enough to make the no-bailouts policy to satisfy the requirements in Definition 1.

Proposition 6 *Increasing a liquidity requirement $\underline{x}$ exacerbates bankers' risk taking by increasing the severity of the lack of commitment of bailouts when the liquidity requirement is binding in the worst static equilibrium ($\underline{R} < \underline{x} + \rho_0$) but it is not binding on the equilibrium path of the best resistant bailout plan ($R_r^* > \underline{x} + \rho_0$).*

Proof. In the stage game, with the liquidity requirement the authority has no incentives to set $R_t < \underline{x} + \rho_0$ since doing so increases the distortion in households saving decisions but it has no benefit on avoiding the inefficient downscale of risky investment for any expected policy $R_t^e \in [\rho_0, \underline{x} + \rho_0]$. Hence, if the liquidity requirement is binding, then $\underline{R} = \underline{x} + \rho_0$, so $\underline{R}$ is increasing in $\underline{x}$.

In the repeated game, if without the liquidity requirement the best resistant sustainable bailout is $R_r^* > \underline{x} + \rho_0$ but the worst equilibrium bailout policy in the stage game is $\underline{R} < \underline{x} + \rho_0$, then the only effect of $\underline{x}$ on the condition (**??**) is by reducing the penalty $\wp (R_r, \underline{R})$. Therefore, R_r^* is decreasing in $\underline{x}$. ∎

The result in this proposition applies when the liquidity requirement $\underline{x}$ is welfare improving in the worst static equilibrium but not on the equilibrium path of the best resistant bailout policy, i.e., when $\underline{R} < \underline{x} + \rho_0 < R_r^*$. Then the "penalty" of the authority's deviation from a bailout plan is decreasing in $\underline{x}$ as welfare in the worst possible equilibrium improves. The fragility problem of bailout policy becomes worse, i.e., the best resistant bailout plan is decreasing in $\underline{x}$.

Although this result is presented here for simplicity of exposition under one particular form of limited enforceability of liquidity requirements, it can easily generalize. The critical feature is that a given financial regulation curbs more bankers' risk-taking when risk-taking is higher. Thus, the penalty on deviations from a bailout plan is decreased by the regulation, so the size of the best resistant bailout increases. If this force is strong enough, it can overcome the direct effect of the regulation on banks' risk taking.

5.2 Other prudential policies

We now revisit the prudential policies studied in Section 3. The main difference relative to liquidity requirement is that these policies affect both the momentary and the intertemporal

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trade-off on the equilibrium path of the best resistant bailout.

As the effect of these prudential policies on the momentary trade-off is already studied in Section 2, I focus here on the effect on the penalty. The logic is the same than for liquidity requirements: If the prudential policy is less detrimental/improves more welfare on the worst equilibrium path than on the path of the best resistant bailout, the prudential policy decreases the penalty on authority's deviations, and thus making worse the fragility problem from lack of commitment.

The three prudential policies studied in the static game of Section 3 cover all possible cases regarding their effects on this penalty.

Crises resolution funds. Section 3 sets this policy up as a tax τ levied from bankers' risky investment i to finance an amount $T = \tau i$ of reinvestment j in the distress state. If there is no distress, the tax revenue is rebated to bankers in stage $s = 1$. For comparison, I assume that this policy scheme is maintained. Later I discuss a variation in which the fund accumulates intertemporally by not giving rebates in periods of no distress.

Proposition 7 *A non-accumulable crisis resolution fund alleviates the lack of commitment of bailouts by increasing the penalty of a deviation in the authority's bailout policy.*

Proof. Ex-ante welfare under this prudential policy for a time-invariant bailout policy R is

$$W^{ex-ante}(R;\tau) = cons + (1-\gamma)^{-1} R^{1-1/\gamma} - R^{-1/\gamma} + [\beta(\rho_1 - \rho_0) - (1-R)(1-\tau)] i(R;\tau)$$

for

$$i(R;\tau) = \frac{A}{1 + (1-\alpha)[R + (1-R)\tau] - \rho_0}.$$

$\frac{\partial^2 W^{ex-ante}(R;\tau)}{\partial\tau\partial R} > 0$. Thus, the penalty $\wp(R, \underline{R}; \tau) = \frac{1}{1-\delta}[W^{ex-ante}(R;\tau) - W^{ex-ante}(\underline{R};\tau)]$ is increasing in τ. ∎

Implicit in the proof of this proposition is that $\frac{\partial W^{ex-ante}(R;\tau)}{\partial\tau} < 0$, so a crises resolution fund is suboptimal for a given bailout policy R. This is because, although this prudential policy reduces the households' cost of bailouts, it also reduces the scale of risky investment, which has positive expected payoff in spite of the distress risk. However, a general evaluation of this policy involves its effect on the fragility problem introduced by lack of commitment of bailouts. Section 3 highlights that a crisis resolution fund may increase the static incentives of the authority to implementing a bailout. In contrast, Proposition 9 shows that this prudential policy unambiguity increases the intertemporal cost of a deviation in bailout

policy. This is because the scale of risky investment decreases by more due to τ when the bailout policy is $\underline{R}$ instead of $R > \underline{R}$, so the crises resolution fund is more detrimental to welfare on the path of the largest equilibrium bailout than on the path of the best resistant bailout.

Overall, if the authority has short horizon, i.e., low δ, the static incentives prevail, so such a crises resolution fund would be suboptimal as it decreases the scale of risky investment and increases the size of bailouts. In contrast, if the authority has δ high enough, then a crises resolution fund is not suboptimal but for a different reason than it has been designed for.

Adding the possibility of building up a crises resolution fund with the tax levied on periods with no distress creates a disassociation between the tax τ and the assistance T. To avoid endogeneizing them, let assume that T is the maximum that the authority is willing to use. Let also assume that $T < i$; otherwise the problem becomes trivial. The tax τ is treated as exogenous as it is decided before distress occurs and the focus of the paper is on the response of R to prudential policies.

The rebate in periods of no distress cannot be used to leverage funds for banks' investment since households' break even constraint on lending to bankers is given by

$$(1 + \tau) i + xi - A = \alpha (\rho_0 + xi).$$

Bankers choose $xi = (R^e - \rho_0) i - R^e T$. Thus, the tax τ unambiguously decreases risky investment scale i. Similar to Section 3, this effect decreases the static incentives of the authority to implementing a bailout. In contrast to Section 3, however, the tax does not directly relates to the assistance in an episode of distress, so here the worst equilibrium bailout $1 - \underline{R}$ unambiguously decreases in τ, The assistance T reduces the burden on households of a bailout, so $1 - \underline{R}$ unambiguously increases in T.

Turning to the intertemporal trade-offs involved in a bailout, it still holds, as in Proposition 9, that the tax decreases ex-ante welfare my more when bailouts are larger. This effect reinforces the static result that the tax alleviates the lack of commitment problem of bailouts in spite of being detrimental to welfare if the bailout size is given. Conversely, the assistance T is more welfare improving when bailouts are larger, so static and intertemporal effects of T make the lack of commitment problem of bailouts worse.

Prudential taxes. This prudential policy also involves taxes τ on bankers' risky investment i, but its rebate $T = \tau i$ occurs every period in $s = 2$ regardless there is distress or not. The reason is that, by design, this policy seeks to curb risk-taking without other

effects. Section 2 shows that this prudential policy backfires because bankers are able to tilt their portfolios to risky investment such that they completely undo the effect of prudential taxes on the level of their risky investment. For the same reason, this policy has no effect on ex-ante expected welfare, so it is also innocuous on the penalty for deviations on bailout plans.

Public debt as prudential policy. The important part of households' ex-ante utility in (28) affected by the tax ζ for public debt service is

$$u\left[\left(1-\zeta\right)\left(e_1 - S\left(R_t\right)\right)\right] + S\left(R_t\right)$$

where, as solved in Section 3, $S\left(R_t\right) = e_1 - \left[R_t\left(1-\zeta\right)^{\gamma-1}\right]^{-1/\gamma}$. This expression enters in households utility with and without distress depending only on the realization of the interest rate. Using the functional form of households' utility function and the solution of $S\left(R_t\right)$, this expression becomes

$$\left(1-\zeta\right)^{\frac{1}{\gamma}-1}\left[\left(1-\gamma\right)^{-1} R_t^{1-1/\gamma} - R_t^{-1/\gamma}\right].$$

This term is decreasing in R_t, so the tax ζ has stronger impact on welfare on the worst equilibrium path than on the path of the best resistant bailout plan provided that $\delta \in \left(0, \overline{\delta}\right)$. The tax to service public debt thus increases the penalty of authority's deviations. This effect reinforces the result in Section 3 about public debt serving as substitute of commitment for bailout policy. As argued in Section 3, the key is that the service of public debt is predetermined at the time of implementing a bailout.

If the authority could at some cost repudiate its debt, then this argument would apply in the subspace of parameters where the authority would not do so. However, if public debt default has future welfare costs on households, for instance because the exclusion of international financial markets, then public debt still has effect on incentives to bailout through the intertemporal cost of bailouts. Similarly, assume the authority could interrupt its service of public debt at no direct cost of the default, but it cannot do it anytime there is distress. Then public debt would still have effect on the future generations welfare cost of future bailouts.

6 Concluding remarks

This paper calls attention to the delicate interaction between ex-ante policies, such as financial regulations and prudential policies, and the lack of commitment problem of bailouts. This interaction is delicate because ex-ante policies work as predetermined variables that have multiple effects on the benefits and costs involved in a bailout decision at the time of implementation. Thus, there are conditions in which financial regulation and prudential policies may exacerbate this lack of commitment problem – and others which they may alleviate it. This paper focuses on liquidity requirements, a crises resolution fund and prudential taxes are examples of well-intended prudential policies that may backfire by fueling expectations of larger bailouts. Besides, this paper also studies public debt management as an example of policies usually with no prudential motivation that may play such a role by their side effect on curbing the expectations of bailouts.

These points are made in a repeated game where banks' leverage and liquidity play an important role and where the authority must consider the static and intertemporal trade-offs involved in a bailout. In this environment the lack of commitment of bailouts creates a fragility problem instead of the standard time-inconsistency problem. I argue that the standard approach of Sustainable Plans (Chari and Kehoe, 1990) is uninformative for policy analysis in this context. I propose a refinement that recovers the usefulness of this approach that may find application in other contexts where lack of commitment of policy creates equilibrium multiplicity.

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