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Financial Firm Resolution Policy as a Time-Consistency Problem

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The financial crisis and the recession of 2007–2009 have shown the importance of government regulation and intervention in the financial services sector. During the crisis, governments in Europe and North America, among others, implemented a large variety of actions intended to mitigate the adverse impact of the financial sector disruptions on the macroeconomy as a whole. Soon after, broad-ranging reforms of the government oversight and regulation policies of the financial sector were introduced. One of the central objectives of these reforms is to improve government policy toward large financial institutions that face, or are in, the state of insolvency.

The problem of optimal design of government policy toward financial institutions in distress is very complex. This article is devoted to discussing one important aspect of this problem: the issue of time consistency. Our main objective in this article is to provide an elementary exposition of a fundamental economic insight of Kydland and Prescott (1977), which is that an ex ante optimal policy may require the government to tolerate inefficient outcomes ex post. In the context of policy toward insolvent institutions, this means that optimal policy may require the government to refrain from bailing out a firm despite the large adverse consequences that the firm's failure may have for the macroeconomy as a whole. To make this point, in the first part of this article, we build a simple model with a time-consistency problem associated with the government bailout policy toward large (systemically important) financial institutions.

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As a matter of practice, perhaps because of political-economy constraints, it may be impossible for a future, benevolent government to tolerate large adverse consequences of its inaction in a state of economic crisis, even if there are good reasons ex ante (prior to a possible crisis) to promise to not act ex post. As private-market participants are aware of this intolerance, the government will be expected to bail out large insolvent firms in order to protect the macroeconomy in crisis. This expectation may give private-sector investors an incentive to take on excessive risks, because large losses that excessive risk-taking can generate may be socialized, i.e., borne in part by the taxpayer, while large gains that can be realized will generally be retained by the investors. Recognizing this incentive, the government should take action ex ante to eliminate excessive risk-taking before the crisis state is induced.

In the second part of this article, we use the simple framework of our model to discuss some policies that have, in various formats, been proposed as means for either diminishing the probability of the next crisis or decreasing the severity of it. In particular, we discuss the following five types of mitigating measures: changes to the financial sector infrastructure that diminish the size of the spillover effects; direct government monitoring of risk-taking in the financial sector; regulations banning management and employee compensation practices consistent with firms' seeking excessive risks; levying a tax on extraordinary profits that may be attained in the financial sector under excessive risk-taking; and, finally, imposing binding capital requirements on financial firms. Given the simple structure of our model, we can discuss these measures only at a general, abstract level. Such a discussion, however, can be useful in organizing thoughts relevant to answering the concrete questions that policymaking and rule-writing authorities must confront in the face of the time-consistency problem of optimal government regulation of the financial sector.

Our analysis shows that government resolution policy toward large financial firms can be helpful in eliminating excessive risk-taking only to the extent that it decreases the negative spillover effect caused by failure of a large financial firm. Moreover, in order to have any effect, plans for ex post actions, like the resolution regime, must reduce the spillover effect to a level tolerable by a future government facing a state of crisis. Changes in policy that only marginally decrease the spillover effect do not have any impact on the equilibrium outcome. It is also clear in our model that the resolution regime should not be viewed as a commitment device for the government. Although institutional structure can have an effect on final outcomes, if future governments lack commitment, it will be impossible to achieve the commitment outcome by having the current government legislate that no bailouts are to be had in the future. Thus, the only way to eliminate inefficient bailouts is to remove the temptation for future (benevolent) governments to assume private investors' losses. An efficient resolution mechanism can do it only if it can eliminate the negative spillover.

Assuming that spillover effects cannot be completely eliminated, a combination of binding capital requirements and monitoring of risk-taking and managerial incentives seem necessary to eliminate the inefficient bailout equilibrium. These policies can achieve the efficient outcome not by giving the government the power to commit, but rather by preventing the private sector from taking advantage of the government's lack of that power. In this way, current restrictions on the private sector's actions prevent damaging spillovers and, hence, remove future governments' temptation to use public funds to cover private losses. To be sure, capital requirements and monitoring of risk-taking are costly. Yet, these costs should be weighed against the cost of allowing the private sector to take on risks large enough to induce the next financial crisis.

The results of Kydland and Prescott (1977) spurred a large literature on the economics of optimal government policy with time-consistency constraints. This literature primarily focuses on fiscal and monetary policy of the government. Important contributions to the analysis of these problems include Barro and Gordon (1983); Lucas and Stokey (1983); Chari and Kehoe (1990); Chari, Christiano, and Eichenbaum (1998); and King and Wolman (2004). Beyond the applications to fiscal and monetary policy, Cochrane (1995) studies the provision of long-term health insurance and King (2006) discusses the time-consistency problem in the context of government policy toward floodplain development and the provision of insurance against catastrophic events.

An article most directly related to the topic of the present article is Chari and Kehoe (2009). Like we do here, they study the problem of time consistency of government bailout policy when bankruptcy is costly ex post. In addition to this problem, Chari and Kehoe (2009) simultaneously address the question of why optimal contracts within the firm lead to costly bankruptcies. Our model provides an exposition of the time-consistency issue at a more elementary level. In particular, we make strong assumptions on investors' preferences that give us a simple form of the firm's capital structure (debt versus equity financing). Also, we model the spillover effects of the firm's failure in reduced form.

This article is organized as follows. Section 1 presents the model. Section 2 studies equilibrium with government policy choices restricted to the singe option: bailout or firm failure. The time inconsistency of optimal policy is presented there. Section 3 considers additional policy tools and their potential for eliminating time inconsistency. Section 4 concludes.

1. THE MODEL

Consider a financial institution (firm) with total liabilities normalized to one. The firm's financial structure will be modelled as consisting of debt with face value $1 - k$ and equity in the amount $k < 1$. (To keep a concrete number in mind, we can think of k as being equal to 0.05.)

There are three homogenous classes of agents in the model: financial institution equityholders, financial institutions debtholders, and the government. Uncertainty is represented in the model simply by two equally likely states of nature: a good state g, and a bad state b.

There are two possible projects that the institution can invest in: a prudent project P and a risky project R. Each project takes an up-front investment of size normalized to one. Given the funds available to the firm, only one project can be funded. The funded project represents the asset side of the firm's balance sheet.

The payoff structure of the projects is as follows. The prudent project P pays $1+k$ in state g, and $1-k$ in state b. Note that the expected return on P is $\mathbb{E}[P] = \frac{1+k}{2} + \frac{1-k}{2} = 1$. Thus, discounting with zero net interest rate, the net present value (NPV) of P is zero. Also note that the return on P is sufficient to cover the firm's debt face value in every state of nature. The risky project R pays $2-\delta$ in state g, and 0 in state b, where $\delta > 0$. The expected return on R is $\mathbb{E}[R] = \frac{0}{2} + \frac{2-\delta}{2} = 1 - \frac{\delta}{2} < 1$, i.e., the NPV of R is negative. We will assume $2 - \delta > 1 + k$, i.e.,

$$1 - \delta > k, \tag{1}$$

which means that R has a higher best-case-scenario payoff than P. (For example, we could think of δ as being equal to 0.8.) Because both projects pay more in state g then they do in state b, we will call states g and b, respectively, good and bad.

We will assume that bond investors are risk-averse with preferences given by $-I + \min\{D_b, D_g\}$, where I is the amount invested and D_b and D_g are the returns on the investment I in state b and g, respectively. Thus, bond investors value only the riskless part of the state-contingent return vector (D_g, D_b). Given these preferences, the firm must provide a riskless gross return equal to one in order to float debt. Under the prudent project P, the firm's assets are worth at least $1 - k$ in every state of nature, but in state b they are not worth more than that. Thus, $1 - k$ is the largest face value of riskless debt that the firm should be able to float under project P without any anticipation of government bailout.

Equity investors are risk-neutral, discount at the same net interest rate of zero, and seek to maximize the return on equity.

The government has a loss function with penalty proportional to the losses suffered by debt investors, in case they suffer any. This loss function captures the adverse effects that an event of default of the financial institution would have on the broader economy. For every dollar lost by the bond investors, the adverse effect on the broader economy is M dollars. Thus, given that the loss sustained by debt is $\max\{I - D, 0\}$, the loss function of the government is given by $M \max\{I - D, 0\}$. This loss function is motivated by the fact that debt investments may be leveraged and, thus, the firm's default may trigger deleveraging and a cycle of additional defaults in the economy. Also, debt defaults may cause disruptions in the secondary wholesale funding market, where fixed income instruments are used as collateral. We do not assume here that losses in equity value lead to such disruptions. Particularly interesting will be the case of $M > 1$. In this case, the loss to the larger economy exceeds the private loss debtholders sustain in case of firm default.

In the baseline model, agents take actions sequentially in three rounds. These rounds of moves describe the strategic interaction that takes place between debt investors, equity investors, and the government. First, the government announces its policy. Second, investors invest funds and select which project the firm will take on: P or R. Then, nature chooses the state of the world: g or b. Third, the government can take action. In the baseline case, we concentrate on the government policy choice consisting of bailing the debtholders out or not bailing them out in the event of firm default. Later on, we will extend this framework to consider other actions that the government could take, like making additional transfers, levying taxes, imposing capital requirements, applying a resolution policy toward the firm (if needed), etc. We will consider several specifications.

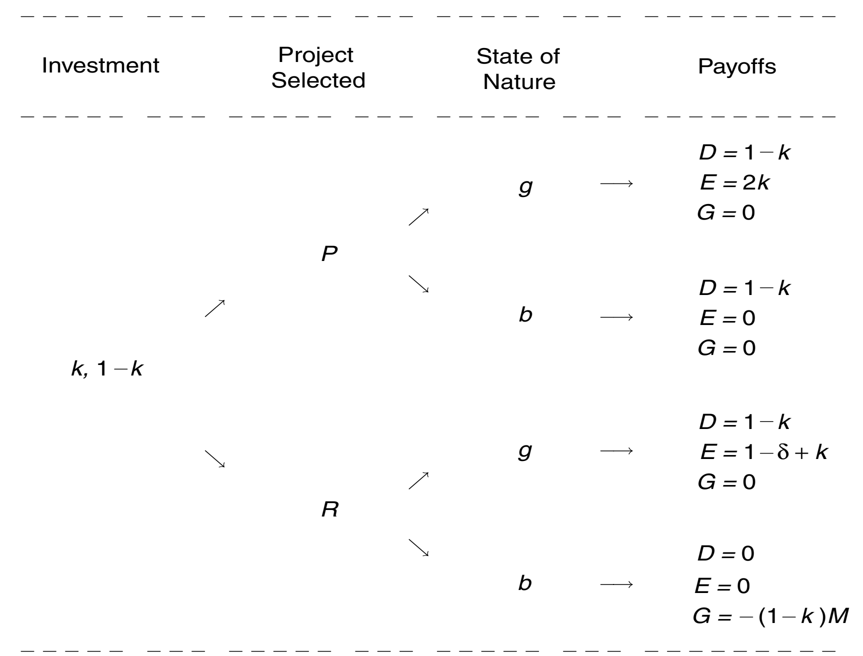
Denoting by D, E, and G the payoffs to, respectively, debt, equity, and the government, Figure 1 summarizes the three stages of interaction between the agents and presents terminal payoffs absent any government action. There are four terminal nodes in the game tree depicted in Figure 1: two representing payoffs under project P and two representing payoffs under project R. The firm is insolvent only if it selects the risky project R and the state of nature is bad. The payoffs in that case are given in the bottom node of the game tree. Since the firm's assets are worth zero in this state, so are its liabilities. Through channels that are not modelled here, bond default causes a disruption to the larger economy, which in turn gives the government a negative payoff of $-(1 - k)M$. To emphasize, Figure 1 shows payoffs that are realized in the absence of any government transfers or other actions.

We want to analyze the effect of government policy on the final outcome of the game. This outcome will be determined by the actions that debt and equity investors choose under a given specification of government policy. An outcome in which the investors' actions maximize their profit will be called an equilibrium.

2. OPTIMAL GOVERNMENT ACTION WITH POLICY OPTIONS RESTRICTED TO BAILOUT OR NO BAILOUT

In this section, we consider the outcomes that strategic interaction given in the game form specified above will lead to under two possible government

Figure 1 The Game Tree with Payoffs



actions in the crisis/insolvency node of the event tree. Action one is to bail out the debtholders and avoid the disruption to the larger economy. Action two is the opposite: no bailout. This set of actions available to the government is very restrictive, and we relax it in the next section. In this section, we analyze this case to highlight the problem of time consistency.

We proceed by asking which action the government would prefer at the ex post stage if the firm is insolvent. If the disruption that the firm's default causes is large, bailing the firm out is optimal ex post. We then study the optimal policy from the ex ante perspective. We show that not bailing out is optimal ex ante.

Optimal Ex Post Bailout Policy

Given the payoff structure of Figure 1, let us consider the question of optimal government action in the "crisis" node in which the firm is insolvent. If the bottom payoff node of the game tree in Figure 1 is reached, the firm defaults, debtholders suffer a loss $1-k$, and the government suffers a loss $(1-k)M$. One action that the government can take in the crisis node is to bail the debtholders out, i.e., make them whole by, for example, buying the firm's debt at face value. Because the assets backing up these claims are worthless in this node, the cost to bail debtholders out is $1-k$. But bailing debtholders out eliminates any disruption to the larger economy, the cost of which would be $(1-k)M$. Clearly, the optimal government bailout decision in the crisis state depends on the value of the larger economy disruption parameter M. If $M \leq 1$, the government's loss is smaller when the firm is allowed to fail, i.e., there is no incentive for the government to bail debtholders out in the crisis node. If $M > 1$, the best policy for the government in this node is to provide a full bailout to the debtholders.

Suppose that $M > 1$, which means the best action for the government ex post is to make debtholders whole if the firm is insolvent. Given this policy, what are the best investment decisions for the private-sector players? Because debtholders are fully repaid in every terminal node (either by the firm or by the government), debt investors provide funds $I = 1-k$ and collect the same payoff $D = 1-k$ in every state of nature, independent of which investment project is implemented. Under this payoff structure, therefore, debtholders have no incentive to influence the choice of the investment project, so the firm will choose the project that maximizes equityholders' value (i.e., debtholders do not monitor/discipline equityholders at all).

Which project will then the equityholders choose for the firm? Despite the fact that no bailout money is ever given to the equityholders, and despite the fact that the NPV of P exceeds the NPV of R, the equityholders prefer project R over project P. Indeed, if P is selected, the expected terminal value of equity is $\frac{0}{2} + \frac{2k}{2} = k$. If R is selected, the expected terminal value of equity is $\frac{0}{2} + \frac{1-\delta+k}{2}$, which is strictly larger than k due to (1). Thus, equity investors will select R.[1]

If $M > 1$ and the government uses its best ex post policy, the firm will be able to raise the required amount of debt and run the inefficient project R. This way, the expected value of the equity stake in the firm is maximized, and the expected loss to the government is $\frac{0}{2} + \frac{1-k}{2}$, which is strictly greater than zero.

Optimal Ex Ante Bailout Policy

Suppose now that the government can choose the action it will take ex post (i.e., after the project payoff is realized) already at the ex ante stage (i.e., before private-sector investors act). In particular, the government can announce ex ante whether or not it will make debt whole ex post in case the crisis node of the event tree is reached. We assume here that this announcement is credible, i.e., the announced policy will be adhered to with no reconsideration. What

[1] This is a version of the classic risk-shifting problem of Jensen and Meckling (1976). However, in our model, government plays an important role.

policy would the government choose to commit to? A bailout or letting the firm fail?

The answer depends on what the private-sector investors choose ex ante knowing what the government will do ex post. Consider first the policy in which the government announces it will bail the creditors out if the firm is insolvent. As we saw before, under this policy debtholders agree to provide funds and are indifferent in regard to which project is selected, as they receive the reservation return on their investment in any state of nature. Equityholders prefer the risky project R, so R will be implemented by the firm. The expected loss to the government is $\frac{1-k}{2}$.

Consider now the optimal actions of the private-sector players when the government announces ex ante that it will not bail the debtholders out in the crisis state. What is the response of the private agents to this pre-announced action? Equityholders still want to select R, as this selection continues to maximize the expected value of equity.[2] Debtholders, however, refuse to invest in the firm if R is to be selected, because without a government bailout the value of their investment turns out to be zero with a 50 percent chance.[3] Thus, if debt investors are to be attracted to the firm at all, the firm must convince debt investors that P will be selected. This can be done through private contracts, e.g., via an appropriate covenant attached to the debt contract. (This practice of debtholders monitoring the firm is often referred to as market discipline.) With P selected, the firm ends up solvent in both states of nature. The adverse effect for the larger economy, therefore, never occurs. The loss to the government is zero.

Which of the two options will the government choose? Its own loss is minimized, attaining the value of zero, with the pre-announced policy of no bailout. The social value of the outcome obtained under this policy, as well, is higher than the value obtained under the bailout policy. To see this, recall that project R has a negative expected NPV of $\frac{-\delta}{2}$. If the government bails out ex post, equity investors' equilibrium response is to implement R, and bond investors' equilibrium response is to not care if R or P is implemented. In this equilibrium, the expected NPV of debt investment is zero, the expected NPV of equity investment is

$$\frac{1-\delta+k}{2}-k=\frac{1-\delta-k}{2}, \tag{2}$$

[2] Note that even with the bailout, the ex post value of equity is zero in the crisis state. Thus, equity payoff is not decreased if there is no bailout in this state.

[3] Because we assumed that bond investors are infinitely risk-averse, a cashflow with any chance of zero payout is worth zero to them, and hence they will not invest in project R, absent government support. The infinite risk-aversion assumption is not critical here. With no bailout, project R will not be implemented if the risk premium that bond investors require is sufficiently high (not leaving any residual value to equity investors). High risk compensation will be required even if bond investors' risk aversion is large but finite.

and the expected NPV of the government loss is $\frac{1-k}{2}$. Adding the loss generated by R and the value of equity we have

$$\frac{\delta}{2}+\frac{1-\delta-k}{2}=\frac{1-k}{2}, \tag{3}$$

which equals the value of the government loss resulting from the bailout. It is important to note that under the bailout policy bailout money is paid to debtholders and the value of equity is "wiped out" in the crisis state. Yet, effectively, in addition to covering the expected loss of the wasteful project R selected by the firm, government bailout money makes for an indirect handout to equityholders in the form of the high expected return that equity investors earn in this equilibrium.

The social value obtained in equilibrium under the no-bailout policy, in turn, is non-negative because the NPV of project P is zero.[4] Under no bailout, the equilibrium expected NPV of debt investment and the government loss are both zero. The value of equity is equal to the NPV of P, which was normalized to zero. Thus, the pre-announced no-bailout policy leads to an efficient equilibrium outcome.

Time Consistency and Commitment

A key insight here, which goes back to Kydland and Prescott (1977), is that the optimal ex ante policy may be not time consistent. What does it mean? If $M > 1$, we notice that the optimal ex ante policy calls for a different action in the insolvency node than what the optimal ex post policy calls for once this node is reached. Thus, the optimal policy plan is not internally consistent as we move (in time) from the ex ante stage to the ex post stage.

With $M \leq 1$, there is no inconsistency. At the ex ante stage, the government can announce no bailout and, if the private sector selects project R and the state of nature is b, the government's best option ex post is in fact to not bail out. With $M \leq 1$, therefore, the government could announce nothing ex ante about what it will do and obtain the efficient outcome. This is because the private sector would be expecting no bailout knowing that the government faces no ex post incentive to bail out anybody.

With $M > 1$, the government does have an incentive to bail debtholders out in the insolvency state, and the private sector knows it. Can the government convince the private sector to stay away from the risky, inefficient project R when this project is exactly what maximizes the value of private claims? In the previous subsection, we assumed that the government can pre-announce

[4] It is straightforward to modify the example we have used here to have a strictly positive expected value of the prudent project P.

its policy and that the investors take it as given that the government always adheres to the pre-announced policy. This seems like a very strong assumption.

A weaker alternative assumption about the government's commitment power is that the threat of no bailouts is not a credible one. If the private sector does not believe that the government can follow through on a promise to let the firm fail, then the investors will select project R despite this threat. Without commitment, thus, the government's policy choices are reduced to those plans that are time consistent. In our model, with $M > 1$, this means that the government cannot promise to not provide a bailout in the crisis node, and, in effect, the inefficient project R is implemented in equilibrium.

It is worth pointing out here that the inefficient equilibrium would not exist if there were no government in our model. Debt investors agree to invest in the wasteful project R because they know that in the crisis state the government will bail them out. The government is benevolent, yet its lack of commitment power combined with the assumed spillover effect make investment in the inefficient project R a rational choice for private-sector investors. Because governments fulfill useful functions unrelated to bailouts of the financial sector, we take the existence of a benevolent, deep-pocketed government as given in our model.

In conclusion, the analysis in this section shows that a government whose policy options for resolution of a large financial institution are restricted to bailing out or allowing for failure is in a very difficult position when $M > 1$, i.e., when the spillover effects of the firm's failure are large. The ex ante optimal policy is not time consistent. Unless the government is committed to not bailing out failing firms regardless of the consequences, and the market participants actually believe this, excessive risks are taken and inefficient bailouts happen in equilibrium. In this equilibrium, although debt- not equityholders receive bailout funds, taxpayers make an indirect handout of value to equityholders.[5] In addition to this transfer, economic value is lost through firms' selection of inefficient investment projects whose large upside value makes the handout to equityholders possible. In the next section, we discuss several possibilities for how an expanded policy choice set can alleviate the problem of time inconsistency.

3. ALLEVIATING THE TIME-CONSISTENCY PROBLEM

The direct way of combating the time-inconsistency problem is to build an infrastructure acting as a so-called commitment device for the policymaker. A commitment device is something that makes it very costly, or—better yet—impossible, for the decisionmaker to deviate ex post from the pre-announced

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[5] Note that even when the government provides a bailout, the equity value is "wiped out" in the bad state b. Despite this wiping out, equityholders do benefit from the bailout.

course of action. In simple decisionmaking settings with time-consistency problems, commitment devices may be available and effective.[6] In the case of the optimal government policy toward a large financial institution, because of political-process constraints, for example, such devices may be difficult or impossible to implement. In this section, we will therefore discuss alternative, indirect ways in which the time-consistency problem may be alleviated or altogether avoided in this model.

In particular, we will discuss the following five possibilities:

1. Decreasing the impact of firm failure on the larger economy.

2. Direct monitoring of the firm's risk-taking by the government.

3. Banning employee compensation practices indicative of excessive risk-taking.

4. Taxing extraordinary profits.

5. Imposing binding capital requirements on the firm.

In all these cases, our discussion changes, or goes beyond, the basic structure of the model we described in Section 1.

Decreasing M

It is clear from the previous discussion that there is no time-inconsistency problem when $M \leq 1$. Therefore, if there are actions that can be taken in practice to decrease the negative spillover effect of a single firm's default on the economy as a whole (i.e., decreasing M), these can clearly be useful to alleviate the time-consistency problem.

Efficient resolution policy under either the bankruptcy code or the Orderly Liquidation Authority of the Dodd-Frank Act can be consistent with reducing M. The question of what is the best way to reduce the negative ex post spillover effect is beyond the scope of this article. However, our analysis of the time-consistency problem provides an important observation. The inefficient bailout equilibrium can be eliminated not by legislating commitment, but rather by building a legal framework and financial infrastructure in which the government is no longer tempted to bail firms out as the spillover effects become relatively small. Therefore, government resolution policy toward large financial firms improves economic efficiency to the extent that it helps decrease spillovers. If the negative spillover effect of a financial firm

[6] A driver who tends to impulsively speed in certain road conditions may choose to drive an underpowered car in order to eliminate the possibility of acting on this impulse. In this case, the choice of a slow car is a commitment device.

default remains large, the government will be tempted to bail the firm out in a crisis state regardless of what the pre-announced resolution policy may say. Therefore, even if the pre-announced policy promises no bailouts, private sector investors may still expect a bailout to occur as long as spillovers are sufficiently large. As we have seen, such an expectation may lead to excessive risk-taking by the private sector.

At a deeper level, however, one could ask why M should be larger (greater than one) in the first place. Why is there a spillover effect?

We will not be able to address this question using the simple model at hand, but it is clear that there are two possibilities here. One is that the nature of the financial intermediation technology is such that having $M > 1$ is more productive than having $M \leq 1$. This may be because of increasing returns to scale in the provision of financial services, benefits of leverage, synergies from having different financial product lines under one corporate structure, etc. If this is the reason for $M > 1$, then changing resolution policies or forcing institutions into a shape in which their M is less than one has real costs. These costs should be weighted against the costs of moral hazard—excessive risk-taking—that arise in equilibrium with bailouts.

The other possibility is that there are no increasing returns to scale, but rather institutions become large/leveraged/interconnected precisely because, with $M > 1$, they receive an implicit and unpriced government guarantee for their debtholders. If firms become large (often in this context called "too big to fail") not for efficient production reasons but just so they can take on risk backed up by the unpriced government guarantee, then there is no economic cost to changing resolution policy or forcing the institutions into a shape in which their $M \leq 1$.

Given the scale of the time-consistency problem discussed here, further research directed at discerning which of these two possibilities is in fact a correct representation of reality is needed. This question is very difficult partly because, going back and gathering data, it is not easy to establish the exact policy regime that was in effect when the data were generated. Even more so, it is hard to know what the private sector's perception of the policy regime was at the time. As we have discussed, this perception has a strong impact on behavior and, thus, will have an impact on the data gathered.

Direct Monitoring of Project Choice

Clearly, if the government can directly monitor the firm and control the choice of the project, then it can ensure that the risky and wasteful project R is not implemented. This would eliminate the need for bailout because the firm is never insolvent if R is never implemented.

Monitoring and controlling firms' risk-taking is a traditional role of bank supervision, which of course is a costly activity. These costs, however, may be smaller then the expected present value of the ex post bailout costs.

We should note, however, that monitoring the firms may not be 100 percent effective, in the following sense. As long as risky projects R are out there and the government cannot commit to no bailouts, equity investors have an incentive to escape the control of the government by funding the project outside of the scope of any control mechanisms that the government may have in place at a particular point in time. (Recall the pre-crisis "shadow banking system.") Thus, in addition to monitoring the existing financial firms, the government should monitor risk-taking in general to minimize the possibility that project R is implemented under some other institutional arrangement that could have similar adverse consequences for the economy as a whole. This adds difficulty to the task of direct government monitoring of risk-taking.

Compensation Restrictions

One way in which the government could prevent the firm from implementing project R could be to limit the compensation practices that give the firm's employees incentives to take large risks.[7] In our simple model, we think of equityholders as those choosing the investment project, i.e., the project being a part of the definition of the firm. In practice, shareholders hire staff/management to operate the project. For large firms, in particular, hired managers control the operations and make investment decisions. In order to align the incentives of the managers with those of the equityholders, executive compensation packages make pay dependent on realized equity values. Executives, however, may be less inclined to take risk than the shareholders, as managers' exposures usually are large. If the shareholders desire to structure the firm in such a way that it takes on large risks similar to our risky project R, the compensation package for its manager may be different than that under which the manager would be implementing a prudent project similar to P.

Executive compensation schemes may be easier to examine than the whole portfolio of the firm's assets. Therefore, one way for the regulators to limit risk-taking may be to regulate executive compensation schemes at large financial institutions. Because of standard (not related to the possibility of government bailout) agency problems faced by financial firms, identifying compensation schemes that induce excessive risk-taking (as opposed to those that merely induce adequate managerial effort) may be very difficult in

[7] In the Unites States, as well as in Europe, regulatory agencies are currently working on rules restricting loan officers' and bank executives' compensation with that goal in mind. (For a rule proposal on incentive-based compensation arrangements in the United States see Federal Register, Vol. 76, No. 72, April 14, 2011. Loan officer compensation rules have been amended in Federal Register, Vol. 75, No. 185, September 24, 2010.)

practice. Phelan and Clement (2009) and Jarque and Prescott (2010) study optimal compensation of bankers using the tools of mechanism-design theory.

Taxing Extraordinary Profits

Suppose the government considers taxing the profits that the firm makes in the good state g in order to remove the incentive to invest in the risky project R. Can such a tax be effective? The answer to this question depends on whether or not the government knows if profits, when realized, are because of excessive risk-taking or not.

In the simple model studied here, even assuming that the government does not directly observe the project choice made by the firm, the government can tell with certainty which project was selected just by observing the realized payoff. This is because $2 - \delta \neq 1 + k$ and $0 \neq 1 - k$ and thus, the so-called full-support condition is not satisfied in our simple model. If the government sees payoff $2 - \delta$, it knows that R must have been selected by the firm. For this reason, it is possible in this model to tax the firm's returns only if project R was selected. Such a tax can in fact correct the incentives of the private sector.

Indeed, let the firm's profit in node (R, g), i.e., when project R is selected and the state of nature is g, and only in this node, be taxed in some amount $\tau(R, g)$. This amount can be thought of as a "windfall profit" tax—it occurs only if the realized payoff is $2-\delta > 1+k$, where $1+k$ represents the "normal" profit level that is realized in node (P, g) of the game tree. With this tax, the expected value of equity under R is $\frac{1}{2}0 + \frac{1}{2}(2 - \delta - \tau(R, G) - (1 - k))$, which is the same as without the tax less $\frac{\tau(R,g)}{2}$. The value of equity under P is unchanged, i.e., it remains equal to zero. Thus, when

$$\tau(R, g) \geq 1 - \delta - k,$$

the value of equity under R becomes less than under P, so this tax corrects the firm's incentive to invest.

In reality, however, it may be hard to tell even ex post if the firm's risk-taking behavior, represented here by the choice of the project, was prudent or risky. Suppose then that the government can observe the realized state of nature but not the firm's payoff. Any tax on profits in the good state g must be the same independent of which project was selected. It is immediate that such a tax, $\tau(g)$, decreases the value of equity under both P and R, by the amount $\frac{\tau(g)}{2}$. Since R was selected without the tax, i.e., when $\tau(g)$ was zero, it will continue to be selected with $\tau(g)$ different from zero. Thus, this tax cannot correct the risk-taking behavior and the inefficient project selection in equilibrium.

Further extensions of the model could include other, more complicated tax instruments. Even in a model in which the full-support condition is satisfied so the government cannot detect the project selection ex post, likelihood ratios can be used to statically discriminate between risky and prudent firm behavior. This information can then be used to implement taxation and other ex post policies that discourage risky investment. Existing work on this problem includes Marshall and Prescott (2001, 2006).

Imposing Binding Capital Requirements

Finally, let us consider the effects of a binding capital requirement that government regulations could impose ex ante, i.e., before investors select the project and fund it. We will show that a large enough capital requirement eliminates the firm's incentive to take on excessive risk.

Up until now, we have assumed that equity investors provide k dollars in initial investment and bond investors provide $1 - k$. That amount is the minimum level of equity investment necessary to ensure that debt issued by the firm is riskless under project P with no government support. (Even in the bad state b the firm can fully repay the debtholders if the face value of debt is no larger than $1 - k$ because project P pays off $1 - k$ in state b.) In this section, we will consider other levels of initial equity capital investment than just k. Let us denote the initial equity investment amount by κ, which may not be equal to k. We will also suppose that the government mandates that κ not be smaller than some minimal amount $\underline{\kappa} \leq 1$. That is, government regulations impose on the firm a minimum capital requirement constraint

$$\kappa \geq \underline{\kappa}.$$

With equity investment κ, the amount of debt investment the firm must raise (and hence the face value of debt it issues) is $1 - \kappa$.

If the government chooses a required capital level $\underline{\kappa}$ such that $\underline{\kappa} \leq k$, then the minimum capital requirement constraint $\kappa \geq \underline{\kappa}$ is not binding, so it has no effect on equilibrium outcomes. We will therefore focus on binding capital requirements, $\underline{\kappa} > k$. We will also assume that the firm will not choose to hold more capital than the minimum level required. This is motivated by the notion, which is not explicitly modelled here, that debt financing is less expensive than equity financing.

Let us now examine the terminal payoffs to debt investors, equity investors, and the government when the capital requirement is binding. Equity investment is $\kappa = \underline{\kappa} > k$, and debt investment is $1 - \kappa = 1 - \underline{\kappa} < 1 - k$. Under project P, even in state b the firm's assets are worth more than the face value of debt, $1 - k > 1 - \underline{\kappa}$, so debt investors are repaid in full in both states. The expected payoff to equity is

$$\frac{1-k-(1-\underline{\kappa})}{2}+\frac{1+k-(1-\underline{\kappa})}{2} = \frac{\underline{\kappa}-k}{2}+\frac{\underline{\kappa}+k}{2} = \underline{\kappa},$$

which equals the initial investment, so equity investors break even in expectation. There is no government bailout when P is implemented, so the payoff/cost to the government is zero.

Under project R, the firm's assets are worthless in state b. The government bails out debtholders and incurs a loss in the amount $1-\underline{\kappa}$. The expected cost of the bailout is $\frac{1-\underline{\kappa}}{2}$. Comparing with (3), it is immediately clear that the cost of the bailout is smaller when capital investment is larger. Thus, imposing a capital requirement with $\underline{\kappa} > k$, even if the bailout equilibrium is not eliminated, decreases the expected cost to the taxpayer. Thus, in the inefficient bailout equilibrium, the cost to the taxpayer is lower when the firm's leverage is lower (equity to assets ratio is higher).

To show that a capital requirement $\underline{\kappa}$ can be chosen to eliminate the need for bailouts altogether, let us now calculate the NPV of equity in the bailout equilibrium as a function of $\underline{\kappa}$. Under R , in state g, the firm's assets are worth $2-\delta > 1-\underline{\kappa}$, so the firm is solvent and the payoff to equity in this state is $2-\delta-(1-\underline{\kappa}) = 1-\delta+\underline{\kappa}$. In state b, the firm is insolvent and equity is worthless. The NPV of equity, thus, is

$$\frac{1-\delta+\underline{\kappa}}{2}-\underline{\kappa} = \frac{1-\delta-\underline{\kappa}}{2}. \tag{4}$$

As before, cf. (3), the value of equity equals the expected cost to the government, $\frac{1-\underline{\kappa}}{2}$ here, less the amount of waste of value generated by project R, that is $\frac{\delta}{2}$. It is clear from (4) that if the capital requirement $\underline{\kappa}$ satisfies

$$\underline{\kappa} \geq 1-\delta, \tag{5}$$

then the NPV of equity is not greater than zero. This means that by selecting R, equity investors cannot do better than just break even. Thus, equity is not worth more under R than under P. For a sufficiently high capital requirement, we can see that equity investors' incentive to take on the wasteful project R is removed. The firm will not select the inefficient project R if doing so implies gambling with its own money (to a sufficiently high degree).

We should note here that under a capital requirement satisfying (5), the firm is still levered. In fact, if $\underline{\kappa} = 1-\delta$, the amount of debt the firm can raise is $\delta > 0$. In order to eliminate the bailout equilibrium, it is not necessary to require all-equity financing. However, the amount of leverage cannot be too high. (For example, if $\delta = 0.8$, the minimum capital requirement would be 20 percent of assets.)

It is interesting to note that sufficient capital requirements do not solve the time-consistency problem by making the government committed to no bailouts. With $\underline{\kappa} = 1-\delta$, if the firm were to select the risky project R, the government would still provide a bailout to creditors in state b, in the amount δ. The expected loss to the government would still be positive in this case. That loss, in fact, equals the amount of value destroyed in the project R, which is $\frac{\delta}{2}$. The key here is the fact that, with a sufficient amount of their own capital on the line, by running project R, the firm cannot extract from the government more than that amount. If $\underline{\kappa}$ is strictly larger than $1 - \delta$, even by a small bit, the bailout equilibrium ceases to exist because the amount of value lost in R is more than the amount of resources that can be extracted from the uncommitted government. Thus, we see that, rather than serving as a commitment device for the government, sufficient capital requirements provide the right risk-taking incentives for equity investors.

Given that, as we assume here, capital financing may be more costly than debt financing, regulators should be careful not to set capital requirements at an unnecessarily high level. However, the fact that capital is costly should not be used as a rationale for tolerating the inefficient bailout equilibrium. As our discussion shows, the costly bailout equilibrium can be eliminated by a correct capital requirement policy. The cost of equity financing is exogenous to this argument, i.e., government policy cannot change that. Given the restrictions faced by the government, it is important to draw a distinction between the problems government policy can and cannot solve. In our model, the inefficient bailout equilibrium is an example of the former and the high cost of equity capital is an example of the latter.

4. CONCLUSION

The main purpose of this article is to provide an elementary exposition of the time-consistency problem in the government's choice of its policy toward large financial firms that face insolvency. We use a simple model to show how this problem arises when the failure of a large financial institution has sufficiently large spillover effects for the economy as a whole, which the government is trying to prevent. The equilibrium outcome is efficient if the government is credibly committed to not bailing the firm out in case its excessive risk-taking backfires. Under the assumption of perfect government credibility, the private sector behaves prudently and the government's commitment is never tested in equilibrium.

A government's full commitment to letting a large firm fail and cause adverse spillover effects on the economy is a very strong assumption. Given political-economy constraints, it is probably impossible to achieve such a level of commitment in practice. The lack of time consistency of optimal policy therefore should be considered a very real and serious problem. In the context of our model, we discuss several ways in which excessive risk-taking and inefficient bailouts can be addressed despite the lack of commitment.

One such way involves making changes to the process of resolution of insolvent financial firms. These changes should be aimed at decreasing the negative spillover effects to sufficiently small levels. This approach may be a fruitful way of thinking about the solution, but it requires further fundamental research, given the incomplete understanding that we have of how exactly the spillover effects arise in the economy. It is also hard to know if efficient resolution policy can restrict spillovers to a degree sufficient to eliminate the government's ex post incentive to bail out systemically important firms.

The second way in which excessive risk-taking can be controlled in our model involves direct government supervision of the financial sector firms' actions. If the government, at a reasonable cost, can observe investment activities of the firms, it can enforce prudent risk-taking. This is the most direct way in which it is possible to prevent the equityholders from taking advantage of the implicit safety net that the government provides by being unable to commit to letting a large firm fail in a bad economy.

Although direct monitoring of investment is very straightforward in our simple model, it may be difficult and costly to effectively implement in practice. The costs of monitoring financial firms' compensation schemes may be lower than the costs of monitoring entire portfolios of assets. For that reason, restrictions on the structure of executive and financial firm employee compensation packages can be a cost-effective means of helping eliminate excessive risk-taking.

The fourth way we discuss involves imposing taxes on the extraordinary profits firms achieve if they take on an excessive amount of risk and are lucky to see that strategy pay off in high profits. That method, however, may be particularly hard to implement in practice given the government's imperfect information about what exactly constitutes an excessive amount of profit in a given macroeconomic state.

Finally, we discuss how binding capital requirements can eliminate bailouts. With enough own equity capital, firms will not seek excessive risk even if the government stands ready to bail them out in bad times. With firms behaving prudently, bad times are not bad enough to necessitate government support. In this way, bailouts are eliminated. Binding capital requirements are quite simple to implement in practice. Given our imperfect understanding of how a fully optimal resolution or supervision policy should be designed, capital requirements seem to be the most practical solution to the excessive risk-taking problem as of now.

The model discussed in this article can be extended in several directions. One is to study the interaction between moral hazard and commitment in a dynamic setting in which the government can manage private-sector expectations and its own reputation. Standard results in the repeated games literature state that, if the government is patient enough, equilibria can be constructed in which the government would not bail out in the (R, b) node of the event tree and, thus, this node is never reached in equilibrium. In such an equilibrium, bailouts, although off-equilibrium events, would still constrain the level of efficiency attained in the equilibrium outcome. If the government's patience is sufficiently low (perhaps because of the electoral cycle), however, the efficient equilibrium cannot be sustained in the repeated-game setting. Given the political-economy constraints, effective reputation-based deterrents to moral hazard may be hard to establish.

Another extension of this model can involve relaxing the assumptions we made on the preferences of debt and equity investors. However, one should expect that the basic message of the model is not going to change if debt investors are modelled as having some risk-tolerance and equity investors as being somewhat risk-averse.

In this article, we look at a single large firm whose default, by assumption, can cause negative spillovers. In practice, firms of different sizes will have different potential for causing spillovers. Our model could be extended to discuss how the time-consistency problem and optimal government policy depend on the firm's size. Also, in our discussion we have not been specific about what kind of financial firm we have in mind. These firms can be commercial banks, broker-dealer units, or insurance companies, among others. Another way to extend our discussion is to consider the case of banks in particular, whose liabilities include federally insured deposits. In the case of insured deposits, the guarantee of an ex post bailout is explicit. In that case, discussion of optimal policy would include the issue of optimal ex ante pricing of federal deposit insurance.

Our analysis makes clear that the scale of the time-consistency problem of government policy toward large financial firms is determined by the spillover effects in which the failure of one large firm can have a significant impact on the macroeconomy as a whole. Optimal government regulation policies, including the optimal level of capital requirements, and, consequently, the optimal structure of the financial services sector will depend on what we can understand about the nature and size of this spillover effect. Further research on this important topic is needed.

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