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"Taming SIFIS"

TAMING SIFIS
by

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Abstract

We model a Systemically Important Financial Institution (SIFI) that is too big (or too interconnected) to fail. Without credible regulation and strong supervision, the shareholders of this institution might deliberately let its managers take excessive risk. We propose a solution to this problem, showing how insurance against systemic shocks can be provided without generating moral hazard. The solution involves levying a systemic tax needed to cover the costs of future crises and more importantly establishing a Systemic Risk Authority endowed with special resolution powers, including the control of bankers' compensation packages during crisis periods.

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1 INTRODUCTION

The main legacy from the subprime crisis of 2007-09 is probably the threat posed by "Systemically Important Financial Institutions" (SIFIs) to the stability of the financial sectors of most developed countries. Even if the Too Big To Fail (TBTF) issue has long been recognized as of major importance[1], the way the subprime crisis has been managed by public authorities in many countries does not leave any ambiguity: it is now clear that any large financial institution that encounters financial problems can expect to be bailed out by public authorities on the grounds that it is TBTF or Too Interconnected To Fail. The turmoil that followed the failure of Lehman Brothers in September 2008 has indeed led governments to believe they had to commit to an unconditional support of any troubled financial institution whose failure might create major disruptions. Of course this commitment is a disaster in terms of moral hazard and market discipline. From a forward looking perspective, public authorities could not convey a worse message to market participants and bank managers.

A similar pattern emerged after the Continental Illinois bail-out in 1984 , and at the time, it took more than five years[2] for market discipline to be somewhat restored . But this bail-out was a single event, and the Comptroller of the Currency of the time tried to maintain, as much as he could, some ambiguity on which banks were really TBTF . This time all ambiguity has been resolved in a dramatic way: all large financial institutions will always be rescued. Public authorities of G20 countries have even agreed to publicly commit to a systematical bail-out. Unless resolute reforms are undertaken, it will probably take a very long time to restore market discipline again[3].

The Financial Regulation Bill (also called the Dodd Bill) passed by the U.S. Congress in July 2010 rightly identifies this issue as a priority, and endows the Fed with special regulatory powers vis a vis these SIFIs, including non-banks. A new institution is created, the "Financial Stability Oversight Council" in charge of identifying, monitoring and addressing systemic risks posed by large and complex financial firms and making recom-

[1] In a premonitory book, Stern and Feldman (2004) rightly identified TBTF as a major regulatory issue and proposed a whole range of policy measures in order to fix it.

[2] Flannery and Sorescu [1996] show indeed that banks'debt spreads only started reflecting default risks around 1989, after a regulatory transition toward letting market participants share the losses when a banking firm fails.

[3] Moreover an indirect outcome of the crisis has been an increased concentration of the banking systems of many countries, the surviving banks becoming even bigger than before and in some countries at least, close to be Too Big to Be Bailed out.

mendations to regulators so as to avoid that these firms threaten the financial stability of the United States. In the same spirit, the European Commission has launched a European Systemic Risk Council who has received a similar mission. However the regulatory instruments that need to be used for this purpose have not been specified explicitly by legislators.

The objective of this paper is to explore what can be done for "taming the SIFIs". For this purpose we develop a simple model of a TBTF institution. We consider a multiperiod model with moral hazard: at each date the manager selects the level of risk taken by the SIFI. This choice is unobservable by third parties. Taking a high level of risk generates private benefits for the manager, who is protected by limited liability. The manager's risk choice depend on the structure of the compensation package that shareholders offer him. This compensation package in turn depends on the resolution procedure used by supervisors when there is a crisis. Our paper is thus related to two strands of the academic literature.

The first of these strands studies bank resolution procedures. Two recent contributions to this literature are Shim(2006), and Kocherlakota and Shim(2007), who consider the impact of different modes of regulatory intervention on the incentives of bank managers, and look at the social cost of the liquidation of banks assets. By contrast, our model is specific to SIFIs, in the sense that we do not allow any asset liquidation, even partial: the SIFI must continue operating at full scale. Other papers study how different types of regulatory sanctions or restrictions that can be imposed as a bank becomes more and more undercapitalized, in line with the US regulation of Prompt Corrective Action (Shim, 2006; Freixas and Parigi, 2009). These papers assume that banks' shareholders are able to perfectly monitor bank managers, thus assuming away the potential agency problem between bank managers and shareholders. This assumption is not suitable for SIFIs, which are large and complex organizations, typically held by a diffuse shareholders. Thus our paper models the conflict of interest between managers and shareholders.

The second strand of the literature connected to our work is the theory of multiperiod contracts under moral hazard. The methodology developed by Spear and Srivastava (1987) and Thomas and Worral (1990) has recently been applied to corporate finance models as in DeMarzo and Fishman (2007), and Biais, Mariotti, Plantin and Rochet (2007). The discussion paper version of this last paper (BMPR 2004 in the sequel) contains developments that are closely related to the present paper. Other recent contributions to this field use continuous time models, in particular Sannikov (2003), DeMarzo, Fishman, He and Wang (2008), or Biais, Mariotti, Rochet and Villeneuve (2007). Myerson (2009) uses a very similar framework for modeling corruption and delegation of local government.

Another specificity of our SIFI is that it is exposed to risks having a very small probability of generating a very large loss (extreme events). If this loss materializes, its size is such that shareholders are not willing to recapitalize the bank. For the same reason, a private insurance solution is not possible since the size of the loss exceeds the capacity of private insurers. This is why a public intervention is needed. We examine the impact of different resolution procedures and show that moral hazard can only be avoided if the SIFI is supervised by a strong and independent institution, which we call the Systemic Risk Authority (SRA). We show that, in conformity with the recommendations of many experts, this SRA should be endowed with special resolution powers for SIFIs and that a systemic tax should be levied with the objective to fund the cost of these future resolutions. However, we go further and suggest that the SRA should also have a say on the compensation packages of the managers of the SIFIs. The control of managers remunerations during bank restructuring episodes might be a necessary complement to classical regulatory instruments. [4]

The paper is organized as follows. The model is developed in Section 2. Section 3 starts by studying the situation where public authorities have not anticipated the possibility of a crisis, and shows that in this case moral hazard is inevitable. Then we show that moral hazard can be avoided if a special resolution procedure for SIFIs can be credibly announced in advance. The section also provides conditions under which it is optimal to be tough, i.e. expropriating shareholders and removing managers every time a crisis occurs. Finally, we suggest a way to reduce the cost of these restructuring episodes by offering a grace period to new managers. In Section 4 we show that this contract is optimal when the probability of crises is small enough. However, if the compensation package of the manager is not controlled by the SRA, the shareholders of the SIFI choose a remuneration that does not depend on the performance of the bank. To avoid excessive risk taking during the grace period, it is thus necessary to let the SRA have a say on the pay of the bank's manager, at least during the period immediately following the restructuring.

[4] There is a growing empirical literature on the impact of compensation packages on financial firms' risk taking: Fahlenbrach and Stulz (2010), Kose, Mehran, and Qian (2008),and Chesney, Stromberg and Wagner (2010). For a theoretical contribution on this topic, see Cheng, Hong and Scheinkman (2009.

2 THE MODEL

There is a single Systematically Important bank, or more generally Financial Institution, that we call a SIFI. The term "systematically important" refers to the fact that public authorities cannot let it shut down. There can be several reasons for this, such as the size or "interconnectedness" of the SIFI, but there are not modeled explicitly. We content ourselves with assuming that the closure of the SIFI would inflict too large externalities on the rest of the economy. Clearly, this opens the door to possibilities of exploitation of this situation by the shareholders of the SIFI, to the detriment of taxpayers. The main objective of the paper is to examine what can be done to limit these possibilities, which constitute the core of the "Too Big to Fail" syndrome.

The SIFI has a fixed size[5], and its activities generate at each period ($t = 0, 1, \dots$) a positive cash flow μ. The possibility of a "systemic crisis" is modeled by a (small) probability λ that the bank experiences (large) losses C. We offer two alternative interpretations of this technology:

- derivative products like CDSs: the SIFI sells protection and receives at each period a premium μ, but it may be obliged to cover big losses C if a credit event occurs (crisis). The case of AIG, which was bailed out by U.S. authorities in 2009, fits this interpretation.
- transformation of a volume C of deposits into risky investments. The cash flow μ is then interpreted as the (per period) net return on investment, after interest has been paid to depositors. If a crisis occurs, all investment is lost, and depositors must be repaid in full. The large commercial banks that invest massively into AAA tranches of CDOs or other highly speculative products fit well this interpretation.

The SIFI (from now on, we call it the "bank") has to be run by a manager. This manager can be selected among a pool of potential candidates who are all identical: they are risk neutral and discount the future at rate δ_M . They do not have any initial wealth that could be pledged. A potential manager accepts to manage the bank if and only

[5] Several commentators suggest to downsize the banks that are too big to fail, or to split complex institutions into simpler independent entities. We do not discuss this issue here. Several recent papers in corporate finance use contract theory to show how varying the size of a firm or a mutual fund as a function of its past performance could be a useful instrument for incentivizing managers. For a discussion of this issue,in the context of a dynamic moral hazard model of a corporation, see Biais et al. (2010).

if he is promised expected payments that have an expected present value of at least U, corresponding for example to the utility equivalent of the training cost that has to be incurred (once and for all) so as to be able to manage the bank. U also represents the social cost of replacing an incumbent manager.

The bank is owned by private investors (the bank's shareholders), who are risk neutral, and have a discount factor $\delta > \delta_M$. Note that managers are more impatient than shareholders. We assume that the bank is socially useful: if it operates forever, its activity generates an expected social surplus $V_{FB} = \frac{\mu - \lambda C}{1-\delta}$ that exceeds the training cost U. In this first best situation, the bank's ex ante shareholder value would be $S_{FB} = \frac{\mu-\lambda C}{1-\delta} - U > 0$. However, we also assume that

$$\delta(\frac{\mu - \lambda C}{1-\delta}) < C, \tag{1}$$

which means that the bank's shareholders prefer to default in the advent of a crisis: the losses are higher than the discounted continuation value of the bank. In this case, when a crisis occurs, shareholders refuse to inject the capital needed to cover the losses. In the absence on public intervention, the bank would be closed after the first crisis, and its ex ante shareholder value would be:

$$S_0 = \frac{\mu}{1-(1-\lambda)\delta} - U. \tag{2}$$

However, the negative externalities inflicted on the rest of the economy would be too large (and in particular bigger than the bail out cost C) so that public authorities would be compelled to intervene: this is precisely why the bank is called "systematically important".

Note that the above assumption implies that the bail-out cost C is quite large. To be consistent with our previous assumption (that $V_{FB} > U$) this requires that λ be quite small. Thus the crisis events studied in our model are characterized by large losses C occurring with a small probability λ.

Social welfare would be increased if the bank could buy private insurance. Suppose indeed that the losses of the bank could be covered by a private insurer in exchange for a fair premium $P = \lambda C$ paid at each period. Then the bank could continue forever, generating the first best social surplus $V_{FB} = \frac{\mu-\lambda C}{1-\delta}$.Note however that such insurance would have to be compulsory, since shareholder value is higher without insurance:because of our assumption that $\delta(\frac{\mu-\lambda C}{1-\delta}) < C$, $\frac{\mu-\lambda C}{1-\delta}$ is indeed smaller than $\frac{\mu}{1-(1-\lambda)\delta}$.

However the private insurance solution is made impossible by the size C of potential losses: it is assumed to exceed the capacity of any private insurer. Thus insurance against crises can only be provided by public authorities, which may have extended resolution powers, like firing the managers and expropriating the shareholders in the advent of a crisis. This decision, which we call "restructuring" the bank, has a positive cost Γ (that must be borne in addition to C and U) and it is therefore ex post inefficient. We have already seen that, since potential managers are identical to the incumbent manager, it is never **ex post** optimal to replace the latter (remember the presence of a training cost $U > 0$). Similarly, the presence of the restructuring cost Γ implies that it is never ex post optimal for public authorities to expropriate shareholders. It would always be ex post more efficient to let the bank continue **without** changing its management and ownership.

The second important feature of our model is moral hazard, captured here as an asset substitution problem. The manager has, in each period, the possibility to select (without being detected) an alternative investment that is more risky than the optimal investment(it has a higher probability of losses $\lambda + \Delta\lambda > \lambda$) but provides him with a private benefit B per period. We assume that high risk taking is socially inefficient: private benefits are less than the expected cost of the increase in risk:

$$B < C\Delta\lambda.$$

As explained below, an important consequence of moral hazard is that it might be necessary for public authorities to commit to restructure the bank after a crisis (even if it is ex post inefficient), in order to provide the bank manager with ex ante incentives for limited risk taking.

3 RESOLUTION PROCEDURES FOR SIFIS

This section first studies the situation where public authorities have not anticipated the possibility of a crisis, and moral hazard is inevitable. Then we show how this moral hazard can be avoided if a strong and independent systemic risk authority is put in place ex ante. Then a special resolution procedure for SIFIs can be credibly announced in advance. We provide conditions under which it is optimal to be tough, i.e. expropriating shareholders and removing managers every time a crisis occurs. Then we suggest a way to reduce the cost of these restructuring episodes by offering a grace period to new managers.

3.1 Non-anticipated crisis

Consider first a situation in which public authorities have not anticipated the crisis: they are just obliged to intervene ex post. Then there is no point in restructuring the bank, because this would be costly and it is too late to change the risk decisions previously made by the manager. In this situation, shareholders anticipate that they will not be penalized in the event of a crisis, and therefore they have no incentives to design a compensation contract that would lead the manager to take a low level of risk. Given that the manager is more impatient than the shareholders, it is in fact efficient for them to let the manager obtain a private benefit B in each period (without paying him any bonus in case of success) and offer him a single payment at the signature of the contract, which we call a **golden hand shake** $G = U - \frac{B}{1-\delta_M}$. Whether there is a crisis or not, shareholders collect the entire cash flow μ, and the initial value of their shares is thus:

$$S_0 = \frac{\mu}{1-\delta} - G = \frac{\mu}{1-\delta} - U + \frac{B}{1-\delta_M}. \tag{3}$$

The fact that the manager's compensation is independent of his performance leads to excessive risk taking. Moreover taxpayers incur the cost of bailing out the bank in case of crisis. The expected present value of the cost for taxpayers is thus $\frac{(\lambda+\Delta\lambda)C}{1-\delta}$. This cost could be ex ante transferred to shareholders by requiring the bank to pay a systemic tax $T = (\lambda+\Delta\lambda)C$ in each period. This would prevent subsidization of the bank by taxpayers but would not curb its excessive risk taking. To do this, one needs to go further, and create ex ante a systemic risk authority that is endowed with resolution powers. We now examine what precise agenda should be given to this systemic risk authority.

3.2 A Strong and Independent Systemic Risk Authority

We have just seen that excessive risk taking would not be curbed by a simple insurance system, even if this system is fully financed ex ante by fair premiums. The reason is moral hazard: insurance premiums cannot be conditioned on risk taking decisions, because these decisions are unobservable. Of course there is a large academic literature that analyzes the tools designed by the insurance industry for dealing with this problem: bonus/penalty systems (also called experience ratings), deductibles, tort systems and the like. But these tools would be insufficient here, as we are studying an extreme configuration, with very big losses that occur very infrequently. This situation requires the intervention of a special institution, that we call a systemic risk authority (SRA). This special institution must benefit from the backing of the Treasury (in order to be able to cover the huge losses associated with a crisis) but at the same time must be independent from political powers, so as to resist the temptation of a bail-out, which is always the ex post efficient solution to a crisis. The SRA should also be strong, in the sense that it should be endowed with special resolution powers allowing to fire the manager and expropriate the shareholders in case of a crisis.

Consider thus a situation where such a strong and independent SRA has been put in place. In the advent of a crisis, this authority is committed to restructure the bank, i.e. expropriating the shareholders and removing the managers. Immediately after this restructuring has taken place, the authority sells off the shares of the bank to new shareholders for a price S. By convention, the restructuring cost Γ includes the cost organizing of this new equity issue. New shareholders then offer a contract to a new manager, specifying an initial payment G (the golden hand shake) and a salary (or bonus) s that is paid to the manager at each period, until a crisis happens. The expected continuation pay-off of the manager, denoted w, is thus given by:

$$w = (1 - \lambda)(s + \delta_M w). \tag{4}$$

By solving this equation we obtain:

$$w = \frac{(1 - \lambda)s}{1 - (1 - \lambda)\delta_M}. \tag{5}$$

The associate golden handshake is then

$$G = U - w. \tag{6}$$

The condition ensuring that risk taking is not excessive (the Incentive Compatibility Condition or ICC) is simply:

$$(1-\lambda)(s+\delta_M w) \geq (1-\lambda-\Delta\lambda)(s+\delta_M w)+B, \tag{7}$$

which is equivalent to:

$$w \geq (1-\lambda)\frac{B}{\Delta\lambda} \equiv b, \tag{8}$$

or:

$$s \geq (\frac{1}{1-\lambda}-\delta_M). \tag{9}$$

Finally, the Government levies a systemic tax T in order to cover the expected cost of bail outs:

$$T = \lambda[C+\delta\{\Gamma-(S-G)\}]. \tag{10}$$

The term between brackets corresponds to the net present value of the cash inflow that the government needs to inject in case of a crisis: an immediate payment C and, in the next period (hence the discounting) the difference between the restructuring cost Γ and the revenue collected by selling off the bank to new shareholders. This last term is itself equal to the difference between the continuation value S for shareholders and the golden hand shake G that must be paid to the new manager[6]

Shareholder value S is determined by a similar condition:

$$S = \mu - T + (1-\lambda)[-s+\delta S], \tag{11}$$

where s represents the salary (bonus) that must be promised to the manager if he succeeds. We have seen above that the minimum bonus that preserves the incentives of the manager is such that:

$$(1-\lambda)s = [1-\delta_M(1-\lambda)]b. \tag{12}$$

[6]By convention, the systemic tax T is paid at the beginning of each period (before potential losses are incurred), out of the operating cash flow μ, which cannot be seized by the SRA. Formulas would be slightly different (without altering the results) if we adopted the alternative conventions that T is only paid when there are no losses and that μ can be seized by the CRA if there is a crisis.

Solving these three equations in S, s and T we obtain:

Proposition 1: *The optimal combinations*[7] *of systemic tax T, golden handshake G and managerial bonus s that preserve the manager's incentive compatibility condition and participation constraint, together with the expected budget constraint of the SRA, give rise to the following level of social surplus:*

$$V = \frac{\mu - \lambda[C + \delta(\Gamma + U)] - (1-\lambda)(\delta - \delta_M)b}{1-\delta}, \tag{13}$$

Maximum[8] *shareholder value is:*

$$S = V - b = \frac{\mu - \lambda[C + \delta(\Gamma + U)] - [1 - (1-\lambda)\delta_M - \lambda\delta]b}{1-\delta} \tag{14}$$

The social surplus formula obtained in Proposition 1 has a natural interpretation. In each period the bank generates a cash flow μ. With probability λ there is a crisis, in which case the cost C is incurred immediately and the additional costs Γ (restructuring) and U (training a new manager) have to be incurred at the next period. With probability $(1-\lambda)$ there is no crisis and the only social cost is associated with the back loading of the payments to the manager. This is needed to provide him with the incentives to select the correct level of risk: instead of receiving upfront his full training cost U, the manager only receives $G = U - b$ and is promised for the future a salary s as long as there is no crisis. Since the manager is more impatient than the shareholders, this back loading is socially costly.

3.3 Introducing a grace period for the manager

Suppose that the SRA considers offering a "grace period" to the new manager. This means that if a crisis occurs during the first period of the manager's mandate, the systemic risk authorities promise to inject the amount needed to continue operating the bank, but do not restructure it. They let the manager (and the shareholders) continue independently of the outcome: the manager is guaranteed to keep his job for at least one period. After this "grace period" the previous contract is implemented, comprising the restructuring

[7] Several combinations are optimal, given the neutrality of transfers between the government, the shareholders and the managers.

[8] It is obtained by giving all the surplus to shareholders: the SRA breaks its expected budget and the participation constraint of the manager is binding.

of the bank in case of a crisis, a systemic tax T and a managerial bonus s as above. For the moment we only consider a one shot deviation from the previous contract: the grace period is only offered to the new manager. In the next section, we look at the stationary situation where, in the future also,every newly hired manager also benefits from such a grace period.

The benefit generated by the grace period is associated with avoiding a costly restructuring, should a second crisis occur immediately after the bank has been restructured. Thus the systemic tax is smaller during the grace period: $T_0 = \lambda C$. The cost associated with the grace period is that the manager must be promised a higher bonus u_+^Hin case of success, because the manager knows that he will not be fired if a crisis occurs. The minimum bonus that is needed to provide the appropriate incentives for risk taking during the grace period is:

$$u_+^H = \frac{B}{\Delta\lambda}. \tag{15}$$

Recall that the bonus needed to provide incentives in subsequent periods is only

$$s = [1 - \delta_M(1 - \lambda)]\frac{B}{\Delta\lambda}. \tag{16}$$

This is smaller than u_+^H because of the threat to be fired in case of a crisis.

Thanks to the grace period, the golden hand shake can be reduced to:

$$G^* = U - b(1 + \delta_M), \tag{17}$$

provided this term is positive. This corresponds to the situation where the cost U of the training needed for being able to manage a large bank is large. In the alternative situation, the manager receives no golden handshake, and the participation constraint of the manager is not binding, since the manager has no initial wealth that could be pledged[9].

In both cases, the overall surplus generated by offering a grace period to the new manager is given by:

$$V^* = \mu - \lambda C + \delta(V - b) + \delta_M b. \tag{18}$$

[9]Myerson (2010) discusses this issue in a very similar model applied to a very different problem: the organization of local governments in Ancient Mesopotamia;

Indeed, after the grace period, the previous contract is implemented, leading to a continuation value $S = V - b$ for shareholders (thus it is discounted at rate δ), and a promised continuation pay-off b for the manager (thus it is discounted at rate δ_M).

Now if we compare with the surplus generated by the previous contract, we obtain:

Proposition 2: *Guaranteeing a grace period (immediately after a restructuring episode) to a newly hired manager is socially beneficial if and only if the total cost of restructuring (including the cost of training a new manager) is higher than the cost of back loading the compensation of the manager:*

$$\Gamma + U > \frac{(\delta - \delta_M)}{\delta} b. \tag{19}$$

Proof: *It results from a simple comparison between the two equations that characterize* V and V^* :

$$V^* = \mu - \lambda C + \delta(V - b) + \delta_M b = \mu - \lambda C - b(\delta - \delta_M) + \delta V, \tag{20}$$

and:

$$V = \mu - \lambda C - \lambda\delta(\Gamma + U) - b(\delta - \delta_M)(1 - \lambda) + \delta V. \tag{21}$$

It is easy to see that $V^* > V$ *if and only if* $\Gamma + U > \frac{(\delta - \delta_M)}{\delta} b$.

One may wonder whether the grace period could be extended to more than one period, or whether more complex compensation schemes might be welfare improving. The following section shows that this is not the case when the probability of a crisis is small enough: the contract characterized in Proposition 2 is then the socially optimal contract.

4 THE OPTIMAL CONTRACT

Following BMPR (2004), we adopt the standard recursive method used for solving repeated moral hazard problems. The decisions specified in a contract are parametrized by the continuation pay-off of the bank manager (the agent). This continuation pay-off is denoted w. The main difference with BMPR (2004) is that, because of our Too Big To Fail situation, the bank is never closed nor downsized. However the regulator has the power to restructure the bank, i.e. expropriate the shareholders and replace the manager.

At the beginning of each period, the contract specifies (as a function of the current manager's continuation pay-off w) the probability $1 - \pi(w)$ that the bank is restructured, With the complement probability $\pi(w)$, the manager continues and the contract specifies:

- the current payments to the agent, $u_+(w)$ and $u_-(w)$ conditionally on its performance (the two outcomes are denoted $+$, when there is no crisis, and $-$ when a crisis occurs),
- the continuation payoffs $w_+(w)$ and $w_-(w)$ promised to the agent after the current period. They are also conditional on cumulated performance w.

We restrict attention to the case where excessive risk taking is so costly that it is always socially optimal (even in the second best contract) to prevent this behavior by giving appropriate incentives to the agent.

The time line of events within each period is represented as follows:

[time line to be included]

The socially optimal (second best) regulatory contract is parameterized by the continuation pay-off w of the agent. It is characterized by a social surplus function $V(w)$ that satisfies the following Bellman equation:

$$\begin{aligned} V(w) &= \max \pi\left[\mu + (1-\lambda)\{\delta_M w_+ + \delta S(w_+) + \lambda - C + \delta_M w_- + \delta S(w_-\right] + \\ &\quad +(1-\pi)V(0) \end{aligned}$$

under the constraints

$$\Delta\lambda(u_+ + \delta_M w_+ - u_- - \delta_M w_-) \geq B \tag{22}$$

$$w = \pi\left[(1-\lambda)(u_+ + \delta_M w_+) + \lambda(u_- + \delta_M w_-)\right] \tag{23}$$

$$u_+ \geq 0;\ w_+ \geq 0;\ u_- \geq 0;\ w_- \geq 0 \text{ and } 1 \geq \pi \geq 0,$$

where $S(w)$ is the value of the firm's equity when the manager's continuation pay-off is w.

The incentives for the manager to take a low level of risk depend upon its compensation package. He has the choice between an expected return of $(1-\lambda)(u_+ + \delta_M w_+) + \lambda(u_- + \delta_M w_-)$ when taking low risk and an expected return equal to $(1-\lambda-\Delta\lambda)(u_+ + \delta_M w_+) + (\lambda + \Delta\lambda)(u_- + \delta_M w_-) + B$ when taking a high level of risk (and obtaining the private benefit B). The incentive compatibility condition is satisfied if and only if

$$\Delta\lambda(u_+ + \delta_M w_+ - u_- - \delta_M w_-) \geq B \tag{24}$$

The compensation packages that maximize managerial incentives correspond to $u_- = w_- = 0$ (the manager is fired without bonus if a crisis occurs). However this is costly to the SRA, since it implies restructuring the bank. The optimal way to trade-off between managerial incentives and restructuring costs is given by Proposition 3: when λ is small enough, restructuring systematically after a crisis, except if it occurs immediately after a previous restructuring episode: thus the contract described in Proposition 2 is indeed the optimal contract. BMPR (2004) obtain a complete characterization of the optimal contract for all values of the parameters. We focus here on extreme losses, corresponding to a very small λ and a very large C.

Since we constrain the systemic risk authority to balance its expected budget in each period, it must be that $S(w) = V(w) - w$. We can thus eliminate S from the Bellman equation, and express everything as a function of V.

Note also that the objective function does not depend on current payments u_+ and u_-.The above program can thus be dramatically simplified by eliminating these variables in the constraints. For the general method we refer to BMPR (2004). We just need to note here that when (22) holds with equality and $\pi > 0$, one can explicitly solve for u_+ and u_-: $u_+ = \frac{w}{\pi} - \delta_M w_+ + \frac{\lambda b}{1-\lambda}$and $u_- = \frac{w}{\pi} - b - \delta_M w_-$. The positivity constraints are then equivalent to $\pi\left(\delta_M w_+ - \frac{\lambda b}{1-\lambda}\right) \leq w$ and $\pi\left(\delta_M w_- + b\right) \leq w$ respectively, where b is defined by $b = (1-\lambda)\frac{B}{\Delta\lambda}$. Before stating the simplified problem, it is useful to introduce the following auxiliary function: $\widehat{V}(w) = \delta V(w) - (\delta - \delta_M)w$

Thanks to this simplification, the optimal contract can be equivalently associated with the Bellman function V that solves for all w : the simpler problem:

$$V(w) = \max \pi\left[\mu - \lambda C + (\lambda\hat{V}(w_-) + (1-\lambda)\hat{V}(w_+))\right] + (1-\pi)V(0) \tag{25}$$

under the constraints

$$0 \leq \pi \leq 1 \tag{26}$$

$$\pi\left(\delta_M w_- + b\right) \leq w \tag{27}$$

$$\pi\left(\delta_M w_+ - \frac{\lambda b}{1-\lambda}\right) \leq w. \tag{28}$$

$$w_+ \geq 0 \qquad w_- \geq 0 \tag{29}$$

The last thing to be remarked is that restructuring must occur with probability one when $w = 0$ (this is the only possible way to provide the agent, who has limited liability, with a zero continuation value. Therefore: $V(0) = \max_{w_0} V(w_0) - \Gamma - U$ It is easy to establish existence and uniqueness of the solution V.

Lemma 1: *When the bank is Too Big to Fail*[10] *(so that it is socially optimal to let the bank continue forever), there exists a unique continuous bounded solution to (25)* under the constraints (26)(27)(28) *that satisfies* $V(0) = \max_{w_0} V(w_0) - \Gamma - U$

Proof: This is an easy consequence of Blackwell's fixed point theorem (see Stokey and Lucas 1989).

A direct adaptation of BMPR (2004) then gives a characterization of this solution when λ is small enough:

Proposition 3 *When* $\Gamma + U > b(\frac{\delta - \delta_M}{\delta})$ *and* λ *is small enough, the optimal contract can be described as follows:*

- *when a new manager is hired (this is what we call the grace period; it includes the initial period where the bank is started), he is guaranteed to keep his job for one period and is promised a continuation utility* $w_+ = w_- = b$*, irrespectively of its current performance. He receives a high bonus* $u_+^H = \frac{b}{1-\lambda} = \frac{B}{\Delta\lambda}$ *in case of success and nothing in case of a crisis;*

- *in all other periods, the manager receives a (lower) bonus* $u_+^L = b(\frac{1}{1-\lambda} - \delta_M)$ *in case of success and is fired (with no indemnity) in case of a crisis.*

  Proof: see Appendix.

When the probability of crises λ is larger, it can be shown that the optimal contract still involves a grace period. However, it is less tough in the following sense: after the grace period, the consequence of a single loss is just to suppress the bonus to the manager. It takes several consecutive losses to provoke the restructuring of the bank.

[10] Otherwise there would still be a unique solution of the Bellman equation, but it would satisfy $V(0) = 0$.

5 IS REGULATORY CONTROL OF BANKERS' REMUNERATIONS NECESSARY?

Proposition 3 clarifies the role of the SRA: restructuring the bank after a crisis, and levying the systemic tax that is needed to cover the expected cost of crisis resolution. However the grace period introduces a peculiarity: if a crisis occurs during this period (that is, immediately after a restructuring episode), the SRA should bail out the bank without firing the managers nor expropriating the shareholders. If shareholders are free to choose the remuneration package of the manager (as it should be in general), they will prefer, during the grace period, to pay him a low bonus $b - B$ irrespectively of his performance rather than paying him a high bonus $u_+^H = \frac{b}{1-\lambda} = \frac{B}{\Delta\lambda}$ only in case of success. This reduces the expected cost of the compensation paid by shareholders (who are thus strictly better-off) to the manager, but the manager obtains the same expected pay-off (because he takes excessive risk and gets the associated private benefit B).

However this is socially harmful: excessive risk is always taken by newly hired managers, with the consent of shareholders. Avoiding this necessitates some form of intrusion of the SRA during the grace period, for example by forbidding that bonuses be paid in case of losses.

Proposition 4: *We make the same assumptions as in proposition 3. If the SRA does not control the compensation of the manager during the restructuring period, the new shareholders find it optimal to pay the manager irrespectively of its performance. As a result the manager chooses an excessive level of risk during the first period.*

Proposition 4 can be extended to the case where the probability of crises is higher and the optimal contract is as described in the comments after Proposition 3. Thus the result that bankers remunerations should be controlled by the Systemic Risk Authority during crisis periods is robust.

6 Appendix

Proof of Proposition 3:

We show that when $k \equiv \frac{(\Gamma+U)\delta}{b(\delta-\delta_M)} > 1$ and λ small enough:

$$\frac{1}{\lambda} > \frac{\delta}{\delta_M} Max(0, k-1-\delta_M),$$

the optimal contract is the one described in Proposition 3. It is easily checked that in this case, the associated social surplus function $V(w)$ is piece-wise linear:

$$\begin{aligned}
V(w) &= K_0 + \alpha_0 w \qquad \text{for } w \leq b \\
V(w) &= K_1 + \alpha_1 w \qquad \text{for } b \leq w \leq b^* \\
V(w) &= K_2 \qquad \text{for } b^* \leq w,
\end{aligned}$$

Where we use the notation $b^* = b(1+\delta_M)$. The grace period corresponds to the situation where $w = b^*$ and $V(b^*) = K_2$. The subsequent periods correspond to $w = b$ and $V(b) = K_0 + \alpha_0 b = K_1 + \alpha_1 b$. Finally, restructuring episodes corresPond to $w = 0$ and $V(0) = K_2$.

The auxiliary function $\widehat{V}$ is defined by:

$$\begin{aligned}
\widehat{V}(w) &= \delta K_0 + \alpha_0' w \qquad \text{for } w \leq b \\
\widehat{V}(w) &= \delta K_1 + \alpha_1' w \qquad \text{for } b \leq w \leq b^* \\
\widehat{V}(w) &= \delta K_2 + \alpha_2' w \qquad \text{for } b^* \leq w
\end{aligned}$$

Where $\alpha_k' = \delta\alpha_k - (\delta - \delta_M)$ for $k = 0, 1$ and $\alpha_2' = -(\delta - \delta_M)$. The optimality of our contract requires that V be concave, with a maximum for $w = b^*$and that $\widehat{V}$ be maximum for $w = b$. This is guaranteed if

$$0 < \alpha_1 < \frac{\delta - \delta_M}{\delta} < \alpha_0 \tag{30}$$

Notice that if $V()$ is continuous the above formulas imply that it is also concave.

Case 1: Consider first the case where neither constraint (27), nor (28) is binding. In this case, $w_- = w_+ = Arg \max \widehat{V} = b$, and $\pi = 1$ is optimal if:

$$\mu - \lambda C + \widehat{V}(b) \geq V(0) \tag{31}$$

and that for $w_- = w_+ = b$ neither (27) nor (28) are violated, which is equivalent to

$$b^* \leq w \tag{32}$$

From this we are able to compute the associated payments to the agent in both states: $u_- = w - b^*$; $u_+ = w - b(\delta_M - \frac{\lambda}{1-\lambda}) = w - b + (b - b(\delta_M - \frac{\lambda}{1-\lambda}))$.

Case 2: Second, consider the case where one of the two constraints (27) or (28) is binding.

In this case, $\pi = 1$ solves the maximization problem, again provided that the function between brackets is an increasing function of π. Notice that if (27) is not binding, this would lead to $w_- = b$, in which case w would be large enough for (28) not to be binding either. Consequently, (27) only will be binding, thus implying $u_- = 0$ and $w_- = \frac{w-b}{\delta_M}$ while $w_+ = b$ and $u_+ = w - b(\delta_M - \frac{\lambda}{1-\lambda})$ are as in Case 1.

Then the condition for the function between brackets to be increasing is:

$$\mu - \lambda C + \lambda \widehat{V}(\frac{w-b}{\delta_M}) + (1-\lambda)\widehat{V}(b) \geq V(0) \tag{33}$$

Note that, as $\widehat{V}$ reaches its maximum for $w = b$, $\widehat{V}(\frac{w-b}{\delta_M}) < \widehat{V}(b)$ and consequently, condition (33) implies (31).

Since the couple $(\pi = 1, w_- = b)$ is supposed to violate constraint (27), it must be that $w < b^*$. Simultaneously, the non-negativity of $w_- = \frac{w-b}{\delta_M}$ implies $b \leq w$.

$$b \leq w < b^* \tag{34}$$

while $w_+ = b$ satisfies (28) whenever $w > b$.

Case 3: Third, consider the case where (27) is binding while $w_- = 0$. Then, $\pi = \frac{w}{b}$, and $w_+ = Min(b, \frac{1}{\delta_M}(b + \frac{\lambda b}{1-\lambda})) = b$. Then we have $u_- = 0$, and $(1-\lambda)u_+ = (\frac{w}{\pi}) - \delta_M(1-\lambda)w_+ = b(1 - \delta_M(1-\lambda))$.The necessary condition for ((27)) to be binding at $w_- = 0$ is then:

$$w \leq b \tag{35}$$

Again, (28) will be satisfied as $w = \pi b \leq b$.

Note that, (32), (34) and (35) cover all possible cases and are mutually exclusive.

We now determine the expression of V that is given by the above solution. We have to distinguish three different cases.

- First, for $b^* \leq w$, using $w_- = w_+ = b$, and $\pi = 1$ we obtain

$$V(w) = \mu - \lambda C + \delta V(b) - (\delta - \delta_M)b \equiv K_2. \tag{36}$$

- Secondly, going to the other extreme, assume $w \leq b$. Replacing case 3 solution, we obtain

$$V(w) = \frac{w}{b}\left[\mu - \lambda C + \lambda\delta V(0) + (1-\lambda)\delta V(b) - (1-\lambda)(\delta - \delta_M)b\right] + (1 - \frac{w}{b})V(0) \tag{37}$$

  So that $\alpha_0 = \frac{1}{b}\left[\mu - \lambda C + \lambda\delta V(0)) + (1-\lambda)\delta V(b) - (1-\lambda)(\delta - \delta_M)b - V(0)\right]$ and $K_0 = V(0)$

- Third , assume $b \leq w \leq b(1+\delta_M)$. Replacing the case 2 solution yields:

$$V(w) = \mu - \lambda C + \lambda\widehat{V}(\frac{w-b}{\delta_M}) + (1-\lambda)\widehat{V}(b)$$

$$\begin{aligned} V(w) &= \mu - \lambda C + \lambda\delta V(\frac{w-b}{\delta_M}) + (1-\lambda)\delta V(b) - \\ &\quad -\lambda(\delta - \delta_M)\frac{w-b}{\delta_M} - (1-\lambda)(\delta-\delta_M)b \end{aligned} \tag{38}$$

  Since $w \leq b(1+\delta_M)$ implies $\frac{w-b}{\delta_M} \leq b$, $V(\frac{w-b}{\delta_M}) = K_0 + \alpha_0\frac{w-b}{\delta_M}$

  and

$$\begin{aligned} V(w) &= \mu - \lambda C + \lambda\delta\left[K_0 + \alpha_0\frac{w-b}{\delta_M}\right] + (1-\lambda)\delta V(b) - \\ &\quad -\lambda(\delta-\delta_M)\frac{w-b}{\delta_M} - (1-\lambda)(\delta-\delta_M)b \end{aligned}$$

  So that $\alpha_1 = \frac{\lambda}{\delta_M}\left[\delta\alpha_0 - (\delta - \delta_M)\right]$ and

$$K_1 = \mu - \lambda C + \lambda\delta\left[V(0) - \frac{V(b)-V(0)}{\delta_M}b\right] + (1-\lambda)\delta V(b) + \lambda(\delta-\delta_M)\frac{b}{\delta_M} - (1-\lambda)(\delta-\delta_M)b$$

that is,

$K_1 = V(b) - \lambda\delta\left[\frac{V(b)-V(0)}{\delta_M}b\right] + \lambda(\delta - \delta_M)\frac{b}{\delta_M}$ It is easy to check that $V()$ is a continuous function.

$$V(b) = [\mu - \lambda C + \lambda\delta V(0) + (1-\lambda)\delta V(b) - (1-\lambda)(\delta - \delta_M)b]$$

Then we can solve for the values of $V(0), V(b)$ and $V(b^*)$, using

$$V(0) = V(b^*) - \Gamma - U,$$

$$V(b^*) = [\mu - \lambda C + \delta V(b) - (\delta - \delta_M)b]$$

Replacing $V(0)$ by its expression, we obtain

$$V(b) = [\mu - \lambda C + \lambda\delta\,[\mu - \lambda C - \Gamma - U + \delta V(b) - (\delta - \delta_M)b] + (1-\lambda)\delta V(b) - (1-\lambda)(\delta - \delta_M)b]$$

so that

$$V(b) = \frac{(1+\lambda\delta)(\mu - \lambda C) - \lambda\delta(\Gamma + U) - [(1 - \lambda + \lambda\delta)(\delta - \delta_M)b]}{1 - \lambda\delta^2 - (1-\lambda)\delta}$$

Using $1 - \lambda\delta^2 - (1-\lambda)\delta = (1-\delta)(1+\lambda\delta)$ this simplifies to

$$V(b) = \frac{1}{1-\delta}\left[\mu - \lambda C - (\delta - \delta_M)b - \frac{\lambda\delta(\Gamma + U) - \lambda(\delta - \delta_M)b}{1 + \lambda\delta}\right]$$

This allow us to compute

$$V(b^*) = \frac{1}{1-\delta}\left[\mu - \lambda C - (\delta - \delta_M)b - \frac{\lambda\delta^2(\Gamma + U) - \lambda\delta(\delta - \delta_M)b}{1 + \lambda\delta}\right]$$

or, equivalently

$$V(b^*) = \frac{1}{1-\delta}\left[\mu - \lambda C - \frac{\lambda\delta^2(\Gamma + U) + (\delta - \delta_M)b}{1 + \lambda\delta}\right]$$

Using $V(0) = V(b^*) - (\Gamma + U)$, we obtain:

$$V(0) = \frac{1}{1-\delta}\left[\mu - \lambda C - \frac{(1 - (1-\lambda)\delta)(\Gamma + U) + (\delta - \delta_M)b}{1 + \lambda\delta}\right]$$

From these expressions we can compute

$$V(b) - V(0) = V(b) - V(b^*) + \Gamma + U = \Gamma + U + \frac{1}{(1-\delta)(1+\lambda\delta)}\left[\Gamma\lambda\delta(\delta - 1) + \lambda(1-\delta)(\delta - \delta_M)b\right]$$

simplifying by $(1-\delta)$ yields:

$$V(b) - V(0) = \frac{1}{(1+\lambda\delta)}\left[\Gamma + U + \lambda(\delta - \delta_M)b\right]$$

Notice that $V(b) - V(0) > 0$. This allows to write α_0 in a simple form:

$$\alpha_0 = \frac{V(b) - V(0)}{b}$$

and

$$\alpha_1 = \frac{V(b^*) - V(b)}{\delta_M b} = \frac{\Gamma + U + V(0) - V(b)}{\delta_M b}$$

Our initial assumptions that $\alpha_0 > \frac{\delta - \delta_M}{\delta}$, $\frac{\delta - \delta_M}{\delta} > \alpha_1$, $\alpha_1 > 0$ can be rewritten as:

$$\frac{V(b) - V(0)}{b} > \frac{\delta - \delta_M}{\delta} \tag{39}$$

$$\frac{\delta - \delta_M}{\delta} > \frac{\Gamma + U + V(0) - V(b)}{\delta_M b} \tag{40}$$

$$\frac{\Gamma + U + V(0) - V(b)}{\delta_M b} > 0 \tag{41}$$

Notice first that (41) and (39) are equivalent, so only two conditions are required. Consider then condition (39) . Using the value of $V(b) - V(0)$ given above yields

$$\delta\left[\Gamma + U + \lambda(\delta - \delta_M)b\right] > (1 + \lambda\delta)(\delta - \delta_M)b$$

This is equivalent to our assumption that

$$\delta\Gamma > b(\delta - \delta_M)$$

Regarding (40), it is possible to rewrite it as:

$$\frac{\delta - \delta_M}{\delta} > \frac{(\Gamma + U)\lambda\delta - \lambda(\delta - \delta_M)b}{\delta_M b(1 + \lambda\delta)}$$

which is equivalent to:

$$(\delta - \delta_M)\delta_M b(1 + \lambda\delta) > \lambda\delta\left[\delta(\Gamma + U) - (\delta - \delta_M)b\right]$$

or

$$(\delta - \delta_M)b\left[\delta_M(1 + \lambda\delta) + \lambda\delta\right] > \lambda\delta^2(\Gamma + U)$$

Finally, this is equivalent to:

$$\delta_M(\delta - \delta_M)b > \lambda\delta\left[\delta(\Gamma + U) - (1 + \delta_M)(\delta - \delta_M)b\right]$$

When $\delta(\Gamma + U) - (1 + \delta_M)(\delta - \delta_M)b \leq 0$ this is always satisfied. Otherwise, this is true when

$$\frac{b(\delta-\delta_M)\delta_M}{\delta[\delta(\Gamma+U)-(\delta-\delta_M)b\{1+\delta_M\}]}>\lambda$$

which is clearly equivalent to what we have assumed.

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