

The Pre-Commitment Approach in a Model of Regulatory Banking Capital

Edward S. Prescott

The pre-commitment approach to bank capital regulation is a radical departure from existing bank regulatory methods. First proposed in Kupiec and O'Brien (1995c), the approach advocates letting banks choose their capital levels and fining them if losses exceed this level. The essence of the proposal is to use fines (or other penalties) to encourage risky banks to hold more capital than safer ones.

Since a change in regulatory method will affect the banking sector, it is crucial to ascertain what will happen if the proposal is implemented. Because the approach is so new, there exists only a small literature explaining and evaluating it. Accordingly, the goal of this paper is to produce understanding of the pre-commitment approach and to determine its effectiveness as a regulatory tool.

Regulators care about banks' capital levels because the deposit insurance fund is liable in the event a bank is unable to repay its depositors. For a given portfolio, a higher ratio of capital to assets reduces the insurance fund's exposure to losses because there are proportionally fewer deposits to repay in the event of a loss. Along with the monitoring of banks and deposit insurance premiums, capital requirements are an essential part of the mechanism used by regulators to insure deposits.

Since 1988, regulators have used capital requirements to protect against credit risk, that is, against the event of borrower default. They have done so by

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categorizing bank assets into different risk categories, taking the risk-weighted sum of the assets, and then requiring capital to be roughly 8 percent of the total.¹ These rules, however, did not consider other sources of risk such as those from movements in market prices. Changes in market prices are particularly important sources of risk to banks that have large trading portfolios of derivatives and other financial securities.

Concern that these sources of risk are a hazard to the banking system and to the insurance fund produced three different proposals for using capital to protect against the risk in banks' trading portfolios: the standardized approach, the internal models approach, and the pre-commitment approach. The result of the ensuing public discussion was the adoption of the internal models approach, scheduled to take effect January 1, 1998. However, this decision has not precluded continued consideration of future regulatory changes. In particular, the pre-commitment approach continues to be studied by the Federal Reserve Board. (See Greenspan [1996].)

Before analyzing the pre-commitment approach, it is helpful to summarize the other two approaches. The reader interested in more details should consult Kupiec and O'Brien (1995a) or Bliss (1995). The standardized approach, very roughly, requires regulators to handle market risk in the same way credit risk is handled: Assets are categorized, and capital charges corresponding to the riskiness of each category are imposed. A criticism of this approach is that trading accounts are complicated and regulators do not have the resources or knowledge to thoroughly evaluate these complications. Consequently, any uniform formula would probably do a poor job of evaluating banks' risks.

In contrast, both the internal models approach and the pre-commitment approach try to use banks' superior knowledge and expertise to deduce appropriate capital levels. The internal models approach works, as the name suggests, by using banks' own models. Each bank's model is used to estimate a statistic called value-at-risk (VAR). Value-at-risk is a measure of potential losses. It satisfies the following condition: losses will only exceed it a given function at a time. For example, a 1 percent VAR of 3 million dollars means that losses will only exceed 3 million dollars 1 percent of the time.

In theory, the approach requires capital to be set equal to the 1 percent VAR. In practice, the approach calculates a 1 percent VAR for a ten-day trading period and then multiplies the result by three. Assuming the models are accurate, the multiple means that the percent level is substantially less than one. There are some other features to the approach such as checks on the quality of banks' models. The interested reader may consult the previously mentioned citations for more information. One criticism of this approach is that it discour-

¹ The Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA) also uses capital requirements. FDICIA restricts bank activities and even allows for regulatory intervention if bank capital levels get low enough. See Spong (1994) for a summary.

ages banks from developing accurate models and instead encourages them to develop models that produce low capital levels. See Bliss (1995) for a good discussion and some poignant criticisms.

1. MOTIVATION

What will happen if the pre-commitment approach is implemented? One way to find out is to try the proposal. While actual results provide the ultimate judgment on a policy, economy-wide regulatory experiments are expensive and risky. It is preferable to first use inexpensive and safer alternative sources of information. One such source, though indirect, is examples (or lack thereof) of contractual arrangements similar to the pre-commitment approach used in different settings. Still, in the absence of an actual experiment, the best source of information is to hypothesize the results, that is, to perform thought experiments. The most rigorous thought experiments use mathematical models. A good model increases knowledge of what might happen when an untried policy is implemented.²

This paper contains one such thought experiment conducted on the pre-commitment approach. A private information model of banking capital regulation is developed to argue the following points. First, the proposal may be interpreted as a *menu* of contracts, a well-established economic concept. Several examples of their use outside the banking industry are provided. Second, under the assumptions laid out in this paper, menus are beneficial. Third, there are principles underlying the optimal design of fine schedules. Proper use of these principles can minimize the distortions to capital holdings caused by private information. Fourth, schedules in which fines are assessed only when there are losses (as the proposal presently specifies) will potentially need to be large to be effective. Still, there are a few issues not directly addressed by the model. These issues and possible extensions of the model that can address them are discussed later.

One objective of the paper is to foster a better understanding of the basic concepts underlying the pre-commitment approach. Part of this basic understanding requires elucidating what the pre-commitment approach is *not*. In particular, the approach's use of incentives may give the mistaken impression that the approach is a plan for deregulation. For example, Allen (1996) describes the approach with the term "self-regulation." While it is true that banks choose their level of capital (so they "regulate" themselves in the same sense that one would set a thermostat), their choice is made under an explicit set of rules and penalties. In this sense the pre-commitment approach is just as much a regulatory scheme as the other approaches. It is most definitely not a

² See Lucas (1980) for a statement of this methodological view.

proposal for deregulation. Instead, it is a plan to alter and improve banking capital regulation.

2. MENUS OF CONTRACTS

Underlying the pre-commitment approach is the well-established economic principle that it may be desirable for economic agents (banks in this application) to choose from a *menu* of contracts. In this paper, banks each choose an item from a menu designed by the regulator. In the context of the pre-commitment approach, an item on the menu consists of a capital level and an associated fine schedule. For example, the menu could consist of two items, one with low capital requirements and high fines, and another with high capital requirements but low fines.

Menus of contracts are pervasive and have been studied extensively by economists. Examples of such menus include those presented by insurance companies to potential customers. Each company offers a number of combinations of a premium with contingent payments. The contingencies are usually identifiable events, such as a fire or an accident, and the payments are limited by deductibles and co-payments. Faced with the menu, the customer usually chooses a single combination from the menu of choices. A fundamental issue for the design of insurance contracts, and for this paper, is that customers know their risks better than insurers, so the menus must be carefully designed with this point in mind. Otherwise, as in the case of life insurance, a life insurer that does not price its policies properly may end up only selling policies to high-risk individuals. This problem is called adverse selection in the insurance literature.

Some public utilities also use menus. Wilson (1993) contains a striking description of the rate schedules of the French electrical utility *Electricité France*.³ In addition to differentiating its rates among observable features of its customers, such as residential versus commercial use, this utility also allows customers to choose from several options. For example, after paying a fixed charge based on the power rating of their appliances, professional offices face a menu that includes a further fixed charge and a per-unit-of-usage charge that depends on the time of day.

The menu contains three items: basic, empty hours, and critical times options. The basic option charges a fixed monthly fee and a fee per kilowatt hour consumed that is independent of the time of day. The empty hours option differs from the basic option by charging a 25 percent higher fixed fee but offers a 50 percent discount on usage during off hours. The remaining item on the menu is the critical times option. Compared with the basic option, its fixed fee is 50 percent lower and its per-usage fee is 36 percent lower. Unlike the basic

³ His description is based on its rate schedules as of February 1987.

option, however, the critical times option contains one important contingency; if the utility announces that power is in short supply, there is an 800 percent surcharge on energy usage!

The schedules described in Wilson (1993) are clearly designed to separate customers by their power needs. The critical times option seems designed to select consumers who can afford to shut down their office on short notice, while the empty hours option is designed for customers with off-peak demand. No doubt, the design of the menu has something to do with the short-run capacity of electrical production and associated problems of peak usage.

Features of the Model

The following four features of the model underlie the use of menus in this paper:

- Several types of banks, which differ in the probability distribution of the returns on their assets;
- Private information on bank types, i.e., the assumption that a bank knows its probability distribution of returns but the regulator does not;
- A regulator who desires banks' capital levels to depend on bank type;
- A regulator who has the ability to levy fines on banks.

The first feature, a heterogeneous group of banks, is necessary because otherwise all banks would hold the same amount of capital, eliminating the need for a menu. The second feature, private information, is necessary because without it, that is, if both the bank and the regulator know the quality of the bank's portfolio, the regulator could simply figure out each bank's capital level himself. In contrast, with private information the regulator cannot arbitrarily control the actions of banks but instead may only indirectly influence them by setting penalties based on variables, such as bank returns, that the regulator can observe. The assumption of private information seems realistic because it corresponds to the idea that banks are better at assessing their portfolio than regulators.

The third feature, the desirability of heterogeneous capital levels, creates a potential conflict with banks' behavior under the assumption of private information. Private information hides the fundamental characteristics of the bank from the regulator. In this way, private information can be a problem if a regulator tries to set capital levels that depend on banks' types. For example, suppose the regulator wanted one type of bank to hold more capital than another type and suppose that banks prefer to hold less capital to more. Because the regulator is ignorant of bank types, a bank that is supposed to hold the higher amount of capital could post the lower amount instead. The regulator would be powerless to do anything about it since as mentioned, he could not distinguish one type of bank from another.

Differential capital levels may be feasible, however, when combined with fines, the last essential feature of the environment. The implementation works by letting the regulator provide banks with a menu of contracts. Each item on the menu consists of a capital level and an associated fine schedule. The idea is that it may be possible (and desirable) to design the fine schedules to affect each type of bank differently. The differential effect may be enough to get each type of bank to hold the amount of capital the regulator desires for it. Exactly how the menu needs to be designed will be elaborated later.

3. THE MODEL

In order to illustrate menus of contracts as clearly as possible, a simple model is described. The model leaves out several realistic features of the banking system. In particular, the important moral-hazard problem of bankers taking on too much risk because of deposit insurance is left out. The reason for this omission is that the goal of this paper is to describe as clearly as possible how menus of contracts work, and it is private information on bank types, not moral hazard in bankers' actions, that underlies the use of menus of contracts. Moral hazard could be included, and more will be said later on how to do this, but only at the cost of considerable complication.

Environment

Imagine the following banking system, which possesses the previously described four features. A bank's type is θ ; there are two types of banks, called θ_1 and θ_2 (or type-1 and type-2), that differ in the riskiness of their portfolios. Assume type-1 banks are riskier than type-2. There is a continuum of banks, and each type of bank comprises a positive fraction of the banking sector. Let $h(\theta)$ denote the positive fraction of the banking sector consisting of type- θ banks, where, of course, $h(\theta_1) + h(\theta_2) = 1$. Both the regulator and the banks know the distribution of bank types, $h(\theta)$. Each bank's type is private information: it knows the riskiness of its portfolio but the regulator does not.

For simplicity, assume that each bank has an equally sized fixed base of deposits. Bank assets produce returns, q , which are *net* of payments to its depositors. Returns, q , may be positive or negative and are a function of a bank's type and an idiosyncratic, that is bank-specific, shock.⁴ Each bank's return is distributed according to the probability function $p(q|\theta)$. Type-1 and type-2 banks differ in the distribution of their returns. Unlike its type, a bank's return is public information, that is, observed by both itself and the regulator.

Before realizing returns, banks hold capital, k , which costs them $r > 0$ per unit. Capital is not invested but simply sits in the bank and is repaid at the end

⁴ Because there is a continuum of banks there is no aggregate uncertainty in the economy. Later there will be a short discussion of what might happen if aggregate uncertainty is included.

of the period.⁵ Regulators have the power to fine banks, $f \geq 0$, after returns are realized. Restricting fines to be nonnegative precludes regulators from making transfers to banks.

Preferences

Assume that banks are risk neutral and that their sole objective is to maximize profits (returns net of fines and the cost of capital). Their utility function is

$$U(f, q, k) = q - f - rk,$$

so expected utility for a type- θ bank is

$$\int_q p(q|\theta)U(f, q, k) dq.$$

Since utility equals returns minus fines and capital costs, it is possible in this model for utility to be negative. The pre-commitment approach focuses solely on the trading portfolio, so conceivably losses resulting from bad performance and from fines would be paid from the rest of the bank portfolio. In this case, regulators should consider the effect fines would have on the rest of the bank's portfolio. The model, like the proposal, does not explicitly confront this problem. The model, however, does indirectly address the problem through its treatment of negative profits. More will be said about this point later, when discussing bankruptcy.

Negative utility becomes more problematic if, as recent discussions of the proposal have suggested, the approach is expanded to other sources of risk like credit risk. (See Seiberg [1996].) For example, if the proposal is extended to the bank's entire asset portfolio, then there is no longer a "rest of the bank" to obtain funds from. Limited liability constraints will bind, limiting the regulator's ability to impose fines. These concerns can be incorporated into the model, though it does complicate some of the analysis. More will be said about limited liability later.

Allocations

The model can be solved to determine the optimal *allocation*. An allocation is a statement of two things: how much capital each type of bank posts and how much a type- θ bank is fined if it produces return q .

Definition 1 *An allocation in this model is a function $k(\theta)$ describing capital holdings and a function $f(q, \theta)$ describing fine schedules.*

⁵ Needless to say, this model is not based on a sophisticated theory of bank capital structure. The model does, however, provide a simple non-Modigliani-Miller economy, where banks want to hold less capital than regulators want them to. This latter feature is consistent with the prevailing view that deposit insurance leads to excessive leveraging of banks.

In this model, an allocation is equivalent to the menu of contracts. The two items on the menu are the two pairs of functions, $(k(\theta_1), f(q, \theta_1))$, and $(k(\theta_2), f(q, \theta_2))$. Each item consists of a capital level and a fine schedule.

The Approach

This private-information problem is analyzed by solving a constrained-minimization program. Economists solve these programs to find an allocation that minimizes an objective function while satisfying a set of constraints.⁶ An objective function is a way of ranking alternative allocations according to some criterion. Constraints are conditions that allocations must satisfy in order to be feasible. For example, if the economy contained a limited supply of a raw material, there needs to be a constraint that in the aggregate, firms do not use more than the total supply of the raw material. In this paper the constrained-minimization program represents the problem facing a regulator who is designing capital regulations to further society's objectives given the limitations imposed by constraints on the regulator's and the banks' behavior.

Objective Function

The objective function is the total cost of capital used by the banking system. The goal is to find a feasible allocation that minimizes the objective function's value. Admittedly, the total cost of capital is a simple measure of social welfare, but it makes sense in this context for the following reason. Since the distribution of bank types is fixed and banks do not undertake any investment, allocating the returns is simply a transfer among the participants. Rather than specifying what happens to fines or how bank profits are distributed to consumers, it is simplest to ignore these distributional issues. Consequently, attention is focused on the resource cost in the economy, the cost of capital. The idea is that the cost of capital represents the opportunity cost of alternative uses of capital outside the banking system. Accordingly, the objective function is

$$\sum_{\theta} h(\theta)rk(\theta).$$

Regulator's Constraint

The perspective underlying this model is that the regulator designs the capital regulations to minimize banking capital. The earlier discussion, however, argued that the regulator wants to protect the insurance fund. This desire is modeled by requiring that the regulator limit the number of bankruptcies in the economy. Besides protecting the insurance fund, other reasons for this behavior might include preventing potentially harmful systemic events like a

⁶ Actually, economists usually maximize an objective function, but in this model minimization is appropriate.

banking panic or even avoiding the political repercussions from too many bank failures. These concerns are modeled by simply requiring that the regulator set capital levels so that no more than a fraction, α , of banks fail. Bankruptcy is defined as an event in which losses exceed capital.

Definition 2 *A bank is bankrupt if losses exceed capital, that is, if $q + k < 0$.*

The regulator's constraint is written

$$\sum_{\theta} h(\theta) \int_{q+k(\theta)<0} p(q|\theta) dq \leq \alpha. \quad (1)$$

The term $\int_{q+k(\theta)<0} p(q|\theta) dq$ is the fraction of type- θ banks that fail.

Constraints on Fines

In this model, fines only transfer resources among members of the economy and do not enter the objective function. As a consequence, large fines could be imposed to enforce capital allocations. To avoid this possibility, and to capture the idea that there are limitations or costs to imposing fines, explicit restrictions on fines are imposed. Individual fines are limited to be no more than a fixed amount, \bar{f} . Since fines must also be nonnegative, each fine $f(q, \theta)$ is then required to be in the range

$$0 \leq f(q, \theta) \leq \bar{f}. \quad (2)$$

For similar reasons, the total amount of fines that can be assessed on the banking sector are not allowed to exceed \bar{F} , that is,

$$\sum_{\theta} h(\theta) \int_q p(q|\theta) f(q, \theta) dq \leq \bar{F}. \quad (3)$$

Again, the goal of these constraints is to limit the imposition of fines. If the level of any particular fine is too high, then limited liability concerns, as discussed earlier, need to be considered explicitly. Furthermore, if total fines are too large, no one would run a bank. These constraints are a crude but convenient way of limiting fines. A more realistic alternative would be to assume that total fines may be assessed only in an amount equal to insurance fund payments to depositors of failed banks.⁷

⁷ This latter specification was studied under the assumption of limited liability. Unfortunately, it complicated the analysis and hid some of the basic insights of menus of contracts. In particular, the parameters \bar{F} and \bar{f} become functions of the capital levels. Yet another specification is to make banks risk averse and put bank utility in the objective function. This specification avoids the extremely high fines that are characteristic of models with risk neutrality; but it produces the unappealing result that the regulator is insuring banks (not just depositors) and doing so by often making transfers *to* them.

Incentive Constraints

Incentive constraints take into account the effect of private information. To see how private information restricts the set of feasible allocations, consider the following allocation, which is assumed to satisfy constraints (1), (2), and (3). Set $k(\theta_1) > k(\theta_2)$ and set $f(q, \theta) = 0$ for all returns q and types θ . This allocation makes capital depend on a bank's type but never fines banks. If bank types are known, that is, they are not private information, then this menu of contracts could be implemented by fiat. The regulator simply orders each type- θ bank to hold capital level $k(\theta)$.

Now consider the same allocation, but under the assumption that bank types are private information. Since the regulator does not know a bank's type, it cannot order a bank to hold $k(\theta)$. After all, a bank of one type could simply claim to be a different type. Instead, the regulator must induce banks to hold $k(\theta)$ by letting them choose from a menu of contracts.

Under private information, a type-1 bank is faced with the following decision: Does it choose a type-1 or a type-2 contract? The answer in this case is that it chooses the type-2 contract, as the following equation demonstrates:

$$\int_q p(q|\theta_1)q \, dq - rk(\theta_1) < \int_q p(q|\theta_2)q \, dq - rk(\theta_2). \quad (4)$$

The left-hand side of equation (4) is the utility of a type-1 bank that posts $k(\theta_1)$ units of capital. This level is less than the right-hand side of the inequality; that is, the utility of the same bank if it pretends to be a type-2 bank and posts $k(\theta_2)$ units of capital. Thus, this allocation is not feasible if there is private information because no type-1 bank acting in its self-interest would ever hold the higher level of capital.

Economists ascertain which allocations are feasible under private information by using the *revelation principle*. The revelation principle says that it is sufficient to consider a menu of contracts with one item for each type as long as the menu, or equivalently the allocation, is *incentive compatible*. As a matter of convenience, economists index each item on the menu by the θ of the type- θ bank choosing that item. Because economists index each item by the type choosing it, incentive constraints are sometimes called truth-telling constraints.

Definition 3 *In this model an allocation is incentive compatible if*

$$\int_q p(q|\theta_1)(q - f(q, \theta_1)) \, dq - rk(\theta_1) \geq \int_q p(q|\theta_1)(q - f(q, \theta_2)) \, dq - rk(\theta_2), \quad (5)$$

and

$$\int_q p(q|\theta_2)(q - f(q, \theta_2)) \, dq - rk(\theta_2) \geq \int_q p(q|\theta_2)(q - f(q, \theta_1)) \, dq - rk(\theta_1). \quad (6)$$

As the previous example suggested, incentive compatibility embodies the ability of banks to act in their own interest. Each incentive constraint is a way

of writing the maximization problem facing a bank. For example, a type-1 bank has two choices. It can claim to be a type-1 or a type-2 bank. Constraint (5) states that a type-1 bank prefers to claim it is a type-1 bank rather than a type-2 bank. If there was also a third type of bank, there would need to be four additional incentive constraints. One constraint would state that a type-1 bank prefers a type-1 allocation to a type-3 allocation. Another constraint would ensure that a type-2 bank prefers a type-2 allocation to a type-3 allocation. And two more constraints would be necessary to ensure that it is incentive compatible for the type-3 bank to claim to be a type-3.

Now that the description of the constraints is complete, all the pieces are in place to formally state the problem of finding a feasible allocation that minimizes the cost of capital used by the banking sector. For an allocation to be feasible, it must satisfy the following constraints: prevention of too many bankruptcies, limitations on the regulator's power to levy fines, and compatibility with banks' incentives. The optimal allocation in this economy will be the solution to the following constrained-minimization program.

The Constrained-Minimization Program

$$\min_{k(\theta) \geq 0, f(q, \theta)} \sum_{\theta} h(\theta) rk(\theta)$$

s.t. (1), (2), (3), (5), and (6).

The Solution

The analysis makes the following two assumptions about the distribution of bank returns, $p(q|\theta)$.

Assumption 1 For all $q < 0$, $p(q|\theta_1) > p(q|\theta_2)$.

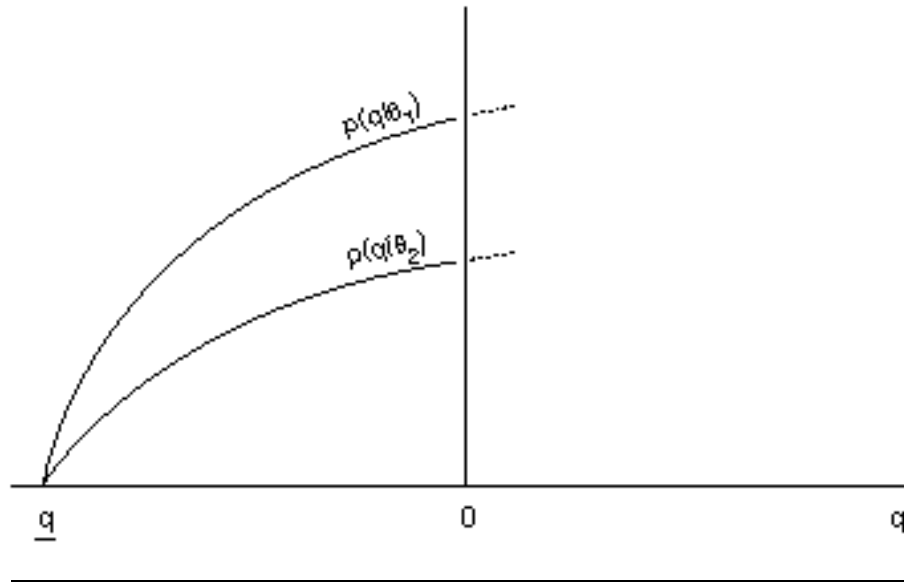
Assumption 1 says that there is a higher probability of each loss level for type-1 (risky) banks than for type-2 (safe) banks.

Assumption 2 For all θ , $p(q|\theta)$ is increasing and weakly concave over the range $q < 0$.

An example of a pair of probability functions that satisfy Assumptions 1 and 2 is illustrated in Figure 1. The figure shows only the probabilities for the portion of returns, q , that is negative.⁸ These assumptions are one way of expressing the idea that type-1 banks are riskier than type-2 banks.

⁸ The negative portion of the returns is important because it is all that matters for determining whether the set of allocations satisfying constraint (1) is convex.

Figure 1 A Pair of Probability Functions (Shown only over the Range $\underline{q} < q < 0$) that Satisfy Assumptions 1 and 2



Capital Allocation

Under Assumptions 1 and 2, there is a decreasing marginal decline in bankruptcies for both types of banks as their capital level increases. Furthermore, for a fixed level of capital, the marginal decline is higher for type-1 banks than type-2 banks. The relative sizes of the marginal declines in bankruptcies leads to the following proposition.

Proposition 1 *The optimal allocation must satisfy $k(\theta_1) \geq k(\theta_2)$.*

Proof: If $k(\theta_1) < k(\theta_2)$, then raise $k(\theta_1)$ and lower $k(\theta_2)$ such that they are equal and do not violate the regulator's constraint. Also, set all fines to zero. This allocation is trivially incentive compatible. But because of Assumptions 1 and 2, $h(\theta_1)k(\theta_1)$ is raised by less than $h(\theta_2)k(\theta_2)$ is lowered, thus lowering the total amount of capital in the system.

The proposition should be evident from inspecting Figure 1. A $k(\theta_1) = k(\theta_2)$ allocation is trivially incentive compatible and uses less total capital than a $k(\theta_1) < k(\theta_2)$ allocation. One useful implication of Proposition 1 is that incentive constraint (6) does not bind at an optimal allocation. In other words, a type-2 bank has no incentive to pretend that it is a type-1 bank, so this constraint can be ignored in the analysis.

For further analysis of capital levels it is necessary to study the first-order conditions to the program.⁹ Let ν denote the Lagrangian multiplier on the regulator's constraint (1), and μ_1 the multiplier on the type-1 bank's incentive constraint (5). The first-order condition on $k(\theta_1)$ is

$$r + \nu p(-k(\theta_1)|\theta_1) - \frac{r\mu_1}{h(\theta_1)} = 0, \quad (7)$$

and on $k(\theta_2)$ it is

$$r + \nu p(-k(\theta_2)|\theta_2) + \frac{r\mu_1}{h(\theta_2)} = 0. \quad (8)$$

Equating the two first-order conditions and rearranging terms produces

$$-\mu_1 \frac{r}{\nu} \left(\frac{1}{h(\theta_1)} + \frac{1}{h(\theta_2)} \right) + p(-k(\theta_1)|\theta_1) = p(-k(\theta_2)|\theta_2). \quad (9)$$

Lagrangian multipliers on binding inequality constraints are positive so the first term in equation (9) is negative, which implies that $p(-k(\theta_1)|\theta_1) > p(-k(\theta_2)|\theta_2)$. The inequality means that at the solution the marginal decrease in bankruptcies from an increase in capital of type-1 banks is greater than that of type-2 banks.

It is easy to see the role of private information in determining fines and capital levels if the private-information solution is compared with the *full-information* solution. By full information it is meant that a bank's type is not only known by the bank but also by the regulator. In terms of the program, solving for the full-information optimum requires first removing the incentive constraints, equations (5) and (6). The first-order conditions for the full-information program are identical to (7) and (8) except now $\mu_1 = 0$. This drops the first term from equation (9). Letting $k_f(\theta)$ denote the full-information solution, the first-order conditions imply that $p(-k_f(\theta_1)|\theta_1) = p(-k_f(\theta_2)|\theta_2)$.

As the following proposition proves, the optimal full-information allocation is for type-1 (risky) banks to hold strictly more capital than type-2 (safe) banks.

Proposition 2 $k_f(\theta_1) > k_f(\theta_2)$.

Proof: Assumptions 1 and 2 and the first-order condition $p(-k_f(\theta_1)|\theta_1) = p(-k_f(\theta_2)|\theta_2)$ imply that $-k_f(\theta_1) < -k_f(\theta_2)$. Therefore, $k_f(\theta_1) > k_f(\theta_2)$.

While both the private-information and full-information models are characterized, in general, by risky banks holding more capital, the amounts differ. As the next proposition shows, type-1 (risky) banks hold less capital under private information than they do under full information, while the order is reversed for type-2 (safe) banks.

⁹ First-order conditions are sufficient for finding the solution to a constrained-minimization problem when the objective function is weakly convex and the set of feasible allocations is convex. Both conditions are satisfied by this model. Satisfying the latter condition was the reason for making Assumptions 1 and 2.

Proposition 3 $k_f(\theta_2) < k(\theta_2) \leq k(\theta_1) < k_f(\theta_1)$.

Proof: First-order conditions imply

$$\begin{aligned} p(-k_f(\theta_1)|\theta_1) &= p(-k_f(\theta_2)|\theta_2), \text{ and} \\ p(-k(\theta_1)|\theta_1) &> p(-k(\theta_2)|\theta_2). \end{aligned} \tag{10}$$

Since $p(q|\theta)$ is increasing over the range $q < 0$, for the regulator's constraint (1) to be satisfied by a private-information allocation there are only two possible capital allocations: Either, $k(\theta_1) < k_f(\theta_1)$ and $k(\theta_2) > k_f(\theta_2)$, which implies fewer type-1 banks and more type-2 banks fail. Or, $k(\theta_1) > k_f(\theta_1)$ and $k(\theta_2) < k_f(\theta_2)$, which implies more type-1 banks and fewer type-2 banks fail. Only the first option, however, satisfies equation (10), because $p(q|\theta)$ is increasing and weakly concave. The remaining claim of the proposition, $k(\theta_2) \leq k(\theta_1)$, was proven in Proposition 1.

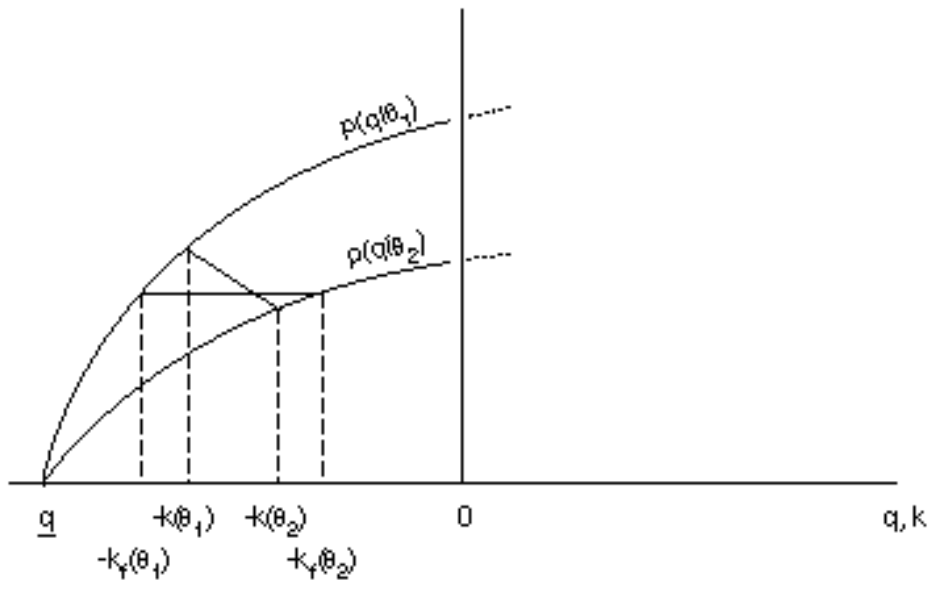
As Proposition 3 implies and Figure 2 summarizes, private information reduces the spread between $k(\theta_1)$ and $k(\theta_2)$. The private-information solution would like to replicate the full-information solution but it cannot because the full-information solution does not satisfy the incentive constraints. In fact, the full-information solution uses less capital than the private-information solution. (This result can be formally shown by using Proposition 3 and noting that the full-information problem is identical to the private-information problem except with fewer constraints.)

As a final point of reference, consider an allocation where $k(\theta_1) = k(\theta_2)$. This is an allocation where all types of banks are treated identically as in the standardized approach discussed in the introduction. Proposition 1 does not prove that the private-information solution is always better than treating all banks identically, but it suggests that it usually is. Later, a numerical example will be provided where, indeed, it is better. The value of using the pre-commitment approach relative to the standardized approach will be calculated from the objective function. It will be the difference in total capital used by the private-information solution and the total capital used by the best allocation where all banks hold the same level of capital. The measure will depend on the ability of the regulator to spread out capital allocations by using fines.

Fine Schedules

The previous analysis showed that, despite private information, capital levels may still differ across bank types. Any difference has to be supported by a fine schedule which discourages type-1 banks from pretending to be type-2 banks. Equation (3) limits the total amount of fines which may be assessed on the banking sector. If this constraint binds, then precisely how fines are assessed is important.

Figure 2 Capital Allocations for the Private-Information and Full-Information Models



The first observation regarding fines is that since only incentive constraint (5) binds, fines need to be assessed only on banks which claim they are type-2 (safe) banks. At first, it might not seem intuitive that only the safe banks are fined. But it makes sense when it is realized that safe banks get the benefit of lower capital levels. This consideration necessitates penalties to dissuade type-1 banks from pretending they are type-2 banks. True, it is possible to fine both types of banks, but any fine on banks declaring themselves to be type-1 would be wasted since type-2 banks have no incentive to pretend they are type-1 banks. Fines on type-1 banks would only give them an additional incentive to pretend they are type-2 banks. This discussion is summarized in the following point about optimal fine schedules.

Lesson 1 *Not all bank types need to be subject to fines. In particular, banks which post the highest level of capital do not need to be fined.*¹⁰

¹⁰ With more than two types there can be varying degrees to which banks are fined, as the numerical example in the following section illustrates. Furthermore, if moral hazard is added, then it might be necessary to fine all banks for one return or another. Still, even with the addition of moral hazard, different types of banks would be fined to varying degrees.

The next issue is how the regulator should assess fines on type-2 banks. The answer can be deduced from the constraints on fines, (2) and (3), along with the binding incentive constraint (5). The right-hand side of the incentive constraint (5) shows that a type-1 bank receives expected *disutility* from declaring it is a type-2 bank in the amount

$$\int_q p(q|\theta_1)f(q, \theta_2) dq. \quad (11)$$

The size of this term is important because it has to be large enough to convince type-1 banks to decline the benefit from choosing the lower capital level.

For each realization of the return, q , the penalty has two components, the size of the fine and the probability the fine will be imposed. Since the bank is risk neutral, it does not care whether the size of the fine or the probability of the return is high. It cares only that the sum of their products is high. Banks heed only the expected value of fines, not their distribution across returns.

The distribution of fines across returns does matter, however, to the regulator. The first, and most obvious, way it matters is that fines can be no more than \bar{f} . There is also a second, less obvious, way in which the distribution of fines matters to the regulator. Constraint (3) limits the total amount of fines the regulator may impose in equilibrium. Because of this constraint, a fine of $f(q, \theta_2)$ lowers the amount of fines the regulator may assess if other returns are realized. This quantity is lowered by

$$p(q|\theta_2)f(q, \theta_2). \quad (12)$$

This product depends on $p(q|\theta_2)$ and not $p(q|\theta_1)$ because in *equilibrium* only type-2 banks receive fine $f(q, \theta_2)$. Remember, incentive compatibility requires that fines are set so that type-1 banks never pretend to be type-2 banks (or vice versa). The distribution of fines matters because the fine schedule $f(q, \theta_2)$ is multiplied by $p(q|\theta_1)$ in incentive constraint (5), but it is multiplied by $p(q|\theta_2)$ in fine constraint (3).

The trade-off between the fine's effect on the incentive constraint and its effect on the fine constraint can be measured by the deterrent effect per unit of assessed fine.

$$\frac{p(q|\theta_1)f(q, \theta_2)}{p(q|\theta_2)f(q, \theta_2)} = \frac{p(q|\theta_1)}{p(q|\theta_2)}.$$

The quotient on the right-hand side of the equation is often called a *likelihood ratio*. It is very important in private-information models, and it is an important point of this analysis.

Lesson 2 *Fines are best assessed on returns, q , with the highest likelihood ratio $\frac{p(q|\theta_1)}{p(q|\theta_2)}$.*

Lessons 1 and 2 suggest the best way for the regulator to assess fines. First, only fine banks declaring themselves to be type-2 banks. Next, set the fine

$f(q, \theta_2)$ as high as possible on the return, q , with the highest likelihood ratio $p(q|\theta_1)/p(q|\theta_2)$. Once the maximum fine, \bar{f} , is reached, then the regulator should set fines as high as possible on the return with the next highest likelihood ratio. This procedure should be continued until no more fines can be levied.

4. A NUMERICAL EXAMPLE

This section reiterates the lessons of the previous analysis by presenting a numerical example. The example shows how private information distorts allocations and how likelihood ratios influence fines. It also shows how it may be beneficial, despite private information, to differentiate banks by type. This is done by comparing the private-information solution with an allocation in which all banks hold the same level of capital. As discussed earlier, this latter allocation can be viewed as the standardized approach, though for reasons to be discussed later, the analogy leaves out at least one important feature of that approach.

It should be noted that the numbers used in this example are *not* drawn from any data but instead are purely hypothetical. Thus, the quantitative implications of the example, that is, the size of fines and the size of welfare costs, do not describe the actual economy. Instead, the results should be viewed as emphasizing the qualitative properties of the models.

This example adds a third type of bank, θ_3 , to the previous analysis. As noted earlier, the addition of a third bank type only requires that more incentive constraints are added to the constrained-minimization program. As before, type-2 banks are safer than type-1 banks, but now, type-3 banks are the safest of all. The three types comprise the following fraction of banks in the banking system:

$$h(\theta_1) = 0.3, \quad h(\theta_2) = 0.3, \quad h(\theta_3) = 0.4.$$

Only a fraction $\alpha = 0.06$ of the banks may fail, and the cost of capital for banks is $r = 0.12$. Total fines \bar{F} are restricted to be less than or equal to 0.04. Fines imposed on returns, \bar{f} , are limited to be less than 0.1, though this latter constraint will not bind in equilibrium.

The assumed probability functions, $p(q|\theta)$, for the three types of banks are as follows:

	$q \in [-1, 0]$	$q \in (0, 1]$	$q \in (1, 2]$	$q \in (2, 3]$
$p(q \theta_1)$	$0.6q + 0.6$	0.35	0.20	0.15
$p(q \theta_2)$	$0.3q + 0.3$	0.10	0.45	0.30
$p(q \theta_3)$	$0.2q + 0.2$	0.10	0.20	0.60

The functions can be broken into two parts: probabilities on negative returns and probabilities on positive returns. The probability on negative returns,

$q \in [-1, 0]$, that is, $-1 \leq q \leq 0$, is the only portion of the distribution which matters for the bankruptcy constraint. For each type of bank, the probability function increases linearly over this range. As indicated in Figure 3, these functions satisfy Assumptions 1 and 2. For the positive returns, the probability functions are linear but discontinuous. For example, $p(q \in (0, 1]|\theta_1) = 0.35$ means that there is a 35 percent chance that a type-1 bank's return will fall in this range and that each return within this range is equally probable.

The following table lists computed optimal capital levels for all three models. The first three rows list the capital holdings for each type of bank. The fourth row lists the total capital held by the banking system. If scaled by the cost of capital, the fourth row is also the value of the objective function at the optimal allocation. The first column of numbers, denoted by "Stand." represents the standardized approach; that is, all banks are treated identically by requiring them to hold the same capital level. The second column denotes the private-information model, when the regulator can offer a menu of contracts, while the third column lists capital allocations under the full-information model.

	Stand.	Priv. Info.	Full Info.
θ_1	0.415	0.484	0.690
θ_2	0.415	0.420	0.380
θ_3	0.415	0.278	0.077
Total	0.415	0.382	0.352

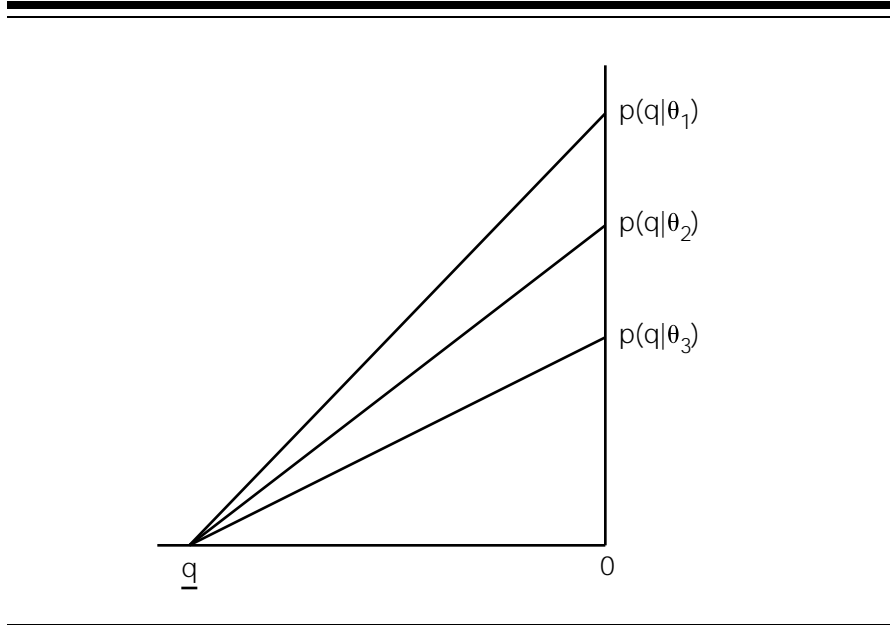
The table contains two implications. First, moving from left to right, total capital decreases over successive models, as it should, since allocations are less constrained with each model. Second, the profile of capital levels changes. The private-information allocation spreads out capital levels, compared to the standardized allocation, but not as much as the full-information solution, which is consistent with Proposition 2.

Private information also affects the distribution of bank failures. The next table lists failure rates for each type of bank.

	Stand.	Priv. Info.	Full Info.
θ_1	0.103	0.080	0.029
θ_2	0.051	0.051	0.058
θ_3	0.034	0.052	0.085
Total	0.060	0.060	0.060

Again, the choice of model has a sizable effect on the distribution of bank failure rates. Under the standardized approach, type-1 banks, the riskiest ones,

Figure 3 Probability Functions (Shown over the Range $\underline{q} < q < 0$) Used in the Numerical Example



have the highest failure rate. For each increasingly safer type, the fraction of failures decreases. Under private information, this ranking slightly changes, and failure rates for all three types are bunched closely together. The full-information solution spreads out failure rates across types but in a different direction than the standardized solution. Under full information, type-3 (safe) banks fail the most.

As this paper has consistently emphasized, a schedule of expected fines is necessary to implement menus of contracts under private information. (Remember, fines are not required for the other two models.) The following table shows the calculated optimal fine schedules as a function of the report, θ , and the return, q , for the private-information model.

θ	$q \in [-1, 0]$	$q \in (0, 1]$	$q \in (1, 2]$	$q \in (2, 3]$
θ_1	0.0	0.000	0.000	0.000
θ_2	0.0	0.022	0.000	0.000
θ_3	0.0	0.053	0.031	0.000

In reporting the fines, the convention was adopted to assess fines in equal amounts within each interval of positive returns. The reason for making this assumption is that within each range the likelihood ratio is a constant, so

there is an indeterminacy in how fines are allocated within each of these ranges. Not varying the fine within each range seems to be the simplest way of presenting the results.

As the earlier analysis showed, fines are never assessed on a bank which declares itself to be type-1, the riskiest type. The reason is that type-1 banks post the highest capital level, so the other banks have no incentive to claim to be type-1. Type-1 banks, however, have incentives to declare themselves type-2 or even type-3 banks.

As the earlier analysis also showed, fines are effective when levied on the return with the highest likelihood ratio, $\frac{p(q|\theta_1)}{p(q|\theta_2)}$. Consequently, fines are assessed if a bank claims to be type-2 and the return is $q \in (0, 1]$. For this same return, banks declaring themselves to be a type-3 bank are also fined. The reason is again to preclude type-1 banks from declaring themselves to be a type-3 bank.

Along with type-1 banks, type-2 banks have an incentive to post a lower capital level, though in their case, they must only be prevented from declaring themselves to be a type-3 bank. Again, likelihood ratios provide a guide for the best way to arrange fines. Fines are most effective against type-2 banks when imposed on returns with $q \in (1, 2]$.

It should be noted that, in general, the addition of a third type of bank complicates the analysis. For example, fines which help one incentive constraint bind might weaken another. In general, optimal fines need not take the exact form of the schedules listed in the table, although any optimal fine schedule will make extensive use of the likelihood ratios.

5. THE PRE-COMMITMENT APPROACH

What does the previous analysis say about the conceptual basis of the pre-commitment approach? It makes a clear statement in support of menus of contracts. Menus of contracts reduce the amount of capital used in the system by allocating it more efficiently across types of banks. Insofar as the pre-commitment approach is a menu of contracts, it is based on conceptually firm economic grounds.

What does the previous analysis say about the specifics of the pre-commitment approach? Remember, the proposal advocates fining banks only when losses exceed capital. One of the lessons of the previous analysis was that fines should be imposed when a high likelihood ratio exists, regardless of whether or not losses exceed capital. Another lesson was that the size of the fine should depend on the amount of capital posted. Lower capital levels require higher fines to preserve incentive compatibility, while higher capital levels require fewer fines. The pre-commitment approach is silent on this issue. In the context of the model, the approach's proposed fine schedule is not optimal.

Now, it might very well be that the proposal's schedule of fines, while not optimal, works reasonably well. After all, optimality is a statement about

ranking alternatives, not about the absolute size of any differences in the value of the objective function. To make this latter assessment requires numbers based on data, particularly data on the distribution of returns. That exercise is outside the scope of this paper. Nevertheless, there is enough information to obtain an idea about the *quantitative* size of fines required to implement the proposal's fine schedule. This calculation at least provides some sense of the quantitative implications of the proposal.

To pursue this aim, consider an economy, much like the one in the numerical example, with only two types of banks, one riskier than the other. As before, the risky bank is indexed by θ_1 and the safer bank is indexed by θ_2 . Also, assume that $k(\theta_1) > k(\theta_2)$ is desired by the regulator.

It is convenient to divide the range of losses into two portions. Let q_1 denote losses exceeding $-k(\theta_1)$ and let q_2 denote losses exceeding $-k(\theta_2)$ but not $-k(\theta_1)$, that is, $q_1 < -k(\theta_1) \leq q_2 < -k(\theta_2)$. The purpose of making this division is that, in the proposal, banks are fined only if losses exceed capital, which means type-1 banks are fined only when q_1 is realized, while type-2 banks are fined if either q_1 or q_2 is realized. Also, let $q_{1,2}$ denote the range consisting of both q_1 and q_2 .

Recall that type-2 banks hold less capital than type-1 banks, so assume that the only binding incentive constraint is on type-1 banks, equation (5). Furthermore, to be consistent with the proposal, fines are set to zero, $f(q, \theta) = 0$, if losses do not exceed capital, $k(\theta)$. Any return for which this is the case has no effect on the incentive constraint and does not need to be written down explicitly. The incentive constraint, after removing the terms equaling zero and subtracting out expected returns, is

$$\int_{q_1} p(q|\theta_1)(-f(q, \theta_1)) dq - rk(\theta_1) \geq \int_{q_{1,2}} p(q|\theta_1)(-f(q, \theta_2)) dq - rk(\theta_2). \quad (13)$$

Again, the left-hand side is the utility a type-1 bank gets from telling the truth, while the right-hand side is its utility from lying (after subtracting out expected returns).

At this point, it is helpful to introduce some new notation. First, define $\Delta k = k(\theta_1) - k(\theta_2)$ as the difference in capital levels. Next, let $f_{av}(q_{1,2}, \theta_2)$ be the average deterrent effect of fines over the range $q_{1,2}$. More precisely,

$$f_{av}(q_{1,2}, \theta_2) = \frac{\int_{q_{1,2}} p(q|\theta_1) f(q, \theta_2) dq}{\int_{q_{1,2}} p(q|\theta_1) dq}.$$

A constant level of fines set at this value over the range $q_{1,2}$ would be enough to preserve incentive compatibility. This calculation is useful for obtaining some idea about necessary magnitudes of fines.

Now, the incentive constraint (13) can be rearranged to obtain

$$f_{av}(q_{1,2}, \theta_2) \geq \frac{\int_{q_1} p(q|\theta_1) f(q, \theta_1) dq}{\int_{q_{1,2}} p(q|\theta_1) dq} + \frac{r\Delta k}{\int_{q_{1,2}} p(q|\theta_1) dq}. \quad (14)$$

The average deterrent effect of the fines must be no less than the sum of the two benefits a type-1 bank obtains from claiming to be a type-2 bank: the gain from no longer receiving fines, $f(q, \theta_1)$, plus the lower capital costs, $r\Delta k$. Both terms are divided by the probability that the average fine is imposed, $\int_{q_{1,2}} p(q|\theta_1) dq$.

The size of the first term depends on the distribution of losses, something on which this paper has little to say. Still, its sign is positive, so the second term provides at least a lower bound on the size of the average fine. This lower bound is

$$f_{av}(q_{1,2}, \theta_2) > \frac{r\Delta k}{\int_{q_{1,2}} p(q|\theta_1) dq}. \quad (15)$$

At a minimum the fine has to be large enough to offset any cost savings from a type-1 bank posting a lower capital level. Kupiec and O'Brien (1995b) contains a similar equation.

To assess the size of fines requires several parameter values. Two, which the regulator will set, are the probability that losses will exceed the chosen capital level and the time frame for evaluating the portfolio. Because of the preliminary state of the proposal, it is not clear what parameter values shall be used. Still, the discussion in the literature seems to focus on setting a capital level such that losses occur no more than 1 to 5 percent of the time. For example, see Kupiec and O'Brien (1995c), Bliss (1995), or Marshall and Venkataraman (1996).

Probably a better source of information is the criteria regulators will actually use in the internal models approach. This approach uses a 1 percent criterion over a ten-day trading period. However, it then multiplies by three the number produced by the bank's VAR model. This multiplication means that in practice the percent criterion is substantially less than one. The exact number depends on the tail of the distribution and would seem difficult to ascertain.

Despite the inability to obtain specific numbers, the internal models approach indicates two features the chosen numbers need. The time period should be relatively short and capital should be set so capital rarely exceeds losses. Accordingly, for the following calculations assume that the time frame is a quarter and set the probability of losses $\int_{q_{1,2}} p(q|\theta_1) dq$ over a range of 0.005 to 0.03. The time frame is longer than that which the internal models approach uses but the probability of a loss is higher. As a starting point, these numbers seem as good as any others.

The remaining number, the cost of capital, is more difficult to estimate. The model, while effective for illustrating menus of contracts, is not a good theory of capital structure. In the model, capital is only invested in a riskless storage technology and is used to satisfy claims in the event of a loss. In reality, the

cost to a bank of a different equity structure is the change in the bank's value. Its value may depend on the equity structure because of deposit insurance or it may depend on other factors often cited by the corporate finance literature such as taxes, bankruptcy, or managerial incentives. Consequently, rather than taking a stand on a particular number, calculations are made for a range of possible numbers.

Say the lower bound on the quarterly cost of capital is 0.5 percent. For an upper bound, the real cost of equity capital for banks is used. Kuprianov (1997) calculates a nominal cost of equity capital to be 14.5 percent in 1995. In real terms, this is close to 12 percent, or 3 percent quarterly.

The following table reports the average fine as a percentage of assets satisfying equation (15) for the ranges described above. The numbers are calculated for a 1 percent difference in capital level, Δk . The rows list the cost of capital, while the columns list the probability of losses exceeding capital.

	$\int_{q_{1,2}} p(q \theta_1) dq$			
r in %	0.005	0.010	0.020	0.030
0.5	1.000	0.500	0.250	0.167
1.5	3.000	1.500	0.750	0.500
3.0	6.000	3.000	1.500	1.000

Remember, the numbers in the table ignore the first term in equation (14), so they still might not be sufficient to implement the proposal.

Many of these numbers seem high. For example, with a quarterly cost of 1.5 percent and a 0.01 chance of a loss, the fine must be set at 1.5 percent of assets per unit of capital. If there is a 5 percent difference in capital levels between the two items on the menu, the average fine per *quarter* on safe banks must be 7.5 percent of assets. And this number ignores the first term in equation (14). Still, other numbers, particularly for low costs of capital, do not seem so unreasonable.

Equation (15) and the calculations presented in the table should be viewed as providing the following cautionary note to the proposal's fine schedule.

Lesson 3 *If fines are assessed only in low probability states, then they need to be set at high levels to offset the certain benefit of choosing a lower capital level.*

The potentially large size of required penalties, which is also noted in Kupiec and O'Brien (1995b), is a concern for the proposal. In its defense, Kupiec and O'Brien (1995c, 1995b) argue that other penalties, such as higher future capital requirements or increased supervision, may also be imposed. Since the model is static and penalties are pecuniary, the model says nothing

about these alternatives, though conceivably it could be modified to handle them. A dynamic variant might involve the repeated version of Program 2, randomly redrawing each bank's riskiness every period. The tools exist to handle this problem. For example, see Green (1987), Phelan and Townsend (1991), and Atkeson and Lucas (1992) for analysis of dynamic versions of other private-information problems. This modification of the model, however, is outside the scope of the paper.

Other Issues

The model in this paper abstracted from numerous issues not necessary to illustrate menus of contracts. Still, it is worthwhile to discuss what was left out and whether the issues not addressed by the model are important. One such issue is the previously discussed dynamic penalty schemes. This section lists several additional issues not addressed by the model, and for some of the issues it discusses how the model may be extended to analyze them.

Moral Hazard

Banks do not control their portfolios in this model, although of course they do so in reality. By changing their asset holdings, banks alter the distribution of their returns. As with bank types, it is reasonable to assume that many of the adjustments a bank makes to its portfolio are private information. It is these unobserved adjustments, plus their possible harmful effects, which have led to the use of the term moral hazard to describe these problems. Penalty schemes should be designed to handle moral hazard as well as bank heterogeneity.

One way to model banks' ability to alter their portfolio would be to modify the technology to $p(q|a, \theta)$, where a is a costly action taken by the bank, and along with θ , is not observed by regulators. This specification would incorporate moral hazard, which is usually associated with deposit insurance. Now, θ might be interpreted as the quality of the management.¹¹ There is a nonbanking literature on variants of this problem (see, for example, Christensen [1981], Laffont and Tirole [1986], or Prescott [1995]), but none of these models include capital or anything resembling it.¹² The addition of moral hazard will modify but not negate the messages of the three lessons. For example, Lesson 1 said that risky banks should not be fined. With moral hazard, however, it might be necessary

¹¹ Another option is to put θ into a bank's preferences and let it represent a bank's taste for risk.

¹² To be sure, there are a few banking papers that include capital. Giammarino, Lewis, and Sappington (1993) and Besanko and Kanatas (1996) both assume that returns are determined by $p(q|a + \theta)$. However, they assume that not only returns, q , are observable but also the sum $a + \theta$. Consequently, there is no need for return-dependent fines, which is a fundamental issue for the pre-commitment approach. Chan, Greenbaum, and Thakor (1992) separately analyze moral hazard and hidden information in a banking model with capital.

to fine risky (high capital) as well as safe (low capital) banks, but the relative size of the fines will differ across types.

Limited Liability

As discussed earlier, the model allowed for negative utility. If the bank experienced a loss, the regulator could still impose a fine. In practice, because of limited liability, if a bank experiences a loss, there are no assets to fine.

It is straightforward to add limited liability to the model, though it does complicate the analysis. Adding limited liability does not change this paper's message that menus of contracts may be valuable. However, adding limited liability does limit the ability of the regulator to assess fines. The limitation is particularly restrictive if a bank experiences a loss or a low return. If the proposal is to be extended to a bank's entire portfolio, then it will be necessary to fine banks when they do not experience a loss. The pre-commitment approach, as presently proposed, only assesses fines when there is a loss.

Aggregate Shocks

What would happen if there was a large shock to the market? Would regulators want to enforce fines? For example, consider a large number of banks trading in derivatives markets. If there was a large drop in market price, analogous to a stock market crash, banks might try to liquidate their holdings to avoid future fines. Such liquidation could cause further price declines if the banks comprised a large enough portion of the market.

In the context of the model, an aggregate shock could be included by indexing fines by the aggregate shock, ε , in addition to bank-specific shocks. The fine schedule would be written $f(q, \theta, \varepsilon)$ and might contain contingencies reducing fines on banks if the loss on the portfolio was due to an aggregate shock as opposed to a bank-specific shock. This sort of schedule contains relative performance features, where banks are compared with a market aggregate.

Time Inconsistency

Can regulators commit to imposing fines? Committing to future actions may be difficult. For example, consider the taxation problem facing a government at any particular point in time. At that moment, it seems optimal to tax all existing capital and to promise never to tax capital in the future. That way, there are no economic distortions since the initial capital stock is inelastically supplied and the promise to not tax future capital gives people an incentive to invest. However, the next period the government will face the same problem and tax all the capital in that period. If the government taxes this period, then people will realize that the government could make the same promise the next period, renege on this period's promise. Consequently, they do not invest this period. This problem is called time inconsistency.

For banking regulation, the same logic applies to fines. Once returns are realized, it may be “optimal” from the perspective of that period to assess no fines (particularly if the fine would cause bankruptcy) and to promise never to forgive fines again. However, if the regulator can forgive now, he can forgive in the future. For fines to be effective, their imposition must be credible. Large fines which cause a bank to fail, or fines during adverse macroeconomic conditions, may not be credible.

Standardized Approach

The allocation in which all banks held the same amount of capital was described earlier as the standardized approach. In the model, it performed poorly as a regulatory scheme. The allocation was included to show the potential benefits of differentiating bank capital levels by their type. In the context of the model, that allocation is the best approximation of the standardized approach. However, there is an aspect to the approach, not incorporated by the model, which may be beneficial.

Consider a modification to the paper’s model where now, before a bank reports its type, the regulator gains access to the bank’s portfolio and evaluates its riskiness. Now, the regulator’s evaluation need not be as sophisticated as the bank’s. It just needs to have some degree of accuracy. The standardized approach, as described in the introduction, could be considered one such evaluation, albeit a crude one.

This approach is different from the paper’s model because by evaluating the bank’s portfolio the regulator has obtained a *signal*. If this signal is at all correlated with the true riskiness of the portfolio, then it is valuable to include it in the contract. The reason for including it is that the signal, if correlated, affects the regulator’s posterior distribution about a bank’s type. In other words, it provides information to the regulator about the bank’s type. When viewed in this context, the standardized approach may be viewed as a form of monitoring. The value of the signal, of course, would depend on both the quality of the signal and the cost of obtaining it.

It should be emphasized that the pre-commitment approach and the standardized approach are not incompatible. For example, if the signal is partially correlated with a bank’s type, then it still might be valuable for the bank to choose from a menu of contracts. The difference from the contract in the paper’s model would be that the menu faced by the bank would depend on the signal observed by the regulator.¹³

¹³ If the signal was perfectly correlated with bank type and did not cost anything to obtain, the model would be equivalent to the full-information model discussed earlier.

6. CONCLUSION

To conclude, this paper makes several statements about the pre-commitment approach and menus of contracts. First, the approach is a proposal to use menus of contracts, a widely used contracting device. Second, in the model presented, properly designed menus are beneficial. Third, the proper design of fine schedules entails fining safe (low capital) banks but not risky (high capital) banks and basing the size of fines on likelihood ratios. Fourth, the fine schedules associated with the proposal should be viewed with caution. Fines which only occur in low probability states, as suggested by the proposal, potentially need to be large to offset the certain benefits of lowering capital. Last, the pre-commitment approach is not a market-based system. Instead, it is a regulatory scheme, just like the other proposals, but one which employs incentives.

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