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Rebalancing the Three Pillars of Basel II

1. Introduction

The ongoing reform of the Basel Accord is supposed to rely on three "pillars": a new capital ratio, supervisory review, and market discipline. But even a cursory look at the proposals of the Basel Committee on Banking Supervision reveals a certain degree of imbalance between these three pillars. Indeed, the Basel Committee (BIS 2003) gives a lot of attention (132 pages) to the refinements of the risk weights in the new capital ratio, but it is much less precise about the other pillars (16 pages on Pillar 2 and 15 pages on Pillar 3).[1]

Even though the initial capital ratio (BIS 1988) has been severely criticized for being too crude and opening the door to regulatory arbitrage,[2] it seems strange to insist so much on the importance of supervisory review[3] and market discipline as necessary complements to capital requirements while remaining silent on the precise ways[4] this complementarity can work in practice. One possible reason for this imbalance is a gap in the theoretical literature. As far as I know, there is no tractable model that allows a simultaneous analysis of the impact of solvency regulations, supervisory action, and market discipline on the behavior of commercial banks.

This paper aims to fill that gap by providing a simple framework for analyzing the interactions between the three pillars of Basel II. We start by offering a critical assessment of the academic literature on the three pillars,[5] and argue that none of the existing models allows for a satisfactory integration of these pillars. We therefore develop in Section 3 a new formal model that tries to incorporate the most important criticisms of existing theoretical models of bank regulation. Section 4 shows that minimum capital ratios can be justified by a classical agency problem, à la Holmström (1979), between bankers and regulators, even in the absence of mispriced deposit insurance. We demonstrate in Section 5 that, under restrictive conditions, these capital requirements can be reduced if banks are mandated to issue subordinated debt on a regular basis (direct market discipline). Finally, Section 6 explores the interactions between market discipline and supervisory action and shows that they are complementary rather than substitutes.

2. The Three Pillars in the Academic Literature

Most of the academic literature on Basel I concentrates on the credit crunch of the early 1990s[6] and on the distortions of banks' asset allocation generated by the wedge between the market assessment of banks' asset risks and its regulatory counterpart in Basel I. Several theoretical articles (for example, Koehn and Santomero [1980], Kim and Santomero [1988], Furlong and Keeley [1990], Rochet [1992], and Thakor [1996]) use static portfolio models to explain these distortions. In such

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models, appropriately designed capital requirements could be used to correct the incentives of bank shareholders to take excessive risks, due to the mispricing of deposit insurance or simply to the limited liability option. Using a different approach, Froot and Stein (1998) model the buffer role of bank capital in absorbing liquidity risks. They determine the capital structure that maximizes the bank's value when there are no audits or deposit insurance.

Yet, as pointed out by Hellwig (1998) and Blum (1999), static models fail to capture important effects of capital requirements. The empirical literature (for example, Hancock, Laing, and Wilcox [1995] and Furfine [2001]) has tried to calibrate dynamic models of bank behavior in order to study these intertemporal effects. However, none of these papers has studied the interactions of capital requirements with supervisory action[7] and market discipline.

The literature on continuous time models of bank behavior was initiated by Merton (1977). Assuming an exogenous closure date, he shows that the fair price of deposit insurance can be computed as a European put option. Merton (1978) extends this framework by considering random audits and endogenous closure dates.[8]

Merton's seminal contributions have been extended in several directions, in particular:

- Fries, Mella-Barral, and Perraudin (1997) introduce deposit withdrawal risk and study the impact of banks' closure policies on the fair pricing of deposit insurance;
- Bhattacharya et al. (2002) study closure rules that can be contingent on the level of risk taken by banks; and
- Levonian (2001) introduces subordinated debt in Merton's (1977) model and studies its impact on bankers' incentives for risk taking.

3. A Formal Model

Our model aims to take seriously most of the criticisms of previous models of bank regulation while remaining tractable.[9]

First, it is a dynamic model, because static models necessarily miss important consequences of bank solvency regulations.[10] The simplest dynamic models are in discrete time, like those of Calem and Rob (1996) or Buchinsky and Yosha (1997), but they typically do not yield closed-form solutions and entail the use of numerical simulations. For transparency, we instead use a continuous time model, à la Merton (1977, 1978), which requires using diffusion calculus but is ultimately revealed to be more tractable. Following Merton, we therefore assume that the (economic) value A_t of a bank's assets at date t follows a diffusion process:

$$\frac{dA}{A} = \mu dt + \sigma dW, \tag{1}$$

where dW is the increment of a Wiener process and μ and σ are the drift and volatility of asset value. For simplicity, we assume that all investors are risk neutral[11] and discount the future at a constant rate $r > \mu$. The bank's assets continuously generate an instantaneous cash flow $x_t = \beta A_t$, where $\beta > 0$ is the constant payout rate.[12]

We depart from the complete frictionless markets assumption made by Merton (1977, 1978)[13] and many of his followers, since this assumption implies that the social value of banks is independent of their liability structure, a hardly acceptable feature if one wants to study the consequences of solvency regulations for banks. Following Gennotte and Pyle (1991), we assume instead that banks create value by monitoring borrowers, and thus acquire private information about these borrowers. The counterpart to this private information is that the resale value of a bank's assets (typically, in case of liquidation) is only a fraction λA (with $\lambda < 1$) of the economic value A of these assets.[14]

We also assume that the monitoring of borrowers has a fixed-cost component,[15] equivalent to a flow cost $r\gamma$ per unit of time (its present value is therefore γ). From a social perspective, a bank should thus be closed when its asset value falls below some threshold A_L (the liquidation threshold). The social value of the bank, denoted $V(A)$, equals the expected present value of future cash flows $x_t = \beta A_t$, net of monitoring costs $r\gamma$, until the stopping time τ_L (the first time t that the bank hits the liquidation threshold A_L), when the bank is liquidated and its assets are resold at price λA_L. As shown in the appendix, this social value equals:

$$V(A) = (A - \gamma) + \{\gamma - (1 - \lambda)A_L\}\left(\frac{A}{A_L}\right)^{-a}, \tag{2}$$

where a is the positive root of the quadratic equation:

$$\frac{1}{2}\sigma^2 x(x+1) - \mu x = r. \tag{3}$$

Notice that this total value is composed of two terms:

- the value A of its assets, net of monitoring costs γ, and
- the option value associated with the (irreversible) closure decision.

As in the real options literature (see, for example, Dixit and Pindyck [1994]), the social value of the bank is maximized for a threshold A_L that is below the break-even threshold $A_0 = \frac{\gamma}{1-\lambda}$. More specifically, the level of A_L that maximizes the social value of the bank (notice that this level is independent of A, and thus is time consistent) is what we call the first-best closure threshold:

$$A_{FB} = \frac{a}{(a+1)}\frac{\gamma}{(1-\lambda)}. \tag{4}$$

Thus, our model captures an important feature of real-life banking systems:[16] even in the absence of moral hazard, government subsidies, and the like, the failure rate of banks cannot be zero. The socially optimal failure rate takes into account the embedded real option: given that bank closures are irreversible (and entail a real cost, due to the imperfect resaleability of banks' assets), it is optimal to let banks operate (up to a certain point) below the break-even level, defined by the condition $A_0 - \gamma = \lambda A_0$, in the hope that they recover. In more concrete terms, the fact that the resolution of bank failures costs money (ex post) to the Deposit Insurance Fund (DIF) does not necessarily imply some kind of inefficiency. This feature is illustrated in Exhibit 1.[17]

So far, we have introduced only one of the two important features of banking: the opacity of banks' assets,[18] which implies that they have to be monitored and cannot be resold at full value. We now introduce the second feature: the bulk of a bank's liabilities consists of retail deposits D, fully insured by a DIF and paying interest rD. The DIF is financed by a premium P paid at discrete dates. We assume that this premium is fair (so we rule out systematic subsidies from the DIF to the banks) but cannot be revised by continuous readjustments. The academic literature has insisted a lot on the "moral hazard" problem created by the put-option feature of deposit insurance. It has been extensively argued that this feature, and more generally the limited liability of bank shareholders, gives these shareholders incentives to take excessive risks, especially when banks are insufficiently capitalized. We focus here on a different agency problem, also created by limited liability, but of a different nature: bankers[19] may not have enough incentives to monitor their assets when their value becomes too small.[20] We assume that when monitoring stops (we say that the banker "shirks"), the quality of bank assets deteriorates,[21] and the dynamics of asset value become:

$$\frac{dA}{A} = (\mu - \Delta\mu)dt + \sigma dW, \tag{5}$$

where $\Delta\mu > 0$. Equation 5 indicates that the shirking/monitoring decision impacts only the expected profitability of the bank's assets and not the risk. Most of the academic literature has considered the polar case in which μ is unchanged but σ increases by moral hazard (the asset-substitution problem). Which specification is more appropriate is an empirical question.[22] In Décamps, Rochet, and Roger (2004), we consider the general case in which both μ and σ are altered by the banker's decision.

In the absence of shirking, the value of the bank's equity is given by a simple formula in the spirit of equation 2 (see the appendix for all mathematical derivations):

$$E(A) = A - D - \gamma + (D + \gamma - A_L)\left(\frac{A}{A_L}\right)^{-a}. \tag{6}$$

As in Merton (1977, 1978), the value of the bank's equity is the sum of two terms:

- the value of assets A net of debt (deposits) D (and of the monitoring cost, which does not appear in Merton [1974]) and
- the value of the limited liability option.

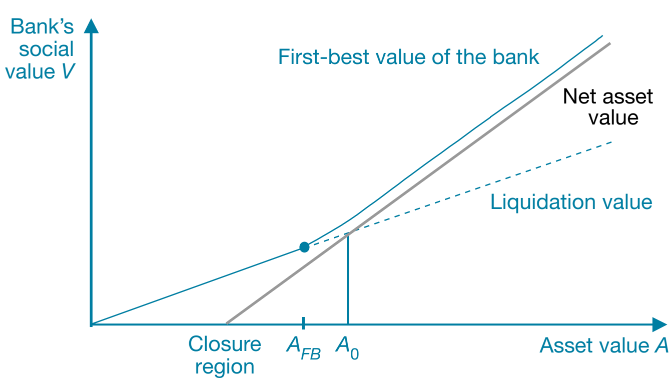
However, as in Merton (1978) but in contrast to Merton (1977), the value of the limited liability option is not of the Black-Scholes type (it is actually simpler). This is because it can be exercised at any time, which corresponds to a down-and-out barrier option, instead of at a fixed date, which corresponds to a European option. In Merton (1978), the closure option can be exercised only after an audit by the supervisor. Here we assume that, thanks to the information revealed by the market (indirect market discipline), closure can occur at any time.

A_L is now chosen by shareholders so as to maximize equity value. The corresponding threshold is:

$$A_E = \frac{a}{a+1}(D + \gamma). \tag{7}$$

At this threshold, the marginal value of equity is zero: $E'(A_E) = 0$ (smooth-pasting condition). Shirking is optimal

Exhibit 1
The Real Option Embedded in a Bank's Social Value



for bankers whenever their expected instantaneous loss from shirking, $AE'(A)\Delta\mu$, becomes less than the instantaneous monitoring cost γr. Since $E'(A_E) = 0$, this has to be true for some interval $[A_E, A_S]$.

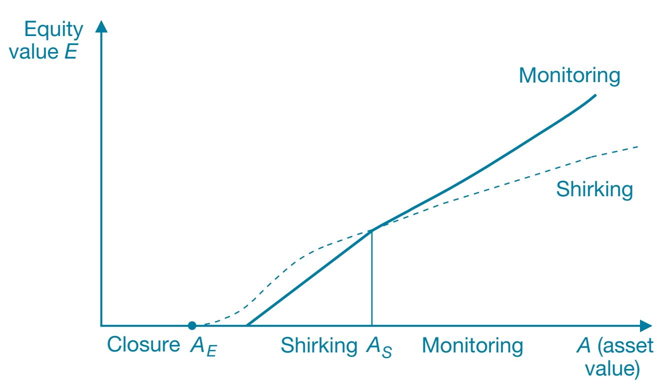
Proposition 1: When the cost of monitoring $\frac{\gamma}{D}$ *(per unit of deposits) is smaller than* $\frac{a+1}{\lambda a} - 1$, *there is a conflict of interest between shareholders and the DIF: insufficiently capitalized banks shirk.*

Interestingly, there are parameter values for which the agency problem does not matter: when $\frac{\gamma}{D}$ is large ($> \frac{a+1}{\lambda a} - 1$), shareholders decide to close the bank before the shirking constraint becomes binding. However, when $\frac{\gamma}{D}$ is smaller than this threshold, there is a conflict of interest, even in the absence of mispriced deposit insurance. It is similar to the conflict of interest between bondholders and shareholders of undercapitalized firms.

Exhibit 2 represents the typical pattern of the value of the bank's equity *E*, as a function of the value *A* of its assets, in the case where deposits are fully insured (and therefore depositors have no incentives to withdraw), but the bank is left unregulated. The closure threshold A_E (below which the bank declares bankruptcy)[23] and the shirking threshold A_S (below which the bank shirks) are chosen by bankers so as to maximize the value of equity. The reason why shirking is sometimes preferred by shareholders (in the intermediate region $A_E \le A \le A_S$) even though it is socially inefficient is not the deposit insurance option (as is the case for asset-substitution problems, where typically $\gamma = \Delta\mu = 0, \Delta\sigma^2 > 0$), but rather the agency problem between the bank and the Deposit Insurance Fund. Indeed, the cost of monitoring is entirely borne by the bank, but the bank collects only a fraction of the benefits of monitoring. When these benefits are small, the banker prefers to shirk. As we describe in the next section, this can be prevented by imposing a minimum capital ratio.

Exhibit 2

The Possibility of Insufficiently Capitalized Banks Shirking



4. Justifying the Minimum Capital Ratio

In our model, the justification of a minimum capital ratio is not an asset-substitution problem (as in the vast majority of academic papers on the topic[24]), but an agency problem between the banker and the supervisors, who represent the interests of the DIF: insufficiently capitalized banks shirk, that is, they stop monitoring their assets. To avoid this problem, we assume now that when the value of the bank's assets hits some threshold A_R chosen by the regulator, the bank is liquidated and the shareholders are expropriated.[25] This regulatory threshold A_R is designed in such a way that bankers are never tempted to shirk.

Proposition 2:

1) Under the assumption of Proposition 1 (that is, $\frac{\gamma}{D} < \frac{a+1}{\lambda a} - 1$*), bank shirking can be eliminated if bank regulators impose liquidation whenever the bank's assets fall below the following threshold:*

$$A_R^O = \frac{a(D+\gamma) + \frac{r\gamma}{\Delta\mu}}{a+1}. \tag{8}$$

2) When $\frac{\gamma}{D}$ *is larger than* $\frac{\Delta\mu}{r + a\Delta\mu}$, *this liquidation threshold can be implemented by imposing a minimum capital ratio:*

$$\frac{A-D}{A} \ge \rho_R \equiv \frac{\gamma(r + a\Delta\mu) - D\Delta\mu}{\gamma(r + a\Delta\mu) + aD\Delta\mu}. \tag{9}$$

The condition $\frac{\gamma}{D} > \frac{\Delta\mu}{r + a\Delta\mu}$ ensures that the minimum capital ratio ρ_R is positive. When it is not satisfied, banks can be allowed to continue for negative equity values. We focus here on the more interesting case of Proposition 2, where $\rho_R > 0$.

Notice that when liquidation costs are large enough, the first-best liquidation threshold

$$A_{FB} = \frac{a}{a+1} \frac{\gamma}{1-\lambda}$$

is smaller than the regulatory threshold

$$A_R^O = \frac{a(D+\gamma) + \frac{r\gamma}{\Delta\mu}}{a+1}.$$

This means that bank supervisors are confronted with time consistency problems: even if ex ante, agency considerations imply that a bank should be closed whenever $A \le A_R^O$, ex post it is optimal to let it continue (and provide liquidity assistance). These forbearance problems are examined in Section 6.

We now examine the policy implications of our first results. We interpret bank solvency regulations as a closure rule intended to avoid shirking by insufficiently capitalized banks: every time the asset value of the bank falls below A_R^O, the bank should be closed. However, we argue that bank assets are opaque and cannot be marked to market in continuous time. The traditional view of the role of supervisors was to evaluate these assets periodically through on-site examinations. In particular, most academic papers[26] assumed that A_t was observable only through costly auditing that had to be performed more or less with uniform frequency across banks. We argue in favor of a more modern modeling strategy whereby bank supervisors can rely on market information and adapt the intensity or frequency of their examinations to the market assessment of the bank's situation. This can be done by conditioning risk weights on market ratings of assets (Pillar 1) or using yield spreads of bank liabilities and private ratings to reassess the solvency of the bank (Pillars 2 and 3). In our model, it would mean inferring A_t, the (unobservable) value of the bank's assets, from the market price of equity (if the bank is publicly listed), that is, inverting the function $A \to E(A)$. This is how our model captures the notion of "indirect market discipline": using as much publicly available information as possible to allocate scarce regulatory resources in priority to the banks in distress. In our model, it leads to a simple policy recommendation of organizing a regulatory framework with two regimes:

- A light regime for "healthy" banks (those for which asset value A is way above the closure threshold A_R^O, where A is inferred from accounting data and market information), only imposing accurate reporting and transparency.
- A heavy regime for "problem" banks (those for which A gets close to A_R^O), imposing restrictions on what the bank can do and closely examining its books.

This two-regime regulatory framework (a simplified version of the prompt corrective action provisions of the Federal Deposit Insurance Corporation Improvement Act, or FDICIA)[27] is examined formally in Section 6. For the moment, we discuss direct market discipline and, more specifically, how the subdebt proposal can, under certain conditions, reduce capital requirements.

5. Market Discipline and Subordinated Debt

We now consider that the bank is mandated to issue a certain volume B of bonds, each paying a continuous coupon c per unit of time.[28] These bonds are subordinated to deposits: if the bank is liquidated (when asset value hits threshold A_L), the DIF receives λA_L but bondholders receive nothing. Anticipating this possibility, bondholders require a coupon rate c above the riskless rate r. To maintain the convenience of the stationarity of the bank's financial structure, we assume that bonds have an infinite maturity (unless of course the bank is liquidated) but are randomly renewed according to a Poisson process of intensity m.[29] In more intuitive terms, a fraction mdt of outstanding bonds is repaid at each instant at its face value B and the same volume mdt is reissued,[30] but at its market value $B(A)$. This is where market discipline comes in:[31] if the bank's asset value A deteriorates (for example, if bankers stop monitoring their assets), the finance cost of the bank increases immediately, since at each instant a fraction m of the bonds has to be repaid at face value B and reissued at market value $B(A) < B$ (notice also that $B' > 0$). In the appendix, we show that the value of equity becomes:

$$(10)\quad E(A, B) = A - \gamma - D - B\frac{c+m}{r+m} + (D + \gamma - A_L)\left(\frac{A}{A_L}\right)^{-a} + \frac{c+m}{r+m}B\left(\frac{A}{A_L}\right)^{-a(m)},$$

where $a(m)$ is the positive root of the quadratic equation

$$\frac{1}{2}\rho^2 x(x+1) - \mu x = r + m.$$

The new regulatory threshold A_R^{SD} is the smallest value of A_L that guarantees that bankers will not shirk. It is defined implicitly by:

$$A_R^{SD}\frac{\partial E}{\partial A}(A_R^{SD}, B) = \frac{\gamma r}{\Delta\mu},$$

where A_L is taken to equal A_R^{SD}. After easy computations, we obtain:

$$(11)\quad A_R^{SD} = A_R^O + \frac{a(m)}{a+1}\left(\frac{c+m}{r+m}\right)B.$$

Not surprisingly, this threshold is higher than A_R^O (all else being fixed), since the bank is now more indebted. However, the capital ratio becomes:

$$(12)\quad \rho_R^{SD} = 1 - \frac{D+B}{A_R^{SD}}.$$

It is smaller than $\rho_R = 1 - \frac{D}{A_R^O}$, whenever $\frac{A_R^{SD}}{D+B} < \frac{A_R^O}{D}$, which is equivalent to:

$$(13)\quad a(m)\frac{c+m}{r+m} < a + \frac{\gamma}{D}\left(a + \frac{r}{\Delta\mu}\right).$$

Since $a(m)$ increases with m (which $a(0) = a$ and $a(+\infty) = +\infty$), we see that this condition can be satisfied, but m (the frequency of renewal of bonds, which is inversely proportional in our model to their average maturity) and $\frac{c-r}{r}$ (the relative spread on subordinated debt) have to be small enough. Thus, we obtain:

Proposition 3: If banks are mandated to issue subordinated bonds on a regular basis, regulators can reduce capital requirements (Tier 1) if two conditions are satisfied: the average maturity must not be too small[32] *(m small) and the coupon paid on the bonds must not be too large ($\frac{c}{r}$ close to 1). However, the total requirement, capital + subdebt (Tier 1 + Tier 2), is always increased.*

Proposition 3 shows the limits of the mandatory subdebt proposal. Only when properly designed (that is, with a maturity that is not too small or a frequency of renewal that is not too large) and when markets are sufficiently liquid and bank assets not too risky (so that the relative spread $\frac{c-r}{r}$ is not too large) can mandatory subdebt allow regulators to decrease capital requirements.

6. Market Discipline and Supervisory Action

We now come to what we consider the most convincing rationale for market discipline: preventing regulatory forbearance by forcing regulators to intervene before it is too late. As is well documented in the literature on banking crises, banking authorities are very often subject to political pressure for bailing out the creditors of banks in distress. To capture this in our model, we consider what would happen if subdebt holders where de facto insured in the case where the bank is liquidated (that is, whenever the value of its assets hits the regulatory threshold). This bailout obviously does not affect the social value of the bank but only leads to a redistribution of wealth between the DIF and bondholders. Bonds become riskless[33] and perfect substitutes for deposits in the view of equityholders. The frequency of renewal of bonds ceases to play any disciplining role.

Proposition 4: If subdebt holders are insured by the DIF, subdebt ceases to play any disciplining role: Direct market discipline can work only in the absence of regulatory forbearance.

Proposition 4 shows the existence of some form of complementarity between market discipline and supervisory action: direct market discipline can work only if supervisors can credibly commit not to bail out bondholders.

We now examine a second form of complementarity between market discipline and supervisory action: if financial markets are suitably efficient and liquid, and if banks issue publicly traded securities (equity or bonds), the market prices (or yields) of these securities will provide objective signals about the situation of these banks. We do not address the difficult statistical question of which security (equity or subordinated bonds) gives the most useful information to bank supervisors.[34] Our model has only one state variable, A, and both the equity price $E(A)$ and the subdebt price $B(A)$ are monotonic functions of A and thus sufficient statistics for A. In our simple model, by observing market prices of either equity or bonds, regulatory authorities can perfectly infer the true value of A.

Our model is obviously not appropriate for analyzing such statistical considerations. It is, however, well adapted to study another, equally important question: namely, how market discipline can limit forbearance. Market information is then viewed as providing objective signals that oblige supervisors to intervene. Indirect market discipline is thus useful in two ways: it allows supervisors to save on audit costs for the banks that are well capitalized, and simultaneously it forces supervisors to intervene early enough when a bank is in trouble. This is captured in our model in the following way.

We consider that bank supervisors are required to inspect banks whenever the value of their assets hits an inspection threshold A_I (with $A_I > A_R$). Inspection allows them to detect shirking and close the banks that do shirk. The value of equity is still given by equation 6 (for simplicity, we return to the case with no subordinated debt):

$$E(A) = A - \gamma - D + (D + \gamma - A_R)\left(\frac{A}{A_R}\right)^{-a}.$$

But now the condition for no shirking becomes

$$\forall A \geq A_I,\ AE'(A) \geq \frac{\gamma r}{\Delta\mu}, \tag{14}$$

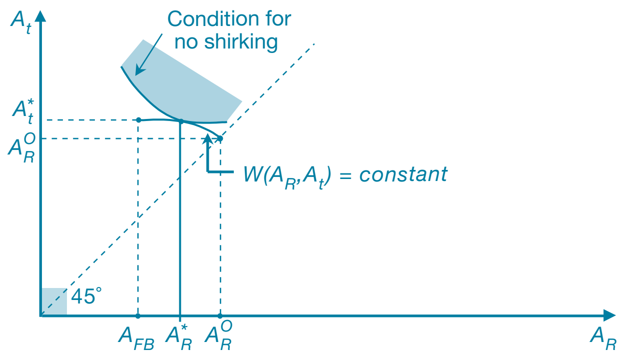
which is equivalent to:

$$A_I - a(D + \gamma - A_R)\left(\frac{A_I}{A_R}\right)^{-a} \geq \frac{\gamma r}{\Delta\mu}. \tag{15}$$

This formula shows that for any closure threshold A_R, there is a minimum inspection threshold A_I that prevents shirking: it is given by equality in equation 15. The corresponding curve in the (A_R, A_I) plane is represented in Exhibit 3. Notice that the

Exhibit 3

The Optimal Combination of Inspections (Threshold A_I^*) and Closures (Threshold A_R^*)



Note: *W* is proportional to the social value of the bank, net of auditing costs.

previous case (no inspection, closure at A_R^O) corresponds to the intersection of this curve with the first diagonal ($A_R = A_I = A_R^O$).

In Exhibit 3, we represent the optimal combination of inspection and closure thresholds by (A_R^*, A_I^*). It is obtained by maximizing the social value of the bank:

$$V(A, A_R) = A - \gamma + [\gamma - (1-\lambda)A_R]\left(\frac{A}{A_R}\right)^{-a},$$

net of the expected present value of auditing costs:

$$(16) \qquad C(A, A_R, A_I) = E\left(\int_0^{\tau_R} \xi I\!I_{A_t \leq A_I} e^{-rt} dt\right) dt,$$

where the auditing cost ξ is incurred only when the asset value of the bank lies in the interval $[A_R, A_I]$, $I\!I_{A_t \leq A_I}$ is the indicator function that takes a value of 1 when $A_t \leq A_I$ (and zero otherwise). Here, τ_R denotes the first time that $A_t = A_R$ (closure time). It can be shown that the expected present value of auditing costs C is proportional to A^{-a}:

$$(17) \qquad C(A, A_R, A_I) = A^{-a}\varphi(A_R, A_I).$$

Thus, after simplification by A^{-a}, we obtain:

Proposition 5: The optimal value of the closure threshold A_R^* and the inspection threshold A_I^* can be obtained by maximizing

$$(18) \qquad W(A_R, A_I) \equiv (\gamma - (1-\lambda)A_R)A_R^a - \varphi(A_R, A_I),$$

under the incentive compatibility constraint (equation 15).

We have that $A_R^* < A_R^O$, which indicates that prompt corrective action allows the reduction of capital requirements. When auditing costs are small, A_R^* becomes close to the first-best closure threshold A_{FB}, which means that prompt corrective action also reduces the severity of the time consistency problem of bank supervisors.

Proposition 5 illustrates the substitutability between Pillar 2 (supervisory action) and Pillar 1 (capital requirements). This was already a feature of Merton's (1978) model, in which the frequency of bank examinations could be substituted for more stringent capital requirements. However, here the introduction of Pillar 3 (market discipline) changes the picture: the intensity of regulation can be modulated according to market information (in the spirit of the prompt corrective action provisions of FDICIA), and symmetrically, supervisors can be forced to intervene when market signals reveal the distress of a bank (so that forbearance becomes more costly to supervisors or politicians). Notice also that market discipline decreases the (ex-post) benefits of forbearance by reducing the bank closure threshold (capital requirements), another illustration of the complex interactions between the three pillars of Basel II.

7. Conclusion

This paper develops a formal model of banking regulation that permits analysis of the interactions between the three pillars of Basel II. It differs from previous models in several important ways:

- it is a dynamic model, in which solvency regulations are interpreted as closure thresholds, rather than complex tools intended to correct the mispricing of deposit insurance;
- the justification of regulation is not (primarily) to prevent asset substitution by banks (deposits are not subsidized in our model), but rather to prevent shirking by the managers of undercapitalized banks;
- bank supervisors can use market information as a complement to the information provided by bank examinations; thus, they can save on scarce supervisory resources and allocate them in priority to the banks in distress; and
- the returns on banks' assets are endogenous, since they depend on the monitoring decisions of bankers.

Although very simple, this model allows a formal analysis of the interactions between the three pillars of Basel II. In particular, we show in Proposition 3 that mandatory subdebt (direct market discipline) may, under some restrictions, allow regulators to decrease capital requirements. More important, we show that market discipline and supervisory action are complementary rather than substitutes (Propositions 4 and 5): one cannot work well without the other.

In terms of policy implications, our theory points to a serious rebalancing of the three pillars of Basel II. The initial motivation of Basel I was to guarantee a level playing field for international banking, given that the large banks of some countries could take enormous risks without having much capital, benefiting from implicit guarantees by their governments. So the fundamental idea behind the Cooke ratio was harmonization, that is, to set a uniform standard for internationally active banks. It turns out that the Cooke ratio (or more generally, the risk-based capital methodology), although imperfect, was revealed to be extremely useful as an instrument for measuring bank risk. That is probably why it was applied rapidly (with minor changes) by the regulatory authorities of many countries within their jurisdictions (although it was initially designed for large, internationally active banks).

Probably in response to the harsh critiques of the crudeness of the Cooke ratio, the Basel Committee began a process of complexification, alternating new proposals and consultation periods with the banking industry (BIS 1999, 2001, 2003). The outcome of this long process is an extremely complex instrument (the McDonough ratio) that results from intense bargainings with large banks, and will probably never be implemented as such.

In this analysis, we argue that banking authorities should instead keep arm's-length relationships with bankers and that scarce supervisory resources should be used, according to priority, to control the behavior of banks in distress, rather than to implement an extremely complex regulation that will ultimately be bypassed in some way or another by the largest or most sophisticated banks. By contrast, there is an urgent need (once again) to guarantee a level playing field in international banking. The development of large and complex banking organizations with multinational activities implies that supervisory authorities of different countries urgently need to harmonize their institutional practices. Market discipline can provide a very useful tool for defining a harmonized and clear mandate for banking authorities across the world, in an attempt to eliminate political pressure and regulatory forbearance. This should be the top priority of the Basel Committee.

Mathematical Appendix

Here we derive the mathematical formulas used in our analysis.

First-Best Value of the Bank

The value of the bank (when assets are monitored) equals the expected present value of future cash flows βA_t, net of the monitoring cost $r\gamma$, until the stopping time τ_L (the first time t that A_t hits the liquidation threshold A_L) when the bank is liquidated. The formula is:

(A1) $$V = E\left[\int_0^{\tau_L} e^{-rt}(\beta A_t - r\gamma)\,dt + \lambda A_L e^{-r\tau L}\right].$$

Using classical formulas (see, for example, Dixit [1993] or Karlin and Taylor [1981]), we obtain:

(A2) $$V = A - \gamma + \{\gamma - (1-\lambda)A_L\}\left(\frac{A}{A_L}\right)^{-a},$$

where A is the current value of A_t, and a is the positive root of the quadratic equation:

(A3) $$\frac{1}{2}\sigma^2 x(x+1) - \mu x = r.$$

Value of the Bank's Equity

In the absence of regulation, equityholders choose the liquidation threshold that maximizes the value of their equity. Using the same classical formulas as we use to establish equation A2, we obtain:

(A4) $$E(A) = (A - \gamma - D) + (D + \gamma - A_L)\left(\frac{A}{A_L}\right)^{-a}.$$

As for the total value of the bank (equation A2), the second term is an option value that is maximized when

(A5) $$A_L = A_E \equiv \frac{a}{a+1}(D+\gamma).$$

At this threshold, the value of the bank's equity has a horizontal tangent (as represented in Exhibit 2 in the text):

(A6) $$E'(A_E) = 0.$$

If equityholders decide to stop monitoring, the dynamics of asset value become

$$\frac{dA}{A} = (\mu - \Delta\mu)\,dt + \sigma dW,$$

but they save the monitoring cost $r\gamma$. Shirking becomes optimal for equityholders whenever the instantaneous loss of equity value $E'(A)A\Delta\mu$ is less than this monitoring cost. Because $E'(A_E) = 0$ (see equation A5), this condition is always satisfied in the neighborhood of the liquidation point. However, we have to check that this incentive constraint binds after the bank becomes insolvent. This is true whenever

$$\lambda A_E \le D$$

or

$$\lambda a(D+\gamma) \le (a+1)D,$$

which is equivalent to the condition of Proposition 1, namely:

$$\frac{\gamma}{D} \le \frac{a+1}{\lambda a} - 1.$$

This ends the proof of Proposition 1.

Minimum Capital Ratio

Suppose bank regulators impose a closure threshold $A_R \le \frac{D}{\gamma}$: if the bank's asset value hits A_R, the bank is liquidated and shareholders receive nothing. By an immediate adaptation of equation A4, shareholders' value becomes:

(A7) $$E(A) = A - \gamma - D + (D + \gamma - A_R)\left(\frac{A}{A_R}\right)^{-a}.$$

The condition for eliminating shirking is:

(A8) $$\forall A \ge A_R,\quad E'(A)A\Delta\mu \ge \gamma r.$$

Using equation A7, we see that this is equivalent to:

(A9) $$\forall A \ge A_R,\quad A - a(D + \gamma - A_R)\left(\frac{A}{A_R}\right)^{-a} \ge \frac{\gamma r}{\Delta\mu}.$$

Provided that $A_R \le \gamma + D$ (this will be checked ex post), the left-hand side of equation A9 is increasing in A, therefore equation A9 is equivalent to:

$$A_R(1+a) - a(D+\gamma) \ge \frac{\gamma r}{\Delta\mu}$$

or

(A10) $$A_R \ge A_R^O \equiv \frac{a(D+\gamma) + \frac{\gamma r}{\Delta\mu}}{a+1}.$$

A_R^O represents the minimum asset value that preserves the incentives of the banker. The associated capital ratio is:

$$\rho^R = \frac{A_R^O - D}{A_R^O} = \frac{\gamma\left(a + \frac{r}{\Delta\mu}\right) - D}{a(D+\gamma) + \frac{\gamma r}{\Delta\mu}}.$$

SUBORDINATED DEBT

Consider now that the bank issues a volume B of subordinated bonds, paying a coupon cB per unit of time, and randomly renewed with frequency m. The market value of these bonds $B(A)$, as a function of the bank's asset value, satisfies the differential equation

$$\text{(A11)} \quad rB(A) = cB + m(B - B(A)) + \mu AB'(A) + \frac{1}{2}\sigma^2 A^2 B''(A),$$

with the boundary conditions:

$$B(A_L) = 0 \text{ and } B(+\infty) = \frac{cB}{r}.$$

The solution of this equation is:

$$\text{(A12)} \qquad B(A) = B\frac{c+m}{r+m}\left[1 - \left(\frac{A}{A_L}\right)^{-a(m)}\right],$$

where $a(m)$ is the positive root of the quadratic equation:

$$\text{(A13)} \qquad \frac{1}{2}\sigma^2 x(x+1) - \mu x = r + m.$$

In a comparison with equation A3, we see immediately that $a(0) = a$. Moreover, equation A13 shows that $a(m)$ increases with m.

The value of equity becomes:

$$\text{(A14)} \quad E(A,B) = A - \gamma - D - \frac{c+m}{r+m}B + (D + \gamma - A_L)\left(\frac{A}{A_L}\right)^{-a} + \frac{c+m}{r+m}B\left(\frac{A}{A_L}\right)^{-a(m)}.$$

AUDITING COSTS

By definition, the expected present value of auditing costs is defined by

$$C(A, A_R, A_I) = E\left[\int_0^{\tau_R} \xi II_{A_t \le A_I} e^{-rt} dt | A\right],$$

where τ_R is the first time that A_t hits the closure threshold A_R. By the usual arguments (see Dixit [1993]), one can establish that C satisfies the following differential equation:

$$rC = \mu AC'(A) + \frac{1}{2}\sigma^2 A^2 C''(A) \quad A \ge A_t,$$

with the limit condition

$$C(+\infty) = 0.$$

Therefore, $C(A) = kA^{-a}$, where a is (as before) the positive solution of the equation:

$$r = -\mu x + \frac{1}{2}\sigma^2 x(x+1),$$

and k is a constant that depends on A_R and A_I:

$$k = \varphi(A_R, A_I).$$

Endnotes

1. This imbalance is also reflected in the comments on Basel II; see Saidenberg and Schuermann (2003) for an assessment.

2. See, for example, Santos (1996) and Jones (2000). The alleged role of risk-based capital ratios in the "credit crunch" of the early 1990s is discussed in Bernanke and Lown (1991), Berger and Udell (1994), Peek and Rosengren (1995), and Thakor (1996).

3. For example, the Basel Committee (BIS 2003) insists on the need to "enable early supervisory intervention if capital does not provide a sufficient buffer against risk."

4. In particular, despite the existence of very precise proposals by U.S. economists (Calomiris [1998]; Evanoff and Wall [2000]; see also the discussion in Bliss [2001]) for mandatory subordinated debt, these proposals are not discussed in the Basel II project.

5. Reviews of this literature can be found in Thakor (1996), Jackson et al. (1999), and Santos (2000).

6. Discussions of this issue can be found in Berger and Udell (1994), Thakor (1996), Jackson et al. (1999), and Santos (2000).

7. However, Peek and Rosengren (1995) provide empirical evidence of the impact of increased supervision on bank lending decisions.

8. Merton (1977, 1978) assumes that bank assets are traded on financial markets (in order to use the arbitrage pricing methodology), which implies that the social value of banks is independent of their liability structure.

9. The model is a variant of the one used by Décamps, Rochet, and Roger (2004), who also analyze the interactions between the three pillars of Basel II.

10. The main problem is that, in a static model, solvency regulations have an impact only when they are binding. However, the great majority of banks today have much more capital than the regulatory minimum (this was not the case in 1988). Hence, it is difficult to explain the impact of a capital ratio in today's world by using a static model. For other critiques, see Blum (1999).

11. Small depositors are risk averse but they are fully insured and do not play an active role in our model. In any case, risk neutrality is not crucial for our results, but it simplifies the analysis. We could assume alternatively that all investors use the same risk-adjusted measure for evaluating risky cash flows.

12. Because of risk neutrality, the expected net present value of these cash flows (conditional on the information available at date t) has to coincide with A_t, which is equivalent to the condition $\beta = r - \mu$.

13. In Merton (1978), there are audit costs but no liquidation costs due to the resale of banks' assets, as we have here. As a result, social surplus is unaffected by liquidation decisions.

14. A similar assumption is made in the corporate finance literature (Leland 1994; Leland and Toft 1996; Fries, Mella-Barral, and Perraudin 1997), but $(1 - \lambda)$ is interpreted as a "physical" liquidation cost. Here, it is a cost due to the opacity of bank assets.

15. A proportional cost of monitoring, if any, can be subtracted with the drift in equation 1.

16. Of course, our desire to get closed-form solutions limits our model to one state variable only. This means that we cannot address important questions such as the way banks allocate their assets among different classes of risks and the hoarding of liquid assets as another buffer against risk. The first topic is addressed by the vast literature on risk-weighted ratios (Koehn and Santomero 1980; Kim and Santomero 1988; Furlong and Keeley 1990; Rochet 1992; Thakor 1996). The second topic is addressed in Milne and Whalley (2001).

17. Notice that the first-best social value of the bank is a convex function of asset value. However, when agency problems are taken into account, and make the liquidation threshold become greater than A_0, the value function becomes concave, and thus exhibits risk aversion.

18. Morgan (2002) provides indirect empirical evidence on this opacity by comparing the frequency of disagreements among bond rating agencies over the values of firms across sectors of activity. He shows that these disagreements are much more frequent, all else being equal, for banks and insurance companies than for other sectors of the economy.

19. We assume that bank managers act in the best interest of shareholders. It would be interesting, but presumably difficult, also to introduce an agency problem between managers and shareholders.

20. Bliss (2001) argues that this agency problem may be fundamental: "Poor (apparently irrational) investments are as problematic as excessively risky projects (with positive risk-adjusted returns). Evidence suggests that poor investments are likely to be the major explanation for banks getting into trouble."

21. We assume that this deterioration—that is, $\Delta\mu$ in equation 5—is so large that shirking is never optimal from a social viewpoint.

22. In the appendix to his paper, Bliss (2001) convincingly argues that the asset-substitution problem might have been overemphasized. He reviews several empirical articles that conclude that bank failures are often provoked by "bad investments" rather than "bad luck" (and excessive risk taking).

23. Following Leland (1994), we assume that shareholders are not cash constrained. In Décamps, Rochet, and Roger (2004), we examine the alternative case in which bankruptcy is precipitated by the bank's liquidity problems. Note that when there is shirking, the value of A_E is no longer given by equation 7.

24. See Santos (2000) for a review.

25. This is similar to protected debt covenants, whereby bondholders (or banks) retain the option of restructuring a firm before it is technically bankrupt. See Black and Cox (1976) for a formal analysis.

26. The seminal paper on this topic is Merton (1978). More recent references are Fries, Mella-Barral, and Perraudin (1997) and Bhattacharya et al. (2002).

27. The consequences of FDICIA are assessed in Jones and King (1995) and Mishkin (1996).

28. The mandatory subdebt proposal has been discussed extensively: see, for example, Calomiris (1998), Estrella (2000), and Evanoff and Wall (2000, 2001). The only formal analysis I am aware of is Levonian (2001). However, Levonian uses a Black-Scholes type of model in which the bank's returns on assets are exogenous. For empirical assessments of the feasibility of the subdebt proposal, see Hancock and Kwast (2001) and Sironi (2001).

29. This approach is borrowed from Leland and Toft (1996) and Ericsson (2000).

30. The average maturity of bonds is thus $\int_0^{+\infty} mte^{-mt}dt = \frac{1}{m}$.

31. The disciplining role of periodical repricing of debt has been shown by Levonian (2001). It is close in spirit to the disciplining role of demandable deposits (Calomiris and Kahn 1991; Carletti 1999).

32. Recall that in our model, bonds theoretically have an infinite maturity but are randomly repaid with frequency m. The average (effective) maturity is $1/m$.

33. Arbitrage considerations then imply that the coupon rate c must equal r.

34. On this topic, see, for example, Bliss (2001), Evanoff and Wall (2002), Gropp, Vesala, and Vulpes (2002), and the references therein.

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