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"Capital Regulation, Heterogeneous Monitoring Costs, and Aggregate Loan Quality"

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CAPITAL REGULATION, HETEROGENEOUS MONITORING COSTS, AND AGGREGATE LOAN QUALITY

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Abstract

This paper develops a banking-sector framework with heterogeneous loan monitoring costs. Banks are exposed to the moral hazard behavior of borrowers and endogenously choose whether to monitor their loans to eliminate this exposure. After analyzing an unregulated banking system, we examine several cases in which regulatory capital requirements bind the notional loan supplies of various subsets of banks. To gauge the impact of capital requirements, we define loan 'quality' in terms of either the ratio of monitored to total loans or the ratio of monitoring banks to total bank population. We find that binding capital requirements unambiguously increase the market loan rate and reduce aggregate lending, but, in all but one case, have an ambiguous effect loan 'quality.' Equally important, we show that capital requirements create a misallocation of monitoring activity within the banking system. These results suggest that the benefit/cost ratio of capital requirements is not necessarily greater than unity.

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CAPITAL REGULATION, LOAN MONITORING COSTS, AND AGGREGATE LOAN QUALITY

Do capital requirements, such as the present-day Basel capital standards (see Bank for International Settlements, 2001) and the updated requirements proposed for implementation by 2007, contribute to greater overall safety and soundness of the banking system? Ranging from the earliest work by Mingo (1977), Mingo and Wolkowitz (1977), Koehn and Santomero (1980), Furlong and Keeley (1989, 1990), Gennotte and Pyle (1991), and Furlong (1992) to the more recent contributions of Berger et al. (1995), Besanko and Kanatas (1996), Thakor (1996), Calem and Rafae (1999), answers to this question have been offered using frameworks involving one bank or a set of identical banks equally constrained by capital requirements. A recently emerging literature seeking to examine the implications of capital requirements for monetary policy, which includes Blum and Hellwig (1995), Chami and Cosimano (2001), Jacques and Schirm (2004), Kopecky and VanHoose (2004a, 2004b), Seater (2001), Tanaka (2002), and Van den Heuvel (2003, 2002), has likewise analyzed models with a uniformly capital-constrained banking system.

In the real world, capital requirements bind only a fraction of banks, as emphasized in empirical analyses by Berger and Udell (1994), Brinkmann and Horvitz (1995), Cecchetti and Li (2003), Kishan and Opiela (2000, 2004), Lown and Peristiani (1996), and Peek and Rosengren (1996; 1995a, b). Thus, there is a difference between the observed characteristics of banks and the theoretical models used to analyze the behavior of the banking system. From the viewpoint of policy analysis, does it make any difference whether these requirements bind only a subset of banks? If not, then the representative-bank approach provides an adequate framework for analyzing the effects of capital requirements. However, if the characteristics of banks that are not capital-constrained influence the nature of banking-sector equilibria, then the representative-bank model provides an incomplete and perhaps biased perspective of the effects of capital requirements. Our objective is to incorporate an endogenous loan default rate at the individual-bank level into a model of aggregate loan market behavior. In our view, capital requirements are essentially aimed at influencing bank decision-making regarding exposure to loan default. They affect both the quantity of bank lending and the quality of the loans extended. A framework that fails to recognize the endogeneity of banks' decisions about exposure to loan default does not provide a sufficiently rich insight into the effects of capital requirements.

To focus on endogenous loan default, we make the following assumptions:

1. Banks optimally choose between two levels of exposure to loan default;
2. One level of loan-default exposure requires the monitoring of loans by the bank;
3. Monitoring loans is costly, and these monitoring costs are heterogeneous across banks;
4. Banks have quadratic resource costs associated with balance-sheet adjustments, as in Cosimano (1988) and Elyasiani et al. (1995);
5. The amount of book equity is predetermined and identical across all banks.

As Diamond (1984) has stressed, because of exposure to the moral hazard behavior of borrowers and thus loan default, one of the important functions of banks is to act as delegated monitors with respect to their loan portfolios. To stress the importance of monitoring, we allow banks to optimally choose whether to engage in the costly monitoring of their loans and thus to determine their exposure to loan default. In our framework, monitored loans have a lower loan default rate than non-monitored loans, and aggregate lending by the banking system as a whole depends on the monitoring decisions of all the individual banks. As in previous representative-bank models of capital requirements, our model yields implications for aggregate bank lending and the equilibrium market loan rate. Most importantly, however, our framework also yields predictions about the proportion of banks that monitor their loans (implying selection of a lower loan default rate) and the proportion of aggregate lending that banks monitor.

We find that explicit recognition of loan default provides a model-dependent motivation and justification for the institution of capital requirements and for the analysis of their effects. Do capital requirements induce more banks to optimally create loans with a lower default rate? In our model this question has a non-trivial answer.

To generate closed-form solutions for individual banks' optimal portfolios, we assume quadratic resource costs. Our assumption that <u>book</u> equity is predetermined and identical across banks reduces the model's complexity, thereby allowing us to focus on the fundamental implications of endogenous default risk and optimal monitoring choices within an aggregate banking model—which is a novel contribution. How restrictive is our book equity assumption? Capital requirements are defined in terms of the <u>book</u> value of equity, and book equity itself is the result of past decisions made by the bank regarding the amount of retained earnings and the placement of new equity. Predetermining book equity, therefore, implies that our analysis is static. In a dynamic model, book equity would tend to deviate over time from its predetermined initial value as banks instituted longer run capital structure decisions. Note, however, that within our static framework capital structure decisions do occur. Even though book equity is predetermined and identical across banks, the model gives rise to <u>cross-sectional</u> distributions for loans, deposits, the <u>market</u> value of equity, and thus capital structure (defined in terms of either the <u>book</u> or <u>market</u> values of equity). Essentially, our analysis provides a static starting point for future research into the dynamic path of book equity and the evolution of the banking system associated with that path. As noted, we also assume that book equity is identical across banks. At present, there is no empirical evidence regarding the sign of the relation between book equity and loan monitoring costs. Depending on this sign, some of our theoretical findings would be enhanced, and others would be attenuated. But given the lack of empirical evidence, it seems prudent, in light of the complexities already inherent in the model, to assume that there is no relationship, which implies an assumption of identical book equity.

As noted above, even with our restrictive assumption about book equity, the optimal size of loan portfolios differs across banks. The resulting cross-sectional differences in lending imply that capital requirements may bind all banks or a subset of banks. When all banks are bound, the model bears a close (although not identical) resemblance to a standard representative-bank model. Even in this case, we find that imposing fully binding capital requirements on a previously unrestricted banking system has ambiguous effects on both the share of banks that choose to monitor their loans and the proportion of aggregate loans that they monitor. Once an all-binding capital regime is in place, however, imposing more-stringent requirements will then increase both ratios, thereby enhancing aggregate loan quality, albeit at a cost that we discuss later. In the more realistic situation of a *partially* bound banking system, the *only* unambiguous conclusion—at least, given our assumptions about the relevant ranges of parameter values—is a reduction in aggregate lending and a higher market loan rate. A regime with partially binding capital requirements has an indeterminate effect on the share of monitoring banks and on the proportion of aggregate loans that is monitored. These results contrast sharply with the representative-bank model and indicate that partially binding capital requirements do not necessarily lead to higher *quality* loans (i.e., exposure to a lower default rate).

The outline of the paper is as follows. The banking-sector model is presented in Section 1. Section 2 examines the equilibrium that emerges in the absence of regulatory capital constraints and thereby provides a benchmark case describing the behavior of an unregulated banking system. To reveal the model's basic insights, Section 3 focuses on only two special cases: capital requirements that either bind an *ad hoc* subset of banks or the entire banking system. The Appendix discusses several more realistic cases. Section 4 concludes the paper with a brief summary.

1. The Model

The model assumes a perfectly competitive banking system operating within a certainty environment. Deposit insurance exists, so depositors do not need to determine a deposit default rate. Banks face heterogeneous loan-monitoring costs. To model this heterogeneity, we locate banks along a unit interval, with the bank incurring the lowest marginal loan-monitoring cost set at zero and the bank incurring the highest marginal loan-monitoring cost set at unity. As shown below, this assumption allows us to divide the banking system into two classes of banks: monitoring and non-monitoring.

The structural equations of the banking model are as follows:

Balance sheet: $$R + G + L = D + \overline{E}, \qquad \overline{E} > 0 \tag{1}$$

Reserve requirements: $$R \geq \rho D \tag{2}$$

Securities rate: $$r_G = r + \psi \tag{3}$$

Public's loan demand: $$L = l_0 - l_1 r_L \tag{4}$$

Capital requirements: $$\overline{E} \geq \theta L \tag{5}$$

Profit: $$\hat{\pi} = \hat{R}_L L + r_G G - r_D D - \frac{f}{2}L^2 - \frac{g}{2}G^2 - \frac{a}{2}D^2 - \left(\frac{i}{1-i}\right)\frac{c}{2}L^2 \tag{6}$$

where $R \equiv$ reserves, $L \equiv$ loans, $G \equiv$ government securities, $D \equiv$ insured deposits, $\overline{E} \equiv$ book equity, $\rho \equiv$ effective required reserve ratio, $\theta \equiv$ capital requirement ratio, $r \equiv$ interest rate determined by the interest-rate targeting policy of the monetary authority, $r_L \equiv$ market loan rate, $r_G \equiv$ securities rate, $r_D \equiv$ deposit rate, $\psi \equiv$ market premium on government securities, $\hat{R}_L$ = the effective rate of return on loans (defined below), and $\hat{\pi}$ = profit.

Equation (1) is the balance sheet constraint for a typical bank. Equation (2) gives the reserve-requirement constraint that banks must meet under the simplifying assumption that excess reserves equal zero. The parameter ρ is the *effective* required reserve ratio for deposit liabilities, taking into account sweep accounts that banks use to transfer funds from reservable transactions deposits to nonreservable savings deposits. Equation (3) is the market rate on government securities. We assume that government securities have term-structure and/or liquidity premia, both of which are determined by factors outside the banking sector. These premia are represented by ψ. Equation (4) is the public's loan demand schedule, which, following Cosimano (1988), is assumed to be linear. Equation (5) defines a capital requirement on loans that may be imposed by regulators, where θ is the capital requirement ratio.[1] If capital requirements are imposed, we assume that their imposition is unexpected by the banking system. This assumption allows us to compare solutions for pre- and post-capital requirement regimes within the static framework of this paper. A dynamic model would be needed to analyze the influence of an expected imposition of capital requirements on the behavior of the banking system.

Equation (6) is the profit expression for a bank that chooses to monitor its loans. The parameters *a, f*, and *g* have nonnegative values that govern the magnitude of quadratic resource costs for individual balance-sheet items. By assumption, these costs functions do not allow for economies of scope. Positive values of these coefficients ensure upward-sloping marginal resource costs for loans, deposits, and government securities. In the special case with $g = 0$, which allows sharper analytic results in some instances, there is no quadratic resource cost associated with managing the bank's portfolio of government securities, and portfolio separation holds.[2]

We introduce heterogeneity into the banking system by assuming that loan monitoring is a costly activity and that banks have different monitoring cost structures due to idiosyncratic factors associated with the management skills at bank *i*. Essentially,

[1] Chami and Cosimano (2003) argue that this constraint always binds before the other constraints established under the Basel Accord.

[2] See Elyasiani *et al.* (1995) for an analysis of quadratic adjustment costs and portfolio separation.

managers at some banks are more adept, as reflected by lower marginal monitoring costs, at evaluating their borrowers' behavior than managers at other banks. Greater proficiency at monitoring loans may be due, for example, to the use of highly sophisticated and specialized bank-specific data analysis, none of which is transferable within the time frame of our stationary-state model. In addition, we also recognize that monitoring has technological components that are likely to be common across all banks. For example, standard data analysis software is available for use by any bank. We denote this common (or more precisely, transferable) component by *c*, which is a nonnegative constant. The monitoring cost function for each bank *i,* therefore, contains both transferable and non-transferable components and is given by $\left(\frac{i}{1-i}\right)\frac{c}{2}L_i^2$.

This function has cost implications for both the individual bank and the aggregate banking system. At the micro level, the marginal cost of monitoring at bank *i* is given by $\left(\frac{i}{1-i}\right)cL_i$, so there are increasing <u>internal</u> marginal costs of monitoring loans; that is, the larger is the volume of bank loans, the higher is the marginal monitoring cost. Of course, in reality, marginal monitoring costs at a given bank may be constant over a wide range of bank loan quantities. However, as bank loan volume rises, the bank will presumably engage in lending activity with ever less familiar borrowers, and marginal monitoring costs eventually increase. With regard to the aggregate banking system, the effect of heterogeneity is to introduce rising <u>external</u> marginal monitoring costs. The derivative of the assumed monitoring cost function with respect to *i* is $\left(\frac{1}{(1-i)^2}\right)\frac{c}{2}L_i^2 > 0$. As index *i* increases, the *i*th marginal bank that engages in monitoring has a higher marginal cost of monitoring loans than the more efficient banks located below *i* on the unit interval. Consequently, in our model the individual bank has rising internal monitoring costs and the aggregate banking system faces rising external monitoring costs. Monitoring is not a zero cost activity.

Why do banks monitor loans in our model? We envisage a loan market in which entrepreneurs borrow funds from banks to finance highly idiosyncratic projects.[3] We also assume that these entrepreneurs will act in a moral-hazard-like fashion by using some of the proceeds of their loans to pay for unproductive activities. Banks are cognizant of this type of behavior and may choose to monitor borrowers to prevent it. For simplicity, we assume that a monitoring bank is always successful in preventing unproductive entrepreneurial behavior, in which case the proportion of non-defaulting loans is α (i.e., the loan default rate is $1-\alpha$). The rate α is assumed to be based on macro factors and thus outside the endogenous influence of both banks and borrowers. If a loan does default, there is no remaining liquidation value. Hence, for a bank engaging in monitoring (an *M* bank), the effective return to lending is $\hat{R}_L^M = \alpha r_L$. To achieve this outcome, however, bank *i* must incur the quadratic monitoring cost, $\left(\frac{i}{1-i}\right)\frac{c}{2}L_i^2$.[4]

Banks that choose not to monitor loans do not incur a monitoring cost. Let δ $\left(0<\delta<\alpha\right)$ represent the effect on the loan payoff rate that results from the hidden action of entrepreneurs who fritter away some of their loan proceeds. From the viewpoint of a non-monitoring (*NM*) bank, therefore, the proportion of non-defaulting loans is $\alpha-\delta$ (i.e., the loan default rate is $1+\delta-\alpha$). The effective return to lending at a bank that does not monitor its loans is therefore $\hat{R}_L^{NM} = (\alpha - \delta)r_L$.[5]

2. Banking Sector Equilibrium without Capital Regulation

We begin by considering an environment in which there is no binding regulatory

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[3] The idea is that bank loans serve a clientele who cannot, in general, finance their projects by issuing debt in the public capital markets. In this sense, bank loans are 'special.'

[4] We also assume that $c \leq f$. This condition implies that monitoring costs at the median bank (i = ½), are no higher than other resource costs associated with lending.

[5] The benefit to monitoring can also be introduced as a continuous variable affecting, say, the size of δ so that there would be a cross-sectional distribution for δ within the banking system. There are, however, technical difficulties with this approach. In our view an either-or framework for δ provides the essential economic insight into the monitoring decision at the micro bank level and does lead to an aggregate cross-sectional distribution for monitoring activity.

capital constraint or any expectation of the imposition of a capital requirement. In this static setting, (5) is nonbinding on decision-making, and banks that monitor their loans maximize (6) subject to (1), (2), (3) and $\hat{R}_L^M = \alpha r_L$. In a static model, maximizing (6) is equivalent to maximizing the market value of equity, which equals the perpetual stream of maximized profits, all of which are paid out as dividends,[6] discounted at the required return on equity. The latter includes the sum of the interest rate, r, and a premium. Factors such as financial risk defined in terms of the leverage ratio (i.e., the ratio of deposits to the market value of equity) can be included in the required return on equity. Within a certainty framework, however, financial risk does not seem to be a relevant factor.[7]

2.1 Optimal Behavior of Monitoring and Non-monitoring Banks

The necessary conditions for profit maximization by a monitoring bank are:

$$\alpha r_L - fL_i - \left(\frac{i}{1-i}\right)cL_i - \lambda_i \geq 0, \tag{8a}$$

$$r_G - gG_i - \lambda_i \geq 0, \tag{8b}$$

$$-r_D - aD_i + \lambda_i(1-\rho) \geq 0, \tag{8c}$$

$$-L_i - G_i + (1-\rho)D_i + \bar{E} \geq 0, \tag{8d}$$

where λ_i is the Lagrange multiplier associated with the balance-sheet constraint at bank *i*. Equations (8a) – (8d) yield the following optimal loan, securities and deposit quantities for a monitoring bank:

$$L_i^M = \frac{[g(1-\rho)^2 + a]\alpha r_L - ar_G - g(1-\rho)r_D + ag\bar{E}}{[fg(1-\rho)^2 + a(f+g)] + c\left(\frac{i}{1-i}\right)[g(1-\rho)^2 + a]}; \tag{9a}$$

[6] Predetermined book equity is consistent with the assumption that all profit is paid out as dividends since in this case retained earnings are zero.
[7] Nonetheless, the model can be solved with financial risk in the required return on equity, although at an increased cost in complexity.

$$G_i^M = \frac{-\alpha r_L + \left[\left(f + c\frac{i}{1-i}\right)(1-\rho)^2 + a\right] r_G + \left(f + c\frac{i}{1-i}\right)(1-\rho) r_D + a\left(f + c\frac{i}{1-i}\right)\overline{E}}{[fg(1-\rho)^2 + a(f+g)] + c\left(\frac{i}{1-i}\right)[g(1-\rho)^2 + a]}; \quad (9b)$$

$$D_i^M = \frac{g(1-\rho) r_L + \left(f + c\frac{i}{1-i}\right)(1-\rho) r_G - \left(f + g + c\frac{i}{1-i}\right) r_D - g\left(f + c\frac{i}{1-i}\right)\overline{E}}{[fg(1-\rho)^2 + a(f+g)] + c\left(\frac{i}{1-i}\right)[g(1-\rho)^2 + a]} \quad (9c)$$

Equations (9a) – (9c) show that L_i^M, G_i^M, and D_i^M depend on the value of *i*. As *i* increases, the marginal monitoring cost of bank *i* shifts upward and the size of the *i*th bank's loan portfolio declines. Thus, the model clearly predicts a cross-sectional negative relation between the optimal quantity of loans and the index *i* for a monitoring bank, while the relation between *i* and both G_i^M and D_i^M is uncertain *a priori*.

Let Ω represent a bank on the margin between whether or not to monitor, so that non-monitoring banks lie in the interval, $\Omega < i < 1$. A non -monitoring bank maximizes (6) with $c = 0$, subject to (1), (2), and (3) but with $\hat{R}_L^{NM} = (\alpha - \delta) r_L$. Given the assumption of identical book equity, all non-monitoring banks maximize the same profit function and thus determine identical optimal quantities for loans, securities and deposits: [8]

$$L_i^{NM} \equiv L^{NM} = \frac{[g(1-\rho)^2 + a](\alpha - \delta) r_L - a r_G - g(1-\rho) r_D + ag\overline{E}}{fg(1-\rho)^2 + a(f+g)}, \Omega < i \leq 1; \quad (10a)$$

$$G_i^{NM} \equiv G^{NM} = \frac{-(\alpha - \delta) r_L + [f(1-\rho)^2 + a] r_G + f(1-\rho) r_D + af\overline{E}}{fg(1-\rho)^2 + a(f+g)}, \Omega < i \leq 1; \quad (10b)$$

$$D_i^{NM} \equiv D^{NM} = \frac{g(1-\rho) r_L + f r_G - (f+g) r_D - fg\overline{E}}{fg(1-\rho)^2 + a(f+g)}, \Omega < i \leq 1. \quad (10c)$$

It is important to define the value of *i* at which the *i*th monitoring bank and all

[8] In contrast to the set of monitoring banks, therefore, the market value of equity is the same for all non-monitoring banks.

non-monitoring banks have loan portfolios of equal size. Let Γ denote the *i*th monitoring bank at which this equivalence occurs. It follows from (9a) and (10a) that the value of Γ , which is independent of both the loan rate and the index *i*, is given by

$$\Gamma \equiv \frac{\delta[fg(1-\rho)^2 + a(f+g)]}{\delta[fg(1-\rho)^2 + a(f+g)] + c\{(\alpha-\delta)[g(1-\rho)^2 + a] + c[g(1-\rho)^2 + a][ag\overline{E} - ar_G - g(1-\rho)r_D]\}} < 1. \quad (10d)$$

A monitoring bank located between 0 and Γ lends *more* than any non-monitoring bank.[9] Note that Γ is independent of both the loan rate and the index i.

2.2 Equilibrium in the Unregulated Banking System

The model is solved by simultaneously determining the equilibrium values of both the market loan rate and the division of the banking system into two subsets of monitoring and non-monitoring banks. The division defines a value of *i*, denoted Ω^*, that represents the marginal monitoring bank. Banks located between Ω^* and 1 comprise the equilibrium class of non-monitoring banks.

The solutions for r_L and Ω are derived by constructing two subsidiary functions, a loan-market equilibrium condition and a profit-equalization condition. We first examine the loan-market condition. Aggregate loan supply (L^S) equals the sum of loans originating in the monitoring (0 - Ω) and non-monitoring (Ω - 1) sectors,

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[9] Increases in $\overline{E}$ and *c* affect Γ negatively. An increase in the exogenous amount of book equity at all banks enhances the lending capacity of each bank. However, when monitoring banks increase their desired lending in response to the increase in book equity, the resulting increase in marginal monitoring costs tends to retard the change in the desired quantity of their bank loans. A similar influence is not present at non-monitoring banks. Thus the size of the loan portfolio of the non-monitoring banks increases relative to that at the ($i = \Gamma$) monitoring bank, and Γ declines. An increase in *c*, the common component of monitoring costs, raises the marginal cost of monitoring that all banks face and thus reduces the set of monitoring banks that could optimally lend more than the typical non-monitoring bank. Increases in δ, r_G and r_D positively affect Γ. Consider an increase in the loan default rate, δ . Lending at non-monitoring banks drops in response to this increase, but has no effect on the optimal behavior of the ($i = \Gamma$) monitoring bank. Essentially, monitoring becomes a more profitable activity and thus Γ increases. Higher rates on government securities and deposits produce the same outcome, because increases in these interest rates generate larger desired loan reductions at non-monitoring banks than at monitoring banks. Essentially, monitoring banks are able to economize on marginal monitoring costs as they reduce loans, which in turn lowers the overall negative impact on their optimal loan quantities in response to the higher securities and deposit rates. By definition, this mechanism is not operative at non-monitoring banks.

$$L^s = \int_0^{\Omega} L_i^M \, di + (1 - \Omega) L_{NM} \tag{11a}$$

It can be shown that the loan supply of monitoring banks is

$$\int_0^{\Omega} L_i^M di = \gamma_M(\Omega) \times \left\{ [g(1-\rho)^2 + a]\alpha r_L - a r_G - g(1-\rho) r_D + ag\overline{E} \right\}, \tag{11b}$$

where $\gamma_M(\Omega)$ is a complicated nonlinear polynomial expression reported in Table 1. Note that as $\Omega \rightarrow 0$, $\gamma_M(\Omega) \rightarrow 0$ and $L^s \rightarrow L_{NM}$; all loans are supplied by non-monitoring banks. At the other extreme, as $\Omega \rightarrow 1$, $\gamma_M(\Omega)$ converges to a value that yields $L^s \rightarrow L_M$ and monitoring banks account for all lending. The *loan market equilibrium (LME) locus* is obtained by equating loan supply in (11a) with loan demand in (4). The resulting equation is a function of r_L and Ω.

Table 1 Goes Here

The *profit-equalization locus* (*EP*) depicts the optimal decision of the marginal monitoring bank defined as $i = \Omega$. For this bank the value of optimal profit must be at least as large as the optimal profit that it would attain if it were operating as a non-monitoring bank. The *EP* condition is derived by first substituting the optimal loan, deposit, and securities equations into the relevant profit functions that apply when operating either as a monitoring or non-monitoring bank. Equalizing the two optimal profit functions then yields a second relation between r_L and Ω. The *LME* and *EP* conditions jointly determine the equilibrium values of the loan rate and Ω, which in turn can be substituted into (11) or (4) to derive aggregate lending. Knowledge of aggregate lending and Ω^* allow us to infer the cross-sectional characteristics of the loan portfolio.

In spite of the simplicity of the basic structure of the model, the functional forms of *LME* and *EP* are complex polynomials, even in the case of portfolio separation with *g* = 0. Nevertheless, over most ranges of parameter values we would expect the *LME* and *EP* loci to have the basic shapes illustrated in panel (a) of Figure 1.

Figure 1 Goes Here

Consider first the *LME* locus. Its slope depends on the sign of the derivative of γ_M with respect to Ω in (11c) and is most likely negative, as drawn in Figure 1. Consider an initial equilibrium at a small value of Ω, so that only the most cost-efficient banks are engaged in monitoring loans. With low loan-monitoring costs, these banks will have larger optimal loan portfolios than non-monitoring banks.[10] As Ω increases, the nominal loans of the newly added monitoring banks will exceed the loan quantity that they had supplied when they were operating as non-monitoring banks (although the difference between the two loan amounts will shrink as Ω increases). The net effect is an ongoing increase in aggregate loan supply, leading to a decline in the market loan rate and thus a negatively sloped *LME* locus.[11]

Now consider the *EP* locus shown in panel (a) of Figure 1. A higher loan rate raises the effective return per dollar of loans at all banks and thus the effective dollar return to the elimination of the δ component of loan default. Non-monitoring banks, therefore, will respond to the higher loan rate by reconsidering their loan-monitoring decision. It is likely that some non-monitoring banks with relatively lower marginal monitoring costs will opt to monitor their loans. This process will continue until a marginal bank (with relatively higher monitoring costs) perceives identical profit whether or not it monitors its loans. This logic defines bank $i = \Omega$ and implies an upward slope

[10] Such an outcome is completely consistent with the Γ value in (10d) that defines the value of i at which the quantities of nominal loans supplied by monitoring and non-monitoring banks are equal.

[11] The *LME* locus is also likely to have a convex shape in this region because loan-monitoring costs increase at the *extensive* margin. This implies that increasingly less efficient banks become part of the Ω sector, which curtails the extent of the rightward shift in loan supply. As a result, the rate of decline in the loan rate subsides. An upward sloping *LME* locus may also exist. As Ω continues to increase towards unity, it is possible that an ever larger proportion of monitoring banks may extend fewer loans relative to the size of their loan portfolios when they had been non-monitoring banks. Such an outcome would have a negative net impact on loan supply, leading to an induced increase in r_L and a positively sloped *LME* locus. Consequently, under certain parameter configurations the *LME* locus can take on a parabolic shape. Other shapes are also possible, given the complexity of the expression for γ_M. However, for the likely values of the model's parameters, *LME* will slope downward, as drawn in Figure 1.

for the *EP* locus, as depicted in panel (a).[12]

At the Ω^*, r_L^* equilibrium in panel (a), the profit of banks lying to the left of Ω^* is higher when monitoring their loans, while banks to the right of Ω^* earn higher profit when not monitoring. Bank $i = \Omega^*$ is indifferent between monitoring and not monitoring; its profit is equivalent either way.[13] As noted above, Ω^* and r_L^* are complex functions of all parameters. This complexity arises partly because nominal loan supply at bank *i* is not itself a smooth function of the variable, *i.* Panel (b) of Figure 1, which depicts equation (11a), illustrates this feature by deriving equilibrium aggregate lending. Conditional on r_L^*, the downward-sloping L_M schedule gives the optimal quantity of lending at monitoring bank *i*, while the horizontal L_{NM} schedule depicts the optimal quantity of loans at non-monitoring banks, which does not depend on *i.* The dashed area below the L_M schedule up to Ω^* represents total lending by monitoring banks, and the area below the L_{NM} schedule to the right of Ω^* gives total lending by non-monitoring banks. The sum of these two areas is aggregate lending.[14] By inspection, aggregate lending is not smooth at $i = \Omega^*$.

Our analysis of capital requirements is based on the cross-section of loans illustrated in panel (b) of Figure 1. The intersection of the L_M and L_{NM} schedules determines Γ. Within the interval $[0, \Gamma)$, monitoring banks lend more than non-

[12] Nonetheless, the *EP* locus does not necessarily slope monotonically upward, because the choice to monitor loans alters the entire structure of a bank's balance sheet, including its holdings of interest-bearing securities and the issuance of interest-expense-generating deposits. Under certain parameter configurations, some banks will choose to monitor their loans in response to a *lower* loan rate. These banks will optimally reduce their loans and deposits and increase their security holdings. Consequently, the upward slope of the *EP* locus depicted in Figure 1 reflects an assumption that the direct loan-market effect on bank loan-monitoring incentives predominates over the possible indirect effects resulting from such portfolio reshufflings. This factor also adds to the complexity of the model's solutions.

[13] There are two additional constraints that must be satisfied at Ω^*, r_L^*. At this equilibrium, $\pi^M(i = \Omega^*) \geq 0$ and $\pi^{NM}(i = \Omega^*) \geq 0$. If these restrictions are not satisfied, banks will exit the banking industry before the Ω^*, r_L^* equilibrium is attained.

[14] We are assuming that $\pi^M(i \to 1) \geq 0$ and $\pi^{NM}(i \to 1) \geq 0$.

monitoring banks while the reverse holds within the [Γ , Ω^*] interval.[15] The model therefore displays a broad cross-section of loan portfolios in the banking system even though all banks have an identical amount of book equity. In particular, some monitoring banks will have smaller loan portfolios than non-monitoring banks. A lower monitoring cost, therefore, does not automatically ensure a larger loan portfolio.

An important implication of the Ω^*, r_L^* equilibrium in panel (a) is that an unregulated banking system produces an equilibrium degree of loan quality. In panel (b), quality could be defined in terms of either Ω^* or the ratio of monitored loans to total loans. Irrespective of the quality measurement used, each monitoring bank incurs increasing *internal* monitoring costs as loans rise to their optimal level. Moreover, the banking-sector equilibrium induces the last bank to monitor its loans. The $i = \Omega^*$ bank defines the *extensive* margin. Thus, at the equilibrium *intensive* and *extensive* margins, the banking system balances the marginal benefits of 'quality" loans (i.e., eliminating the δ component of loan default) with the marginal costs of producing 'quality.'

3. Banking Sector Equilibrium with Regulatory Capital Requirements

In the representative-bank model, capital requirements either do or do not bind *all* banks. In contrast, in our model in which optimal loan portfolios are heterogeneous across banks, requirements typically will bind subsets of both constrained and non-constrained banks.[16] The precise size of each subset and the division between monitoring and non-monitoring banks would depend on the specific value of the capital-requirement ratio in conjunction with the entire set of model parameters. Although we cannot solve for the general case, we can provide insight into the model's assessment of the effects of capital requirements by considering two special cases. In the first case, we assume that

[15] As drawn in panel (b), Γ lies to the left of Ω^*. It is also possible that Γ is greater than Ω^*.

[16] We note that heterogeneous levels of predetermined book equity would also imply a cross-sectional distribution of loan quantities. However, this cross section would not be based on decisions regarding the endogenous exposure to loan default. Thus, the motivation for capital requirements would be problematic within such a framework.

the (unexpected) imposition of capital requirements affects only banks that had extended relatively large quantities of loans when unconstrained. The second case examines the standard assumption of universally binding capital requirements. We discuss whether our findings can be applied to slightly more realistic cases in the Appendix.

3.1 Binding Capital Requirements for a Subset of Monitoring Banks and All Non-Monitoring Banks

Recall that Γ defines the set of monitoring banks that extend at least as many loans as the set of non-monitoring banks. We illustrate the effects of capital requirements by assuming that these requirements bind the $[0, \Gamma]$ subset of monitoring banks, where $\Gamma < \Omega^*$, and that all non-monitoring banks have an initial <u>notional</u> loan quantity equal to the constrained amount, $\frac{\overline{E}}{\theta}$. By construction, therefore, the notional loan quantity of the monitoring banks in the $[0, \Gamma]$ interval exceeds $\frac{\overline{E}}{\theta}$. Because L_{NM} equals $\frac{\overline{E}}{\theta}$ in this situation, aggregate loan supply is $L^s = \Gamma\frac{\overline{E}}{\theta} + \int_{\Gamma}^{\Omega} L_i^M di + (1 - \Omega)\frac{\overline{E}}{\theta}$. Thus, capital requirements are partially binding across the banking system because monitoring banks between Γ and Ω^* are not bound.

The *LME* function for this case is

$$r_L = \frac{l_0 + \tilde{\gamma}_M(\Omega, \Gamma) \times [ar_G + g(1-\rho)r_D - ag\overline{E}] - [1-(\Omega - \Gamma)]\frac{\overline{E}}{\theta}}{l_1 + \tilde{\gamma}_M(\Omega, \Gamma) \times \alpha[g(1-\rho)^2 + a]}, \tag{12}$$

where the value of $\tilde{\gamma}_M(\Omega, \Gamma)$ is reported in Table 1. Assuming portfolio separation (g = 0), $c \leq f$, and $l_0 > \frac{\overline{E}}{\theta}$, we have that $\frac{\partial r_L}{\partial \Omega} < 0$ in (12). Thus, when all non-monitoring banks (at least initially) and the constrained $[0, \Gamma]$ monitoring banks have identical loan portfolios, the *LME* locus slopes downward. We continue to assume that the *EP* locus slopes upward over the relevant range of Ω.

Figure 2 provides a graphical analysis of the adjustment of the banking system. In panel (a), the solid *LME* and *EP* curves represent the initial *unconstrained* case with Ω^* the initial equilibrium proportion of monitoring banks and r_L^* the corresponding equilibrium loan rate. Capital requirements are then imposed in such a way that the constrained loan quantity for $[0, \Gamma]$ monitoring banks and the notional loan quantity for all non-monitoring banks have the same value, $\frac{\bar{E}}{\theta}$. With respect to *LME*, the binding capital constraint reduces lending by the $[0, \Gamma]$ monitoring banks. This reduction represents the difference between the notional quantity of loans and the constrained quantity and is shown as region A in panel (b) of Figure 2. As a result, the market loan rate tends to increase at Ω^*, and the *LME* locus shifts upward to LME'.

Figure 2 Goes Here

Regarding the *EP* locus, consider the decision of non-monitoring banks in the $(\Omega^*, 1)$ region. As the market loan rate rises above r_L^*, the L_M and L_{NM} schedules shift to L'_M and L'_{NM} in panel (b) of Figure 2. According to our assumption for this case, non-monitoring banks cannot achieve the notional loan quantity given by L'_{NM}. Thus, the equal-profit tradeoff for these non-monitoring banks is not based on the notional loan quantities along L'_{NM} and L'_M (as occurs on *EP* in the unconstrained case) but rather on the constrained loan quantity, $\frac{\bar{E}}{\theta}$ and the notional loan quantity, L'_M. With $\frac{\bar{E}}{\theta}$ strictly less than the notional L'_{NM} value, the profit to continuing to <u>not</u> monitor loans declines within the $(\Omega^*, 1)$ region. At loan rates above r_L^*, therefore, monitoring will be initiated by a larger set of non-monitoring banks relative to the size of the set given by the unconstrained *EP* locus. This reasoning implies that the *EP* locus shifts rightward as represented by EP' in panel (a) of Figure 2.

Given the extent of the shifts in *LME* and *EP*, the net effects are an increase in the equilibrium loan rate to $r_L^{*\prime}$ and a rightward shift in the location of the marginal monitoring bank to $\Omega^{*\prime}$. The latter is an especially desirable outcome for capital regulation as long as the movement to $\Omega^{*\prime}$ signifies an increase in monitoring activity within the banking system. But will all banks that *had* monitored their loans in an unconstrained environment continue to monitor once they are bound by capital requirements? The answer is no. The imposition of capital requirements changes the monitoring decision of some of the intra-marginal banks lying within the $(0, \Gamma)$ interval. Once lending by these banks, which had monitored at the initial unconstrained Ω^* equilibrium, is constrained to $\frac{\overline{E}}{\theta}$ by the binding capital requirement, these banks will select a <u>second-best</u> portfolio allocation. Substituting $\frac{\overline{E}}{\theta}$ and (12) into (6) and noting that monitoring banks in the $(0, \Gamma)$ interval regard the monitoring cost, $\left(\frac{i}{1+i}\right)\frac{c}{2}\left(\frac{\overline{E}}{\theta}\right)^2$, as predetermined, profit maximization yields identical <u>second-best</u> security and deposit quantities for both the set of non-monitoring banks and the capital-constrained $(0, \Gamma)$ subset of monitoring banks:

$$\hat{G}_i^{M} = \hat{G}_i^{NM} = \frac{(1-\rho)^2 r_G - (1-\rho)r_D + a\left(\frac{1-\theta}{\theta}\right)\overline{E}}{g(1-\rho)^2 + a}; \tag{13a}$$

$$\hat{D}_i^{M} = \hat{D}_i^{NM} = \frac{(1-\rho)r_G - r_D + g(1-\rho)\left(\frac{1-\theta}{\theta}\right)\overline{E}}{g(1-\rho)^2 + a}. \tag{13b}$$

In this second-best situation, banks that *would* have monitored their loans now will do so only if their profit is at least as large as the profit earned by non-monitoring banks. Specifically, monitoring by banks located in the $(0, \Gamma)$ interval will continue to occur as long as the net return on monitored loans, $\alpha r_L \frac{\overline{E}}{\theta} - \left(\frac{i}{1+i}\right)\left(\frac{c}{2}\right)\left(\frac{\overline{E}}{\vartheta}\right)^2$, is at least as large as the net return on unmonitored loans, $(\alpha-\delta)r_L$. This condition will hold for the set of banks within the interval $0 \le i \le \Lambda$, where $\Lambda \equiv \frac{\delta r_L}{\left(\frac{c}{2}\right)\left(\frac{\overline{E}}{\theta}\right) - \delta r_L}$, which can be shown to be strictly less than Γ for reasonable ranges of parameter values.[17] Note that compared to the pre-capital-requirement equilibrium, (13a) and (13b) indicate that security holdings and deposits are identical for both the subset of $(0, \Gamma)$ banks that continues to monitor in the capital-constrained environment $(0, \Lambda)$ and the subset that ceases monitoring (Λ, Γ). Hence, only the parameters governing the trade-off between monitoring costs and the extent of the resulting reduction in the loan default rate directly influence the decision whether to continue to monitor for these two subsets of banks. The other parameters enter this decision indirectly through their influence on the market loan rate and then on the magnitude of Λ.

Given our particular specification of capital requirements, what is the induced change in aggregate loan quality? Regarding the division of banks into monitoring and non-monitoring groups, previously monitoring banks in the $(0, \Lambda)$ interval continue to monitor loans while banks in the (Λ, Γ) interval cease their monitoring activities. However, the equilibrium value of Ω rises from Ω^* to $\Omega^{*\prime}$. Thus, banks in the $(\Omega^*, \Omega^{*\prime})$ interval, which had not monitored their loans when capital requirements were not in force, optimally *switch* to monitoring activity. Note that the imposition of capital requirements does not directly constrain the endogenous choices of these banks; they willingly switch because of the induced increase in the market loan rate. The net effect on the relative sizes of the two classes of banks depends, therefore, on all of the structural parameters of the model.

The implications of the model for the quantity and 'quality' of the aggregate loan portfolio are illustrated in panel (b) of Figure 2. Area *B* represents loans that are no longer monitored; they are exposed to a higher default rate and can be viewed as lower quality loans. The newly monitoring $(\Omega^*, \Omega^{*\prime})$ banks optimally choose to reduce their (previously unmonitored) lending by area *C*. Nonetheless, the loans that they do extend,

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[17] The specific condition for $\Lambda < \Gamma$ is $\dfrac{\overline{E}}{\theta} > \dfrac{2a}{c}\left[2\delta f + (\alpha - \delta)c - ar_G\right]r_L$.

given by area D, are now monitored. Finally, the increase in the equilibrium loan rate induces a change in the desired loan portfolio of monitoring banks in the (Γ, Ω^*) interval. There are two sets of monitoring banks in this interval. Banks in the (Γ, Φ) subset increase their lending to the capital-constrained level of loans, $\frac{\overline{E}}{\theta}$, while the unconstrained banks in the (Φ, Ω^*) subset increase their notional lending to the quantity given by the dashed $L_M{}'$ curve. The sum of these two changes is given by area E.

In the new ($\Omega^{*\prime}$, $r_L^{*\prime}$) equilibrium, aggregate bank lending declines by the sum $A + C - E$, while the size of the net increase in quality (safer) loans is given by the sum, $E + D - A - B$. The regulatory agency must be concerned about the size of these two areas since an important aim of capital requirements is to increase the 'safety' of the banking system. Clearly, the effect of the exogenous α component of the loan default rate is attenuated because the aggregate quantity of bank loans declines and bank holdings of government securities increase.[18] With regard to the δ component of the loan default rate, the net effect on 'quality' is uncertain *a priori*, both absolutely and as a proportion of the quantity of outstanding loans. Because capital requirements are in the nature of a tax, the private banking system responds to the imposition of the tax by altering the manner in which it conducts business. In our model, loan quality—that is, the management of exposure to a borrower's moral hazard behavior—is an endogenous activity. Capital requirements have the unintended effect of reducing the scope of loan-monitoring activity by a subset of efficient producers of quality loans. Thus, overall loan quality, as measured by exposure to the δ default rate, is not necessarily enhanced by capital requirements.

Moreover, it is almost certain that the total social cost of loan-monitoring is relatively higher in a partially binding capital requirement regime compared to an unregulated banking system. This result occurs because banks in the (Ω^*, $\Omega^{*\prime}$) interval

[18] This implies that banks tend to bear a greater resemblance to money market mutual funds.

in panel (b) of Figure 2 are induced to become monitors. From society's point of view, these are higher cost monitoring banks compared to the lower cost banks in the (Λ, Γ) interval that no longer engage in monitoring. Thus, the net effect of capital requirements is to assign monitoring activity to inherently less efficient monitors. Not only are capital requirements problematic for enhancing aggregate loan quality, but they also interfere with the most cost-effective allocation of scarce resources.

3.2 The Case of Binding Capital Requirements for All Banks

We now examine the very stringent case in which capital requirements (unexpectedly) bind *all* banks to a loan quantity that is below their unconstrained notional amount. We analyze this case for two reasons. First, it provides the closet analogue of our model to the standard representative-bank model. Second, it allows us to determine an upper limit to the efficacy of capital requirements.

The assumed capital requirement implies that (5) holds as an equality for the entire banking system and that all banks are constrained to the loan quantity $\hat{L} = \frac{\overline{E}}{\theta}$.

Equating aggregate loan demand and supply yields the *LME* locus,

$$\hat{r}_L = \frac{l_0 - \frac{\overline{E}}{\theta}}{l_1}, \tag{14}$$

By inspection, in a fully capital-constrained banking system (14) is independent of Ω.

In this setting, each bank treats $\hat{L}$ as a binding constraint and re-optimizes by maximizing (6) with respect to securities and deposits, which yields identical securities and deposit quantities for *all* monitoring and non-monitoring banks, as given by (13a) and (13b). Substituting these expressions and $\hat{L} = \frac{\overline{E}}{\theta}$ into (6) and equalizing profit for the marginal monitoring/non-monitoring bank gives the following *EP* locus:

$$\hat{r}_L = \frac{1}{2}\left(\frac{\Omega}{1-\Omega}\right)\left(\frac{c}{\delta}\right)\left(\frac{\overline{E}}{\theta}\right). \tag{15}$$

In contrast to the case of partially constraining capital requirements, the universally constrained case can be solved for the equilibrium value of Ω:

$$\hat{\Omega} = \frac{l_0\left(\frac{\overline{E}}{\theta}\right)^{-1} - 1}{l_0\left(\frac{\overline{E}}{\theta}\right)^{-1} - 1 + \frac{1}{2}l_1\left(\frac{c}{\delta}\right)}. \tag{16}$$

Assuming that $l_0 > \frac{\overline{E}}{\theta}$, $\hat{\Omega}$ lies between 0 and 1. An immediate implication of this variant of the basic model is that the imposition of universally binding capital requirements does not completely eliminate the influence of the δ component of loan default. Non-monitoring banks continue to play a role in the banking system.

A graphical depiction of the determination of $\hat{\Omega}$ appears in panel (a) of Figure 3. The solid lines graph the initial unconstrained equilibrium, while the dashed lines represent the *EP* and *LME* loci in which the banking system is universally constrained by regulatory capital requirements. The dashed *EP* locus has an unambiguous positive slope.[19] As noted above, the dashed *LME* locus is independent of Ω. Because aggregate bank lending is reduced under a universally binding constraint, the market loan rate increases, as does the share of banks that monitor their loans. Moreover, (16) indicates that in contrast to Ω^*, whose value is determined by all the structural parameters pertaining to bank behavior, the value of $\hat{\Omega}$ depends only on factors affecting the trade-off between loan monitoring costs and the default rate δ. This result arises because in this case all banks are constrained to the loan quantity, $\frac{\overline{E}}{\theta}$, which is below the notional amount of even the smallest-sized bank. In contrast to Figure 2, *every* bank in Figure 3 views both its loans and associated monitoring costs (if monitoring) as predetermined.

Because monitoring costs play no role at the margin and banks are assumed to be identical in every other aspect, all banks' balance sheets are identically configured. The

[19] We graph this locus below the original *EP* locus, although the shift is in fact uncertain.

monitoring decision of each bank, therefore, depends solely on the influence of δ and c on the second-best level of profit. All banks to the left of $\hat{\Omega}$ choose to monitor their loans, while all banks to the right of $\hat{\Omega}$ choose not to do so.[20] Within this stringent capital requirement regime, therefore, the regulatory authority may reduce the scope of non-monitored loans, but it can *never* eliminate them entirely. Moreover, as discussed previously, any enhancement in loan quality comes at the expense of a misallocation of real monitoring resources. Stringent capital requirements induce the replacement of relatively efficient monitoring activity with less efficient monitoring.[21]

Figure 3 Goes Here

Suppose now that the banking system is at the ($\hat{\Omega}$, $\hat{r}_L$) equilibrium in Figure 3 and that the regulator implements even tighter capital requirements. Both the market loan rate and the equilibrium value of Ω rise. In this case it can also be shown that the proportion of monitored to total loans rises. Thus, only in this extreme case that has heretofore received the greatest attention in the literature—yet which arguably is the least realistic—is it possible to reach an unequivocal judgment that capital requirements contribute positively to aggregate loan quality. While loan quality is higher, it is achieved, however, at the expense of a further reduction in aggregate lending, a higher

[20] It can be shown that an area such as *B* in Figure 2 does not exist in the universally binding capital requirements case. In particular, r_L rises sufficiently to shrink area B to zero in panel (b) of Figure 3.

[21] Panel (b) of Figure 3 graphs the loan-supply effects of universally binding capital requirements. The solid lines represent the initial unconstrained equilibrium. As the loan rate rises, the notional L_M and L_{NM} schedules shift upward. Because all banks are effectively constrained to lend no more than $\frac{\bar{E}}{\theta}$, total market lending declines to the rectangular area beneath the dashed horizontal $\frac{\bar{E}}{\theta}$ line in panel (b). Relative to the initial equilibrium, aggregate lending by the banking system declines by the dashed area labeled *A*. This result is similar qualitatively to the case of partially binding capital requirements. In addition, given the increase of Ω to $\hat{\Omega}$, more banks engage in monitoring (in contrast to the ambiguous result under partially binding requirements) but the proportion of monitored to total loans may rise or fall, depending on the induced changes in total loans and Ω. The latter ambiguity remains, therefore, as we move from partially to universally binding capital requirements.

market loan rate, and a greater misallocation of monitoring resources.

4. Conclusion

Real-world banks differ from each other in a variety of attributes. We focus on one specific aspect that seems especially important for questions dealing with the effects of capital requirements on 'loan quality.' In our model banks that have otherwise identical characteristics are assumed to possess different skill levels when engaged in loan monitoring activities. We first analyze a banking system that is not constrained by capital regulations and show that each bank's decision to monitor is endogenous, which thereby endogenizes the entire banking system's aggregate exposure to loan default. We then introduce various forms of capital requirements and investigate their effect on the behavior of banks and the endogenous level of default. Except in one extreme case, our findings indicate that regulatory capital requirements have an ambiguous effect on aggregate loan quality. Moreover, even if capital requirements reduce the extent of loan defaults, they accomplish this outcome by inducing a misallocation of monitoring activity within the banking system. Less efficient loan monitors tend to replace more efficient monitors, resulting in an increase in the real resource costs expended by the banking system on monitoring activity.

Appendix

The two capital-constrained banking environments in sections 3.1 and 3.2 are special cases that depend on defining a capital requirement ratio in terms of specific aspects of aggregate nominal loan supply within an unregulated banking system. Of the two, the latter corresponds to the case most often discussed in the literature because it exhibits most of the characteristics of a representative-bank model. Nevertheless, the former is arguably more indicative of the types of ambiguities that are likely to emerge in practice when the banking system is only partially constrained by capital requirements.

We briefly discuss two alternative settings for the capital requirement ratio. In Figure 2, suppose capital requirements are loosely set such that they do not affect notional lending by non-monitoring banks, even taking into account a positive induced loan-supply response arising from an increase in the equilibrium loan rate. In this case, the size of area *A,* which represents a reduction in lending by now-constrained monitoring banks, would not change. Area *B* might also remain unchanged because when forced to lend below their notional loan quantity, some re-optimizing monitoring banks with higher marginal monitoring costs may perceive effective loan returns insufficient to justify a continuation of their monitoring activity and thus decide to become non-monitoring banks. This outcome is not, however, pre-ordained (as it is in the specific situation illustrated in Figure 2), because the decision to monitor would depend not only on the parameters governing the trade-off between monitoring costs and the elimination of the δ component of loan default but on all of the structural parameters pertaining to bank behavior. Consequently, a number of possible outcomes could arise for the area analogous to *B*, depending on the vector of structural parameters. Areas such as *C* and *D* would most certainly be smaller because aggregate lending would not decline as much as depicted in Figure 2. The extent of the shift in *LME* would thereby be curtailed, leading to a smaller change in the number of non-monitoring banks that opt to monitor their loans. Finally, the change in Area *E* would depend on the size of the induced increase in the market loan rate. The net effect on the proportions of both monitoring banks and monitored loans would remain ambiguous. Although total lending would be lower, some of the reduction in lending would consist of loans that had previously been monitored. The overall effect on loan quality would continue to be ambiguous.

As a second case, suppose that the capital requirement ratio is set higher than the level assumed in Figure 2 so that *all* non-monitoring banks are strictly bound by capital requirements.[22] In this case, panel (b) in Figure 2 would be slightly more complicated. The horizontal $\frac{\overline{E}}{\theta}$ schedule would intersect the L_M schedule to the right of and below the intersection shown in Figure 2. A larger fraction of monitoring banks and *all* non-monitoring banks would be immediately constrained. Area *A* would certainly be larger than that in Figure 2. Depending on the increase in the market loan rate, however, the sizes of areas *B, C, D,* and *E* could be larger or smaller. Although aggregate bank lending would decline, the overall effect on loan quality would remain uncertain. Thus, while Figure 2 graphs a very special capital-requirement case among numerous possibilities, it does provide a fairly complete illustration of the basic implications of the imposition of capital requirements in a banking system with heterogeneous loan monitoring costs. Market loan rates rise, and lending declines, but the effect on loan quality is theoretically indeterminate.

[22] Recall that in Figure 2 the capital requirement ratio is set such that the notional quantity of loans at non-monitoring banks is equal initially to the capital-constrained quantity of loans. Thus in Figure 2 notional loans at non-monitoring banks are not strictly bound.

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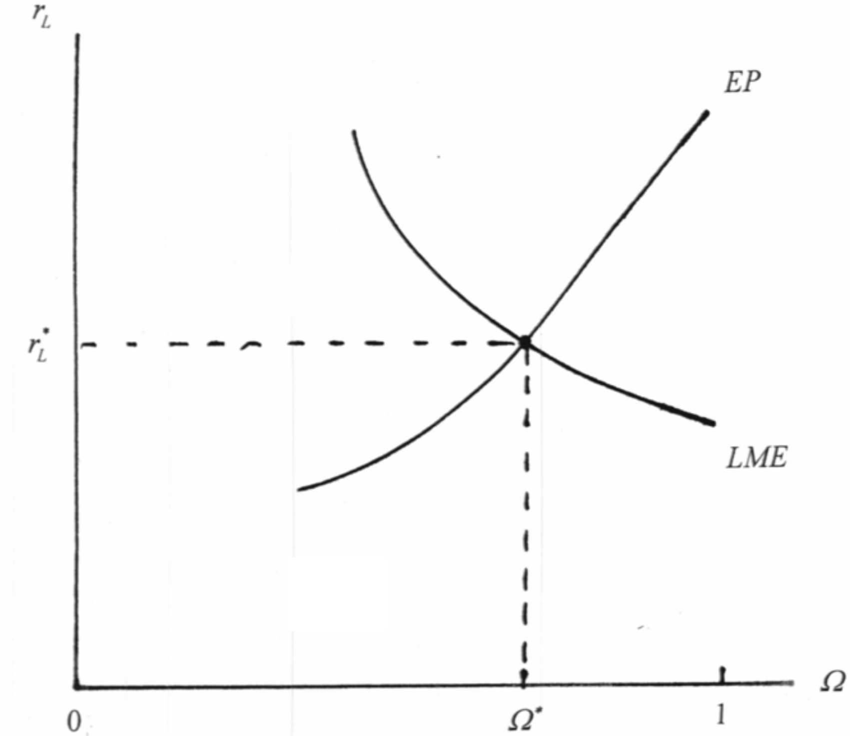
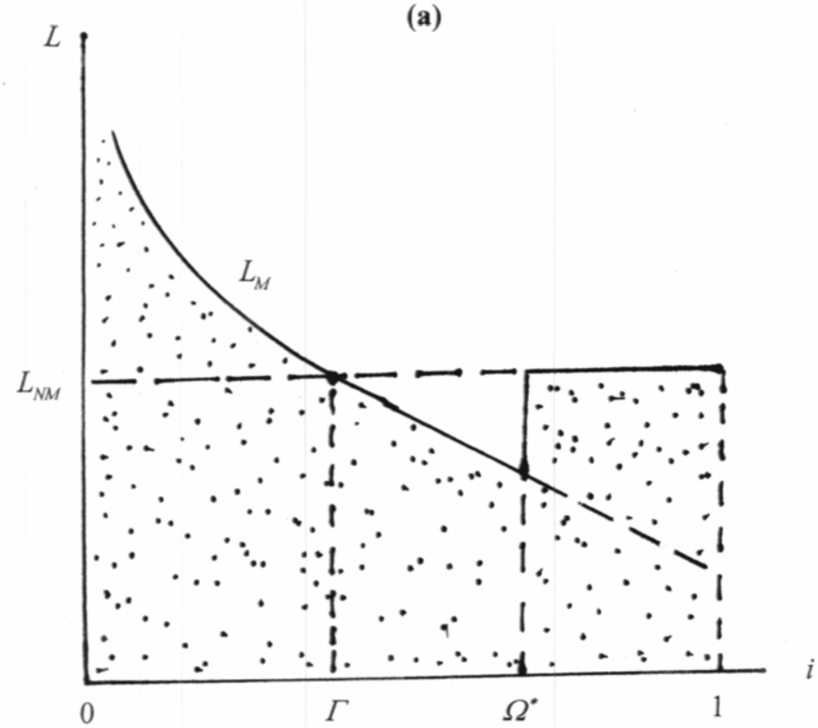
Figure 1

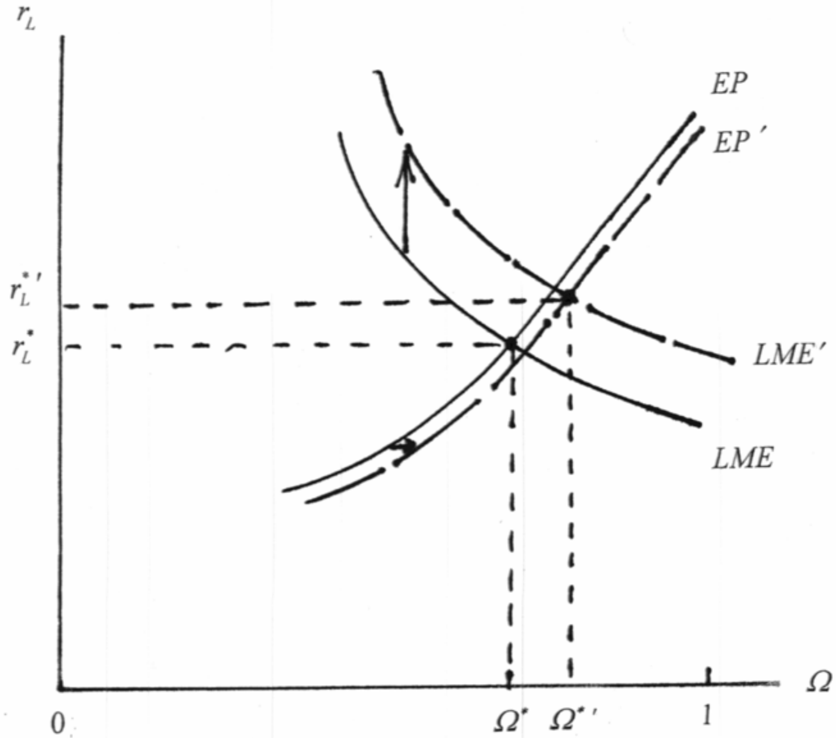


(a)



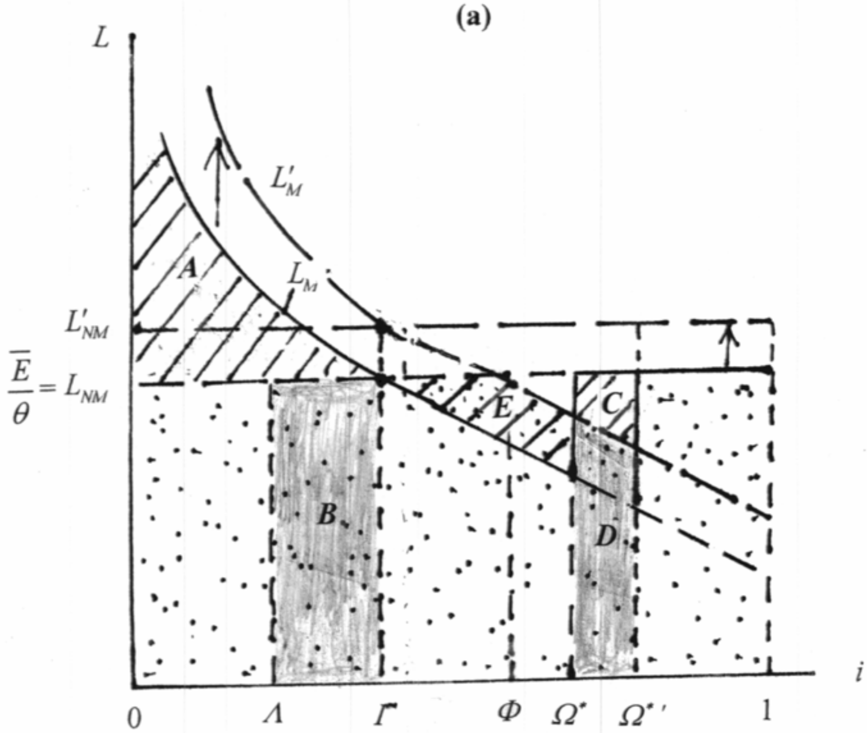
(b)

Figure 2



r_L
EP
EP ′
$r_L^{*}{}'$
r_L^{*}
LME′
LME
Ω
0
Ω*
Ω*′
1

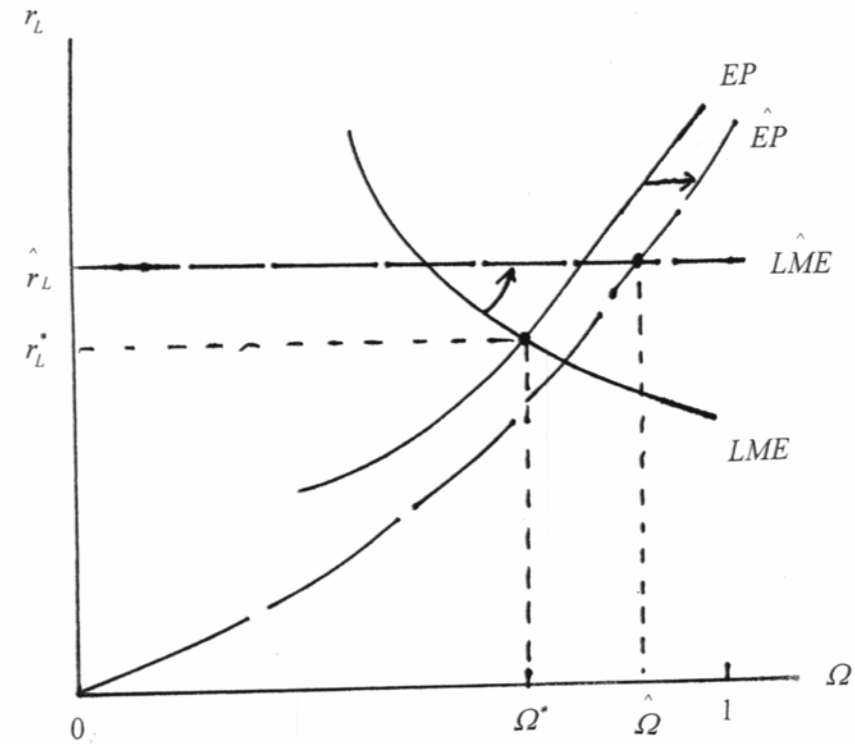
(a)



L
L'_M
A
L_M
L'_{NM}
$\frac{\overline{E}}{\theta} = L_{NM}$
E
C
B
D
i
0
Λ
Γ
Φ
Ω*
Ω*′
1

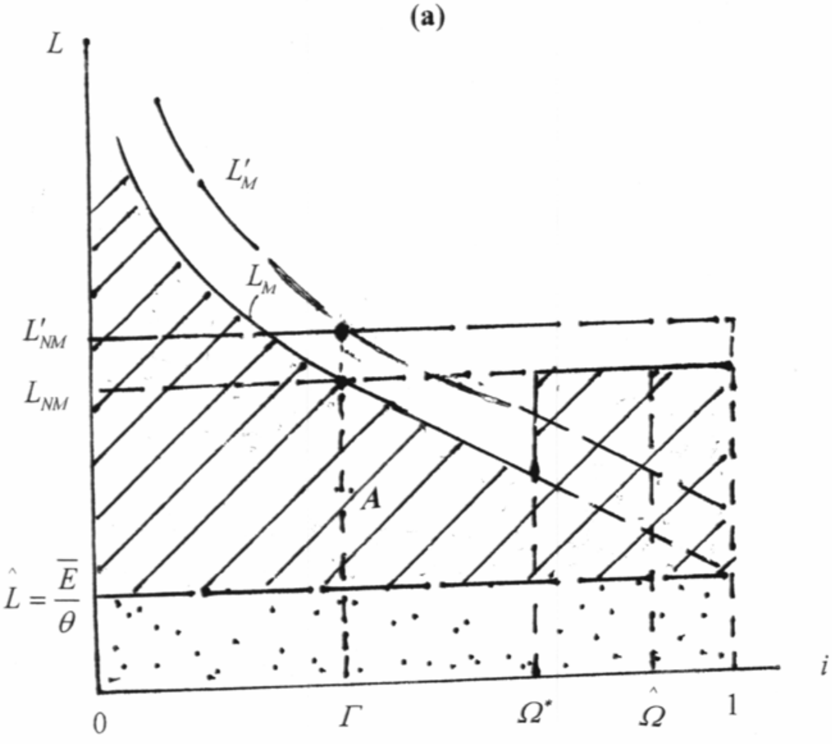
(b)

Figure 3



r_L
EP
$\hat{EP}$
$\hat{r}_L$
r_L^*
$\hat{LME}$
LME
Ω
0
Ω^*
$\hat{\Omega}$
1

(a)



L
L'_M
L_M
L'_{NM}
L_{NM}
A
$\hat{L} = \dfrac{\overline{E}}{\theta}$
i
0
Γ
Ω^*
$\hat{\Omega}$
1

(b)

Table 1

$$\gamma_M(\Omega) \equiv \int_0^{\Omega} \left(\frac{1-i}{[(1-i)f + ci]g(1-\rho)^2 + a[(1-i)(f+g) + ic]} \right) \mathrm{d}i$$

$$= \frac{\{[fg(1-\rho)^2 + a(f+g)] - c[g(1-\rho)^2 + a]\}\Omega + c[g(1-\rho)^2 + a] \ln \left[\frac{[fg(1-\rho)^2 + a(f+g)] + \{c[g(1-\rho)^2 + a] - [fg(1-\rho)^2 + a(f+g)]\}\Omega}{fg(1-\rho)^2 + a(f+g)} \right]}{\{c[g(1-\rho)^2 + a] - [fg(1-\rho)^2 + a(f+g)]\}^2}.$$

$$\tilde{\gamma}_M(\Omega, \Gamma) \equiv \frac{\{[fg(1-\rho)^2 + a(f+g)] - c[g(1-\rho)^2 + a]\}(\Omega - \Gamma) + c[g(1-\rho)^2 + a] \ln \left[\frac{[fg(1-\rho)^2 + a(f+g)] + \{c[g(1-\rho)^2 + a] - [fg(1-\rho)^2 + a(f+g)]\}\Omega}{[fg(1-\rho)^2 + a(f+g)] + \{c[g(1-\rho)^2 + a] - [fg(1-\rho)^2 + a(f+g)]\}\Gamma} \right]}{\{c[g(1-\rho)^2 + a] - [fg(1-\rho)^2 + a(f+g)]\}^2}.$$