DISCUSSION PAPER SERIES

No. 1237

BANKING SCOPE, FINANCIAL INNOVATION, AND THE EVOLUTION OF THE FINANCIAL SYSTEM

Arnoud W A Boot and Anjan V Thakor

FINANCIAL ECONOMICS

Centre for Economic Policy Research

ISSN 0265-8003

BANKING SCOPE, FINANCIAL INNOVATION, AND THE EVOLUTION OF THE FINANCIAL SYSTEM

Arnoud W A Boot and Anjan V Thakor

Discussion Paper No. 1237
September 1995

Centre for Economic Policy Research
25–28 Old Burlington Street
London W1X 1LB
Tel: (44 171) 734 9110

This Discussion Paper is issued under the auspices of the Centre's research programme in **Financial Economics**. Any opinions expressed here are those of the author(s) and not those of the Centre for Economic Policy Research. Research disseminated by CEPR may include views on policy, but the Centre itself takes no institutional policy positions.

The Centre for Economic Policy Research was established in 1983 as a private educational charity, to promote independent analysis and public discussion of open economies and the relations among them. It is pluralist and non-partisan, bringing economic research to bear on the analysis of medium- and long-run policy questions. Institutional (core) finance for the Centre has been provided through major grants from the Economic and Social Research Council, under which an ESRC Resource Centre operates within CEPR; the Esmée Fairbairn Charitable Trust; and the Bank of England. These organizations do not give prior review to the Centre's publications, nor do they necessarily endorse the views expressed therein.

These Discussion Papers often represent preliminary or incomplete work, circulated to encourage discussion and comment. Citation and use of such a paper should take account of its provisional character.

CEPR Discussion Paper No. 1237

September 1995

ABSTRACT

Banking Scope, Financial Innovation, and the Evolution of the Financial System*

This paper explores the implications of financial system design for financial innovation. We begin with assumptions about the investment opportunities of firms, their observable attributes, and the roles of commericial banks, investment banks, and the financial market. We examine the borrower's choice between bank and financial market funding, the commercial bank's choice of monitoring capacity, and the investment bank's choice of whether to invest in financial innovation. Our main result is that financial innovation in a universal banking system is stochastically lower than innovation in a financial system in which commercial and investment banks are functionally separated. This result is accompanied by a host of policy implications regarding the effects of fragmentation and the evolution of financial systems.

JEL Classification: G10, G24
Keywords: banking scope, financial innovation, financial system design

Arnoud W A Boot
FEE/Department of Financial Management
University of Amsterdam
Roeterstraat 11
1018 WB Amsterdam
THE NETHERLANDS
Tel: (31 20) 525 4272

Anjan Thakor
Finance Department
School of Business
Indiana University
Bloomington
IN 47405
USA
Tel: (1 812) 855 7972

*This paper is produced as part of a CEPR research programme on *Finance in Europe: Markets, Instruments and Institutions*, supported by a grant from the Commission of the European Communities under its Human Capital and Mobility Programme (no. ERBCHRXCT940653). Thakor would like to thank the NBD Chair in Finance for financial support. The authors thank Anjolein Schmeits (in particular) and Kathleen Petrie for research assistance, participants at the NYU/Salomon Brothers Conference on Universal Banking and finance workshops at the University of Miami and the University of Utah for their helpful comments.

Submitted 4 August 1995

NON-TECHNICAL SUMMARY

The paper explores how the structure of a country's financial sector affects incentives for financial innovation. In particular, we examine the impact of banking scope – the choice between universal and functionally separated banking – on the incentives of institutions to engage in financial innovation. This issue is of great importance for analysing the efficiency of bank-dominated systems *vis-à-vis* market-dominated systems (e.g. Germany versus the United States). In addition to explaining how financial innovation is influenced by banking scope, the analysis sheds light on a host of related system design issues, such as the desirability of concentration in banking, the potential 'path dependence' in the evolution of the financial system, and the desirable starting point of a new financial system. The latter is particularly relevant for the emerging economies in Eastern Europe.

Our analysis thus points to the many important effects that financial system design is likely to have on credit allocation and economic development. The ramifications of this for the structuring of financial systems in ex-communist economies are transparent and echoed in the following quote from *The Economist* (1994):

> *Yet the German model may not be suitable for economies that are making the painful transition from central planning to capitalism. One priority should be to create a stable banking system that wins depositor's trust while allocating credit on the basis of market forces. A second should be to encourage a rapid structuring of the hugely inefficient industries that central planning has created. And a third should be to promote the development of efficient and competitive capital markets. An unthinking dash for a universal-banking system could make it harder to meet any of these priorities.*

We have focused in our analysis on the impact of two key aspects of financial system design on financial innovation – the degree to which the banking system is functionally separated (or universal) *and* the degree of fragmentation in the banking system. *Both* aspects are important in driving our results. Most importantly, we establish a deleterious effect of universal banking on financial innovation. This result presupposes a high degree of consolidation with universal banking. Without such consolidation, a universal bank would *not* discern a dampening of the demand for its loan due to its own financial innovation. Thus, in a very fragmented universal banking system – we are

unaware of any such system in the real world – financial innovation would not be discouraged by the universal nature of banking.

Academic research has kept abreast of the practical interest in this topic. There are three strands of the literature that are relevant. First is the research on financial innovation and security design (see, for example, Allen and Gale (1988, 1991, 1994b), Boot and Thakor (1993), Duffie and Rahi (1995) and Yun (1994)). This literature seeks to explain what motivates financial innovation and how securities are designed, priced and marketed. A second literature – that has grown somewhat independently – is concerned with the policy question of banking scope, i.e. whether the banking system should contain functionally separated commercial and investment banks or universal banks (see, for example, Berlin, John and Saunders (1994), Kanatas and Qi (1994), Puri (1994), Rajan (1993), and Kroszner and Rajan (1994a, 1994b)). The focus here has largely been on potential conflicts of interest associated with universal banking. More recently, attention has focused on the broader issue of *financial system design* (see, for example, Allen (1992), Allen and Gale (1994a), Boot and Thakor (1995), Neave and Johnson (1993), and Sabani (1992)). This literature has sought to address a comprehensive set of questions concerned with the manner in which financial system design impinges on individual risk sharing opportunities, the allocation and cost of capital for corporations, corporate governance, and the restructuring of firms in financial distress. Since the design of contracts, institutions and markets, as well as the determination of banking scope, are all part of the details of how a financial system should be configured, the emerging literature on financial system design promises to provide valuable unifying insights.

BANKING SCOPE, FINANCIAL INNOVATION

AND THE EVOLUTION OF THE FINANCIAL SYSTEM

> Perhaps it is this specter that most haunts the working men and women: the planned obsolescence of people that is of a piece with the planned obsolescence of the things they make.
> STUDS TERKEL

I. INTRODUCTION

We study the implications of alternative designs of the financial system with a view to improving our understanding of the pros and cons of functionally separated banking (the U.S. system, for example) *vis a vis* universal banking (the German system, for example). There has been a great deal of practical interest in this subject as exemplified by the following quote from *The Economist (1994)*:[1]

> What do the Porsche 911 and Deutsche Bank have in common? The answer is that both these German creations are widely considered to be perfect models--and nowhere more so than in Central Europe. While car lovers around the world admire the Porsche's sleek lines, bankers and policy makers in Warsaw, Prague and Budapest are impressed by lines of another kind: those on Deutsche's balance sheet...This model of "universal" banking has sometimes been seen as a cornerstone of Germany's post-war economic success. Unsurprisingly, neighboring countries that are rebuilding their financial systems from the rubble of communism are tempted to copy it. That would be a mistake.

Academic research has kept abreast of the practical interest in this topic. There are three strands of the literature that are relevant. First is the research on financial innovation and security design (see, for example, Allen and Gale (1988,1991,1994b), Boot and Thakor (1993), Duffie and Rahi (1995) and Yun (1994)). This literature seeks to explain what motivates financial innovation and how securities are designed, priced and marketed. A second literature -- that has grown somewhat independently -- is

---

[1] See "Central Europe's Model Bank", *The Economist*, August 27 - September 2, 1994.

concerned with the policy question of banking scope, i.e., whether the banking system should contain functionally separated commercial and investment banks or universal banks (see, for example, Berlin, John and Saunders (1994), Kanatas and Qi (1994), Puri (1994), Rajan (1993), and Kroszner and Rajan (1994a, 1994b)). The focus here has largely been on potential conflicts of interest associated with universal banking. Somewhat more recently, attention has focused on the broader issue of *financial system design* (see, for example, Allen (1992), Allen and Gale (1994a), Boot and Thakor (1995), Neave and Johnson (1993), and Sabani (1992)). This literature has sought to address a comprehensive set of questions, concerned with the manner in which financial system design impinges on individual risk sharing opportunities, the allocation and cost of capital for corporations, corporate governance, and the restructuring of firms in financial distress. Since the design of contracts, institutions and markets, as well the determination of banking scope, are all part of the details of how a financial system should be configured, the emerging literature on financial system design promises to provide valuable unifying insights.

This paper focuses on the effect of financial system design on financial innovation. In particular, we examine the impact of banking scope -- the choice between universal and functionally separated banking -- on the endogenously-determined incentives of institutions to engage in financial innovation, and thus on each borrower's choice of financing source and its cost of capital. In addition to explaining how financial innovation is influenced by banking scope, the analysis speaks to a host of related system design issues, such as the implications of banking industry fragmentation or consolidation, the potential path dependence in the evolution of the financial system, and the desirable starting point of a new financial system. Thus, our research touches all three strands of the literature mentioned earlier -- financial innovation and security design, the implications of banking scope, and overall financial system design and evolution.

The model is characterized by four key players -- commercial banks, investment banks, borrowing firms, and the financial market. The actions of each are endogenously determined according to an optimization program. Commercial banks specialize in post-lending monitoring to deter asset-substitution moral hazard. Investment banks assist borrowers in raising funds in the capital market and design securities (through financial innovation) to lower their borrowers' cost of capital. Borrowers optimize through their choice of financing source, which is predicated on an observable attribute that varies cross-sectionally. The financial market consists of informed and other traders. How many traders become informed (and hence trading volume) depends on the design of securities and the attributes of firms that access the capital market. Thus, the actions of investment banks and borrowers impact the "price efficiency" of the capital market. The advantage of capital market financing for the borrower is that informed traders possess payoff-relevant information that the borrower does not have and this information is noisily transmitted to the borrower through the market price of its debt security, thereby leading to improved real decisions and an enhanced payoff.

In this setting, the borrower trades off the advantage of bank financing (which lies in the bank's ability to attenuate asset-substitution moral hazard) against the advantage of capital-market financing (which stems from the feedback role of capital market prices). We assume that the severity of the borrower's moral hazard is captured by a publicly-observable quality attribute, with lower values of this attribute representing more severe moral hazard. It can then be shown that there is a "quality cutoff" in the borrower's choice of financing source. Borrowers below this quality cutoff approach banks because the moral hazard problem is the most severe for them, whereas borrowers above this cutoff access the capital market. Since this cutoff is endogenously determined by the tension faced by the borrower between the value of moral hazard amelioration and the value of the information conveyed by the capital market price, financial innovation affects this cutoff as well. If an investment bank can design a *new* security that results in the equilibrium security price reflecting more of the information possessed by the informed agents, then this innovation will cause the quality cutoff to decline as more borrowers gravitate to the capital market.

If the financial system has functional separation between commercial and investment banks, then each investment bank will choose its investment in innovation based on the cost of the innovation relative to the expected increase in its fee revenue that comes from sharing in the borrower's elevated payoff due to the innovation. But the decision rule is different if we have universal banking. Now the investment banking arm of the universal bank internalizes the potentially pernicious effect of financial innovation on the customer base of the commercial banking arm, i.e., the commercial bank's borrowers may defect to the efficiency-enhanced financial market. The equilibrium level of financial innovation is lowered as a consequence. This provides one perspective on the higher rate of financial innovation in the U.S. relative to Europe.

The structure of the banking industry -- manifested in its fragmentation/competitiveness -- affects *interbank* competition and hence the price at which bank credit is available. This leads to a link between banking industry structure -- either with functional separation or with universal banking -- and the quality cutoff that delineates bank borrowers from capital market borrowers (even ignoring financial innovation incentives). Moreover, the sophistication of the financial market is an important determinant of the impact of a financial innovation. For example, the introduction of an exotic new option is likely to be less successful in an underdeveloped financial market than in a more developed, sophisticated financial market. But the success or failure of the financial innovation in turn affects the *future* evolution of the financial market. Hence, the evolution of the financial market is likely to be path-dependent (see also Dinc (1994)).

Our analysis points, therefore, to the many important effects that financial system design is likely to have on credit allocation and economic development. The ramifications of this for the structuring of financial systems in ex-communist economies are transparent and echoed in the following quote from *The*

Economist (1994):[2]

> Yet the German model may not be suitable for economies that are making the painful transition from central planning to capitalism. One priority should be to create a stable banking system that wins depositors' trust while allocating credit on the basis of market forces. A second should be to encourage a rapid restructuring of the hugely inefficient industries that central planning has created. And a third should be to promote the development of efficient and competitive capital markets. An unthinking dash for a universal-banking system could make it harder to meet any of these priorities.

We have focused in our analysis on the impact of two key aspects of financial system design on financial innovation -- the degree to which the banking system is functionally separated (or universal) *and* the degree of fragmentation in the banking system. *Both* aspects are important in driving our results. In particular, the deleterious effect of universal banking on financial innovation predicted by our analysis presupposes a high degree of consolidation with universal banks. Without such consolidation, a universal bank would *not* discern a dampening of the demand for its loans due to its own financial innovation. Thus, in a very fragmented universal banking system -- we are unaware of any such system in the real world -- financial innovation would not be discouraged by the universal nature of banking.

The rest is organized as follows. Section II presents the model. Section III presents an analysis of the borrower's choice of financing source. Section IV contains an analysis of the decisions of commercial and investment banks for a financial system with functionally separated commercial and investment banking as well as for a financial system with universal banking. Section V discusses key policy implications. Section VI concludes. All proofs are in the Appendix at the end of the paper.

II. THE MODEL

A. Investment Choices of Firms

There is universal risk neutrality, and the riskless rate is zero. Each firm in the economy has a

[2] See "Central Europe's Model Bank", *The Economist*, August 27 - September 2, 1994.

single-period project that needs a \$1 investment. The quality of project available to the firm is random. With probability $\theta \in (0,1)$, the firm has only a good project available. This project yields a terminal payoff of \$$Y > 0$ with probability (w.p.) $\eta \in (0,1)$ and 0 w.p. $1-\eta$. With probability $1-\theta$, the firm will have a choice between this good project and a bad project. The latter yields a contractible payoff of 0, but generates a noncontractible private rent $R > 0$ for the firm's manager.[3] We will later impose parametric restrictions that ensure that the manager will always prefer the bad project with external financing even though he would prefer the good project with self financing.

Each potential borrower is characterized by an observable parameter $\theta \in (0,1)$. Let G be the cumulative distribution over the cross-section of θ's, and $g(\theta)$ the associated density function. This parameter θ is the commonly-known prior probability assigned by the market to the event that a randomly selected borrower will have access only to the good project, and therefore pose no asset-substitution moral hazard problem.

B. Role of Commercial Banks

Commercial banks (CBs) specialize in post-lending monitoring that resolves asset-substitution moral hazard. Thus, if a firm borrows from a bank, the choice of the good project can be ensured w.p. 1. The bank incurs a cost $C > 0$ to monitor each borrower, and it must decide at the outset how much monitoring capacity to acquire for the period. Let N_0 denote the monitoring capacity the bank acquires at the beginning of the period, at a total cost of CN_0. With this capacity, the bank can monitor at the most N_0 borrowers. If loan demand exceeds N_0, then the demand in excess of N_0 must either be rationed or extended loans without post-lending monitoring. If loan demand falls short of N_0, then the excess of N_0 over the realized loan demand remains unutilized.

We visualize an imperfectly competitive banking industry. As in Besanko and Thakor (1992), we can imagine banks lying along the circumference of a circle, engaging in competition constrained by

[3] This can be viewed as a control rent as in O'Hara (1993) or Boot and Thakor (1995).

spatial considerations on the part of borrowers.[4] In particular, we view the lack of perfect competition -- and any rents arising therefrom -- as related to the bank's monitoring ability. Thus, each bank earns a rent of $\tau > C$ on each borrower it monitors.

C. The Capital Market

The basic idea we want to model is that the capital market includes traders who acquire costly information relevant to the real decisions of firms that even the managers of these firms may not possess. For example, a security analyst may be invited to a briefing on Merck's plans for future drug introductions and may therefore learn something of relevance to Eli Lilly's decisions that the managers of Lilly are unaware of. Alternatively, there may be traders/analysts who are industry specialists who develop special skills in assessing shifts in customer preferences, changes in the competitive structure of the industry, and so on. These informed traders will attempt to profit from this information by taking positions in the securities issued by the firms about which they have superior information. Although the presence of liquidity-motivated trades will mask the trades of the informed traders, the total order flow will at least noisily reveal informed trading. Based on this, the firm may be able to infer some of the information possessed by the informed traders and this may lead it to make a value-enhancing real decision. This is one way to visualize the information aggregation role of the capital market and the feedback role of prices. The informed traders observe a market opportunity that they conjecture the firm will exploit and thus take a position in the firm's securities based on that conjecture, and the firm noisily infers the availability of this opportunity from the order flow for its securities and acts on it, thereby rationalizing the initial conjecture. What we present below is an example of how one can formalize this intuition about the interaction between the real decisions of firms and capital market price determination.

Suppose there are two types of investors/traders in the capital market: liquidity traders and

[4] The spatial representation is best viewed as an allegory for more general product-differentiation-based imperfections in competition.

discretionary agents. The aggregate demand of the liquidity traders for any asset is random and exogenously specified. A discretionary agent can become an "informed" agent at a private cost. This investment generates a privately observed signal, ϕ, that reveals payoff-relevant information about the firm's operating environment. Each informed agent receives exactly the same signal. This information can be "favorable" (*f*) or "unfavorable" (*u*). If $\phi=f$, then the firm can make real investment decisions that can enhance its good project's payoff to $Y+\alpha$ w.p. η and α w.p. $1-\eta$, where $\alpha \in (0,1)$. If $\phi=u$, then the payoff enhancement opportunity does not exist. This signal ϕ is unavailable to the firm's manager, but if the informed agents demand the security only when $\phi=f$, then the manager can infer valuable information from the aggregate demand for the security or its price. This inference will be noisy, however, because of liquidity trade randomness. For a similar approach to modeling the real impact of the capital market, see Allen (1992), Boot and Thakor (1994), and Holmstrom and Tirole (1993).

The larger the fraction of the total trade volume that is potentially accounted for by informed traders, the more revealing is the order flow, and the smaller is the expected gain to each informed trader from his information. Thus, the measure of informed traders, Ω, is endogenously determined in this setting through an equilibrium condition which states that the equilibrium value of Ω should be such that each discretionary agent is indifferent between becoming informed and staying uninformed, i.e., the expected profit of each informed agent, net of the cost of becoming informed, should be zero.

The equilibrium price of the security is set to be equal to its expected value, with the expectation conditioned on the information contained in the aggregate demand, D, for the security; thus the discretionary uninformed traders earn zero expected profit on their trading. One can think of a competitive market maker setting the equilibrium price to clear the market, after observing D but being unable to distinguish the individual components of the demand attributable to the different types of traders.[5]

The capital market has no monitoring capability. Thus, if the firm has a choice of project, it is anticipated that the bad project will be chosen by the manager. The market maker takes this into account in setting the security price. Moreover, she also accounts for the fact that there are some (sufficiently high) values of D such that project-payoff enhancement will occur and other (sufficiently low) values of D for which it will not. To ensure comparability with the bank financing case, we assume that capital market funds are raised through debt securities.

D. The Role of the Investment Bank

The investment bank's (IB's) role is to underwrite the firm's debt offering in the capital market. Moreover, the IB can engage in security design innovation that improves the information sensitivity of the securities offered by the firm, as in the model developed by Boot and Thakor (1993). This heightened information sensitivity increases the expected payoff to the informed traders, *ceteris paribus*, and thus increases the equilibrium measure of informed traders.[6] This benefits the firm in two ways in the state in which it invests in the good project. First, it improves the information content of D, and thus leads to a higher probability of realizing the project payoff enhancement. Second, because the information content of D increases, the expected cost of borrowing in the capital market declines since it becomes "easier" for the market maker to detect the presence of the informed traders.[7] These issues are formally dealt with later.

We assume that the IB shares the gains from financial innovation with the issuing firm through an increase in its fee, as long as it faces no competition from other IBs. This is possible only if the IB

---

[5] We also assume no short sales by agents other than the market maker and that the market maker absorbs any supply/demand imbalances.

[6] See Boot and Thakor (1993) for details.

[7] When the informed bid for the security and D is high enough to convince the firm to take advantage of the opportunity to enhance the good project's payoff, the payoff to bondholders increases by α in the state in which it would be 0 without the enhancement initiative. This lowers the interest rate the firm must pay.

is the *only* institution that comes up with the innovation. If there is another IB that comes up with the same innovation, then none can profit from the innovation because they compete away their rents through a standard Bertrand undercutting argument.

We assume that an investment of $\xi > 0$ by an IB results in a successful innovation with probability one.[8] In the next section we will make precise what it means to the IB to have a successful innovation.

E. Sequence of Events

There are three dates: $t=0,1,2$. At $t=0$, each commercial bank chooses its monitoring capacity N_0, and each investment bank determines the probability with which it will invest in financial innovation. After it is known how many investment banks have successfully innovated, each borrower approaches either a commercial bank or the capital market for funds; whether all of these borrowers will actually need loans will be known only at $t=1$.

At $t=1$, total loan demand is realized. Based on the earlier decisions of borrowers, we now come to know the realized loan demand for commercial banks and the aggregate volume of debt to be underwritten in the capital market. Those who opted to borrow from commercial banks will be extended monitored loans at an interest factor r_B until the bank's monitoring capacity is exhausted; if there is any loan demand left over, it will be satisfied by extending unmonitored loans at an interest factor r_{NB}.[9] We view this descriptively as a process whereby all those seeking loans are viewed as belonging to a homogeneous pool, and the commercial bank selects all at once a random subset of these borrowers to extend monitored loans to at r_B. Thus, prior to the bank's selection of this subset, each borrower views the probability of receiving a monitored loan at r_B as P, with $P \in (0,1)$ if loan demand exceeds the bank's monitoring capacity, and $P=1$ otherwise. The interest factors r_B and r_{NB} and the probability P are all derived endogenously in the next section.

[8] It does not matter to the analysis if we make the outcome of the innovation initiative random, i.e., assume that the investment ξ produces a successful innovation with a probability less than one.

[9] In an ex post sense, these borrowers would have been better off going to the capital market. However, they are locked into their choice of financing source by this stage.

Also observed at $t=1$ is the aggregate order flow D, but not how much of it came from each type of trader. The measure of informed traders, although not directly observable, is inferred. Thus, at $t=1$ each firm chooses its project, the price of each firm's debt is determined, and payoff-enhancing investment decisions by firms are also made (or not). Finally, at $t=2$ all payoffs are realized and creditors are paid off if possible.

III. ANALYSIS OF THE BORROWING FIRM'S CHOICE OF FINANCING SOURCE

A. Cost of Borrowing From a Commercial Bank

If the CB plans to monitor the borrower, then it knows that the borrower will choose the good project w.p.1, and the CB will be repaid w.p. η. The equilibrium repayment obligation, r_B, thus solves:

$$\eta r_B = 1 + \tau,$$

which yields

$$r_B = \frac{1+\tau}{\eta}. \tag{1}$$

If the CB does not monitor, then it knows that the probability is θ that the borrower will invest in the good project and $1-\theta$ that it will invest in the bad project. The equilibrium repayment obligation, r_{NB}, thus solves

$$\theta\eta r_{NB} + \{[1 - \theta] \times 0\} = 1,$$

which yields

$$r_{NB} = 1/\eta\theta. \tag{2}$$

The borrower's expected payoff if it is monitored is $\eta[Y - r_B]$. Its expected payoff if it is not monitored is $\theta\eta[Y - r_{NB}] + [1 - \theta]R$. To ensure that the borrower prefers to be monitored, we need

$$\eta[Y - r_B] > \theta\eta[Y - r_{NB}] + [1 - \theta]R. \tag{3}$$

We assume that exogenous parameters are restricted such that

$$\eta Y > R+\tau. \tag{PR-1}$$

Given (PR-1), (3) will hold for all $\theta < 1 - \tau[\eta Y - R]^{-1} \equiv \theta^0$. Note that (PR-1) also guarantees that the borrower will prefer the good project with self-financing. We also need to ensure that the borrower prefers the bad project with external financing, even when external financing involves the payoff enhancement α. The sufficient condition for this is[10]

$$\eta[Y + \alpha - 1] < R. \tag{PR-2}$$

Next, we check to see whether the bank prefers to monitor. If the bank extends a loan at r_B and monitors the borrower, its expected profit will be $1+\tau$. At this loan price, if the bank does not monitor, its expected profit will be $\theta[1+\tau]$, which is less than its expected profit from pursuing a monitoring strategy. Similarly, if the bank extends a loan at r_{NB}, then its expected payoff if it monitors will be $\eta r_{NB} = 1/\theta$, and its expected payoff if it does not monitor will be $\theta\eta r_{NB} = 1 < 1/\theta$. Thus, regardless of the price at which the bank extends a loan, it will strictly prefer to monitor.

Let P be the probability that a bank will have available the capacity to monitor a borrower; since only monitored borrowers are charged r_B, P is also the probability that a borrower will receive a loan at r_B from the bank. 1-P is the probability that a borrower will be extended an unmonitored loan at r_{NB}. We will later derive P endogenously.

Define $\bar{\theta} \equiv [1+\tau]^{-1}$. Then for a borrower with $\theta < \bar{\theta}$, the expected payoff is

$$\begin{aligned} \Pi_B(\theta) &= P\eta[Y - r_B] + [1-P]\,[\theta\eta\{Y - r_{NB}\} + \{1-\theta\}N] \\ &= P\eta Y - P\tau + [1-P][\theta\eta Y + \{1-\theta\}N] - 1. \end{aligned} \tag{4}$$

B. Cost of Borrowing in the Capital Market

Let $Pr(\phi = f|D)$ denote the conditional probability assessed by the uninformed traders that the informed traders have received a favorable signal. This probability is conditioned on the total demand,

---

[10] (PR-1) and (PR-2) imply the joint restriction $\eta Y \in (R+\tau, R+\eta - \eta\alpha)$, which implies $\tau < \eta[1 - \alpha]$.

D, for the security. A higher realization of D implies a higher probability that the informed traders are in the market, and hence a greater willingness on the borrowing firm's part to engage in the value-enhancing decision. For simplicity, we let $Pr(\phi=f|D)$ represent the probability that the firm will implement the value-enhancing decision and experience an enhancement of α in its project payoff. We can now write the equilibrium repayment obligation, $r_F(D)$, of the firm as a function of the realized demand for its security. It is a solution to

$$\theta\ \{\Pr(\phi=f|D)[\eta\hat{r}_F(D) + \{1-\eta\}\alpha] + [1-\Pr(\phi=f|D)][\eta\hat{r}_F(D)]\} = 1. \tag{5}$$

Note that in writing (5) we recognize that bondholders get repaid only if the firm is locked into the good project since there is no monitoring in the capital market to deter asset substitution by the firm; the probability of the good project being taken is θ. Moreover, wherever project payoff enhancement occurs, bondholders are repaid in full in the successful state (this happens w.p. η) and recover $\alpha < 1 < \hat{r}_F(D)$ in the unsuccessful state (this happens w.p. $1-\eta$). Solving (5) yields

$$\hat{r}_F(D) = \frac{1-\theta\Pr(\phi=f|D)[1-\eta]\alpha}{\theta\eta}. \tag{6}$$

Let $\Lambda(D|\Omega)$ represent the cumulative distribution function for D, conditional on the measure of informed traders, Ω. Then the firm's expected payoff is

$$\Pi_F(\theta) = \theta\int\eta[Y + \alpha\Pr(\phi=f|D) - \hat{r}_F(D)]\,d\Lambda(D|\Omega) + [1-\theta]R. \tag{7}$$

Define $q \equiv q(\Omega) \equiv \int Pr(\phi=f|D)d\Lambda(D|\Omega)$ and $r_F \equiv r_F(\Omega) \equiv \int\hat{r}_F(D)d\Lambda(D|\Omega)$. Then we can write (7) as

$$\Pi_F(\theta) = \theta\eta[Y + \alpha q - r_F] + [1-\theta]R. \tag{8}$$

C. Firm's Choice of Financing Source

The firm will make its financing source choice by comparing $\Pi_B(\theta)$ in (4) with $\Pi_F(\theta)$ in (8). Making this comparison, we obtain the following result.

Proposition 1: Define

$$\hat{\theta} \equiv \frac{P[\eta Y - R - \tau]}{\alpha q + P[\eta Y - R]} \in (0,1). \tag{9}$$

Then the firm prefers bank financing if its $\theta \leq \hat{\theta}$ and capital market financing if $\theta > \hat{\theta}$. Moreover, all bank-financed borrowers pay a lower interest rate on monitored loans than on non-monitored loans.

Thus we see that the borrower's choice depends on the publicly observable quality parameter θ. A higher θ means a lower likelihood that the borrower will substitute projects to the lender's detriment, so that θ can be viewed as a representation of the severity of moral hazard. The more severe the moral hazard, the more valuable is the CB's monitoring service. As θ increases, the monitoring becomes less valuable and at some point the value lost due to not monitoring is more than offset by the expected project payoff enhancement due to capital market financing. At this point the borrower, who has sufficiently high quality, will switch to capital market financing.

IV. ANALYSIS OF THE DECISIONS OF COMMERCIAL AND INVESTMENT BANKS

A. The Commercial Bank's Choice of Lending Capacity in a Functionally Separated Banking System

We assume that total credit demand N is uniformly distributed over $(\underline{N}, \bar{N})$ and that θ is uniformly distributed over (0,1). Then the CB's choice of lending capacity, N_0, is made to maximize

$$W(\hat{\theta}) = \int_0^{\hat{\theta}} \left\{ \int_{\underline{N}}^{N_0/\hat{\theta}} \frac{N\tau}{[\bar{N} - \underline{N}]} dN + \int_{N_0/\hat{\theta}}^{\bar{N}} \frac{(N_0/\hat{\theta})\tau}{[\bar{N} - \underline{N}]} dN \right\} d\theta - CN_0. \tag{10}$$

There are a few points worth noting about (10). First, the CB's lending to the unmonitored borrowers does not appear here because the CB's expected profit on those loans is zero and hence leaves its overall expected profit W unchanged. Second, the portion of the total realized loan demand, N, that accrues to the CB is $\hat{\theta}N$. If the CB's monitoring capacity $N_0 > \hat{\theta}N$ (i.e., if $N < N_0/\hat{\theta}$), then lending equals demand and some monitoring capacity is wasted. On the other hand, if $N_0 < \hat{\theta}N$, then lending equals the monitoring capacity and some loans are extended without monitoring. Third, (10) indicates that the CB's expected profit depends only on $\hat{\theta}$ and the probability of $\theta \leq \hat{\theta}$. As long as these two quantities remain unchanged, the details of how θ is distributed between 0 and $\hat{\theta}$ are irrelevant. The following proposition follows readily from (10).

Proposition 2: The CB's optimal monitoring capacity is given by

$$N_0^* = \hat{\theta}\,[\bar{N} - C\{\bar{N} - \underline{N}\}\tau^{-1}] \in (\underline{N}, \bar{N}). \tag{11}$$

The probability that a borrower with $\theta < \hat{\theta}$ will receive a monitored loan with a repayment obligation of r_B is

$$P = \frac{[\tau\bar{N} - C\{\bar{N} - \underline{N}\}]}{\tau[\bar{N} - \underline{N}]}\left\{1 + \ln\left(\frac{\bar{N}\tau}{\bar{N}\tau - C[\bar{N} - \underline{N}]}\right)\right\} - \frac{\underline{N}}{[\bar{N} - \underline{N}]}. \tag{12}$$

Next we present a corollary that provides some useful comparative statics.

Corollary 1: $\partial P/\partial\tau > 0$. Moreover, $\partial\hat{\theta}/\partial\tau < 0$ only if $\partial P/\partial\tau < P^2[\hat{\theta}\alpha q]^{-1}$.

It is intuitive that P is increasing in τ. Since the CB earns a rent τ on its lending only if it extends a monitored loan, the higher this rent the greater is the investment the CB makes in monitoring. As for the behavior of $\hat{\theta}$, note that an increase in τ has two opposite effects. On the one hand, a higher τ implies a higher P, which makes a bank loan more attractive to the borrower. But on the other hand, a higher τ implies a higher borrowing cost on monitored loans, which makes it less attractive for a borrower to approach a bank. An increase in τ should diminish the attractiveness of a bank loan (and hence reduce $\hat{\theta}$). Thus, increases in τ reduce $\hat{\theta}$ if the first effect $(\partial P/\partial\tau)$ is not too large.

Holding fixed Ω, the measure of informed traders in the capital market, equations (9), (11) and (12) completely characterize the equilibrium with functionally separated banking. Next we turn to the IB's problem.

B. The Investment Bank's Problem in a Functionally Separated Banking System

Inspection of (6) reveals that the reduction in the firm's cost of borrowing due to informed trading is captured in the term $\theta Pr(\phi=f|D)[1-\eta]\alpha/\theta\eta$. The expected value of this is $q(\Omega)[1-\eta]\alpha/\eta$ (see the definition following (7)). This is the cost saving available to the firm with the *existing* security. We assume that the role of financial innovation is to alter security design and *increase* the measure of informed traders from Ω to $\Omega^* > \Omega$. Boot and Thakor (1993) explain how altered security design can achieve this by making more information-sensitive securities available to wealth-constrained informed traders. Define

$$\Delta \equiv q(\Omega^*) - q(\Omega).$$

Then the cost reduction attributable to the financial innovation is $\Delta[1-\eta]\alpha/\eta$. We assume that if the IB responsible for the innovation is the *only* one to bring it to market, then it *shares* in the borrowing firm's cost saving. Thus, its reward for the innovation is an increase in its fee revenue by an amount $F \equiv k\Delta[1-\eta]\alpha/\eta > \xi$, where $k \in (0,1)$ is an exogenously specified fraction and $\xi > 0$ is what the IB must invest in order to come up with the financial innovation. It is assumed that there are many IBs in the market and any can avail of the financial innovation by investing ξ.

Proposition 3: There does not exist a symmetric pure strategy Nash equilibrium in the game in which multiple IBs compete to innovate.[11] If there are M > 1 IBs competing, then the probability, z_*, with which each IB innovates in a mixed-strategy Nash equilibrium with functionally separated banking is

$$z_* = 1 - \sqrt[M-1]{\frac{2\xi}{F[\underline{N} + \bar{N}][1 - \hat{\theta}^*]}} \tag{13}$$

and $\hat{\theta}^*$ is the quality cutoff that emerges with the new security created by financial innovation.

For simplicity, we will assume henceforth that M=2. This does not sacrifice generality since these two IBs will still ensure a competitive investment banking industry.

C. The Universal Bank's Problem

With universal banking, the CB and the IB are part of the same bank. Assume that there are two universal banks. Thus, the universal bank maximizes the sum of its expected profits from commercial and investment banking (see (10) and (A-2) in the Appendix). Conditional on the universal bank investing in financial innovation, the total expected profit maximized by the universal bank is

$$W(\hat{\theta}) + \frac{F[\underline{N} + \bar{N}][1 - \hat{\theta}][1 - z]}{2} - \xi \tag{14}$$

where z is the probability with which each universal bank innovates, and $W(\hat{\theta})$, the profit from the

[11]This assertion relies on a particular interpretation of pure and mixed strategies, namely that each IB innovates with the same interior probability in a mixed strategy equilibrium. Alternatively, if one views z_* as the fraction of IBs such that each innovates with probability one and $1-z_*$ as the fraction of IBs who do not innovate, then we can interpret this as an *asymmetric* Nash equilibrium with pure strategies.

commercial bank's lending, was defined in (10).

Now, the cutoff $\hat{\theta}$ will be affected by whether there is financial innovation at all, and if there is innovation, then by whether only one universal bank innovates or whether two or more universal banks innovate. Let $\hat{\theta}_{ni}$ represent the cutoff with no innovation at all, $\hat{\theta}_1$ the cutoff if only one universal bank innovates, and $\hat{\theta}_2$ the cutoff if two or more universal banks innovate. Note that it does not make any difference to the quality cutoff whether two universal banks innovate or more than two universal banks innovate since two universal banks provide just as competitive a setting as more than two. We can now solve for $\hat{\theta}_1$ and $\hat{\theta}_2$.

The borrower's expected utility from financial market financing with only one universal bank innovating is:

$$\pi_F(\theta) = \theta\eta[Y+\alpha q-r_F] + [1-\theta]R + \theta\eta[\{1-k\}\Delta\{1-\eta\}\alpha/\eta]. \tag{14}$$

Note that in writing (13), we recognize that when only one universal bank innovates, the expected gain from innovation is shared between the universal bank and the borrower. Now, $\hat{\theta}_1$ is obtained by equating (4) and (14). This yields

$$\hat{\theta}_1 = \frac{P[\eta Y-R-\tau]}{\alpha q + P[\eta\gamma-N] + [1-k]\Delta[1-\eta]\alpha}. \tag{15}$$

Comparing this to (9), we see that $\hat{\theta}_1 < \hat{\theta} = \hat{\theta}_{ni}$. We can similarly derive

$$\hat{\theta}_2 = \frac{P[\eta Y-R-\tau]}{\alpha q + P[\eta Y-R] + \Delta[1-\eta]\alpha}. \tag{16}$$

Observe that $\hat{\theta}_2 < \hat{\theta}_1$. We now have our main result.

Proposition 4: The equilibrium probability of financial innovation in a universal banking system, z_u, is lower than the equilibrium probability of financial innovation in a functionally separated banking system, z_s.

The intuition is as follows. When a functionally separated IB determines whether to innovate, it is unconcerned about the impact the innovation will have on the loan demand faced by a CB. However, when it is the universal bank that determines whether to innovate, it *internalizes* the depressing effect that the innovation will have on the loan demand faced by its CB unit.[12] Consequently, it needs a higher expected profit from the innovation than does a functionally separated IB. Since a positive profit from innovation is available only if the universal bank in question is the *only* bank that innovates, the only way to increase the expected profit from innovation is to *lower* the probability with which each competing bank innovates in a mixed-strategy Nash equilibrium.

Proposition 4 is obtained in a static setting. As we discuss in section VA, the propensity of a universal banking system to innovate less is likely to be exacerbated in a dynamic setting.

V. IMPLICATIONS OF ANALYSIS

In this section we discuss the implications of our analysis for various aspects of financial system design.

[12]This result is independent of the organizational details of the universal bank, i.e., whether the IB and the CB are divisions or subsidiaries. It depends only on the fact that the universal bank maximizes the sum of the expected profits of its IB and CB.

A. Intertemporal Considerations

An important consideration precluded by our static analysis is reusability of information by CBs. A CB's investment in monitoring is likely to be intertemporally reusable.[13] This means that the cost of monitoring a borrower at date $t+1$ is likely to be lower than the cost of having monitored the same borrower at date t. The customers of a CB are therefore likely to be more profitable to the CB over time.[14] By contrast, financial innovation yields only a single-shot gain due to imitation by rivals.

When this consideration is introduced in our analysis, we see that a universal bank innovates with an even lower probability since it now imputes a greater cost to the loss in loan demand suffered by its CB due to the financial innovation. Thus, intertemporal considerations are likely to strengthen the result that there will be less financial innovation in economies with universal banks.

B. Banking Scope and Capital Market Development

Perhaps the clearest implication of our analysis is that banking scope--a regulatory choice variable--affects the development of the capital market. In our model this effect arises from the lower incentives for financial innovation with universal banking than with functionally separated banking. This stochastic lowering of financial innovation with universal banking means a higher $\hat{\theta}$ and hence fewer borrowers accessing the capital market. With lower aggregate trading volume as well as less financial innovation, we should expect capital markets in economies with universal banking to be less developed than those in economies with functionally separated banking. Moreover, since capital market funding is more attractive for borrowers in functionally separated financial systems, CBs in such economies will suffer an initial loss of customers that will lead to lost opportunities for intertemporal information reusability. Consequently, CBs are likely to lose *more* market share to the capital markets over time in

---

[13] This is one aspect of informational reusability in banking. See Bhattacharya and Thakor (1993) and Boot, Greenbaum and Thakor (1993) for further discussions of information reusability.

[14] See Greenbaum and Thakor (1995) for empirical evidence.

functionally separated financial systems than in universal banking economies. These observations are consistent with the higher incidence of financial innovation and the greater intertemporal loss of market share by CBs in the U.S. relative to the universal banking economies of Germany, Switzerland and the Netherlands, for example.

We doubt that the architects of the Glass-Steagall Act foresaw the enormously positive impact the Act would have on the development of U.S. capital markets or on the incentives for financial innovation. The Act had its roots in the desire to limit the power of banks, reduce conflicts of interest, and limit the scope of the deposit insurance safety net. Nonetheless, our analysis provides a framework within which to understand the unintended consequences of banking scope legislation like the Glass-Steagall Act.

C. The Role of Regulatory Attitudes

There are many who believe that the attitudes of regulators play an important role in determining bank behavior. For example, in countries dominated by a few large universal banks, regulators have apparently been loathe to permit the widespread introduction of innovations like commercial paper, exchange-traded derivatives and structured notes. Such behavior has a nice interpretation in the context of our analysis. In countries with dominant universal banks, senior bank executives typically have significant influence over bank regulators. Regulatory reluctance to permit unabated financial innovation can then be viewed as a reflection of the desire of universal banks themselves to restrict financial innovation.

D. Path Dependence in the Evolution of Financial Systems

Financial innovation is likely to be path-dependent. It is plausible that Δ is a function of the sophistication of capital market participants.[15] The ability of market participants to appreciate the payoff implications of a new security will likely depend on their experience with existing securities, the attributes

[15] See Gale (1992) for a related approach to explain the success of financial innovation.

of which may depend on the development of the capital market. Thus, a financial innovation is likely to result in a larger Ω^* in a better-developed capital market. And as IBs themselves become more skilled at security design, their costs of innovation are likely to decline as well, i.e., ξ will fall. Both effects will lead to greater financial innovation by IBs operating in better-developed capital markets. This difference in the pace of financial innovation further widens the development gap between better-developed capital markets and their less-developed counterparts.

This implies that even if the regulation of banks and capital markets were to be perfectly harmonized internationally, different financial systems are likely to display disparate levels of financial innovation and differing fractions of total credit allocation accounted for by CBs simply due to disparities in the sophistication of their capital markets. Moreover, how sophisticated a capital market is at date t is likely to depend on the history of financial innovation until date t. A financial system that has historically been dominated by universal banks is likely to have a poorer history of financial innovation, according to our earlier arguments. This appears consistent with the different patterns of capital market development in continental Europe and the U.S.

E. Commercial Banking Fragmentation Implications

Greater fragmentation of commercial banking is typically taken to mean greater competition among CBs. In our model this implies a lower τ for each CB. From the Corollary 1 we know that $\partial\hat{\theta}/\partial\tau < 0$. Thus, increased fragmentation in commercial banking will lead to an increase in $\hat{\theta}$ and hence more business for CBs. Corollary 1 also tells us that the probability, P, of extending a monitored loan declines as τ decreases. Moreover, holding $\hat{\theta}$ fixed, the bank's optimal investment in monitoring capacity, N_0^*, diminishes as τ decreases.

The result that $\hat{\theta}$ increases, without any reduction in the value of capital market funding to borrowers, implies that the overall effect of increased competition among CBs is to elevate borrower welfare as well as the average quality of bank loans (since $\hat{\theta}$ increases, the average quality of bank loans increases with it). However, the effect of increased competition on the bank's investment in monitoring capacity is ambiguous since a higher $\hat{\theta}$ implies a higher N_0^* *ceteris paribus* but a lower τ (which leads to a higher $\hat{\theta}$) diminishes N_0^* for a fixed $\hat{\theta}$.

F. Implications of Increased Competition in Investment Banking

Fragmentation and the resulting increased competition in investment banking will diminish the inclination of any IB to introduce a financial innovation. Recall that the probability of each IB innovating is chosen such that the net present value of the innovation to the IB is zero. From (13) we see that $\partial z_i / \partial M < 0$. More importantly, however, the probability that there will be *any* innovation at all -- the probability that at least one out of M IBs will innovate -- declines as M increases.[16] Hence, increased competition among IBs leads to stochastically lower innovation.

G. Overall Financial System Design

Our analysis shows that financial systems with universal banking can be expected to innovate less and have capital markets that display lower development than financial systems with functionally separated banking. Since an important role of the financial market in our model is to provide informational feedback to managers of firms that facilitates improved real decisions, borrowers make better real decisions on average in functionally separated financial systems.

On the other hand, there is on average better attenuation of asset-substitution moral hazard in a financial system with universal banking because a larger measure of borrowers use CBs. The welfare

---

[16] In a takeover bidding context, Spatt (1989) provides a proof of this claim. See also Thakor (1995) for a proof in a credit rationing context.

implications of financial system design are therefore ambiguous.[17]

Stepping outside our model, a factor that might favor universal banking is related to scope economies based on information sharing made possible by the marriage of commercial and investment banking. However, potential gains from scope economies could be vitiated by conflicts of interest in a universal bank (see Rajan (1993)).[18]

There is another aspect of financial system design, however, that could tilt the balance in favor of a functionally separated system. As the capital market becomes more developed, it should become easier for outsiders to wrest corporate control away from incumbent managers in firms. Since this should ameliorate asset-substitution moral hazard[19], the benefits of having a larger measure of borrowers monitored by CBs diminish. Financial innovation then looks relatively more attractive and the case for a financial system with functionally separated banking becomes stronger.

H. Mixed Financial Systems

We have considered functionally separated banking and universal banking as two extremes. What about "mixed" financial systems in which stand-alone IBs and CBs compete with universal banks?

We believe that stand-alone banks would be competitively disadvantaged in a universal banking system for two reasons. First, scope economies would give universal banks a powerful competitive edge over their stand-alone counterparts. In the context of our model, one way to introduce scope economies would be to assume that if there is any redundant monitoring capacity in the CB unit of the universal bank, it could be partly used in the underwriting activities of the IB. This would lower expected underwriting costs, and some of the savings could be passed along to the universal bank's customers.

---

[17] Because our capital market model has exogenously-specified security demand from liquidity traders, it is not amenable to welfare analysis.

[18] See also Kroszner and Rajan (1994) for empirical evidence on conflicts of interest.

[19] In our model, the manager's choice of the bad project hurts both shareholders and bondholders.

Second, to the extent that large universal banks are likely to have greater influence over regulators than (smaller) stand-alone IBs or CBs, regulatory policy could also be slanted in favor of universal banks. For example, financial innovations where scope economies could be exploited more fully may be favored over others when it comes to regulatory approval. A good example is commercial paper with backup loan commitments. The universal bank can underwrite the commercial paper issue and also sell the backup loan commitment.

Both of these considerations imply that stand-alone banks are unlikely to be major players in universal banking economies, an observation that appears consistent with what we observe.[20] Hence, it seems improbable that overall financial innovation in a universal banking system with some stand-alone CBs and IBs could match the financial innovation in a functionally separated financial system.

At a more general level, the issue of stand-alone investment banks competing with universal banks raises the important issue of competitiveness of different financial systems in an increasingly integrated global economy. While cross-border competition is limited at present, it does exist nonetheless. How would a bank-dominated (universal banking) system compete with a market-dominated (functionally separated) system? This is an interesting question for future research.

VI. CONCLUSION

We have focused on the financial innovation implications of financial system design. Our main findings and observations are summarized below.

- There is an observable-quality cutoff such that borrowers with observable qualities below that are funded by commercial banks and borrowers with observable qualities above that are funded in

[20]The point is not that such stand-alone banks could not exist, only that their actions are unlikely to have much impact on the profits of the universal banks.

the capital market. As commercial banking becomes more competitive, this cutoff increases.

- There exists a mixed-strategy Nash equilibrium in the financial innovation game such that each competing investment bank invests in financial innovation with some probability less than one. The equilibrium probability of innovation is lower in a financial system with universal banking than in a financial system with functionally separated banking.

- The evolution of a financial system is likely to be path-dependent. Well-developed financial systems provide stronger incentives for financial innovation and develop faster.

- Banks are likely to lose more market share over time to capital markets in financial systems with functionally separated banking than in a universal banking system.

- The choice of financial system design rests on the tradeoff between the superior attenuation of asset-substitution moral hazard in a universal banking system versus superior financial innovation and better real decisions in a functionally separated financial system.

Perhaps the most significant point of our paper is that there is a vital link between the behavior of commercial banks and developments in capital markets, and that any discussion of financial system design must adopt an essentially integrated approach. Moreover, bank regulation and capital market regulation, which are typically the responsibilities of different regulatory agencies, should be conducted in an integrated manner.

Future research should perhaps attempt to join together the implications of financial system design derived in recent papers. For example, Allen and Gale (1994a) conclude that bank-dominated financial systems provide better intergenerational risk sharing and market-dominated systems provide better cross-sectional risk sharing. It would be interesting to incorporate risk sharing considerations in the approach we have taken.

APPENDIX

Proof of Proposition 1: We know that $\hat{\theta}$ solves $\Pi_B(\theta) = \Pi_F(\theta)$, where $\Pi_B(\theta)$ is defined in (4) and $\Pi_F(\theta)$ in (8). Thus, the borrower prefers capital market funding to a CB loan if

$$\theta\eta[Y+\alpha q - r_F] + [1-\theta]R > P\eta Y - P\tau + [1-P][\theta\eta Y+\{1-\theta\}R] - 1.$$

Substituting $r_F = \frac{1-\theta q[1-\eta]\alpha}{\theta\eta}$ in the above inequality and performing a few algebraic manipulations, we obtain the result that the borrower strictly prefers capital-market funding if

$$\theta > \frac{P[\eta Y - R - \tau]}{\alpha q + P[\eta Y - R]} \equiv \hat{\theta},$$

prefers CB financing if $\theta < \hat{\theta}$, and is indifferent if $\theta = \hat{\theta}$. Moreover, it is straightforward to show that $\hat{\theta} < \theta^0$. Now, define $\bar{\theta} \equiv [1+\tau]^{-1}$. Then, it is transparent that $r_B < r_{NB} \forall\ \theta < \bar{\theta}$. It is easy to show that $\hat{\theta} < \bar{\theta}$. Thus, all those who apply for bank loans find that $r_B < r_{NB}$. This completes the proof. □

Proof of Proposition 2: Performing the necessary integration, (10) can be written as

$$W(\hat{\theta}) = \frac{\tau N_0^2}{2\hat{\theta}[\bar{N}-\underline{N}]} - \frac{\hat{\theta}\underline{N}^2\tau}{2[\bar{N}-\underline{N}]} + \frac{\tau N_0\bar{N}}{[\bar{N}-\underline{N}]} - \frac{\tau N_0^2}{\hat{\theta}[\bar{N}-\underline{N}]} - N_0 C.$$

The first-order condition, $\partial W(\hat{\theta})/\partial N_0 = 0$, yields

$$\frac{\tau\bar{N}}{[\bar{N}-\underline{N}]} - \frac{\tau N_0^*}{[\bar{N}-\underline{N}]\hat{\theta}} - C = 0,$$

which then gives us (11). The second-order condition is

$$\partial^2 W(\hat{\theta})/\partial N_0^2 = \frac{-\tau}{[\bar{N} - \underline{N}]\hat{\theta}} < 0.$$

Since $C < \tau$, it is transparent from (11) that $N_0^* \in (\underline{N}, \bar{N})$.

To derive P, note that

P = Prob(no shortage of monitoring capacity) × Prob(each loan will be monitored when there is no monitoring capacity shortage)

+ Prob(shortage of monitoring capacity) × Prob(loan will be monitored when there is a capacity shortage)

= Prob(no monitoring capacity shortage) × 1

+ Prob(monitoring capacity shortage) × $\frac{\text{monitoring capacity}}{\text{loan demand}}$

$$= \int_{\underline{N}}^{N_0^*/\hat{\theta}} \frac{1}{[\bar{N} - \underline{N}]} dN + \int_{N_0^*/\hat{\theta}}^{\bar{N}} \frac{N_0^*}{\hat{\theta} N[\bar{N} - \underline{N}]} dN$$

$$= \frac{N_0^*[1 + \ln(\bar{N}\hat{\theta}/N_0^*)]}{\hat{\theta}[\bar{N} - \underline{N}]} - \frac{\underline{N}}{\bar{N} - \underline{N}}. \qquad \text{(A-1)}$$

Substituting for N_0^* from (11) into (A-1) yields (12). □

Proof of Corollary 1: Differentiating (12) with respect to τ and doing a little algebra gives

$$\partial P/\partial \tau = \frac{C}{\tau^2} \left\{ \ln \left(\frac{\bar{N}\tau}{\bar{N}\tau - c[\bar{N} - \underline{N}]} \right) \right\} > 0.$$

Moreover, differentiating (9) with respect to τ yields

$$\partial\hat{\theta}/\partial\tau = \frac{-[\alpha q + P\{\eta Y - R\}]P + [\eta Y - R - \tau]\alpha q[\partial P/\partial\tau]}{[\alpha q + P\{\eta Y - R\}]^2}$$

< 0 only if $\partial P/\partial \tau < P^2[\hat{\theta}\alpha q]^{-1}$. □

Proof of Proposition 3: To show that there cannot be a symmetric pure strategy Nash equilibrium in the innovation game, suppose that we conjecture that no IB innovates in equilibrium. Then, it must pay for one IB to innovate since it will have a monopoly on the innovation and therefore earn positive expected profit. Thus, no-innovation cannot be an equilibrium. Next, suppose that it is an equilibrium for each IB to innovate w.p. 1. Then, no IB can profit from the innovation and hence cannot recover its investment of ξ in innovation. Thus, it cannot be an equilibrium for each IB to innovate w.p. 1.

Let $z \in (0,1)$ be the probability with which each IB innovates in a symmetric mixed strategy Nash equilibrium. Consider a particular IB. Its expected profit from innovation is

$$[1-\hat{\theta}^*] \times \frac{[\bar{N} + \underline{N}]}{2} \times [1 - z]^{M-1} \times F - \xi. \qquad \text{(A-2)}$$

In writing (A-2), note that the expected credit demand faced by the IB is

$$\int_{\hat{\theta}}^{1} \int_{\underline{N}}^{\bar{N}} \frac{N}{[\bar{N} - \underline{N}]} dN \, d\theta = \frac{[1-\hat{\theta}][\bar{N} + \underline{N}]}{2}.$$

Moreover, the IB in question can profit from its financial innovation only if *no* other IB innovates. Since the probability that an IB will not innovate is $[1-z]$ and there are M-1 other IBs, the probability that the remaining M-1 banks will not innovate is $[1-z]^{M-1}$.

To obtain a symmetric mixed strategy Nash equilibrium, we have to ensure that the IB is indifferent between innovating and not innovating. Since the IB's expected profit from not innovating is zero, this means the required equilibrium condition is

$$\frac{[1-\hat{\theta}^*][\bar{N} + \underline{N}][1 - z]^{M-1} \times F}{2} - \xi = 0. \qquad \text{(A-3)}$$

Solving (A-3) yields (13). □

Proof of Proposition 4: With universal banking, the bank's objective is to maximize (14). Let z_u be the probability with which each universal bank innovates in a mixed strategy Nash equilibrium. Note that the rule by which innovation rents are shared between the IB and the borrower is immaterial to the analysis. From our earlier analysis,

$$\hat{\theta}_{ni} > \hat{\theta}_1 > \hat{\theta}_2.$$

Consider now a particular universal bank and assume that there are two universal banks in the market. If the universal bank in question innovates, its expected profit is

$$z_u[W(\hat{\theta}_2) + 0] + [1 - z_u]\left[W(\hat{\theta}_1) + \frac{F\{\bar{N} + \underline{N}\}\{1-\hat{\theta}_1\}}{2}\right] - \xi. \tag{A-4}$$

Note that the probability that the other universal bank will innovate is z_u and in this case each bank earns zero profits in investment banking and an expected profit of $W(\hat{\theta}_2)$ from commercial banking. The probability that the other universal bank will not innovate is $1-z_u$, and in this case the universal bank in question earns an expected profit of $\frac{F\{\bar{N} + \underline{N}\}\{1 - \hat{\theta}_1\}}{2}$ on its innovation and an expected profit of $W(\hat{\theta}_1)$ on its CB lending. If the universal bank in question does not innovate, then its expected profit is

$$z_u[W(\hat{\theta}_1)] + [1 - z_u][W(\hat{\theta}_{ni})]. \tag{A-5}$$

A key difference between (A-4) and (A-5) is that now if the other universal bank does not innovate, then no bank innovates and the expected profit on commercial bank lending is $W(\hat{\theta}_{ni})$ since the quality cutoff is $\hat{\theta}_{ni}$.

Now, z_u is obtained by setting (A-4) equal to (A-5). Solving this gives us

$$z_u = \frac{FN_m[1 - \hat{\theta}_1] - \xi + W(\hat{\theta}_1) - W(\hat{\theta}_{ni})}{FN_m[1 - \hat{\theta}_1] + 2W(\hat{\theta}_1) - W(\hat{\theta}_{ni}) - W(\hat{\theta}_2)} \tag{A-6}$$

where $N_m \equiv \frac{[\bar{N} + \underline{N}]}{2}$. Note that $W(\hat{\theta}_1) < W(\hat{\theta}_{ni})$ since W is increasing in $\hat{\theta}$. We wish to compare (A-6) and (13). Note first that

$$z_u < \frac{FN_m[1-\hat{\theta}_1] - \xi + W(\hat{\theta}_1) - W(\hat{\theta}_{ni})}{FN_m[1-\hat{\theta}_1] + W(\hat{\theta}_1) + W(\hat{\theta}_2) - W(\hat{\theta}_{ni}) - W(\hat{\theta}_2)} \quad \text{(since } W(\hat{\theta}_2) < W(\hat{\theta}_1))$$

$$= 1 - \frac{2\xi}{F[\bar{N} + \underline{N}][1-\hat{\theta}_1] + 2\{W(\hat{\theta}_1) - W(\hat{\theta}_{ni})\}}.$$

And, evaluating the above at $\hat{\theta}_1 < \hat{\theta}^*$, we have

$$z_u < 1 - \frac{2\xi}{F[\bar{N} + \underline{N}][1 - \hat{\theta}^*] + 2\{W(\hat{\theta}^*) - W(\hat{\theta}_{ni})\}}$$

$< z_s$ with M=2 since $W(\hat{\theta}^*) < W(\hat{\theta}_{ni})$.

Thus, $z_u < z_s$ if $\hat{\theta}_1 = \hat{\theta}^*$. But given that $z_u < z_s$, we have $\hat{\theta}_1 < \hat{\theta}^*$. But since z_u at $\hat{\theta}_1 < \hat{\theta}^*$ will be even lower than z_u at $\hat{\theta}_1 = \hat{\theta}^*$, we have completed the proof. □

REFERENCES

Allen, Franklin, "Stock Markets and Resource Allocation" in *Capital Markets and Financial Intermediation* (e.d. Colin Mayer and Xavier Vives), Cambridge University Press, 1992.

Allen, Franklin and Douglas Gale, "Optimal Security Design," *Review of Financial Studies* 1(3), 1988, 229-263.

Allen, Franklin and Douglas Gale, "Arbitrage, Short Sales, And Financial Innovation." *Econometrica* 59(4), 1991,1041-1068.

Allen, Franklin, and Douglas Gale, "A Welfare Comparison of the German and U.S. Financial Systems", working paper, Wharton School, February 1994a.

Allen, Franklin, and Douglas Gale, *Financial Innovation and Risk Sharing*, MIT Press, Cambridge, MA, 1994b.

Berlin, Mitchell, Kose John and Anthony Saunders, "Bank Equity Stakes in Borrowing Firms and Financial Distress", working paper, Indiana University, August 1994.

Besanko, David and Anjan V. Thakor, "Relationship Banking, Deposit Insurance, and Portfolio Choice." in *Capital Markets and Financial Intermediation* (eds: Colin Mayer and Xavier Vives), Cambridge University Press, 1992.

Bhattacharya, Sudipto, and Anjan V. Thakor, "Contemporary Banking Theory", *Journal of Financial Intermediation* 3, October 1993, 2-50.

Boot, Arnoud W. and Anjan V. Thakor, "Security Design", *Journal of Finance* 48, 1993, 1349-1378.

Boot, Arnoud W., and Anjan V. Thakor, "Financial System Architecture", working paper, Indiana University, and Tinbergen Insitute/University of Amsterdam, May 1995.

Boot, Arnoud W., Stuart Greenbaum and Anjan V. Thakor, "Reputation and Discretion in Financial Contracting", *American Economic Review* 83, 1993, 1165-1183.

Dinc, Serdar, "Integration of Financial Systems and Institutional Path Dependence", working paper, Department of Economics, Stanford University, November 1994.

Duffie, Darrell, and Rohit Rahi, "Financial Market Innovation and Security Design", *Journal of Economic Theory*, 1995.

The Economist, "Central Europe's Model Bank", August 27 - September 2, 1994.

Gale, Douglas, "Information Capacity and Financial Collapse", in *Capital Markets and Financial Intermediation*(e.d. Colin Mayer and Xavier Vives), Cambridge University Press, 1992.

Greenbaum, Stuart, and Anjan V. Thakor, *Contemporary Financial Intermediation*, Fort Worth, Texas Dryden Press, 1995.

Holmstrom, Bengt, and Jean Tirole. "Market Liquidity and Performance Monitoring," *Journal of Political Economy* 101-4, 1993, 678-709.

Kanatas, George, and Jianping Qi, "Should Commercial Banks be Prohibited from Underwriting Corporate Securities?", working paper, University of South Florida, December 1993.

Kroszner, Randall S., and Raghuram G. Rajan, "Is the Glass-Steagall Act Justified? A Study of the U.S. Experience with Universal Banking Before 1933", *American Economic Review* 84, 1994a, 810-832.

Kroszner, Randall S., and Raghuram G. Rajan, "The Role of Firewalls in Universal Banks," working paper, University of Chicago, 1994b.

Neave, Edwin H., and Lewis D. Johnson, "Governance and Financial System Organization", working paper 93-26, School of Business Research Program, Queen's University, October 1993.

O'Hara, Maureen, "Real Bills Revisited: Market Value Accounting and Loan Maturity", *Journal of Financial Intermediation* 3, 1993, 51-76.

Puri, Manju, "The Long-Term Default Performance of Bank Underwritten Security Issues", *Journal of Banking and Finance* 18, 1994, 397-418.

Rajan, Raghuram, G., "A Theory of the Costs and Benefits of Universal Banking", working paper, University of Chicago, 1993.

Sabani, Laura, "Market Oriented Versus Bank Oriented Financial Systems: Incomplete Contracts and Long Term Commitments", unpublished manuscript, Universita' di Roma "La Sapienza" Dipartimento di Economia Pubblica and Trinity College, Cambridge, 1992.

Spatt, Chester, S., "Strategic Analyses of Takeover Bids", in *Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory, Volume 2* (eds: Sudipto Bhattacharya and George M. Constantinides), Rowman & Littlefield Publishers, Inc., New Jersey, 1989, pp. 106-121.

Thakor, Anjan V., "Capital Requirements, Monetary Policy and Aggregate Bank Lending: Theory and Empirical Evidence", working paper, Indiana University, May 1995.

Yun, Youngkeol, "Competition and Cooperation Among Investment Banks in the Market for Financial Innovations", working paper, University of Southern California, November 1994.