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Liquidity, Banks, and Markets

Effects of Financial Development on Banks and the Maturity of Financial Claims

Douglas W. Diamond

The amount of liquidity that banks offer depends on the degree of direct participation in financial markets — that is, on the liquidity of financial markets. Conversely, banks influence the amount of liquidity offered by financial markets.

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Summary findings

Financial markets and financial institutions compete to provide investors with liquidity. Diamond examines the roles of banks and markets when both are active, characterizing how development of the financial markets affects the structure of and market share of banks.

Banks create liquidity by offering claims with a higher short-term return than exist without a banking system. The amount of liquidity that banks offer depends on the degree of direct participation in financial markets — that is, on the liquidity of financial markets. Conversely, banks influence the amount of liquidity offered by financial markets.

As more investors participate in financial markets, allowing markets to provide more liquidity, banks shrink and banks make fewer long-term loans. Moreover, the banking sector's ability to subsidize those with immediate liquidity need is reduced.

More liquid markets also lead to physical investment with longer maturity, a smaller gap between the maturity of financial assets and the maturity of physical investments. Financial assets have a shorter maturity than physical investments, but this gap approaches zero as the market approaches full liquidity.

Diamond provides an analytical basis for developing short-term markets as a way to stimulate the supply of long-term finance and supports the practitioner's view that short-term financial markets are a prerequisite for the development of viable long-term finance.

This paper — a product of the Finance and Private Sector Development Division, Policy Resear Department — is part of a larger effort in the department to investigate the role of long term finance in the development process. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Daniele Evans, room N9-026, telephone 202-473-8526, fax 202-522-1155, Internet address devans@worldbank.org. January 1996. (32 pages)

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Introduction

Financial markets and financial institutions compete as ways of providing borrowers with access to capital and of providing liquidity to investors. This paper examines the roles of markets and banks when both are active, characterizing the effects of financial market development on both the structure and market share of banks. Banks create liquidity by offering claims with higher short-term returns for given long-term returns than exist without the banking system. The amount of liquidity that banks offer is influenced by the liquidity (degree of direct participation) in the financial market. Conversely, the amount of liquidity that markets offer is influenced by the activities of banks. As direct participation in markets increases, and markets provide more liquidity, the banking sector shrinks, with banks' holdings of long-term assets falling most rapidly, while the ability of the banking sector to subsidize those with immediate liquidity needs is reduced. More liquid markets also lead to longer maturity physical investment, a longer average maturity of financial assets, and a smaller gap between the maturity of financial assets and physical investments. If the financial market is illiquid (not all investors participate continuously), financial assets have a shorter maturity than do real investments, but this gap approaches zero as the market approaches full liquidity.

Financial markets are imperfectly liquid in this model. I use a very general, but not very deep, characterization of the amount of liquidity in markets. Liquidity is limited because of limited participation in secondary markets. Only a fraction of those investors who do not have a special motive to trade (such a need for immediate cash) are active in the market. Many models with private information about the value of assets have implications similar to the limited participation model. My model has limited participation, but no explicit private information about the value of assets: assets are riskless. Even without private information, the cost of time in the market suggests that some investors will not always participate in markets. In the model, there are no frictions or transaction costs inhibiting trade between the subset of investors who are active in the market. The limited participation/illiquid market influences the prices at which trade takes place between the active investors and the real investments decisions made in anticipation of the prices that will prevail. Related models that use limited participation for different purposes are Merton [1987] which examines and the effect on the relative prices of risky assets when some investors participate only in a subset of asset markets, and Allen and Gale [1994], which examines the implications of limited participation for the volatility of asset prices. Wallace [1988] argues that the Diamond-Dybvig [1983] model can usefully be interpreted as a model where no investors participate in financial markets because they are separated.

The need for liquidity is generated by uninsurable uncertainty about the desired timing of consumption. Formally, these are uninsurable (due to private information) preference shocks, as in Bryant [1980] and Diamond-Dybvig [1983]. As in Diamond-Dybvig [1983], the desired amount of liquidity is increasing in the degree of risk aversion, because investors are willing to give up some long-term return to avoid losses from liquidating assets. The Diamond-Dybvig model explains why banks would create liquidity by cross-subsidizing some depositors: they offer those who withdraw early for liquidity a high return that partly comes at the expense of those who do not withdraw early. Bank deposits provide more liquidity than holding assets directly, and investors all invest through the bank. The model does not consider markets-- the illiquidity of assets is an assumed part of technology and markets are not needed.

The illiquidity of assets in this paper's model comes from limited participation in markets. This allows a role for markets and for banks. It also provides a framework to study the interaction between banks and markets. The Diamond-Dybvig model, where illiquidity is not linked to the operations of markets, has been interpreted as being inconsistent with active markets. Jacklin [1987] shows that if there exists a competitive secondary market where bank deposits trade for other financial assets, then banks cannot cross-subsidize investors with differing needs for liquidity. In addition to Jacklin [1987], Haubrich and King [1990], von Thadden [1991], and Hellwig [1994] examine the effects of competitive and perfectly liquid financial markets, and reach largely negative conclusions about viability of bank liquidity creation. This has been interpreted as meaning that the cross-subsidization role of banks is incompatible with an active financial market.[1] This paper shows that when the illiquidity of assets is due to illiquidity of markets, banks create liquidity in two ways: by holding some of the economy's assets to fill in for gaps due to limited participation in markets and also by cross-subsidization. Banks and markets coexist and influence each other's activities.

A banking system that competes with an illiquid financial market produces liquidity directly and indirectly. Banks produce liquidity directly by offering deposits that offer more liquidity than the market. They produce liquidity indirectly, because offering liquid deposits makes financial markets more liquid than they would otherwise be. Investors' partial reliance on the banking system as a source of liquidity diverts some of their demand for liquidity from financial markets. The banking system influences the price of liquidity in the market, which influences the desirability of holding assets directly. In addition, the banking system's effect on the liquidity of the market influences the desirability of holding claims that can be issued by other, competing banks. The influence of the market liquidity on the desirability of alternative bank claims implies that the claims offered by banks are subject to an ex-ante coalition constraint that other banks not be able to offer dominating claims, as well as the ex-ante constraint that an individual not prefer to hold all assets directly.

1.1 Limited Participation: Motivation

The model presented below is based on limited participation in financial markets by investors. There are several motivations for this limited participation, including differential opportunity costs of time, but the way it is specified in the model is best motivated by information asymmetry, where some investors cannot easily evaluate some assets. No formal analysis of information acquisition costs is presented, and limited participation is simply assumed. Only a fraction of investors are active in the secondary market at a given time. This limited participation reduces the ability of financial markets alone to reallocate claims and

[1]The Jacklin result drops the Diamond-Dybvig assumption that consumption is observable and that those who withdraw use the proceeds for consumption.

consumption goods as investors' desired holdings change unexpectedly.

Markets with low investor participation rates are those with less developed financial markets. Improved information disclosure systems and better legal enforcement of contracts allow more investors to participate directly in markets. The model explores how increased financial market participation influences the role and structure of the banking system and the maturity structure of real and financial assets.

There are three dates 0, 1 and 2. As of date 0, all investors are identical, but each is uncertain when he or she will need to consume and have need liquidity. On date 1, investors learn their type. Type 1 investors need to consume on date 1, and place no value on date-2 consumption. They will sell any assets they own on date 1. All type 1 investors participate in financial markets because consumption needs provide a strong motivation to trade. Type 2 investors want to consume on date 2, and place no value on date 1 consumption. Some type 2 investors will participate in a market for hard-to-value assets (because they have the information or expertise to value assets), and others will not. Type 2 investors who participate and are active in the market are denoted as type 2A investors. Type 2 investors who do not participate in the market are denoted as type 2B agents. Only types 1 and 2A are active in the financial market.

On date 0, investors do not yet know their type (all are identical). Apart from any financial claim offered by financial institutions, investors can choose between two types of real assets. The first is a one-period, self-liquidating, short-term asset that yields a one period ahead cash flow of $R\leq 1$ per unit invested (with constant returns to scale). This asset is available at date 0 or date 1. The second real asset is a two-period long-term asset that yields a two-period ahead cash flow of $X>R^2$ (with constant returns to scale) and nothing in one period. Because $X>R^2$, the long-term asset generates higher date-2 value than repeatedly using the short-term asset. The long-term asset can be sold in the secondary market at date 1. Type 2B investors do not participate in the market for the long-term asset at date 1, implying that any capital invested on date 1 by type 2B investors will go into new short-term assets. On date 1, type 1 investors sell long-term assets to type 2A investors. The price of the long-term asset on date-1 depends on the fractions of investor types and on financial institutions or other contractual arrangements that are in place.

The limited participation in financial markets is important for the allocation of capital to long-term versus short-term real assets and to the consumption opportunities available to investors. Investors can limit the need to use financial markets by entering into contracts at date 0 that limit the need to trade assets at date 1 and reduce the imbalances in financial markets. However, because some investors are able to trade (types 1 and 2A), the types of institutions that fill in the gaps in markets must take account of their trading opportunities. Limited participation implies that institutions must fill in for those who are not active in markets, and also take account of the opportunities available to those who do participate in markets. Holmström and Tirole [1995] provides an alternative motivation for limited participation in their study of private and government-provided liquidity: it motivates limited participation by moral hazard in borrowing firms, as in Diamond [1991]. Gorton-Pennacci [1990] examines the ability of intermediaries or firms to create riskless securities when private information causes problems in risky asset markets. Their paper does not have limited participation in markets, but their results have a related focus.

1.2 The Role of Financial Institutions

Financial institutions can substitute for illiquid markets. Institutions can economize on the holding of liquid assets by avoiding the possibility that nonparticipating type 2B agents hold excessive liquidity. It is also possible, given the informational motivation for limited participation, that financial institutions could participate in markets on behalf of investors. Both roles for financial institutions are examined. No costs of operating financial institutions are introduced, in the interest of simplicity. The existence of variable costs, however, would suggest that to implement a given set of consumption opportunities, there should be smallest possible scale of the banking industry. This allows the model to analyze the effects of financial market development on the scale and activities of the banking sector.

1.3 Outline of the Paper

Section 2 describes the model and characterizes the total amount of liquidity optimally created by the combination of the financial markets and the banking system. This characterization is stated in terms of the consumption opportunities offered to investors. Section 3 shows how financial market development that increases the liquidity of financial markets changes the amount of liquidity provided by banks. Section 4 describes the implications of optimal liquidity creation for the scale of the banking industry, the contracts the banking system offers, the assets that banks fund with those deposits, and the maturity structure of financial and real assets. Section 5 presents a detailed example to illustrate the results in the paper. Section 6 concludes the paper.

2. The Model

There are three dates 0, 1 and 2. As of date 0, all investors are identical, but each is uncertain about which date he or she will need to consume and need liquidity. Each is endowed with one unit of date-0 capital. There are three types of agents as of date 1: type 1, type 2A and type 2B. As of date 0, an investor is of type τ on date 1 with probability q_τ. Define $c_{t\tau}$ as the consumption on date t of a type τ investor. Type 1 agents will need liquidity: they need to consume at date 1, and have utility of date 1 consumption $U(c_{11})$. Type 1 agents place no value on date 2 consumption. Types 2A and 2B do not need liquidity on date 1 and place no value on date-1 consumption. The only difference between the two types differ is their participation in a secondary market for assets on date 1. Type 2A agents are active in the secondary market, and type 2B agents are not active. They have identical utility functions: their utility is $U(C_{22j})$ for $j \in \{A,B\}$.

Investors are risk averse. Formally, each has a state-dependent utility function, where the state is private information. The form of the utility function is:

$$u(c_1,c_2;\ \theta) = \begin{cases} U(c_1) & \text{if j is of type 1 in state } \theta \\ U(c_2) & \text{if j is of type 2A or 2B in state } \theta \end{cases}$$

where $U: R_{++} \rightarrow R$ is twice continuously differentiable, increasing, strictly concave, and satisfies Inada conditions $U'(0)=\infty$, and $U'(\infty)=0$. Also, the relative risk aversion coefficient $-cU''(c)/U'(c)>1$ everywhere.

Investors maximize expected utility. These preferences are identical to those assumed in Diamond-Dybvig [1983], except here types 2A and 2B are distinguished. Diamond-Dybvig [1983] allows no secondary market, which essentially assumes that are only types 1 and 2B.

Liquidity is assumed to be difficult to obtain. Real asset investments that payoff quickly are less profitable than long-term investments. In addition, the limited participation in secondary markets limits their ability to allocate all available liquidity to its best use. There are two types of real assets. The first is a one-period short-term asset that yields a one period ahead cash flow of $R \leq 1$ per unit invested (with constant returns to scale). The second real asset is a two-period long-term asset that yields a two-period ahead cash flow of $X > R^2$ (with constant returns to scale) and nothing in one period. The long-term asset can be sold in the secondary market at date 1.

In the Diamond-Dybvig [1983] model there are no secondary markets, but long-term assets can be physically liquidated for a return that weakly exceeds the return on short-term assets, implying that all investment should be long-term.[2] The current model implies a non-trivial decision on how to allocate investment between short and long-term assets, due to potential for illiquidity of asset markets.

Investors have a demand for liquidity, and the most profitable assets may be illiquid. Financial institutions such as banks can improve liquidity in two ways. By centralizing the holding of liquid assets, the institution reduces the opportunity cost of excess liquidity held by those investors who do not participate in the market. In addition, there is some ability to cross-subsidize investors: investors who need to consume unexpectedly at date 1 (type 1) receive higher returns at the expense of those who neither need to consume nor are actively trading in the market (type 2B).

To characterize the role of intermediaries and markets in providing the optimal amount of liquidity, I solve for the ex-ante optimal set of incentive-compatible consumption opportunities, and later determine

[2]Diamond-Dybvig also assume that $R=1$. The minor generalization to $R \leq 1$ is not important to the results in this draft.

how these are related to markets and intermediaries.

The optimal financial mechanism solves the following maximization problem.

$$\max_{c_{11},c_{22A},c_{22B}} \Psi = q_1 U(c_{11}) + q_{2A} U(c_{22A}) + q_{2B} U(c_{22B})$$

Subject to several constraints. First is the resource constraint:

$$\frac{q_1 c_{11} + q_{2A} c_{12A} + q_{2B} c_{12B}}{R} + \frac{q_1 c_{21} + q_{2A} c_{22A} + q_{2B} c_{22B}}{X} \leq 1$$

Consumption on the "wrong" date (by a type who assigns no value to consumption on that date) is never optimal, and at the optimum $c_{21}=c_{12A}=c_{12B}=0$.

There are two additional types of constraints. At date-0, investors must choose to join the financial mechanism, instead of either investing directly, or joining a competing mechanism. In addition, at date-1 the realized type of each agent is private information. As a result, it must be incentive- compatible for each to self-select the consumption stream implied by the optimal mechanism.

On date 1, an agent who joins this financial mechanism will be given a choice of claims on date-1 and on date-2 consumption. I defer discussion of the institutional details of how intermediaries implement the optimal incentive-compatible consumption opportunities. The standard method for characterizing the optimal consumption is to examine direct mechanisms where each investor reveals his or her type, and is given type-continent consumption on each date, subject to the constraint that each investor is willing to make an honest report.

Investors of type 1 and 2A have the ability to trade anonymously at date 1, and to privately consume the proceeds from those trades. The individuals can write contracts where they exchange payments at date 0 for promised payments at date 1 and date 2, but they cannot be prevented from trading these claims among themselves. Trade will turn out to be required to support the optimal mechanism. It is simplest to characterize the financial mechanism in terms of the holding, before any trade, of date-1 and date-2 claims on date 1 by each type of investor, rather than the final consumption of each investor type after trade occurs. Let $W_{t\tau}$ denote the date-1 holding of date t claims by a type τ investor. Most of the analysis is most compactly stated in terms of $W_{t\tau}$, and it is a useful input into determining the assets that investors hold directly and those held indirectly through banks. This decomposition of date-1 holdings before trade is briefly described in the next section. This section could be skipped on first reading to avoid extra details.

2.1 Direct Holdings and Bank Claims

Date-1 holding of claims by investors (before any trade) include the direct holdings chosen on date 0 plus the claims that they obtain from financial intermediaries. Let δ_t denote the proportion of date 0 capital invested directly assets maturing on date $t\in\{1,2\}$, and let β denote the proportion of date 0 capital invested through the intermediary mechanism. The date-0 resource constraint is $\delta_1 + \delta_2 + \beta \leq 1$. On date-1, each investor has direct holding of claims on date t consumption of d_t, where $d_1=\delta_1 R$ and $d_2=\delta_2 X$.

The claims obtained or "withdrawn" from financial intermediaries are denoted by lower case w: define $w_{t\tau}$ as the claim on date-t consumption "withdrawn" by a type τ investor at date $t\in\{1,2\}$, who "deposited" a fraction β of his or her endowment of one unit at date 0 . The total claim, $W_{t\tau}$, on date t consumption held by investor type τ on date 1 (before any trade) is: $W_{t\tau}=d_t + w_{t\tau}$.

I examine cases where banks have no market-trading advantages over individuals and where banks can participate in the market on behalf of its non-participating members. The model's implications are similar in each case. If banks trade in the market at date 1, then banks offer date-2 claims in exchange for date-1 claims (or vice versa), and these offers would be available only to those who participate in the market (types 1 and 2A). The notation for bank trades in the market is as follows. Let m_2 denote the net number of date-2 claims sold in the market by banks on date-1 to buy claims that mature on date 1 (both expressed as a proportion of the per-capita date-0 endowment). If instead the bank is on balance buying date 2 claims, then $m_2=0$ and $m_1>0$ is the number of date-1 claims the bank is selling (in the same units). If banks have no advantages over investors, then like type 2B agents, banks cannot buy existing date-2 maturing assets (with maturing assets' proceeds) at date-1, and $m_1=0$ and $m_2\geq 0$ is required. If the bank does not trade at all on date 1, then $m_1=m_2=0$. I defer further discussion of the bank's trading to section 4.

Types 1 and 2A can trade in the market at date 1. This implies that the consumption on date 1 of type 1 agents must satisfy $q_1c_{11} \leq q_1W_{11} + q_{2A}W_{12A} + m_1$. Consumption of date 2 by type 2A agents must satisfy $q_{2A}c_{22A} \leq q_1W_{21} + q_{2A}W_{22A} + m_2 + R(q_1W_{11} + q_{2A}W_{12A} + m_1)$. Type 2B agents do not have access to the financial market and can make use of claims on date-1 consumption only by investing in new short-term investments at date 1, implying that $c_{22B}=W_{12B}R + W_{22B}$.

Motivated by costs of financial intermediation, I will characterize the smallest scale of the banking system that will deliver the optimal type-contingent consumption. This implies the largest direct holding and the smallest intermediated holding of assets. Until section 4, I only analyze the optimal quantities of total claims, $W_{t\tau}$, held by each agent. In section 4, the determination of direct and bank claims is reintroduced.

2.2 Secondary Market Prices

Let b_1 denote that price at which a one unit claim on date-2 consumption trades for on date 1. Price formation is very simple: those who are type 1 have no use for future consumption, and will sell claims on date-2 goods at any positive price. Type 2A agents will buy date-2 maturing assets with date-1 claims, at any price $b_1\leq 1/R$ (which allows a yield of at least R). Type 2A agents would sell date-1 claims to buy date-1 claims to invest if $b_1>1/R$. Type 2B agents do not participate in the date-1 secondary market. The market clearing condition is that the supply of long-term assets by type 1 agents equal the demand by type 2A agents. The supply of long-term assets for sale at date 1 (given $b_1>0$) is $q_1W_{21}+m_2$. The demand on date 1 for assets with date-2 payoffs (the supply of assets with date-1 payoffs) is $q_{2A}W_{12A}+m_1$, so long as $b_1 \leq \frac{1}{R}$. The market clearing price is then given by $b_1 = \min\{\frac{1}{R}, \frac{q_{2A}W_{12A}+m_1}{q_1W_{21}+m_2}\}$. This implies that $c_{t\tau}$, the consumption in period t of a type $\tau\in\{1,2A,2B\}$ of agent is as follows:

$$c_{11} = W_{11} + W_{21}b_1$$
$$c_{22A} = \frac{W_{12A}}{b_1} + W_{22A}$$
$$c_{22B} = W_{12B}R + W_{22B}$$

2.3 Incentive Compatibility

The type-contingent consumption offered on date-1 is incentive-compatible if and only if no investor prefers the consumption implied by the claims $W_{t\tau}$ intended for another type of investor. Let $c_{t\tau}^{\bar{\tau}}$ denote the consumption on date t of a type τ investor who misrepresents himself or herself as a type $\bar{\tau}$ investor, choosing the claims $W_{1\bar{\tau}}, W_{2\bar{\tau}}$ and trading at the market price b_1 if of type 1 or 2A. Using this definition, and the definitions of individual consumption, $c_{t\tau}$, given above, the following are the date-1 constraints on incentive-compatible consumption, $(\text{IC } \tau,\bar{\tau})$.

Date 1 incentive-compatibility constraints:

$$c_{11} = W_{11} + b_1W_{21} \geq W_{12A} + b_1W_{22A} = c_{11}^{2A} = c_{22A}b_1 \qquad \text{(IC 1,2A)}$$
$$c_{11} = W_{11} + b_1W_{21} \geq W_{12B} + b_1W_{22B} = c_{11}^{2B} = c_{22B}b_1 \qquad \text{(IC 1,2B)}$$
$$c_{22A} = \frac{W_{12A}}{b_1} + W_{22A} \geq \frac{W_{11}}{b_1} + W_{21} = c_{22A}^{1} = \frac{c_{11}}{b_1} \qquad \text{(IC 2A,1)}$$
$$c_{22A} = \frac{W_{12A}}{b_1} + W_{22A} \geq \frac{W_{12B}}{b_1} + W_{22B} = c_{22A}^{2B} \geq c_{22B} \qquad \text{(IC 2A,2B)}$$
$$c_{22B} = W_{12B}R + W_{22B} \geq W_{11}R + W_{21} = c_{22B}^{1} \qquad \text{(IC 2B,1)}$$
$$c_{22B} = W_{12B}R + W_{22B} \geq W_{12A}R + W_{22A} = c_{22B}^{2A} \qquad \text{(IC 2B,2A)}$$

The constraints (IC 1,2A) and (IC 2A,1) together imply that $c_{11} = c_{22A}b_1$ and that $b_1 = \frac{c_{11}}{c_{22A}}$. If the relative price on date 2 consumption in terms of date 1 consumption were not equal to $\frac{c_{11}}{c_{22A}}$, either type 1 or type 2A would prefer to take and then sell the claim withdrawn by the other type of investor, because the date-1 market value of the claims would differ. The market value of the amount withdrawn by type 1 investors must equal that of type 2A investors, otherwise both will take the one with higher market value, and trade to get higher consumption on the desired date. This implies that type 1 and 2A are indifferent between taking the claims intended for either of the two types, and that the mechanism can give the same claims to both types and set $W_{11}=W_{12A}$ and $W_{21}=W_{22A}$. Making the claims given to types 1 and 2A identical loosens the constraints (IC 2B, 1) and (IC 2B, 2A) that type 2B agents do not select the claims intended for other types, by minimizing $\max\{W_{11}, W_{12A}\}$. The date-1 incentive constraints (IC t,τ) can be satisfied several ways, discussed later.[3]

Note that if $c_{22A} > c_{22B}$, some date-1 claims must be held by type 2A agents ($W_{12A}>0$), and this implies that there must be trade to allow type 2A to consume at date 2 and not on date 1.

2.4 Voluntary Deposits at Date 0

The constraints that limit the amount of liquidity that can be provided are the date-0 constraints on voluntary deposits into the mechanism (usually referred to as participation constraints, but this could be confused with participation in markets). For investors to choose to deposit in the bank requires that the bank give them a type-contingent consumption bundle that is as desirable as what can be obtained from joining no bank and just holding assets directly or by choosing to deposit in another bank. The binding constraint is that the bank must not allow another bank to offer a dominating contract. Discussion of the possibility of selecting individual direct investment follows.

Individuals can form alternative mechanisms ("competing banks") at date-0, subject to the same incentive and resource constraints as the mechanism analyzed above, and with access to the same anonymous market at date-1. This ability imposes coalition incentive-compatibility constraints. The importance of coalition incentive constraints in this setting was suggested by Jacklin [1987] who studies the effects of ex-post, i.e., date 1, coalition formation by trade in markets. Their importance was further clarified by von Thadden [1991] who looks at the implications of ex-ante coalition formation, where competing banks are formed.

2.4.1 Competing Banks on Date 0

Suppose that at date 0, a competing bank contract can be proposed by "Bank II." Bank II accepts deposits at date 0 and offers date 1 and date 2 type-contingent payments, and a portfolio policy. A contract offered by Bank I is date-0 coalition incentive compatible if no dominating contract can be proposed on date 0 by Bank II. A contract offered by Bank II can offer its members claims on date-1 and date-2 consumption that its type 1 or type 2A members can use to trade on date-1 in the anonymous market that includes members of Bank I. Suppose that Bank I proposes a contract that, if no competing contract were proposed, would lead to type-contingent consumptions$(c^I_{11}, c^I_{22A}, c^I_{22B})$ with $\frac{c^I_{11}}{c^I_{22A}} > \frac{R}{X}$. If no competing contract is proposed, then b_1, the date-1 price of date-2 claims, will be high: $b_1^I = \frac{c^I_{11}}{c^I_{22A}} > \frac{R}{X}$. This allows Bank II to

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[3]If the date-1 incentive constraints were the only constraints, it would be incentive feasible to treat types 2A and 2B identically, despite the ability of types 1 and 2A to trade. For example, set $W_{11}=c_{11}$ and $W_{21}=0$. Then $c_{22A} = c_{22B} \geq Rc_{11}$ can be implemented by setting $W_{21}=W_{12A}=W_{12B}=0$, and $W_{22A}= W_{22B}= c_{22A} \geq Rc_{11}$. This implies a date-1 price of $b_1=c_{11}/c_{22A}<1/R$, and self-selection by all types. Proposition 2 shows that, at the optimum, $c_{22A} \geq c_{22B} \geq Rc_{11}$ even when the date-1 incentive constraints are not imposed.

propose a dominating contract. Suppose that Bank II proposes a contract that gives the same c_{22B} as Bank I ($c_{22B}^{II} = c_{22B}^{I}$), but invests more of the remaining capital in long-term assets (and less in short-term) to give types 1 and 2A tradable claims slightly biased toward date 2 consumption. Investing one unit more in long term assets and one less in short-term claims allows an R decrease in date-1 and a X unit increase in date-2 claims. Choose $\varepsilon>0$ such that $W_{11}^{II}=W_{12A}^{II}=W_1^{II}=\frac{q_1c_{11}^{I}}{q_1+q_{2A}}-\varepsilon$, and $W_{21}^{II}=W_{22A}^{II}=W_2^{II}=\frac{q_{2A}c_{22A}^{I}}{q_1+q_{2A}}+\frac{\varepsilon X}{R}$ such that

$\frac{R}{X} \le \frac{q_1W_1^{II}}{q_{2A}W_2^{II}} < \frac{c_{11}^{I}}{c_{22A}^{I}}$.[4]

This implies that:

$$c_{11}^{II} = \frac{q_1c_{11}^{I}}{q_1+q_{2A}} - \varepsilon + \left[\frac{q_{2A}c_{22A}^{I}}{q_1+q_{2A}}+\frac{\varepsilon X}{R}\right]b_1 = \frac{q_1c_{11}^{I}}{q_1+q_{2A}} - \varepsilon + \left(\frac{q_{2A}c_{22A}^{I}}{q_1+q_{2A}}+\frac{\varepsilon X}{R}\right)\frac{c_{11}^{I}}{c_{22A}^{I}}$$

$$= c_{11}^{I} + \varepsilon\left(\frac{c_{11}^{I}X}{c_{22A}^{I}R} - 1\right) > c_{11}^{I}$$

Similarly, for type 2A agents:

$$c_{22A}^{II} = \left[\frac{q_1c_{11}^{I}}{q_1+q_{2A}} - \varepsilon\right]\frac{1}{b_1} + \frac{q_{2A}c_{22A}^{I}}{q_1+q_{2A}}+\frac{\varepsilon X}{R} = \left(\frac{q_1c_{11}^{I}}{q_1+q_{2A}} - \varepsilon\right)\frac{c_{22A}^{I}}{c_{11}^{I}} + \frac{q_{2A}c_{22A}^{I}}{q_1+q_{2A}}+\frac{\varepsilon X}{R}$$

$$= c_{22A}^{I} + \varepsilon\left(\frac{c_{11}^{I}X}{c_{22A}^{I}R}-1\right) > c_{22A}^{I}$$

Trade with members of bank I at price b_1^I would allow members of bank II to get date 1 consumption at date-0 cost $(b_1^I X)^{-1}<(1/R)$ which is less than the actual date-0 cost of date 1 consumption. If the price ratio, b_1, of date 1 to date 2 consumption is not in line with marginal productivity, R/X, a competing bank can offer a dominating contract. A symmetric argument rules out $b_1<R/X$. If, and only if, $b_1=R/X$, is there no dominating contract possible for a competing bank.

I assume that interbank deposits are identifiable as such (if only by their size). This prevents a competing bank from obtaining the liquidity creation of other banks by investing directly in the one-period deposits of the banks.[5] Note that, in practice, the interest rate on interbank deposits is sometimes below the

[4] As an alternative to increasing W_2^{II}, bank II could directly sell long-term assets at date 1, increasing m_2 by $\varepsilon X/R$.

[5] If interbank deposits could not be identified, an argument similar to the above shows that not only must $b_1=R/X$, but W_1 must also equal R and $W_2=X$. This would mean not only $c_{11}/c_{22A}=R/X$, but also $c_{11}=R$, $c_{22A}=c_{22B}=X$.

rate offered to depositors with similar maturity. Some benefits of liquidity creation can be focused on the individual bank's depositors. However, the effect of banks' liquidity creation on market liquidity is available to all competitors, due to free-entry into trades in the anonymous secondary market.

The possibility of entry by competing banks implies that the amount of liquidity provided by financial markets is the amount offered by the physical productivity of short-term productive assets, which is more liquidity than markets offer when there are no banks.

2.5 Incentives for Excess Direct Holdings by Individuals

The individual incentive to join the financial institution is assured by the coalition incentive constraint that competing banks cannot offer dominating contracts at date 0, which implies that $b_1 = \frac{c_{11}}{c_{22A}} = \frac{R}{X}$. If the individual at date-0 does not deposit any capital in the bank, then he or she will hold a portfolio of long and short-term assets (a fraction $\alpha \in [0,1]$ in short-term, and $1-\alpha$ in long-term). The type-contingent consumption from holding assets directly is for 1: $\alpha R + (1-\alpha)b_1 X = R$ (for all α), type 2A: $\alpha R/b_1 + (1-\alpha)X = X$ (for all α), type 2B: $\alpha R^2 + (1-\alpha)X \leq X$ (equal to X for $\alpha=1$). These consumption levels can be offered by the bank, and the bank offers consumption levels that are most preferred on date 0. Unless $\alpha=1$, the bank has a strictly better set of consumption opportunities from which to choose. Investors will not choose to deviate to holding all of their assets directly.

An even stronger individual participation constraint is satisfied. Individual investors can freely choose at date 0 to deposit any fraction of their capital in the bank, and each will choose the correct fraction to deposit if the bank offers the optimal consumption allocations. This is discussed below in section 4, where the allocation of investor wealth between direct holdings and bank claims is discussed.

3. The Optimal Amount of Liquidity

The banking system creates more liquidity than there would be without a banking system or secondary markets. The banking system also makes the secondary market more liquid: secondary markets will offer the amount of liquidity implied by the short-term physical return on capital. The condition for banks to create more liquidity than secondary markets is that not too many investors participate in the secondary market. *Proposition 1 states this result.*

Proposition 1: If there is limited participation in the secondary market ($q_{2B}>0$), then banks hold the physical short-term liquid assets and increase the liquidity of the secondary market until the price of long-term assets on date 1 is $b_1=\frac{R}{X}$. If the coefficient of relative risk aversion is above one, and a sufficient fraction of investors may not participate, $q_{2B}>\hat{q}_{2B}>0$, then banks provide more liquidity than does the secondary market, and set $c_{11} > R$ and $c_{22B} < X$.

The next proposition shows the effect of increased secondary market liquidity (increased q_{2A}) on the amount of liquidity created by banks.

Proposition 2: Increasing individual participation in the secondary market (increasing q_{2A} by reducing q_{2B}) weakly reduces the liquidity that banks create relative to secondary markets (c_{11}-R), and reduces c_{11}, the amount of liquidity available to investors.

Proofs: See Appendix.

Banks produce less liquidity when more investors participate in the secondary market because more of the benefit from a higher short-term return goes to those who profit from trading (and have high consumption) rather than to those who need short-term liquidity for unexpected consumption purposes (and have low consumption). In equilibrium, increased participation in the market reduces the consumption of those who need liquidity (reducing c_{11}) and those who trade actively (reducing c_{22A}). The consumption of those who do not need liquidity and do not participate in the secondary market can increase or decrease (c_{22B} can rise or fall), but $c_{22B} - c_1$ rises as participation increases: there is less risk-sharing between those who turn out to need liquidity and those who do not participate in secondary markets.

4. Direct Holdings and Bank Claims

Not all of the financial claims need to be held by banks at date 0 for them to augment the liquidity available to investors. If there are variable costs associated with running wealth though intermediaries, the scale of the banking sector is determined by the minimum scale of banks that is needed to implement the desired amount of liquidity. The scope for direct holdings arises because the set of optimal tradable claims held by investors at date 1 (before trade) assigns a positive claim on date-2 consumption to all types ($W_{2\,min} = \min\{W_{21}, W_{22A}, W_{22B}\} > 0$). This implies one constraint on direct holding: $d_2 \leq W_{2\,min}$, the total type-contingent holdings of date-2 on date-1 are then $W_{2\tau} = d_2 + w_{2\tau}$, where $w_{t\tau}$ is the type-contingent holding of date t claims on the bank selected by type τ. Investors who are of type 2B (and do not to participate in markets) hold no maturing short-term physical assets at date 1 ($W_{12B}=0$), to avoid inefficient rollover of short-term assets. This implies that all short-term claims are bank liabilities. Because all date-1 claims are bank liabilities, this implies $W_{1\tau} = w_{1\tau}$. Subject to the choice of bank claims being incentive-compatible, liquidity can be provided by all investors investing directly at date 0 a fraction $\frac{d_2}{X}$ of their wealth into long-term assets.[6] .

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[6]This shows that the optimal mechanism can *assign* a specified fraction direct holdings in return for allowing access to banks. I show below that the optimal mechanism can allow investors at date 0 to freely choose the proportions of direct and intermediated investment.

4.1 The Scale of the Banking Sector

This section analyzes the minimum fraction, β, of assets invested through banks. There are several constraints on β. The banking system must hold all of the physical short-term assets. Otherwise, type 2B's, who do not participate at date 1, will inefficiently rollover short-term assets. For date-1 consumption to equal c_{11}, short term assets with a date-1 value of at least q_1c_{11} must be held, implying that at least a fraction

$$\beta \geq \beta_1 = \frac{q_1c_{11}}{R} \qquad \text{(Minimum holding of Liquidity)}$$

of date-1 maturing assets must be held by banks at date 0.

4.1.1 Incentive Compatibility

Investors hold no date-1 claims directly on date 0. Each invests β in banks, and $1-\beta$ directly in long term date-2 assets implying that on date-1 (before trade) each holds a date-2 direct claim of $d_2=(1-\beta)X$. The constraint that entry by a competing bank not be profitable implies $c_{22A} = c_{11}(X/R)= c_{11}/b_1$. This implies that and that the only potentially binding incentive constraint on date 1 withdrawals from banks is that type 2B's select the proper withdrawal and that, at the optimum, the type 2A and type 1 withdrawals are equally attractive to type 2B agents. To avoid inefficient rollover of short-term assets, type 2B agents will have no date-1 maturing claims: $W_{12B}=0$, implying they take no date-1 maturing bank claims: $w_{12B}=0$. The constraint that 2B agents not select 2A claims is:

$$c_{22B} = w_{22B}+(1-\beta)X \geq w_{12A}R + w_{22A}+ (1-\beta)X = c_{22B}^{2A} \qquad \text{(IC 2B,2A)}$$
$$=(c_{22A} - (1-\beta)X-w_{22A})\frac{R}{X}R + (1-\beta)X + w_{22A}.$$

The smallest possible fraction of assets held by banks, β, is achieved by setting a contract where those with access to the market continue to hold no bank claims after date 1 and $w_{22A}=0=w_{21}$. Noting that $c_{22A}=c_{11}X/R$, the constraint on type 2B consumption is $c_{22B} - (1-\beta)X \geq R(c_{11}-(1-\beta)R)$ or:

$$\beta \geq \beta_{IC} = 1-\frac{c_{22B}-Rc_{11}}{X-R^2}. \qquad \text{IC: Incentive compatibility}$$

The analysis shows that $c_{22B}-Rc_{11}$ increases as market liquidity increases (q_{2A} increases), and reaches a maximum of $X-R^2$ when $q_{2A}=1-q_1$. The value of β_{IC} decreases to zero as q_{2A} increases to $1-q_1$. This implies that as the market becomes very liquid, the IC constraint does not bind, because $\beta_{IC}\to 0$.This implies that when the market becomes very liquid, the banking system does not hold long-term assets. Given sufficient risk aversion, $c_{22B}-Rc_{11}$ is sufficiently large at low levels of liquidity that $\beta_{IC}>\beta_1$, and as the market becomes illiquid, the fraction of long-term assets held by the banking system, $\beta_{IC} - \beta_1$, increases. The long-term assets held by individuals provide them with liquidity because they can either sell them to banks in the secondary market, or borrow from banks, using them as collateral. In this view of banks' liquidity role, the bank provides liquidity by offering liquid deposits and by making long-term assets more liquid, through the increase in market liquidity.

The ability for investors to choose to deposit part of their endowment in the bank (and hold the rest directly in long-term assets), does not change the set of feasible final consumption possibilities. So long as $\beta \geq \beta_{IC}$, the bank will offer contracts where $w_{11}=w_{12A} \leq w_{22B}/R$. No matter what fraction an individual investor allocates to the bank, it is incentive-compatible for that investor when of types 1 and 2A to withdraw $w_{11}=w_{12A}$ at date 1 and when of type 2B to withdraw w_{22B} at date 2. Deviating to a smaller or larger value of β leaves c_{11}/c_{22A} unchanged, which leaves the market price of date 2 consumption on date 1, b_1, unchanged. Holding the correct fraction $1-\beta$ in long-term assets directly leads to the type-contingent consumption from the optimal mechanism. Choosing another level of β allows the individual to obtain a level of type-contingent consumption that would be feasible and incentive compatible: too high a β reduces c_{11} and c_{22A}, increasing c_{22B}, too low a β does the reverse. If the banking system offers claims that are consistent with the optimal levels of $c_{tt'}$, then each individual will choose the correct bank deposit, β.[7]

The constraints on minimum banking system market share in this section are based only on the constraint that investors choose the proper withdrawal. In addition, there are resource constraints represented by the market-clearing condition (definition of b_1). If bank's ability to trade in markets is limited similar to individuals, then resource constrains imply that banks may need to hold more assets than the constraints above imply. This is analyzed in the next section.

4.2 Scale of the Banking Sector and Banks' Ability To Trade Assets

To determine the link between bank trades in the market and the implied scale of the banking sector, begin with the benchmark where banks do not trade in the financial market, and $m_1=m_2=0$. If the bank makes no trades, the resource constraint implies that banks must hold sufficient assets is to provide type 1 agents with consumption c_{11}, plus provide enough date-2 assets to provide the excess of type 2B's consumption over that of obtained from their direct holdings of assets. All investors will choose the same direct holding on date 0, when their liquidity need and type is unknown. The consumption of type 2A

[7]If individuals differ in their amount by which they relative risk aversion exceeds one, they could choose individualized amounts of liquidity by selecting different levels of β. So long as the date-1 incentive compatibility constraint is satisfied, no other agent's feasible set is influenced by another's choice of β.

agents can come from direct holdings of date-2 claims by type 1 and 2A agents. Because type 2A consumption is $c_{22A}=c_{11}X/R$, the value of direct holding is: $d_2=q_{2A}c_{11}X/(q_1+q_{2A})R$. This implies that the balance of date-0 capital is invested by the bank, and the scale of the banking sector must satisfy:

$$\beta \geq \beta_{MC} = 1 - \frac{q_{2A}c_{11}}{R(q_1+q_{2A})}, \qquad \text{(MC = Market Clearing, investors only)}$$

assuming that this satisfies $\beta_{MC} \geq \beta_{IC}$. $\beta_{MC} \geq \beta_1$, because the market clearing condition requires that all liquid assets be held by the bank, as well as some long term assets (because $c_{11} \geq R$). If the bank cannot trade assets, the scale of the banking industry is $\max\{\beta_{MC},\beta_{IC}\}$. The value of β_{MC} decreases with increased market participation, and β_{MC} goes from 1 to q_1 as q_{2A} goes from 0 to $1-q_1$.

If a bank's access to the market is not superior to type 2B individuals, it cannot buy date-2 assets with date-1 claims on date 1. This limited market access would imply that $m_1=0$ and $m_2 \geq 0$. If the bank were to sell date-2 assets (to type 2A agents) on date-1, setting $m_2>0$, it would need to hold more than β_{MC} assets at date-0, increasing the scale of the bank. Alternatively, if the bank did not have limited access to markets, it could buy date-2 assets on date-1 with date-1 claims, and set $m_1>0$ and $m_2=0$. In this case, it could hold fewer assets on date-0, because it would not need to fund the consumption of type 2B agents in excess of their direct holdings. The resource constraint implied by market clearing implies that the scale of the bank on date-0 is $\beta_{MC} - m_1/R$.

By buying long-term assets on date 1, or equivalently, lending against them at market rates, the bank could shrink until $\beta_{MC} - m_1/R$ is equal to to the smaller of β_{IC} and β_1. If the bank can participate on behalf of type 2B's, it can set $m_1>0$, and operate at a smaller scale.

In summary, whether or not the bank can participate in markets on behalf of investors, the banking sector shrinks as financial market participation increases and markets become more liquid. There are other interesting interpretations of these results. Because the banking system issues the short-term financial assets, its scale is a measure of the proportion of short-term financial assets in the economy. Whenever the scale of the banking sector exceeds that implied by the minimal liquidity needs of the economy (its scale exceeds $\beta_1 = \frac{q_1c_{11}}{R}$), then the banks hold long-term assets as well. Proposition 3 summarizes the results in section 4.

Proposition 3 The scale of the banking sector, the fraction of financial assets that are short-term, the fraction of real assets that are short term, and the gap between the maturity of financial and real assets all decrease as direct market participation increases (q_{2A} increases, while q_{2B} decreases).

5. Example to Illustrate Results on Debt Maturity and Scale of Banking Industry

This example will illustrate the model's implications, focusing on the results about the aggregate maturity of financial and physical assets in economies with various levels of market liquidity. Suppose that the physical assets are as follows: If one invests \$1 at date 0, the liquid short-term yields R=\$1 at date 1 (similarly between dates 1 and 2). Investing \$1 in the long-term asset yields X=\$2 at date 2. The coalition incentive-compatibility constraint of no dominating competing bank implies that the date-1 price of a unit claim on date-2 is $b_1=½$, and a claim on X=2 at date-2 sells for 1 on date 1.

There are 100 investors, 20 will be of type 1 (and consume at date 1), and 80 will be of type 2 (and consume at date 2). Each begins with \$1 to invest on date 0. It is not known which investors will be of each type. As of date 0, each investor has a probability q_1=.2 of being of needing to withdraw and thus being of type 1. A fraction .8 of investors will be of either of type 2A or 2B. Assume that investors have constant relative risk aversion, with relative rate of risk aversion, $-cU''(c)/U'(c)=2$; let $U[c]=110-\frac{100}{c}$, to keep numbers round. Constant relative risk aversion of 2 allows the model to be solved in closed form.

Consider the case where there is no one is active in the financial market, and no investor is of type 2A. Suppose that the bank does not cross-subsidize investors, and invests at date 0 a fraction .2 in date-1 maturing assets and .8 in date-2 maturing assets. This yields $c_{11}=1$ or $c_{22B}=2$, and date 0 expected utility equals

$$.2[110-\frac{100}{1}]+.8[110-\frac{100}{2}]=50.$$

This amount of liquidity is not possible without banks when no one participates in the secondary market. If each investor put a fraction α of date-0 wealth into short-term assets and the remainder in long-term, each would consume $c_{11}=\alpha 1$, $c_{22B}=(1-\alpha)2$, and any feasible direct holdings imply $c_{11}=0$ when $c_{22B}=2$ or imply $c_{22B}=0$ when $c_{11}=1$. When there are no markets, banks liquidity role is important even when there is no cross-subsidization. Cross-subsidization, however, is also desirable.

There exists a more liquid asset that each investor would prefer. The ex-ante optimum type contingent consumption is $c_{11}=1.306$ and $c_{22B}=1.847$, when $q_{2A}=0$ (see table 1 below). These consumption levels lead to expected utility of: .2U(1.306) + .8U(1.847), or

$$.2[110 - \frac{100}{1.306}] + .8[110 - \frac{100}{1.847}] = 51.3 > 50.$$

The investors prefer this more liquid asset.

5.1 A bank can provide this liquidity through demand deposits.

Suppose that each investor invests exclusively though that bank at date 0. The bank pays 1.306 to those who withdraw at date 1, and pays 1.847 to those who withdraw at date 2. The bank receives $100 in deposits as of date 0, and invests a fraction close to .26 in short-term assets(26 short-term), .74 in long-term assets (74 long term). At date 1, the bank's maturing assets are worth 26, 20 type 1 depositors withdraw, allowing each to get 26/20=1.306. There remain 74 long-term assets at date 2, when they will be worth X=2 each. If on that date, there remain 80 depositors, each will receive: $(74 \cdot 2)/80 = 1.847$. The bank's cross subsidization of investors leads to a more liquid deposit. The bank invests in a portfolio with 74% long-term physical assets, and issues 100% short-term liabilities that can be withdrawn at date 1. Intermediaries create liquidity by offering short-term financial assets which allow the tradeoff of liquidity against expected return, implicitly allowing insurance, where those who turn out to be type 2B investors subsidize type 1 investors.

There is no role for markets in this liquidity creation. The bank need not use the secondary market to get liquidity, because the individual uncertainty about how much liquidity is needed is diversified away by dealing with many depositors. In addition, if a *perfectly liquid* secondary market exists, then there is no scope for creating liquidity by asset management (the cross-subsidy just described), as shown by Jacklin [1987]. If banks tried to cross-subsidize, all investors would prefer to hold assets directly.

To see the effect of a competing perfectly liquid market, suppose that **all** of the 80 type 2 investors participate in a competitive secondary market at date 1; all are of type 2A and there are no type 2B investors. If the bank offers more than 1 to those who withdraw at date 1, then no one would choose to invest in the bank at date 0. The date 1 secondary market price of a claim on 2 units of date 2 consumption will exceed what the bank offers, if investors deposit in the bank. In the example where the bank offers 1.306 at date 1, each type 2 investor who deposits in the bank will be able to withdraw 1.306 at date 1, or 1.847 at date 2. Any investor who holds long-term claims directly will own a claim on 2 units of date 2 consumption, which he can consume at date 2 if of type 2, and will be able to sell it to a type 2A who deposits in the bank for at least 1.306 if of type 1. Only if $c_{11}=1$ and $c_{22A}=2$, will investors (or competing banks) choose to hold claims that mature on both dates. A *perfectly liquid* secondary market implies that banks are not needed to fill in for limited liquidity of markets and

Table 1: Optimal Final Consumption Levels as Market Liquidity Changes

q_1=.2, q_{2B}=1-q_1-q_{2A}

q_{2A} (Rate of participation in secondary market)	c_{11}	c_{22A}	c_{22B}	c_{22B}-Rc_{11}
0.00	1.306019	2.612038 (not relevant)	1.84699	0.54097
0.05	1.236068	2.472136	1.84262	0.60655
0.10	1.187342	2.374684	1.83942	0.65208
0.15	1.151383	2.302766	1.83697	0.68559
0.20	1.123724	2.247448	1.83503	0.71131
0.25	1.101773	2.203546	1.83346	0.73169
0.30	1.08392	2.16784	1.83216	0.74824
0.35	1.069111	2.138222	1.83106	0.76195
0.40	1.056624	2.113248	1.83013	0.77350
0.45	1.045953	2.091906	1.82932	0.78337
0.50	1.036726	2.073452	1.82861	0.79189
0.55	1.028668	2.057336	1.82799	0.79932
0.60	1.02157	2.04314	1.82744	0.80587
0.65	1.015269	2.030538	1.82695	0.81168
0.70	1.009639	2.019278	1.82650	0.81687
0.75	1.004576	2.009152	1.82611	0.82153
0.79	1.00088	2.00176	1.82576	0.82488

also that banks cannot cross-subsidize investors. When all investors participate in the market, the amount of liquidity is independent of the activities of the banking system.

5.2 Illiquid Secondary Markets: Limited Participation

Suppose that only a fraction of type 2 investors (who are without a need to trade for consumption) participate in the secondary market. I continue to assume that the probability of being type 1 is q_1=.2. Assume that the probability of being of type 2A and participating in the market is q_{2A}=.3. The probability of being type 2B (and not participating) is q_{2B}=.5. The optimal incentive-compatible final consumption levels of each type of investor as the liquidity of the secondary market changes are given in Table 1 (higher q_{2A} implies a more liquid market).

I now show how bank deposit contracts work for the case where q_{2A}=.3, q_{2B}=.5. A deposit contract is one where the holder deposits $\beta \leq 1$ at date 0, and then can withdraw $r_1=w_{11}=w_{12A}$ at date 1, or $r_2=w_{22B}$ at date 2. The bank deposit is short-term, because the investor can withdraw at date-1 without selling it in the market. Each investor invests directly a fraction $1-\beta$ of date-0 wealth.

In the case where the bank can buy long-term assets on date 1 on the same terms as those who participate in the market at that date (and sell short-term claims to buy long-term at date 1, setting $m_1>0$), the incentive constraint that type 2B's not withdraw from the bank at date 1 ($r_2 \geq Rr_1$) is binding, and the size of the banking section is β_{IC}=.25176. Each investor on date 0 holds a fraction .25176 of his portfolio as bank deposits. Withdrawing on date 1 or on date 2 yields $r_1=r_2$=.33568. Each investor on date 0 also holds a fraction .7482 of his portfolio as long-term assets directly, and these are worth .7482 on date 1 or 1.4964 on date 2. The bank invests the .25176 (per capita) as follows: it holds q_1c_{11}=.21678 in short-term assets and holds $\beta-q_1c_{11}$=.25176-.21678=.03498 in long-term assets.

The date-1 market works as follows. Market clearing on date-1 requires that the date-1 value of long-term claims supplied, $q_1(1-\beta)X(R/X)$, equal the date-1 value of short-term claims offered to buy them, $q_{2A}r_1+m_1$, or that m_1, the bank's sale of short-term assets on date-1, equal $q_1(1-\beta)R-q_{2A}r_1$= 0.489. The bank sells 0.489 date-1 claims to buy .978 in date-2 assets sold by type 1 agents (or makes loans against that many date-2 assets at market rates).

Under the assumption that banks have no informational advantage in participating in markets, the size of the banking sector must be larger: when q_{2A} is .3, the fraction of wealth invested through banks, β, equals β_{MC} = 0.34965. The bank must hold more long-term assets to reduce the supply offered for sale by individuals to the amount that will be purchased by type 2A investors who participate in the secondary market. Some of the demand for liquidity must be diverted from the secondary market. With no bank trade, each investor invests .65035 directly in long-term assets at date 0, and as a result directly holds a claim worth 1.3007=2(.65035) if held until date-2. Each investor deposits .34965 in short-term deposits issued by the bank, and accepts a deposit contract with that returns r_1=.43357 if withdrawn at date-1 or r_2=.53146, if held until date 2.

The market clears at date 1 without any trade from the bank. The date-1 value of long-term assets supplied is $q_1(1-\beta)X(R/X)$=0.13007, and the date-1 value of maturing assets offered in exchange is $q_{2A}r_1$=0.13007. More details of this example are in Appendix II.

Table 2: Scale of the banking industry. If banks participate in the secondary market, the scale is the larger of the value in the column Incentive Compatibility or Enough Liquidity. If banks do not participate in the secondary market, the scale of that given in the column titled Market Clearing with investors only.

	Incentive Compatibility	Enough liquidity	Market clearing, with investors only
q_{2A}	$\beta_{IC} = 1 - \frac{c_{22B} - Rc_{11}}{X - R^2}$.	$\beta = \beta_1 = \frac{q_1 c_{11}}{R}$	$\beta_{MC} = 1 - \frac{q_{2A} c_{11}}{R(q_1 + q_{2A})}$
0.00	0.45903	*0.26120*	**1.00000**
0.05	0.39345	*0.24721*	**0.75279**
0.10	0.34792	*0.23747*	**0.60422**
0.15	0.31441	*0.23028*	**0.50655**
0.20	0.28869	*0.22474*	**0.43814**
0.25	0.26831	*0.22035*	**0.38790**
0.30	0.25176	*0.21678*	**0.34965**
0.35	0.23805	*0.21382*	**0.31966**
0.40	0.22650	*0.21132*	**0.29558**
0.45	0.21663	*0.20919*	**0.27588**
0.50	0.20811	*0.20735*	**0.25948**
0.55	0.20068	**0.20573**	**0.24564**
0.60	0.19413	**0.20431**	**0.23382**
0.65	0.18832	**0.20305**	**0.22362**
0.70	0.18313	**0.20193**	**0.21473**
0.75	0.17847	**0.20092**	**0.20691**

	Incentive Compatibility	Enough liquidity	Market clearing, with investors only
0.79	0.17512	**0.20018**	**0.20132**
0.80	0.00000	**0.20000**	**0.20000**

Italics indicate that the β constraint is not binding, **bold indicates a β constraint that is binding.**

The financial assets have shorter maturity than the physical assets in the economy whenever the bank invests partly in long-term assets, because the bank offers short-term deposits. The bank always invests in long-term assets when banks do not participate in secondary markets and also when the Incentive Compatibility constraint is binding and $\beta_1 < \beta_{IC}$.

In the case where banks can trade in secondary markets, Table 2 show the bank investment in long-term assets (per capita), the fraction of the economies financial assets which are short-term, the fraction of the economies real assets which are short-term. As the market becomes more liquid, the market share of the bank falls, the average maturity of financial and real assets rises, and the gap between the maturity of financial assets and physical assets falls.

Table 3: The effects of increased market liquidity (higher q_{2A} is a more liquid market).

q_{2A}: participation rate (.8 is full participation)	Fraction of per-capita wealth that banks invest long-term	Fraction of real investment which is short-term	Fraction of financial assets which are short-term	Gap between fraction of short-term financial assets and short-term real assets
0	0.19783	0.26120	0.45903	0.19783
0.05	0.14623	0.24721	0.39345	0.14623
0.1	0.11045	0.23747	0.34792	0.11045
0.15	0.08413	0.23028	0.31441	0.08413
0.2	0.06395	0.22474	0.28869	0.06395
0.25	0.04796	0.22035	0.26831	0.04796
[redacted]				
0.35	0.02423	0.21382	0.23805	0.02423
0.4	0.01517	0.21132	0.22650	0.01517
0.45	0.00744	0.20919	0.21663	0.00744
0.5	0.00077	0.20735	0.20811	0.00077
0.55	0.00000	0.20573	0.20573	0.00000

0.6	0.00000	0.20431	0.20431	0.00000
0.65	0.00000	0.20305	0.20305	0.00000
0.7	0.00000	0.20193	0.20193	0.00000
0.75	0.00000	0.20092	0.20092	0.00000
0.79	0.00000	0.20018	0.20018	0.00000
0.8	0.00000	0.20000	0.20000	0.00000

As the market becomes more liquid, the maturity of debt increases, and the market share of banks falls (this can also be interpreted as value of the equity market representing an increased share of wealth).

This example can also demonstrate the importance of a sufficiently large financial intermediary sector when there are illiquid financial markets. The banking-system allows consumption allocations that dominate those with assets held directly. For example, with q_{2A}=.3 and q_{2B}=.5, the optimal allocations yield c_{11}=1.08392. To achieve this level of consumption on date 1 by type 1 investors, with banks' market share equal zero, and all assets held directly, each investor must invest a fraction .4336 in short-term assets at date-0. The banking system only invests q_1(1.08392)=.21678 in liquid assets, economizing on liquidity. The outcome with a zero bank market share and a fraction .4336 of each investor's portfolio in short-term assets at date-0 is the following triple of consumption levels: c_{11}=1.0872, c_{22A}=1.889 *(below that with banks, 2.1784)*, and c_{22B} = 1.567 *(below that with banks, 1.83216)*.

6. Conclusion

With limited participation in markets, the banking system creates liquidity in two ways. Banks fill the liquidity gap in markets by diverting demand for liquidity from markets. This improves the market's liquidity, increasing the price of illiquid assets, b_1, to R/X (which is in excess of what it is when all assets are held directly). If investors are sufficiently risk averse and enough do not participate in markets, there is also direct liquidity creation, with banks providing a cross-subsidy to those who withdraw early (financed by those who do not withdraw early).

The clearest application of the model is to the understanding of financial development in developing economies. Limited liquidity of secondary markets implies that the maturity structure of financial claims will adjust to fill the gap by allowing individuals to hold self-liquidating claims. As the financial markets develop one should expect to see increased use of longer-term claims such as long-term debt or equity. The analysis implies that there will be a small supply of long-term direct claims in economies where few participate in financial markets. The banking system will have a large role in the allocation of capital and the provision of liquidity. This analysis abstracts from important problems with enforcement of property rights over collateral and other bankruptcy/enforcement issues that are also present in many developing countries.

More liquid markets lead to less liquidity creation by banks, a smaller banking sector, and a longer average maturity of financial assets. More liquid markets also lead to longer maturity physical investment, and a smaller gap between the maturity of financial assets and physical investments. In addition, as more liquid markets force the banking system to shrink, the banks' holdings of long-term assets (term loans) will shrink more rapidly than it holdings of shorter-term loans. Hoshi, Kashyap, Scharfstein [1990] is an empirical study that documents the effects of market development on banks and banks' structure. Regulatory changes opened access to the Japanese bond market. The effects were broadly in line with the implications of this model. Banks' market share was reduced, and banks' holdings of long-term assets fell more rapidly than did holdings of short-term assets.

The analysis also has implications for the effect of development of the banking sector on financial markets. The model can easily accommodate costs of financial intermediation (for example a proportional cost of banks holding assets), but the analysis is much more complicated with very few new insights. The effects of these costs can be seen by comparing the case where there are no intermediation costs, analyzed here, with that where the costs are so large that all assets are held directly. When intermediation costs are so high at all assets are held directly, each investor invests more in more liquid assets, yet the consumption of those who need liquidity (c_{11}) is lower, and the secondary market price of long-term assets (b_1) is lower than it is when banks face low intermediation costs. Reduced intermediation costs make financial markets more liquid, and lower the opportunity cost of liquidity. In addition, in the case that banks can participate in the market, the reduction of intermediation costs also increases the volume of trade in the financial market. Reduced bank costs can increase the volume of trade even when banks cannot access the secondary market, because the increased holding of long-term assets by individuals due to the higher secondary market prices of long-term assets. This suggests that improvements in banking, through reduced costs or less oppressive regulation, will be conducive to the liquidity of financial markets and to financial market development. Improvements in access to financial markets (increased disclosure and transparency) which make the market more liquid will diminish the role of banks, but will also reduce banks costs if the improvements provide increased bank access to the market. This two-way causality suggests that empirical study of the roles of banks and markets must use structural information to disentangle the effects. The line of empirical research started by Demirgüç-Kunt and Levine [1995] on banks, markets, and development has documented that banks and markets tend to develop together. Future work should attempt to disentangle the conflicting effects of banks and markets on each other. The current model of the link between liquidity provided by financial institutions and liquidity provided by markets is quite rudimentary, but I hope that further refinement gives more insight into these issues in financial structure and development.

Appendix I:

Proof of Proposition 1:

Substituting in the resource constraint, the objective function, Φ, becomes:

$$\Phi = q_1 U(c_{11}) + q_{2A} U\left(\frac{c_{11}X}{R}\right) + q_{2B} U\left(\frac{\left(1 - q_1\frac{c_{11}}{R} - q_{2A}\frac{c_{11}}{R}\right)X}{q_{2B}}\right)$$

$$\Phi'(c_{11}) = q_1 U'(c_{11}) + q_{2A} U'\left(\frac{c_{11}X}{R}\right)\frac{X}{R} - (q_1+q_{2A}) U'\left(\frac{\left(1 - q_1\frac{c_{11}}{R} - q_{2A}\frac{c_{11}}{R}\right)X}{q_{2B}}\right)\frac{X}{R}.$$

At $c_{11} \leq R$, the resource constraint implies that $c_{22B} = \dfrac{\left(1 - q_1\frac{c_{11}}{R} - q_{2A}\frac{c_{11}}{R}\right)X}{q_{2B}} \geq X$ and $c_{22A} \leq X$.

$U(c)$ is more risk averse than $\log(c)$, and $U'(c) > Z\,U'(cZ)$ for $Z>1$, implying that

$U'(c_{11}) > U'\left(c_{11}\frac{X}{R}\right)\frac{X}{R}$. Risk aversion implies that $U'\left(c_{11}\frac{X}{R}\right)\frac{X}{R} > U'\left(\dfrac{\left(1 - q_1\frac{c_{11}}{R} - q_{2A}\frac{c_{11}}{R}\right)X}{q_{2B}}\right)\dfrac{X}{R}.$

These two results imply that $\Phi'(c_{11})>0$ for $c_{11} \leq R$. Because $\Phi(c_{11})$ is continuous but not differentiable at $c_{11}=R$, the optimal value of $c_{11} \geq R$.

The function Φ is concave:

$$\Phi''(c_{11}) = q_1 U''(c_{11}) + q_{2A} U''\left(c_{11}\frac{X}{R}\right)\frac{X^2}{R^2} + \frac{(q_1+q_{2A})^2}{q_{2B}} U''\left(\frac{\left(1 - q_1\frac{c_{11}}{R} - q_{2A}\frac{c_{11}}{R}\right)X}{q_{2B}}\right)\frac{X^2}{R^2} < 0, \text{ because } U''(c)<0.$$

Proof that the right derivative at $c_{11}=R$ is negative, if q_{2B} is small:

Set $c_{11} = R+\varepsilon$, for $\varepsilon>0$. From $q_{2B} = 1-q_1-q_{2A}$

$$\Phi'(R+\varepsilon) = q_1 U'(R+\varepsilon) + q_{2A} U'\left(\frac{(R+\varepsilon)X}{R}\right)\frac{X}{R} - (q_1+q_{2A}) U'\left(\frac{\left(1 - (q_1+q_{2A})\frac{R+\varepsilon}{R}\right)X}{1-q_1-q_{2A}}\right)\frac{X}{R} =$$

$$= q_1 U'(R+\varepsilon) + q_{2A} U'\left(\left(1+\frac{\varepsilon}{R}\right)X\right)X - (q_1+q_{2A}) U'\left(\frac{\left(1 - (q_1+q_{2A})\left(1+\frac{\varepsilon}{R}\right)\right)X}{1-q_1-q_{2A}}\right)\frac{X}{R}$$

$$= q_1\left[U'(R+\varepsilon) - U'\left(\left(X - \frac{(q_1+q_{2A})\varepsilon X}{1-q_1-q_{2A}}\right)\frac{X}{R}\right)\right] + q_{2A}\frac{X}{R}\left[U'\left(\left(X+\frac{\varepsilon X}{R}\right)\right)X - U'\left(\left(X - \frac{(q_1+q_{2A})\varepsilon X}{1-q_1-q_{2A}}\right)\right)\right]$$

For any fixed $\varepsilon>0$ (and for all smaller values of ε), one can choose $q_{2B} = 1-q_1-q_{2A}>0$ such that $q_{2A}\frac{X}{R}\left[U'\left(\left(X+\frac{\varepsilon X}{R}\right)\right) - U'\left(\left(X - \frac{(q_1+q_{2A})\varepsilon X}{1-q_1-q_{2A}}\right)\right)\right]$ is arbitrarily negative; in particular, less than $-q_1\left[U'(R+\varepsilon) - U'\left(\left(X - \frac{(q_1+q_{2A})\varepsilon X}{1-q_1-q_{2A}}\right)\frac{X}{R}\right)\right]$, implying that the right derivative at $c_{11}=R$ is negative, if $q_{2B}>0$ is sufficiently small.

By a similar argument, if q_{2A} is sufficiently small, then there exists $\epsilon>0$ such that $\Phi'(R+\epsilon)>0$, and because $\Phi(c_{11})$ is concave, the right derivative at c_{11}-R is positive, and the optimal value of c_{11} exceeds R.

As to proposition 2, increasing liquidity implies that more type 2 agents participate, and that q_{2B} decreases as q_{2A} increases, and if the solution is not at the kink at $c_{11}=R$, then $c_{11}>R$, and $c_{22A}>c_{22B}$ With $c_{11}>R$, then $c_{22A}=c_{11}X/R>c_{22B}$, from concavity of U(.), we have $U'(c_{11})X/R>U'(c_{22B})X/R$, and as a result, $\Phi'(c_{11})$ is strictly decreasing in q_{2A}.

$\frac{\partial \Phi'(c_{11})}{\partial q_{2A}} = \frac{X}{R}[U'(c_{22A}) - U'(c_{22B}) - \frac{q_1 + q_{2A}}{q_{2B}}(c_{22B} - c_{22A})U''(c_{22B})] <0$, because at the optimum $c_{22A}>c_{22B}$ and concavity of U( ) implies both $U'(c_{22A})<U'(c_{22B})$ and $U''(c_{22B})<0$.

Combined with the previous result that $\Phi''(c_{11})<0$, this implies that $\frac{\partial c_{11}}{\partial q_{2A}} = -\frac{\partial \Phi'(c_{11})}{\partial q_{2A}} \Big/ \Phi''(c_{11}) < 0$, and the optimal value of c_{11} is decreasing in q_{2A}. This proves Proposition 2.

Appendix II

The remaining details of the example where $q_{2A}=.3$ and the scale of the banking industry is the smallest such that the bank need not trade in secondary markets are as follows.

Each investor **invests .65035 directly in long-term assets** at date 0, and as a result directly holds a claim worth 1.3007=2(.65035) if held until date-2. Each **investor deposits .34965 in short-term deposits issued by the bank,** and accepts a deposit contract with that returns $r_1=.43357$ if withdrawn at date-1 or $r_2=.53146$, if held until date 2.

The market clears at date 1 without any trade from the bank. The date-1 value of long-term assets supplied is $q_1(1-\beta)X(R/X)=0.13007$, and the date-1 value of maturing assets offered in exchange is $q_{2A}r_1=0.13007$.

The bank delivers these returns by investing the .34965 (per-capita) in 0.2168 short term assets, and

0.1328 long-term assets. The bank has .2168 to fund date-1 withdrawals, and a fraction q_1+q_{2A}=.2+.3=.5 are withdrawn then, giving each .2168/.5=.43357.

The bank delivers r_2 = .5312 to those who leave their money in the bank until date-2. The type 2B depositors leave their money in the bank until date 2, and type 2B's are a fraction .5 of the initial depositors. The bank has date-2 maturing assets worth .1328(X)=.1328(2)=.2656, implying that each type 2B depositor receives .2656/.5 = .5312.

At date 1, both types 1 and 2A withdraw r_1: type 1's consume and type 2A's invest directly. A type 1 consumer sells his or her long-term assets at date 1, for price b_1 = ½ per unit of date-2 value, and thus a type 1 consumes a total of: $c_{11} = r_1 + w_2 b_1$=.4336 + 1.3008(½)=1.084. Type 2A reinvests the r_1 withdrawn from the bank, obtaining date 2 consumption of r_1/b_1, for total date-2 consumption of: $c_{22A} = w_2 + r_1/b_1$= 1.3008+.4336/(½) = 2.168.

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