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## LIQUIDITY, BANKING, AND BANK FAILURES\*

BY STEPHEN D. WILLIAMSON<sup>1</sup>

### 1. INTRODUCTION

One view of the role played by banks is that they transform "illiquid" primary assets into "liquid" assets. Banks are able to profit from this transformation as some private agents, for one reason or another, prefer liquid bank liabilities to the primary assets which back them. While the provision of liquidity may be socially desirable, there is a widely held belief, arising in part from American experience during the Free Banking Era (1837-63), that unregulated banking systems are inherently unstable.<sup>2</sup> Even some of the most strident supporters of laissez-faire, including Friedman (1960), advocate regulations on banking activities to prevent institutional collapse. In this paper, a model is constructed in which banks bring about a liquidity transformation of assets and where bank failure is possible, yet there is no role for government intervention in the banking sector.

Formal models of banking and bank instability are relatively new. In studies by Diamond and Dybvig (1983), Haubrich and King (1983), Jacklin (1983, 1984), Smith (1984) and Waldo (1985), banking institutions play an insurance role when private agents face uncertain liquidity requirements. The models of Diamond and Dybvig and Waldo capture bank instability in the form of a "bad" equilibrium in which a bank "run" or "panic" occurs and production is interrupted. In these models, bank runs are random events which cause a fall in output below what it would be in a "good" equilibrium. Such models can be faulted on three counts. First, bank runs occur in part due to an exogenously imposed sequential service constraint. Second, as Jacklin (1984) shows, the "good" equilibrium can be supported with decentralized securities trading, in which case runs cannot occur. Even in the more general models of this type examined by Jacklin (1984), banking (i.e., demand deposit) contracts cannot improve on equity contracts in the absence of ad hoc restrictions on demand deposit trading. Third, Gorton (1985a) finds evidence that, at least during the National Banking Era, U.S. banking "panics" were systematic events. In essence, these models do not explain a special role for banking institutions, and since a bank run is a "sunspot" equilibrium, they do not provide a theory of bank failure.

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<sup>2</sup> Rolnick and Weber (1984, 1986), and to some extent King (1983), attempt to dispel the belief that the Free Banking Era was a period of instability in banking.

In the model we construct, primitive assets are illiquid in the sense that buyers and sellers are asymmetrically informed concerning the future value of these assets. This illiquidity, combined with a demand for liquidity by some consumers, generates a role for banking. Our model shares several features with those of Diamond and Dybvig (1983), Freeman (1985), Jacklin (1983, 1984), and Smith (1984). The period structure is similar: a demand for liquidity results from agents' random preferences, and there exist primitive short-term and long-term assets. One important difference is that all agents are risk neutral, so that a role for banking does not arise due to the benefits from risk sharing.<sup>3</sup> Another difference is the approach we take to showing how decentralized markets and alternative ways of organizing trade may or may not support optimal allocations. This approach is similar to that in Boyd and Prescott (1986), though they work with a one-period framework which cannot address the issues related to banking and liquidity which we wish to examine. As in Boyd and Prescott, optimal allocations are core allocations which satisfy incentive compatibility constraints. With decentralized trade in capital, an equilibrium may not exist or it may be suboptimal, due to the possibility that those wishing to sell good quality capital may not be able to credibly distinguish themselves from those selling inferior capital. Banking institutions are able to obviate this illiquidity problem (i.e., adverse selection problem) in that bank contracts support the optimal allocation in all states of the world. Essentially, banks internalize an externality.

A banking institution is a coalition of agents that maximizes the expected utility of its members by becoming large. The contracts written by these coalitions with their members are similar to real-world banking contracts in that deposit contracts provide for early withdrawal, the coalition holds debt, and agents who borrow from the bank also hold compensating balances.

Though banking coalitions can achieve an allocation which is strictly preferred to the capital market equilibrium allocation by all agents in some states, all agents are indifferent to the two allocations in other states. Therefore, some banking coalitions may agree, *ex ante*, to dissolve in some states of the world and trade capital, foregoing the complex organizational structure and rich contracts of a banking system for simpler trading arrangements. We interpret this institutional failure as a bank failure, and justify the interpretation by drawing a correspondence between the predictions of our model with respect to states where bank failures are possible, and empirical observations concerning periods when large numbers of bank failures occur. In particular, bank failures in our model are possible in states where output is lower, the demand for liquidity is higher, and agents are worse off in relation to average experience. This is in accord with empirical evidence for the United States (Bernanke 1983, Friedman and Schwartz 1963, and Gorton 1985), which shows that a high rate of bank failure tends to be associated with recession, a high currency-deposit ratio, and a large aggregate quantity of deposit withdrawals.

<sup>3</sup> Boyd and Prescott (1986), Diamond (1984), and Williamson (1986) construct single-period models of financial intermediation with risk-neutral agents.

In our model, bank failures are only symptomatic of particular states of endowments, preferences, and technology. Such failures do not cause the associated drop in output and “bad times.” Since the resulting allocation is optimal, no government intervention is desirable. Our results therefore differ from those of Diamond and Dybvig (1983), for example, in that bank failures are systematic events, and the existence of failures does not call for interventions in the form of government deposit insurance, lender-of-last-resort privileges, and the like.<sup>4,5</sup>

The remainder of the paper is organized as follows. In Section 2, the model is constructed, and in Section 3 an optimal allocation is defined and computed. In Section 4, it is shown that ex post trading of capital supports the optimal allocation in some states of the world, and that banking coalitions support an optimal allocation in all states. Bank failures are discussed in Section 5. The final section summarizes and concludes the paper.

## 2. THE MODEL

There are four periods, 0 through 3. In period 0, a countable infinity of identical agents are born, and they may choose at this time to write contracts. In period 1, each agent is endowed with one unit of capital and learns her type,  $(i, j)$ , where  $i, j = 1, 2$ .

Type  $(1, j)$  agents die in period 2, and their preferences are ordered according to  $E(c_2)$ , where  $E$  is the expectation operator and  $c_i$  is consumption in period  $i$ . A type  $(2, j)$  agent dies in period 3, and her preferences are ordered according to  $E(c_2 + c_3)$ . Type  $(2, j)$  agents have the ability to mimic type  $(1, j)$  agents by “hiding” in period 3.

A type  $(i, j)$  agent is endowed with type  $j$  capital. All capital is perfectly divisible and may be used in period 1 in one of two production processes. Production process 1 yields one unit of the period 2 consumption good for each unit of capital input in period 1, while process 2 yields a random return in period 3. That is, for each unit of type  $j$  capital applied to process 2 in period 1, output is  $r_1$  units of the period 2 consumption good with probability  $\pi_j$ , and  $r_2$  units with probability  $1 - \pi_j$ . Returns are publicly observable. We have  $r_1 > r_2$  and  $\pi_1 > \pi_2$ , and we assume that:

$$(2.1) \quad \pi_1 r_1 + (1 - \pi_1) r_2 > 1$$

$$(2.2) \quad \pi_2 r_1 + (1 - \pi_2) r_2 < 1$$

Inequalities (2.1) and (2.2) imply that, in autarky, a type  $(2, 1)$  agent will prefer process 2 production to process 1 production, while agents of types  $(1, 1)$ ,  $(1, 2)$ , and  $(2, 2)$  will prefer process 1 production to process 2 production.

The composition of the population is determined by a random variable  $X =$

<sup>4</sup> In Gorton (1985b), bank failure can be optimal and failures are systematic, but Gorton simply assumes that banks exist, and assumes the structure of contracts.

<sup>5</sup> In Smith (1984), bank “instability” is in some sense systematic. However, as in Diamond and Dybvig, this generates a role for government intervention, though in the form of deposit interest rate ceilings rather than deposit insurance.

$(X_{11}, X_{12}, X_{21}, X_{22})$ , where  $X_{ij}$  is the fraction of type  $(i, j)$  agents. We have  $X_{ij} > 0$  and

$$\sum_{i=1}^2 \sum_{j=1}^2 X_{ij} = 1.$$

In period 1,  $X$  takes on a value  $x$ , which is known to all before trading occurs and before production decisions are made. In period 0, it is public knowledge that  $X$  is distributed according to the probability distribution function  $F(X)$ .

This model shares several features with other models of banking and intermediation. As in Diamond and Dybvig (1983), Freeman (1985), Jacklin (1983, 1984), Smith (1984), and Waldo (1985), agents have random preferences and there exists a long-term, and a short-term, production technology. However, in contrast to Diamond and Dybvig, Jacklin, Smith, Waldo, and Haubrich and King (1983), there exists no insurance role for banking here, as all agents are risk neutral and know their preferences before production decisions are made. Boyd and Prescott (1986) specify an environment with a countable infinity of risk-neutral agents in which financial intermediation arises endogenously. However, theirs is a one-period model which cannot address the questions associated with liquidity and banking which we wish to examine here.

Before indicating the sense in which our model captures the notion of illiquidity, it would be useful to precisely define "liquidity." A "fully liquid" asset is defined by Tobin (1965, p. 3) to be an asset which is "convertible without delay into currency at full market value." For our purposes, this definition is not very helpful. Implicitly, Tobin has told us that currency is liquid, without defining liquidity. Also, in equilibrium an asset is exchanged for its market value, which cannot be anything less than "full." What we take Tobin to mean is that an asset is illiquid if the asset holder and potential buyers of the asset are asymmetrically informed concerning its future value in exchange or consumption. If we could elicit agent's beliefs in real-world markets, we would expect to find less agreement among buyers and sellers of consumer durables than among buyers and sellers of currency, with respect to the future values of these assets. That is, ranking assets in terms of our notion of liquidity and according to traditional notions would produce similar results.

In the above sense, capital is an illiquid asset in our model. Agents who learn they are type  $(1, j)$  in period 1 wish to consume in the next period. These agents can do this either by using their capital to produce the period 2 consumption good, or by trading capital before making investment decisions. A type  $(2, j)$  agent would be willing to exchange up to  $\pi_1 r_1 + (1 - \pi_1) r_2$  units of type 2 capital for type 1 capital. However, any agent offering more than one unit of type 2 capital for one unit of type 1 capital would have to contend with sellers of type 2 capital claiming their capital to be of type 1.

For a demand for liquidity to provide a role for banking institutions, it must be coupled with the existence of illiquid primary assets, as is the case here. In the models of Diamond and Dybvig (1983), Jacklin (1983, 1984), Smith (1984), and

Waldo (1985), there is a demand for liquidity, but primary assets are not illiquid in the sense we have defined it. As Jacklin (1983) has shown, in Diamond and Dybvig's model the "good" allocation can be supported by a market for shares.<sup>6</sup> Even in the generalized versions of the Diamond and Dybvig model in Jacklin (1983, 1984), the superiority of demand deposit contracts over equity contracts depends on exogenously imposed trading restrictions on demand deposits.

### 3. OPTIMAL ALLOCATIONS

Our optimal allocations are similar to "equilibrium allocations" in Boyd and Prescott (1986), with some differences due to the different structure of our model. We invoke the revelation principle (Harris and Townsend 1981), and restrict attention to allocations in which it is in each agent's interest to reveal her type in period 1. Variables are defined as follows:

- $c_{ij}^2 \equiv$  consumption in period 2 by an agent of type  $(i, j)$ .  
 $c_{ij}^3 \equiv$  consumption in period 3 by an agent of type  $(i, j)$  not contingent on the return on the agent's capital if any of this capital was allocated to process 2 production.  
 $c_{ijk} \equiv$  consumption in period 3 by an agent of type  $(i, j)$  if the return on the agent's capital allocated to process 2 production is  $r_k$ .  
 $z_{ij} \equiv$  proportion of the capital endowment of a type  $(i, j)$  agent which is allocated to process 1 production in period 1.

The optimality criterion we will use is the expected utility of a representative agent in period 0. Since all agents are identical at this date, the probability of an agent becoming type  $(i, j)$  in period one is  $X_{ij}$ . We let  $u_{ij}$  denote the expected utility of a type  $(i, j)$  agent conditional on information available in period 1.

$$(3.1) \quad u_{ij} = \begin{cases} c_{ij}^2, & i = 1 \\ c_{ij}^2 + c_{ij}^3 + \pi_j c_{ij1} + (1 - \pi_j) c_{ij2}, & i = 2 \end{cases}$$

A social planner will then seek to maximize:

$$(3.2) \quad E \left[ \sum_{i=1}^2 \sum_{j=1}^2 X_{ij} u_{ij} \right]$$

The expectation in (3.2) is taken with respect to  $X$ . Note that:

$$(3.3) \quad \text{If } z_{ij} = 1, \text{ then } c_{ijk} = 0, \quad i, j, k = 1, 2$$

Resource constraints for periods 2 and 3 respectively, are:

$$(3.4) \quad \sum_{i=1}^2 \sum_{j=1}^2 X_{ij} (c_{ij}^2 - z_{ij}) \leq 0$$

<sup>6</sup> This allocation is supported by a banking system in the absence of bank runs.

$$(3.5) \quad \sum_{i=1}^2 \sum_{j=1}^2 X_{ij} [c_{ij}^3 + \pi_j c_{ij1} + (1 - \pi_j) c_{ij2}] \\ \leq [\pi_1 r_1 + (1 - \pi_1) r_2] \sum_{i=1}^2 X_{i1} (1 - z_{i1}) + [\pi_2 r_1 + (1 - \pi_2) r_2] \sum_{i=1}^2 X_{i2} (1 - z_{i2})$$

We must also have:

$$(3.6) \quad z_{ij} \leq 1 \quad i, j = 1, 2$$

Let  $v_{ij}(k, l)$  denote the expected utility in period one of a type  $(i, j)$  agent who claims to be type  $(k, l)$ . We have  $v_{ij}(i, j) = u_{ij}$ . For agents to truthfully report  $(i, j)$ , the following incentive compatibility constraints must be satisfied. We assume that if agents are indifferent, they report the truth.

$$(3.7) \quad u_{ij} \geq v_{ij}(k, l) \quad (k, l) \neq (i, j)$$

In addition, agents must prefer their allocation to what they could achieve without participation in the mechanism:

$$(3.8) \quad u_{ij} \geq 1, \quad (i, j) = (1, 1), (1, 2), (2, 2)$$

$$(3.9) \quad u_{21} \geq \pi_1 r_1 + (1 - \pi_1) r_2$$

Note that under autarky, type  $(1, 1)$ ,  $(1, 2)$ , and  $(2, 2)$  agents choose to utilize the process 1 production technology and consume in period 2. Type  $(2, 1)$  agents utilize the process 2 technology and consume in period 3.

Let  $c$  denote the vector of  $c_{ij}^k$ 's and  $c_{ijk}$ 's and let  $z = (z_{11}, z_{12}, z_{21}, z_{22})$ .

**DEFINITION 1.** *An optimal allocation,  $(c^0, z^0)$ , maximizes (3.2) subject to the resource constraints (3.4) and (3.5), the constraints (3.1), (3.3), and (3.6), and the incentive constraints (3.7), (3.8), and (3.9). In addition, if  $(c^0, z^0)$  is an optimal allocation, there exists no subset of agents in period 1, with population parameter vector  $X^d$ , which can achieve a different allocation  $(c^d, z^d)$  which satisfies:*

$$(3.10) \quad u_{ij}^d > u_{ij}^0 \quad \text{for some } (i, j)$$

$$(3.11) \quad \text{If } u_{ij}^d < u_{ij}^0 \quad \text{then } X_{ij}^d = 0$$

$$(3.12) \quad \text{If } u_{ij}^d > u_{ij}^0 \quad \text{then } X_{ij}^d \geq X_{ij}$$

$$(3.13) \quad \text{If } u_{ij}^d = u_{ij}^0 \quad \text{then } X_{ij}^d \leq X_{ij}$$

$$(3.14) \quad \text{If } u_{ij}^d > u_{ij}^0 \quad \text{and } u_{kl}^d > u_{kl}^0, \quad \text{then } X_{ij}^d / X_{kl}^d = X_{ij} / X_{kl}$$

*Resource constraints:*

$$(3.15) \quad \sum_{i=1}^2 \sum_{j=1}^2 X_{ij}^d (c_{ij}^{2d} - z_{ij}^d) \leq 0$$

$$\begin{aligned}
(3.16) \quad & \sum_{i=1}^2 \sum_{j=1}^2 X_{ij}^d [c_{ij}^{3d} + \pi_j c_{ij1}^d + (1 - \pi_j) c_{ij2}^d] \\
& \leq [\pi_1 r_1 + (1 - \pi_1) r_2] \sum_{i=1}^2 X_{i1}^d (1 - z_{i1}^d) + [\pi_2 r_2 + (1 - \pi_2) r_2] \sum_{i=1}^2 X_{i2}^d (1 - z_{i2}^d)
\end{aligned}$$

*Incentive constraints:*

$$(3.17) \quad u_{ij}^d \geq v_{ij}^d(k, l) \quad (i, j) \neq (k, l)$$

$$(3.18) \quad u_{ij}^d \geq 1 \quad (i, j) = (1, 1), (1, 2), (2, 2)$$

$$(3.19) \quad u_{21}^d \geq \pi_1 r_1 + (1 - \pi_1) r_2$$

*Other constraints:*

$$(3.20) \quad x_{ij}^d \leq 1 \quad i, j = 1, 2$$

A “ $d$ ” superscript is used to denote a variable for the deviant coalition, defined as is the corresponding non-superscripted variable for the coalition of the whole.

The optimal allocation is contingent on the state of the world,  $X$ . Given  $X = x$ , it is in each agent’s interest to truthfully report her type, and no coalition of agents can obtain a strictly preferred allocation. Deviant coalitions are composed of agents who weakly prefer the allocation proposed by the deviant coalition to the candidate optimal allocation. Agents who strictly prefer the deviant allocation are drawn to the deviant coalition in the same relative proportions as they exist in the population.

The above definition of an optimal allocation is quite similar to Boyd and Prescott’s (1986) definition of an “equilibrium allocation,” though we use an ex ante welfare criterion, in that expected utility is maximized, as of period 0, before agents learn their types. We also use a somewhat different definition of a deviant coalition.<sup>7</sup>

To compute optimal allocations, we choose  $(c, z)$  to maximize (3.2) subject to (3.1) and (3.3) through (3.9), and the constraint that there exist no deviant coalition. To simplify this problem, first note that we can remove the expectation operator from (3.2). Then, choosing  $(c, z)$  to maximize (3.2) subject to (3.1) and (3.3) through (3.9) is a linear programming problem, solutions to which we call incentive-efficient (IE) allocations. If any IE allocations are immune from deviant coalitions then these are optimal allocations, and we are finished.

To compute the IE allocations, first note that the resource constraints (3.4) and (3.5) must be binding, since otherwise the value of the objective function could be increased without violating any of the constraints. Given this, we must have  $c_{ij}^3 = c_{ijk} = 0$  for  $i = 1$  and  $j, k = 1, 2$ , since otherwise we could increase the value of the objective function while introducing slack into the constraints (3.7). That is, we should not allocate consumption to dead agents. Since having  $c_{ijk} > 0$  for

<sup>7</sup> The Boyd and Prescott framework has only two agent types. Therefore, in our model we add (3.14).



$i = 2$  may help with respect to incentive constraints, if  $z_{11} < 1$  then  $z_{21} < 1$  and if  $z_{12} < 1$  then  $z_{22} < 1$ . That is, if capital of type  $j$  is to be allocated to process 1 production, we allocate the capital of type  $(1, j)$  agents first. Note also that (3.1) and (3.7) imply that  $c_{11}^2 = c_{12}^2$  and  $u_{11} = u_{12}$ .

Define two new variables:

$$(3.21) \quad Y_i = X_{1i}z_{1i} + X_{2i}z_{2i} \quad i = 1, 2$$

Also, let  $U(X)$  denote the maximized value of (3.2) (without the expectation operator) subject to (3.1) and (3.3) through (3.9).

**PROPOSITION 1.** *The IE allocations are: if  $X_{11} \leq X_{22}$ , then  $Y_1 = 0$ ,  $Y_2 = X_{12} + X_{22}$ ,*

$$U(X) = X_{12} + X_{22} + [X_{11} + X_{21}][\pi_1 r_1 + (1 - \pi_1)r_2],$$

$c_{221} = c_{222} = 0$ . For this case, the solution for  $c_{11}^2$ ,  $c_{21}^2$ ,  $c_{22}^2$ ,  $c_{21}^3$ ,  $c_{22}^3$ ,  $c_{121}$ , and  $c_{122}$  is not unique. If  $X_{11} \geq X_{22}$  then

$$Y_1 = X_{11} - X_{22}, \quad Y_2 = X_{12} + X_{22},$$

$c_{11}^2 = 1$ ,  $c_{21}^2 = c_{22}^2 = c_{221} = c_{222} = 0$  and

$$U(X) = X_{11} + X_{12} + (X_{21} + X_{22})[\pi_1 r_1 + (1 - \pi_1)r_2].$$

For this second case, the solution for  $c_{21}^3$ ,  $c_{22}^3$ ,  $c_{211}$  and  $c_{212}$  is not unique.

**PROOF.** Substituting using (3.4) and (3.5), (note that these are satisfied with equality), the objective function can be rewritten as:

$$\begin{aligned} & [X_{11} + X_{21}][\pi_1 r_1 + (1 - \pi_1)r_2] + [X_{12} + X_{22}][\pi_2 r_1 + (1 - \pi_2)r_2] \\ & + Y_1[1 - \pi_1 r_1 - (1 - \pi_1)r_2] + Y_2[1 - \pi_2 r_2 - (1 - \pi_2)r_2]. \end{aligned}$$

Therefore, given (2.1) and (2.2), if we were constrained only by (3.6) then the objective function would be maximized by setting  $Y_1 = 0$  and  $Y_2 = X_{12} + X_{22}$ . If  $X_{11} > X_{22}$ , then this cannot be a solution since in this case (3.8) implies that (3.4) is not satisfied. However, in the case where  $X_{11} \leq X_{22}$ , one solution, given that (3.3) implies  $c_{221} = c_{222} = 0$ , is

$$\begin{aligned} c_{11}^2 &= 1, & c_{21}^2 &= c_{21}^3 = c_{212} = 0, \\ c_{211} &= [\pi_1 r_1 + (1 - \pi_1)r_2]/\pi_1, \\ c_{22}^3 &= (X_{11}/X_{22})[\pi_1 r_1 + (1 - \pi_1)r_2], \end{aligned}$$

and

$$c_{22}^2 = [X_{22} - X_{11}]/X_{22}.$$

This allocation is not unique as we could increase  $c_{211}$  by some  $\varepsilon > 0$  and decrease  $c_{22}^3$  by  $X_{21}\pi_1\varepsilon/X_{22}$ . For sufficiently small  $\varepsilon$ , this will not violate any

constraints, and all agents would be indifferent between this and the original allocation.

In the case where  $X_{11} > X_{22}$ , if we were to maximize the objective function subject to (3.4), (3.5), and (3.8), ignoring the other constraints, we would set  $Y_1 = X_{11} - X_{22}$  and  $Y_2 = X_{12} + X_{22}$ . This implies  $c_{11}^2 = 1$ , and  $c_{21}^2 = c_{22}^2 = c_{221} = c_{222} = 0$ . It remains to determine  $c_{22}^3$ ,  $c_{211}$ , and  $c_{212}$ . One solution is

$$c_{212} = 0, \quad c_{22}^3 = \pi_1 r_1 + (1 - \pi_1) r_2$$

and

$$c_{211} = [\pi_1 r_1 + (1 - \pi_1) r_2] / \pi_1.$$

This is not a unique solution, as all agents would be indifferent to an increase in  $c_{211}$  by  $\varepsilon > 0$ , and a decrease in  $c_{22}^3$  by  $X_{21} \pi_1 \varepsilon / X_{22}$  which, for sufficiently small  $\varepsilon$ , would not violate any constraints. Q.E.D.

If agents could precommit in period 0 and if each agent's type were public information, the "first best optimum" which a central planner could achieve would involve setting  $Y_1 = 0$  and  $Y_2 = X_{12} + X_{22}$ . We would then have

$$U(X) = X_{12} + X_{22} + (X_{11} + X_{21})[\pi_1 r_1 + (1 - \pi_1) r_2] \quad \text{for all } X.$$

For the case  $X_{11} \leq X_{22}$ , the IE allocations are first best. However, in the case  $X_{11} > X_{22}$ , even if all type 2 capital is allocated to process 1 production, this is insufficient to make all type (1,  $j$ ) agents as well off as they would be in autarky, and some type 1 capital must be allocated to process 1 production. Thus, IE allocations are not first best if  $X_{11} > X_{22}$ .

**PROPOSITION 2.** *The set of optimal allocations is the subset of IE allocations for which  $u_{21} = \pi_1 r_1 + (1 - \pi_1) r_2$ ,  $u_{11} = u_{12} = 1$ , and*

$$u_{22} = \begin{cases} 1 - X_{11}/X_{22} + (X_{11}/X_{22})[\pi_1 r_1 + (1 - \pi_1) r_2], & X_{11} \leq X_{22} \\ \pi_1 r_1 + (1 - \pi_1) r_2, & X_{11} \geq X_{22}. \end{cases}$$

**PROOF.** Consider first the case where  $X_{11} \leq X_{22}$ , and consider as a candidate optimal allocation a (\*) allocation which is IE and where  $u_{21} > \pi_1 r_1 + (1 - \pi_1) r_2$ . Then there is a deviant coalition which can propose an allocation such that  $X_{11}^d = X_{11}/(1 - X_{21})$ ,  $X_{12}^d = X_{12}/(1 - X_{21})$ ,  $X_{21}^d = 0$ , and  $X_{22}^d = X_{22}/(1 - X_{21})$ . One such allocation is:

$$c_{211}^d = [\pi_1 r_1 + (1 - \pi_1) r_2] / \pi_1, \quad c_{21}^{2d} = c_{22}^{2*} + [X_{21}/X_{22}] c_{21}^{2*}, \\ c_{22}^{3d} = [X_{11}/X_{22}] [\pi_1 r_1 + (1 - \pi_1) r_2], \quad z_{11}^d = 0, \quad z_{12}^d = z_{22}^d = 1.$$

By replacing "o" by "\*" in (3.10) through (3.20), (3.10) through (3.20) are satisfied, so that (\*) allocations are not optimal allocations in this case.

For the case  $X_{11} \geq X_{22}$ , again consider a (\*) allocation as a candidate optimal allocation. Then there is a deviant coalition which can propose an allocation

such that

$$X_{11}^d = X_{11}/(1 - X_{21}), \quad X_{12}^d = X_{12}/(1 - X_{21}), \quad X_{21}^d = 0,$$

and

$$X_{22}^d = X_{22}/(1 - X_{21}).$$

One such allocation is:

$$\begin{aligned} c_{211}^d &= [\pi_1 r_1 + (1 - \pi_1)r_2]/\pi_1, & c_{21}^{2d} &= c_{222}^d = c_{22}^{2d} = 0, & c_{11}^{2d} &= c_{12}^{2d} = 1, \\ c_{22}^{3d} &= \pi_1 r_1 + (1 - \pi_1)r_2, & z_{11}^d &= X_{11} - X_{22}, & z_{12}^d &= z_{22}^d = 1 \end{aligned}$$

Replacing “o” by “\*”, (3.10) through (3.20) are satisfied, which implies that the (\*) allocations are not optimal allocations in this case as well.

We then need only consider as candidate optima those IE allocations for which  $u_{21} = \pi_1 r_1 + (1 - \pi_1)r_2$ . We will first examine the subset of such allocations for which  $u_{11}(=u_{12}) > 1$ , and call these (\*\*) allocations. Since IE allocations have the property  $u_{11} = 1$  for  $X_{11} \geq X_{22}$ , we need only consider the case  $X_{11} < X_{22}$ . Here, for any (\*\*) allocation, there exists a deviant coalition which can propose an allocation such that

$$X_{11}^d = X_{11}/(1 - X_{12}), \quad X_{12}^d = 0, \quad X_{21}^d = X_{21}/(1 - X_{12}),$$

and

$$X_{22}^d = X_{22}/(1 - X_{12}).$$

One such allocation is

$$\begin{aligned} c_{12}^d &= c_{11}^d = c_{11}^{**}, & c_{211}^d &= [\pi_1 r_1 + (1 - \pi_1)r_2]/\pi_1, \\ c_{22}^{3d} &= (X_{11}/X_{22})[\pi_1 r_1 + (1 - \pi_1)r_2], & c_{21}^{2d} &= c_{212}^d = c_{21}^{3d} = 0 \end{aligned}$$

and

$$c_{22}^{2d} = c_{22}^{2**} + (X_{12}/X_{22})(c_{12}^{2**} - 1).$$

This allocation satisfies (3.10) through (3.20), and the (\*\*) allocation is therefore not optimal.

Now we can confine our attention to “o” allocations, which are IE and where  $u_{21} = \pi_1 r_1 + (1 - \pi_1)r_2$  and  $u_{11} = u_{12} = 1$ , which implies, given Proposition 1, that

$$u_{22} = \begin{cases} 1 - X_{11}/X_{22} + (X_{11}/X_{22})[\pi_1 r_1 + (1 - \pi_1)r_2], & X_{11} \leq X_{22} \\ \pi_1 r_1 + (1 - \pi_1)r_2, & X_{11} \geq X_{22}. \end{cases}$$

Since with an IE allocation each agent is as well off as in autarky, there exist no deviant coalitions with only one type of agent. Coalitions containing only the following types of agents can give their members levels of expected utility no

greater than in autarky: a) (1, 1) and (1, 2); b) (1, 1) and (2, 1); c) (1, 2) and (2, 2); d) (1, 2) and (2, 1); e) (2, 1) and (2, 2); f) (1, 1), (1, 2), and (2, 1); g) (1, 2), (2, 1), and (2, 2). This follows from the incentive constraints (3.17), (3.18), and (3.19), and (3.7), (3.8), and (3.9) then imply that (3.10) cannot be satisfied for any of these coalitions. The only remaining possible types of deviant coalitions to consider are those containing only the following types of agents: 1) (1, 1) and (2, 2); 2) (1, 1), (2, 1), and (2, 2); 3) (1, 1), (1, 2), and (2, 2); 4) (1, 1), (1, 2), (2, 1), and (2, 2). None of these possible types of deviant coalitions can satisfy (3.10) through (3.16). Therefore, “o” allocations are optimal. Q.E.D.

It follows from Proposition 2 that, optimally, all gains from trade go to type (2, 2) agents. There can be no gains from trading with agents of type (2, 1) or type (1, 2), and since incentive compatibility implies that  $u_{11} = u_{12}$ , agents of types (1, 1), (1, 2), and (2, 1) are indifferent between optimal allocations and autarky.

#### 4. SUPPORTING OPTIMAL ALLOCATIONS: CAPITAL MARKETS AND BANKING

At this stage, we wish to examine the market structures and institutions that will support optimal allocations. In particular, we want to show that assets are illiquid, at least in some states of the world, in the sense that agents do not always reveal the true characteristics of their capital endowments in equilibrium on a decentralized capital market. “Banking” institutions are capable of transforming illiquid assets into liquid assets, and thus obviate this problem.

4.1. *Capital Market Equilibrium.* The first arrangement we look at is decentralized trade in capital. Capital markets open in period 1 and involve exchanges of (alleged) type 1 capital for type 2 capital. Trading occurs before investment decisions are made. We assume that if agents are indifferent concerning revelation of their capital endowment type, they tell the truth. Let  $p$  denote the price of type 1 capital in terms of type 2 capital, and let  $p^*$  denote the equilibrium price.

**PROPOSITION 3.** *If  $X_{11} \geq X_{22}$ , then  $p^* = 1$  and the capital market equilibrium allocation is optimal.*

**PROOF.** Suppose  $X_{11} \geq X_{22}$ . If  $p < 1$ , the supply of type 1 capital is zero and the demand is positive. If  $p > 1$ , all type (1,  $j$ ) agents will supply alleged type 1 capital and the demand for type 1 capital is no greater than  $X_{22}$ . Therefore, there is an excess supply of type 1 capital no smaller than  $X_{11} + X_{12} - X_{22} > 0$ . For  $p = 1$ , type (1, 2) agents will allocate their capital to process 1 production and will consume the proceeds, while type (2, 1) agents will allocate their capital to process 2 production and will consume in period 3. Type (1, 1) agents are indifferent between autarky and selling capital, while type (2, 2) agents prefer to sell their type 2 capital and buy capital supplied by type (1, 1) agents. In equilibrium, a fraction  $X_{22}/X_{11}$  of the capital endowment of type (1, 1) agents is sold and the

remaining fraction is retained by type (1, 1) agents. All capital owned by type (1, 1) agents after trading is allocated to process 1 production. We therefore have  $u_{11} = u_{12} = 1$ ,  $u_{22} = \pi_1 r_1 + (1 - \pi_1)r_2$  and  $u_{21} = \pi_1 r_1 + (1 - \pi_1)r_2$ . Given Proposition 2, this is an optimal allocation. Q.E.D.

**PROPOSITION 4.** *If  $X_{11} < X_{22}$  and a capital market equilibrium exists, it is not optimal.*

**PROOF.** Suppose  $X_{11} < X_{22}$ . Then if  $p < 1$ , the supply of type 1 capital is zero and the demand is positive, so we cannot have  $p^* < 1$ . For  $p = 1$ , type (1, 1) agents are indifferent between selling type 1 capital and autarky, while type (2, 2) agents wish to exchange their endowment for type 1 capital. There is therefore an excess demand for type 1 capital of  $X_{22} - X_{11}$ , and  $p^* \neq 1$ . Therefore, if a capital market equilibrium exists, we must have  $p^* > 1$ , in which case all type (1, 2) agents will supply type 2 capital, and claim that it is type 1. In equilibrium, some type 2 capital will be allocated to the type 2 production process and, as a result, the allocation is not IE and therefore not optimal, given Propositions 1 and 2.

Q.E.D.

**PROPOSITION 5.** *If  $X_{11} < X_{22}$ , a capital market equilibrium may not exist.*

**PROOF.** Suppose  $X_{11} < X_{22}$  and that:

$$(4.1) \quad (X_{11} + X_{12})^{-1} \{X_{11}[\pi_1 r_1 + (1 - \pi_1)r_2] + X_{12}[\pi_2 r_1 + (1 - \pi_2)r_2]\} \leq 1$$

From the proof of Proposition 4, if an equilibrium exists, we will have  $p^* > 1$ , and all type (1, 1) and type (1, 2) agents will supply alleged type 1 capital. In addition, some type (2, 2) agents may also claim their capital to be type 1 and sell it on the market. If an agent were to buy type 1 capital on the market and apply it to process 2 production, the return in terms of the period 3 consumption good is less than or equal to unity, given (4.1). Therefore, since  $p^* > 1$ , the return to selling type 2 capital for alleged type 1 capital and using this capital in either production process is less than unity, the opportunity cost of type 2 capital. Therefore, an equilibrium does not exist. Q.E.D.

In the case where  $X_{11} \geq X_{22}$ , there is no illiquidity problem. In equilibrium, the price of capital is such that it is not in the interest of those holding type 2 capital to sell it under the false claim that it is type 1. All agents know that what other agents claim to be type 1 capital is just that. However, if  $X_{11} < X_{22}$ , there exists no equilibrium in which type (1, 1) agents can credibly claim that the capital they are selling is in fact type 1, since these agents will not be alive in period 3 when the returns are realized. Agents are asymmetrically informed in period 1 concerning the expected return on capital, and assets are therefore illiquid. This illiquidity leads either to the non-existence of equilibrium or to the non-optimality of equilibrium if it exists.

4.2. *Banking.* The illiquidity problem in a decentralized capital market arises due to adverse selection; owners of type 2 capital may sell it as type 1 capital and thus impair the trading process. In this section, we show how a collective, i.e., a “bank,” can induce self-selection.

We define a bank to be a coalition of  $n$  agents which forms in period 0 and writes contracts contingent on the future state of the world. Since all agents are identical in period 0, we can think of the coalition in period 1 as being composed of  $n$  agents who are each an independent draw from the period 1 population. Let  $W_{ij}^n$  be a random variable which denotes the fraction of type  $(i, j)$  agents in a coalition composed of  $n$  agents. The problem the coalition solves, given  $n$ , is then the same problem solved by the coalition of the whole in Section 3, replacing  $X$  by  $W^n = (W_{11}^n, W_{12}^n, W_{21}^n, W_{22}^n)$ . From Propositions 1 and 2, the level of expected utility attained by a representative agent in the coalition, denoted  $U(n)$ , is:

$$(4.2) \quad U(n) = E[f(W^n)]$$

where

$$f(W^n) = \begin{cases} \pi_1 r_1 + (1 - \pi_1) r_2 + (W_{12}^n + W_{22}^n)[1 - \pi_1 r_1 - (1 - \pi_1) r_2], & W_{11}^n \leq W_{22}^n \\ \pi_1 r_1 + (1 - \pi_1) r_2 + (W_{11}^n + W_{12}^n)[1 - \pi_1 r_1 - (1 - \pi_1) r_2], & W_{11}^n \geq W_{22}^n \end{cases}$$

Note that  $f(W^n)$  is a concave function, as  $W_{12}^n + W_{22}^n < W_{11}^n + W_{12}^n$  for  $W_{11}^n > W_{22}^n$ .

Iterating expectations in (4.2), we get:

$$(4.3) \quad U(n) = E\{E[f(W^n) | X]\}$$

Since  $W^n \rightarrow X$  as  $n \rightarrow \infty$ , we have:

$$\begin{aligned} \lim_{n \rightarrow \infty} U(n) &= E[f(X)] \\ &= E\{f(E[W^n | X])\} \\ &> E\{E[f(W^n) | X]\} \\ &= U(m) \end{aligned}$$

for any finite  $m$ , where the inequality follows from the concavity of  $f(\cdot)$  and the fact that, for finite  $m$ ,  $\Pr [W_{11}^m < W_{22}^m | X_{11} \geq X_{22}] > 0$  and  $\Pr [W_{11}^m > W_{22}^m | X_{11} \leq X_{22}] > 0$ .

Banking coalitions will then choose to grow large ( $n \rightarrow \infty$ ), as this maximizes the expected utility of a representative member of the coalition. Though all agents are risk neutral, the expected payoff to a member of the coalition is a concave function of the fractions of agent types in the coalition. Coalition members are then effectively risk averse, and they can diversify against risk by forming a large coalition, so that the fraction in the coalition of each agent type converges to the corresponding fraction in the population.

We can then have an equilibrium with banking coalitions, in which  $N$  large coalitions form in period 0, each of which maximizes the expected utility of its

members by offering optimal allocations. Given Proposition 2, if  $X = x$  in period 1, an agent of type  $(i, j)$  in a particular coalition,  $k$ , will be indifferent between the allocation offered by coalition  $k$  and that offered by any other coalition. There will then be no incentive for agents to form alternative coalitions in period 1.

An equilibrium with banking coalitions yields an optimal allocation. What we want to show is that such an equilibrium can be achieved through contracts which exhibit features of real-world banking contracts. One such arrangement is the following. Each coalition agrees in period 0 that in period 1 the bank will offer its members a choice of contracts. In exchange for one unit of type 2 capital, the bank offers a "type 2" deposit contract. This contract gives its holder the right either to withdraw one unit of the consumption good in period 2, or to receive a stream of payments in periods 2 and 3 of  $[(X_{22} - X_{11})/X_{22}, X_{11}[\pi_1 r_1 + (1 - \pi_1)r_2]/X_{22}]$  if  $X_{11} \leq X_{22}$  or of  $(0, \pi_1 r_1 + (1 - \pi_1)r_2)$  if  $X_{11} \geq X_{22}$ . The bank offers holders of type 1 capital a "type 1" deposit contract in exchange for a debt contract with the bank. This debt contract specifies that the borrower (the owner of the capital) make a payment to the bank of  $[1 - \pi_2 r_1 - (1 - \pi_1)r_2]/(\pi_1 - \pi_2)$  in period 3 or "default," in which case the bank receives the entire return on the agent's capital. The agent will then default only if the return on capital is  $r_2$ . The type 1 deposit contract is a kind of compensating balance held with the bank, which may be withdrawn in period 2 in exchange for one unit of the period 2 consumption good. If held until time 3, it gives a return of  $\{\pi_1 - \pi_2[\pi_1 r_1 + (1 - \pi_1)r_2]\}/(\pi_1 - \pi_2)$ . If a type 1 deposit is withdrawn in period 2, the agent defaults on her debt and relinquishes title to her capital to the bank. There is a covenant attached to the debt which states that the borrower cannot allocate her capital to process 1 production.

If  $X_{11} \leq X_{22}$ , the bank allocates all type 1 capital to which it has claim to process 2 production, and all type 2 capital to process 1 production. If  $X_{11} \geq X_{22}$ , then all type 2 capital is allocated to process 1 production,  $X_{11} - X_{22}$  units of type 1 capital are allocated to process 1 production, and the remaining type 1 capital is allocated to process 2 production. Requests for withdrawal are made simultaneously, and the bank allocates the available quantity of the consumption good equally in period 2 among those who request withdrawal. This amounts to introducing the possibility of suspension of convertibility, which will never be invoked, as it is never in the interest of type  $(2, j)$  agents to withdraw.

The resulting allocation is:

$$\begin{aligned} c_{11}^2 = c_{12}^2 &= 1, & c_{22}^2 &= 1 - X_{11}/X_{22} \text{ if } X_{11} \leq X_{22}, & c_{22}^2 &= 0 \text{ if } X_{11} \geq X_{22}, \\ c_{22}^3 &= [X_{11}/X_{22}][\pi_1 r_1 + (1 - \pi_1)r_2] \text{ if } X_{11} \leq X_{22}, \\ c_{22}^3 &= \pi_1 r_1 + (1 - \pi_1)r_2 \text{ if } X_{11} \geq X_{22}, \\ c_{21}^3 &= \{\pi_1 - \pi_2[\pi_1 r_1 + (1 - \pi_1)r_2]\}/(\pi_1 - \pi_2), \\ c_{211} &= \{\pi_1 r_1 + (1 - \pi_1)r_2 - 1\}/(\pi_1 - \pi_2), & c_{221} &= c_{222} = c_{212} = 0. \end{aligned}$$

As is easily checked, this is an optimal allocation.

Banks in our model are like banks in the real world in the sense that they are “large” (they hold a diversified portfolio and write contracts with a large number of depositors), and write banking-type contracts. Their liabilities are deposit contracts which allow for early withdrawal, and their assets are the debt of other agents and the economy’s primitive assets. If the bank holds an agent’s debt, it also requires that the agent hold a compensating balance with the bank.

This model captures two features of the role played by banks and shows how these features are intimately related. First, banks provide a liquidity transformation. With decentralized capital markets, an adverse selection problem may exist which impairs agents’ ability to trade assets. Banks solve this problem with the aid of a more complex set of contracts. Second, banks play an information-gathering role which produces a more efficient allocation of capital. As banking contracts solve the illiquidity problem, this induces agents to reveal their private information. This information is then used by banks to direct capital to its most efficient use. An aspect of financial intermediation which is not captured here is the “delegated monitoring” role of intermediary institutions, contained in the work of Diamond (1984) and Williamson (1986, 1987). In these models, intermediation economizes on ex post “bankruptcy” costs. Delegated monitoring is not a feature of our model, since it is not directly related to the phenomena we wish to study here (i.e., a particular notion of liquidity and the role of banks in providing a liquidity transformation).

## 5. BANK FAILURES

In period 1 states, where  $X_{11} \geq X_{22}$ , all agents are indifferent between the equilibrium allocation with banking coalitions and the capital market equilibrium allocation. Thus, the demand for banking services is low in some states, in that a complex organizational structure with rich contracts is inessential; the same allocation can be achieved with relatively simple contracts and patterns of trade. Note that no financial contracts are necessary with a decentralized capital market; trade requires only the exchange of capital at a point in time. One equilibrium arrangement which yields an allocation identical to that achieved with the banking contracts described in the previous section, is for some banking coalitions to dissolve (or “fail”) in some period 1 states where  $X_{11} \geq X_{22}$ . Members of dissolved coalitions then proceed to trade capital in period 1. Bank failure in some contingencies is then an optimal arrangement which all coalition members would agree to in period 0.

The question we should answer at this point is: To what extent is the interpretation of the institutional “collapse” in our model as a bank failure justified? The first step in answering this question is to establish our empirical knowledge concerning periods when large numbers of bank failures occur. The following is a list of relevant stylized facts for the United States, concerning such periods: (i) Deposit withdrawals are higher than average, (ii) aggregate output is lower than



average, (iii) economic agents are worse off than average, (iv) promises to pay are not kept.

Facts (i) and (ii) are documented in Bernanke (1983), Friedman and Schwartz (1963), and Gorton (1985a). Our model is consistent with these facts given some restrictions on the distribution function  $F(\cdot)$ . Suppose that the fraction of agents in the population endowed with type 1 capital is a constant,  $\alpha$ , where  $0 < \alpha < 1$ . Also, suppose that the fractions of type 1 and of type 2 agents endowed with type 1 capital are equal. That is,  $(1 - \alpha)X_{11} = \alpha X_{12}$  and  $(1 - \alpha)X_{21} = \alpha X_{22}$ . We then have:

$$(5.1a) \quad X_{12} = [(1 - \alpha)/\alpha]X_{11}$$

$$(5.1b) \quad X_{21} = \alpha - X_{11}$$

$$(5.1c) \quad X_{22} = 1 - \alpha - [(1 - \alpha)/\alpha]X_{11}$$

Therefore, the population can be described in terms of a single random variable,  $X_{11}$ . Let  $X_{11}$  be distributed according to the probability distribution function  $G(X_{11})$ . Assume that, for any  $x \in (0, 1)$ ,  $0 < G(x) < 1$ .

Let  $Z$  denote a random variable which takes on a value of unity in states of the world where bank failures are possible, and is zero otherwise. That is, given (5.1),

$$(5.2) \quad Z = \begin{cases} 1, & X_{11} \geq \alpha(1 - \alpha) \\ 0, & X_{11} < \alpha(1 - \alpha) \end{cases}$$

The demand for liquidity can be measured in our model by the proportion of type  $(1, j)$  agents in the population. With banking contracts, all of these agents will withdraw their deposits in period 2. Letting  $D$  be a random variable denoting the demand for liquidity, we have

$$(5.3) \quad D = X_{11} + X_{12} = X_{11}/\alpha$$

If we measure output, denoted  $Y$ , as the sum of period 2 and period 3 production of the consumption good (which equals aggregate consumption) we have, given (5.1),

$$Y = \begin{cases} X_{11}/\alpha + (1 - X_{11}/\alpha)[\pi_1 r_1 + (1 - \pi_1)r_2], & \text{if } Z = 1 \\ 1 - \alpha + \alpha[\pi_1 r_1 + (1 - \pi_1)r_2], & \text{if } Z = 0 \end{cases}$$

We are interested in the association between output and the demand for liquidity on the one hand, and states of the world where bank failures are possible on the other. That is, we want to know how  $Y$  and  $D$  covary with  $Z$ . From (5.2), (5.3), and (5.4), we get:

$$(5.5) \quad \begin{aligned} \text{cov}(D, Z) &= (1/\alpha)G(\alpha/[1 - \alpha])\{E[X_{11} | Z = 1] - E[X_{11}]\} > 0 \\ \text{cov}(Y, Z) &= [1 - \pi_1 r_1 - (1 - \pi_1)r_2] \text{cov}(D, Z) < 0 \end{aligned}$$

Therefore, states of the world in which bank failures are a possibility tend to be states where the demand for liquidity is high and output is low. When some

banks are failing, banks remaining in operation will tend to be experiencing larger-than-average deposit withdrawals.

Fact (iii), of course, cannot be documented since welfare is not observable. However, fact (iii) seems an acceptable characterization of periods described as “banking panics” or “financial crises.” In our model, the expected utility of an agent at time 1 who knows the state of the world but does not know her type, is the sum of per capita consumption in periods 2 and 3. We have already shown that this variable ( $Y$ ) covaries negatively with  $Z$ . That is, agents are, on average, worse off in states where bank failure is possible.

Though our model conforms with facts (i), (ii), and (iii), it does not exhibit fact (iv), which some might argue is an important element of bank failures. However, to us the important feature of bank failure is a change from a complex financial structure to more primitive trading, rather than the promises to pay which are not met in the transition. Abstracting from this feature does not seem to involve the loss of anything essential.

The following is an interpretation of what happens during a “banking panic” or “financial crisis,” which has been formalized in Diamond and Dybvig (1983). For unexplained reasons, a bank run occurs where, because depositors expect other depositors to do the same, requests for withdrawal are made at banks. These requests are met in sequence; loans are liquidated and production is disrupted. As a result, all requests for withdrawal cannot be met, banks fail, real output falls, and agents are, on average, badly off. The bank run can be prevented through an appropriately designed deposit insurance program or by instituting a lender of last resort. Thus, government intervention improves matters. As we have shown, our model is consistent with some of the same observations explained in the Diamond-Dybvig approach, concerning periods when bank failures occur in large numbers. In spite of the fact that such periods are associated in our model with bad times, the resulting allocation is optimal and government intervention is inappropriate. Here, large numbers of withdrawals are not a cause but a symptom of institutional failure. Banks fail because there is a low demand for banking services associated with particular states of endowments, technology, and preferences.

It might be argued that important elements which are ignored in our model are the transactions costs (i.e., bankruptcy costs) associated with the dissolution of a banking organization. Ex post, such costs involve a deadweight loss, and taking them into account might imply either that bank failures would not occur (if banks internalize these costs) or that government intervention to prevent bank failures might be beneficial (if banks do not internalize bankruptcy costs). However, note that our model also does not include any costs associated with large organizations and complex contracts, such as agency costs and costs of writing contracts. The existence of costs of this type would imply a benefit from the dissolution of a bank. The positive and normative implications of a model including both the costs of holding organizations together and of dissolving them are impossible to predict *a priori*; this would be an interesting topic for further research.

## 6. CONCLUSION

In this paper, we have constructed a model in which an illiquidity problem arises. With decentralized trading in capital, an equilibrium does not exist in some states of the world, or if an equilibrium exists some agents have an incentive to make false claims in selling their capital. Buyers and sellers of capital are then asymmetrically informed in equilibrium concerning the expected returns on capital, and resources are misallocated.

Banking institutions, which in our model are large multi-agent coalitions, are able to alleviate this illiquidity problem; i.e., they internalize an externality. Bank deposits provide for early withdrawal, banks hold debt, and agents who take out loans with banks hold compensating balances.

Since, in some states of the world, agents are indifferent between the equilibrium allocation achieved with banking and the capital market equilibrium allocation, members of banking coalitions may agree *ex ante* that in some or all of these states the coalition will dissolve, and coalition members will simply trade capital. These bank failures are then systematically related to the state of endowments, preferences, and technology, and they tend to occur when output is low and when the demand for liquidity is high. In a state of the world in which some banks are failing, banks remaining in operation will be experiencing larger-than-average withdrawals and such a state will tend to be associated with “bad times.”

This model is novel, among multi-period models which start from first principles to explain deposit banking, in that: 1) a role for banking arises in a model where all agents are risk neutral; 2) bank failures are systematic events; 3) the existence of bank failures does not imply that government intervention is desirable. While states of the world in which banks fail have features which some might associate with “bank panics,” “bank runs,” or “financial crises,” such failures are by no means undesirable in our model.

Though the institutional failure in our model can be interpreted as a bank failure, and such an interpretation is justified by the correspondence between the model’s predictions and empirical observations, the degree of abstraction, imposed by the constraint of current modeling technology, may make this interpretation unpalatable to some. Clearly, this paper is only a step in building better models of banking and intermediation which generate predictions conforming to what we observe, and which yield useful information about the effects and desirability of interventions.

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<sup>8</sup> The views expressed in this paper are my own and are not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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