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BANK PANICS, SUSPENSIONS, AND GEOGRAPHY: SOME NOTES ON THE "CONTAGION OF FEAR" IN BANKING

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I. Introduction

The seminal paper of Diamond and Dybvig (1983) has given rise to a large literature exploring the possible causes and consequences of panics affecting the entire banking system.[1] Most of this literature follows Diamond and Dybvig in modelling banks as being subject to withdrawal demand caused, in part, by exogenous shocks that affect individuals' "liquidity preference". In particular, individual agents who experience certain shocks are motivated to liquidate bank deposits at certain points in time. Banks design contracts with depositors that take account of these shocks, and that are meant to generate particular consumption streams for agents who experience particular sets of circumstances.

In the model of Diamond and Dybvig,[2] panics can occur because the shock that impinges on each agent is privately observed. Specifically, banks design contracts which imply that only depositors in particular states should make withdrawals at any given time. However, banks do not observe depositors' states, and hence cannot ration funds in ways that respect the terms that the original contract was meant to generate. This inability to ration funds in such a manner leaves banks vulnerable to runs, since excessive numbers of agents can demand funds. Banks, being unable to ration funds according to "need," must then either "suspend" convertability of deposits or find themselves unable to honor their obligations to depositors.

This mechanism for generating runs, while internally consistent, does not seem particularly attractive if the objective of the literature on panics is to confront observations on historical bank panics. First, the Diamond-Dybvig, Bental, Eckstein and Peled (1985), Chari-Jagannathan (1984), and Jacklin (1983) models cannot give rise to bank runs unless (a) the shock that an individual depositor has experienced at any date is unobservable, or (b) banks under the Federal Reserve System (1930-33). The apparently different consequences of regional banking problems under different regulatory regimes seem deserving of examination, and also seem to require some departure from the Diamond-Dybvig framework.

The above constitutes an extended argument that observed bank panics cannot be understood by relying on models that require private information about characteristics of depositors (or of banks) at the time withdrawals are made. The obvious alternative is to follow the literature on banking problems that pre-dates Diamond-Dybvig. This literature; e.g., Kareken and Wallace (1978), emphasizes the role of government regulation and intervention in the banking system, and attributes problems in banking to some consequences of these regulations and interventions. Such attribution is time-honored; Friedman and Schwartz (1963) strongly (and cogently) argue that the role of the Federal Reserve System in preventing suspensions (restrictions) of cash payments by banks in 1930-31 was the primary cause of the severity of banking problems during the Depression.

This paper is an attempt to understand why panics occur with such sharply differing frequency and severity under different regulatory regimes, and to understand how panics can be generated without appealing to the possession of private information by banks or by bank depositors. In particular, as suggested above, the experiences with respect to panics in the U.S. under Free Banking, under the National Banking Systems, and under the (pre-FDIC) Federal Reserve System are very different. The analysis that follows attempts to understand panics in a context that also permits some understanding of the consequences of changes in regulatory regimes.

The model that will be developed here formally constitutes a hybrid of the models developed by Diamond and Dybvig, and by Bhattacharya and Gale (1985), However, the banking system can remain solvent if regulators permit suspensions (restrictions) of payments by the reserve agent under appropriate circumstances. Moreover, if such suspensions are allowed, depositors are better off, in expected utility terms, in the presence of a reserve agent. If, on the other hand, regulators prevent suspensions by the reserve agent, the banking system will eventually collapse with probability one.

The bank panics that arise in the model, then, are the result of having a geographically disparate banking system (e.g., of having "unit banking" - like restrictions), and of imposing regulatory restrictions on reserve agents. In the absence of a reserve agent (as under the Free Banking System), there will be no panics. If the reserve agent is allowed to suspend convertability of deposits, there can be panics, but the banking system does not collapse. Also, if the economy were permitted to have integrated national banks (no unit banking or branching restrictions), the system would be immune to panics. This is consistent with the vastly different banking experiences in the U.S. and Canada in 1930-33, for instance.[6]

Since the model to be presented is motivated in large part by features of the National Banking System, the paper proceeds as follows. Section II provides a description of the National Banking System, and lays out a set of observations that it seems any model of panics must be able to confront. Section III then develops a series of three models. The first is a model of a unit banking system with no reserve agent. The second adds a reserve agent, but abstracts from aggregate uncertainty. The third introduces aggregate uncertainty. The role of regulations in necessitating periodic restrictions of convertability is explored. Section IV concludes.

which is typical of the actions of country banks in crises, suggests that these banks draw only on reserve agents at these times. In fact, the cash reserves of country banks were "almost stationary" in normal periods [Sprague, p. 19], and generally rose during panics. Hence there will be no loss in abstracting from cash reserve holdings by country banks.

The remaining banks, which were located in fifteen cities that were designated redemption cities, fell into two groups. Those banks outside of New York were required to hold a reserve of 25%, half of which could be deposited with New York banks. Until 1887, only New York was designated a "central reserve" city, accounting for its unique position in the regulatory structure.

Clearly, then, the New York banks were at the heart of the National Banking System. It is these banks which motivate the "reserve agent" to be introduced into the model below. In the model there will be a single reserve agent. This is not a completely accurate description of the New York reserve agents, but it is also one which does little violence to reality. First, despite the fact that there were fifteen reserve cities, and in New York alone fifty national banks, seven New York banks held amounts ranging from 70% - 80% of all the bankers' deposits in the city. [Sprague, p. 15] Moreover, during the panic of 1873 all of the national banks of New York "were converted, to all intents and purposes, into a central bank [which] ... included virtually all the banking power of the city." [Sprague, p. 90] Thus it is not unreasonable to develop a model in which there is a single reserve agent.

In the model, the reserve agent will hold only bankers' deposits; i.e., it will have no individual depositors. Again this simplification does little violence to reality. The seven large New York reserve agents had liabilities to bankers three times as great as those to individuals.[7] As stated by Sprague (p. 18), it "seems clear that these banks ... were carrying on their operations

B. The Panic of 1873

A general description of the panic of 1873 appears in Sprague, and hence would be superfluous here. However, it will be useful to lay out some facts about the panic that will subsequently guide construction of the model.

First, prior to the panic of 1873 there were no significant changes in the monetary circumstances of the U.S., nor was there any unusual expansion of bank credit. [Sprague, p. 5-6] Reserves of banks were high by historical standards [Sprague, p. 10],[9,10] and the onset of the panic did not appear to be the result of any arrival of "bad news" about banks or the banking system. According to Sprague (p. 81),

> All of the failures which occurred during the crisis were ... due to the "criminal mismanagement of their officers or to the neglect or violation of the National Bank Act on the part of their directors."
> It would not be difficult to find many quite normal periods during which both the number of failures and the losses of creditors were far more considerable than in 1873. The solvency of the banks was at no time in question. The defects in the banking system which were disclosed were in its organization .... Moreover, the banks were in what was for them a normal condition of strength at the time.

Moreover, "few banks failed during the crisis or during the subsequent months and years of depression. And of the failures which did occur hardly any involved serious loss to the creditors." [Sprague, p. 2][11] Thus it will be desirable to construct a model in which panics can arise without any occurrences that are unusual other than that real activity is depressed. Also, some banks should be liquidated during the panic, but should be liquidated with relatively little loss to depositors.

Second, the bulk of withdrawals during the panic were made by agents with readily observable characteristics. Hence the Diamond-Dybvig (or Chari-Jagannathan) device of having depositors be privately informed about payoff-relevant characteristics cannot be germane to observed panics. In particular,

> Had all the New York banks been purely local institutions, with no responsibilities to the rest of the country, there can be little doubt that they would have been able to weather the storm without further difficulty. But the most considerable withdrawals of currency which they had to meet came from the out-of-town banks, and demands from that quarter showed no signs of diminishing .... [Sprague, p. 51]

Suspension (or, as Friedman and Schwartz would have it, restriction) of cash payments occurred on September 24 in New York. Shortly following this, suspension became general throughout the U.S.

It is necessary, then, to have a model in which panics occur because of the special position of reserve agents vis-a-vis the rest of the banking system. In fact, the discussion of the panics of 1893 and 1930-33 will make this necessity all the more apparent. In particular, it appears necessary to subject central reserve city banks to speculative withdrawal demand by other banks.

A final point that is worthy of note is the fact that the panic of 1873 left the Pacific coast untouched. According to Sprague (p. 67), "general business was largely independent of that in the rest of the country" in the Pacific coast. In the context of the model presented below, this would mean that banks in this region had no relations with a central reserve agent. They would then not be subject to the occurrence of panics in the model.

C. The Panic of 1893

As was the case in the panics of 1930-33, the panic of 1893 had a distinct geographic flavor to it. Again, in a manner reminiscent of 1873, the New York banks were in a (historically) strong position with respect to reserve holdings; according to Sprague (p. 153) "they were far more amply provided with cash than has been customary in periods of active business either before or since." In fact, the reserve position of the banking system as a whole was "reasonably

While the outflow of cash from New York had not yet created any difficulties for New York banks, on June 15 mechanisms for the issue of clearing-house loan certificates were established. Thus New York banks were already anticipating problems that might be produced due to their positions as reserve agents, even though "no bank in the city was in difficulty." [Sprague, p. 170]

By July 8, the total loss of reserves of the New York banks was $40 million.[14] Nonetheless, this "serious strain had been met boldly and successfully." [Sprague, p. 173] However, "during the third week of July a second wave of distrust of the banks spread over the West and South." [Sprague, p. 175] The outflows of funds from New York occasioned by this new set of regional problems then led the New York banks to partially suspend (restrict) cash payments. It is apparent, then, that suspension of cash payments in New York was due to the special reserve agent position of the New York banks. Further, suspension of payments in New York closely preceeded general, nationwide suspension.

Two final points of note are as follows. (i) "In 1873 suspension was one of the initial causes interrupting the normal course of business. In 1893 it was rather of the nature of a last straw adding to the burdens resting on the business community." [Sprague, p. 199] Thus it is reasonable to view the problems of 1893 as occurring in the context of (rather than being the cause of) depressed business conditions.[15] (ii) Of the 158 national bank <u>failures</u> that occurred in 1893, 153 were in the South and West. [Noyes, p. 193] Thus problems that caused bank liquidation were apparently geographically restricted to certain regions. This observation motivates the modelling strategy employed below.

D. The Panic of 1907[16]

A number of aspects of the panic of 1907 that are fairly challenging for existing models of panics are discussed by Smith (1984). Hence it will be portfolio were held in the form of bonds of the chartering state, all banks in a given region (or state) were subject to very similar shocks. Therefore large numbers of banks in a given state might tend to experience difficulties simultaneously. However, in the absence of a central reserve agent, these difficulties could not be transmitted to other regions. Rolnick and Weber (1985) argue convincingly that, in fact, there were periods when large groups of regional banks were forced to liquidate. These regional problems were geographically confined, however, so that in the absence of central reserve agents there was no apparent contagion of bank failures.

Two additional aspects of the situation Rolnick and Weber describe are relevant to the modelling strategy below. First, because of the nature of the portfolios of representative free banks (and in particular because of their general similarities within a given state), the same shocks tended to impinge on all of the customers of any given bank. The modelling strategy followed below will, as a simplification, adopt a specification in which all of the depositors of any given bank (all the residents of any given region) experience the same shock. This permits considerable simplification without doing violence to actual experience (in this instance). It also permits the model to reproduce the second important observation of Rolnick and Weber (p. 5), that "very few free bank closings involved losses to noteholders." The specification adopted below permits liquidated regional banks to meet all of their contractual obligations, at least when there is not a central reserve agent.

F. The Panics of 1930-33

As was the case in 1893, the sequence of panics experienced from October 1930 to March 1933 had distinctly regional aspects. Moreover, the nature of the transmission mechanism for regional banking disturbances again appears to viewed as exogenous shocks. This is worthy of note, since it is consistent with the modelling strategy employed below. Finally, it might be noted that Wicker's argument suggests that a single shock (the failure of Caldwell and Company) was directly responsible for the banking problems of an entire (four state) region. This is again consistent with the type of model developed in the sequel, since as a simplification all the agents in a given location will be subject to the same disturbance. As has been seen, such a simplifying assumption is in fact not at variance with observation in many circumstances.

As an aside that is relevant to the formulation of the model in the next section, two additional facts about the panic of 1930 should be mentioned. First, the panic produced "no discernible interest rate effects." [Wicker (1982), p. 47] This is relevant, since the model employed will follow Diamond and Dybvig in viewing rates of return on investments as technologically determined. Such a formulation, while not consistent with all observations from historical panics, is apparently not inconsistent with all panic experiences. Second, the panic produced relatively minor expenditure effects. [Wicker (1982), p. 440-441] Thus it seems appropriate to model the onset of the panic as a shock which bank failures do not necessarily feed back on. This will be the strategy adoped below.

Following the panic of 1930, there was a second crisis in March 1931. The culmination of the period of sustained banking difficulties began with a "renewed series of bank failures ... in the last quarter of 1932, mostly in the Midwest and Far West." [Friedman and Schwartz, p. 324] Runs in particular states occurred, leading to the declaration of state banking holidays in Nevada, Iowa, Louisiana, and Michigan by February 14, 1933. Thus, as previously, the onset of the panic had a regional nature.

In this instance, it is fairly easy to follow how these regional difficulties were transmitted so as to become general.

> We have already expressed the view that under the pre-Federal Reserve banking system, the final months of 1930 would probably have seen a restriction, of a kind that occurred in 1907, of convertability of deposits into currency .... Restriction would almost certainly have prevented the subsequent waves of bank failures that were destined to come in 1931, 1932, and 1933 .... [Friedman and Schwartz, p. 311]

Moreover, they argue (p. 311) that "the existence of the Reserve System prevented concerted restriction." Thus the failure to suspend cash payments was responsible for the severity of the banking problems of 1930-33.

To summarize, the role of the existing regulatory structure in giving rise to geographic "contagion" in banking panics appears to be central. An extreme example of how central this issue is would appear to be the consequences of actions to prevent suspensions of convertability implicit in the creation of the Federal Reserve System. As put by Friedman and Schwartz (p. 330), "one would be hard put to it indeed to find a more dramatic example of how far the result of legislation can deviate from intention than this contrast between the earlier restrictions of payments and the banking holiday under the Federal Reserve System, set up largely to prevent their repetition."

In light of the evident importance of the regulatory structure in influencing the course of observed bank panics, it should now seem appropriate to construct a model that emphasizes this role.

III. The Model

A. A Model with no Reserve Agent

As argued above, it is implausible to assert that historical panics were the result of "speculative" withdrawal demand of the Diamond-Dybvig or Chari-Jagannathan (1984) type, particularly since such a mechanism for generating panics appears to require that agents making speculative (as opposed to other

All of these banks and depositors are identical _ex ante_ (i.e., as of t=0). The depositors are Diamond-Dybvig style depositors, who may be described as follows. If these agents place deposits in a bank at t=0, they will deposit their entire endowment. Let c_t denote the consumption of an arbitrary depositor at date t. Then depositors, as of t=0, have utility functions of the Diamond-Dybvig type, denoted $U[c_1 + \phi(s)c_2]$, defined on R_+. It will be assumed that $cU''(c)/U'(c) < -1 \; \forall \; c\varepsilon R_+$. $\phi(s)$ is a random variable that is realized at time 1, and is identical for all depositors assigned to location s.[21] For a resident of location s, $\phi(s)$ has the probability distribution

$$\text{(1)} \quad \begin{aligned} &\phi(s) = 0 \text{ with probability } p \\ &\phi(s) = 1 \text{ with probability } 1 - p. \end{aligned}$$

Thus, at this point, there is no aggregate uncertainty. Finally, the realization of $\phi(s)$ is observable by all agents.

Banks behave as follows. Banks in location s take deposits (at most) from depositors in location s. Let $r_t(s)$ denote payments by the bank in location s to depositors who withraw at date t; t=1,2. Since all depositors of the bank are identical, and since payments can (in principal) be made contingent on $\phi(s)$, there is no scope for "runs" on local banks.[22] Then, since again all depositors in location s are identical at t=1, clearly

$$r_1(s) = \begin{cases} 1 \text{ if } \phi(s) = 0 \\ 0 \text{ otherwise} \end{cases}$$

$$r_2(s) = \begin{cases} 0 \text{ if } \phi(s) = 1 \\ R \text{ otherwise} \end{cases}$$

The sequential service constraint prevents r_1 from being contingent on, among other things, the volume of withdrawals at t=1. The reserve agent, then, can make payments at t=1 state contingent only by suspending (or restricting) cash payments. Regulators permit suspension only when failure to suspend will demonstrably result in insolvency on the part of the reserve agent.

One of the objectives of this exercise is to show that, under the modification of introducing geographically dispersed banks and a regulated reserve agent, the Diamond-Dybvig formulation can essentially reproduce observed panics without the assumption of private information. In order to give the model here the flavor of the Diamond-Dybvig model, the reserve agent will be viewed as a cooperative entity that maximizes the expected utility of regional bank depositors as of t=0. An alternative formulation that would produce the same result would be to have some fixed finite number of reserve agents (each serving large numbers of "country banks") that compete for interbank deposits. In any event, the reserve agent is viewed as choosing (r_1,r_2) in the following manner. At t=0, all banks will, for risk pooling reasons familiar from Diamond-Dybvig, deposit all of their funds with the reserve agent. At t=1 bank s will withdraw all its reserve agent deposits if $\phi(s) = 0$. These deposits are then divided in a pro rata manner among the depositors of bank s. Hence per person consumption in location s if $\phi(s) = 0$ is r_1. Similarly, per person consumption in location s if $\phi(s) = 1$ (and there is no "run") is r_2. Then (r_1,r_2) is chosen to solve the problem

$$\max pU(r_1) + (1-p)U(r_2)$$

subject to the resource balance condition

$$(2) \quad r_2 = \frac{R}{1-p} - R[\frac{p}{1-p}]r_1$$

reserve agent are a possibility, although these runs can be forestalled by appropriate suspensions as well. Runs on the reserve agent here are exactly of the Diamond-Dybvig variety, but have a different interpretation than in Diamond-Dybvig. In particular, runs occur in this context only because the reserve agent is prevented (by regulation) from restricting time 1 withdrawals (except through suspensions). Thus the run is a consequence of the "sequential service constraint."

To see that runs on the reserve agent can occur as a result of self-fulfilling prophecies (as in Diamond-Dybvig), suppose that all local banks conjecture that a fraction f of all local banks are planning to make withdrawals at t=1. If f satisfies

$$(5)\quad \frac{R}{1-f} - R\left[\frac{f}{1-f}\right]r_1^* < r_1^*$$

then all local banks will have an incentive to withdraw their funds from the reserve agent at t=1. Moreover, since $r_1^* > 1$, (5) will be satisfied for f sufficiently near one. Thus if f=1 a run which is a self-fulfilling prophecy occurs.

As in Diamond-Dybvig, these runs can be prevented if the reserve agent is permitted to suspend convertability of interbank deposits whenever time 1 withdrawal demand is too large. In particular, if the reserve agent refuses to make payments at t=1 whenever f (the fraction of country banks withdrawing at t=1) exceeds p, then it is a dominant strategy for banks with $\phi(s) = 1$ to withdraw at t=2. Hence only banks with $\phi(s) = 0$ withdraw at t=1, and runs do not occur. Notice that a suspension here does not involve failure by any banks to make payments (or to offer to make payments) to individual depositors, but only involves a refusal by the reserve agent to make shipments to country banks.

Of course if the reserve agent is permitted to suspend whenever f > p, runs will not occur and suspensions will never be observed. Thus this section should so that r_2 (the interest rate on second period withdrawals) is obviously contingent on the aggregate state, σ, and on first period withdrawals.

Finally, as a description of regulatory behavior, $f = \sigma$ unless banks (the reserve agent, and hence banks in general) suspend (or partially suspend) convertability of deposits. Suspension is permitted by regulators if and only if a failure to suspend will result in insolvency of the reserve agent at t=1. Here insolvency involves an inability to pay all country banks who withdraw at t=1 r_1 per unit deposited. Insolvency will result if payments at t=1, fr_1, are such that $r_2(\sigma,f) < r_1$, since then all country banks will have an incentive to withdraw at time 1. Hence suspension is permitted whenever $f \geq \sigma^*$, where σ^* satisfies

$$(8) \quad r_2(\sigma^*,\sigma^*) \equiv \frac{R}{1-\sigma^*} - R\left(\frac{\sigma^*}{1-\sigma^*}\right)r_1 = r_1$$

Thus total withdrawals at t=1 are given by

$$(9) \quad \begin{aligned} f &= \sigma; \quad \sigma \varepsilon [\underline{\sigma},\sigma^*] \\ f &= \sigma^*; \quad \sigma \varepsilon [\sigma^*,\bar{\sigma}], \end{aligned}$$

where (9) should be viewed as a regulatory restriction. It will be verified below that the range of values of σ which would result in insolvency of the reserve agent if a suspension did not occur is, in fact, an interval. This justifies the formulation in (9). σ^* is a choice variable for the reserve agent at t=0.

It remains to describe what transpires in the event of a suspension ($\sigma > \sigma^*$) at t=1. If the reserve agent suspends at time 1, then it makes payments of r_1 per

$$(12)\quad c_2(\sigma) \equiv \frac{R}{1-\sigma} - R\left(\frac{\sigma}{1-\sigma}\right)r_1 \geq r_1$$

$\forall\ \sigma \leq \sigma^*$. σ^*, of course, satisfies (12) with equality. (12) is the incentive compatibility condition since, in the absence of (12), all country banks will wish to make withdrawals at t=1. The reserve agent is not permitted to design contracts that have this effect.

Following Diamond-Dybvig, the reserve agent can again be viewed as a co-operative entity, or alternatively, it would be possible to view there as being a finite number of reserve agents who were Nash competitors. In either case, the reserve agent would choose r_1 and σ^* to solve the problem

$$(\text{P})\quad \max \int_{\underline{\sigma}}^{\sigma^*} \sigma U(r_1)g(\sigma)d\sigma + \int_{\underline{\sigma}}^{\sigma^*} (1-\sigma)U[c_2(\sigma)]g(\sigma)d\sigma +$$

$$\int_{\sigma^*}^{\bar{\sigma}} [\sigma^* U(r_1) + (\sigma-\sigma^*)U(0)]g(\sigma)d\sigma + \int_{\sigma^*}^{\bar{\sigma}} (1-\sigma)U[c_2(\sigma)]g(\sigma)d\sigma$$

subject to (11), (12),

$$(13)\quad \frac{R}{1-\sigma^*} - R\left(\frac{\sigma^*}{1-\sigma^*}\right)r_1 \geq r_1,$$

with equality unless $\sigma^* = \bar{\sigma}$, and subject to

$$(14)\quad \bar{\sigma} \geq \sigma^* \geq \underline{\sigma}$$

$$(15)\quad \frac{1}{\sigma^*} \geq r_1 \geq 0.$$

The solution to this problem gives equilibrium values of r_1 and σ^*.

(P) can be written as

$$(17)\quad U'(r_1) \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma g(\sigma)d\sigma = R \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma U'[\frac{R}{1-\sigma} - R(\frac{\sigma}{1-\sigma})r_1]g(\sigma)d\sigma$$

Now by hypothesis $1 \geq r_1$, which also implies that $R/(1-\sigma) - R\sigma r_1/(1-\sigma) \geq R$. Thus (17) implies that

$$U'(1) \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma g(\sigma)d\sigma \leq RU'(R) \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma g(\sigma)d\sigma$$

or that $U'(1) \leq RU'(R)$. But this contradicts the assumption that $cU''(c)/U'(c) < -1 \ \forall\ c$. [See Diamond-Dybvig, p. 407] Thus $r_1 > 1$.[25]

Having stated proposition 1, it is easy to establish that $0 = \underline{\sigma} < \bar{\sigma} < 1$ and (16) together imply that $\underline{\sigma} < \sigma^* < \bar{\sigma}$. This is now done in two steps.

<u>Proposition 2.</u> If $\underline{\sigma} < \bar{\sigma} < 1$ and (16) hold, then $\sigma^* < \bar{\sigma}$.

<u>Proof.</u> Suppose the contrary, so that $\sigma^* = \bar{\sigma}$. Then the expected utility (as of t=0) of a representative depositor is

$$(18)\quad \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma U(r_1)g(\sigma)d\sigma + \int_{\underline{\sigma}}^{\bar{\sigma}} (1-\sigma)\ U[\frac{R}{1-\sigma} - R(\frac{\sigma}{1-\sigma})r_1]g(\sigma)d\sigma \geq \int_{\underline{\sigma}}^{\sigma^*} \sigma U(\hat{r}_1)g(\sigma)d\sigma +$$

$$\int_{\underline{\sigma}}^{\sigma^*} (1-\sigma)\ U[\frac{R}{1-\sigma} - R(\frac{\sigma}{1-\sigma})\hat{r}_1]g(\sigma)d\sigma + \int_{\sigma^*}^{\bar{\sigma}} [\sigma^* U(\hat{r}_1) + (\sigma-\sigma^*)U(0)]g(\sigma)d\sigma +$$

$$\int_{\sigma^*}^{\bar{\sigma}} (1-\sigma)U[\frac{R}{1-\sigma} - R(\frac{\sigma^*}{1-\sigma})\hat{r}_1]g(\sigma)d\sigma$$

for all choices of $\hat{r}_1$ and σ^* that satisfy (12) - (15). It is now shown that (18) contradicts (16), establishing the proposition.

must hold.

It is now easy to show that (20) contradicts (16). In order to see this, notice that (12) and $\sigma^* = \bar{\sigma}$ imply that

$$\frac{R}{1 + (R-1)\sigma} \geq r_1 \;\forall\; \sigma\varepsilon[\underline{\sigma},\bar{\sigma}].$$

Moreover, since $\bar{\sigma} < 1$,

$$(21)\quad \frac{1}{\bar{\sigma}} > \frac{R}{1 + (R-1)\bar{\sigma}} \geq r_1.$$

But (21) and (20) imply that

$$U'(\bar{\sigma}^{-1}) \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma g(\sigma)d\sigma < R \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma U'[\frac{R}{1-\sigma} - R(\frac{\sigma}{1-\sigma})(\bar{\sigma}^{-1})]g(\sigma)d\sigma$$

$$= R\int_{\underline{\sigma}}^{\bar{\sigma}} \sigma U'[(\frac{R}{1-\sigma})(\frac{\bar{\sigma} - \sigma}{\bar{\sigma}})]g(\sigma)d\sigma,$$

contradicting (16). Hence (19) is positive, and $\sigma^* = \bar{\sigma}$ is, in fact, not an equilibrium choice. Thus $\sigma^* < \bar{\sigma}$.

<u>Proposition 3.</u> If $\underline{\sigma} = 0$, then $\sigma^* > \underline{\sigma}$.

<u>Proof.</u> Suppose to the contrary that $\sigma^* = \underline{\sigma} = 0$. Then the expected utility of a representative depositor (as of t=0) is given by

$$U(0) \int_{\underline{\sigma}}^{\bar{\sigma}} \sigma g(\sigma)d\sigma + \int_{\underline{\sigma}}^{\bar{\sigma}} (1-\sigma)U(\frac{R}{1-\sigma})g(\sigma)d\sigma.$$

IV. Conclusions

A model has been developed that attempts to capture, depending on assumptions about the existence of a central reserve agent, several key features of the operation of banking during the Free Banking Era, and under the National Banking System. The model carefully abstracts from any informational asymmetries, and in principal allows banks to ration funds to individual depositors (as in fact they did historically). System-wide panics cannot occur in the absence of a geographically dispersed banking system, and in the absence of a reserve agent subject to regulations on the kinds of state contingencies that can be incorporated into its deposit contracts. This appears to be broadly consistent with the observations listed in Section II.

It remains to remark on two possibilities that were not discussed above. The first concerns what would happen if the reserve agent were not allowed to suspend convertability ex post (i.e., after contracts solving the problem (P) above were entered into). This failure to suspend if $\sigma > \sigma^*$ would, of course, result in $r_2(\sigma,f) < r_1$ holding, with a consequent general demand for withdrawals from the reserve agent at t=1. In short, the banking system as a whole would be insolvent. As the discussion in Friedman and Schwartz (1963) indicates, this is not implausible as a description of what occurred in 1930-33. Thus the model confirms the Friedman-Schwartz assertion that a restriction of cash payments in 1930 could have averted the worst of the crisis.

The second possibility to be discussed is as follows. It is possible to imagine that the restrictions creating the kind of banking system described above could be lifted, i.e., that prohibitions on interstate banking and on branching could be eliminated. The creation of a single (or a set of) nation-wide (geographically integrated) banks would eliminate the potential for panics, so long as banks continued to be allowed to ration funds to individual depositors

Notes

1 See, for instance, Bental, Eckstein and Peled (1985), Chari and Jagannathan (1984), Gorton (1985), Jacklin (1983), Smith (1984), and Waldo (1985).

2 And in all of the literature mentioned in footnote 1 except Smith (1984). Gorton (1985) has privately observed shocks impinge on banks.

3 These and subsequent claims are documented in Section II below.

4 "Speculative" withdrawal demand is defined here, and throughout the paper, as withdrawal demand that occurs (only) because those engaged in these withdrawals are "speculating" about the solvency of a particular bank (or the banking system).

5 This terminology is motivated by that in use under the National Banking System.

6 An alternative explanation for this difference, suggested to me by Tom Courchene, is that Canadian banks were able to issue notes, and to use their own notes in meeting withdrawal demand. This argument would suggest important differences between note issuing and non-note issuing banks in "panic situations," and an important role for regulations regarding how depositors can demand payments. These are again issues regarding different banking "regulations."

7 This figure is from Sprague (1910). As pointed out to me by David Laidler, Sprague's calculation to arrive at this figure deducts clearing-house exchanges from individual deposits.

8 It is common in the literature on the history of the banking system at this time to question the practical significance of usury laws. However, for whatever reasons, the rate of interest on inter-bank deposits paid by New York banks over the period 1888-1907 "remained quite stable at 2 percent per annum ...." [James (1978), p. 263] This point is reiterated by James (p. 265): "in spite of substantial general downward pressure on interest rates in the 1890's, the rate on bankers' balances remained virtually fixed at 2 percent with some short-lived deviations." Thus, interest rate adjustments were not used to "protect or augment" the resources of New York banks.

9 The ratio of cash holdings to individual deposits for national banks as a whole was higher in 1873 than in all but three subsequent years before 1910. [National Monetary Commission (1910), Table No. 12] (although it should be noted that these figures do not include the holding of national bank notes by these banks). It is true that this ratio was lower in 1873 than it had been in previous years, but even so Sprague argues that (p. 10) "the cash foundation of the credit structure had not been seriously weakened ...."

[20] It would be straightforward (in an obvious way) to embed the model described here in an overlapping generations setting. Then the arrangements described here would be repeated over time, with "panics" occurring periodically. Since such an extension would be fairly trivial, for ease of exposition a "one-shot" version of the model is described here.

[21] The assumption that all the depositors in a given location experience the same shock is an inessential simplification. It also permits the model to reproduce a number of the observations cited in Section II.

[22] One may think of local banks as being permitted to suspend payments if $\phi(s) = 1$, but there is nevertheless a demand for withdrawals at t=1.

[23] That $r_2^* > r_1^*$ is implied by the assumption $cU''(c)/U'(c) < -1$. See Diamond and Dybvig.

[24] Again, this is true since $cU''(c)/U'(c) < -1$.

[25] The fact that $r_1 > 1$ implies that $c_2(\sigma)$ is decreasing in σ. Hence if (12) holds with equality for σ^*, it is violated for all $\sigma > \sigma^*$. Thus suspension of convertability is required for all $\sigma > \sigma^*$. This validates the assertion above that suspensions must occur whenever $f\varepsilon[\sigma^*,\bar{\sigma}]$.

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