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Government Deposit Insurance and the Diamond-Dybvig Model

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Abstract

The apparent banking market failure modeled by Diamond and Dybvig [1983] rests on their inconsistently applying their "sequential servicing constraint" to private banks but not to their government deposit insurance agency. Without this inconsistency, banks can provide optimal risk-sharing without tax-based deposit insurance, even when the number of "type 1" agents is stochastic, by employing a "contingent bonus contract." The threat of disintermediation noted by Jacklin [1987] in the nonstochastic case is still present but can be blocked by contractual trading restrictions. This article complements Wallace [1988], who considers an alternative resolution of this inconsistency.

Key words: deposit insurance, bank runs, Diamond-Dybvig model, market failure

1. Introduction

In what has become a classic article, Douglas W. Diamond and Philip H. Dybvig (DD [1983]) construct a model of a simple economy in which, they claim, purely voluntary bank deposit contracts cannot achieve an optimal degree of risk sharing for the representative agent in a world of individual decision-making. They claim to have shown that this optimal outcome is attainable with government-insured deposit contracts that are ultimately backed up by the government's general taxation power. Their paper has been the focal point of a large literature (e.g., Qi [1994]; Jacklin [1993]; Russell [1993]; Haubrich and King [1990]; Engineer [1989]; Chari and Jagannathan [1988]; Freeman [1988]; Jacklin and Bhattacharya [1988]; Jacklin [1987]; Postlewaite and Vives [1987]) and continues to be widely cited as providing a definitive theoretical case for government deposit insurance.

To be sure, there is a growing perception, reinforced by the 1989 collapse and taxpayer bailout of the Federal Savings and Loan Insurance Corporation and by the 1991 exhaustion of the Bank Insurance Fund of the Federal Deposit Insurance Corporation, that government-backed deposit insurance may create adverse incentives to take undesirable risks that would be reduced or eliminated in its absence.[1] DD ([1983], p. 417) themselves recognize the possibility of such costs but argue that "in this case there is a trade-off between optimal risk sharing and proper incentives for portfolio choice." Despite criticism by Wallace [1988], the DD paper continues to be widely cited as pertinent to the issue, receiving 28 *SSCI* citations in 1996 alone.

DD ([1983], p. 408) make the crucial assumption that the banking system is subject to what they call a "*sequential service constraint*, which specifies that a bank's payoff to any agent can depend only on the agent's place in line and not on future information about agents behind him in line." The key to their results is that they inconsistently apply this constraint to banks but not to their governmental deposit insurance agency. They do not make it clear whether this constraint is required by the timing of consumption. In this article we show that when banks and the government deposit agency are equally exempt from this constraint, a readily implementable modification of the deposit contract achieves the same optimal outcome in the world DD model as does tax-backed deposit insurance. This contract is much simpler than an alternative proposed by Jacklin [1993]. We go on to show that in order to implement the DD deposit insurance program, the scope of the market would have to be much more restricted than is generally appreciated to prevent complete disintermediation. A similar problem arises with our modified deposit contract but can be avoided by a further modification of the contract.

The inconsistency in the DD model has already been noted by Wallace [1988], who instead resolves it by "taking sequential service seriously," as he puts it, by making it equally impossible for either banks or the government to make any agent's ultimate payoff depend on future information about agents behind him or her in line. This article complements the critique thus begun by Wallace by exploring the alternative resolution of this inconsistency and by clarifying and resolving the ancillary problem of disintermediation.

In Section 2, we review the assumptions and conclusions of the original DD model. Section 3 shows how what we call the "contingent bonus contract" achieves the same results as the DD deposit insurance plan based on our interpretation that the DD sequential service constraint is dispensable. Section 4 demonstrates that disintermediation will upset the operation of the DD system, as well as our contingent bonus contract, in the critical stochastic case, and that this can be prevented by a further modification of the contract. Section 5 details the relationship of our article to that of Wallace. Section 6 concludes, and an Appendix provides details for Section 4.

2. The Diamond-Dybvig model

The DD model has three periods, $T = 0,\ 1,\ 2,$ and a single homogeneous good. Each agent is endowed with one unit of the good at time 0 and none in subsequent periods.

There is a single production process that yields $R > 1$ units of the good in period 2 for every unit of the good invested in period 0. The process may be interrupted at time 1, in which case each unit invested may be salvaged on a 1-for-1 basis. Once interrupted, the process may not be resumed. However, units of the good may be costlessly stored from period 1 to period 2.

All agents are identical as of period 0. At time 1, a fraction t of them find themselves to be type 1 agents with utility function

$$u(c_1), \tag{1}$$

and the remaining fraction $1 - t$ find themselves to be type 2 agents with utility function

$$\rho u(c_2), \tag{2}$$

where c_T indicates consumption in period T by agents of type T, ρ is a positive constant less than unity, and $u(c)$ is increasing, strictly concave, and twice continuously differentiable and satisfies Inada conditions $u'(0) = \infty$ and $u'(\infty) = 0$.[2] In period 0, agents act so as to maximize the expected value

$$EU = tu(c_1) + (1 - t)\rho u(c_2) \tag{3}$$

of this state-dependent utility function. Whether an agent is type 1 or type 2 is not directly observable by anyone but the agent.

Given t, the optimal values $c_1^*(t)$ and $c_2^*(t)$ of c_1 and c_2 may be found by solving the following first-order conditions for expected utility maximization:

$$u'(c_1^*) = \rho R u'(c_2^*), \tag{4}$$

$$tc_1^* + (1 - t)c_2^*/R = 1. \tag{5}$$

Equation (4) implies that the sign of $c_1^{*\prime}(t)$ will equal that of $c_2^{*\prime}(t)$, while (5) implies $c_1^*(1) = 1$ and $c_2^*(0) = R$.

DD additionally impose the special restrictions $\rho > 1/R$ and $-cu''(c)/u'(c) > 1$, in order to guarantee that the solution to (4) and (5) also satisfies

$$1 < c_1^*(t) < c_2^*(t) < R \tag{6}$$

for $0 < t < 1$. These restrictions also imply that $c_1^{*\prime}(t)$ and $c_2^{*\prime}(t)$ will both be negative. The restriction $\rho > 1/R$ implies that it is less desirable to be a type 1 than a type 2 person. This gives rise to the potential for an insurance market, in which type 2's compensate type 1's for their bad luck.

Left to themselves without banks or other financial intermediaries, agents would invest directly in the production process to obtain $c_1 = 1$ and $c_2 = R$. DD point out that this "autarky" solution is not optimal, since it does not satisfy the above first-order conditions under the special restrictions. However, it cannot be improved on by directly state-contingent contracts, since an individual's "type" is nonverifiable private information.

DD then consider a "bank" that accepts a unit deposit from each agent in period 0, invests these goods in the production process, and gives depositors the option of withdrawing funds in period 1 or period 2. The bank pays $r_1 > 1$ for deposits redeemed at the option of the depositor in period 1 and then distributes its remaining resources in a pro rata fashion to its remaining depositors in period 2. DD ([1983], p. 408) make the crucial assumption that this bank is subject to a "sequential servicing constraint" that requires that "a bank's payoff to any agent can depend only on the agent's place in line and not on future information about agents behind him in line."

In the simplest case, the DD bank announces r_1 in advance of depositors' declarations of intent to withdraw and pays the same r_1 to all comers so long as it has any resources. Let

f be the fraction of depositors who ask to redeem their deposits in period 1. If $f < 1/r_1$, the bank will be able to pay the remaining depositors

$$r_2 = \frac{R(1 - r_1 f)}{1 - f} \tag{7}$$

per unit deposited, in period 2. However, if $f \geq 1/r_1$, only the first $1/r_1$ depositors in line to withdraw funds in period 1 will receive r_1 before the bank runs out of assets and fails. The remaining depositors will receive nothing in either period.

If t is publicly known, the bank may simply set $r_1 = c_1^*(t)$. If only type 1 agents withdraw funds in period 1, f will equal t, r_2 will equal $c_2^*(t)$, and the welfare optimum will have been attained. As long as $f = t$, type 2's will have no incentive to withdraw in period 1, since they will do better to wait until period 2 and receive $r_2 > r_1$. But if type 2's fear that the bank will fail because other type 2's may withdraw, a self-justifying panic may set in, and the bank actually will fail. Once enough type 2's have withdrawn that $r_2 < r_1$, an avalanche of withdrawals will begin. The model thus has two Nash equilibria, and there is no way to rule out the unfavorable run equilibrium.

DD point out that in this simple case, in which t is nonstochastic, or at least observable at the beginning of period 1, this possibility of bank runs can easily be eliminated while retaining the sequential servicing constraint, simply by modifying the deposit contract in such a way that the bank reserves the right to suspend payments to depositors at time 1 after f reaches t. This provision makes the bank run-proof and eliminates the incentive of type 2's to withdraw funds early. Only type 1's will withdraw in period 1, all type 1's will be able to do so, and the welfare maximum will be attained.

The problematic case arises when t is stochastic and is not publicly observable. If the bank pays a fixed return $r_1 = c_1^*(f^*)$ to the first f^* customers in line in period 1, after which point it suspends until period 2, then with nonzero probability either $f^* > t$, in which case type 1's receive too little, or else $f^* < t$, in which case some type 1's will not be able to withdraw when they need to. Any other fixed r_1 would also be suboptimal. On the other hand, if the bank pays depositors a variable return that depends on f_j, the place of individual depositor j in line, then type 1 depositors who are otherwise identical will receive different returns, once again a suboptimal outcome under the DD assumptions.

DD propose to eliminate this problem with what they characterize as a tax-backed government deposit insurance program. Under their system, banks promise a fixed r_1 and pay this to whatever fraction f of depositors that wish to withdraw funds. If $f > 1/r_1$, the bank fails, and the insuror pays off the remaining period 1 withdrawals. This insurance is financed with a tax $\tau(f)$ on all period 1 wealth, which is levied whether or not the bank fails. This tax depends on the actual, ultimately observed, value of f:

$$\tau(f) = 1 - c_1^*(f)/r_1.\text{[3]} \tag{8}$$

Tax receipts in excess of those necessary to meet withdrawals in period 1 are turned over to the bank to be distributed in period 2 to the remaining depositors. Note that if the bank happens to have set r_1 below $c_1^*(f)$, this DD "tax" will actually be negative.

Note that this tax must be collected entirely in the form of deposits after depositors have declared their intention to withdraw but before they actually receive goods, for otherwise an inefficient interruption of production would occur. The position of this article is that DD are thus implicitly acknowledging that the timing of consumption is such that this is feasible.

The after-tax proceeds to period 1 withdrawers with this deposit insurance scheme are

$$v_1 = V_1(f) = r_1[1 - \tau(f)] = c_1^*(f), \tag{9}$$

regardless of r_1 and regardless of whether the bank fails. The after-tax proceeds to period 2 withdrawers are

$$v_2 = V_2(f) = R[1 - fc_1^*(f)]/(1 - f) = c_2^*(f), \tag{10}$$

again regardless of r_1 and regardless of whether the bank fails. With these payouts, $V_2(f) > V_1(f)$ for all $f \in [0, 1]$, and hence type 2's will never withdraw early. Therefore, $f = t$, and the optimal outcome is attained.

By standing ready to bail out depositors in the event of a speculative run, the government deposit insurance plan proposed by DD appears to ensure that such a run will never occur in the first place. DD ([1983], p. 404) draw the conclusion that "government deposit insurance can improve on the best allocations that private markets provide."

3. The contingent bonus contract

In fact, this conclusion derives only from DD's inconsistent assumption that "a bank ... must provide sequential service and cannot reduce [or otherwise alter] the amount of a withdrawal after it has been made" (DD [1983], p. 414), while the deposit insurance agency is under no such restriction. It may be true that banks traditionally have offered such "sequential service," and it may even be true that in most countries they are required to do so by regulation or even by statute. However, it is nowhere written in the laws of the "private market" that this must be the case if there is an important reason to do otherwise.

The "banks" DD describe are essentially mutual insurance companies. They provide insurance against unforeseeable contingencies, at the same time that they are mutually owned, in the sense that their participants or "depositors," in one way or another, sooner or later receive all the proceeds from their operations.[4] It is common for mutual insurance companies to charge premiums that are based on a worst-case scenario and then to distribute a rebate or "dividend" to their participants that is contingent on the company's actual experience.

The "banks" in the DD model, in fact, promise their depositors *nothing at all* if they leave their money in for two periods. The return r_2 they actually get, as given by (7), is a function of the bank's experience in period 1. In particular, it is a function of f. Now if depositors thus trust the bank's management to faithfully administer the assets, to contain costs, and to calculate r_2 as a function of f, there is no reason they should not trust the management to make r_1 a function of f as well.

To be sure, such a bank would have to observe the final value of f before it could completely distribute this r_1 for withdrawing depositors to consume. But so does the taxation authority in the DD model. In order for the DD tax to work, depositors must first state their intention to withdraw and then pay taxes before being allowed to consume, for otherwise the type 1 agents could simply consume the promised r_1 and "die" before paying their taxes, leaving behind an uncollectable tax bill. Furthermore, the DD tax must actually be collected in deposits before they are withdrawn, not in goods, for otherwise there would be an inefficient interruption of the production process on those tax receipts that were plowed back into the bank.

Specifically, consider an institution whose prospectus requires it to pay depositors who announce an intention to withdraw in period 1 a total return of

$$r_1 = c_1^*(f) \tag{11}$$

and to distribute the remaining assets to the remaining depositors with a period 2 payment of

$$r_2 = R(1 - fr_1)/(1 - f) = c_2^*(f). \tag{12}$$

This contract precisely duplicates the payoffs of the deposit contract with government deposit insurance described by DD and therefore prevents runs while achieving the unconstrained expected utility optimum.

In practice, this "bank" could unconditionally promise depositors in both period 1 and period 2 a base payment of one unit of output per unit deposited, this being the liquidating value of the bank's assets. Depositors demanding withdrawals in period 1 could actually be given this base payment at the time they make this demand, with the remainder, $r_1 - 1$, coming later, but still in period 1, as a contingent bonus to be determined and distributed only after the withdrawal volume is known. Such an arrangement would facilitate using at least the base value of the deposits as a payments medium. Again, the timing of this secondary distribution is no more a problem than it would be with the DD tax-backed deposit insurance program.

In order to provide efficient insurance, our "bank" would have to have a representative clientele so that the fraction of type 2 agents among its depositors is identical to that of the population as a whole. If necessary, this can be achieved by a single bank that serves the entire population.[5]

The reason the market is able to duplicate the DD government-backed insurance scheme is that their "tax" in fact does not subsidize, or even promise to subsidize, the banking sector at the expense of the nonbanking sector. Although DD assume that the tax falls on all period 1 wealth, they also assume that all resources are (for some unspecified reason) initially deposited in the banks during period 0 so that there is in fact no nondeposit wealth to tax. In reality, all their "tax" does is make a self-financing redistribution between period 1 withdrawers and nonwithdrawers; but this is something the bank can do by itself without the government's general taxation powers.

Note that the marginal tax rate on r_1, as determined by (8), is 100%. The DD "tax" thus takes away *everything* the bank offers during period 1 and replaces it with $c_1^*(f)$, regardless of r_1. DD ([1983], p. 413) claim that in their model, "Deposit insurance guarantees that the promised return will be paid to all who withdraw." This claim is true but only vacuously so, when we consider that their program simultaneously guarantees that the promised return will be entirely taken away and replaced with something different as soon as it is paid.[6]

4. The disintermediation threat with optimal risk-sharing

The DD assumption that all resources are deposited in the bank back in period 0 is also crucial, since without it their deposit insurance scheme falls apart. This problem, a form of "disintermediation," arises because the bank attempts to offer its depositors payoffs $r_1 > 1$ and $r_2 < R$ that are different from those offered by nature. An opportunity for arbitrage therefore arises in which during period 0 agents invest some portion k of their initial endowment directly in the production process instead of depositing everything in the bank. Agents who turn out in period 1 to be type 2 will simply hold these side investments to maturity for a return of $R > r_2$, while those who turn out to be type 1 will sell these invested goods at a favorable price P to type 2 agents who own bank deposits that can be withdrawn in period 1. It is shown in the Appendix to an earlier version of this article, available from the authors on request, that equilibrium will not occur until k has increased so high that P falls to 1 for all values of t, and any residual funds deposited in the banks are all withdrawn during period 1. In this equilibrium, consumption will take on its autarky values $c_1 = 1,\ c_2 = R$, so that none of the potential gains from insuring against consumption risk are realized, and welfare is lower (in ex ante expected value terms) than when all resources are deposited during period 0.

The disintermediation outcome arises because during period 0, each agent takes the aggregate level of k, and therefore the period 1 distribution of $P,\ v_1$, and v_2 as given. Given this distribution, it is to each agent's individual advantage to withhold as many resources as possible from the banking system during period 0. As all agents do this together, the aggregate level of k rises, and the distribution of P falls. This is to agents' collective disadvantage, but individual agents do not take this into account in their own decentralized decision-making.[7]

Unfortunately, essentially the same disintermediation problem arises with our contingent bonus contract as set out in Section 3 above. Once such a contract is in place, depositors will have an incentive to patronize direct investment on the side, until the banking system ceases to exist for all practical purposes.

However, trading restrictions, as suggested already by Jacklin [1987] in the nonstochastic case, would be sufficient to prevent disintermediation in either the DD deposit insurance case or out uninsured contingent bonus case. If depositors, when they deposit funds in period 0, are simply required to sign a binding agreement not to trade either deposits or withdrawn funds for invested capital goods during period 1, disintermediation will be blocked. Fortunately, the depositors against whom this restriction must be enforced are the type 2 agents who will still be alive to recover damages from in period 2 and not the type 1 agents who will be "dead" by then.

An alternative to trading restrictions would be to force or induce agents to invest all their period 0 endowment in banks that provide the optimal risk-sharing so that early withdrawing type 2 depositors have no one to trade with. In a previous version of this article, a mechanism was developed by means of which agents could be induced to voluntarily deposit all their resources in the risk-sharing bank through a further modification of the contingent bonus contract that makes payoffs depend on whether any agents are observed to be investing directly. However, trading restrictions would contractually achieve the same result with less complexity, yet without the intrusiveness of an outright ban or prohibitive tax on direct investment.

5. The Wallace model

As already indicated, DD do not make it clear whether their sequential service constraint is simply an institutional habit or whether it is a more fundamental obstacle imposed on banks by the timing of consumption. The DD model thus contains an internal inconsistency, in that this restriction is imposed on banks, yet for some unstated reason is not imposed on the government deposit insurance authority. This is a removable inconsistency, but there is no way of knowing which way of resolving it would constitute the "true" DD world. In our view, the more natural resolution is to assume that it is not a fundamental restriction, since DD do not impose it on their government deposit insurance plan. This is the interpretation we have applied above.

In his 1988 paper, "Another Attempt to Explain an Illiquid Banking System: The Diamond and Dybvig Model with Sequential Service Taken Seriously," Neil Wallace adopts the alternative interpretation and instead investigates what would happen if the "sequential service" constraint were "taken seriously"—that is, applied equally to the government and to the banks.[8]

The relevance of Wallace's analysis to the DD model is unfortunately obscured by his having couched it in terms of a "camping trip economy" in which the issue at hand is late-night snacks rather than bank deposits. Nevertheless, it can readily be translated back into the bank deposit framework of DD by assuming that during a unit time interval contained within period 1, agents successively learn that they are type 1 at a randomly determined rate. If at the end of the unit time interval, they have not learned they are type 1, then they know that they are type 2. The sequential servicing constraint can be made into a fundamental restriction on this economy, by assuming that if and when they discover that they are type 1, they must consume immediately or not at all. For example, the news may be that they will die in the immediate future, before the end of the unit time interval but before all the eventual type 1 agents have received this news. In this world, it is true that our contingent bonus contract would not work, nor, as Wallace was the first to point out, would the DD tax-backed government deposit insurance system. Government deposit insurance therefore does not improve on the best allocation the market can provide under *either* interpretation of the DD model.

Wallace ([1988], pp. 13–15) goes on to demonstrate that in such a world, the optimal period 1 consumption of type 1 agents would be different, depending on the agent's position in line. This is contrary to the claim of DD that the optimal consumption of type 1 agents must be equal across type 1 agents (p. 412). Wallace's position is correct for the sequential consumption economy just described, however, since in it, different type 1 agents really are in a different position regarding the rest of the economy. Generally speaking, successive type 1 agents should receive returns $r_1(\zeta)$, which will optimally be a declining function of the fraction ζ of depositors who have to date learned that they are type 1, since $dE(t \mid \zeta)/d\zeta > 0$. Banks may implement these returns without giving type 2 agents any incentive to withdraw early by substituting the observable fraction of depositors who have withdrawn to date for ζ. The DD proposition that type 1 agents should receive equal returns is correct only in a world in which type 1 sequential consumption is not a fundamental property of the economy.

Unfortunately, the structure of Wallace's analysis is further obscured by his having imposed the sequential service requirement through his unnecessarily strong assumption 7, that "during period 1, people are isolated from one another, although each contacts a central location at some instant during the period." This assumption kills two birds for him with one stone, in that it simultaneously imposes a real need for sequential service and knocks out the period 1 capital market that is required for disintermediation to take place. In doing so, however, it unnecessarily ties two distinct aspects of the problem together as if they were one. In fact, a sequential consumption constraint can be imposed directly on the economy, as above, without assuming that individuals are economically isolated or out of communication in such a way that period 1 capital markets are infeasible.

If a period 1 capital market is technologically feasible and type 1 consumption must be sequential as above, a disintermediation problem will potentially afflict the operation of Wallace's declining return contract. In this case, artificial contractual trading restrictions will still permit the welfare optimum (as constrained by sequential consumption) to be achieved without government deposit insurance or other market intervention.

6. Conclusion

We have shown that the potential market failure Diamond and Dybvig have modeled can easily be rectified without taxpayer-backed government deposit insurance, simply by resolving the inconsistency of their "sequential service constraint" and by employing what we call a "contingent bonus contract." This contract is self-financing and does not require either potential or actual taxpayer assistance. It involves no more stringent timing requirements than does the DD government deposit insurance plan.

We go on to show that the DD government insurance system, as they formulate it, is vulnerable to a disintermediation threat that will destroy the functioning of their plan. In its simplest form, our contingent bonus plan is vulnerable to the same disintermediation threat. However, a further modification of our contract is sufficient to guarantee its success in the world DD have modeled.

Our article may be considered to be an extension and completion of Wallace [1988], who has already shown that when the DD sequential service requirement is instead applied equally to banks and to the government, the DD government deposit insurance plan is unworkable.

Depository institutions serve many important functions not modeled by DD, including clearing of payments, transformation of loan denomination, diversification of default risks, and economization of information.[9] By focusing in this article on the consumption-insurance function DD have postulated, we do not mean to imply that this is an important real-world function of banks, nor do we advocate that banks actually attempt to implement our modified contingent bonus contract. Our purpose is merely to lay to rest the notion that the DD model constitutes a theoretical case, as they put it (DD [1983], p. 413), that "government deposit insurance can improve on the best allocations that private markets provide."[10]

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Notes

1. See, e.g., Buser, Chen, and Kane [1981]; Kane [1989]; Calomiris [1990]; Kane and Yu [1995]; Duan and Yu [1994]; Wheelock and Wilson [1994]. McCulloch [1981, 1985] shows that government deposit insurance may furthermore provide financial intermediaries with macroeconomically undesirable incentives to transform maturities between assets and liabilities, leading to aggregate economic fluctuations.
2. DD actually assume that type 2 agents have utility $\rho u(c_1^2 + c_2^2)$, where c_k^i is period k consumption of type i agents. However, because of the availability of free storage, we may set $c_1^2 = 0$ without any loss of generality. This inconsequential modification greatly simplifies the notation.
3. DD introduce a $\bar{t}$, which represents the greatest possible realization of t, into their definition of $\tau(f)$. We have omitted this $\bar{t}$ here, as it serves no function. There is no reason in their model to bound t below unity, since $c_1^*(1) = 1$.
4. The mutual nature of these banks is explicitly acknowledged by DD ([1983], p. 408).
5. This paragraph is in answer to a specific criticism raised by Philip Dybvig at the St. Louis Federal Reserve Bank Symposium on Deposit Insurance, December 11, 1992.
6. Jacklin [1993] extends his earlier [1987] consideration of the deposit contract to the crucial uncertainty case of the DD model. He proposes what he calls a "market rate deposit," that during period 1 pays a variable dividend d that is a function of the price p of the ex-dividend deposit itself. Since the amount agents are willing to pay for the deposit is a function of d, d and p must be determined simultaneously by the market. Although more cumbersome than our "contingent bonus contract," these "market rate deposits" are an equivalent resolution of the DD optimal risk-sharing problem in the case of a stochastic t.
7. This disintermediation problem has already been noted by Jacklin ([1987], p. 42), in the special case of the DD model in which t is nonstochastic. However, Jacklin does not address the problematic general case of the DD model, treated in the Appendix to the prepublication version of this article, in which t is stochastic and not publicly observable and in which government deposit insurance is alleged to be necessary and sufficient to achieve the optimal outcome. This general case is of critical importance, since it is only in it that the alleged need for government-backed deposit insurance arises. See also the related model of Haubrich and King [1990].
8. Wallace does touch on the possibility of simply discarding the DD sequential service requirement in the second paragraph of his conclusion but dismisses the possibility as "inconsistent with participation in an illiquid banking system."
9. McCulloch [1986, 1987, 1993] investigates how depository institutions could satisfactorily serve these more important functions without the assistance of taxpayer-backed government deposit insurance. Jacklin [1993] stresses informational asymmetries.
10. The overlapping generations extension of the DD model by Qi [1994] goes beyond the scope of this article.

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