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Aspects of Monetary and Banking Theory and Moral Hazard

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I. Introduction

WE CONSIDER TWO problems in monetary and banking theory in this paper. The first of these deals with differences between monetary and tax-transfer resolutions of risk-sharing problems in overlapping-generations [12, 15] models of fiat money under uncertainty.

Our second contribution—the scenario for which is also motivated in part by interventions needed for risk-sharing reasons—is an attempt to provide a rationale for interest-rate controls on the liabilities of intermediaries that invest in risky assets. Both models consider environments in which uncertainty exists, private markets are incomplete, and most importantly, some material payoff-relevant actions are not (perfectly) observable. The goal of this research is to provide further momentum to theoretical developments that serve to integrate information-based models of investment and intermediation with theories of unbacked fiat money, and the control of "monetary" institutions.

In recent years, there has been a great deal of research interest in explicating the micro-economic foundations of fiat money (i.e., valued government-created assets which are unbacked by payoffs from productive investments or taxes), and the uniqueness and criteria for regulation of depository intermediary firms. Important contributions have been (among others) the works of Bryant [3], (the papers in) Kareken and Wallace [7], Fama [6], Merton [10], and Diamond and Dybvig [5]. Asymmetric-information based foundations of intermediary functioning have been provided by the papers of Leland and Pyle [9], followed by Diamond [4]. In most of this work, there has usually been a dichotomy between models that focus on providing and analyzing a role for fiat money, and those which analyze the rationale, regulation, and pricing of capital market intermediaries and their contracts. Regrettably, we persist in having this dichotomy in our work. Some recent work, like Fama [6], does merge these two aspects, however, by emphasizing perfect-information complete-market environments in which the financial structure irrelevance theorems of Modigliani and Miller [10] apply.

Models of unbacked fiat money, many different types of which are to be found in Kareken and Wallace [7], can be usefully dichotomized as being of two types. In the first, fiat money serves the function of opening up or expanding trading opportunities among contemporaneously living agents, who have endowment

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patterns that are tilted towards particular commodities and/or time points, and who face imperfect borrowing-lending markets. For example, Townsend [14] considers models in which "spatially separated" agents do not meet frequently enough to trade IOUs. In many of these models, a given positive nominal stock of fiat money, transfers of which are used for trading goods, has constant real value over time in equilibrium, thus providing no real rate of return. This results in utility-maximizing agents with positive time-preference being at *corner solutions* of zero money holdings in periods in which they are effectively "borrowing" by running down money balances. It is possible then to make a case for Pareto-improving subsidization of money holdings by taxation, of a lump sum or even distortionary variety. It is easy to show that these conclusions extend to models in which borrowing-lending contracts have an irreducible level of default risk owing to imperfect monitoring of available endowment/income of borrowers.

A second class of fiat money models, originating in the classic paper of Samuelson [12], has considered fiat money in an environment in which capital markets are incomplete across succeeding generations of finite-lived individuals. Acquiring and disposing of fiat money at different stages of the life cycle allows agents to align their consumption over time in patterns that are different from their endowment patterns. Without uncertainty, and with homogeneous agents within each generation, it is possible to have a stationary, Pareto-optimal fiat money equilibrium in which a constant nominal stock of fiat money has a real value that increases at the growth rate of population across generations.[1]

With market incompleteness of *this* type, it is possible to consider the ever-living institution of the state (which creates and controls the stock of fiat money), that also has the ability to levy taxes and transfers across agents. If there is uncertainty, in endowments or in payoffs from an irreducibly risky physical investment opportunity that agents have access to, these taxes and transfers serve, in part, the function of risk-sharing across agents of adjacent generations. Private capital markets may be unable to provide such risk-sharing, because agents of the succeeding generation are not around when the current generation makes its investment decision. However, fiat money, coupled with an interventionist monetary policy that alters the stock of money and thus the price level in response to realized payoffs from risky investments, is also capable of achieving such risk-sharing. Weiss [16] has considered such a monetary mechanism.

In Section II, we analyze the differences between tax-transfer and monetary resolutions of the intergenerational risk-sharing problem, and identify a key advantage that the monetary resolution has in a scenario where investment and "productive ability" are imperfectly observable. We also consider the comparison with a perfect-information environment. It is to be hoped that further develop-

[1] Tobin [13] and Weiss [16] have shown that if money holdings provide a "non-pecuniary return" over and above their "store of value" payoffs then, with certainty but with physical investment feasible, there can be a rationale for *taxing* the rate of return to money to provide incentives for capital investment. In essence, with this non-pecuniary return to money (usually captured through a differentiable "proxy" utility), capital investment is stopped *before* the intertemporally efficient point where marginal return to capital equals the growth rate of population. It is not clear if this overcomes the reverse effect obtained from an *explicit* modeling of the transactions role of money, along the lines of Townsend [14], for example.

ment and integration of these ideas in the context of explicit models of intermediaries within intra-generational capital markets, will enable us to distinguish the welfare properties of differing modes of regulation and insurance.

In Section III, we take up a partial equilibrium model of intermediaries which is motivated by the recent work of Merton [10]. We analyze the choice (unobservable to outsiders) among risky assets by levered shareholders of intermediaries, in a multi-period model in which differences between lending and borrowing rates serve important incentive-creating functions. We show that in an environment with deposit insurance provided by the state—"justified" by considerations of the kinds emphasized by Leland and Pyle [9], or Diamond and Dybvig [4]—interest rate and entry controls should be a concomitant part of optimal regulation, in order to create desirable incentives for asset choice that maximizes the overall returns to depositors and owners of intermediaries. Such choices may not come about when asset choices are made in the ex post (given contracts) interests of equityholders.

Even in the absence of deposit insurance, when deposit liability holders have to consider default risk in evaluating their payoff, we show that, for an important class of choice sets, it may be the case that equilibria in which lending and borrowing rates of intermediaries diverge sufficiently to create desirable incentives, may not exist. Our work here is also related to the contributions of Klein and Leffler [8], on the role of price-cost margins in providing incentives to maintain product quality.

II. Risk-Sharing, Incentives, and Money in Overlapping-Generations Models

We shall first analyze optimal allocations in a single-commodity overlapping-generations model with the following characteristics. Each generation has the same finite, but large, number of price-taking agents with identical (within and across generations) lives of two periods, endowment pattern (1, 0) across periods. In addition, agents of each generation have access to a stochastic constant-returns-to-scale investment technology which, with (non-durable) investment of K, provides payoff next period of $f(K)$, where

$$f(K) = \tilde{\alpha} \cdot K \tag{1}$$

where α is an intertemporally *i.i.d.* random variable with bounded support, the same across members of a given generation. Besides physical capital, agents can also invest their first-period wealth in fiat money balances, for which the rate of return is endogenously determined in equilibrium. All agents have identical utility functions for consumption (C_1, C_2) in their first and second periods, given by

$$V(C_1, C_2) = U(C_1) + \beta U(C_2)$$
$$\beta < 1,\ \mathrm{Lim}_{C\to 0}\ U' = \infty,\ \mathrm{Lim}_{C\to\infty}\ U' = 0,\ U'' < 0 \tag{2}$$

Throughout, primes denote derivatives. Agents maximize expected utility, e.g., without taxation they choose K and M, real money balances, to maximize

$$\mathrm{Max}_{K,M}\ U(1 - K - M) + \beta E[U(\tilde{\alpha}K + \tilde{Z}M)] \tag{3}$$

where $\tilde{Z}$ is the rate of return on money balances, determined in equilibrium. Needless to say, agents replace previous generations forever.

Consider a monetary equilibrium in this economy which results from the existence of a fixed nominal stock of fiat money—created by the state at some past time. It is clear that an equilibrium is one in which the real (goods) value of such money is constant over time. The reason is that the young of each generation, facing identical endowment and investment opportunities (in capital and money, under the maintained hypothesis) will want to hold the same volume of "real balances," which becomes a riskless (but not intergenerationally risk-sharing) asset in this economy. In such an equilibrium, each generation bears the risk of its stochastic $\tilde{\alpha}$ completely by itself.

Consider now the optimal allocation problem faced by a central planner in this economy, who can control *both* consumption and capital investment. From the results for a similar environment of Brock and Mirman [2] on the sufficiency of aggregate endowment as the state variable, we know that its problem can be expressed as choosing $C(W)$, $K(W)$ where:

$$C(W) = \text{consumption of the current old}$$

$$K(W) = \text{physical investment} \tag{4a}$$

$$W - C(W) - K(W) = \text{consumption of the current young as a function of } W \tag{4b}$$

$$W = \text{Aggregate endowment per young-old pair} \tag{4c}$$

(4d)

to maximize

$$J(W) = \textstyle\sum_{i=1}^{\infty} \{\rho^{i-1} E_{\alpha i} V_i\} \tag{5}$$

where $E_{\alpha i}$ is the expectations operator over the i-th generation's $\tilde{\alpha}i$, V_i is the utility of the i-th generation, given by

$$V_i = U(C_{1i}) + \beta U(C_{2i})$$

and $\rho < 1$ is the central planner's intergenerational discount rate.

By the principle of optimality, we obtain the Bellman equation

$$J(W) = \text{Max}_{C(W),K(W)} \{\beta U(C(W)) + \rho U(W - C(W) - K(W)) + \rho E_\alpha J(1 + \alpha K(W))\} \tag{6}$$

Given our assumptions, existence of an optimal program and a bounded value function is guaranteed for $\rho < 1$. The limiting solution as $\rho \to 1$, "maximizes the expected utility of the representative generation."

By taking first-order conditions with respect to $C(\cdot)$ and $K(\cdot)$ in equation (6), and then totally differentiating (6) to substitute for J' $(1 + \alpha K(W))$, we obtain easily that the optimal decision rules and value function must satisfy the differential equations.

$$U'(W - C^*(W) - K^*(W)) = E_\alpha \beta\alpha U'(C^*(1 + \alpha K^*(W))) \tag{7}$$

$$\beta U'(C^*(W)) = \rho U'(W - C^*(W) - K^*(W)) = J'(W) \tag{8}$$

where asterisks denote optimal investment and sharing rules.

If the central planner can not control investment decisions, but he can have tax/transfer rules, and he chooses

$$C^{+}(1 + \alpha K(W)) = \alpha K(W) + [C^{*}(1 + \alpha K^{*}(W)) - \alpha K^{*}(W)] \tag{9a}$$

by providing a (stochastic) transfer to the old of $[C^{*}(1 + \alpha K^{*}(W)) - \alpha K^{*}(W)]$, then it is easily verified that if young agents choose investment $K(W)$ to maximize

$$\text{Max}_{K(W)}\, E_{\alpha}[U(W - C^{*}(W) - K(W)) + \beta U(C^{+}(1 + \alpha K(W)))] \tag{9b}$$

they will set the *maximizer* $K^{+}(W)$ to equal $K^{*}(W)$. (Thus, the objective function in (9b), in its *first*-period consumption as well as second-period, is consistent with (9a)). Hence, decentralized implementation of the central planner's desired allocation will be possible. However, note that to implement the tax/transfer rule embodied in equation (9a), the central planner needs to know (ex post) the realized value of α *per se*—to compute $\alpha K^{*}(W)$—and not just $\alpha K(W)$, the gross payoff to investment.

Consider now a classic moral hazard situation in which the central planner only observes the payoff $[\alpha K(W)]$ for each agent, but not α or $K(W)$ separately.[2] An intelligent central planner will realize that if he made the allocation rule for each agent

$$C^{+}(1 + \alpha K(W)) = C^{*}(1 + \alpha K(W)) \tag{10}$$

by providing a transfer to the old of $[C^{*}(1 + \alpha K(W)) - \alpha K(W)]$—that is, make an old agent's reward the first-best optimal function of *his* investment payoff—then the agent maximizing as in (9b) will *not* set $K^{+}(W) = K^{*}(W)$. Instead, the agent will invest less since the marginal payoff from increased investment will be privately perceived to be $\left[\alpha \dfrac{dC^{*}}{d(\alpha K)} < \alpha\right]$ for each realization of α, and *not* the full social marginal product α embodied in the first-best investment rule, equation (7).

The central planner, recognizing this inefficiency to be of the moral hazard type, will try to take account of the fact that *others'* productivities also provide information about an agent's α. Suppose he proposed to follow the tax/transfer rule of equation (9a), with the modification that $\alpha K^{*}(W)$ is now *not* the (unobservable) payoff from optimal investment, but the economy-wide average payoff for agents of the same generation. A first-best efficient equilibrium arises when agents are small, and feel they *can not influence this average*. As can be readily gleaned from maximization of (9b) subject to (9a), $K^{+}(W) = K^{*}(W)$ will result. The same equilibrium is also a Nash equilibrium when an agent's reward is based on (9a), with $\alpha K^{*}(W)$ being the average of *others*' payoffs.

Suppose, however, that agents differ in "productive capacity." To keep things simple, assume that agents invest and obtain payoffs in aggregates of *firms of different sizes*, and the central planner does not know how many agents constitute each firm. As a result, in his tax/transfer rules, he has no means of taking account of size differences, which first-best efficiency would require, without using the ex-post productivity of each firm as an argument in his tax/transfer function.

[2] This is tantamount to assuming that allocations of income are less monitorable than income itself. Alternatively, one might envisage an "effort" dimension to investment.

However, as we noted before in discussing the naive transfer rule (10), doing so results in agents not perceiving privately the full incremental benefits from marginal investment, and therefore it leads to underinvestment.

Active monetary policy constitutes an alternative way to handle this problem. Under such a policy, there is a monetary equilibrium, with the money supply characteristic that injection of new money by the center to the new generation of young is dependent upon the aggregate/average payoff from investment of agents in the previous generation, i.e., on W. Such a monetary policy generates a fulfilled-expectations random price path for money that results in a return pattern that agents can use to "hedge" the risks of capital investment. Firms which are made up of larger numbers of agents simply hedge by holding proportionately higher money balances in the first period.

As long as each agent/firm is small, and treats the generation-wide average payoff from investment to be unaffected by its action, full marginal benefits from investment are perceived to accrue privately.

In this section, we formalize this monetary policy idea. In the Appendix, we have provided an example which shows that, even though full marginal benefits from investment are "preserved" for private gain, the first-best efficient allocation attainable with lump-sum tax/transfer rules—equation (9a)—is *not* attainable as a monetary equilibrium.[3] We restrict our attention to cases in which the first-best optimal allocation rule has the feature that

$$C^*(W) > W - 1, \tag{11}$$

i.e., the old always get a net positive transfer from the young in their second period, so that the limitations of monetary intervention are less than obvious.[4]

We shall illustrate the idea of activist monetary policy by considering the hypothetical case which would generate the first-best efficient allocation of equations (7) and (8). Define the functions

$$M_0(W) \equiv C^*(W) - (W - 1) \tag{12a}$$

an arbitrary non-negative valued function $M_y(W)$, and a random (α-measurable) "rate of return" function

$$Z(W) \equiv \frac{C^*(1 + \alpha K^*(W)) - \alpha K^*(W)}{M_y(W) + M_0(W)} \tag{12b}$$

and

$$M^*(W) \equiv M_0(W) + M_y(W). \tag{12c}$$

The interpretation is that $M_0(W)$ is the *terminal* real value of money balances held by the current old when per-capita endowment is W, $M_y(W)$ is the real value of new money injected by the state to the young, and $M^*(W)$ is the total

[3] The basic intuition behind this is that monetary intervention results in agents taking privately optimal decisions on *two* markets, on both money balances and physical investment, whereas only the latter is (efficiently) privately chosen with lump-sum tax/transfers.

[4] One way to guarantee (11) would be to change the specification of technology, equation (1), to a decreasing-returns one, e.g., $f(K) = \alpha g(K)$, $g' > 0$, $g'' < 0$, and assume that the upper bound of the support of f' falls below one sufficiently fast, e.g., before $K = ½$ in the case with $\beta \rightarrow 1$, $\rho \rightarrow 1$.

real value of money balances (voluntarily) held by the young in their portfolios. Then the existence of a monetary policy that attains a particular first-best efficient allocation $\{C^*(W), K^*(W)\}$ implies the existence of a function $M_y(W)$ such that, for all W attainable given optimal investment $K^*(W)$,

$$\{K^*(W), M^*(W)\} \in \text{ArgMax}_{K,M} U(1 + M_y(W) - M - K) + \beta E_\alpha U(Z(W)M + \alpha K) \qquad (13)$$

The idea is that the central planner would inject new nominal money transfers, in the proportion $\frac{M_y(W)}{M_0(W)}$ to existing balances, to the new-born young, in order to sustain such an efficient monetary equilibrium.[5] Notice that, in the maximization problem (13), the young agent is assumed to be a "distribution-taker" with respect to $Z(W)$. This is equivalent to his taking the average investment payoff of *his* generation, and the consequent money transfers to the *next* generation, to be unaffected by his actions. As a result, the first-order condition in (13) with respect to K will embody the full marginal productivity of investment α. In this sense, monetary intervention preserves full incentives for (unobservable) capital investment, *despite* the heterogeneity of agent/firm sizes.

Although the existence of an $M_y(W)$ function satisfying (13) can be disproved in general (see the Appendix), despite the preservation of private benefits from investment, this feature should imply that the central planner empowered with such monetary tools should be (often) able to attain a Pareto-superior allocation, to that obtainable by one who is constrained to follow the "naive" rule of equation (10), or even the second-best optimal (distortionary) tax/transfer rule. However, showing this would involve difficult comparisons across two second-best equilibria, which themselves are optimal over tax/transfer and monetary interventions.

It is useful, before going on to considerations of intermediation and interest rate controls in Section III, to point out some differences between our work and some other recent models of overlapping generations under uncertainty. We differ with Weiss [16] in considering both tax/transfer and monetary resolutions of risk-sharing problems, emphasizing their difference, and in *not* having a non-pecuniary payoff to money balances. Weiss [16] also has each generation knowing its α *before* investing, unlike here. Weiss's assumption makes the real value of a given nominal money balance stochastic over time. Similar stochasticity of real balances can be had by appending markets for borrowing and lending within each generation, and letting the ratio of lenders and borrowers be stochastic; Sargent and Wallace have considered this in some preliminary work. It has been difficult, in general, to obtain clear Pareto rankings of welfare across alternative intervention policies, which leads us to suspect that difficult second-best analyses might be necessary quite generally.

III. Intermediaries, Deposit Insurance, and Interest Rate Controls

One part of the package of regulations on intermediary firms that has come under increasing criticism and revision, is Regulation Q interest rate ceilings on their

[5] The necessity of (13) holding for monetary policy to achieve this goal is clear; we have *not* shown sufficiency (since we can generate counter-examples to (13) holding).

liabilities. Much of the opposition to them has arisen from inflexible (at least in the short-run) *nominal* interest rate controls resulting, in a decade of high and varying inflation, in periods of "disintermediation" from particular classes of financial intermediaries, causing short-run funds availability problems to real sectors (like housing) that these intermediaries were geared up to serve. Of course, other components of regulations, like non-interest-bearing required reserves, controls on asset portfolios, entry controls, and deposit insurance without adequate response of premia to asset risk, have also been criticized.

One old-fashioned "justification" for interest rate controls has been that, in their absence, unfettered competition for deposits would lead intermediaries to invest in riskier assets in order to pay the charges on deposits. Implicit in this argument has been the presumption that, perhaps for reasons having to do with their "suitability" as transactions/money balances, risky bank asset portfolios, resulting in risky deposits in the absence of insurance, are inherently undesirable. However, in the presence of deposit insurance, it has not been clear why intermediaries investing in risky assets is inherently bad. And while models of bank "runs" have been built (e.g., Diamond and Dybvig [5], Bryant [2]) in which illiquidity of longer-term investments makes mass withdrawals costly for everyone, the role of asset risk in precipitating runs has not been clearly explicated.

We take a simpler view of the choice of asset risk by intermediary firms here and show that, when the choice of risk-levels is *unobservable* then, with deposit insurance and in some cases without it, interest rate and entry controls serve to generate efficient choice of risk levels. (For example, with risk-neutral preferences, any sacrifice of attainable higher mean asset payoffs constitutes inefficient choice.) The key additional ingredients of our story are (a) decision making by levered equity-holders in intermediaries, and (b) multi-period decision horizon, which make differences between lending and borrowing rates for intermediaries conducive to controlling risk, i.e., to equityholders being interested in more than just the upper tail of the distribution of asset payoffs. In its spirit, our model is closely related to the work of Merton [10]. However, we differ in that we close the model with an endogenous rather than exogenous choice of risk levels, and consider questions regarding the choice of interest rates paid to depositors. We also eschew diffusion-process modeling with continuously observable valuation, because of the difficulties of modeling unobservable asset choices in that framework.

Before proceeding to the model, the two underlying assumptions of (a) levered intermediary payoff structures, and (b) deposit insurance, need to be explicated. The "classical" model of intermediaries existing to save on (duplicated) transactions/monitoring costs in asset choice does not explain why their liability structure should not be all-equity. However, two modern approaches suggest that the essence of intermediary functioning may also involve making commitments regarding payoffs to some groups of liability holders.

The first of these is the asymmetric information story of Leland and Pyle [9] and Diamond [4], which suggest that intermediaries save not only on duplicated monitoring costs, but also on indirect costs of transmitting information about assets through signals, or investment in costly "proxies" (like insider holdings of undiversified stocks) whose costs are correlated with asset attributes. By diversifying risks across assets, intermediaries are able to provide signals at lower costs. In providing such signaling, the "non-insider" liability holders may inherently end up with debt-type contracts. Alternatively, the process of *direct* collection of (partial) information about assets portfolios, and diversification on the basis of that information, may proceed beyond the boundaries of individual firms. The aggregate entity may be something like an insurer of "deposit liabilities" held by non-insider liability holders of individual intermediary firms, who do not, for reasons connected with transactions/convenience costs, diversify across intermediary firms.

A second line of rationalization for fixed payoff commitments and deposit insurance is contained in the recent work of Diamond and Dybvig [5]. In their work, fixed payout commitments by firms which aggregate assets diversify (potentially perfectly) the risk of losses through early liquidation of illiquid assets, due to changes in consumption preferences, across agents. Deposit insurance serves to protect agents from bank runs. In their model, insurance is backed by governmental taxation powers.

We consider below a simple asset choice problem of the levered shareholders of an intermediary whose depositors are protected by deposit insurance, so that only the promised interest rate d is of concern to them. Each unit of deposits can be invested in only one among a set of constant-returns-to scale investment opportunities with different payoff distributions. For simplicity, we shall assume zero *infusion* of initial funds by shareholders, but our qualitative results are not affected by requiring deposit inflows to be matched by equity inflows. The intermediary firm does business over three periods (time-points), $t = 0$, $t = 1$, $t = 2$. Asset attributes, deposit levels, and interest rates, are chosen irrevocably at $t = 0$. Cash flow outcomes are observed at $t = 1$ and, based on their adequacy relative to deposit liability commitments, the intermediary is allowed to continue, or is liquidated by merger. We take the asset payoff distributions to be exogenously given. In practice, asset markets for intermediaries often involve loans rather than technological opportunities. In that simplification, as well as those of not endogenizing overall levels of deposit inflow, number of intermediaries etc., our model is very much in the partial equilibrium "tradition." Informally, however, this endogeneity is considered.

Consider an intermediary that invests in assets which have *two* random payoffs, $\tilde{X}_1$ and $\tilde{X}_2$. $E(\tilde{X}_2|X_1)$ is common knowledge.[6] The intermediary has deposits of amount I, on which it pays a promised interest rate d. Other intermediaries have (at the margin) access to investment opportunities at the rate $r \geq d$, to which depositors do *not* have access. The deposits are insured by a government agency which has knowledge of the *set* of probability distribution of payoffs $\{F(X)\}$'s available to the intermediary. If, on realization of X_1,

$$X_1 + \frac{E(\tilde{X}_2|X_1)}{(1 + r)} < I(1 + d)$$

the insurer forces liquidation (merger) of this intermediary's assets to (with) another. For simplicity, we assume zero liquidation/bankruptcy costs, although

[6] $E(*|\cdot)$ is the conditional expectations operator.

these may be there and serve to support (partial) signaling mechanisms. If liquidation/merger does not happen, the intermediary pays $\frac{I(1+d)}{2}$ to depositors this period, and $\frac{I(1+d)^2}{2}$ next period (to make the discounted value at rate d equal I). In case of liquidation, depositors get $I(1+d)$ at $t=1$. We assume, for simplicity, that

$$\tilde{X}_2 | X_1 = X_1(1+r)$$

with probability 1, so that, conditional on liquidation in the first period, there is no default risk in the second period. Henceforth, we denote $\tilde{X}_1$ as X.

We assume the distribution of X, $F(X)$, has bounded support $[0, \bar{X}]$. Then the discounted expected profit for the shareholders of the intermediary is given by

$$\pi = \int_Z^{\bar{X}} \left[\frac{1}{(1+r)}(X-Z) + \frac{1}{(1+r)^2}(X(1+r) - Z(1+d)) \right] f(X)dX \tag{14a}$$

where

$$Z \equiv \frac{I(1+d)}{2} \tag{14b}$$

and $f(X)$ is the strictly positive density function of $F(X)$. We can simplify this to

$$\begin{aligned} \pi &= \frac{1}{(1+r)} \int_Z^{\bar{X}} \left[2(X-Z) + \frac{Z(r-d)}{(1+r)} \right] f(X)dX \\ &= \frac{1}{(1+r)} \left[2(\bar{X}-Z) - 2\int_Z^{\bar{X}} F(X)dX + \frac{Z(r-d)}{(1+r)}(1-F(Z)) \right] \end{aligned} \tag{15}$$

Consider now the intermediary's choice of $F(X)$ among members of a "family" of distributions. Investigation of equation (15) easily reveals that if these distributions are ordered by first-order stochastic dominance, the intermediary is necessarily motivated to select the efficient (expected payoff maximizing) distribution. However, in the case of mean-preserving single-crossing distributions, ordered by riskiness in the Rothschild-Stiglitz sense, if $r = d$, then the intermediary is motivated to take the riskiest asset with the lowest $[\int_Z^{\bar{X}} F(X)dX]$. However, if $r > d$, and Z is below the "crossing point" of this family of distributions, then the ordering across distributions of $(-\int_Z^{\bar{X}} F(X)dX)$ and $(1 - F(Z))$ are the reverse of each other, and if $(r - d)$ is sufficiently large, the intermediary will be induced to choose the least risky distribution. By continuity, it follows that even if the riskiest distribution had a slightly lower mean (e.g., change the support to $([-\epsilon, \bar{X} - \epsilon])$, with $r = d$ the intermediary would prefer it, but with r sufficiently higher than d, it will prefer the least risky distribution. It is clear that this type of switching is possible with any single-crossing "family" of distributions.

What about the insuring agency's actions? The insuring agency may *anticipate* the choice of risk, and it may charge the intermediary an "actuarially fair" ex ante premium which reflects the discounted expected value

$$\frac{1}{(1+r)}\int_0^Z [I(1+d) - 2X]f(X)dX$$

of its payouts to depositors, for the anticipated choice of $F(X)$, but since it can not monitor the choice of "riskiness," it can not make its premium contingent on choice of risk.

Let d^* be the highest deposit interest rate that is consistent, given r, with efficient (maximizing expected payoff) asset choice by intermediaries. The discrepancy between d^* and r serves the same function for preserving asset "quality," as the premium of price over cost in the model of Klein and Leffler [8]. However, insured depositors are strictly better off with a higher d. Thus, if individual intermediaries are small, and they perceive a very high elasticity of increases in deposit volume to increases in d then, since $d < r$, they have an incentive to raise d beyond d^*, to increase expected profits to equity. Thus, an equilibrium in which expected payoff maximizing assets are chosen can not be sustained.

On the other hand, if depositors payoffs are not fully protected by deposit insurance, they too care about the level of asset risk chosen. Suppose the set of asset payoff distributions over $[0, \bar{X}]$ is ordered by second-order stochastic dominance, with a one-to-one mapping from mean M to distribution function $F(\cdot)$ which is continuous in the sup norm. Then, depositors' discounted expected payoff P is a continuous function of d and M, strictly increasing in d, and decreasing in M. M itself is chosen by equityholders in response to d. We thus have the (right) derivative,

$$\frac{DP(M,d)}{Dd} = \frac{\partial P}{\partial d} + \frac{\partial P}{\partial M}\frac{DM}{Dd} \tag{16}$$

The first term on the right hand side of (16) is strictly positive as long as bankruptcy is not an event of probability 1. *If* the equityholders' choice function $M(d)$ is continuously differentiable in d at d^*, the highest d consistent with the choice of the *highest* M, then the second term in (16) is zero, and *locally* $P(M, d)$ is strictly increasing in d. Thus, if the intermediary perceives a sufficiently high response of deposit volume to a rise in d, d^* is not sustainable in equilibrium.[7]

The message of the above analysis is clearcut. If efficient asset choice is all-important, interest rate controls should restrict d to lie below d^*. (A cost of this

[7] Such differentiability may *not* obtain for distributional choice sets. For example, for the *mean-preserving* "family,"

$$F(X) = X - \gamma \sin(2\pi X),\ X\epsilon[0, 1],\ 0 \le \gamma \le \frac{1}{2\pi},$$

the choice of γ, by maximizing in (15), is not continuous in d. This is related to existence issues discussed in Bhattacharya [1]. Even without this differentiability, however, it may be that d^* lies strictly below $d_{\max}$, the highest d below which the total response of P to d rising is positive. Again d^* will not be sustainable if intermediaries perceive a high enough elasticity of response of deposit volume to an increase in d.

intervention is, of course, the effect on volume of savings.) Furthermore, entry controls are also necessary. While we have taken r to be exogenous, in reality it too is determined by competition in loan markets, and the $(r - d)$ differential can be lowered in that way, thus destroying incentives for efficient asset choice. Judicious entry controls would need to consider the nature of competition, and the level of entry that would be consistent with preserving the desired $(r - d)$ differential. Resulting deadweight losses in savings and investment decisions will also need to be traded off. Auctioning the profitable bank charters should help provide funds for further study of these issues.

APPENDIX

In this section, we provide a counterexample regarding the existence of an $M_y(W)$ function that is consistent with the restrictions of equations (12) and (13), and hence illustrate non-existence of a monetary policy that is capable of attaining the first-best optimal allocation. Denoting the first and second terms on the right hand side of equation (13) by U_1 and U_2, and taking first order conditions w.r.t. K and M we obtain that

$$U_1' = E_\alpha \beta \alpha U_2' \tag{A1}$$

$$U_1' = E_\alpha \beta Z U_2' \tag{A2}$$

must be satisfied, at values of arguments $(W - C^*(W) - K^*(W))$ for U_1' and $C^*(1 + \alpha K^*(W))$ for U_2'.

Suppose we can show that for the random variable

$$Z^\circ(W) \equiv \frac{C^*(1 + \alpha K^*(W)) - \alpha K^*(W)}{C^*(W) - (W - 1)} \tag{A3}$$

that

$$E_\alpha \beta Z^\circ U_2' - U_1' \geqslant 0 \tag{A4}$$

with the marginal utilities evaluated at the same values of arguments as before, i.e., at the first-best allocation. This is clearly necessary for there to be a positive $M_y(W)$ which makes (A1) and (A2) hold. We exhibit a case in which (A4) is violated. Note that we are *not* comparing across alternative monetary equilibria, and that a $M_y(W)$ which is zero everywhere can not attain the first-best, as discussed in Section II above.

Assume U to be logarithmic $U(C) = \log C$, and denote (random) $W_f \equiv (1 + \alpha K^*(W))$, so that we have

$$Z^\circ_\alpha(W) = \frac{C^*(W_f) - \alpha K^*(W)}{C^*(W) - (W - 1)} \tag{A7}$$

$$U_1' = \frac{1}{(W - K^*(W) - C^*(W))} \tag{A8}$$

$$U_2' = \frac{1}{C^*(W_f)} \tag{A9}$$

and the optimality condition for $K^*(W)$, equation (7), gives

$$\frac{1}{(W - K^*(W) - C^*(w))} = E_\alpha \frac{\beta\alpha}{C^*(W_f)} \tag{A10}$$

Substituting from (A7) – (A9), we note that satisfaction of (A4) requires that

$$E_\alpha \frac{\beta(C^*(W_f) - \alpha K^*(W))}{C^*(W) - (W - 1)} \frac{1}{C^*(W_f)} - \frac{1}{(W - K^*(W) - C^*(W))}$$

$$= \frac{E_\alpha\left(\beta - \dfrac{\beta\alpha K^*(W)}{C^*(W_f)}\right)}{C^*(W) - (W - 1)} - \frac{1}{(W - C^*(W) - K^*(W))} \geq 0$$

Using (A10), this simplifies to the condition that,

$$\frac{\beta - \dfrac{K^*(W)}{(W - C^*(W) - K^*(W))}}{C^*(W) - (W - 1)} \geq \frac{1}{(W - C^*(W) - K^*(W))}$$

Cross-multiplying both sides (by positive quantities), we obtain the condition

$$\beta(\mathrm{W} - \mathrm{C}^*(\mathrm{W}) - \mathrm{K}^*(\mathrm{W})) - \mathrm{K}^*(\mathrm{W}) \geq \mathrm{C}^*(\mathrm{W}) - (\mathrm{W} - 1) \tag{A11}$$

The most favorable lower bound on W is one which would not be violated once the process of investment has been ongoing, i.e.,

$$\underline{W} = 1 + \underline{\alpha} K^*(\underline{W}) \tag{A12}$$

where $\underline{\alpha}$ is the lower bound on the support of $\tilde{\alpha}$, and we assume that $\underline{\alpha} < 1$; this is necessary for interior optimal investment levels as $\rho, \beta \rightarrow 1$

Now, equation (8) implies that

$$\frac{\beta}{\mathrm{C}^*(\mathrm{W})} = \frac{\rho}{(\mathrm{W} - \mathrm{C}^*(\mathrm{W}) - \mathrm{K}^*(\mathrm{W}))} \tag{A13}$$

so that (A13) and (A12) imply that for (A11) to be satisfied, we must have

$$\rho C^*(\underline{W}) - \frac{(\underline{W} - 1)}{\underline{\alpha}} \geq C^*(\underline{W}) - (\underline{W} - 1)$$

which is not possible for $\rho \leq 1$, which we assumed to have the social planner's optimization problem be well-defined and produce interior solutions.

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