Sluggish Deposit Rates: Endogenous Institutions and Aggregate Fluctuations

by Joseph G. Haubrich

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Introduction

The interest rates that banks pay on deposits move more slowly than money-market interest rates, a phenomenon documented in several recent studies (Flannery [1982], Hannan and Berger [1991], and Neumark and Sharpe [1992]). Understanding deposit-rate sluggishness has important direct consequences for comprehending money demand and bank profitability, as well as indirect consequences for understanding almost all industrial pricing.

However, even when this recent work takes an explicitly microeconomic approach, it does not consider market conditions that lead to the existence of banks. It may therefore distort the lessons of sluggishness both for macroeconomics and for industrial structure. This paper approaches the issue in terms of the microfoundations of banking. Although this theory may not be all-inclusive and may work in combination with other effects, ignoring it may mean that previous explanations of interest-rate sluggishness are misleading and that attempts to draw parallels with other industries regarding price rigidities could be biased.

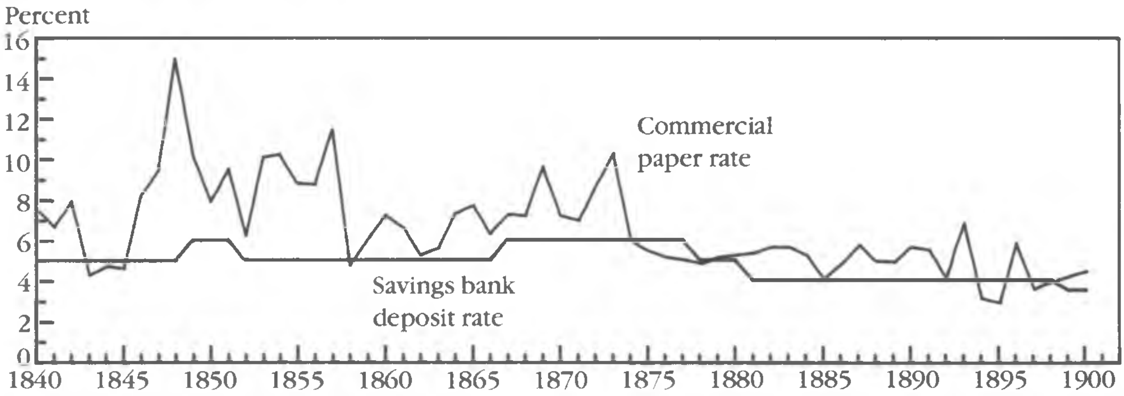
The sluggish adjustment of bank interest rates relative to prevailing market rates, as shown in figures 1 and 2, has puzzled economists since at least the mid-nineteenth century. Figure 1 compares the savings bond deposit rate with the commercial paper rate from 1840 to 1899. Figure 2 compares the same rate paid on savings bank deposits with the interest rate charged on call money from 1857 to 1899. In both cases, the bank rate shows substantially less movement than the market rate.[1] In fact, bank interest rates appear to be even more rigid than predicted by this paper. The stability of nominal rates, even in the face of the inflation of the 1850s and the deflation preceding resumption of the gold standard in 1879, suggests that for some reason, interest rates did not index to the inflation rate or to the money supply.

Many of the price and nonprice constraints producing macroeconomic behavior originate not from an auction market, but from an organization. Banks, labor contracts, and corporations set interest rates, wages, and prices. I contend that such institutions arise to solve problems of risk and private information—precisely those problems associated with a recession, which

■ 1 For evidence on twentieth-century inflexibility, as well as explanations based on exogenously motivated banks, see Flannery (1982), Klein (1972), Weber (1966), and the references cited therein.

FIGURE 1

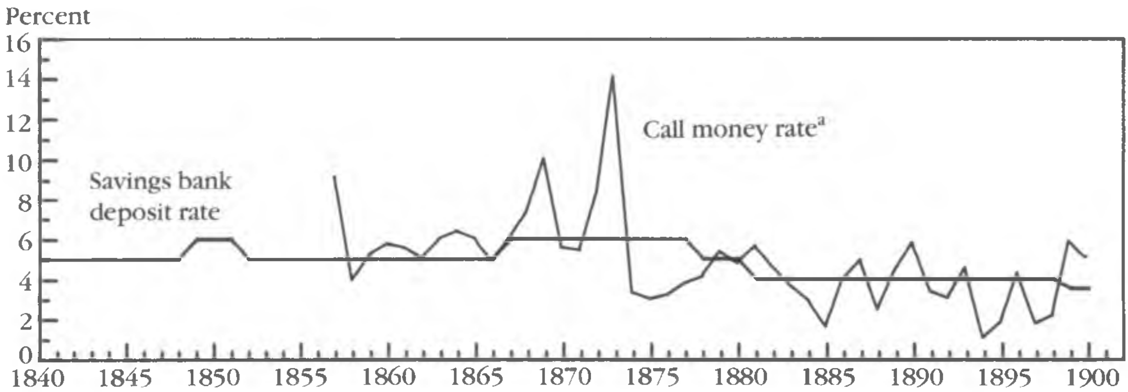
Regular Deposit Rate and Commercial Paper Rate, Yearly Averages



SOURCE: Homer (1977).

FIGURE 2

Regular Deposit Rate and Call Money Rate, Yearly Averages



a. Data were unavailable prior to 1857.
SOURCE: Homer (1977).

changes the uncertainty that is the very basis of the institution. Thus, the equilibrium prices faced by agents adjust in a way that no market could mimic. Individual agents respond to a macroeconomic shock only after it has been filtered through an organization. Derivative markets then react and alter individuals' response to disturbances.

This paper builds on the recent information-based banking models of Diamond and Dybvig (1983), Smith (1984), and Haubrich and King (1990). As in those papers, banks in this model arise endogenously in response to a demand for insurance against private risk. Banks are the optimal contract arising from uncertainty. The macroeconomic approach leads to some modifications, however. These changes should provide a picture of banks that can be more easily and realistically integrated with aggregate fluctuations. Diamond and Dybvig introduce a basic insurance-theoretic banking model in which the bank insures individuals facing a privately observable preference risk: Some individuals die early and therefore need to consume early. Because it is costly to remove goods from storage early, such individuals face a liquidity problem. A deposit bank, by setting proper interest rates, can pool the risk between those who die and those who survive.[2]

The present paper makes several changes in that basic structure. First, the uncertainty generating the bank is somewhat different. The privately observed shock alters endowments, not preferences, which seems to capture more realistically what actually constrains agents' liquidity. It also seems more plausible that these endowment shocks are correlated with aggregate disturbances. Also, the shock is a continuous random variable. The continuum, in combination with the endowment risk, allows use of the optimal taxation literature deriving from Mirrlees (1971) to provide a clearer picture of the insurance role of banks. This in turn sets the stage for the second and main innovation of the paper: the interaction between the aggregate shock and individual uncertainty.

This interaction takes a particular form. Increases in the underlying productivity of the economy, leading to higher market interest rates, induce greater individual uncertainty. This assumption has previously been presented in various forms, but it is by no means obviously true. Analysis along these lines produced the neo-Keynesian concept of autonomous investment, which is investment driven not by demand or savings, but by technological advances and the introduction of new products. It plays a prominent role in the business cycle theories of such diverse authors as Robertson (1915) and Hicks (1950), and also shares the property that low values imply a small, uniform advance while high levels mean a divergence of growth across industries and firms.[3] The assumption also suggests the effects of aggregate disturbances, such as business cycles, on the distribution of income. For example, Dooley and Gottschalk (1984) find the variance of weekly earnings to be negatively correlated with the unemployment rate.[4]

Some macroeconomic work based on contract theory makes similar assumptions. Grossman, Hart, and Maskin (1983) consider shocks that increase the dispersion of the value of marginal product. Haubrich and King (1991) posit a link between the size and dispersion of monetary shocks as an incentive for sticky nominal price contracts.

This paper differs in the sense that it introduces endogenously arising financial institutions as a response to the uncertainty and traces the consequences of those institutions. In section I, the economic environment is specified and the standard representative-agent solution is discussed. The forces motivating the endogenous formation of banks are then presented in section II, under the assumption that there are no aggregate shocks. With that analysis in hand, the mutual interaction of banks, private risks, and aggregate shocks is explored in section III. A final section summarizes and concludes.

I. The Economic Environment

This investigation begins by specifying a hypothetical stochastic economy with three basic elements central to the problem at hand. First, agents face an intertemporal decision problem concerning the correct amounts of storage and consumption. Second, the aggregate opportunities vary in a stochastic fashion; that is, there exist shocks common across all individuals. Third, agents face idiosyncratic, privately observable risks concerning their income (endowment). This paper examines the simplest hypothetical economy that incorporates these features. The economy lasts for three periods, $T = 0, 1, 2$. The two consumption periods allow intertemporal choice, and the stochastic intertemporal terms of trade provide the aggregate disturbance. There is also uncertainty due to environmental randomness in $T = 1$, which is private information.

■ 2 In Diamond and Dybvig (1983), insurance against private preference shocks is complete due to restrictions on preferences. Haubrich and King (1990) analyze a richer environment, in which insurance against privately observable income shocks is desirable. But in the Haubrich–King setup, insurance is incomplete because there is a trade-off between insurance and intertemporal efficiency. Both papers concentrate on the form of the banking contract, not on its interaction with macroeconomic shocks.

■ 3 For applied work justifying the stylized fact of a positive relation between the level of autonomous investment and its dispersion, see the historical section of Schumpeter (1939) or Safarian (1959, chapter 6). For a different view, see Sheffrin (1984).

■ 4 The data show a positive correlation between unemployment and variance of *annual* earnings, however. More generally, income dispersion across agents appears to be positively associated with growth (see Danziger and Gottschalk [1986]). Robinson (1972) also emphasizes the macroeconomic consequences of the increased dispersion of incomes resulting from growth and technological progress.

TABLE 1

The Storage Technology for Three Periods

	$T = 0$	$T = 1$	$T = 2$
Return	–1	1	0
		0	R

SOURCE: Author.

Tastes

Agents are identical, with the following constant elasticity of substitution (CES) utility function:

$$(1) \qquad U = G(u),$$

where $u(c_1, c_2) = (c_1^{\,1-1/\sigma} + \beta c_2^{\,1-1/\sigma})^{\sigma/(\sigma-1)}$ and $G(u) = 1/(1-\gamma)\, u^{1-\gamma}$.

Three important parameters specify preferences: β, the discount factor; σ, the intertemporal elasticity of substitution; and γ, the rate of relative risk aversion toward variation in lifetime wealth. In the economies studied below, agents face uncertainty about lifetime wealth, so that we can meaningfully separate attitudes about risk aversion from those concerning the time pattern of consumption. Once individuals enter period 1, they face neither uncertain income nor risky assets. Thus, agents formulate consumption plans contingent on the level of lifetime wealth. Lifetime utility, but not the consumption strategy, depends on the risk-aversion parameter γ.

Endowments

Each individual has an endowment of a single good in each period. At periods 0 and 2, all agents have identical endowments Φ and y_2. At period 1, each individual receives a *privately observable* income level $y_1(\theta) = \bar{y}_1 + \theta$, where $\bar{y}_1$ is the level of per capita income. Consumers know $\bar{y}_1$ at $T = 0$, and they learn θ at $T = 1$. The idiosyncratic component of income, θ, is continuously distributed on $(\underline{\theta}, \overline{\theta})$ with density function $f(\theta, x)$ having $E(\theta) = 0$ and $E(\theta \mid x) = 0$ (x is an aggregate shock discussed later). I assume a continuum of traders indexed at period 1 by the realized value of θ. Thus, the analysis proceeds as if each value of the distribution is realized (see Judd [1985]).

Intertemporal Technology

Along with preferences and endowments, the actors in the model have a storage technology, that is, an intertemporal production function that rewards long-term storage. Goods stored in $T = 0$ pay no net interest if removed in period 1, but pay a gross return $R > 1$ if left until $T = 2$, as shown in table 1.

This provides a tractable case in which the time paths of investment projects are somewhat irreversible. An alternative motivation is that individuals (banks) cannot costlessly liquidate assets before their maturity. Economywide movements are captured by introducing randomness into the intertemporal technology.

R, the technological rate of return, varies positively with the aggregate shock x. Individuals observe x costlessly and perfectly at $T = 0$, so that they know $R(x)$ from the beginning. Furthermore, the distribution of θ depends on the aggregate shock. A higher value of x induces a mean-preserving spread on the distribution of θ, $f(\theta)$, subjecting agents to more risk. This assumption is designed to capture the view that progress benefits some individuals more than others. Schumpeter (1939) assigns this view a major role:

> Industrial change is never harmonious advance with all elements of the system actually moving, or tending to move, in step. At any given time, some industries move on, others stay behind; and the discrepancies arising from this are an essential element in the situations that develop. (pp. 101–102)

Thus, I separate the effects of an aggregate shock into two components. One is an increase in the productivity of long-term storage, whereby a positive x increases R. The other is an increase in the dispersion of the random variable θ. Following Rothschild and Stiglitz (1970), I let the shift put more weight in the tails of the distribution.[5] These effects cause $f(\theta, x)$ to become riskier (in the sense of a mean-preserving spread) with increases in x and cause $R(x)$ to increase in x. That is, the shock raises market (or technological) interest rates. Conversely, a negative shock decreases R and reduces the dispersion of θ.

This connection between a macroeconomic variable (R) and a microeconomic variable (the

5 As the authors point out, this sort of mean-preserving spread corresponds to natural economic measures of increasing dispersion. Any risk-averse individual will prefer the old distribution, and the new distribution will equal the old distribution plus a noise term.

TABLE 2

Observation of Shocks for Three Periods

$T = 0$	$T = 1$	$T = 2$
x realized $f(\theta, x)$ known	θ realized	$R(x)$ paid off

SOURCE: Author.

individual's endowment risk) is critical in studying the behavior of optimal bank contracts in this economy. Because individuals can observe x at $T = 0$, knowledge of $R(x)$ and $f(\theta, x)$ simplifies the analysis by reducing the problem to comparative statics on the distribution of θ. Additionally, this specification abstracts from the uncertainty about aggregate shocks and instead emphasizes their distributional consequences. I thus concentrate on the *direct* effects of the aggregate shocks, not on uncertainty about them. To recapitulate, then, agents observe x, and thus $f(\theta, x)$ in period 0, and θ obtains in period 1 (see table 2).

As a benchmark for comparison with later results, consider the macroeconomic effects of an aggregate shock in this economy without contracts. The individual uncertainty about the distribution of income has no effect on aggregate variables, so it makes sense to examine only the average individual. The increased dispersion caused by the impulse has no effect on aggregate variables: The per capita change in consumption and savings is the same as if the distribution of income had been entirely ignored.

The simplicity of this macro model underscores a point generic to models of this class; namely, this simple economy can be understood in an aggregate sense by ignoring individual differences and by focusing on the average agent.

II. Economic Institutions and the Exchange of Risk

When facing diversifiable risk, however, agents in this economy will not accept the market structure imposed above. The ability to write contracts at $T = 0$ means that they can improve upon their initial position by creating a richer institutional structure. In the simple world considered here, banks arise endogenously to meet that demand for insurance. The bank is able to pool agents' diversifiable risk by exploiting the production structure of the economy. This section abstracts from aggregate shocks in order to examine the nature of the emergent institutions more clearly.

Demand for Insurance

Whether the market system produces a bank, an insurance company, or a security market depends on the information structure of the economy. If θ were public information, a regular insurance contract with premiums and payoffs could protect people against the diversifiable income risk. The private character of θ gives rise to adverse selection, however, and rules out such insurance. Still, since I assume that individuals may write contracts on any observable quantity, there may be some other way to trade risk.

In one case, individuals might exchange claims on long-term storage maturing in $T = 2$ after receiving their random income. Unfortunately, this ex post security market provides no improvement over autarky. In equilibrium, arbitrage opportunities between production and securities imply that the price of such securities must be one. If a claim on one unit in storage (R tomorrow) sold for more than one, no one would buy it, preferring instead to place one unit in productive storage. If the price were below one, no one would sell (see Diamond and Dybvig [1983] for a more detailed discussion of this point). Selling these bonds is thus equivalent to taking goods out of production. As we have seen, the ability to draw down storage stocks does not eliminate the possibility of low first-period income.[6] There is still room for an institution that can provide insurance and pool risk even if private income shocks are unobservable.

The Organization of Banking

I define a bank as a coalition of individuals, perhaps brought together by an entrepreneur, that receives a deposit Φ in $T = 0$ and pays interest rates r_0 from $T = 0$ to $T = 1$, and r_1 from $T = 1$ to $T = 2$. Agents can withdraw any fraction of the account in any period. A bank is linear if the

6 I assume that Φ is sufficiently large relative to y_1 and y_2 so that market equilibrium takes place "off the corner" at the aggregate level. That is, individuals will want to store some of Φ. Also, Φ is not so large relative to lifetime wealth that agents wish to deposit in $T = 1$.

interest rate paid is independent of the amount in the account. A bank provides agents with a higher level of expected utility than a situation of autarky because the bank partially insures agents against income risk. The provision of insurance is typically incomplete, because the bank faces a trade-off between risk-pooling and the incentives for saving.

Relative to the technological return (or, equivalently, to ex post security markets), banks offer higher short-term yields ($r_0 > 1$) and lower long-term yields ($r_1 < R$). This is how banks provide insurance. To determine the interest rates that actually occur, take the analysis one step further and consider the *optimal linear* bank.[7] This bank sets r_0 and r_1 to maximize the expected utility of agents given the total resources of the bank and the decision rules of the individuals. The analysis closely follows the optimal income taxation investigations of Mirrlees (1971).

An individual must choose consumption and savings withdrawal given the bank's interest rates r_0 (from $T = 0$ to $T = 1$) and r_1 (from $T = 1$ to $T = 2$). If $r_0 > 1$, the problem for a rational individual begins in period 1:

$$(2) \quad \max \; u(c_1, c_2)$$

subject to

$$\text{(i)} \quad y_1(\theta) + w = c_1,$$

$$\text{(ii)} \quad y_2 + r_1(r_0\Phi - w) = c_2.$$

The solution to this problem provides four functions of the income shock and interest rates: an indirect utility function, $v(\theta, r_0, r_1)$; two consumption functions, $c_1^*(\theta, r_0, r_1)$ and $c_2^*(\theta, r_0, r_1)$; and an optimal withdrawal function $w^*(\theta, r_0, r_1)$. With a CES utility function, indirect utility is linear in wealth, $v = \alpha(r_1)\, a(r_0, r_1\theta)$. Since $w^* = c_1^* - y_1(\theta)$, one can straightforwardly show that $\frac{\partial w^*}{\partial r_0} > 0$, $\frac{\partial w^*}{\partial r_1} < 0$, and $\frac{\partial w^*}{\partial \theta} < 0$. Recall the assumption (footnote 6) that the initial endowment is large enough so that the withdrawal will be positive for all θ.

The bank, as a coalition of individuals, wishes to maximize the depositors' expected utility $EG[v(\theta, r_0, r_1)]$ subject to a resource constraint. This constraint, written as equation (3), states that the period 0 present value of assets, Φ, must equal the present value of the liabilities both in period 1, $Ew^*(\theta, r_0, r_1)$, and in period 2, $r_1[r_0\Phi - Ew^*(\theta, r_0, r_1)]$.

$$(3) \quad \Phi = Ew^*(\theta, r_0, r_1) + R^{-1}\{ r_1 [r_0\Phi - Ew^*(\theta, r_0, r_1)]\}.$$

In other words, the bank must be able to cover all withdrawals. Notice that the bank views total withdrawals as certain. Thus, Ew^* involves simply "summing" across all depositors. In addition to the resource constraint (3), the bank is constrained by the individuals' decision rules, such as the withdrawal function, which is a function of bank actions r_0 and r_1 as well as θ.

Banking and Insurance

What are the characteristics of an optimal banking structure? First, consider a small increase in r_0 from its initial position of one and a small decrease in r_1. The bank must respect its budget constraint, that is,

$$(4) \quad 0 = dr_0\,[\Phi - (1/r_1 - 1/R)\, E(\partial c_2^*/\partial r_0)] - dr_1\,\{(y_2 - Ec_2^*) + (1/r_1 - 1/R)\, E[\partial c_2^*/\partial(1/r_1)]\}/r_1^2.$$

When evaluated at $r_1 = R$, expression (4) becomes simply $dr_0\,\Phi = dr_1(y_2 - Ec_2^*)/r_1^*$. Since $Ec_2^* > y_2$, a small increase in r_0 requires a decrease in r_1.

The effects on expected utility can similarly be calculated by differentiation.

$$(5) \quad dU = E(G'\,\partial v/\partial r_0)\, dr_0 + E(G'\,\partial v/\partial r_1)\, dr_1 = E(G'\alpha)\,\Phi\, dr_0 - E\{G'\alpha\,[y_2 - c_2^*(\theta)]\}\, dr_1/r_1.$$

7 Haubrich and King (1990) examine such a bank, but with a nonreversible storage technology. Consideration of linear institutions undoubtedly simplifies the analysis, but more important, it prevents the formation of depositor coalitions that could arbitrage across nonlinearities in the rate structure. In other words, an interest-rate structure that is nonlinear in the size of withdrawals would be subject to raiding by coalitions of depositors at $T = 1$. For example, small depositors might combine funds and act as a syndicate to obtain the better rates received by large depositors. This would change the distribution (especially the expected value) of withdrawals and ruin the bank. A budget just balanced, with some individuals obtaining low interest rates, has no room for everyone to receive high rates. A competitive bank simply could not give everyone a higher interest rate.

Expression (5) indicates that increases in r_0 have an identical wealth effect on all consumers. α is the marginal utility of a unit of period 1 wealth. As discussed above, α is invariant to θ under CES utility. By contrast, the wealth effect of an increase in r_1 is greatest for the largest lenders in period 1, for whom $y_2 < c_2^*(\theta)$. Requiring feasibility of dr_0 and dr_1 and rearranging the resulting expression,

$$(6) \qquad dU = \alpha\, E[G'(c_2^* - Ec_2^*)]\, dr_1 / r_1^2 .$$

With risk aversion, $G'' > 0$, so that the covariance term is unambiguously negative and a small decline in r_1 raises welfare. Intuitively, by raising r_0 and lowering r_1, the bank has shifted wealth from those with high θ's to the average individual. The lucky people with high θ's will attempt to smooth consumption and save the windfall, withdrawing relatively little. The lower r_1 penalizes them. The unlucky people with a low θ withdraw a lot, benefiting from the high r_0. This redistribution provides insurance in T= 0, when θ is unknown. In effect, in period 0, the bank offers an individual a security that 1) has a certain period 1 expected return (Φdr_0), 2) pays negative returns when high θ's occur, and 3) reduces individual risks.

The Optimal Linear Bank

The economic intuition behind these results (small changes in r_0 and r_1 from the initial position $r_0 = 1$ and $r_1 = R$) extends to interpretation of the optimal banking structure. Again, following Mirrlees (1971) and Atkinson and Stiglitz (1980), I derive the result that for the CES case, the optimal level of r_1 satisfies the following condition:

$$(7) \qquad r_1 = R\left(\varepsilon_2 + \delta_2 \frac{\partial c_2^*}{\partial a}\right) \Big/ \left(\varepsilon_2 + \delta_2 \frac{\partial c_2^*}{\partial a} + R\delta_2\right)$$

$$\equiv R \cdot z\left(\varepsilon_2, \delta_2, \frac{\partial c_2^*}{\partial a}\right),$$

where ε_2 is the compensated semi-elasticity of second-period consumption with respect to its price, $p_2 \equiv \frac{1}{r_1}$. ε_2 is a constant because utility is CES, $\varepsilon_2 = (1/c^*)$, and $\frac{\partial c_2}{\partial p_2} > 0$. $\frac{\partial c_2}{\partial p_2}$ is the effect of a wealth increment on second-period consumption, and δ_2 is the risk premium of a private agent for a consumption bet of the form c_2^* / Ec_2^*. Such a bet has expected utility of one but covaries negatively with lifetime marginal utility: $\delta_2 = -\{cov[G', c_2^*(\theta)] / EG' Ec_2^*\}$.

Notice that risk aversion implies $r_1 < R$ and thus $r_0 > 1$, both of which preserve the flavor of the local results above.

Banks and Other Structures

It is worth comparing this bank with the other institutions already discussed. In autarky, each individual agent is subject to income risk. Because the technology is reversible, no one benefits from being able to sell shares in an ex post security market, that is, by transferring goods from T= 2 to T= 1. A simple ex post equity market, then, does not improve upon autarky, because it cannot remove any of the income risk faced by agents.

However, the optimal linear banking structure provides agents with a higher level of expected utility than an ex post market does, because it partially insures agents against income risks. The provision of such insurance is incomplete because the bank pays for insurance by distorting the intertemporal trade-off facing consumers. Relative to ex post security markets, banks offer higher short-term yields ($r_0 > 1$) and lower long-term yields ($r_1 < R$). Without income uncertainty, or with full insurance from another source, the optimal bank would set $r_0 = 1$ and $r_1 = R$, and would serve no economic purpose.

Notice this classic relation between the bank and asset markets: The bank creates long-term assets from short-term liabilities. Though agents may withdraw money from their account at any time, the bank balances these withdrawals and invests partly in long-term production. A nonclassical restriction is the requirement of a choice of institution. As in other models of this sort (Diamond and Dybvig [1983], Haubrich and King [1990], and Jacklin and Bhattacharya [1988]), a bank and an equity market cannot coexist.

A more detailed analysis of these questions would proceed by initially characterizing Pareto-optimal allocations—subject to resource and incentive constraints—and then asking whether particular market arrangements can effectively decentralize these allocations or yield Pareto-optimal quantities as the outcomes of individual choices in a specified market. Because this paper concentrates on the effects of aggregate shocks, and not on the banking contract per se, it will not formalize the mechanism-theoretic approach to this problem. Additionally, a digression here could not do justice to the many interesting issues that arise, and would be redundant in light of the fuller treatment of the banking contract found in Haubrich (1988) and Haubrich and King (1990). Still, an informal discussion summarizing results from the other papers can clarify several related issues.

A key question is which institutions can support the optimal allocations arising from the planning problem. A bank contract supports such allocations, as do some other institutions. The main difference concerns the possibility of bank runs. Adding a sequential service constraint, as in Diamond and Dybvig (1983), will create panics. However, banks without this feature (and indeed mutual funds issuing derivative securities) can support the optimal allocations and remain immune to panics. I consider only such stable institutions.

An equity market does *not* support the optimal allocation. Once a bank exists, there are individual incentives to create a stock market. This would ruin the bank, however, so the planner does not allow that market to open. This exclusivity seems to be a generic defect of this type of banking model. Haubrich (1988) examines the informational assumptions allowing such exclusion. Jacklin and Bhattacharya (1988) interpret banking regulation as a means of preventing the arbitrage that would destroy banks. Gorton and Haubrich (1987) explore coexistence using a somewhat different model.

Finally, support for the full optimum mentioned above requires a nonlinear bank—one that pays contingent on withdrawal size. The general form of the contract remains the same, and the same techniques can be used to characterize the interest-rate schedule, but comparative statics become intractable. The linear bank results from the arbitrage conditions discussed above, which in the planning problem take the form of "multilateral incentive compatibility constraints" (see Haubrich [1988]). The nonlinearities that exist in the real world may result from the inability to arbitrage the bank—perhaps due to transactions costs or to the inability of group members to monitor one another. Still, the linear bank seems a useful approximation.

III. Banking with Aggregate Shocks

This section reintroduces fluctuations into the economy by integrating the banking sector into the basic macro model. It explores how the aggregate random variable x influences bank interest rates and in turn affects savings and consumption. This section illustrates the importance of contracts in economies with connections between a macroeconomic variable, R, and a microeconomic variable, individuals' endowment risk. Recall that a positive x increases R and induces a mean-preserving spread in $f(\theta)$, while a negative draw lowers R and reduces the dispersion of θ. In the presence of banks, this interaction has important consequences.

Individuals can observe x in $T = 0$, so that knowledge of $R(x)$ and $f(\theta, x)$ allows calculation of the interest rates r_0 and r_1. This reduces the problem to comparative statics on the distribution of θ and suggests that it is not uncertainty about aggregate shocks that drives banks' effects on interest rates, but rather the distributional consequences of such shocks.

It will be easier to examine these effects in three steps. First, I examine how r_1 changes with R if the distribution of θ remains fixed. Next, I keep R fixed and note how r_1 changes with the dispersion of θ. Finally, I put the two together.

Pure Aggregate Shocks

The case of an aggregate shock—with no effect on the uncertainty of income—serves as a benchmark for comparison with more complicated scenarios. With a "pure" aggregate shock, if the underlying technological rate of return R increases, the economy is richer and should be able to support a higher interest rate on bank deposits. This is indeed what happens, since

$$dr_1 / dR = z(\delta_2, \partial c_2^* / \partial a, \varepsilon_2)$$
$$- r_1 \delta_2(\varepsilon_2 + \delta_2 \partial c / \partial a + R\delta) > 0 .$$

Thus, the direct or "pure" effect of an aggregate shock moves both bank and market interest rates in the same direction. The second term in the equation is model specific: Because the utility function exhibits constant relative risk aversion, the increased income leads consumers to demand less insurance for a given absolute risk. This term would be absent with constant absolute risk aversion. A short calculation reveals that r_0 rises with R; economically, because of a higher payoff to storage, the bank can afford to distribute more goods, and both bank and market interest rates increase.

Pure Distribution Effects

The next determination is how banks' interest rates move when individuals are subject to greater uncertainty. I wish to sign $\partial z / \partial x$; that is, to hold R fixed, but to allow x to change $f(\theta)$. Equation (7) tells us $r_1 = z(\delta_2, dc_2/da, \varepsilon_2)R$.

Notice that the CES specification makes ε_2 constant, and the homotheticity of indifference curves implies that $\partial c_2/\partial a$ is independent of the distribution of θ. This means that the only term changed by a mean-preserving shift in $f(\theta)$ is δ_2. Not surprisingly, the movement in the interest rate depends on the movement of the risk premium on period 2 consumption. Recall that a greater risk premium indicates a greater demand for insurance, which is provided by a lower interest rate. Notice that $\partial r_1/\partial \delta_2 = -\varepsilon_2 R/(\varepsilon_2 + \delta_2 + \partial c_2^*/\partial a)^2 < 0$. Thus, a mean-preserving spread will decrease r_1 if it increases δ_2. Since δ_2 measures the risk premium on c_2^*/Ec_2^*, we expect it to rise with a risker c_2^*, which in turn is a linear function of θ. Intuitively, a positive shock, say a good harvest, will increase the uncertainty of individual incomes. This drives up δ_2, the risk premium on the lifetime consumption gamble, and sends r_1 down. The bank pools some of the increased risk by pushing r_1 and r_0 closer together, hence further redistributing income from the lucky to the unlucky.

The clear intuition on the effects of a mean-preserving spread belies the complexity of the actual calculation. The multiperiod, multiple-choice problem does not fit the one-variable techniques of Rothschild and Stiglitz (1970, 1971). In a closely related problem, calculating the change in the optimal linear income tax with a change in the ability distribution, Stern (1976) resorts to numerical examples even after specifying both utility and distribution functions. With problems in such a simple case, it is not surprising that more general specifications prove intractable.

Calculating the change in δ_2 is straightforward when G takes the form of log utility.[8] This is the only case for which an intertemporal investor facing a changing investment opportunity set will act as if he were a one-period maximizer (Merton [1982]). With log utility, changes in the interest rate alone do not alter consumption or savings decisions, and the result is a one-period problem on which standard comparative static techniques can be used. In this paper, because interest rates differ across periods, individuals face a changing investment opportunity set. With that problem simplified, comparative statics on the bank problem become feasible. The appendix carries out the calculation for log utility and examines the robustness of the result. A mean-preserving spread also increases the risk premium in another tractable case, quadratic utility.

Another way to obtain results is to restrict the distribution function. The appendix shows that for arbitrary utility functions, a two-point distribution yields the required result, as do certain changes related to the martingale measure of risk. Thus, although the general case seems intractable, a number of specific results support the intuitive conclusion.

Micro and Macro Shocks Together

The pure aggregate shock moves the underlying interest rate. The pure distribution effect, on the other hand, increases individual uncertainty and induces people to pool more risk by accepting a lower interest rate. The combination of both effects means that a macroeconomic disturbance will increase bank interest rates, but by less than the underlying rate. In other words, the aggregate shock x moves R directly, increasing both r_1 and r_0. In fact, without changes in individual uncertainty, an efficient bank would raise r_1 proportionately with R. The distribution effect by itself lowers r_1 when x rises. Both effects together imply that r_1 moves by less than R. Further, we expect that the direct effect dominates the distributional (indirect) effect, and both r_1 and R increase (that is, bank rates move less than one-to-one with the underlying interest rates). Similarly, a negative x decreases R, and the distribution effect raises r_1. Again, sluggishness results. Since the two effects of x—an increase in R and a greater dispersion of θ—are mathematically distinct, we must simply assume the dominance of the direct effect. This assumption accords with the macroeconomic evidence and theories mentioned in section I.

This distribution effect also influences r_0. The bank's budget constraint, (3), implies that a decrease in r_1 requires an increase in r_0. When the dispersion of θ rises, the bank provides more insurance by increasing r_0 and decreasing r_1. This affects consumption and savings in two ways: The higher r_0 augments the wealth of all agents as of $T = 1$, and the lower r_1 makes current consumption more attractive. These distributional

8 The dynamic asset pricing literature often exploits this tractability, which stems from the offsetting income and substitution effects.

consequences counteract the intertemporal effects of the pure gain in *R*, which induces people to consume more later.

The effect on interest rates is an immediate illustration of how contracts change the qualitative macroeconomic behavior of this economy. As the intertemporal price, the interest rate has additional effects. In general, comparing the path of aggregate disturbances will be complicated, but in the case of log utility, simple results emerge. The sluggish adjustment of interest rates dampens the effect of aggregate shocks on consumption and savings. Some lengthy but straightforward calculations show that

$$(8) \qquad 0 > \frac{\partial c_1^*}{\partial x}\ (\text{bank}) > \frac{\partial c_1^*}{\partial x}\ (\text{no bank}), \text{ and}$$

$$(9) \qquad \frac{\partial c_2^*}{\partial x}\ (\text{no bank}) > \frac{\partial c_2^*}{\partial x}\ (\text{bank}) > 0 .$$

Thus, though idiosyncratic risk "washes out" across all agents, it affects the economy because agents form institutions and write contracts to protect against that risk. Even if interest rates adjust one-to-one, the deviation of the bank rate from the technological rate alters behavior. More significant, however, is that the bank filters the effect of the shock by changing the underlying risk. Hence, ignoring or simply exogenously imposing institutions on a macro model seriously distorts conclusions. Figures 1 and 2 give a flavor of possible applications of this model and show that there are useful and tractable extensions of the representative-agent framework.

IV. Conclusion

This paper illustrates how institutions play a central role in aggregate phenomena. In this section, I argue that the results hold in a very general context and that the general study of institutions arising from competition is essential for adequate macroeconomics.

The analysis presented above extends beyond bank rates. Other financial institutions play a part in macroeconomic disturbances, and although this paper argues in terms of risk-pooling, the underlying ideas pertain to risk-shifting as well. The institution studied here is termed a bank, but as a pure financial intermediary, its functions may be duplicated by an appropriate derivative security market.

For example, consider dividend payments. When individuals face private risks, dividend payments may set the return on equity to provide insurance. An interaction between macro- and microeconomic shocks leads to dividends that adjust slowly (Copeland and Weston [1979]).

In fact, the analysis is not limited to financial institutions: Some recent work on labor contracts also discusses the role of aggregate shocks as signals about unobservable individual disturbances. Haubrich and King (1991) examine a case in which the money supply signals individual dispersion, leading to the non-neutrality of perceived money. Grossman, Hart, and Maskin (1983) focus on economies where asymmetric information between firms and workers produces cyclical unemployment.

These new markets and institutions attempt to avoid the problems of adverse selection arising from private information. In this sense, derivative security markets or institutions occupy niches similar to other schemes discussed in the literature. In order for the institution to survive, the incentive structures must force agents to reveal themselves at least partially. Markets cannot always completely exploit this information, because to do so would distort the incentives that allowed revelation in the first place.

This paper provides an equilibrium analysis of how endogenously arising financial institutions alter the impact of macroeconomic shocks. It explains the modifications in consumption and investment decisions as reactions to prices that react sluggishly to the underlying economic disturbances. This suggests that income distribution plays a major role in aggregate disturbances, such as business cycles. It also suggests that a relevant business cycle theory eventually must explicitly model why banks exist and why they take their present form. This explanation of bank rate sluggishness illustrates a powerful principle: When aggregate disturbances also have distributional consequences, the pattern of efficient contract-specified prices can change.

Appendix

In this appendix, I calculate the change in the risk premium δ_2 caused by an increase in individual uncertainty. First, recall that indirect utility and optimal second-period consumption are

(A1) $v = \alpha(r)\,[w(\theta)]$ and

(A2) $c_2^* = r[1 - b(p_2)]\,[w(\theta)] = q(r)\,[w(\theta)]$.

δ_2 can be written as

(A3) $\delta_2 = -[E(v^{-\gamma}c_2) - Ec_2\,Ev^{-\gamma}]/Ec_2\,Ev^{-\gamma}$

$= 1 - E(v^{-\gamma}c_2)/Ec_2\,Ev^{-\gamma}$.

Using (A1) and (A2), I rearrange (A3) to obtain

(A4) $1 - \delta_2 = E[w(\theta)^{1-\gamma}]/E[w(\theta)]\,E[w(\theta)^{-\gamma}]$.

To discuss how δ_2 changes with increases in the dispersion of θ, I employ the techniques of Sandmo (1970) and Rothschild and Stiglitz (1970, 1971) and stretch the distribution by replacing θ with $x\theta$ in order to sign $\partial\delta_2/\partial x$. First, take the derivative:

$\partial\delta_2/\partial x =$

$-[Ew(x\theta)\,Ew(x\theta)^{-\gamma}(\partial/\partial x)\,Ew(x\theta^{1-\gamma})$

$- Ew(x\theta)^{1-\gamma}\,Ew(x\theta)\cdot(\partial/\partial x)\,Ew(x\theta^{-\gamma})]/$

$(EwEw^{-\gamma})^2$.

Without loss of generality, I evaluate this expression at $x = 1$.

(A5) $-\{Ew(\theta)\,Ew(\theta)^{-\gamma}E[(1-\gamma)\,w(\theta)^{-\gamma}\theta]$

$- Ew(\theta)^{-\gamma}Ew(\theta)\,E[-\gamma\,w(\theta)^{-\gamma-1}\theta]\}/$

$(EwEw^{-\gamma})^2$.

Notice that the first and second terms of this expression are positive, as are all the terms after the minus sign (fourth, fifth, and sixth terms). The third term is negative when $\gamma < 1$, making the entire derivative unambiguously positive. Thus, an increase in x increases δ_2 and decreases r_1. When $\gamma < 1$, the sign of expression (A4) becomes ambiguous. Without explicitly determining its sign, though, we can gain some idea of its properties. Simple numerical examples involving uniform distributions indicate that in some cases (A4) is positive. Additionally, (A4) is always positive with a discrete, symmetric, two-point distribution. To see this, write the numerator of (A5) as

$$Ew^{-\gamma}Ew^{-\gamma}\theta$$
$$+\gamma(Ew^{1-\gamma}Ew^{-\gamma-1}\theta - Ew^{-\gamma}Eq^{-\gamma}\theta)\,.$$

The first term is always negative. I can use the linearity of wealth to express w as $(a \pm k)$, where the distribution is the two-point discrete distribution with probability 1/2 on k and $-k$. The sign of (A5) is then the opposite of $(a-k)^{1-\gamma}(a+k)^{1-\gamma}(-4\,a)$, which is always negative. Thus, the risk premium moves positively with x.

When G is quadratic, $G(x) = x - \frac{1}{2}bx^2$, the result also holds. Substitute into (A4) to obtain

(A6) $1 - \delta_2 =$

$$\frac{E\big[1 - b\{a[\alpha(a+\theta)]\}[q(a+\theta)]\big]}{E[1 - b(\alpha\,a + \alpha\,\theta)]\,E[q(a+\theta)]}$$

With a mean-preserving spread on θ, only the numerator of (A6) changes, becoming $E[q(1+\theta)] - baq\,E(a^2 + 2a\theta) - baq\,E(\theta^2)$. The MPS on θ increases the variance, proving the result.

For general utility functions, $1 - \delta_2$ can be expressed as a "martingale measure of risk" as in Nachman (1979, section 4.1). Then, if f is the distribution for c_2,

$$f^*(c) = \frac{G'}{EG'}\,,\quad f = \frac{G'}{\int G'\,f(c)\,dc}\,f(c).$$

Defining $E_f^*(c) - \int c f^*(c)\,dc$, Nachman extends Rothschild and Stiglitz's arguments to show $E_f^*(c) < E(c)$. The assumption on the movement from f to g implies $E_g^*(c) < E(c)$. Similarly, if g is riskier than f^*, it is also risker than f. The new expression for $1 - \delta_2$ is $E_g^*(c) < E_g(c) < E_f^*(c) < E_f(c)$. Again, the desired result follows. Here, the function G is general, but a large shift in dispersion is required.

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