

**RISK SHARING, LIQUIDITY,
AND INFORMATION PRODUCTION
IN THE BANK DEPOSIT CONTRACT**

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I. INTRODUCTION

Despite the central position of financial intermediaries both in the resources allocation process and as a transmission mechanism of monetary policy, there are, to date, relatively few investigations of the banking firm in microeconomic theory. A first set of papers dealt with the portfolio management of intermediaries and the dependence problem of assets selection on the cost and/or the composition of the liabilities¹. Only recently a second group of papers investigated the reasons for the emergence of financial intermediaries as contracts that improve the completion of the market and thus its allocative efficiency.

A distinction must be made in the activity of the banking firm. First, banks operate an accounting network for recording payments or more generally, the transmission of financial wealth among the different agents of the economy.² Their second role on which this paper will focus is the intermediation between final borrowers and final lenders. The study of the bank deposit contract reveals four major types of production in this financial intermediation activity. The bank deposit contract produces specific-risk diversification, liquidity, reliable information on investment projects, and market-risk transformation.

¹See M.A. Klein (6) and D.H. Pyle (10)

²See E.F. Fama (4)

Ignoring the bankruptcy of the bank itself, a bank deposit contract is a substitute for a diversified portfolio, since it is a claim on the diversified assets of the bank. This characteristic, however, is not specific to this type of contract. It is one of the main features of market funds, for example, and does not appear to be a necessary condition to the existence of bank deposits. Thus, it will not be addressed here.

In a recent paper, Diamond and Dybvig (3) have shown that by offering liquidity to investors, bank deposits provide optimal allocation in a world where consumption needs occur at random and privately known times. This contract, however, requires an additional institutional arrangement to prevent a bank run, which is the perverse equilibrium to which the bank deposit contract can also lead. They show that government deposit insurance is a zero cost mechanism to exclude the perverse solution and suggest that the existence of a banker of last resort leads to the same result.

The bank deposit contract, moreover, is the response to another type of asymmetric information. It provides production of reliable information on investment projects. Leyland and Pyle (7) have suggested that intermediation could decrease the welfare cost of the signalling solution in which entrepreneurs are induced to take larger equity positions in their project than they would if information could be directly transferred to lenders. Campbell and

Kracow (2) have shown that financial intermediation creates the condition under which there will be a production of reliable information on projects leading to a rational expectation equilibrium.

Finally, the bank deposit contract is an insurance contract - or a risk sharing arrangement - against the variability of the market return. Over a certain period of time, banks offer investors deposits with stable return while their asset portfolios are subject to the variations of the market return. In other words, banks issue fixed claims to the depositors while their claims on loans are variable. This risk transformation or insurance feature can, to a certain extent, be viewed as a similar problem to the underwriting contract of an investment banking firm.

The purpose of this paper is not to re-demonstrate the efficiency of the bank deposit contract as a mechanism to solve the two information asymmetry problems mentioned above. Its purpose is rather to suggest a formulation of the optimal banking contract that involves together the risk sharing, liquidity, and information production features and to express the "spread" as a function of these three "productions".

Section II presents a simple model based on the risk sharing feature in a similar fashion to what has been developed in the investment banking literature.¹ The optimal bank deposit contract is derived.

¹See G. Mandelker and A. Raviv (8). Also D.P. Baron (1)

In sections III and IV, liquidity aspects and information production are respectively introduced and their impact on the optimal contract is investigated.

The conclusion is drawn in the fifth section.

II. DEPOSIT AS A RISK - SHARING CONTRAT

1. Risk-Neutral Banks

Assume that the economy is composed of three types of agents : investment projects (or firms), banks, and individuals.

The firms will be considered as a whole sector rather than individually assuming that every portfolio is perfectly diversified across all firms, such that the return (x) in these portfolios is independent of any firm-specific risk. The return (x), however, is a random variable depending on the state of nature. It is included in the interval $(-1, +\infty)$ and is characterized by a probability density function $f(x)$, such that

$$\int_{-1}^{\infty} f(x)dx = 1.$$

The banks assets will be composed of loans to these firms (investment projects) with return x . Beside equity and reserves (w) their liabilities consist in deposits bearing a rate which depends on the returns on investment $r(x)$. So, the interest rate on the deposits can take different forms : $r(x) = \bar{r}$ is a constant rate bank deposit similar to a traditional bank savings account in which the bank bears all the risk ; $r(x) = x$ is a mutual fund contract or a "no-bank" contract where the investors keep all the risk ; and all the intermediate forms of $r(x)$ are risk sharing contracts. In other words, there is a continuum of possible arrangements between the banks and the individuals, from the constant rate saving account to a portfolio of investment projects, the "no-bank" contract. Let $S(x)$ be the spread for the banks, where :

$$S(x) = x - r(x) \quad (1)$$

The expected spread is then :

$$E[S(x)] = E(x) - E[r(x)] \quad (2)$$

If we assume that banks are risk neutral, they will be ready to offer deposit contracts as long as their expected spread is positive.

$$E[S(x)] \geq 0 \quad (2')$$

Individuals will be characterized by the amount of wealth they plan to allocate (D_i), and their utility function (U_i). Individuals are risk averse ($U_i' > 0$, $U_i'' < 0$) and their utility functions satisfy Inada conditions ($U_i'(0) = +\infty$, $U_i'(\infty) = 0$). They will select the type of bank deposit contract $r_i(x)$ to maximize their expected utility :

$$\begin{aligned} \text{Max} \quad & E[U_i(D_i(1+r_i(x)))] \\ & r_i(x) \end{aligned} \quad (3)$$

or

$$\begin{aligned} \text{Max} \quad & \int_{-\infty}^{+\infty} U_i(D_i(1+r_i(x))) f(x) dx \\ & r_i(x) \end{aligned} \quad (4)$$

Individuals will be interested by a bank deposit as long as

$$U_i(D_i(1+E[r_i(x)])) \geq E[U_i(D_i(1+x))] \quad (5)$$

They would otherwise choose the "no-bank" solution and invest directly in the "investment projects" market. Substituting (2) into (5) gives :

$$U_i(D_i(1+E[x] - E[S(x)])) \geq E[U_i(D_i(1+x))] \quad (6)$$

Using the certain equivalent identity we can define $\pi_i(D_i, x)$ such that :

$$E[U_i(D_i(1+x))] = U_i(D_i(1+E(x)) - \pi_i(D_i, x)) \quad (7)$$

so,

$$E(x) - E[S(x)] \geq E(x) - \pi_i(D_i, x) \quad (8)$$

or equivalently,

$$E[S(x)] \leq \pi_i(D_i, x) \quad (8')$$

Condition (8') defines an upperbound for the bank spread, such that the loading of the contract is inferior to the "insurance premium" corresponding to the disutility of risk bearing by the individual, which is a function of the variance of x and of his absolute risk aversion.

$$\pi_i(D_i, x) = \frac{U_i''}{U_i'} \left(\frac{\sigma^2(x)}{2} \right) \quad (8'')$$

So, the bound will be higher the higher the risk aversion of the individual and the higher the variance of the return on the market.

Proposition 1

When banks are risk neutral, as long as condition (8') is respected, individuals maximize utility by choosing the constant rate deposit contract $r_i^*(x) = \bar{r}_i = E(r_i(u))$.

This comes immediately from the utility function :

$$E[U_i(D_i(1+r_i(x)))] < U_i(D_i(1+E[r_i(x)])) \quad ///.$$

In this case, the expected spread of the banks will have the following properties for each contract :

$$E[S(x)] = E(x) - \bar{r}_i$$

$$\sigma^2(S(x)) = \sigma^2(x)$$

$\bar{r}_i$ will be bounded by conditions (2') and (8') so,

$$\bar{r}_i \leq E(x)$$

$$\bar{r}_i \geq E(x) - \pi_i(D_i, x) = E(x) - \frac{U_i''}{U_i'} \left(\frac{\sigma^2(x)}{2} \right)$$

The lower bound of the bank deposit rate will be lower the higher the risk aversion of the depositors and the higher the variance of the return on the market. The actual rate will

tend to the upper bound if the supply of bank deposit contract is competitive. It will tend to the lower bound (and possibly be discriminatory) if the banking system is close to a monopoly.

2. Risk-Averse Banks

The modern theory of the firm and of managerial behavior has developed justification for risk aversion in the firm's decision making. The separation between ownership and control for example, can lead to a concave corporate objective functions.

So, let us assume that banks are characterized by a utility function (V) such that $V' > 0$, $V'' < 0$, $V'(0) = +\infty$, $V'(\infty) = 0$. Bankers will choose $r_i(x)$ to maximize the expected utility of the intermediation spread for every contract :

$$\max_{r_i(x)} E[V(w + D_i(x - r_i(x)))] \quad (9)$$

where w = banks' equity and reserves

or,

$$\max_{r_i(x)} \int_{-1}^{+\infty} V(w + D_i(x - r_i(x))) f(x) dx \quad (10)$$

Banks will offer a deposit contract if and only if :

$$E[V(w+D_i(x-r_i(x)))] \geq V(w) \quad (11)$$

We can define $\pi_b[w, D_i(S(x))]$ to substitute by the certain equivalent to obtain

$$V\{w+D_i(E[x-r(x)] - \pi_b[w, D_i(S(x))])\} \geq V(w) \quad (12)$$

or equivalently,

$$E[x] - E[r(x)] \geq \pi_b[w, D_i(S(x))] \quad (12')$$

The spread must be sufficient to compensate the banker for the marginal disutility of the risk he is buying. Similarly, individuals will engage in the contract if and only if

$$E[U_i(D_i(1+r_i(x)))] \geq E[U_i(D_i(1+x))] \quad (13)$$

Again we can define $\pi_i(D_i, 1+r)$ and substitute on both sides by the certain equivalent to obtain :

$$\begin{aligned} U_i\{D_i(E[1+r_i(x)] - \pi_i[D_i, 1+r_i(x)])\} &\geq \\ U_i\{D_i(E[1+x] - \pi_i[D_i, 1+x])\} &\end{aligned} \quad (14)$$

or equivalently,

$$E[x] - E[r_i(x)] \leq \pi_i[D_i, 1+x] - \pi_i[D_i, 1+r_i(x)] \quad (14')$$

The intermediation spread must be less than the insurance premium the individual is ready to pay for the share of the risk transferred to the bank.

The spread must thus satisfy condition (12') and (14') together

$$\pi_b[w, D_i(S(x))] \leq E[x] - E[r_i(x)] \leq \pi_i[D_i, 1+x] - \pi_i[D_i, 1+r_i(x)] \quad (15)$$

This condition shows the obvious conflict of interest between the investor and the banker. Indeed, the utility of the banker increases with the expected spread, while the utility of the depositor decreases with it. This leads us to look for the Pareto optimal contract that should result from the agents maximization processes.

Suppose that banks have a reservation level of utility (C) above which they agree to offer any deposit. C must satisfy inequality (11) and can be assumed to be fixed by the competitive conditions on the market. Then, the optimal contract

can be found by maximizing the individual's utility function under the constraint that the banker's expected utility is larger or equal to C .

$$\text{Max } \int_{-1}^{+\infty} U_i(D_i(1+r_i(x))) f(x) dx \quad (16)$$

subject to

$$\int_{-1}^{+\infty} V(w+D_i(x-r_i(s))) f(x) dx = C \quad (17)$$

This optimal control problem can be solved by maximizing the following Hamiltonian.

$$H = \{U_i[D_i(1+r_i(x))]\} + \lambda \{V[w+D_i(x-r_i(x))]\} f(x) \quad (18)$$

The derivative with respect to the control variable $r_i(x)$ gives for all x ,

$$\frac{\partial H}{\partial r_i^*(x)} = \{U_i'[D_i(1+r_i^*(x))]D_i - \lambda D_i V'[w+D_i(x-r_i^*(x))]\} f(x) = 0 \quad (19)$$

or,

$$\frac{\partial H}{\partial r_i^*(x)} = U_i'[\cdot] - \lambda V'[\cdot] = 0 \quad (20)$$

The second order condition is satisfied since :

$$U''_i [.] + \lambda V''[.] < 0 \quad (21)$$

Since (20) is true for all x , we can differentiate with respect to x to obtain the slope of the optimal contract :

$$\frac{\partial}{\partial x} \frac{\partial H}{\partial r_i^*(x)} = U''_i [.] r_i^{*'}(x) - \lambda V''[.] (1 - r_i^{*'}(x)) = 0 \quad (22)$$

Substituting for $\lambda = \frac{U'_i}{V'}$ from (20),

$$r_i^{*'}(x) = \frac{\frac{V''}{V'}}{\frac{V''}{V'} + \frac{U''_i}{U'_i}} \quad (23)$$

This result confirms our first proposition : when the bank is risk neutral ($V''=0$), the optimal contract is a constant rate deposit. Moreover, equation (23) leads us to the second set of propositions :

Proposition 2.

- The optimal contract will depart from the constant rate deposit the more the bankers is risk averter.
- The slope of the optimal contract is positively related to the absolute risk aversion of the depositor.
- The slope of the optimal contract is not a function of the riskiness of the return on the investment project market. So, an increase in the variance of x , will not affect the choice of the optimal type of contract, but it will push upward the lower and the upper bounds of the expected spread (cfr. equations 15).
- $r^*(x)$ is bounded between zero and one.
- $r^*(-1) > (-1)$, otherwise given that $r^*(x) < 1$, $r^*(x) < x$ for all x , contradicting (13).

III. BANK DEPOSIT AS A LIQUID ASSET

The liquidity feature of bank deposits and its impact on bank deposit contracts can be introduced in our model in a very simple way.

We can assume that consumption needs occur randomly across individuals at any time. Without bank deposits people hit by these random consumption needs liquidate their assets before

maturity to finance their consumption. Through this early liquidation they will realize capital gains or capital losses which will increase considerably the variance of the return on their portfolio.

Alternatively, by holding a bank deposit account people hold a fixed claim that they are, by assumption, allowed to cash without cost. Banks, on the other hand, are assumed to maintain cash reserves to face these withdrawals.

This is going to modify our model in the following way. We have to make a distinction between the return on "direct" investments as they are done by banks or individuals (x_b and x_i respectively). As the investment opportunities are identical for both types of investors they still have the same expected return on these investments :

$$E(x_i) = E(x_b) = E(x) \quad (25)$$

However, due to the early liquidation problem discussed above, the variance of the return is much larger for the individuals than for the banks.

$$\sigma^2(x_i) > \sigma^2(x_b) = \sigma^2(x) \quad (26)$$

Moreover, the cost of maintaining liquidity in the banks' portfolio must be introduced. Banks are no more able to invest the total amount deposited since they need liquid reserves to

satisfy possible withdrawals. Let's assume that the opportunity cost of the liquid fraction of a unit of asset is a proportion (c) of the return of the bank asset. So, the expected cost is $c (1 + E(x))$ ¹.

Proposition 3

- The higher volatility of the return of the individuals' investments in the market due to the difference between the holding period and the maturity of the assets does not affect the type of deposit chosen. This is obvious from equation (23).
- The introduction of the liquidity feature will move upwards the lower and the upper bounds of the expected spread retained by the banks.

First, in the case of risk neutral banks the lower bound will no more be zero as in (2') but will be the expected cost of maintaining liquidity ($c (1 + E(x))$). The upper bound will be higher since by definition (8'), π_i is increasing in the variance of the return of the individuals portfolio.

Second, in the case of risk averse banks, the liquidity problem will modify equation (15) in the following way.

¹ c can be interpreted as the fraction of the deposit actually maintained liquid to face withdrawals and the expected cost of refinancing one invested unit of asset.

$$\pi_b[w, D_i(S(x))] + c(1+x) \leq E[x] - E[r_i(x)] \leq \pi_i[D_i, 1+x_i] - \pi_i[D_i, 1+r_i(x)] \quad (27)$$

where $0 < c < 1$ and,

$$\pi_i'[D_i, 1+x_i] = \frac{U''}{U'} \left(\frac{\sigma^2(x_i)}{2} \right) > \pi_i'[D_i, 1+x] = \frac{U''}{U'} \left(\frac{\sigma^2(x)}{2} \right)$$

since $\sigma^2(x_i) > \sigma^2(x)$.

///.

Thus the two bounds will be higher.

IV. BANKS AS PRODUCERS OF INFORMATION

If financial intermediation is a mechanism through which reliable information on investment projects is produced, we can expect return on bank investment to be higher than through a blind diversification. Indeed, following the Cambell & Kracow (2) argument, the existence of financial intermediaries will bring a better selection of investment projects or avoid an expensive signalling solution but in both cases a higher expected return. So, we can now modify the model developed in section II, in making a distinction again between investment opportunities available to the individuals (x_i) and to the banks (x_b). This time however, we

assume that through better information on the projects, the expected returns on investments done through banks is higher than on direct investment of "uninformed" individuals in a no bank environment. The variance on these returns, however, will be the same since it doesn't describe any project-specific risk but the risk on the return of the whole market. Explicitly, the assumptions in this case are :

$$E(x_i) = E(x) < E(x_b) \quad (28)$$

$$\sigma^2(x_i) = \sigma^2(x_b) = \sigma^2(x) \quad (29)$$

Moreover, let's assume that the cost of conducting the investment evaluation is a constant k , per unit invested.

Proposition 4

- The introduction of the information production feature of the bank deposit contract does not affect the optimal risk sharing arrangement resulting from equation (23).
- The introduction of the information production feature of the bank deposit contract will move upward the lower and the upper bounds of the expected spread retained by the banks.

In the case of a risk neutral bank, the lower limit of the spread will be the cost of conducting the evaluation (k) while the upper limit of the spread will also move upward. This is clear if we look at the modified form of equation (8) :

$$E(x_b) - E[S(x_b)] \geq E(x) - \pi_i(D_i, 1+x)$$

or equivalently

$$E[S(x_b)] \leq E(x_b) - E(x) + \pi_i(D_i, 1+x)$$

Indeed, we have the same result in the case of a risk averse banker. The transformed boundaries condition for the expected spread in this case is :

$$\begin{aligned} \pi_b[w, D_i(S(x_b))] + k &\leq E[x_b] - E[r_i(x_b)] \leq \\ \pi_i[D_i, 1+x] - \pi_i[D_i, 1+r_i(x_b)] + (E[x_b] - E[x]) &\quad (30) \\ &\quad ///. \end{aligned}$$

V. CONCLUSION

The bank deposit contract is a widely used instrument for investment. It can have many different characteristics in terms of return : earning a constant rate of interest or, on the contrary, a return highly volatile and close to the market return.

The model developed here provides a justification for the existence of the contracts despite the significant spread between their return (or expected return) and the return of the market.

The spread is the compensation for the three services produced by banks and attached to these contracts : risk transformation, liquidity, and information production.

We have shown that the optimal type of bank deposit contract (or risk sharing contract) depends on the absolute risk-aversion of the banker and the depositor. It does not depend on the variance of the return on the market and is left unchanged by the introduction of the other features of this contract : liquidity and information production.

We have defined the lower and upper limits of the expected spread retained by the banks and we have shown that the introduction of the liquidity and information production features drives these two bounds upward.

There are two limitations to this approach : first, since we have not specified the utility functions, we cannot solve for explicit optimal contract solutions. Second, the nature of the problem, namely designing the optimal instrument in which to invest one's wealth, is not compatible with solving simultaneously for a general portfolio allocation.

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