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Interest Rate Uncertainty and the Financial Intermediary's Choice of Exposure

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ABSTRACT

The financial intermediary's choice of operating as a broker with minimal risk exposure or as an asset-transformer with interest rate risk is modeled as a funds inventory decision made prior to the resolution of uncertainty regarding the borrowing or lending interest rates. It is shown that an increase in the interest rate uncertainty leads the intermediary to reduce its exposure, thereby offering decreased asset-transformation and more brokerage services. However, a stochastic increase in the interest rates leads to greater asset-transformation and less brokerage services.

THE HIGH AND VOLATILE nominal interest rates associated with contemporary inflation have prompted a pronounced change in commercial bank balance sheets. Low cost deposits have been replaced by alternative funding vehicles bearing high and increasingly variable interest rates (see Budzeika [3, 4], Kane [9] and Silber [13]). In an apparent adaptive response to the loss of deposits, banks have eschewed fixed rate loans in favor of variable rate lending, thereby more closely matching the durations of their assets and liabilities (see Flannery [6] and Boltz and Campbell [2]). This change in bank lending practices has been popularly interpreted as an effort to "immunize" cash-flows in the face of increased interest rate uncertainty (see Haley [8] and Wojnilower [15]). However, apart from Niehans and Hewson [11], the adaptive recomposition of bank balance sheets has not been formally addressed. In this paper, we provide a model of balance sheet duration mismatching and then show that an increase in interest rate volatility is likely to lead an intermediary to choose a balance sheet that is more closely matched.[1]

Balance sheet mismatching can be understood in terms of the two basic functions of financial intermediaries, as explained by Niehans [10]: brokerage and asset-transformation. If a financial intermediary precisely matches the properties of its assets and liabilities and thereby maintains a perfectly hedged position, it functions exclusively as a "broker," joining borrowers and lenders without assuming any risk. The broker's function is then simply to reduce the search costs associated with joining complementary transactors. The brokerage function is

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[1] The implications of duration mismatching adjustments for banks' lending behavior and the allocation of credit are addressed in Deshmukh, Greenbaum, and Kanatas [5].

illustrated by the "best-efforts" contract in investment banking (see Baron and Holmstrom [1]).

Alternatively, the intermediary may modify the attributes of financial claims (such as their duration, numeraire, divisibility, et al.) and may therefore be referred to as an "asset-transformer." Asset-transformation necessitates balance sheet mismatching, which in turn implies some type of risk for the intermediary. For example, duration mismatching results in interest rate exposure whereas numeraire mismatching gives rise to exchange-rate risk. The "firm-commitment" contract of the investment banker illustrates asset-transformation with concomitant interest rate or security price exposure.[2]

In this paper, we focus on duration mismatching and abstract from other claim attributes. We provide a simple characterization of risk exposure relating to the broker's and asset-transformer's modes of intermediation and then examine how the choice of the mode of intermediation is influenced by uncertainty in loan demand and funds supply conditions. The intermediaries, whether brokers or asset-transformers, are assumed to face perfectly elastic loan demand and funds supply, but borrowing or lending interest rates are uncertain and a capacity constraint limits the intermediary's scale of operation. The broker borrows only after all interest rate uncertainty is resolved and therefore assumes no risk in making loans. The asset-transformer, in contrast, borrows in advance and therefore sustains the risk of incorrect estimation of interest rates. The initial loanable funds inventory is therefore interpreted as a measure of the duration mismatching, the extent of asset-transformation, and the consequent interest rate exposure. The initial funds inventory is zero for the broker, and larger inventories imply greater asset-transformation.

With this characterization of duration mismatching, we examine how the intermediary's choice of the extent of asset-transformation is influenced by uncertainty. Increased uncertainty regarding the intermediary's lending or borrowing interest rate is shown to induce the expected profit-maximizing intermediary to reduce its loanable funds inventory and hence move towards the broker's mode of operation. On the other hand, an increase in either of the interest rates is shown to induce the intermediary to hold a larger loanable funds inventory and therefore undertake greater asset-transformation. Thus, simultaneous increases in both the magnitude and the volatility of the lending/borrowing interest rates have an ambiguous effect on the intermediary's choice of exposure and mode of operation. If less asset-transformation is observed as a result of higher and more variable interest rates, the effect of increased volatility must dominate the opposing effect of higher interest rates.

The model is described in Section I, and the results on the effects of increased uncertainty and levels of the lending and borrowing interest rates are presented in Sections II and III, respectively; the concluding section provides interpretation.

[2] Some writers prefer to distinguish between brokers and asset-transformers by stressing that the former transact on behalf of clients, whereas the latter transact on their own account. However, a commercial bank with a perfectly matched balance sheet assumes no risk and restricts itself to the provision of search services. It therefore behaves equivalently to the intermediary transacting on behalf of clients although it formally transacts on its own account.

I. The Model

Consider an intermediary facing a perfectly elastic demand for loans at a currently uncertain interest rate, r. The resolution of uncertainty about r will also establish a new (but currently uncertain) borrowing rate, C_b, for the intermediary. Let L denote a known upper bound on the intermediary's scale of operation. This capacity constraint can be interpreted as a lending maximum arising from a regulatory capital requirement. Alternatively, the capacity constraint can be viewed as the simplest way of giving expression to the intermediary's rising marginal cost of borrowing. Under either interpretation of capacity, resource adjustment costs or rigidities are assumed and the intermediary will never choose to borrow in excess of L. Before the uncertain interest rates r and C_b are realized and loans are made, the intermediary borrows an amount, $L_0 \leq L$ at a currently known interest rate, C_a. After the resolution of the interest rate uncertainty regarding r and C_b, the intermediary may borrow at C_b an additional amount up to $(L - L_0)$.

The essential distinction between an asset-transformer and a broker relates to risk exposure. If the intermediary borrows before the resolution of interest rate uncertainty, it accepts the risk that r will be less than C_a, necessitating below-cost lending. Even if $r > C_a$, there is the risk that $C_b < C_a$. If, on the other hand, the intermediary borrows only after the interest rates are known, it need not lend at a loss, although it still faces the risk that $C_b > C_a$. Since either borrowing strategy involves risk regarding the relationship of C_a to C_b, the relevant distinction between borrowing strategies relates to the possibility of being forced to lend at a loss. Therefore we may represent the intermediary's degree of risk exposure by the initial funds inventory, L_0. For example, the pure asset-transformer borrows $L_0 = L$ and sustains the maximum exposure, whereas the broker borrows only after interest rates are realized and therefore chooses $L_0 = 0$.

In general, the intermediary's problem is to choose the initial borrowing, $L_0 \leq L$, at unit cost C_a, so as to maximize expected profits. If realized $r > C_b$, the intermediary will borrow the additional $(L - L_0)$. If realized $r < C_b$, the intermediary will not borrow beyond L_0; however, it will lend L_0 at any $r > 0$ since the return on idle funds is taken to be zero. Thus, the intermediary's optimal choice of L_0 maximizes expected profits given by

$$\pi(L_0) = E(r)L_0 + (L - L_0)E(\text{Max}(r - C_b, 0)) - C_aL_0, \qquad L_0 \leq L \tag{1}$$

where $E(\cdot)$ is the expectation operator. The third term in Equation (1) is the known cost of borrowing L_0 in advance, whereas the first term is the expected revenue from lending funds borrowed in advance of knowing r and C_b. The second term is the expected profit from lending funds borrowed after the realization of r and C_b.

The rest of the paper examines two cases of this model specialized on the basis of the sources of uncertainty. Section II considers the choice of L_0 when the loan rate, r, is uncertain, but C_b is known; Section III allows C_b to be random, but takes r to be known.

II. Loan Interest Rate Uncertainty

Suppose that both the initial unit cost of funds, C_a, and the future unit cost of funds, C_b, are known but that the loan rate, r, is uncertain. We assume that $C_b > C_a$ in order to provide the intermediary with an incentive to borrow prior to realizing the loan interest rate. The asset-transformer's cost advantage can be understood in terms of the certainty provided to its supplier of funds. The amount L_0 is chosen to maximize the expected profit given by Equation (1). Since $\pi(L_0)$ is linear in L_0, optimal $L_0 = L$ if

$$E(r) - C_a \geq E[\text{Max}(r - C_b, 0)] \tag{2}$$

and optimal $L_0 = 0$ if the inequality in (a) is reversed. Thus, if the expected marginal profit from lending the funds inventory is positive and exceeds that from lending funds borrowed later at C_b, the intermediary will choose to be an asset-transformer and borrow in advance up to its known capacity, thereby undertaking maximum interest rate exposure. Otherwise, it will borrow only after the loan interest rate is known and behave as a pure broker. Of course, brokers and asset-transformers may co-exist provided intermediaries have differing interest rate expectations. However, individual intermediaries will be either pure brokers or pure asset-transformers.

To consider the effect of increased loan interest rate uncertainty, we employ Rothschild and Stiglitz' [12] concept of a "mean-preserving spread" of the probability distribution.[3] Note that the function $u(r) = \text{Max}(r - C_b, 0)$ is convex nondecreasing. Hence, if the random loan rate, r, becomes more uncertain, the left-hand side of (2) remains unchanged, but the right-hand side increases; we therefore conclude that the intermediary is more likely to choose $L_0 = 0$. Thus, there will be an increased tendency towards the broker's mode of operation as the loan interest rate becomes more uncertain. Given an industry comprised of many intermediaries with diverse expectations, increased uncertainty in the lending rate can be expected to result in increased brokerage (reduced asset-transformation) in the aggregate even though each individual intermediary remains either a pure broker or a pure asset-transformer.[4]

In order to consider the effect of an increased loan interest rate level, suppose that the uncertain lending rate r (and hence the lending-borrowing spread) increases in the sense of first-order stochastic dominance.[5] To apply this concept, rewrite (2) as

$$E[\text{Min}(r, C_b)] \geq C_a \tag{3}$$

and note that $v(r) = \text{Min}(r, C_b)$ is nonnegative and nondecreasing in r. Hence, a

[3] A random variable X_1 is more uncertain in the Rothschild-Stiglitz sense than X_2 if $E(X_1) = E(X_2)$, and $E[u(X_1)] \geq E[u(X_2)]$, for any convex nondecreasing function, $u(\cdot)$.

[4] This argument is analogous to Tobin's [14] in which individuals hold either money or bonds exclusively, depending on their interest rate expectations, and aggregation across individuals provides a smooth demand for money function. Alternatively, as in Tobin, an interior solution for each intermediary can be obtained by maximizing the expected utility of profits.

[5] A random variable X_1 is stochastically greater than X_2 if $E[v(X_1)] \geq E[v(X_2)]$, for any nonnegative nondecreasing function, $v(\cdot)$. See Hadar and Russell [7].

stochastic increase in r increases the left-hand side of (3) so that the intermediary is more likely to choose $L_0 = L$ and thereby become an asset-transformer. This shift towards asset-transformation occurs even though the expected returns to both types of intermediaries increase with a stochastic increase in r. This shift occurs because the return to asset-transformers rises linearly with r, whereas the broker's rises linearly only for values of $r > C_b$ and remains unchanged for $r < C_b$.

Thus, for any configuration of known borrowing costs, higher and more volatile loan interest rates tend to work in opposing directions in influencing the intermediary's choice of exposure. Higher loan rates increase the tendency towards asset-transformation whereas greater volatility increases the tendency towards brokerage. If, for example, intermediaries evolve towards brokerage with rising inflation, then the effect of increased interest rate volatility must dominate the effects of rising interest rate levels.

III. Cost of Funds Uncertainty

Now suppose the intermediary knows the future lending rate, r, but the future borrowing cost, C_b, is uncertain. The intermediary's expected profit is again given by Equation (1) and optimal $L_0 = L$ if inequality (2) or, equivalently, (3) is satisfied; otherwise, $L_0 = 0$ and the intermediary will choose to be a pure broker, borrowing only if the realized value of C_b is less than r. Arguments identical to those of the previous section permit us to conclude that increased uncertainty regarding C_b leads to more brokerage, but a stochastic increase in C_b leads to more asset-transformation.

To interpret the mean-preserving spread result, note that the broker's marginal profit, $\text{Max}(r - C_b, 0)$, is asymmetric in C_b in the sense that for $r > C_b$ variations in C_b affect expected profit, but for $r < C_b$ variations in C_b leave expected profit unchanged at zero. Although a mean-preserving spread of the probability distribution of C_b increases the probabilities of both higher and lower values of C_b, the effect on the broker's expected profitability is dominated by the increased probability of lower C_b. The broker's expected marginal profit, $E[\text{Max}(r - C_b, 0)]$, therefore increases with a mean-preserving spread of C_b while that of the asset-transformer, $(r - C_a)$, remains unchanged. Consequently, increased uncertainty regarding C_b provides the intermediary with an incentive to provide brokerage services.

However, if the cost of borrowing as a broker, C_b, increases stochastically, i.e., if the probability distribution of C_b shifts to the right, then the broker's marginal profit, $\text{Max}(r - C_b, 0)$, decreases probabilistically while that of the asset-transformer, $(r - C_a)$, remains fixed. The intermediary therefore has an incentive to provide more asset-transformation and less brokerage services.

IV. Conclusion

We have examined a financial intermediary's decision to borrow in advance of realizing all interest rates and interpreted this decision as the choice between functioning as a broker or as an asset-transformer. Stochastic increases in the

loan rate, r, or in the broker's borrowing rate, C_b, are shown to prompt increases in asset-transformation, but increased uncertainty regarding these interest rates results in reduced asset-transformation. Thus, if intermediaries have indeed evolved towards brokerage, under the impetus of rising inflation for example, this evolution cannot be explained by rising interest rate levels. Rather, the effect of increased interest rate volatility must dominate the opposing effect of higher interest rate levels.

These results provide an intuitive understanding of the intermediary's choice of risk exposure, or degree of balance sheet mismatching. Increases in asset-transformation mean greater balance sheet mismatching and risk assumption. Stochastic increases in r and C_b enhance the expected rewards for accepting such exposure; the former increases the expected return to asset-transformers more than to brokers, whereas the latter reduces the broker's expected return and thereby provides an increased incentive for asset-transformation. Mean-preserving spreads in the probability distributions of r and C_b are increases in uncertainty and prompt an adaptive reduction in asset-transformation even though intermediaries are assumed to be risk-neutral expected profit maximizers. The adaptive responses are spurred by asymmetries in the costs (benefits) of interest rate prediction errors. For example, the benefits of realizing a very high r can be partially captured by borrowing additional funds at C_b and lending as a broker when L_0 is chosen too low. However, there is no similar means for limiting the losses due to very low realized values of r, $(r < C_a)$, when L_0 is chosen too high, i.e., $L_0 > 0$. Similarly, realizing very high values of C_b, $(C_b > r)$, is dealt with by simply not lending as a broker, but very low values impose costs to asset-transformation in terms of forgone opportunities to borrow as a broker.

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