Transparency in the Interbank Market and the Volume of Bank Intermediated Loans

by

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Abstract

In this paper we study the equilibrium interaction through which the interbank market is related to the public lending and borrowing market. It turns out that this interaction is affected by the transparency in the interbank market. Interbank market transparency is modeled by means of more informative signals about future interbank rates. We find that more transparency may increase or decrease the volume of bank intermediated loans in the public market. In particular, the impact of more transparency on the volume of loans depends on the curvature of the marginal cost function of the banking firm. Furthermore, we find that expected profits of the bank are higher when the interbank market is more transparent.

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Key words: banking firm, interbank market, interest rate risk, hedging, transparency.

1 Introduction

In the wake of turbulences on financial markets it is often stressed that greater transparency in economic policy and in data on economic and financial developments is critical for a strong and smoothly functioning financial sector. While the notion of transparency underlying such statements remains often vague, it usually refers to disclosure levels and to the quality of disclosure practices of corporations and official bodies. Higher transparency is understood to reduce uncertainty in the decision making of private market participants, thereby permitting actions that are better suited to the circumstances. In the banking literature, transparency is often identified with regulations fostering prudent behavior and accurate information disclosure by financial institutions (Barth et al. (2004), Dangl and Lehar (2004)). Example for such regulations are the Basel accords which have engendered global convergence of capital standards and harmonization of regulatory guidelines for banks.

This paper proposes a theoretical concept of transparency for the interbank market in the banking industry. While our concept of transparency is narrowly defined, it nevertheless captures important informational aspects that appear to be relevant to any meaningful notion of transparency. Based on this concept we study the role of transparency for the equilibrium relationship between the interbank market and the public borrowing and lending market. The interaction between these markets is shaped, to some degree, by the trade of special futures contracts whose equilibrium rate is an unbiased predictor of the future interbank spot rate. Banks use these futures contracts in support of their asset-liability management.

More precisely, our analysis focuses on the activity of a bank in performing a special type of financial intermediation, thereby ignoring some important specificities of other banking activities.[1] In the public borrowing and lending market the bank extends loans to investors and sells deposits to savers at fixed rates. These rates are determined competitively and are not explained by our model. In order to make the balance sheet balance, the bank may need to purchase or sell funds on the

[1] Typically, earnings from financial intermediation account for at least 80 percent of bank profits (see Mercer (1992)).

interbank market. The spot rate on the interbank market is random (Greenbaum and Thakor (1995), Bessis (2002)). Therefore, the bank is exposed to interest rate risk to the extent that fixed rate loans are funded via trading on the interbank market.

The bank has access to a futures market where, in the face of a random interbank rate, it can hedge its risk exposure. The equilibrium rate of the futures contracts is an unbiased predictor of the interbank rate. Therefore, the terms at which futures contracts are traded depend on the 'transparency' of the interbank market.[2] Interbank market transparency is linked to the informativeness of an observable signal which is (imperfectly) correlated with the future interest rate. The signal conveys some noisy information about the unknown interbank rate and, therefore, allows the bank to update its beliefs. The uncertainty to which the bank is exposed when it decides about loans and deposits depends on the observed signal as well as on the information system within which the signal can be interpreted. We characterize the interbank market as more transparent if the signal conveys more precise information about the unknown interest rate. Thus, more transparency means that the interbank rate risk is reduced through the disclosure of more reliable public information.[3]

In this setting, we analyze the equilibrium interaction through which the interbank market is related to the public lending and borrowing market. This interaction is affected by the prices at which trade takes place on the futures market and, hence, by interbank market transparency. We find that more transparency in the interbank market may increase or decrease the loan volume of the banking firm. Which case applies depends on the curvature of the operational marginal cost function: more transparency stimulates (reduces) the bank's loan volume if the *marginal* cost function is concave (convex). By contrast, profitability of the financial intermedi-

[2]The notion of transparency used in this study is adopted from the work by Drees and Eckwert (2003). These authors have characterized market transparency using a criterion which is conceptually related to the literature that emerged from the seminal works by Blackwell (1953), Drèze (1960), and Hirshleifer (1971, 1975).

[3]In practice, this information may be disclosed by official bodies (e.g., government agencies or central banks), by major market participants with high public visibility, or even through endogenous market mechanisms.

ation business always increases with more transparency regardless of technological parameters and of attitudes towards risk as long as the cost function is convex.

The paper is organized as follows. In section 2 we present the bank's decision problem and introduce the concept of transparency which underlies our analysis. Section 3 contains the main results: we characterize the impact of more transparency on the loan volume and on the bank's expected profits. Section 4 concludes the paper.

2 The Model

We consider the model of a competitive banking firm which extends over two periods. The bank is a classical intermediary, selling deposits D and extending loans L on a public market. In producing the loan services the financial intermediary uses a banking technology which can be represented by a cost function $C(L)$. This strictly increasing and convex function describes the cost of managing a volume L of loans.[4] The rate on loans, r_L, and the rate on deposits, r_D, are both fixed and they satisfy $r_L > r_D$.

The equity capital of the bank, K, is assumed to be fixed over the planning horizon. The issue of deposits has to satisfy a capital requirement by regulation, i.e. $K \geq (1/k)D$.[5] The subsequent analysis proceeds on the assumption that the capital requirement constraint is binding. This assumption will be satisfied as long as the rate on loans is sufficiently higher than the rate on deposits. Then the quantity of deposits is a fixed fraction of the bank's equity capital,

$$D = kK. \tag{1}$$

At the beginning of period 0, the bank faces the following balance sheet constraint:

$$L + M = K + D, \tag{2}$$

[4]For simplicity we assume that the sale of deposits does not cause transaction or management costs. This specification can be generalized without affecting the qualitative results in this paper.

[5]$(1/k)$ denotes the required minimum capital-to-deposits ratio. See, for example, Santomero (1984), Wong (1997), Freixas and Rochet (1998).

where M denotes the bank's net position on the interbank market. If M is positive (negative), the bank lends (borrows) on the interbank market. As mentioned earlier, the rate on deposits, r_D, and the rate on loans, r_L, are fixed. Nevertheless the bank faces some uncertainty which stems from a stochastic rate, $\tilde{r}$, on funds borrowed from (or lent to) the interbank market. The tilde refers to the random nature of the spot interest rate rate which assumes values in $\Omega := [\underline{r}, \overline{r}]$, where $0 < \underline{r} < \overline{r} < \infty$.[6] This rate is revealed only at date 1 when all payments are settled.

Thus, as of date 0 when the bank chooses its loan portfolio, the rate $\tilde{r}$ on the interbank market is random. Yet, prior to making the loan decision the bank observes a signal y. This signal is the realization of a random variable $\tilde{y}$ which is correlated with $\tilde{r}$.[7] The signal, therefore, contains information about the unknown interbank rate. In particular, at the time when the bank makes its portfolio decision, the relevant expectation for $\tilde{r}$ is the updated (in a Bayesian way) posterior belief.

The bank has access to an interest futures market where it can hedge the uncertainty associated with its assets or liabilities on the interbank market (Morgan et al. (1988), Greenbaum and Thakor (1995)). The futures market opens at date 0 *after* the signal has been perceived. A futures contract pays r units of currency at date 1. Let H be the forward commitment of the banking firm, i.e., H denotes the number of futures contracts sold by the bank. We assume that the terms of forward contracting are unbiased, which implies that the futures market clears at a futures rate $r_f(y)$ that is equal to the conditional mean of a contract's payoff,

$$r_f(y) = E[\tilde{r}|y]. \tag{3}$$

Both the payoff and the interest rate of the contract fall due in period 1. The timing

[6] A tilde always signifies a random variable. We delete the tilde when referring to a realization of a random variable.

[7] The signal might be interpreted as some noisy information linked to market tightness which becomes known before the interbank market opens. Examples are information about the foreign exchange position of the central bank, indicators of inflationary pressure, and information about fiscal and monetary policy more generally.

of events is as follows (see Figure 1):

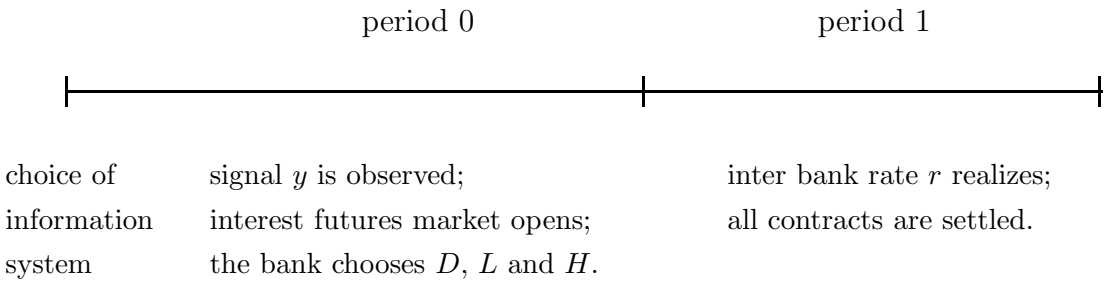

Figure 1

2.1 The Decision Problem of the Bank

The bank maximizes expected utility, defined over random profits,

$$\tilde{\Pi} = r_L L + \tilde{r} M - r_D D - C(L) + H\big(r_f(y) - \tilde{r}\big). \tag{4}$$

$M = D + K - L$ is the net position of the bank on the interbank market. This net position represents the funds which are sold (or purchased, if negative) on the interbank market in order to balance the bank's balance sheet. Profits are realized in period 1 based on the rate r on the interbank market.

Using (1) and (2), profits may be rewritten as

$$\tilde{\Pi} = (r_L - \tilde{r})L + [\tilde{r}(1+k) - r_D k]K - C(L) + H\big(r_f(y) - \tilde{r}\big). \tag{5}$$

The bank's problem may thus be written

$$\max_{L,\,H} E[U(\tilde{\Pi})|y], \tag{6}$$

where $U : \mathbb{R} \to \mathbb{R}$ is a strictly increasing, strictly concave and twice continuously differentiable utility function. The bank maximizes (6) with respect to loan production, L, and forward commitment H. The necessary first-order conditions, which

are also sufficient, are

$$E\big[U'(\tilde{\Pi}^*)\big(r_L - \tilde{r} - C'(L^*)\big)|y\big] = 0, \tag{7}$$

$$E\big[U'(\tilde{\Pi}^*)\big(r_f(y) - \tilde{r}\big)|y\big] = 0. \tag{8}$$

¿From (7) and (8) we obtain the optimal level of loans and the optimal forward commitment as[8]

$$C'(L^*) = r_L - r_f(y), \tag{9}$$

$$H^* = (k+1)K - L^*. \tag{10}$$

Optimal profits are

$$\Pi^* = (k+1)Kr_f(y) - r_D kK + \big(r_L - r_f(y)\big)L^* - C(L^*). \tag{11}$$

Next we define our notion of interbank market transparency. The transparency on the interbank market will be linked to the informational content of the signal y.

2.2 Information Systems and Interbank Market Transparency

We identify the transparency of the interbank market with the 'informativeness' of the signal $y \in Y \subset \mathbb{R}$, which is observed by the bank.[9] The informativeness of the signal depends on the information system within which signals can be interpreted. An information system, denoted by g, specifies for each state of nature, r, a conditional probability function over the set of signals: $g(y|r)$. The positive real number $g(y|r)$ defines the conditional probability (density) that the signal y will be observed if the true (yet unknown) state of nature is r. The bank knows the function $g(y|r)$ by which the signals are generated, given the state of nature. Using Bayes's rule, the bank revises its expectations and maximizes utility on the basis of the updated beliefs.

[8] Condition (10) follows from (8) since, according to (3), the futures market is unbiased.

[9] This concept of transparency is due to Drees and Eckwert (2003). Studying issues of international trade, these authors have applied the concept to markets of foreign exchange.

Let $\pi : \Omega \to \mathbb{R}_+$ be the (Lebesgue-) density function for the prior distribution over Ω. The density for the prior distribution over signals in Y is given by

$$\nu(y) \;=\; \int_\Omega g(y|r)\pi(r)\,\mathrm{d}r \quad \text{for all } y. \tag{12}$$

The density function for the updated posterior distribution over Ω is[10]

$$\nu(r|y) \;=\; g(y|r)\pi(r)/\nu(y). \tag{13}$$

Blackwell (1953) suggested a criterion that ranks different information systems according to their informational contents. Suppose g^1 and g^2 are two information systems with associated density functions $\nu^1(\cdot)$ and $\nu^2(\cdot)$. The following criterion induces an ordering on the set of information systems.

Definition 1 (Informativeness) *Let g^1 and g^2 be two information systems. g^1 is said to be more informative than g^2 (expressed by $g^1 \succ_{\text{inf}} g^2$,), if there exists an integrable function $\lambda : Y^2 \to \mathbb{R}_+$ such that*

$$\int_Y \lambda(y', y)\,\mathrm{d}y' = 1, \tag{14}$$

holds for all $y \in Y$, and

$$g^2(y'|r) = \int_Y g^1(y|r)\lambda(y', y)\,\mathrm{d}y \tag{15}$$

holds for all $r \in \Omega$.

According to this criterion $g^1 \succ_{\text{inf}} g^2$, holds if g^2 can be obtained from g^1 through a process of randomization. The probability density $\lambda(y', y)$ in equation (14) transforms a signal y into a new signal y'. If the y'-values are generated in this way, the information system g^2 can be interpreted as being obtained from the information system g^1 by adding random noise. Note that $\lambda(\cdot, \cdot)$ in (14) is independent of r. Therefore, the signals under information system g^2 convey no information about the value of $\tilde{r}$ that is not also conveyed by the signals under information system g^1.

[10] To simplify notation we distinguish between the functions $\nu(y)$ and $\nu(r|y)$ only by their arguments.

As a consequence, the *a priori* posterior interest rate uncertainty under g^1 will be lower than under g^2.

Our notion of interbank market transparency is based on the informational content of the signal. A signal that conveys information about the future interbank rate affects the economic uncertainty to which the bank is exposed. We characterize the interbank market as more transparent if the signal, y, conveys more precise information about the future interbank rate, r. Thus, higher interbank market transparency implies that interbank rate risk is reduced through the dissemination of more reliable information.

Definition 2 (Interbank Market Transparency) *Let g^1 and g^2 be two information systems for the future interbank rate r. The interbank market is said to be more transparent under g^1 than under g^2, if $g^1 \succ_{\text{inf}} g^2$.*

The following lemma contains a property of information systems that turns out to be a convenient tool for our analysis. The lemma formulates an alternative transparency criterion that is equivalent to the condition stated in Definition 2.

Lemma 1 *The interbank market is more transparent under g^1 than under g^2 if and only if*

$$\int_Y F\big(\nu^1(\cdot|y)\big)\nu^1(y)\,\mathrm{d}y \geq \int_Y F\big(\nu^2(\cdot|y)\big)\nu^2(y)\,\mathrm{d}y$$

holds for every convex function $F(\cdot)$ on the set of density functions over Ω.

A proof of Lemma 1 can be found in Kihlstrom (1984). Note that $\nu^1(\cdot|y)$ and $\nu^2(\cdot|y)$ are the posterior beliefs under the two information systems. Thus, Lemma 1 implies that more transparency (weakly) raises the expectation of any convex function of posterior beliefs. For concave functions, F, the inequality is reversed.

3 Interbank Market Transparency, Volume of Loans, and Profitability

We now turn to the question how the bank's volume of loans on the public market is affected as the interbank market becomes more transparent. The loans decision,

L, is contingent on the signal y. We define the volume of loans, L^v, as the average level of loans before the signal has been observed,

$$L^v = E_y[L(y)] = \int_Y L(y)\nu(y)\,\mathrm{d}y. \tag{16}$$

The following proposition characterizes the impact of more interbank market transparency on the volume of loans in terms of the curvature of the marginal cost function.

Proposition 1 (Loans Volume) *Let g^1 and g^2 be two information systems such that the interbank market is more transparent under g^1 than under g^2. The volume of loans is higher (lower) under g^1 than under g^2, if the marginal cost function $C'(L)$ is concave (convex).*

Proof: In view of (16) and Lemma 1, we have to show that the loans decision, $L(y)$, is convex (concave) in the updated posterior belief $\nu(r|y)$ if $C'(L)$ is a concave (convex) function. By (9), $L(y)$ depends on $\nu(r|y)$ only via the forward rate $r_f(y)$. Since $r_f(y) = E[\tilde{r}|y]$ is linear in the posterior belief $\nu(r|y)$, the loans decision $L(y)$ will be convex (concave) in $\nu(r|y)$ if it is convex (concave) in $r_f(y)$. Obviously, $L(y) = (C')^{-1}(r_L - r_f(y))$ is convex (concave) in $r_f(y)$ if C' is a concave (convex) function. The proof is complete. □

According to Proposition 1, the role of more transparency on the interbank market for the bank's expected level of public loans depends only on the curvature of the marginal cost function. In particular, under the standard specification of decreasing returns to scale, more interbank market transparency may stimulate or depress the volume of loans. If the cost function is quadratic and, hence, the marginal cost function is linear (textbook example), the volume of loans will not be affected by more transparency in the interbank market.

We illustrate this result by comparing two information systems g^1 and g^2, where g^1 is fully informative and g^2 is uninformative. Under the information system g^2, the signal y does not reveal any information about $\tilde{r}$. Thus, the forward rate is equal to the unconditional expectation $\bar{r} := E[\tilde{r}]$, and

$$L^v_{g^2} = (C')^{-1}(r_L - \bar{r}). \tag{17}$$

By contrast, under the information system g^1, the signal reveals the future interbank rate r and, hence, the futures rate is equal to r. In this case (9) is reduced to $C'(L) = r_L - r$ which implies

$$L^v_{g^1} = E[(C')^{-1}(r_L - \tilde{r})]. \tag{18}$$

Using Jensen's inequality, (17) and (18) imply $L^v_{g^1} \overset{(\leq)}{\geq} L^v_{g^2}$ if $(C')^{-1}$ is convex (concave).

The intuition for this result becomes clear if one observes that with more transparency the interbank futures rate becomes more responsive to the signal and, therefore, will be more dispersed: under the uninformative system, g^2, the futures rate does not depend on the signal and, hence, is a constant. Under the fully informative system, g^1, by contrast, the futures rate is just as volatile as the future interbank spot rate. Now, in view of equation (9), more volatility in the futures rate (in the sense of a mean-preserving spread) results in a higher *average* L^* if $C'(L)$ is concave and in a lower *average* L^* if $C'(L)$ is convex.

Next we analyze whether the profitability of the banking business benefits from more interbank market transparency. We use ex ante expected profits as a measure for profitability.

Proposition 2 (Profitability) *Let g^1 and g^2 be two information systems such that the interbank market is more transparent under g^1 than under g^2. Expected bank profits*

$$E(\tilde{\Pi}) = \int_Y \Pi(y)\nu(y)\,\mathrm{d}y \tag{19}$$

are higher under g^1 than under g^2.

Proof: Proceeding along the same lines as in the proof of Proposition 1 we need to show that

$$\begin{aligned} \Pi(y) &= r_f(y)(k+1)K - r_D k K \\ &+ \big(r_L - r_f(y)\big)(C')^{-1}\big(r_L - r_f(y)\big) - C\big((C')^{-1}(r_L - r_f(y))\big) \end{aligned} \tag{20}$$

is a convex function of $r_f(y)$. Differentiating (20) with respect to $r_f(y)$ yields

$$\frac{\partial \Pi(y)}{\partial r_f(y)} = (k+1)K - (C')^{-1}(r_L - r_f(y)). \tag{21}$$

The convexity of the cost function implies that $(C')^{-1}(\cdot)$ is monotone decreasing in $r_f(y)$. Therefore, (21) yields the convexity of the profit function in the interbank forward rate $r_f(y)$. □

According to Proposition 2, expected bank profits increase with more interbank transparency regardless of attitudes towards risk and of technological parameters, as long as the cost function is convex. To gain an intuitive understanding of this result, note that the pricing of futures contracts is conditioned on more information, if the interbank market becomes more transparent. Thus, more volatile equilibrium futures rates are a main consequence of higher interbank market transparency. However, expected bank profits increase in the variability of futures rates: the bank has an option to take funds from the interbank market and lend them on the public market, earning a spread of $(r_L - r_f(y))$ at a cost (strike price) of $C'(L)$ for each incremental loan. Clearly, the value of this option is increasing in the volatility of the spread $(r_L - r_f(y))$ (cf. Black and Scholes (1973), Drees and Eckwert (1995)).

The results in Propositions 1 and 2 do not necessarily confirm the common view according to which transparency promotes economic efficiency: while the banking sector gains from more transparency on the interbank market, the economy as a whole may not. This is because higher transparency may stifle the process of financial intermediation, thereby reducing the volume of loans being extended to investors. These findings need to be interpreted cautiously for at least two reasons. Firstly, they have been derived in a partial equilibrium setting and may not survive without modification in full equilibrium.[11] And secondly, the volume of extended loans is, at best, a rather crude indicator for economic efficiency. Obviously, extending the analysis to a full equilibrium framework is an important task for the future.

[11] In a different context, the role of information in full equilibrium has been investigated by Eckwert and Zilcha (2003, 2004), Orosel (1996), Schlee (2001), and others. The papers by Eckwert and Zilcha and by Schlee focus on the welfare implications of more informative systems. Some of the techniques used in this paper have been borrowed from Eckwert and Zilcha (2001).

4 Concluding Remarks

This paper has proposed a notion of interbank market transparency that was shown to be workable in a concrete model of financial intermediation. Based on this transparency concept, the equilibrium interaction between the interbank market and the public lending and borrowing market has been investigated. Interbank market transparency was defined in terms of the informativeness of a signal that conveys some information about the random interbank spot rate. Thus, when the interbank market becomes more transparent, pricing of futures contracts is conditioned on more information and, therefore, futures rates become more volatile. Our study relates in one common framework the hitherto unrelated issues of lending and borrowing volumes, futures rate volatility, and interbank market transparency. Two main results follow from our analysis: more transparency in the interbank market increases expected bank profits, but does not necessarily stimulate the loan volume in the public market. The loan volume increases (declines) due to more market transparency, if the bank's marginal cost function is concave (convex).

Our analysis can be extended along several lines. Most importantly, a generalization of the partial equilibrium character of the results would be highly desirable. In full equilibrium the loan amounts chosen by different banks at date 0 typically have some impact on the interbank rate $\tilde{r}$ at date 1. Also the assumption of a perfectly competitive banking sector might be replaced with a description which is closer to reality where we often see few large players in many markets. In such more general settings, presumably not all banks would be able to be perfectly hedged unless some other types of traders are introduced into the model. This raises the question what market structure in an equilibrium model would yield an equivalent solution to each bank's problem as the one we have presented here.

Our proposed concept of transparency can also be applied to credit risks rather than (or, in addition to) uncertainties about interbank rates. Taggart and Greenbaum (1978) and Wong (1997) have suggested modeling techniques for credit risks which can be combined with our concept of transparency. In such a setting more transparency would strengthen the ability of banks to differentiate between good and bad risks within the pool of loan applicants. We leave this interesting appli-

cation of our transparency concept to the financial intermediation process in the banking industry for future research.

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