What drives pricing in interbank markets?

Christoph Siebenbrunner [1,2], Michael Sigmund[3]
christoph.siebenbrunner@maths.ox.ac.uk michael.sigmund@oenb.at

[1]Institute for New Economic Thinking
Oxford Martin School

[2]Mathematical Institute
University of Oxford

[3]Oesterreichische Nationalbank

Conference on Network Models and Stress Testing

Disclaimer

The views expressed herein are those of the authors and do not necessarily reflect those of the OeNB or the Eurosystem.

Introduction

- Our goal is to build a model to understand the drivers price formation on interbank markets
- We observe several features of interbank markets that we need to be able to explain:
  - **Different rates for loans and deposits**: we observe price differences for the two sides of the market in an open system.
  - **No "law of one price"**: different banks pay and demand different rates, and the differences are not explained by cost of risk alone.
  - **Interbank market is more than a liquidity pool**: we observe banks that are active on both sides of the market for the same maturities, i.e. they do not only use it to obtain or park excess liquidity.

Model

Assumptions:

- Interbank market clears after regular loan market
- Bertrand competition - optimization via prices
- Banks optimize their profits from interbank business:

$$\max_{p_L, p_D} \Pi = p_L^i * q_L^i - p_D^i * q_D^i$$

Subject to a balance sheet condition:

$$L_i + q_L^i = D_i + E_i + q_D^i$$

p_L^i, q_L^i	... Prices and quantities of interbank lending
p_D^i, q_D^i	... Prices and quantities of interbank deposits
L_i	... Loans and other non-interbank assets
D_i	... Deposits and other non-interbank liabilities
E_i	... Equity

Model

We assume local Bertrand demand functions:

$$q_D^i = a_D^i + a_D X_D^i + b_D p_D^i - c_D p_D^{-i}$$

$a, b \dots$ Elasticity coefficients

$$q_L^i = a_L^i + a_L X_L^i - b_L p_L^i + c_L p_L^{-i}$$

$X \dots$ Control Variables

- Local demand → differentiated Bertrand game
- Consistent with both 'intermediation' and 'money creation' views of banking
- Demand function for deposits under 'money creation' view justified with deposit outflows

Model - Equilibrium

Theorem

There exists a $2 \times N$ matrix $\begin{pmatrix} P_L^* \\ P_D^* \end{pmatrix}$ of loan and deposit prices that constitutes a Nash equilibrium for the Bertrand interbank game described by the optimization problem and the demand and supply functions with players $i = 1, 2, 3, ..., N$ such that for each bank i there exists a vector $p_i^* = \begin{pmatrix} P_{L,i}^* \\ P_{D,i}^* \end{pmatrix}$ satisfying the balance sheet condition $L_i + q_L^i(p_{L,i}^*) = D_i + E_i + q_D^i(p_{D,i}^*)$.

Model - Solution

From the optimisation problem, we derive the following structural equations for interbank prices:

$$b_L p_L^i = \overbrace{L_i - D_i - E_i}^{\text{Funding gap}} + \overbrace{a_L^i - \lambda b_D}^{\text{Fixed effect}} + \overbrace{a_L X_L^i + c_L p_L^{-i}}^{\text{Exogenous drivers}} + \overbrace{b_D p_D^i}^{\text{Interaction term}}$$

$$b_D p_D^i = \overbrace{L_i - D_i - E_i}^{\text{Funding gap}} - \overbrace{a_D^i - \lambda b_L}^{\text{Fixed effect}} - \overbrace{a_D X_D^i + c_D p_D^{-i}}^{\text{Exogenous drivers}} + \overbrace{b_L p_L^i}^{\text{Interaction term}}$$

From Theory to the Empirical Approach

We want to estimate the reduced form of the simultaneous equation system derived from our model:

$$\begin{pmatrix} p_{S,t} \\ p_{D,t} \end{pmatrix} = f \begin{pmatrix} p_{D,t} \\ p_{S,t} \end{pmatrix}$$

- We consider the **simultaneity** of deposit and loan rates a main conclusion from our model
- We run several statistical tests to check whether this theoretical prediction is confirmed empirically

From Theory to the Empirical Approach

- We use data on the entire Austrian banking system
- We use interest rates on interbank loans as prices
- We proxy the average competitors' loan rate (p_S^{-i}) and deposit rate (p_D^{-i}) using reference rates to avoid further endogeneity problems.
- In addition, we control for a number of other potential drivers:
  - Creditworthiness of borrowing banks
  - Relationship lending: the prevalence of relationship lending in interbank markets has been observed in previous literature
  - Size: in imperfect markets, size could confer market power
  - Network centrality: it has been noted by several authors that the position in the interbank network may affect prices as well

Control variables

- **Reference Interest Rates**:
  Deposit rate: 3-month EURIBOR
  Loan rate: 10y Austrian government bond yield
- **Creditworthiness**:
  Deposit rate: "consensus" PD inferred from bilateral ratings
  Loan rate: average risk weight
- **Relationship lending**:
  Existence of long-standing lending arrangements within banking sectors. We control for the share of lending/funding within the same sector.
- **Size**: Total Assets
- **Network centrality measures**:
  Computed for the network of interbank liabilities (deposit rate) and holdings (loan rate)
  - Degree centrality
  - Betweenness centrality
  - Eigenvector centrality
  - Harmonic centrality
  - Katz centrality
  - PageRank

Econometric setup

We estimate a simultaneous equation system using 2SLS and 3SLS:

$$Y_{i,t} = \alpha_i + BX_{i,t} + U_{i,t}$$

$$Y_{i,t} = \begin{pmatrix} \text{Deposit Rate}_{i,t,1} \\ \text{Loan Rate}_{i,t,2} \end{pmatrix}, \quad B^\top = \begin{pmatrix} \alpha_1 & \alpha_2 \\ 0 & \beta_{2,1} \\ \beta_{1,2} & 0 \\ \beta_{1,3} & \beta_{2,3} \\ \beta_{1,4} & 0 \\ 0 & \beta_{2,5} \\ \beta_{1,6} & 0 \\ 0 & \beta_{2,7} \\ \beta_{1,8} & 0 \\ 0 & \beta_{2,8} \\ \beta_{1,9} & 0 \\ 0 & \beta_{2,9} \end{pmatrix}, \quad X_{i,t} = \begin{pmatrix} \mathbf{I} \\ \text{Loan Rate} \\ \text{Deposit Rate} \\ \text{Total Assets} \\ \text{Funding-Sector} \\ \text{Lending-Sector} \\ \text{STI} \\ \text{LTI} \\ \text{PD} \\ \text{Risk Weight} \\ \text{[NW\_Owing]} \\ \text{[NW\_Holding]} \end{pmatrix}$$

Results

Benchmark model (without network centralities) for deposit rate:

McElroy R^2	Loan rate	Total Assets	Funding gap	Sector Share	STI	PD
0.7777	-0.1011 ***	-0.1099 ***	-0.0016 ***	0.001 ***	0.5008 ***	-0.0237 *

Benchmark model (without network centralities) for loan rate:

McElroy R^2	Deposit rate	Total Assets	Funding gap	Sector Share	LTI	Risk weight
0.7777	1.1672 ***	0.2745 ***	-0.0046 ***	-8e-04 **	0.2356 ***	0.0116 ***

We include each of the network centrality measures one-by-one in the benchmark model

- We compare the quality of the models using Hansen's overidentification test
- The results show that Betweenness centrality is the best centrality measure

Results

- We run a series of tests, which confirms the theoretical prediction of the simultaneous determination of loan and deposit rates:
  - Quality of instruments (F-test): all instruments are relevant
  - Exogeneity of instruments (J-test and Lagrange multiplier test): all instruments are exogenous
  - Endogeneity of the RHS endogenous variables (Durbin-Hausman-Wu test): endogeneity is confirmed
  - Whether 3SLS is preferable to 2SLS (System overidentification test): 3SLS is preferable for all models
- We estimate 42 different models for both equations using different combinations of network centralities
- All results are robust regarding the size, sign and standard errors of coefficients

Results

We perform an equation-by-equation fixed effects estimation to quantify the simultaneity bias

- The results show that the interbank spread would be underestimated by over 50%, causing the sign to switch
- The coefficients of several network centralities would be biased, causing the sign to switch for several centralities

Benchmark model (without network centralities) for deposit rate:

Method	Loan rate	Total Assets	Funding gap	Sector Share	STI	PD
SEM	-0.1011 ***	-0.1099 ***	-0.0016 ***	0.001 ***	0.5008 ***	-0.0237 *
FE-OLS	0.0758 ***	-0.0455	-0.0019 ***	0.0011 ***	0.3767 ***	-0.0155

Benchmark model (without network centralities) for loan rate:

Method	Deposit rate	Total Assets	Funding gap	Sector Share	LTI	Risk weight
SEM	1.1672 ***	0.2745 ***	-0.0046 ***	-8e-04 **	0.2356 ***	0.0116 ***
FE-OLS	0.529 ***	0.1216 ***	-0.0052 ***	-7e-04 **	0.4025 ***	0.0102 ***

Conclusion

- We develop a model that is able to explain several observed features of the interbank market
- The model predicts simultaneity of loan and deposit rates, which is confirmed in empirical estimations using Austrian data
- We test several network centralities and find that Betweenness is the best centrality measure for the Austrian interbank market
- Estimating the model without accounting for the simultaneity would cause the coefficients of the network centralities to be biased and even have the wrong sign in several cases