SYSTEMIC RISK IN THE INTERBANK MARKET AND PREVENTIVE POLICIES

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ABSTRACT

We provide the first systematic study of US interbank market organization using an empirical approach unlike previous studies which use rules to classify groups according to their transactions. We determine the drivers of interbank activity and analyze differentiation of interbank activity by tier. We find that three-tier interbank market structure provides a more appropriate explanation of the US interbank activity and its factors than an alternative core-periphery structure. While both three-tier and core-periphery organization models moderate interbank activity, the three-tier structure detects distinct operational characteristics for tier 2 which are not illustrated in the core-periphery model. Using these results we construct a simulation model and estimate the effectiveness of several default resolution methods in addition to a capital policy.

Keywords: interbank market; intermediation; market structure; simulation; cluster analysis; SEM.

JEL classification: C30, C38, C52, E44, G10, G21, L14

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1. INTRODUCTION

The interbank market links different species of financial intermediaries by a sophisticated network of multilateral exposures where various risky activities of some institutions are financed using funds borrowed from others. Specifically, small financial intermediaries use customer deposits to make loans to large universal intermediaries that depend on wholesale short-term funds to finance a gamut of risky activities. As the value of financial assets falls, financial institutions experience increased difficulty in repaying current obligations, raising funds, and remaining solvent and liquid. Furthermore, through these linkages, failed obligations of some institutions lead to distress and losses in other institutions, markets, and economic sectors (Acharya and Yorulmazer, 2008; Iyer and Peydro, 2011; Tedeschi et al., 2012).

The problem of contagion in the interbank market has been established as a source of significant levels of systemic risk (Freixas et al., 2000; Allen and Gale, 2000; Furfine, 1999) well before the Global Financial Crisis of 2007. However, the problem is compounded viciously by structural changes occurring in the market. As the interbank structure changes, so does the pattern of systemic risk generation (Nier et al., 2007; Battiston et al., 2012a; Lenzu and Tedeschi, 2012; Georg, 2013; and Sachs, 2014). Consequently, policies targeted at mitigating systemic risk need to account for the evolving structure of the network. We refer the reader to Allen and Gale (2007), Teteryatnikova (2009), Acharya et al. (2012), and Capponi and Chen (2013) for a more complete discussion in this regard. Hence, interbank market connections constitute an important source of systemic risk (Rochet and Tirole, 1996) and need to be carefully analyzed.

This paper is the first to analyze the structure of the US interbank market through an empirical data analysis directed at aggregate balance-sheet positions instead of bilateral exposure data. By supporting a tiered identification of the interbank market, we seek to motivate and assist the incorporation of actual market structure into theoretical and simulated financial contagion models. We contribute three main findings. We demonstrate that the moderating effect of market structure on interbank activity results is significantly different behavior between the tiers. Second, we find that the three-tier partition marginally outperforms the core-periphery partition in explaining interbank market activity and achieves moderately superior fit than the core-periphery model. Using the data calibrated network we develop a network simulation study showing that the method of liquidating defaulting banks and implementation of capital based policy has a material effect on the ability of a system to withstand shocks.

The rest of this paper is structured as follows. Section 2 discusses our research design, methods and data. Section 3 proposes falsifiable hypotheses regarding the structure of the interbank market and the principal functions of financial intermediaries relying on this market. Section 4 examines the results of cluster analysis to identify interbank market tiers, the results of exploratory and confirmatory factor analysis (EFA and CFA) to locate and measure several ideas concerning bank health, and the results of structural equation modeling (SEM) to support hypotheses concerning the drivers of interbank market activity empirically. Section 5 presents the results of the simulation model used to analyze systemic risk. Section 6 concludes with a discussion of the implications of this study for future research.

2. RESEARCH DESIGN

This study is undertaken in two stages outlined in Figure 1. We begin with an empirical phase to analyze the structure of the interbank market and how this structure affects interbank funding activity. These results are then used in a simulation phase to conduct policy experiments testing preventive policy options for various sources of systemic risk.

2.1. Empirical research

Research questions. Our study aims to answer the following questions. What is the structure of the US interbank market? What factors in financial intermediation explain interbank market activity? How and to what extent do these factors and the interbank market structure interact? How does interbank market structure affect the systemic risk policies of resolution of banks in default and the implementation of capital requirements?

Conceptual map. Figure 1 shows the conceptual model guiding the empirical research in sections 3 and 4. The figure suggests that interbank market activity can be explained in terms of two remote antecedent factors of the change in liquidity and economic conditions mediated by performance reflecting factors such as the change in leverage, change in return, and growth. Furthermore, we posit in this model that the effect of interbank market structure can be tested as a moderator of each relationship. Thus, the model consists of financial performance as mediator of the relationship between economic conditions and change in liquidity with interbank lending and borrowing recognizing potential multi-group moderation by interbank market structure.

Insert Figure 1 about here

Data. The dataset consists of balance sheet data drawn from the quarterly Federal Reserve Call Reports (031 and 041) between 3/31/1992 and 6/30/2014, supplemented by economic and monetary policy series from the Board of Governors releases H.6, H.15, and several series from Federal Reserve Economic Data (FRED). We collect the balance sheet data from the US commercial banks, aggregated to the bank holding company level, for the top 100 bank holding companies by total assets as of 6/30/2014. This dataset does not include direct interbank bilateral exposure data, but only the aggregate positions of each firm at the end of each quarter as represented on balance sheets. A limitation of using commercial bank balance sheet data is that we will not be analyzing a closed system since there are other interbank market participants (credit unions, etc.) not included in our dataset.

The collected data comprises a 30-item scale combining the balance sheet stocks, balance sheet flows, and macroeconomic conditions. There are seven series we associate with the change in liquidity—change and growth in cash to liabilities, change and growth in cash equivalents to total expense, change in reserves, change in cash equivalents, and growth in short term liquidity to assets. There are four leverage series—change and growth in liabilities to assets, and change and growth in assets to capital. There are four growth series—growth in total assets, growth in total liabilities, growth in deposits, and growth of the mismatch between assets and liabilities maturing in the next six months. There are four series reflecting the change in return— change in pre- and post-tax return on equity, and change in pre- and post-tax return on assets. There are four economic conditions series—inflation measured by personal consumption less energy and food, output measured by real GDP, money supply measured by M2, and the natural rate of unemployment. There are four series describing the growth in securities—change and growth in securities available for sale, change and growth in total securities to total assets. There are three profitability growth series—growth in interest income to average assets, growth in the net interest margin, and growth in revenue to average assets.[7]

Methods. We use cluster analysis to determine potential grouping of our population of banks into distinct tiers. We employ the two-step methodology proposed by Chiu et al. (2001) which extends the BIRCH algorithm developed by Zhang, Ramakrishnan, Livny (1996). The distance measure between two clusters (or observations) is related to the decrease in the log-likelihood function as they are combined into one cluster under the assumption that continuous

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[7] Growth in securities and profitability growth are analyzed for the purpose of exploratory and confirmatory factor analysis; however, they are not included in the structural equation model.

variables follow the normal distribution. It is also assumed that variables and observations are independent. Appendix A provides the mathematical details for cluster analysis.

We apply exploratory factor analysis (EFA) (Gorsuch, 1983: 2) to investigate whether the observed variables are adequately correlated and meet criteria of reliability and validity in an effort “to summarize the interrelationships among [them] in a concise but accurate manner as an aid in conceptualization.” Since EFA does not incorporate a priori intuition about how latent factors should be grouped, it is appropriate for an initial investigation of the effect that latent factors may exert on observable measures. To differentiate latent patterns among correlated items, we examine the factor structure extracted via principal component analysis with promax rotation (Fabrigar et al., 1999). We review the adequacy of longitudinal data for factor analysis in Appendix B, following the Anderson (1963), Geweke (1977), Stock and Watson (2011) recommendations that factors and idiosyncratic residuals may not exhibit serial correlation.

The resulting seven-factor measurement model suggested by the EFA is estimated using AMOS (Analysis of Moment Structures) software v22.0, a covariance-based structural equation modeling technique using the maximum likelihood estimation approach. In this approach, the properties of each latent construct are estimated simultaneously via a set of bivariate correlations in one confirmatory factor analysis (CFA) model according to equations (1) - (3). These equations explain how the observable variables $\mathbf{x}_i$ and $\mathbf{y}_i$act as indicators of the exogenous and endogenous latent factors $\boldsymbol{\xi}$ and $\boldsymbol{\eta}$.The vectors $\boldsymbol{\xi}$ (n x 1) and $\boldsymbol{\eta}$ (m x 1) of latent factors are proposed as a result of EFA and supported through CFA. The vectors $\mathbf{x}$ (q x 1) and $\boldsymbol{y}$ (p x 1) are composed of observed variables, $\boldsymbol{\Lambda}_{\boldsymbol{x}}$ (q x n) and $\boldsymbol{\Lambda}_{\mathbf{y}}$ (p x m) are the coefficient matrix describing the relationships of $\mathbf{x}$ to $\boldsymbol{\xi}$ and $\boldsymbol{y}$ to $\boldsymbol{\eta}$. Finally, the measurement errors for $\mathbf{x}$ and $\boldsymbol{y}$ are given by $\boldsymbol{\delta}$ (q x 1) and $\boldsymbol{\epsilon}$ (p x 1), assumed to be uncorrelated with $\boldsymbol{\xi}, \boldsymbol{\eta}$ and each other with expected values of zero. The coefficient matrix $\boldsymbol{B}$ (m x m) shows the effect of endogenous variables on each other such that $(\boldsymbol{I}-\boldsymbol{B})$ is nonsingular.

$$\boldsymbol{x} = \boldsymbol{\Lambda}_{\mathbf{x}}\boldsymbol{\xi} + \boldsymbol{\delta} \tag{1}$$

$$\boldsymbol{y} = \boldsymbol{\Lambda}_{\boldsymbol{y}}\boldsymbol{\eta} + \boldsymbol{\epsilon} \tag{2}$$

$$\boldsymbol{\eta} = \boldsymbol{B}\boldsymbol{\eta} + \boldsymbol{\Gamma}\boldsymbol{\xi} + \boldsymbol{\zeta} \tag{3}$$

In pursuit of a better understanding of interbank activity, we draw upon the empirical associations of interbank activity, bank specific factors, economic conditions, and market structure to seek causal interpretation (Pearl, 2012) through a structural equation modeling (SEM) approach (Bollen, 1989). We conceptualize the mechanism that explains the effect on interbank activity from antecedents (the change in liquidity and economic conditions) as mediated by the factors of financial performance. We thus theorize first, that it is what the financial intermediaries do in response to economic conditions and their change in liquidity that conditions the amount of interbank lending and borrowing; and, second, that interbank market structure moderates the strength of specific channels for the interbank activity mechanism.

Therefore, our structural model can be conceptualized according to equations (1) - (3) following the notation of Bollen (1989) which uses the LISREL method of operating on demeaned variables, removing the need to incorporate intercept terms. The latent variables $\boldsymbol{\xi}$ and $\boldsymbol{\eta}$ are used (alongside exogenous variables $\boldsymbol{z}$ (r x 1)) to estimate a vector of observable variables $\boldsymbol{q}$ (s x 1) through the transformation matrices $\mathbf{E}_{\mathbf{z}}$ (s x r), $\mathbf{E}_{\boldsymbol{\xi}}$ (s x n), and $\mathbf{E}_{\boldsymbol{\eta}}$ (s x m).[8] The disturbance term in equation (4) is given by vector $\boldsymbol{\varsigma}$ (s x 1), assumed to be uncorrelated with $\boldsymbol{\xi}$, $\boldsymbol{\eta}$, and $\boldsymbol{z}$ with zero mean:

[8] In this analysis $\boldsymbol{q}$ represents a vector containing relative interbank borrowing and lending which were not considered in CFA for the construction of a latent factor and $\boldsymbol{z}$ represents a vector containing exogenous variables not included in the measurement model (namely, the effective federal funds rate).

$$\boldsymbol{q} = \mathbf{E}_{\mathbf{z}}\boldsymbol{z} + \mathbf{E}_{\boldsymbol{\xi}}\boldsymbol{\xi} + \mathbf{E}_{\boldsymbol{\eta}}\boldsymbol{\eta} + \boldsymbol{\varsigma} \tag{4}$$

2.2. Simulation framework

Having established a structural model for the interbank market, this paper applies it to construct a simulation model within which regulatory policies may be implemented and compared numerically. The model is initialized with N firms, denoted $n \in \{1, \dots, N\}$ and a lender of last resort denoted institution 0. These firms are partitioned into K tiers which interact according to predetermined rules through the interbank market. Each bank faces random changes in deposits, random returns on a risky portfolio of investments, and the possibility of underpayment by counterparties in the interbank market over the course of T periods. The remainder of this section will outline the balance sheets of simulated entities and develop a model bank activity flexible enough to handle policy. The following definitions and notation are used throughout the paper:

- $r_{m,n}^t$: lending rate offered by entity n lending to m at t;
- $r_{n,0}^t$: rate at which the lender of last resort lends to bank n at t;
- p_n^t : payment made by entity n at t;
- $\tilde{b}_n^t$: interbank borrowing of entity n due at t;
- b_n^t : interbank borrowing of entity n at t which is due at t+1;
- $\tilde{l}_n^t$: interbank lending of entity n due at t;
- l_n^t : interbank lending of entity n at t which is due at t+1;
- $B_{m,n}^t$: amount that entity m borrowed from n at t;
- $\tilde{B}_{m,n}^t$: amount that entity m must pay n due at t;

• $C_{m,n}^{t}$: value of entity m's investments at time t that entity n holds as collateral on borrowing due at t+1;

• $\tilde{C}_{m,n}^{t}$: value of entity m's investments at time t that entity n holds as collateral on borrowing due at t;

• $\tilde{C}_{m,n\_k}^{t}$: value of entity m's investments at time t that entity n intends to keep as part of clearing the interbank market to compensate it for any deficiency in m's cash payment;

• $\tilde{C}_{m,n\_r}^{t}$: value of entity m's investments at time t that entity n intends to return as part of clearing the interbank market (n returns any collateral value above the cash payment and collateral value kept);

• S_{adj}^{t} : matrix which enforces assumptions about the structure of the interbank market to determine which nodes are allowed to interact;

• A_n^t : total assets of entity n at t;

• c_n^t : cash equivalents of entity n at t;

• ξ_n^t : portfolio of risky investments of entity n at t;

• ρ_n^t : reserves of entity n at t held with the lender of last resort;

• L_n^t : total liabilities of entity n at t;

• r_ρ : rate paid on reserves;

• δ_n^t : deposits of n at t;

• r_δ : rate paid on deposits;

• κ_n^t : capital of n at t;

• $Rank_n^t$: asset based rank of n at t.

Balance sheet structure. The balance sheets of simulated entities in this model are simplified to allow ease of computation and facilitate interpretation of the results. We consider total assets as the sum of cash equivalents, a portfolio of risky investments, short term interbank lending, and reserves. The reserve account contains cash equivalent assets held to meet regulatory requirements and as such these funds are unavailable for the purpose of paying off liabilities or investing.

Total liabilities are formed from deposit funds, and interbank borrowing. The difference between assets and liabilities is naturally the bank's book capital:

$$A_n^t = c_n^t + \xi_n^t + \tilde{l}_n^t + \rho_n^t \tag{5}$$

$$L_n^t = \delta_n^t + \tilde{b}_n^t \tag{6}$$

$$\kappa_n^t = A_n^t - L_n^t \tag{7}$$

The interbank liabilities are developed along the lines of Eisenberg and Noe (2001) with the additional consideration of collateral. The lending and borrowing of each bank n in the interbank market is given by equations (8) and (9) where $\mathrm{r}_{\mathrm{a,b}}^{\mathrm{t-1}}$ is the rate that b charges a to borrow $\mathrm{B}_{\mathrm{a,b}}^{\mathrm{t-1}}$ in the previous time period.

$$\tilde{l}_n^t = \sum_{i=0}^{N} \left(1 + r_{i,n}^{t-1}\right) B_{i,n}^{t-1} = \sum_{i=0}^{N} \tilde{B}_{i,n}^t \tag{8}$$

$$\tilde{b}_n^t = \sum_{i=0}^{N} \left(1 + r_{n,i}^{t-1}\right) B_{n,i}^{t-1} = \sum_{i=0}^{N} \tilde{B}_{n,i}^t \tag{9}$$

Bank conditions and liquidation. While purpose and properties of each account will be developed further as the mechanics of this model are developed, it is expedient to mention the regulatory restrictions at this point. We incorporate two regulatory ratios: the capital to asset ratio (10), and the reserve to deposit ratio (11).

$$\frac{\rho_n^t}{\delta_n^t} > \bar{\rho}^t \tag{10}$$

$$\frac{\kappa_n^t}{a_n^t} > \bar{\kappa}^t \tag{11}$$

If bank n does not meet the reserve to deposit requirement (equation (10) is false) then entity n is classified as under-reserved. A bank may become under-reserved if it experiences an inflow in deposits and yet it is unable to allocate sufficient cash to increase reserves. If bank n does not meet the capital to asset requirement (equation (11) is false) then entity n is classified as under-capitalized. Upon incurring a loss in the risky investment a bank will experience a decrease in its capital to asset ratio which may result in an under-capitalized classification. Additionally, bank n is classified as insolvent if it has non-positive capital:

$$\kappa_n^t \leq 0 \tag{12}$$

For our purposes a bank is liquidated when it meets any of the following conditions:

- The bank is insolvent;
- The bank is under-reserved for two consecutive periods;
- The bank is under-capitalized for two consecutive periods;
- The bank fails to repay its obligations to debtors in the interbank market;
- The bank fails to repay depositors.

Simulation model development. The simulation model can be conceptually divided into several stages, each of which completes a different set of tasks. We propose that each time period consider the following stages: 1) Updating, 2) Clearing, 3) Regulation, 4) Liquidation, and 5) Asset Allocation. These stages are addressed in the designated order for each period where the timeframe of interest [0,T) is divided into T discrete intervals $[t, t+1)$, $t \in \{0,1,\ldots,T-1\}$. An important simplifying assumption is that at any point in each stage, banks may liquidate at no penalty as much of their risky portfolio as necessary or, conversely, they can invest more funds in the risky investment. This allows the model to focus on the impact of policy without (at present) becoming bogged down in issues of cash management. For instance, it is implicitly assumed that if an expense or payment is required which exceeds the cash account (such as paying deposit interest, interbank payments, or adjustments to meet regulatory requirements) then a portion of the risky investment portfolio is liquidated to provide the necessary funds.

Stage 1: Updating. The first task is to determine the tier that each bank belongs to using a membership function based upon interbank activity defined according to equation (13). The interbank network consists of a heterogeneous tiered-network of insured and capitalized commercial banks engaged in short-term borrowing and lending in the interbank funding market and to/from a lender of last resort (LOLR). Membership to tiers depends on the activity in the market and institution size, as follows. For each entity n and time t, we have

$$Tier_n^t = f(Rank_n^t, A_n^t, \tilde{l}_n^t, \tilde{b}_n^t)^9 \tag{13}$$

At the beginning of time t we update the deposit account to reflect the random inflow of depositors after accounting for deposit interest. We assume that deposits change follows a straightforward random walk and that deposit interest is paid out as cash expense to depositors on the average deposit balance between t and t-1 leading to equations (14) and (15)[10]

$$Dep.Int.Exp. = \left(\frac{\delta_n^t + \delta_n^{t-1}}{2}\right) r_\delta \tag{14}$$

$$\delta_n^t = \delta_n^{t-1} e^{\left[\left(\mu_\delta - \frac{\sigma_\delta^2}{2}\right) + \sigma_\delta \epsilon\right]} \qquad where\ \eta \sim N(0,1) \tag{15}$$

The second account subject to a random return is the portfolio of risky investments which earn a return or suffer a loss following equation (16). We currently assume that returns of banks m and n are uncorrelated for all m, n and that banks have uniform preferences when constructing the portfolio of assets they hold.[11]

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9 The structural evidence for tiering of the US interbank funding market is discussed in Section 4.1

10 While in the model we have assumed that banks pay out the interest expense in cash to depositors, during parameterization we instead assume that the deposit interest is added to the deposit account. Therefore, we first calculating $\delta_n^t = \delta_{r\_n}^t - \left(\frac{\delta_{r\_n}^t + \delta_{r\_n}^{t-1}}{2}\right) r_{\delta,n}^t$ based on the reported values of $\delta_{r\_n}^t$, $\delta_{r\_n}^{t-1}$, and $r_{\delta,n}^t$; then using equation (10) we are able to estimate μ_δ and σ_δ for our population of banks.

11 A straightforward enhancement to this model would allow heterogeneous risk preferences based upon returns earned by individual banks. Additionally, while returns are currently independent it would be interesting to incorporate herding as a non-constant correlation between portfolio returns which could be used to simulate valuation shocks as particular asset classes change to reflect more accurate information, such as the dramatic system wide re-valuation of MBS assets during the 2007-2008 financial crisis.

$$\xi_n^t = \xi_n^{t-1} e^{\left(\mu_\xi - \frac{\sigma_\xi^2}{2}\right) + \sigma_\xi^2 \eta} \qquad \text{where } \eta \sim N(0,1) \tag{16}$$

We also assume that the central bank pays interest on reserves at rate r_ρ and attribute accrued interest to the interbank liabilities so that we update the remaining balance sheet accounts for each bank according to:

$$l_n^{t-1} \rightarrow \tilde{l}_n^t \text{ and } b_n^{t-1} \rightarrow \tilde{b}_n^t \tag{17}$$

$$c_n^t = c_n^{t-1} + \Delta\delta_n^t - \left(\frac{\delta_n^t + \delta_n^{t-1}}{2}\right) r_\delta + \rho r_\rho \tag{18}$$

$$A_n^t = A_n^{t-1} + \Delta\delta_n^t - \left(\frac{\delta_n^t + \delta_n^{t-1}}{2}\right) r_\delta + \rho r_\rho + \xi_n^{t-1}\left(e^{\left(\mu_\xi - \frac{\sigma_\xi^2}{2}\right) + \sigma_\xi^2 \eta} - 1\right) + \left(\tilde{l}_n^t - l_n^t\right) \tag{19}$$

$$L_n^t = L_n^{t-1} + \Delta\delta_n^t + (\tilde{b}_n^t - b_n^t) \tag{20}$$

$$\kappa_n^t = A_n^t - L_n^t \tag{21}$$

Stage 2: Clearing. For the purpose of clearing the interbank market it is helpful to define a matrix **Π** containing the proportion of bank i's borrowed funds due that comes from each bank j:

$$\Pi_{i,j}^t = \begin{cases} \frac{\tilde{B}_{i,j}^t}{\tilde{b}_i^t} & , if \tilde{b}_i^t \neq 0 \\ 0 & , if \tilde{b}_i^t = 0 \end{cases} \tag{22}$$

We denote by p_n^t the total payment of node n at time t to clear the interbank network. To compute p_n^t in an interbank market where lending is collateralized we build off of the interbank settlement mechanism proposed by Eisenberg and Noe (2001), which is consistent with standard rules imposed by bankruptcy laws. We handle collateral in the case of default following Stigum (1989) which cites several cases where collateral is immediately released to the lender as compensation (any excess collateral is returned to the borrowing institution). Furthermore, we assume that all interbank liabilities have equivalent seniority. Additionally, while a firm may technically default if it has insufficient cash to pay the full interbank liability, we assume that lenders will accept being compensated partially through cash and partially through liquidation of the collateral held without imposing a full default and the resulting liquidation on borrowers. The algorithm provided below has been tested empirically and works for the case where all lending is collateralized or uncollateralized. This method can be extended to handle a mixture of collateralized and uncollateralized lending by splitting the loss vector into two components to reflect the loss experienced by uncollateralized versus collateralized lenders.[12]

We begin by updating the value of the collateral held by lenders through multiplication of the collateral matrix by a diagonal matrix of the returns on bank's risky portfolios R (23). Then, we compute the vector s where s_i is the amount that bank i falls short in paying its borrowing due $\tilde{b}_i^t$. The process of determining the final payment made and compensation received by each bank is recursive, and we initially assume that every bank will make a full payment, that is s is a vector of zeroes for the first iteration.[13]

$$\tilde{C}^t = RC^{t-1}, \text{ where } R_{ii} = e^{\left(\mu_\xi - \frac{\sigma_\xi^2}{2}\right) + \sigma_\xi^2 \eta_i^t} \tag{23}$$

$$s = \tilde{b}^t - p'^t \tag{24}$$

$$\tilde{C}_k = min(diag(s)\Pi'^t, \tilde{C}^t) \tag{25}$$

12 If the shortfall vector is not divided into two components, then as the algorithm iterates it would be possible for the collateral to compensate not only the collateralized lenders but also the uncollateralized lenders without distinction between them. Dividing the shortfall vector into a vector of loss inflicted on collateralized versus uncollateralized lenders would ensure that riskier lenders bear the full loss in case of default.

13 Much of the remaining work is described in matrix notation for simplicity. Moreover, we define several notation elements here for use in the remainder of the paper. Namely, $d = diag(x)$ converts the (a x 1) vector x into a. (a x a) diagonal matrix d such that $d_{ii} = x_i$ and Π'^t denotes the transpose of Π^t. We also use $\mathbf{0}$ & $\mathbf{1}$ to denote vectors of zeroes & ones and represent the Hadamard product of matrices A and B by $(A \circ B)_{ij} \equiv a_{ij} \cdot b_{ij}$. All relational operators should be assumed to operate on matrices by entry to indicate whether the relation holds. Finally, the max and min of two matrices A and B selects the maximum of minimum (resp.) between a_{ij} and b_{ij} for all i and j.

$$\tilde{C}_r = \tilde{C} - \tilde{C}_k \tag{26}$$

Then the loss is distributed proportionally across lenders following (24) which describes the loss each lender experiences if the cash payment were the only payment received; consequently, this shortfall is also the amount collateralized lenders will keep as compensation. Naturally, the collateral which is not kept by lenders as compensation will be returned to borrowing banks leading to equation (26). At this point, under the assumption that the payment vector p'^t will be made, we determine the banks which will default. Following (27), the default is considered a condition when the sum of cash available, expected cash receipts, expected collateral kept as compensation (and assumed to be sold immediately), and the value of returned collateral is less than the payment due. The vector D acts as an indicator listing out which banks are defaulting. Then we determine a new vector p^{nt} for the cash payment by each bank as the minimum of either the sum of all expected available cash or the full payment due, denoted by (28). We allow that the collateral returned to a borrowing bank $\tilde{C}_r$ can be immediately liquidated to pay off debts. This collateral is also allocated as a separate form of payment $\tilde{C}_k$ (collateral kept), which is not a transfer of cash and, therefore, not included with (28). Therefore, the full payment each bank makes is $p^{nt} + \tilde{C}_k\mathbf{1}$.

$$D = \left(\left(\Pi'^t p'^t + c^t + \tilde{C}'_k\mathbf{1} + \tilde{C}_r\mathbf{1}\right) < \tilde{b}^t\right) \tag{27}$$

$$p^{nt} = D \circ \left(\Pi'^t\left(D \circ p'^t + (\mathbf{1} - D) \circ \tilde{b}^t\right) + c^t + \widetilde{C}'_k\mathbf{1}\right) + (\mathbf{1} - D) \circ \tilde{b}^t \tag{28}$$

This iterative process is continued by replacing p'^t with p^{nt} in the first step and determining whether the new potentially lower payment causes more banks to default. We terminate the process when the difference between p^{nt} and p'^t is less than a designated threshold or when the vector D of defaulting banks equals itself from the previous iteration. Any bank which fails to make the full payment $\tilde{b}_n^t$ that it owes through a combination of cash and nonretrieved collateral is declared to default and will be liquidated in stage 4. We decompose the set of banks that default in the interbank market into two groups. First, a group of initial defaults that are unable to repay their liabilities, even if they are paid in full. Second, a group of banks that would have made the full payment, if they received full payment for all interbank loans made. The latter group is categorized as contagion defaults. Mathematically, these are given by equations (29) and (30) respectively, where D^t is the vector indicating which banks default from the final iteration of the clearing algorithm).

$$D_I^t = D^t - D_c^t \tag{29}$$

$$D_c^t = \left(\left(\left(\Pi'^t \tilde{b}^t + c^t + \tilde{C}_r \mathbf{1}\right) > \tilde{b}^t\right) \circ D^t\right) \tag{30}$$

Upon observation of the final vector of cash payments and the matrix of kept, we can determine the loss that banks inflict/incur due to their participation in the interbank market. The loss is established with updates to the cash, risky portfolio, asset, liability, capital, borrowing, and lending balance sheet items following equations (31)-(38).

$$Loss = \tilde{l}^t - \left(\Pi'^t p'^t - \tilde{C}'_k \mathbf{1}\right) - \tilde{C}'_k \mathbf{1} = \tilde{b}^t - p'^t - \tilde{C}'_k \mathbf{1} \tag{31}$$

$$c_n^t \to c_n^t + \left(\Pi'^t p'^t - \tilde{C}'_k \mathbf{1}\right) - \tilde{C}'_k \mathbf{1} - p'^t \tag{32}$$

$$\xi^t \to \xi^t + \tilde{C}_r \mathbf{1} \tag{33}$$

$$A^t \to A^t - \tilde{b}^t - Loss \tag{34}$$

$$L^t \to \delta^t \tag{35}$$

$$\kappa^t \to \kappa^t - Loss \tag{36}$$

$$\tilde{b}^t \to \mathbf{0} \tag{37}$$

$$\tilde{l}^t \to \mathbf{0} \tag{38}$$

Stage 3: Regulation. In the course of Stages 1 and 2, we have not considered the regulatory rules for operational safety of individual firms that constrain the conditions when firms become under-reserved, under-capitalized, or insolvent. If a firm is insolvent, then it is marked for liquidation and receives no further attention in Stage 3, since the traditional method of restoring a satisfactory capital to asset ratio does not apply.

If a firm has positive capital and is under-capitalized, then assets must be lowered in order to restore an adequate capital to asset ratio. This is accomplished by returning cash to depositors, thereby reducing total assets. We first calculate the maximum assets supported by each bank's capital levels (39), then determine the assets (cash) that must be deducted following (40) (note the inclusion of deposits in (39) is trivial).

$$A_{reg}^{t} = \left(\kappa^{t} \circ (\kappa^{t} > 0)\right) * \left(\frac{1}{\bar{\kappa}^{t}}\right) \tag{39}$$

$$A_{return}^{t} = \min(A^{t} - A_{reg}^{t}, c^{t}, \delta^{t}) \tag{40}$$

If a firm is under-reserved, then it does not have enough cash set aside in the reserve account to cover deposits. This can be fixed by either decreasing deposits (returning cash to depositors) or by allocating additional cash to the reserve account. The latter option is considered preferable, because banks will expend far less cash in regaining an adequate reserved status. Specifically, a bank will determine the minimum amount of reserves appropriate for its current deposits following equation (41) and then determine the minimum cash value that must be added to reserves following (42). Next, we update the cash and reserve accounts in (43) and (44) while assets and capital remain unchanged.

$$\rho_{req}^{t} = \bar{\rho}^{t}\delta^{t} \tag{41}$$

$$\rho_{added}^{t} = \min(\rho_{req}^{t} - \rho^{t}, c_{n}^{t}) \tag{42}$$

$$c^{t} \rightarrow c^{t} - \rho_{added}^{t} \tag{43}$$

$$\rho^{t} \rightarrow \rho^{t} + \rho_{added}^{t} \tag{44}$$

Stage 4: Liquidation. When it is determined that a bank has met a sufficient condition for liquidation, we create a list of all defaulting and surviving institutions and apply one of four resolution methods. In the first method, the balance sheet items of the defaulting institution with largest assets are assigned to the surviving bank with the largest assets. The second largest defaulting bank is assigned to the second largest survivor, and so on. This continues until all defaulting banks have been addressed. It is anticipated that this method would result in the lowest administrative effort on the part of regulators. However, it would also likely cause a dramatic increase in the concentration of the banking sector in the case of a material sequence of defaults. Additionally, this method does not consider the geographic or strategic compatibility of surviving and defaulting banks.

In the second resolution method, the balance sheet of the largest defaulting bank is divided into p portions which are assigned to the p largest surviving institutions. The second largest defaulting bank is then divided into p portions which are assigned to surviving banks ranked p+1 to 2p by assets, and so on. When each surviving bank has received a portion of a defaulting bank's balance sheet, we start the process again with the largest survivor and all remaining banks (portions) to be liquidated. This continues until all defaulting banks have been liquidated. This method would mitigate the increase in financial system concentration that method #1 would incur. Additionally, the portions of defaulting banks could be assigned among the p surviving institutions with compatibility as a concern to accelerate the timeframe for integration and a return towards profitability.

A third method is to divide the balance sheet of each defaulting bank evenly among all surviving banks. This can be interpreted as the logical limit of method #2. However, due to the complexity of dividing up each institution, this resolution method can be anticipated to result in the longer timeframes for incorporating defaulted bank assets to survivors and higher administrative costs. Additionally, since each survivor receives an equal portion of the defaulting bank's balance sheet, the largest and smallest survivors receive the same amount of assets and liabilities from each defaulting institution. Under this resolution method, it is possible that a small surviving institution would be assigned management of assets from several larger defaulting banks totaling far more than the survivor's bank's current assets under management, which it may be wholly unable to handle.

Under the fourth resolution method, the balance sheets of each defaulting institution can be divided proportionally among surviving institutions according to the assets of each survivor relative to all surviving banks. This method addresses main issue of method #3 that small banks may be asked to take on significantly more assets than they are currently equipped to manage. This method can be interpreted in the form of an auction, where all survivors bid on and receive at nominal value the assets of each defaulting institution along with a proportional amount of that firm's liabilities with purchases made according to the buying power (asset size) of each survivor.

Stage 5: Asset Allocation. This stage involves determining the extent of each bank's participation in the interbank market, first by determining their desired lending and borrowing amounts based on the structural equation model presented in section X, and then by developing a mechanism to match lenders and borrowers thereby forming the interbank network.

Once the desired lending and borrowing positions are determined (denoted l_{des}^{t} and b_{des}^{t} respectively). We modify b_{des}^{t} such that banks will not borrow to the extent of becoming undercapitalized or beyond their ability to post collateral, where $0 < h^{t} < 1$ is the haircut that firms demand on collateral posted at time t to further mitigate the risk to lenders due to changes in collateral value (45).

$$b^t_{des} \rightarrow \min\left(\max\left(A^t - A^t_{reg}, c^t, \delta^t\right), \xi^t h^t, b^t_{des}\right) \tag{45}$$

We also define an adjacency matrix S^t_{adj} that determines which banks are allowed to borrow and lend to each other in the interbank market. When a core periphery structure is assumed, banks in the core can trade with themselves and with the periphery, following the analysis of Craig and Von Peter (2014). However, when a three-tier structure is imposed, banks are only allowed to interact with banks in adjacent tiers. This means that tier 2 banks trade with all banks, but tiers 1 and 3 only trade within their respective tiers and with tier 2. The lender of last resort is assumed to lend as much as necessary to banks that have an unsatisfied desire to borrow (but it will not borrow funds). This study does not presently attempt to investigate the effect of interbank rates as a policy option. Furthermore, the study assumes that each bank will borrow at a constant rate plus a normally distributed disturbance (equation (46)) and that the lender of last resort charges a premium (making it the most expensive lender).

$$r_{n,m} = r + d\nu \qquad \text{where } \nu \sim N(0,1) \tag{46}$$

We then set up the interbank network by choosing at random a bank that desires to borrow and allowing it to borrow as much as possible from each lender (ordered by in ascending order of lending rates offered) and then moving on to the next randomly chosen bank. This continues until all banks have had a chance to borrow. At that point, they have additional funds available for lending. Thus, this process is repeated until all desired borrowing is satisfied. The rationale behind this method is that banks will want to conduct most of their borrowing at the most attractive rate and conduct a survey of rates available to them before selecting lenders. This method will create a network with highly concentrated paths and potentially small connected groups.[14] The very last step in each round of simulation requires that banks invest excess cash in the risky portfolio such that $\xi^t \to \xi^t + c^t$ and $c^t \to \mathbf{0}$.

3. HYPOTHESIS DEVELOPMENT

In this section, we build on current literature to develop a structural model of interbank activity. In our model, the change in leverage, change in return, and growth serve as measures of financial performance which mediate the effect of changes in liquidity and economic conditions on observable interbank activity. Put differently, it is the financial institutions' change in performance in response to the changing economic conditions and changes in liquidity that conditions their interbank activity.[15] In pursuit of our research questions, we develop three sets of testable hypotheses. The first set consists of the structural organization hypotheses (H1 and H2) to examine the structure of the US interbank market. The second set consists of the measurement model (H3), direct association (H4) and mediation hypotheses (H5 and H6) to examine how factors of financial performance explain interbank market activity. The third set consists of the moderation hypotheses (H8 – H10) to examine how and to what extent the factors of interbank activity and the interbank market structure interact. We test the predictive validity of the alternative structures (H11) by comparing the moderation effects of endogenous variation among financial institutions differentiated by alternative market structure (core-periphery vs. three-tier).

3.1. Formation of interbank market tiering

Several authors have studied the structure of interbank markets empirically. Craig and von Peter (2014) examine the structure of all institutions participating in the German interbank

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[14] In subsequent development, we plan to test alternatives in which a borrower is only able to satisfy a limited fraction of the lender's remaining funds available for lending in each iteration (leading to a more connected network).

[15] Similarly, for Heider et al., (2008: 10) banks are subject to liquidity shocks and "to maximize expected profits… while taking their asset allocation as given."

market using direct bilateral exposure data between Q1:1999 and Q4:2007. They posit the existence of a rule-defined core-periphery structure wherein core banks (small fraction of banks that borrow and lend) are assumed to trade between themselves and with the periphery. The distinguishing feature of periphery banks is that they can only interact with core banks.[16] In a similar study of the US federal funds market, Bech and Atalay (2010) apply the Furfine (1999) methodology to infer bilateral exposures using data from April 1997 to Dec. 2006. They propose the existence of five groups, which trade according to several rules.[17] Unsurprisingly, the structural changes in the interbank market lead to alternative views of the US interbank market structure.[18] One persistent view of the US interbank market since the late 1980s is a three-tier structure (Allen and Saunders, 1986; Stigum and Crescenzi, 2007). Allen and Saunders (1986) differentiate the tiers as primary interdealer market banks, intermediary correspondents, and smaller banks lacking direct access to the primary market. Based on extensive interviews with market participants, Stigum and Crescenzi (2007) also describe the interbank market as three-tiered and consisting of money center banks, regional banks, and smaller banks. The three alternative models of interbank structure—core-periphery, five-group, and three-tier—are shown in Figure 5.

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16 Craig and von Peter (2014) find significant improvement upon Erdos-Renyi and scale-free networks and are able to generalize their method to consider a K-tier organizational scheme. For the German interbank system they find a 17% error rate in network link identification for 3 tiers compared to 12% for 2 tiers.

17 The giant strongly connected component (GSCC) composed of nodes that are connected to every other node in the GSCC through a directed path: the giant in-component (GIN) (resp. giant out-component (GOUT)) with nodes connected to the GSCC by a directed path in but not out (resp. from but not to) the GSCC; the tendrils that are connected to the GSCC only through a path of mixed lending and borrowing links; and the disconnected component with nodes, which participate in the federal funds market but are completely disconnected from the GSCC. Bech and Atalay (2010: 12-14) find the following allocation of institutions among the five groups: GSCC=10% (±1%), G-IN=58% (±5%), G-OUT=17% (±4%), Tendrils=14% (±3%); such that ~7.2% were borrowing from GIN, ~4.8% were lending to GOUT, and ~2.3% of tendrils were borrowing from GIN and lending to GOUT. The disconnected component contained less than 1% (±1%) of institutions.

18 Furfine (1999), Soramaki et al. (2007), and Battiston et al. (2012b) have also considered multi-tiered systems. Further studies of contagion due to interbank payment flows in multi-tier network structures include Iori (2008) and Li (2011).

Insert Figure 2 about here

It would be reasonable to expect that that our dataset of top 100 BHCs filters out the disconnected group with 1% of all participants (Bech and Atalay, 2010). Reconsidering Bech and Atalay (2010) findings (with the omission of transaction directionality but recognizing net transaction activity), the US interbank market may be represented as a core-periphery structure consistent with Craig and von Peter (2014). In this representation, the core component is likely coincident with the GSCC group (Bech and Atalay, 2010), while the periphery component is likely coincident with the combined GIN, GOUT, and Tendrils groups. Alternatively, the US interbank structure may be represented as a three-tier structure consistent with Allen and Saunders (1986) and Stigum and Crescenzi (2007), where the GSCC group is likely coincident with tier 1, while GIN, GOUT, and Tendrils (differentiate by interbank activity share) form tiers 2 and 3.

Exploratory analysis of characteristics of interbank market participants suggests that a tier membership function as a latent construct for the interbank market structure can be formed by certain relevant characteristics of financial intermediaries: interbank lending, interbank borrowing, interbank passthrough, rank, and total assets.[19] To establish the validity of this construct it is essential to show that the institutional characteristics both reliably converge on the latent construct (convergent validity) and are mutually distinct (discriminant validity) (Campbell and Fiske, 1959). Thus,

Hypothesis 1: A construct of core-periphery interbank market structure is formed (H1a) by the five indicators of interbank lending, interbank borrowing, interbank passthrough, rank,

[19] This is discussed in more detail in Section 3.1.

and assets, such that the structure's silhouette measure of cohesion and separation exceeds 0.5 (H1b).

Hypothesis 2: A construct of three-tiered interbank market structure is formed (H2a) by the five indicators of interbank lending, interbank borrowing, interbank passthrough, rank, and assets, such that the structure's silhouette measure of cohesion and separation exceeds 0.5 (H2b).

3.2. Formation of measurement, direct association, and mediation hypotheses

Measurement model hypotheses. "Contemporary banking theory classifies banking functions into four main categories: offering liquidity and payment services, transforming assets, managing risks, processing information and monitoring" (Freixas and Rochet, 2008: 2). Considering the collected 30-item dataset in terms of these four functional categories, it is reasonable to make four conjectures:

- the risk management function reflects changing economic conditions, which may be handled through adjustment of the growth in securities, in addition to demonstrating the bank's internal risk appetite expressed by the change in leverage, the change in return, and profitability growth;
- the change in liquidity factor reflects the larger liquidity provision function;
- the growth latent factor reflect the larger asset transformation function;
- information processing and monitoring may not be observable in the collected dataset.

Accordingly, we argue that seven latent factors of economic conditions, change in liquidity, change in leverage, change in return, growth, growth in securities, and profitability growth reliably measure the variance of our sample dataset.

Hypothesis 3: (H3a) Seven distinct factors of economic conditions, change in liquidity, change in leverage, change in return, growth, growth in securities, and profitability growth converge to a reliable measurement model such that each factor achieves

- *(H3b) reliability, such that each factor's composite reliability (CR) exceeds 0.70;*
- *(H3c) convergent validity, such that the unique one-to-one factor loading is shown by the factor components with average variance extracted (AVE) exceeding 0.50 and CR exceeding AVE;*
- *(H3d) discriminant validity, such that for each factor average variance extracted exceeds maximum shared variance (MSV), and AVE exceeds average shared variance (ASV);*
- *(H3e) the factor measurement model is invariant, such that at 95% confidence there is no statistically significant difference in the factor construction between the interbank market structural groups or configural invariance can be demonstrated.*

Direct association hypotheses. Although there are numerous studies on the individual channels by which heterogeneous banks interact through interbank market activity (see section 3.3), there are many reasons to hypothesize about the direct effect that a change in economic conditions, leverage, liquidity, overall growth, or a change in return would have upon borrowing or lending activity. Methodologically, it makes sense to begin the investigation of potentially complex and heterogeneous effects of financial intermediation and interbank activity parsimoniously—the Occam's razor principle. This approach also makes sense from four perspectives: 1) capital regulation, 2) bank portfolio management, 3) funding liquidity and 4) financial intermediation as delegated monitoring. For the first, Rochet (1992: 1160) argues that capital-focused regulation has a profound effect on "risky behavior of commercial banks … give incentives for choosing "extreme" asset allocations, and are relatively inefficient for reducing the risk of bank failures." For the second, portfolio management determines the leverage banks use, the liquidity risk exposure, and the return banks eventually realize and is generally considered a fundamental behavior of financial intermediaries (e.g. Hart and Jaffee, 1974; Koehn and Santomero 1980).[20] From the third (funding) perspective, banks "finance their assets with interbank funds" (Rochet and Vives, 2004: 1117) and pledge assets as collateral in the interbank market (Freixas et al., 2004; Brunnermeier, 2009).[21] From the fourth (monitoring) perspective, interbank participants cross-monitor counterparty liquidity, leverage, return, and growth to inform pricing and collateral margins relative to economic conditions (Rochet and Tirole, 1996; Freixas and Rochet, 2008). Thus, we make the simplifying hypothesis that a direct associations between institutional economic conditions, change in liquidity, change in leverage, change in return, growth and interbank activity are consistent with literature.

Hypothesis 4: At 95% confidence, the latent factors economic conditions (H4a), change in liquidity (H4b), change in leverage (H4c), change in return (H4d), growth (H4e), and monetary policy (H4f) are significantly associated with interbank borrowing.

Hypothesis 5: At 95% confidence, the latent factors economic conditions (H5a), change in liquidity (H5b), change in leverage (H5c), change in return (H5d), growth (H5e), and monetary policy (H5f) are significantly associated with interbank lending.

Mediation hypotheses. Our mediation hypotheses relate economic conditions, changes in liquidity, changes in leverage, and changes in return with interbank activity. Given our interest in the factors of interbank activity and their interaction with interbank market structure, this

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20 From this perspective, the extant banks can be viewed as successful portfolio managers, taking exogenous flows and choosing a return and growth rate "to maximize the expectation… of the bank's financial net worth" (Rochet, 1992: 1139).

21 See also Heider et al., (2008: 2) who show how "banks' asset risks affects funding liquidity in the interbank market" in addition to Acharya and Skeie (2011) who study the effect that leverage of a bank has on its access to the interbank market in the presence of adverse economic conditions reflected by low market liquidity.

approach to mediation is parsimonious and consistent with our treatment of direct association hypotheses.

Empirical studies of Goldsmith (1969), McKinnon (1973), Shaw (1973), and King and Levine (1993) find a positive association between economic growth and financial development. Bhattacharya and Fulghieri (1994) consider interbank activity as insurance against changes in returns and liquidity. Holmström and Tirole (2001) model assets as cushion against liquidity shocks that condition interbank activity. Heider et al. (2008) find that variation in economic conditions affects interbank activity through risk in counterparty assets. Gertler and Kiyotaki (2010) study "the interaction between banking and the macroeconomic conditions … [choosing a parsimonious] representation of the financial intermediary sector." They model this interaction as mediated by the condition of the balance sheets, where "The size of the external finance premium … depends on the condition of borrower balance sheets." This model gives rise to the well-known financial accelerator effect (Bernanke et al., 1999) where "as balance sheets strengthen with improved economic conditions, the external finance problem declines, which works to enhance borrower spending, thus enhancing the boom. … In this framework, a crisis is a situation where balance sheets of borrowers deteriorate sharply, possibly associated with a sharp deterioration in asset prices, causing the external finance premium to jump … [creating] strains in the interbank market" (Gertler and Kiyotaki, 2010). More directly, economic conditions are typically addressed by policy makers through monetary policy instruments such as the federal funds rate which acts as the reference price of much interbank activity (Stigum, 1989).

Thus, both theoretical and empirical literatures support the parsimonious view of monetary policy, growth, change in return, and change in leverage as mediators of economic conditions, changes in liquidity, changes in leverage, growth, and their effect on interbank activity.[22]

Hypothesis 6: At 95% confidence, the relationships of economic conditions (H6a), change in liquidity (H6b), change in leverage (H6c), change in return (H6d) with interbank borrowing are mediated by changes in leverage, change in return, growth, and monetary policy.

Hypothesis 7: At 95% confidence, the relationships of economic conditions (H7a), change in liquidity (H7b), change in leverage (H7c), change in return (H7d) with interbank lending are mediated by changes in leverage, change in return, growth, and monetary policy.

3.3. Formation of moderation hypotheses: Multi-group boundary conditions

Multi-group structural variance at the model level. A number of studies (Allen and Saunders, 1986; Allen et al., 1989; King, 2008; Ashcraft et al., 2011) find that interbank market activity varies with interbank market structure. For Allen and Saunders (1986) the differentiation is driven by counterparty information asymmetries as institutions that deal with each other frequently (e.g. Tier 1 or Core) set higher spreads on transactions with relatively unknown counterparties (e.g. Tier 2, Tier 3, or Periphery). For Allen et al. (1989), the differentiation originates in the spatial deposit funding advantage held by the less dispersed institutions (Tier 3, Tier 2, and Periphery).[23] For King (2008) the differentiation is induced by counterparty default concerns stemming from information asymmetries. For Ashcraft et al. (2011), the differentiation stems from the skewed distribution of reserves, where banks with more reserves (Tier 3, Periphery) have less need to seek interbank funding. Thus, we hypothesize that the variance in the factors of interbank activity is observable between the interbank market's structural groups.

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22 See also Pagano (1993), Coccorese (2004), and Baum et al. (2009).
23 See Freixas and Rochet (2008: 81-84) and Salop (1979).

Hypothesis 8: At 95% confidence, the structural model of relationships of economic conditions, change in liquidity, change in leverage, change in return, and growth as they relate to interbank borrowing and lending activity is variant, such that there is a statistically significant difference in the relationships between the interbank market structural groups.

Multi-group structural variance at the path level. The studies reviewed above also find specific components of interbank activity that are differentiated by structural groups. Allen, Peristiani, and Saunders (1989: 502-503) mention three ways size may impact bank participation in the interbank market. First, they cite Ho and Saunders (1985) who propose that "managers of smaller regional banks may choose to rely on traditional "deposit-taking" techniques of funds production for reasons of risk aversion." Second, they draw upon the work of Rose and Kolari (1985), Hannan and Hanweck (1988), and Ho and Saunders (1985) to support the idea that, due to a lack of competition, smaller banks may serve regions in which they are able to collect deposits at below market rates. Third, Allen and Saunders (1986) propose that given the choice between a small (rural) and a large (urban) bank with equivalent risk profiles lenders may believe that the small bank has a higher probability of default reducing their access to the federal funds market. They argue this is due to information asymmetries such as a comparative lack of history with and knowledge of the small bank's managers. Thus, we may also infer that as small banks overcome the information asymmetry hurdle and expand geographically,[24] the interbank market will become an increasingly viable source of lending and borrowing funds.

Similarly, in a panel study of commercial bank data from 1986 to 2005, King (2008: 295) finds "that high-risk banks have consistently paid more than safe banks for interbank loans and

[24] The geographic expansion can be expected to pressure the expanding small banks to offer uniform rates across their branches, thus reducing their local deposit funding advantage and increasing the cost effectiveness of borrowing in the interbank market.

have been less likely to use these loans as a source of liquidity." While all banks are subject to differentiated discount window rate,[25] many authors argue that money center banks benefit from implicit preferential liquidity backstop, a form of too-big-to-fail insurance by the Central Bank (e.g., Freixas et al., 2000: 627). Ashcraft and McAndrews (2011: 26) build a model for intraday activity in the interbank market, according to which "Smaller banks hold larger average scaled amounts of nonborrowed reserves overnight than do large banks." Their model implies that small banks due to their larger reserve balances will in general have weaker relationships than large banks between reserve levels and interbank borrowing and lending (lending because small banks will also desire to maintain the large reserve balances and as a result will be less willing to trade with them).

Thus, literature suggests that participation in the interbank market can be expected, ceteris paribus, to increase for banks with larger asset portfolios, more information about their counterparties, lower probability of failure, and more implicit liquidity insurance from the Central Bank. At the same time, the interbank market participation can be expected, ceteris paribus, to decrease for banks with smaller asset portfolios, exogenous stable funding stemming from spatial differentiation advantage, less information about its counterparties, more likely or more expected to fail, and having no preferential treatment at the discount window.

Hypothesis 9: Interbank market structure will moderate the strength of the direct and mediated relationships between economic conditions (H9a), the change in liquidity (H9b), the change in leverage (H9c), the change in return (H9d), growth (H9e), and monetary policy (H9f) with interbank borrowing, such that the relationship will be stronger for lower Tier (Tier 1 stronger than Tier2 stronger than Tier 3, or Core stronger than Periphery).

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[25] The Federal Reserve Discount Window offers short-term credit at the prime or secondary rates, both above the federal funds rate.

Hypothesis 10: Interbank market structure will moderate the strength of the direct and moderated relationships between economic conditions (H10a), the change in liquidity (H10b), the change in leverage (H10c), the change in return (H10d), growth (H10e), and monetary policy (H9f) with interbank lending, such that the relationship will be stronger for lower Tier (Tier 1 stronger than Tier2 stronger than Tier 3, or Core stronger than Periphery).

Alternative interbank market structures. The dominant findings in recent literature suggest that the core-periphery structure found for the German interbank market by Craig and von Peter (2014) may be pervasive. For example, Langfield and Ota (2014) confirm the findings for the UK interbank market, Fricke and Lux (2014) support them for the Italian interbank market, and in ’t Veld and van Lelyveld (2014: 27) verify them for Netherlands, generalizing the core-periphery model as a “*stylized fact* of interbank markets.”

All of the above studies provide support for the core-periphery interpretation using common network analysis methods. At the same time, the authors find some room for alternative representations and acknowledge the common limitations of their network analysis. For example, Langfield and Ota (2014) state “that the UK interbank market closely approximates a core-periphery structure, but that the closeness of this approximation, and the composition of the optimal core, changes significantly across market instruments.” Describing their estimation results, Fricke and Lux (2014) qualify that they “favour the core periphery structure over random graphs (ER), preferential attachment networks (PA), or nested split graphs (NSG), because the [network analysis] error score in the data is much lower for the CP model than for ER, PA or NSG models.” Similarly, in ’t Veld and van Lelyveld (2014) acknowledge that “While the core has a higher average size than the periphery, we observe that the group of core banks can be divided in the small set of the largest banks, and an additional group of medium-sized banks of a size similar to many periphery banks."

Given the above statements for the core-periphery interpretation of the European interbank markets, we hypothesize that the core-periphery model for US interbank market structure also provides better goodness-of-fit to the sample interbank data than does the alternative three-tier model.

Hypothesis 11: The core-periphery structural moderation between economic conditions, change in liquidity, change in leverage, change in return, growth and interbank activity explains the sample US interbank market better than the three-tier structural moderation, as shown by the comparison of the sample multivariate goodness-of-fit statistics.

4. EMPIRICAL RESULTS

4.1. Interbank market tiering

Data suitability. Hair et al. (2010) point out that not every dataset is appropriate for cluster analysis and propose three features that make the data suitable for cluster analysis.

The first suggestion is that variables possess the same scale, since "variables with larger dispersion (i.e., larger standard deviation) have more impact on the final similarity value." To that end, before conducting cluster analysis of interbank activity variables, we convert each observation of interbank lending, interbank borrowing, interbank passthrough, and total assets to reflect the share of that variable controlled at that time.[26]

Second, Hair et al. (2010) recall that there is no statistical basis for cluster inference from a small sample to the properties of a larger population. Put differently, it is desirable for the

[26] The asset (size-based) ranking is not transformed to a share basis due to its ordinal nature. However, the asset ranking is standardized which places it at the same scale as other variables.

sample to adequately represent the population. Our dataset of the 100 largest banks accounts for 90% of assets as well as 95% of the interbank positions reported by the 900 largest bank holding companies between 2013 and 2014; therefore, we claim that our sample portrays the material elements of the interbank market suitably.[27]

Third, Hair et al. (2010) point out that while multicollinearity is not an obstacle for cluster analysis, when present it may lead the clustering algorithm to attribute uneven weight to a subset of the cluster variables representing one of the many traits we wish to capture. In other words, it would introduce a bias toward one concept over the others. While there is some multicollinearity present in the variables used to measure interbank activity, since we are not attempting to cluster around several competing traits (e.g. interbank activity, risk profile, geographic presence), this should not be a severe impairment to the procedure.

Finally, while clustering methods based on Euclidean distance measures do not make assumptions about the distributions of underlying variables, the log-likelihood measure of distance described in Section 2 assumes normality for all continuous variables. Therefore, a logarithmic transformation is applied to the data restoring moderately acceptable skewness and kurtosis values. To avoid complications with the logarithmic transformation for banks which do not participate as lenders or borrowers we add a very small value to the lending and borrowing positions of each observation. The standardized versions of these logarithmic and share transformed variables are used in cluster analysis. Descriptive statistics for the data are provided in Tables 1 and 2 below.

Insert Table 1 about here
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[27] Due to the method of tracing back a firm through time we may have a sample becomes progressively less representative as we move backwards historically.

Insert Table 2 about here

Alternative structures. We find evidentiary support for both Hypotheses 1 and 2, as detailed by the results shown in Table 3. Propositions H1 and H2 tested and supported by the silhouette measure of cohesion and separation (SMCS) value of 0.5298 for the core-periphery structure and SMCS of 0.5469 for the three-tier structure respectively.

Insert Table 3 about here

Figure 4 describes the ranking, interbank borrowing, interbank lending, and interbank passthrough probability distributions of observations shown to belong to the core-periphery structure. There is a clear dichotomy between low rank firms which have high interbank participation and high rank firms with lower interbank participation (recall that the ranking is conducted by assets such that the observation with highest assets has rank one and the lowest assets has rank 100). Figure 5 shows the probability distributions of rank, total assets, interbank borrowing and interbank lending and interbank passthrough for observations partitioned according to the three-tier structure. These vignettes describe a group of observations with very low ranking, high total assets, and the largest positions in interbank borrowing and lending.

Insert Figure 3 about here

Insert Figure 4 about here

Insert Figure 5 about here

4.2. Measurement, direct association, and mediation

Structure in variable data. Based upon the testing results summarized in tables shown and detailed in the discussion below, we support hypothesis 3 as we fail to reject the propositions that:

- Four distinct factors of exogenous flows, economic conditions, asset allocation and interbank activity converge to a single reliable measurement model (H3a);
- CR for all factors exceeds 0.7 (H3b, Reliability)
- AVE > 0.5 and CR>AVE (H3c, Convergent validity);
- AVE > MSV and AVE>ASV (H3d, Discriminant validity);
- At least one variable for each factor does not exhibit difference in the loading coefficient at 95% confidence for metric invariance; the CFA model requires satisfactory fit as measured by CFI, RMSEA, and p-close for configural invariance (H3e; Invariance).

Testing hypothesis H3a involves falsifiability testing that three distinct factors of exogenous flows, economic conditions, and asset allocation adequately describe variation in our dataset. We test this through EFA using IBM SPSS Statistics software, then by examining model and local fit through CFA in AMOS. As shown in Table 4, EFA using principal component extraction and Promax rotation with Kaiser normalization, supports the identification of seven distinct factors among the observed items.

Insert Table 4 about here

Further support for H3a, correlative validity of the identified factors, is provided by examining the correlation matrix organized by factors. Items that load onto a particular factor should correlate strongly with each other, while correlations with other factors' loadings should not be strong. Table 5 shows the results of this analysis, coding strong correlations (>0.5) as green, very weak correlations (<0.2) as red, and neutral correlations (> 0.2 and <0.5) as beige. Visual examination of the pattern supports the convergent validity of the factor definitions, evidenced by strong correlations among items that are expected to load distinctly into unique factors. At the same time, the item correlation pattern supports discriminant validity of the factor definitions, since less than 15% of all items exhibit medium-size (0.2 to 0.5 range) correlations. The factor correlation matrix (Table 8) provides similar support for discriminant validity.

Insert Table 5 about here

Insert Table 6 about here

The results of the EFA are used to set-up a first order CFA model which is used to test the remaining components of hypothesis 3. The formal tests for reliability (H3b), convergent validity (H3c), discriminant validity (H3d), and measurement model invariance (H3e) are discussed below.

Following Peterson and Kim (2013), we begin testing the reliability of each factor by evaluating the Cronbach Alpha statistic for its components which has a value of 0.945 for economic conditions, 0.870 for the change in liquidity, and 0.975 for change in leverage, 0.932 for change in return, 0.917 for growth, 0.845 for growth in securities, and 0.886 for profitability growth satisfying the 0.7 threshold. The composite reliability for factor F (CR_F), a measure of aggregate factor reliability, following Fornell and Larcker (1981) is defined according to equation (47) where λ_j is the loading of component j, and $\sigma^2_{\varepsilon_j}$ is the variance of the measurement error of component j. Bagozzi and Yi (1988) suggest 0.7 as an adequate threshold for CR_F. We test for convergent validity, defined by Krippendorff (2012) as "[t]he extent to which results correlate with variables known to measure the same phenomena and considered valid", using the

Average Variance Extracted of factor F (AVE_F) following equation (48). Convergent validity is supported if AVE_F is greater than 0.5 (Fornell and Larcker, 1981) and if AVE_F is greater than CR_F (Byrne, 2013). We analyze the discriminant validity, the idea that the variances of latent factor F and any other sample do not overlap, through the Maximum Shared Variance (MSV_F) and the Average Shared Variance of factor F (ASV_F), following equations (49) and (50) respectively. The hypothesis test criteria that AVE_F is greater than MSV_F, and AVE_F is greater than ASV_F can be found in Hair et al. (2010).

$$CR_F = \frac{\left(\sum_{j=1}^{C} \lambda_j\right)^2}{\left(\sum_{j=1}^{C} \lambda_j\right)^2 + \sum_{j=1}^{C} \sigma_{\varepsilon_j}^2} \tag{47}$$

$$AVE_F = \frac{\left(\sum_{j=1}^{C} \lambda_j^2\right)}{\left(\sum_{i=1}^{C} \lambda_j^2\right) + \sum_{j=1}^{C} \sigma_{\varepsilon_j}^2} \tag{48}$$

$$MSV_F = \max_{\mathrm{J \neq K}}\left(\rho_{J,K}^2\right) = \max_{\mathrm{J \neq K}}\left[\left(\frac{cov(J,K)}{\sigma_J \sigma_K}\right)^2\right] = \max_{\mathrm{J \neq K}}\left[\left(\frac{E[(J-\mu_J)(K-\mu_K)}{\sigma_J \sigma_K}\right)^2\right] \tag{49}$$

$$ASV_F = \max_{\mathrm{J,K \in F}}\left(\rho_{J,K}^2\right) \tag{50}$$

In Table 7 we show that the composite reliability metrics for each factor are well above the threshold of 0.7 required, supporting factor reliability. The average variance extracted is between 0.5 and the composite reliability for each factor which supports convergent validity. Furthermore, we find that the average variance extracted is greater than both the maximum shared variance and the average shared variance for each factor supporting the discriminant validity of the latent factors.

Insert Table 7 about here

Next, we consider the configural invariance for the measurement model by comparing its goodness of fit statistics in the context of the model's multi-group partitions, as summarized in

Table 8[28] The model in this study satisfies both the complexity (30 variables and 7 factors) and large sample size (over 6000 observations) considerations. The comparative fit index (CFI) (Bentler, 1990) decreases when the sample is partitioned along either the core-periphery or three-tier interbank market structure, however in each case it is below the 0.9 threshold suggested by Hu and Bentler (1999). The root-mean square error of approximation (RMSEA) (Steiger & Lind, 1980) metrics for each model are close or satisfy (for the three tier model) the 0.1 threshold suggested by Hu and Bentler (1999) and interestingly the partitioned models achieve an RMSEA superior to the nonpartitioned model. Finally, the standardized root mean square residual (SRMR) is close to but does not meet the 0.05 threshold suggested by Byrne (2013) for well-fitting models.[29]

Insert Table 8 about here

We verify the presence of differentiation between factor loadings across market structure segments using the group differences test (Gaskin, 2012; 2014). According to this methodology, a factor exhibits pairwise invariance if there is at least one observable variable with no statistically significant difference in loading between segments. Examining the results presented in Table 9 we find that the all factors are invariant across alternative partitions (variables that provide invariance are shaded). In summary, allowing for flexibility when determining adequate thresholds for the goodness-of-fit statistics due to model complexity and the large sample size, we suggest that the CFA measurement model supports metric invariance but is close to supporting configural invariance.

28 Hair et al. (2010) state that “One key point across the results is that simpler models and smaller samples should be subject to more strict evaluation than are more complex models with larger samples.”

29 The χ^2/df metric is not considered since Satorra and Bentler (2001) find that it is sensitive to non-normal data which is present in this dataset.

Insert Table 9 about here

***Direct association*s**. We test the direct association of the five latent factors and monetary policy with interbank borrowing and interbank lending through a straightforward estimation of the structural equation model presented in Figure 6 (Panel A) for a significant relationship using the entire sample. Table 10 indicates that several portions of hypotheses 4 and 5 are supported, particularly the significance of return, growth, and economic conditions.

Insert Figure 6 about here

Insert Table 10 about here

***Mediated association*s**. We test the mediation relationships proposed in hypotheses 6 and 7 using the Baron and Kenny (1986) approach (with and then without mediators) which are illustrated in Figure 6 Panel B. Results are provided in Table 11. Mediation hypotheses are tested via bootstrapping (2000 samples with 95% bias-corrected confidence level). We find that hypotheses 5 and 6 are both supported for several relationships; however, the type of intermediation is often different.

Insert Table 11 about here

4.3. Moderation

Interbank market structure moderation. Before we incorporate the interbank market structure as a consideration of interbank activity in the model described in Figure 6, we test for invariance of the SEM with the expectation that there will be a significant difference. We test for significant differences in model coefficients between groups using the $\Delta\chi^2$ test with a null hypothesis that the model is invariant, results are presented in Table 12 below. We find that there is significant difference in the chi-squared values between constrained and unconstrained versions of the model for both the core-periphery and three-tier interbank market structures. This indicates that we can reject the null hypothesis of model invariance, supporting hypothesis 8. In Table 13 we explore the moderation of direct relationships and find significant evidence in support of moderation of several direct relationships.

Insert Table 12 about here

Insert Table 13 about here

Next we investigate whether the interbank market structure moderates the mediating relationship that change in leverage, change in return, growth, and monetary policy exert on relationships with interbank borrowing and lending. This is undertaken by estimating the nature of mediation for each segment in isolation and comparing these to determine changes in the nature, significance, and direction of association. Results are presented in Tables 14 and 15 for core periphery and three tier structures respectively. We find that the interbank market structure moderates the mediating role of growth between liquidity and borrowing, leverage and borrowing, and leverage and lending whereas the change in return mediate the relationship between leverage and lending for the three tier structure and similar results hold for the core periphery structure.

Insert Table 14 about here

Insert Table 15 about here

Comparison of alternative interbank market structures. Motivated by the desire for a better structural representation of the interbank market for subsequent analysis of systemic risk transmission in this market, we desire to determine which decomposition of the interbank market is a more useful. To this end we compare the goodness of fit for the SEM presented in Figure 10 Panel B for individual partitions of the interbank market and provide the results in Table 16. Model fit is best when all observations are included simultaneously. This is not surprising since the SEM was selected to optimize the model fit for the entire sample. Interestingly, the fit of each segment of the three-tier model is superior to any segment of the core-periphery model. Tier 2 appears to behave significantly differently from tiers 1 and 3. Therefore, a possible cause of the decrease in model fit is that the core and periphery each contain portions of tier 2 which exhibits contrary behavior. This result must be taken with some discretion, since it is also natural to expect that a model which allows calibration with more groups may achieve a better fit.

Insert Table 16 about here
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5. SIMULATION RESULTS

The simulation model outlined in section 5 is run using 500 future paths for both core periphery and three tier market structures.[30] The results are presented in Figures 7 and 8 as a sample of core periphery and three tier market structures respectively. The left column indicates the simulation run without any shock. Defaults occur in the first several periods due to mediocre initialized capitalizations of several banks such that a poor initial return will make them become under-capitalized. However, after period 3 the population stabilizes and grows relatively well. The center column adds a shock to the simulation of a -20% return (with high variance) on the risky investment option which leads banks to become undercapitalized or insolvent. This shock

[30] Market structure plays a role at two points in the simulation: when a bank is classified into a tier this affects who it is allowed to borrow from and lend to in the interbank market and it influences the desired borrowing and lending volumes of each bank.

is particularly detrimental since there is no assumed recovery or bounce back in the risky investment The right column enacts a capital policy inspired by the much debated countercyclical capital policy where instead of worrying about the cost of building up capital before it is needed as a buffer we allow banks to meet lower capital requirements in the case of significant system downturn. Specifically, if the average return in period t (at present we use the simple average of realized returns) is below some threshold τ then we allow the capital to asset requirement at time t to be lowered by $\bar{\kappa}_c$ at time t and the ratio will linearly increase back to standard over the following P periods. This means that banks must now meet the requirement $\bar{\kappa}^{t+p} = \bar{\kappa} - \bar{\kappa}_c(1 - \frac{p}{P})$ where $p \in \{1, \dots, P\}$ is the number of periods after the downturn.[31] We have varied the mechanism for handling default and find that method 2 produces the most advantageous result for both core periphery and three tier market structures (results outlined in figures 7 and 8). Interestingly the core periphery structure appears to be more fragile since the final population in the three tier simulation is approximately 20% larger than in the core periphery simulation. Moreover we see that there is a consistent benefit to implementing the capital based policy. This benefit is that approximately 15-50% fewer defaults occur. However, this policy does not appear to materially improve the preservation of total system assets.

Insert Figure 7 about here

Insert Figure 8 about here

The method that proved worst at handling defaults was method #3 (see Figure 9) where banks in default were liquidated uniformly between all surviving banks, followed by method #4 where defaulting bank balance sheets are attributed proportionally to survivors. In Figure 9 the

31 We have set $\tau = -15\%$, $\bar{\kappa}_c = 2\%$ and $P = 6$. Since the calibration was entirely conducted using quarterly data we assume that the capital requirement will return to normal after 1.5 years.

number of surviving banks at the end is similar to that of figure 7 except that the defaults almost all occur in periods 7-10 whereas using default resolution method #2 they are more spread out. Additionally, using method #3 there will be no periphery banks that survive as they receive more assets than they are able to handle, whereas using method #2 both the core and periphery survive (albeit in reduced numbers). If a bank is insolvent it is resolved as usual. However, undercapitalized banks make an effort to return to a satisfactory capital to assets ratio by returning cash to depositors. This is why instead of seeing a decline of approximately 20% in total system assets, the decline will sometime approach 40%.

Insert Figure 9 about here
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6. DISCUSSION

The structure of the interbank market is immensely important when considering how to prevent contagion and thereby improve financial system resilience. Several authors have tested simple networks with different characteristics and find dramatic differences in the resilience of these networks to shocks. An opportunity to improve these studies would be to incorporate realistic market structure into the simulation of contagion. By investigating this issue in a systematic manner without imposing assumptions about how banks can interact, this study provides researchers the motivation and basis to incorporate market organization into future models. We find that there is some competing evidence of core-periphery and three-tier market structures from cluster analysis. We demonstrate significantly different behavior between segments by analyzing the moderating effect of market structure on the factors of interbank activity.

To determine whether the core-periphery model, proposed for several European countries, is superior to the three-tier model which is also supported through our cluster analysis, we first attempt to determine whether the moderating effect of these partitions is reasonable and useful for interpretation. Second, we analyze which partition achieves superior model fit. Based upon these criteria for our US interbank market sample from 1992 to 2014, we find that the three-tier partition marginally outperforms the core-periphery partition in explaining interbank market activity and its factors. This is potentially due to the distinct behavior of tier 2 compared to tiers 1 and 3 which allows improved detection of moderated relationships. Moreover, the three-tier model achieves consistently better fit than the core-periphery model.

Furthermore, we outline the construction of a simulation model capable of modeling interbank market activity in the presence of collateralized lending, resolving institutions in default and testing policy options. The preliminary results indicate that there can be significant advantages to both finding optimal default resolution mechanisms and flexible capital policy.

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FIGURES

FIGURE 1
Outline of conceptual model with the empirical research supporting simulations studies.

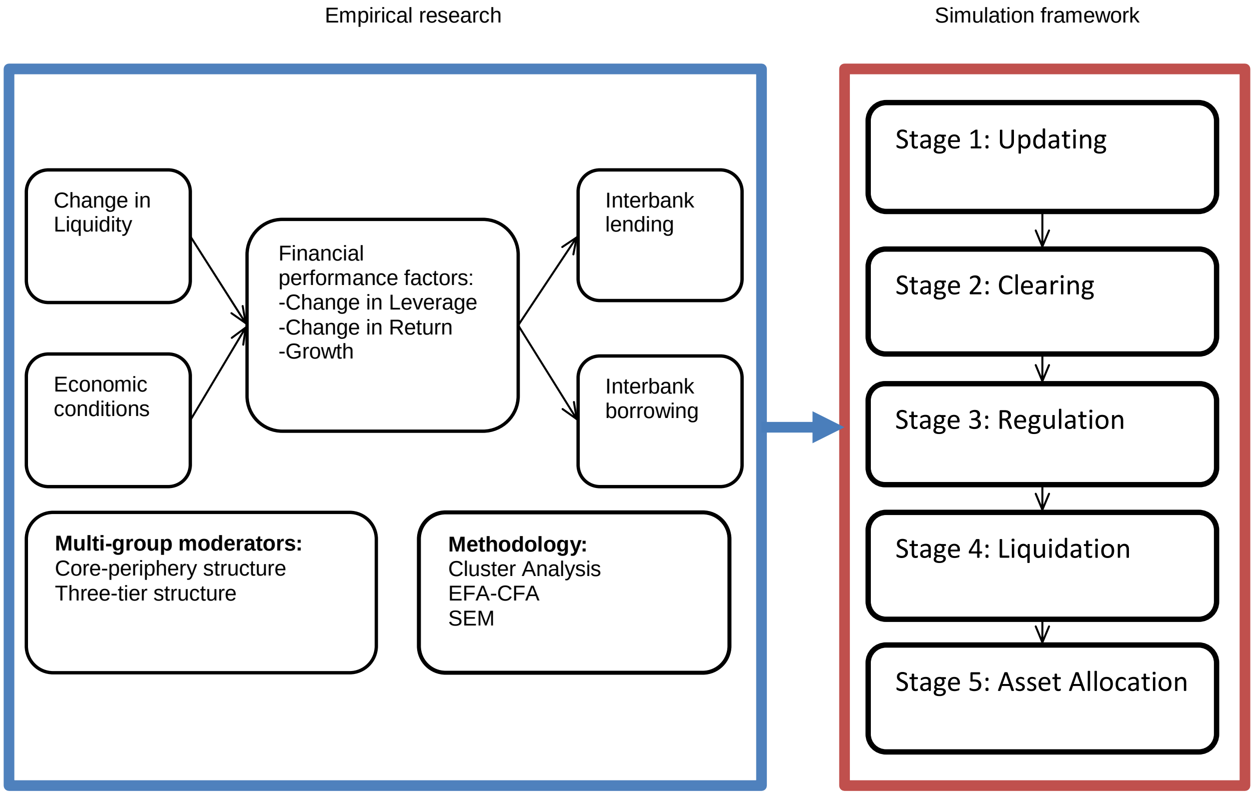


FIGURE 2
Models of interbank structure

Panel A: core-periphery structure | Panel B: 5-group organization structure | Panel C: three-tier structure

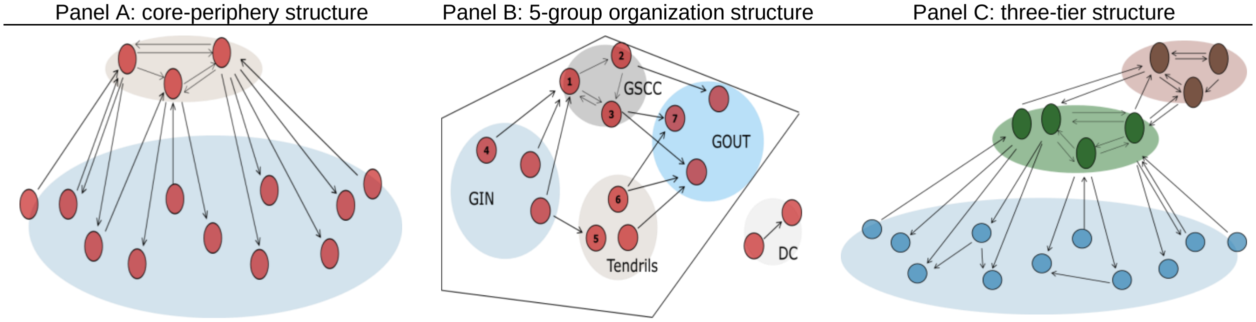


FIGURE 3
The silhouette of cohesion measure for alternative structures

Panel A: core-periphery structure | Panel B: three-tier structure

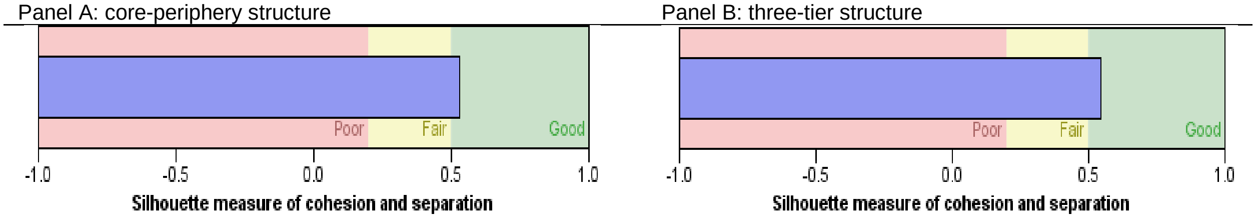


FIGURE 4
Core-periphery distribution of cluster segmentation variables

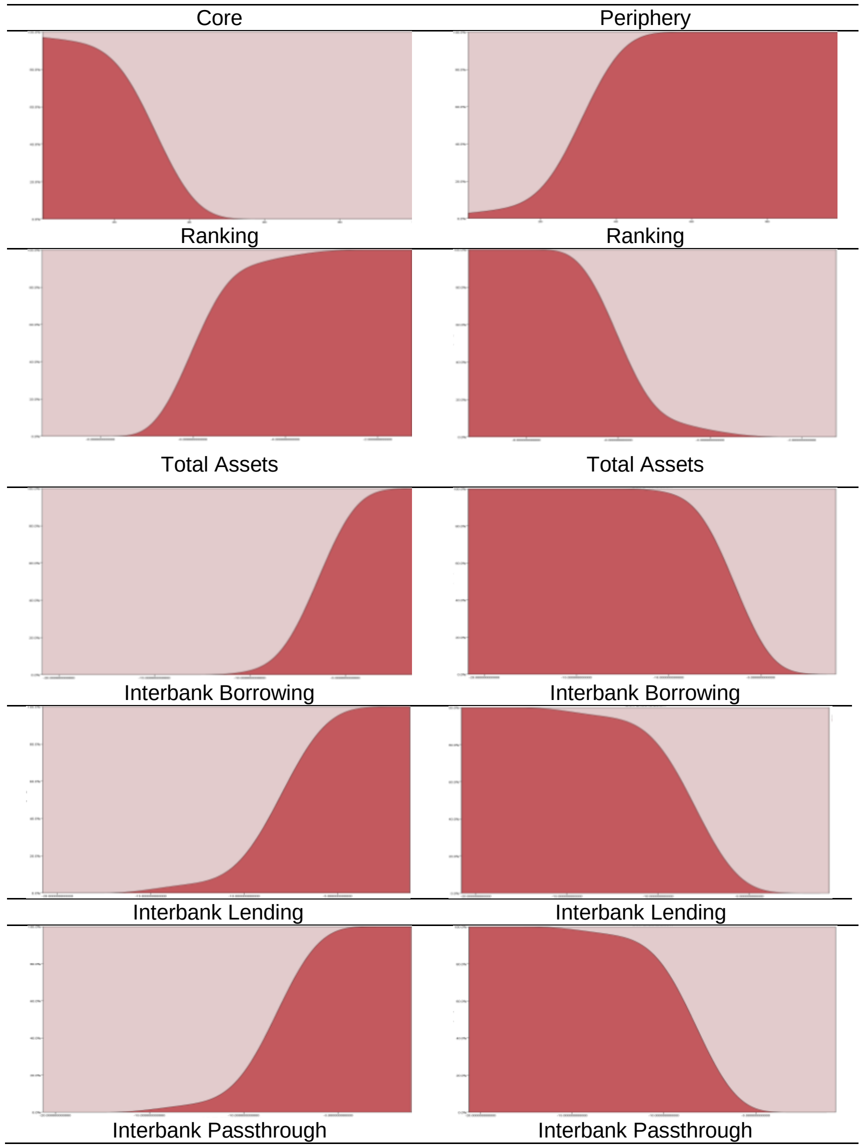


FIGURE 5
Three-tier distribution of cluster segmentation variables

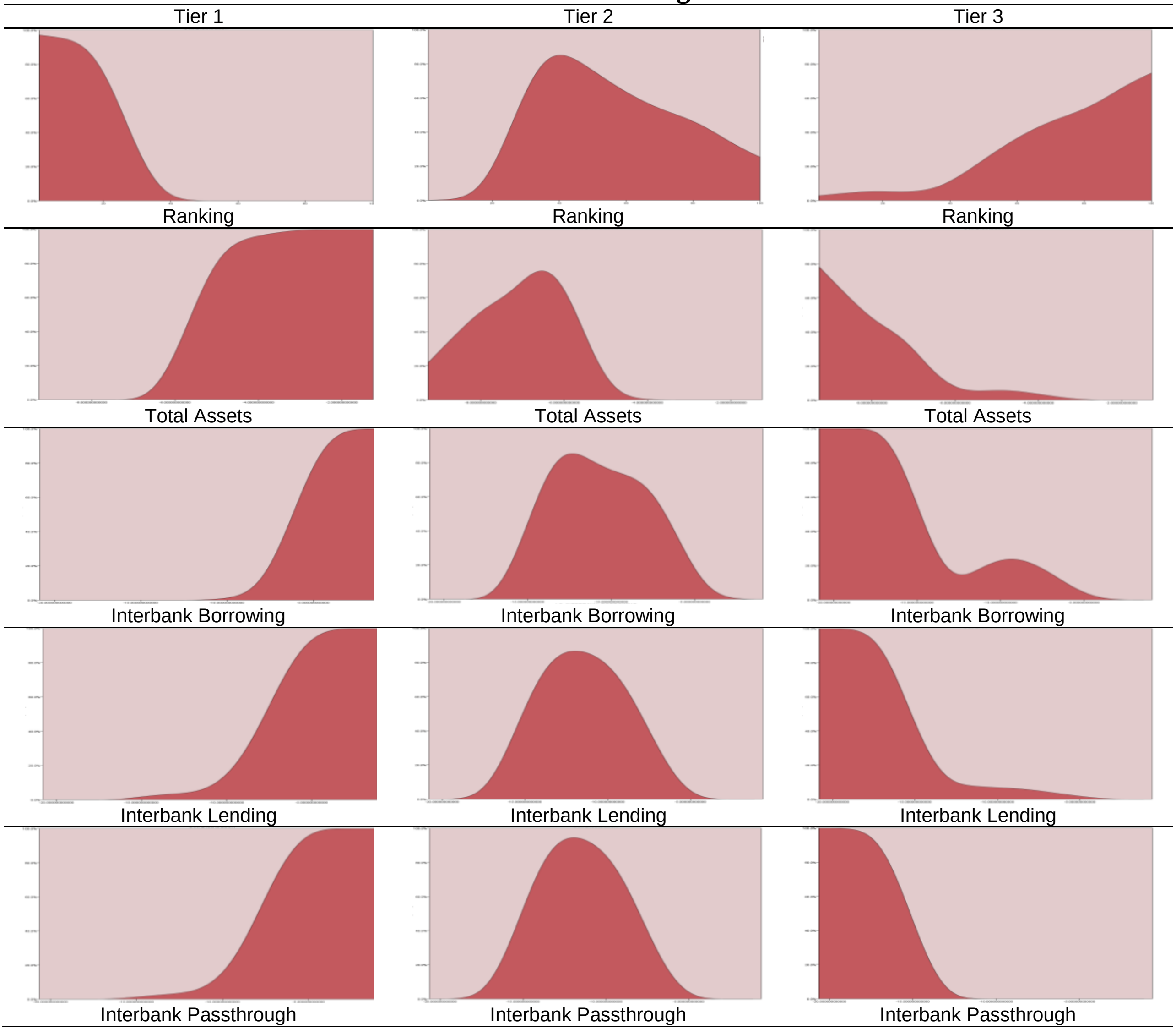


FIGURE6
Structural model for direct association and mediation testing

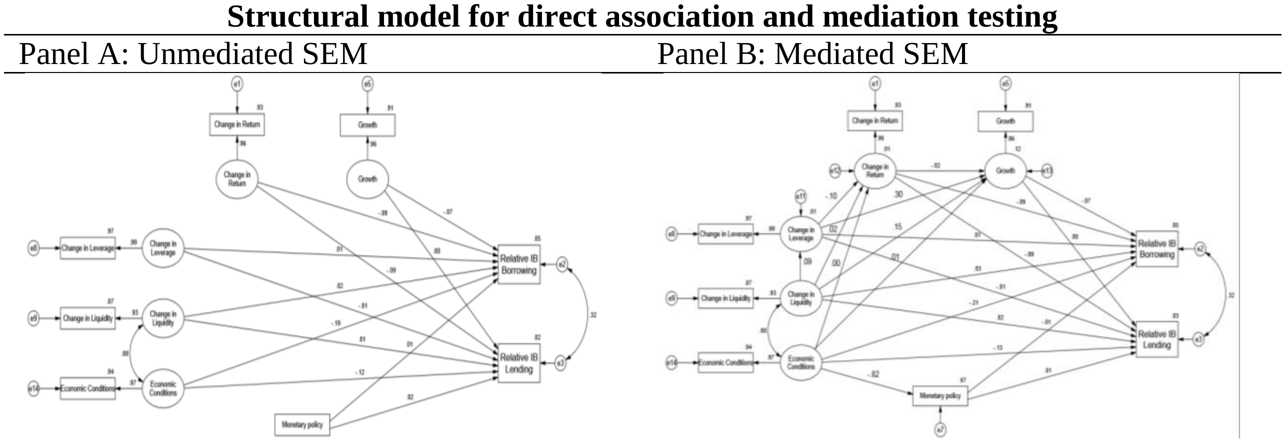
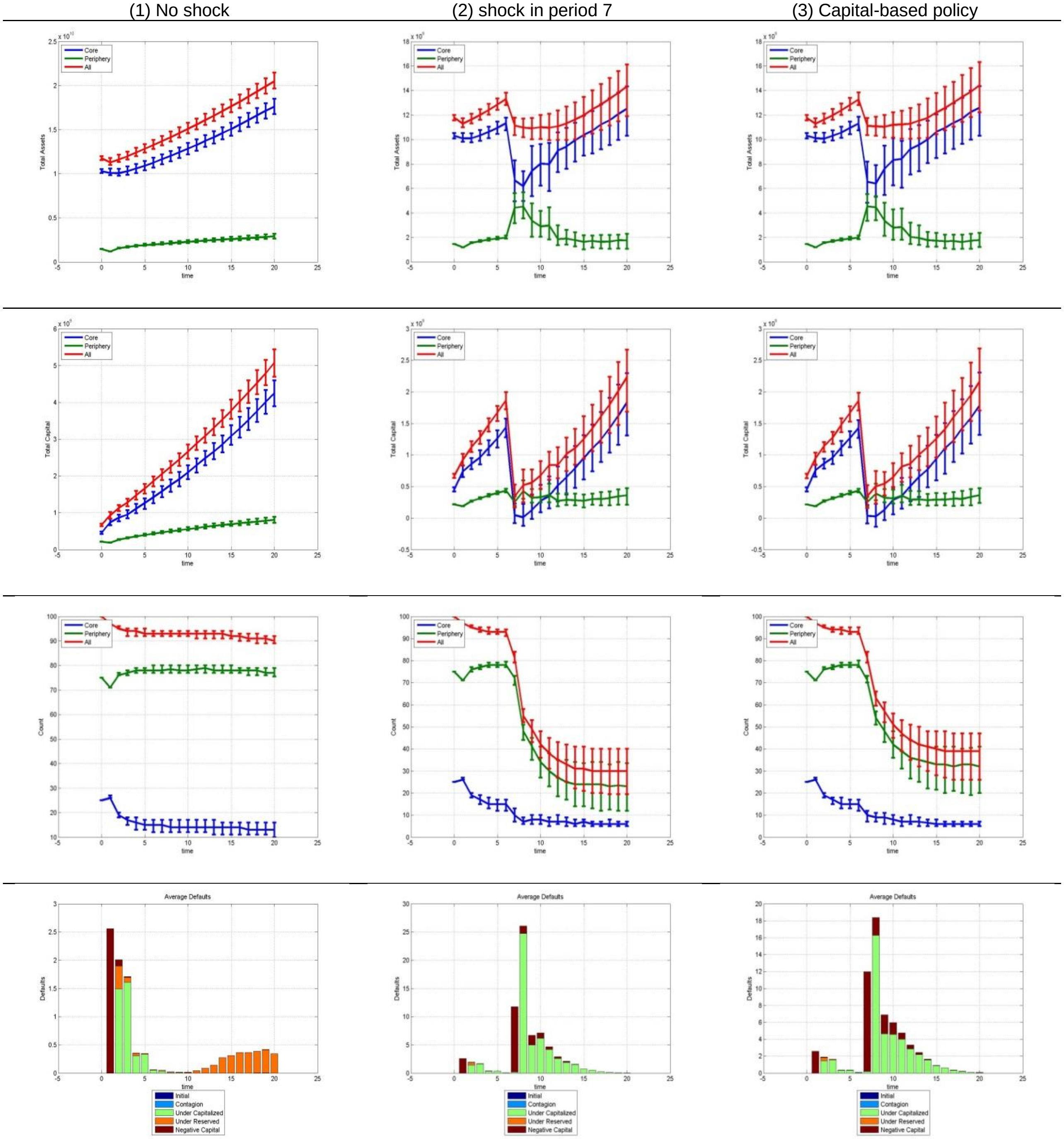


FIGURE 7
Simulation results assuming a core-periphery structure with default resolution method #2

(1) No shock | (2) shock in period 7 | (3) Capital-based policy

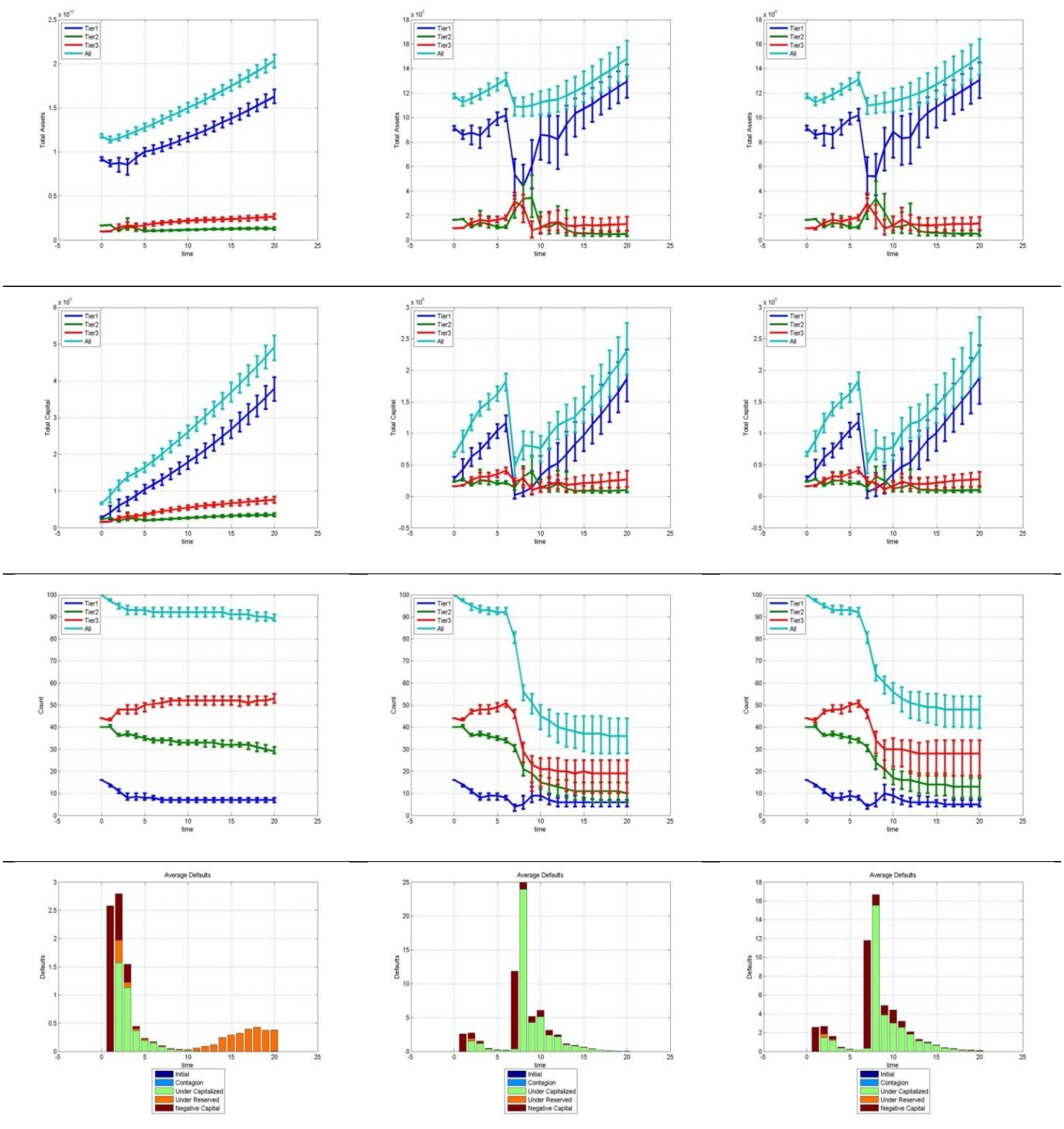


Note: Column 1 displays total assets, capital, population count, and average default (in rows 1-4 resp.) when there is no shock, the center column describes the system when a shock is enacted in period 7, and the third column implements a capital based policy.

FIGURE 8

Simulation results assuming a three tier structure with default resolution method #2

(1) No shock | (2) shock in period 7 | (3) Capital-based policy

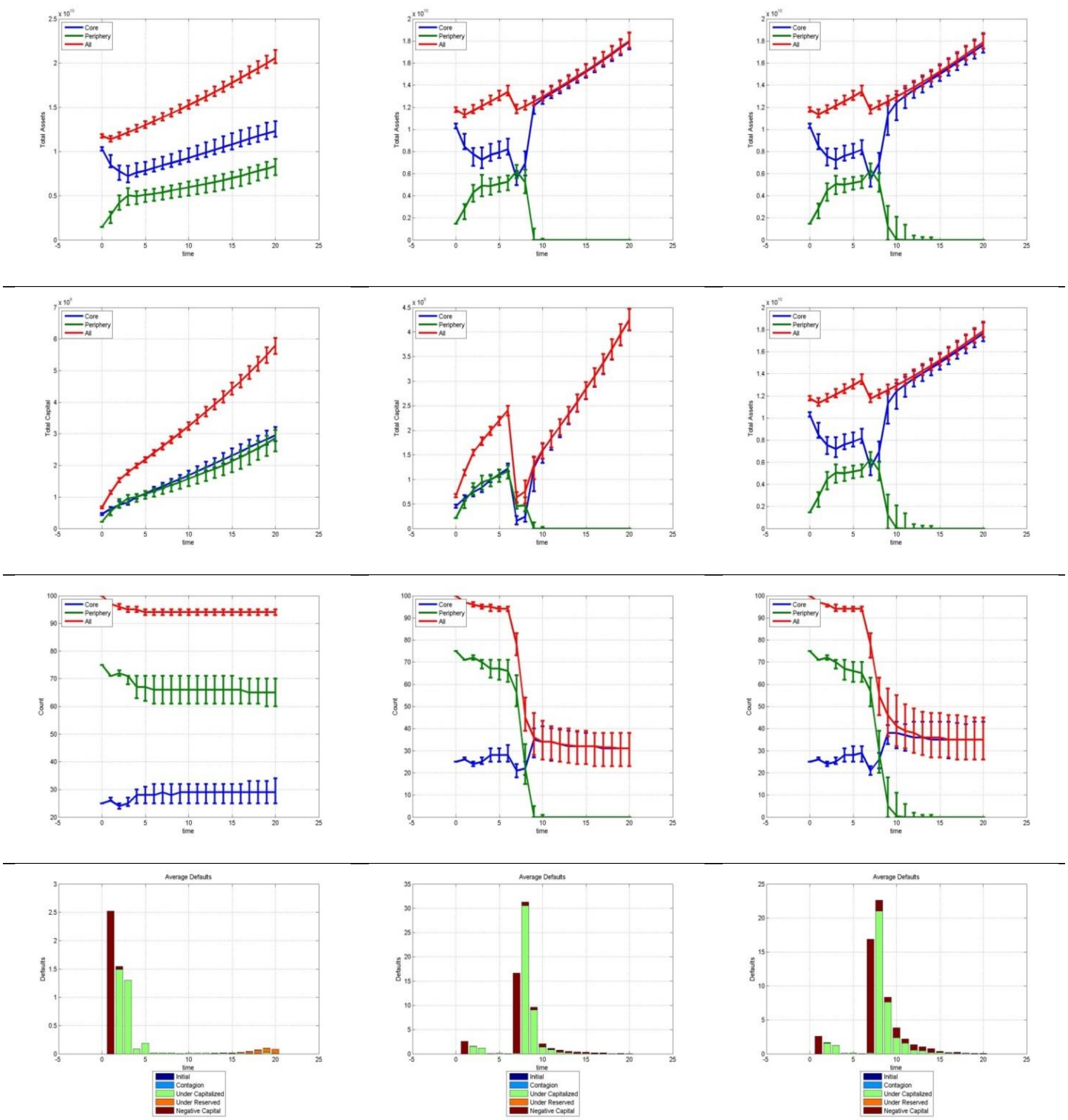


Note: Column 1 displays total assets, capital, population count, and average default (in rows 1-4 resp.) when there is no shock, the center column describes the system when a shock is enacted in period 7, and the third column implements a capital based policy.

FIGURE 9

Simulation results assuming a core-periphery structure with default resolution method #1

(1) No shock	(2) shock in period 7	(3) Capital-based policy



Note: Column 1 displays total assets, capital, population count, and average default (in rows 1-4 resp.) when there is no shock, the center column describes the system when a shock is enacted in period 7, and the third column implements a capital based policy.

TABLES

TABLE 1
Data suitability statistics of logarithm and share transformed data used for cluster analysis

Variable	Tier	N	Mean	Std. Deviation	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
Assets	All	6774	-6.02	1.56	0.87	0.03	0.38	0.06
	Core	4316	-4.36	1.20	0.85	0.05	0.04	0.10
	Periphery	2458	-6.96	0.75	0.36	0.04	1.49	0.07
	1	2133	-4.14	1.14	0.93	0.05	-0.01	0.11
	2	3218	-6.76	0.7	-0.21	0.04	-0.20	0.09
	3	1423	-7.16	0.89	1.17	0.06	2.93	0.13
IB lending	All	6774	-10.26	5.03	-0.85	0.03	0.11	0.06
	Core	4316	-6.33	2.45	0.48	0.05	0.10	0.10
	Periphery	2458	-12.50	4.75	-0.81	0.04	-0.87	0.07
	1	2133	-6.05	2.47	0.38	0.05	-0.07	0.11
	2	3218	-9.79	1.92	-0.58	0.04	-0.08	0.09
	3	1423	-17.64	4.65	1.27	0.06	0.02	0.13
IB borrowing	All	6774	-7.80	4.01	-1.79	0.03	3.55	0.06
	Core	4316	-4.96	1.62	0.60	0.05	0.26	0.10
	Periphery	2458	-9.42	4.06	-1.86	0.04	2.30	0.07
	1	2133	-4.72	1.59	0.57	0.05	0.18	0.11
	2	3218	-7.93	1.71	-1.19	0.04	1.84	0.09
	3	1423	-12.10	5.78	-0.55	0.06	-1.51	0.13
IB Passthrough	All	6774	-10.77	5.30	-0.64	0.03	-0.46	0.06
	Core	4316	-6.31	2.42	0.52	0.05	0.12	0.10
	Periphery	2458	-13.30	4.79	-0.52	0.04	-1.35	0.07
	1	2133	-6.03	2.44	0.41	0.05	-0.06	0.11
	2	3218	-9.96	1.90	-0.48	0.04	-0.28	0.09
	3	1423	-19.67	1.53	2.03	0.06	3.29	0.13

TABLE 2
Descriptive statistics of cluster analysis dataset

	N	Min	Max.	Mean	S.E.	Std.	Variance	Skewness	S.E.	Kurtosis	S.E	ρ(1)	ρ(2)	ρ(3)	ρ(4)	ρ(5)
(1) Ranking	6774	1.00	100.00	42.56	0.30	25.02	625.99	0.14	0.03	-1.03	0.06	1				
(2) Assets^{+}	6774	-9.25	-1.25	-6.02	0.02	1.56	2.45	0.87	0.03	0.38	0.06	-0.92***	1			
(3) IB lending^{+}	6774	-20.79	-0.64	-10.26	0.06	5.03	25.34	-0.85	0.03	0.11	0.06	-0.60***	0.58***	1		
(4) IB borrowing^{+}	6774	-20.86	-0.94	-7.80	0.05	4.01	16.08	-1.79	0.03	3.55	0.06	-0.62***	0.65***	0.40***	1	
(5) IB Passthrough^{+}	6774	-20.62	-0.64	-10.77	0.06	5.30	28.07	-0.64	0.03	-0.46	0.06	-0.65***	0.65***	0.91***	0.65***	1

Note: The properties describe the fully (share- and log-) transformed data, denoted $^{+}$. ρ is the Pearson correlation which is significant at the 0.01 level (2-tailed), denoted by ***.

TABLE 3
Testing alternative structures

Hypothesis	Proposition	Method	Statistic	Hypothesis outcome
H1	H1b	Goodness of fit (silhouette measure)	0.5298	Supported
H2	H2b	Goodness of fit (silhouette measure)	0.5469	Supported

TABLE 4
Exploratory Factor Analysis— Pattern Matrix

Variables	Factor 1	2	3	4	5	6	7
Change in cash to liabilities	0.891						
Growth in cash to liabilities	0.929						
Change in cash to total expenses	0.571						
Growth in cash to total expenses	0.883						
Change in reserves	0.454						
Change in cash	0.764						
Growth in short term liquidity to assets	0.750						
Inflation		0.992					
Output		0.929					
Money supply		0.995					
Unemployment		0.800					
Change in liabilities to assets			0.985				
Growth in liabilities to assets			0.948				
Change in assets to capital			0.939				
Growth in assets to capital			0.983				
Change in pre-tax return on equity				0.912			
Change in pre-tax return on assets				0.909			
Change in post-tax return on equity				0.910			
Change in post-tax return on assets				0.910			
Growth in asset					0.900		
Growth in deposit					0.911		
Growth in liabilities					0.868		
Growth in current asset-liability mismatch					0.858		
Change in securities available for sale						0.728	
Growth in securities available for sale						0.791	
Change in securities to assets						0.872	
Growth in securities to assets						0.902	
Growth in the net interest margin							0.909
Growth in revenue to assets							0.833
Growth in interest income to assets							0.954

Note: Principal Component Analysis extraction was used. Rotation Method: Promax with Kaiser Normalization.

TABLE 5
Correlative validity of EFA factors

		Factor 1 (F1)							Factor 2 (F2)				Factor 3 (F3)				Factor 4 (F4)				Factor 5 (F5)				Factor 6 (F6)				Factor 7 (F7)		
		Change in Liquidity							Economic Conditions				Change in Leverage				Change in return				Growth				Growth in Securities				Profitability Growth		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
	(1) Δ Cash to Lia.	1.00	0.78	0.46	0.74	0.30	0.66	0.58	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.05	0.01	0.05	0.02	0.06	0.10	0.12	0.09	-0.13	-0.02	-0.01	-0.32	-0.26	-0.02	-0.03	-0.04
	(2) G. Cash to Lia	0.78	1.00	0.43	0.93	0.31	0.60	0.62	0.00	0.00	0.00	0.00	0.05	0.04	0.06	0.06	-0.01	-0.01	0.00	0.00	0.11	0.13	0.11	-0.07	0.00	0.03	-0.26	-0.21	-0.03	-0.03	-0.05
	(3) Δ Cash to Exp.	0.46	0.43	1.00	0.47	0.14	0.34	0.31	0.00	0.00	0.00	0.00	0.04	0.04	0.05	0.05	0.04	0.06	0.04	0.06	0.09	0.07	0.09	-0.07	0.00	0.02	-0.16	-0.13	-0.09	-0.09	-0.12
F1	(4) G. Cash to Exp.	0.74	0.93	0.47	1.00	0.30	0.58	0.57	0.00	0.00	0.00	0.00	0.10	0.09	0.11	0.11	0.02	0.01	0.02	0.02	0.23	0.19	0.22	0.00	0.05	0.08	-0.23	-0.19	-0.15	-0.18	-0.20
	(5) Δ Reserves	0.30	0.31	0.14	0.30	1.00	0.50	0.23	0.00	0.00	0.00	0.00	0.07	0.06	0.07	0.07	0.00	-0.01	0.00	-0.01	0.15	0.15	0.15	0.04	0.02	0.01	-0.10	-0.09	-0.02	0.01	-0.01
	(6) Δ Cash	0.66	0.60	0.34	0.58	0.50	1.00	0.42	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	-0.02	-0.02	-0.01	-0.01	0.25	0.22	0.25	0.03	0.13	0.09	-0.19	-0.17	-0.06	-0.05	-0.07
	(7) G. STL to assets	0.58	0.62	0.31	0.57	0.23	0.42	1.00	0.00	0.00	0.00	0.00	0.08	0.08	0.07	0.08	0.00	-0.01	0.00	-0.01	0.05	0.01	0.05	-0.15	0.00	0.00	-0.18	-0.14	-0.05	-0.04	-0.04
	(8) PCE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.96	0.99	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
F2	(9) Output	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	1.00	0.93	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00
	(10) Money stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.93	1.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(11) Unemployment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.53	0.78	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(12) Δ Lia. to assets	0.01	0.05	0.04	0.10	0.07	0.11	0.08	0.00	0.00	0.00	0.00	1.00	0.97	0.87	0.95	-0.02	-0.11	-0.04	-0.13	0.29	0.20	0.40	0.14	0.11	0.12	0.04	0.04	-0.15	-0.12	-0.11
F3	(13) G. Lia. to assets	0.00	0.04	0.04	0.09	0.06	0.11	0.08	0.00	0.00	0.00	0.00	0.97	1.00	0.79	0.88	-0.01	-0.13	-0.04	-0.15	0.27	0.20	0.39	0.13	0.09	0.10	0.03	0.02	-0.14	-0.11	-0.11
	(14) Δ Assets to Capital	0.06	0.06	0.05	0.11	0.07	0.11	0.07	0.00	0.00	0.00	0.00	0.87	0.79	1.00	0.98	-0.02	-0.06	-0.05	-0.09	0.29	0.19	0.37	0.15	0.12	0.13	0.05	0.05	-0.15	-0.13	-0.12
	(15) G. Assets to Capital	0.05	0.06	0.05	0.11	0.07	0.11	0.08	0.00	0.00	0.00	0.00	0.95	0.88	0.98	1.00	-0.02	-0.08	-0.05	-0.10	0.29	0.20	0.38	0.15	0.12	0.12	0.05	0.04	-0.15	-0.13	-0.12
	(16) Δ Pre-tax ROE	0.01	-0.01	0.04	0.02	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-0.02	-0.02	1.00	0.72	0.93	0.67	-0.03	-0.05	-0.04	-0.06	-0.03	-0.04	0.00	-0.01	0.04	0.16	0.00
F4	(17) Δ Pre-tax ROA	0.05	-0.01	0.06	0.01	-0.01	-0.02	-0.01	0.00	0.00	0.00	0.00	-0.11	-0.13	-0.06	-0.08	0.72	1.00	0.66	0.95	-0.04	-0.04	-0.06	-0.06	-0.04	-0.05	-0.01	-0.01	0.07	0.14	0.03
	(18) Δ Post-tax ROE	0.02	0.00	0.04	0.02	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.05	-0.05	0.93	0.66	1.00	0.72	-0.04	-0.06	-0.05	-0.07	-0.02	-0.02	0.00	0.00	0.05	0.18	0.01
	(19) Δ Post-tax ROA	0.06	0.00	0.06	0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.13	-0.15	-0.09	-0.10	0.67	0.95	0.72	1.00	-0.05	-0.05	-0.07	-0.06	-0.03	-0.04	0.00	0.00	0.08	0.16	0.04
	(20) G. Assets	0.10	0.11	0.09	0.23	0.15	0.25	0.05	0.01	0.01	0.01	0.00	0.29	0.27	0.29	0.29	-0.03	-0.04	-0.04	-0.05	1.00	0.77	0.98	0.60	0.34	0.39	-0.01	-0.03	-0.23	-0.18	-0.25
F5	(21) G. Deposits	0.12	0.13	0.07	0.19	0.15	0.22	0.01	0.01	0.01	0.01	0.00	0.20	0.20	0.19	0.20	-0.05	-0.04	-0.06	-0.05	0.77	1.00	0.76	0.66	0.22	0.26	-0.07	-0.07	-0.14	-0.12	-0.16
	(22) G. Liabilities	0.09	0.11	0.09	0.22	0.15	0.25	0.05	0.01	0.01	0.01	0.00	0.40	0.39	0.37	0.38	-0.04	-0.06	-0.05	-0.07	0.98	0.76	1.00	0.59	0.34	0.38	0.00	-0.03	-0.23	-0.18	-0.24
	(23) G. Current AL Miss	-0.13	-0.07	-0.07	0.00	0.04	0.03	-0.15	0.00	0.00	0.00	0.00	0.14	0.13	0.15	0.15	-0.06	-0.06	-0.07	-0.06	0.60	0.66	0.59	1.00	0.22	0.26	0.02	-0.01	-0.10	-0.07	-0.10
	(24) Δ Sec. AFS	-0.02	0.00	0.00	0.05	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.11	0.09	0.12	0.12	-0.03	-0.04	-0.02	-0.03	0.34	0.22	0.34	0.22	1.00	0.67	0.45	0.42	-0.08	-0.06	-0.08
F6	(25) G. Sec AFS	-0.01	0.03	0.02	0.08	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.12	0.10	0.13	0.12	-0.04	-0.05	-0.02	-0.04	0.39	0.26	0.38	0.26	0.67	1.00	0.49	0.56	-0.13	-0.08	-0.12
	(26) Δ Sec. to Assets	-0.32	-0.26	-0.16	-0.23	-0.10	-0.19	-0.18	-0.01	-0.01	0.00	0.00	0.04	0.03	0.05	0.05	0.00	-0.01	0.00	0.00	-0.01	-0.07	0.00	0.02	0.45	0.49	1.00	0.87	-0.05	-0.05	-0.03
	(27) G. Sec. to Assets	-0.26	-0.21	-0.13	-0.19	-0.09	-0.17	-0.14	0.00	-0.01	0.00	0.00	0.04	0.02	0.05	0.04	-0.01	-0.01	0.00	0.00	-0.03	-0.07	-0.03	-0.01	0.42	0.56	0.87	1.00	-0.03	-0.03	-0.01
	(28) G. Net Int. Margin	-0.02	-0.03	-0.09	-0.15	-0.02	-0.06	-0.05	0.00	0.00	0.00	0.00	-0.15	-0.14	-0.15	-0.15	0.04	0.07	0.05	0.08	-0.23	-0.14	-0.23	-0.10	-0.08	-0.13	-0.05	-0.03	1.00	0.60	0.87
F7	(29) G. Rev. to Assets	-0.03	-0.03	-0.09	-0.18	0.01	-0.05	-0.04	0.00	0.00	0.00	0.00	-0.12	-0.11	-0.13	-0.13	0.16	0.14	0.18	0.16	-0.18	-0.12	-0.18	-0.07	-0.06	-0.08	-0.05	-0.03	0.60	1.00	0.70
	(30) G. Int. Inc. to Assets	-0.04	-0.05	-0.12	-0.20	-0.01	-0.07	-0.04	0.00	0.00	0.00	0.00	-0.11	-0.11	-0.12	-0.12	0.00	0.03	0.01	0.04	-0.25	-0.16	-0.24	-0.10	-0.08	-0.12	-0.03	-0.01	0.87	0.70	1.00

TABLE 6
Discriminant validity of 1st order CFA factors

	Change in Liquidity	Economic Conditions	Change in Leverage	Change in Return	Growth	Growth in Securities	Profitability Growth
Change in Liquidity	1						
Economic Conditions	0.004	1					
Change in Leverage	0.101	-0.002	1				
Change in Return	0.013	-0.002	-0.075	1			
Growth	0.188	0.006	0.283	-0.063	1		
Growth in Securities	-0.131	-0.003	0.103	-0.023	0.164	1	
Profitability Growth	-0.110	-0.001	-0.152	0.079	-0.197	-0.086	1

TABLE 7
1st order CFA Reliability and Validity Testing

	Reliability and validity metrics				Factor correlation matrix						
	CR	AVE	MSV	ASV	Change in Liquidity	Economic Conditions	Change in Leverage	Change in Return	Growth	Growth in Securities	Profitability Growth
Change in Liquidity	0.97	0.90	0.09	0.02	*0.95*						
Economic Conditions	0.91	0.73	0.09	0.03	0.31	*0.85*					
Change in Leverage	0.96	0.86	0.00	0.00	0.00	0.01	*0.92*				
Change in Return	0.87	0.52	0.05	0.01	0.08	0.15	0.00	*0.72*			
Growth	0.92	0.74	0.01	0.00	-0.09	-0.05	0.00	0.01	*0.86*		
Growth in Securities	0.82	0.56	0.05	0.01	0.05	-0.02	-0.01	-0.22	0.00	*0.75*	
Profitability Growth	0.87	0.70	0.05	0.01	-0.15	-0.23	0.01	-0.07	0.08	-0.04	*0.84*

Note: Italicized diagonal of the factor correlation matrix shows square root of AVE.

TABLE 8
Goodness of fit metrics considered for configural invariance of CFA

Sample	CFI	RMSEA	standardized RMR
All Observations	0.819	0.141	0.0650
Core-periphery partition	0.817	0.102	0.0686
Three-tiered partition	0.815	0.085	0.0698

TABLE 9
Metric invariance of the CFA model with respect to interbank market structure (hypothesis H3e)

Panel A: Core Periphery Invariance			z-score
Path	Core	Periphery	Core vs. Periphery
Change in Liquidity→Change in cash to liabilities	0.794***	0.786***	-0.409
Change in Liquidity→Growth in cash to liabilities	0.912***	0.982***	3.865***
Change in Liquidity→Change in cash to total expenses	0.392***	0.499***	4.331***
Change in Liquidity→Growth in cash to total expenses	0.879***	0.961***	4.334***
Change in Liquidity→Change in reserves	0.387***	0.282***	-3.784***
Change in Liquidity→Change in interest bearing balances	0.719***	0.567***	-6.079***
Change in Liquidity→Change in cash	0.595***	0.639***	1.973**
Change in Liquidity→Growth in short term liquidity to assets	0.997***	0.951***	-2.581***
Economic Conditions→Inflation	1.024***	0.863***	-8.378***
Economic Conditions→Output	0.963***	0.967***	0.229
Economic Conditions→Money Supply	0.575***	0.832***	12.253***
Economic Conditions→Unemployment	0.948***	0.907***	-2.227**
Change in Leverage→Change in liabilities to assets	0.927***	0.808***	-6.239***
Change in Leverage→Growth in liabilities to assets	0.945***	0.959***	0.806
Change in Leverage→Change in assets to capital	0.971***	0.976***	0.292
Change in Leverage→Growth in assets to capital	0.885***	0.617***	-12.729***
Change in Return→Change in pre-tax return on equity	0.959***	0.948***	-0.57
Change in Return→Change in pre-tax return on assets	0.876***	0.630***	-11.718***
Change in Return→Change in post-tax return on equity	0.948***	0.961***	0.707
Change in Return→Change in post-tax return on assets	0.970***	0.987***	0.977
Growth→Growth in asset	0.726***	0.768***	1.978**
Growth→Growth in deposit	0.956***	0.971***	0.864
Growth→Growth in liabilities	0.559***	0.607***	2.101**
Growth→Growth in current asset-liability mismatch	0.466***	0.395***	-2.719***
Growth in Securities→Change in securities available for sale	0.551***	0.552***	0.051
Growth in Securities→Growth in securities available for sale	0.810***	0.875***	3.264***
Growth in Securities→Change in securities to assets	0.956***	0.999***	2.423**
Growth in Securities→Growth in securities to assets	0.976***	0.982***	0.293
Profitability Growth→Growth in the net interest margin	0.595***	0.565***	-1.313
Profitability Growth→Growth in revenue to assets	0.828***	0.860***	1.585
Profitability Growth→Growth in interest income to assets	0.794***	0.786***	-0.409

Panel B: Three Tier Invariance				z-score		
Path	Tier 1	Tier 2	Tier 3	Tier 1 vs. 2	Tier 1 vs. 3	Tier 2 vs. 3
Change in Liquidity→Change in cash to liabilities	0.789***	0.783***	0.804***	-0.272	0.524	0.774
Change in Liquidity→Growth in cash to liabilities	0.919***	0.977***	0.966***	2.877***	1.864*	-0.499
Change in Liquidity→Change in cash to total expenses	0.360***	0.503***	0.515***	5.369***	4.726***	0.403
Change in Liquidity→Growth in cash to total expenses	0.885***	0.959***	0.940***	3.555***	2.128**	-0.799
Change in Liquidity→Change in reserves	0.362***	0.248***	0.425***	-3.852***	1.691*	5.772***
Change in Liquidity→Change in cash	0.656***	0.591***	0.635***	-2.429**	-0.604	1.539
Change in Liquidity→Growth in short term liquidity to assets	0.606***	0.573***	0.774***	-1.311	5.608***	7.184***
Economic Conditions←Inflation	0.991***	0.929***	0.870***	-3.142***	-5.162***	-2.788***
Economic Conditions←Output	1.022***	0.893***	0.743***	-6.05***	-11.967***	-7.471***
Economic Conditions←Money Supply	0.953***	0.916***	0.926***	-1.951*	-1.152	0.428
Economic Conditions←Unemployment	0.553***	0.671***	0.912***	5.319***	12.212***	8.571***
Change in Leverage←Change in liabilities to assets	0.947***	0.914***	0.905***	-1.646	-1.602	-0.332
Change in Leverage←Growth in liabilities to assets	0.935***	0.819***	0.795***	-5.529***	-5.108***	-0.896
Change in Leverage←Change in assets to capital	0.942***	0.967***	0.943***	1.279	0.074	-1
Change in Leverage←Growth in assets to capital	0.966***	0.979***	0.978***	0.685	0.5	-0.049
Change in Return←Change in pre-tax return on equity	0.865***	0.639***	0.665***	-9.761***	-6.808***	0.906
Change in Return←Change in pre-tax return on assets	0.956***	0.940***	0.976***	-0.768	0.8	1.503
Change in Return←Change in post-tax return on equity	0.861***	0.652***	0.659***	-9.055***	-6.917***	0.239
Change in Return←Change in post-tax return on assets	0.949***	0.945***	0.990***	-0.23	1.648	1.937*
Growth←Growth in asset	0.981***	0.981***	0.980***	-0.04	-0.072	-0.043
Growth←Growth in deposit	0.731***	0.800***	0.672***	2.958***	-1.952*	-4.582***
Growth←Growth in liabilities	0.976***	0.962***	0.957***	-0.707	-0.798	-0.251
Growth←Growth in current asset-liability mismatch	0.547***	0.658***	0.491***	4.429***	-1.766*	-5.645***
Growth in Securities←Change in securities available for sale	0.433***	0.418***	0.408***	-0.512	-0.676	-0.322
Growth in Securities←Growth in securities available for sale	0.572***	0.497***	0.655***	-2.934***	2.709***	5.481***
Growth in Securities←Change in securities to assets	0.803***	0.893***	0.826***	4.156***	0.819	-2.614***
Growth in Securities←Growth in securities to assets	0.968***	0.996***	0.980***	1.422	0.492	-0.688
Profitability Growth←Growth in the net interest margin	0.979***	0.977***	0.988***	-0.084	0.377	0.474
Profitability Growth←Growth in revenue to assets	0.585***	0.573***	0.570***	-0.5	-0.497	-0.111
Profitability Growth←Growth in interest income to assets	0.843***	0.839***	0.880***	-0.203	1.341	1.624

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Shading indicates measurement model group variance.

TABLE 10
Direct association results

Hypothesis	Proposition	Direct Beta	Hypothesis outcome
H4a	Economic Conditions↗ Relative Interbank borrowing	-0.191***	Supported
H5a	Economic Conditions↗ Relative Interbank lending	-0.120***	Supported
H4b	Change in Liquidity↗ Relative Interbank borrowing	0.025*	Not Supported
H5b	Change in Liquidity ↗ Relative Interbank lending	0.015	Not Supported
H4c	Change in Leverage↗ Relative Interbank borrowing	0.008	Not Supported
H5c	Change in Leverage ↗ Relative Interbank lending	-0.014	Not Supported
H4d	Change in Return↗ Relative Interbank borrowing	-0.088***	Supported
H5d	Change in Return ↗ Relative Interbank lending	-0.095***	Supported
H4e	Growth↗ Relative Interbank borrowing	-0.071***	Supported
H5e	Growth ↗ Relative Interbank lending	0.005	Not Supported
H4f	Effective Federal Funds↗ Relative Interbank borrowing	0.013	Not Supported
H5f	Effective Federal Funds ↗ Relative Interbank lending	0.023*	Not Supported

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

TABLE 11
Mediation testing results

Hypothesis	Proposition	Direct Beta w/o Med.	Direct Beta w/ Med.	Indirect Beta	Mediation observed	Hypothesis outcome
H6a-1	Economic Conditions ↗Change in Return ↗ Relative Interbank borrowing	-0.191***	-0.191***	0.000	No Mediation	Not Supported
H7a-1	Economic Conditions ↗Change in Return ↗ Relative Interbank lending	-0.120***	-0.120***	0.000	No Mediation	Not Supported
H6a-2	Economic Conditions ↗ Growth ↗ Relative Interbank borrowing	-0.191***	-0.191***	-0.001	No Mediation	Not Supported
H7a-2	Economic Conditions ↗Growth ↗ Relative Interbank lending	-0.120***	-0.120***	0.000	No Mediation	Not Supported
H6a-3	Economic Conditions ↗ Effective Federal Funds Rate ↗ Relative Interbank borrowing	-0.191***	-0.211***	0.011	No Mediation	Not Supported
H7a-3	Economic Conditions ↗ Effective Federal Funds Rate ↗ Relative Interbank lending	-0.120***	-0.133***	-0.006	No Mediation	Not Supported
H6b-1	Change in Liquidity ↗Change in Leverage ↗ Relative Interbank borrowing	0.024*	0.024*	0.000	No Mediation	Not Supported
H7b-1	Change in Liquidity ↗Change in Leverage ↗ Relative Interbank lending	0.015	0.015	0.000	No Mediation	Not Supported
H6b-2	Change in Liquidity ↗Change in Return ↗ Relative Interbank borrowing	0.024*	0.024*	-0.002	No Mediation	Not Supported
H7b-2	Change in Liquidity ↗Change in Return ↗ Relative Interbank lending	0.015	0.015	-0.002	No Mediation	Not Supported
H6b-3	Change in Liquidity ↗ Growth ↗ Relative Interbank borrowing	0.024*	0.025*	-0.011***	Full Mediation	Supported
H7b-4	Change in Liquidity ↗Growth ↗ Relative Interbank lending	0.015	0.015	0.001	No Mediation	Not Supported
H6c-1	Change in Leverage ↗Change in Return ↗ Relative Interbank borrowing	0.008	0.007	0.008***	Full Mediation	Supported
H7c-1	Change in Leverage↗Change in Return ↗ Relative Interbank lending	-0.014	-0.015	0.009***	Full Mediation	Supported
H6c-2	Change in Leverage ↗Growth ↗ Relative Interbank borrowing	0.008	0.010	-0.022***	Full Mediation	Supported
H7c-2	Change in Leverage↗Growth ↗ Relative Interbank lending	-0.014	-0.014	0.001	No Mediation	Not Supported
H6d-1	Change in Return ↗ Growth ↗ Relative Interbank borrowing	-0.088***	-0.088***	0.002***	Partial Mediation	Supported
H7d-1	Change in Return ↗ Growth ↗ Relative Interbank lending	-0.095***	-0.094***	0.000	No Mediation	Not Supported

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 12
Invariance of SEM from Figure 10 to interbank market structural tiering (H8)

Panel A: Core-periphery structure	Chi-square	df	p-val	Invariant?
Unconstrained	1.855	10		
Fully constrained	245.807	31		
Number of groups		2		
Difference	243.952	21	0.00	No
90% Confidence	4.56	11		
Difference	2.71	1	0.100	
95% Confidence	5.70	11		
Difference	3.84	1	0.050	
99% Confidence	8.49	11		
Difference	6.63	1	0.010	
Panel A: Three tier structure	Chi-square	df	p-val	Invariant?
Unconstrained	0.932	15		
Fully constrained	383.523	57		
Number of groups		3		
Difference	382.591	42	0.00	No
90% Confidence	5.54	17		
Difference	4.61	2	0.100	
95% Confidence	6.92	17		
Difference	5.99	2	0.050	
99% Confidence	10.14	17		
Difference	9.21	2	0.010	

TABLE 13
Multi-group moderation of SEM direct associations from Figure 10

Panel A: Core-periphery Moderation			Unconstrained Std. Coefficients		Direct Moderation	
					z-score	
Hyp.	Path	Predicted	Core	Periphery	Core vs. Periphery	Hypothesis outcome
H9a-d	Economic Conditions↗ Relative Interbank borrowing	Core > Periphery	-0.346***	-0.099***	4.47***	Supported
H10a-d	Economic Conditions↗ Relative Interbank lending	Core > Periphery	0.015	-0.251***	-2.461**	Supported
H9b-d	Change in Liquidity↗ Relative Interbank borrowing	Core > Periphery	-0.002	0.035**	1.435	Not Supported
H10b-d	Change in Liquidity ↗ Relative Interbank lending	Core > Periphery	0.025	-0.003	-1.145	Not Supported
H9c-d	Change in Leverage↗ Relative Interbank borrowing	Core > Periphery	-0.001	0.014	0.583	Not Supported
H10c-d	Change in Leverage ↗ Relative Interbank lending	Core > Periphery	-0.011	-0.026	0.123	Not Supported
H9d-d	Change in Return↗ Relative Interbank borrowing	Core > Periphery	-0.141***	-0.065***	2.209**	Supported
H10d-d	Change in Return ↗ Relative Interbank lending	Core > Periphery	-0.168***	0.007	7.832***	Supported
H9e-d	Growth↗ Relative Interbank borrowing	Core > Periphery	-0.009	-0.1***	-3.516***	Supported
H10e-d	Growth ↗ Relative Interbank lending	Core > Periphery	-0.013	0.066***	1.399	Not Supported
H9f-d	Effective Federal Funds↗ Relative Interbank borrowing	Core > Periphery	-0.033	-0.011	0.416	Not Supported
H10f-d	Effective Federal Funds ↗ Relative Interbank lending	Core > Periphery	0.019	-0.009	-0.569	Not Supported

Panel B:Three Tier Moderation			Unconstrained Std. Coefficients			Direct Mediation			
						z-score			
Hyp.	Path	Predicted	Tier 1	Tier 2	Tier 3	Tier 1 vs. Tier 2	Tier 1 vs. Tier 3	Tier 2 vs. Tier 3	Hypothesis outcome
H9a-d	Economic Conditions↗ Relative Interbank borrowing	Tier 1 >Tier 2 > Tier 3	-0.357***	-0.094***	-0.099*	4.651***	2.598***	-0.329	Partially Supported
H10a-d	Economic Conditions↗ Relative Interbank lending	Tier 1 >Tier 2 > Tier 3	0.02	-0.196***	-0.284***	-1.718*	-3.036***	-2.971***	Partially Supported
H9b-d	Change in Liquidity↗ Relative Interbank borrowing	Tier 1 >Tier 2 > Tier 3	0.003	0.04**	0.016	1.278	0.400	-0.522	Not Supported
H10b-d	Change in Liquidity ↗ Relative Interbank lending	Tier 1 >Tier 2 > Tier 3	0.03	0.005	-0.008	-1.177	-1.254	-0.359	Not Supported
H9c-d	Change in Leverage↗ Relative Interbank borrowing	Tier 1 >Tier 2 > Tier 3	-0.013	0.031	-0.016	1.476	-0.178	-1.306	Not Supported
H10c-d	Change in Leverage ↗ Relative Interbank lending	Tier 1 >Tier 2 > Tier 3	-0.012	0.004	-0.054**	0.531	-0.307	-1.885*	Not Supported
H9d-d	Change in Return↗ Relative Interbank borrowing	Tier 1 >Tier 2 > Tier 3	-0.154***	-0.055***	-0.082***	2.977***	1.231	-0.936	Partially Supported
H10d-d	Change in Return ↗ Relative Interbank lending	Tier 1 >Tier 2 > Tier 3	-0.193***	-0.022	0.039	8.106***	8.351***	1.798*	Partially Supported
H9e-d	Growth↗ Relative Interbank borrowing	Tier 1 >Tier 2 > Tier 3	-0.023	-0.092***	-0.093***	-2.377**	-2.075**	-0.349	Not Supported
H10e-d	Growth ↗ Relative Interbank lending	Tier 1 >Tier 2 > Tier 3	-0.024	0.033	0.081***	1.209	1.962**	1.924*	Partially Supported
H9f-d	Effective Federal Funds↗ Relative Interbank borrowing	Tier 1 >Tier 2 > Tier 3	-0.035	-0.008	-0.079	0.506	-0.977	-1.293	Not Supported
H10f-d	Effective Federal Funds ↗ Relative Interbank lending	Tier 1 >Tier 2 > Tier 3	0.016	-0.055*	0.054	-0.753	0.195	1.604	Not Supported

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

TABLE 14
Multi-group moderation using the core-periphery structure of SEM mediated associations from Figure 10

Hypothesis	Association Path	Core: Direct Beta w/o Med	Core: Direct Beta w/ Med	Core: Indirect Beta	Core: Mediation Type Observed	Periphery: Direct Beta w/o Med	Periphery: Direct Beta w/ Med	Periphery: Indirect Beta	Periphery: Mediation Type Observed
H9a-1m	Economic Conditions ↗Change in Return ↗ Interbank borrowing	-0.309***	-0.310***	0.004	NM	-0.090***	-0.090***	-0.001	NM
H10a-1m	Economic Conditions ↗Change in Return ↗ Interbank lending	0.014	0.014	0.005	NM	-0.227***	-0.227***	0.000	NM
H9a-2m	Economic Conditions ↗ Growth ↗ Interbank borrowing	-0.309***	-0.309***	0.000	NM	-0.090***	-0.090***	-0.001	NM
H10a-2m	Economic Conditions ↗Growth ↗ Interbank lending	0.014	0.014	0.000	NM	-0.227***	-0.227***	0.001	NM
H9a-3m	Economic Conditions ↗ Effective Federal Funds Rate ↗ Interbank borrowing	-0.309***	-0.345***	0.027	NM	-0.090***	-0.100***	0.008	NM
H10a-3m	Economic Conditions ↗ Effective Federal Funds Rate ↗ Interbank lending	0.014	0.016	-0.016	NM	-0.227***	-0.250***	0.008	NM
H9b-1m	Change in Liquidity ↗Change in Leverage ↗ Interbank borrowing	-0.003	-0.003	0.001	NM	0.033**	0.033**	-0.001	NM
H10b-1m	Change in Liquidity ↗Change in Leverage ↗ Interbank lending	0.025	0.025	0.000	NM	-0.002	-0.002	-0.001	NM
H9b-2m	Change in Liquidity ↗Change in Return ↗ Interbank borrowing	-0.003	-0.002	-0.001	NM	0.033**	0.033**	0.000	NM
H10b-2m	Change in Liquidity ↗Change in Return ↗ Interbank lending	0.025	0.025	-0.002	NM	-0.002	-0.002	-0.001	NM
H9b-3m	Change in Liquidity ↗ Growth ↗ Interbank borrowing	-0.003	-0.002	-0.001	NM	0.033**	0.035**	-0.014***	PM
H10b-3m	Change in Liquidity ↗Growth ↗ Interbank lending	0.025	0.025	-0.002	NM	-0.002	-0.003	0.010***	FM
H9c-1m	Change in Leverage ↗Change in Return ↗ Interbank borrowing	0.000	-0.001	0.016***	FM	0.012	0.011	0.005***	FM
H10c-1m	Change in Leverage↗Change in Return ↗ Interbank lending	-0.010	-0.012	0.019***	FM	-0.025	-0.024	0.000	NM
H9c-2m	Change in Leverage ↗Growth ↗ Interbank borrowing	0.000	-0.140***	-0.003	NM	0.012	0.014	-0.026***	FM
H10c-2m	Change in Leverage↗Growth ↗ Interbank lending	-0.010	-0.168***	-0.005	NM	-0.025	-0.026	0.017***	FM
H9d-1m	Change in Return ↗ Growth ↗ Interbank borrowing	-0.140***	-0.141***	0.000	NM	-0.065***	-0.065***	0.004***	PM
H10d-1m	Change in Return ↗ Growth ↗ Interbank lending	-0.168***	-0.168***	0.000	NM	0.007	0.007	-0.002***	FM

Note: * significant at 10%; ** significant at 5%; *** significant at 1%
There is either no mediation (NM), full mediation (FM), or partial mediation (PM) for each relationship.

TABLE 15
Multi-group moderation using the three tier structure of SEM mediated associations from Figure 10

		Tier 1				Tier 2				Tier 3			
Hyp.	Association Path	Direct Beta w/o Med	Direct Beta w/ Med	Indirect Beta	Mediation Type Observed	Direct Beta w/o Med	Direct Beta w/ Med	Indirect Beta	Mediation Type Observed	Direct Beta w/o Med	Direct Beta w/ Med	Indirect Beta	Mediation Type Observed
H9a-1m	Economic Conditions ↗Change in Return ↗ Interbank borrowing	-0.321***	-0.321***	0.000	NM	-0.086***	-0.086***	0.000	NM	-0.086***	-0.086***	0.001	NM
H10a-1m	Economic Conditions ↗Change in Return ↗ Interbank lending	0.018	0.018	0.000	NM	-0.178***	-0.178***	0.000	NM	-0.253***	-0.253***	0.000	NM
H9a-2m	Economic Conditions ↗ Growth ↗ Interbank borrowing	-0.321***	-0.321***	0.000	NM	-0.086***	-0.086***	-0.001	NM	-0.086***	-0.086***	-0.002	NM
H10a-2m	Economic Conditions ↗Growth ↗ Interbank lending	0.018	0.018	0.000	NM	-0.178***	-0.179***	0.000	NM	-0.253***	-0.253***	0.001	NM
H9a-3m	Economic Conditions ↗ Effective Federal Funds Rate ↗ Interbank borrowing	-0.321***	-0.357***	0.029	NM	-0.086***	-0.094***	0.006*	NM	-0.086***	-0.099*	0.065	NM
H10a-3m	Economic Conditions ↗ Effective Federal Funds Rate ↗ Interbank lending	0.018	0.020	-0.013	NM	-0.178***	-0.196***	0.042	NM	-0.253***	-0.283***	-0.044	NM
H9b-1m	Change in Liquidity ↗Change in Leverage ↗ Interbank borrowing	0.002	0.002	-0.001	NM	0.038**	0.038**	0.001	NM	0.015	0.015	-0.002	NM
H10b-1m	Change in Liquidity ↗Change in Leverage ↗ Interbank lending	0.029	0.029	0.000	NM	0.005	0.005	0.001	NM	-0.007	-0.007	-0.003*	NM
H9b-2m	Change in Liquidity ↗Change in Return ↗ Interbank borrowing	0.002	0.002	-0.001	NM	0.038**	0.038**	-0.002*	NM	0.015	0.015	0.000	NM
H10b-2m	Change in Liquidity ↗Change in Return ↗ Interbank lending	0.029	0.029	-0.001	NM	0.005	0.005	-0.001	NM	-0.007	-0.007	0.000	NM
H9b-3m	Change in Liquidity ↗ Growth ↗ Interbank borrowing	0.002	0.002	-0.004	NM	0.038**	0.040**	-0.013***	PM	0.015	0.016	-0.011	NM
H10b-3m	Change in Liquidity ↗Growth ↗ Interbank lending	0.029	0.030	-0.004	NM	0.005	0.005	0.004*	NM	-0.007	-0.008	0.012*	NM
H9c-1m	Change in Leverage ↗Change in Return ↗ Interbank borrowing	-0.013	-0.014	0.018***	FM	0.029	0.028	0.004***	FM	-0.017	-0.018	0.007***	FM
H10c-1m	Change in Leverage↗Change in Return ↗ Interbank lending	-0.012	-0.014	0.022***	FM	0.005	0.005	0.002	NM	-0.054**	-0.052*	-0.004*	NM
H9c-2m	Change in Leverage ↗Growth ↗ Interbank borrowing	-0.013	-0.012	-0.009	NM	0.029	0.031*	-0.026***	FM	-0.017	-0.016	-0.018***	FM
H10c-2m	Change in Leverage↗Growth ↗ Interbank lending	-0.012	-0.011	-0.010	NM	0.005	0.004	0.009*	NM	-0.054**	-0.054**	0.016***	PM
H9d-1m	Change in Return ↗ Growth ↗ Interbank borrowing	-0.154***	-0.154***	0.000	NM	-0.055***	-0.055***	0.000	NM	-0.082***	-0.082***	-0.002	NM
H10d-1m	Change in Return ↗ Growth ↗ Interbank lending	-0.193***	-0.193***	0.000	NM	-0.022	-0.022	0.000	NM	0.040	0.039	0.002	NM

Note: * significant at 10%; ** significant at 5%; *** significant at 1%
There is either no mediation (NM), full mediation (FM), or partial mediation (PM) for each relationship.

TABLE 16
Comparison of SEM goodness of fit when model is applied to individual interbank market segments (H11).

Sample	CMIN / DF	CFI	RMSEA	SRMR
All observations	0.028	1.000	0.000	0.0008
Core	0.116	1.000	0.000	0.0031
Periphery	0.255	1.000	0.000	0.0038
Tier 1	0.049	1.000	0.000	0.0017
Tier 2	0.074	1.000	0.000	0.0012
Tier 3	0.063	1.000	0.000	0.0016

APPENDIX A: CLUSTER ANALYSIS

The distance between clusters i and j is defined as[32]:

$$d^{log}(i,j) = \xi_i + \xi_j - \xi_{<i,j>} \tag{A1}$$

$$\xi_v = N_v \left[\sum_{k=1}^{K} \frac{1}{2} \log(\hat{\sigma}_k^2 + \hat{\sigma}_{vk}^2)\right] \tag{A2}$$

Above, $\hat{\sigma}_k^2$ is the estimated variance of the k^{th} continuous variable across the entire dataset, $\hat{\sigma}_{vk}^2$ is the estimated variance of the k^{th} continuous variable in cluster v, N_v denotes the number of data records in cluster v. Moreover, K is the total number of continuous variables used in the procedure, and $<i, j>$ is the index of the cluster obtained by combining clusters i and j. If $\hat{\sigma}_k^2$ is ignored in the expression for ξ_v, the distance between clusters i and j would be exactly the decrease in log-likelihood when the two clusters are combined. The $\hat{\sigma}_k^2$ term is added to solve the problem caused by $\hat{\sigma}_{vk}^2 = 0$, which would result in the natural logarithm being undefined.[33] The result of this cluster analysis is that each observation i is assigned to one of M tiers, denoted $m(i) \in \{1, \ldots, M\}$ where m is a membership function.

We measure the goodness of the predicted tier membership produced by the cluster analysis in terms of the average silhouette coefficient ρ. The latter balances the desire for each observation in a cluster to be "close" to the other observations in that cluster (similarity within a cluster) against the need for an observation to be "distant" from observations which are not in that cluster (distinction between clusters). It is calculated as:

$$\rho = \frac{1}{n}\sum \rho_i = \frac{1}{n}\sum_i \frac{B_i - A_i}{\max(A_i, B_i)} \tag{A3},$$

[32] The distance measure proposed by Chiu et al. (2001) also allows for the use of categorical variables which is slightly more involved and therefore a simpler version is outlined here.

[33] Initially, each cluster contains only a single observation leading to a variance of zero for that cluster which would make the logarithm term undefined if $\hat{\sigma}_k^2$ was not included.

$$A_i = d^{\log}(i, C(i)) \quad \text{(A4),}$$

$$B_i = \min_{j \neq i}\left[d^{log}\left(i, C(j)\right)\right] \quad \text{(A5),}$$

where $d(i, j)$ is the distance between observations i and j and $C(i)$ denotes the centroid of the cluster to which observation i belongs to. Kaufman and Rousseeuw (2009) find that a silhouette greater than 0.5 indicates reasonable partitioning while a silhouette less than 0.2 implies that the dataset does not exhibit a cluster structure.

APPENDIX B: LONGITUDINAL FACTOR ANALYSIS

The EFA model's core assumptions include that factor ξ & η and idiosyncratic residual δ & ϵ do not exhibit serial correlation. Referring to the assumption of serial correlation Geweke (1977: 365) raises the point that "if the $x_i(t)$ are time series this assumption is almost always inappropriate since $x_i(t)$ and $x_i(t + s)$ will in general be correlated." Stock and Watson (2011: 2) provide the analogy that residuals pick up on issues unique to an individual indicator, like the impact of a salmonella scare which affects restaurant employment but not the pet store next door. Anderson (1963: 7) agrees that shocks in the time dimension may persist across multiple time periods leading to serial correlation issues. However, Anderson concludes that the "day-to-day correlation may be of no greater disadvantage than if the observations were independent". As shown in Table B1, serial correlation testing on the time-ordered data showed the presence of serial correlation. Table B2 indicates that the data is significantly differs from the normal distribution. Descriptive statistics for each data series analyzed in EFA is provided in Table B3.

TABLE B1
Serial correlation testing of data series used in EFA

	Original	
	$LM\ Obs * R^2$ (at –1 lags)	H_0 no serial autocorrelation
Change in cash to liabilities	0.84(ns)	fail to reject the null at *
Growth in cash to liabilities	0.45(ns)	fail to reject the null at *
Change in cash to total expenses	5.13(**)	reject the null at **
Growth in cash to total expenses	0.07(ns)	fail to reject the null at *
Change in reserves	0.95(ns)	fail to reject the null at *
Change in cash	2.18(ns)	fail to reject the null at *
Growth in short term liquidity to assets	4.67(**)	reject the null at **
Inflation	0.83(ns)	fail to reject the null at *
Output	0.25(ns)	fail to reject the null at *
Money supply	0.52(ns)	fail to reject the null at *
Unemployment	0.00(ns)	fail to reject the null at *
Change in liabilities to assets	0.11(ns)	fail to reject the null at *
Growth in liabilities to assets	0.22(ns)	fail to reject the null at *
Change in assets to capital	1.10(ns)	fail to reject the null at *
Growth in assets to capital	0.89(ns)	fail to reject the null at *
Change in pre-tax return on equity	10.39(***)	reject the null at ***
Change in pre-tax return on assets	3.69(*)	reject the null at *
Change in post-tax return on equity	7.43(***)	reject the null at ***
Change in post-tax return on assets	1.35(ns)	fail to reject the null at *
Growth in asset	0.02(ns)	fail to reject the null at *
Growth in deposit	0.13(ns)	fail to reject the null at *
Growth in liabilities	0.00(ns)	fail to reject the null at *
Growth in current asset-liability mismatch	0.28(ns)	fail to reject the null at *
Change in securities available for sale	1.23(ns)	fail to reject the null at *
Growth in securities available for sale	0.25(ns)	fail to reject the null at *
Change in securities to assets	2.60(ns)	fail to reject the null at *
Growth in securities to assets	2.04(ns)	fail to reject the null at *
Growth in the net interest margin	0.50(ns)	fail to reject the null at *
Growth in revenue to assets	1.06(ns)	fail to reject the null at *
Growth in interest income to assets	0.28(ns)	fail to reject the null at *

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

TABLE B2
Normality testing of standardized data series used in EFA

Variable	Lilliefors	Cramer-von Mises	Watson	Anderson-Darling
Change in cash to liabilities	0.11***	31.72***	31.67***	175.25***
Growth in cash to liabilities	0.05***	8.30***	8.27***	49.03***
Change in cash to total expenses	0.10***	25.94***	24.87***	160.09***
Growth in cash to total expenses	0.06***	8.81***	8.77***	52.04***
Change in reserves	0.15***	55.58***	55.51***	303.16***
Change in cash	0.16***	64.12***	63.94***	342.84***
Growth in short term liquidity to assets	0.06***	9.62***	9.61***	56.20***
Inflation	0.10***	15.32***	15.31***	99.70***
Output	0.16***	30.47***	27.06***	177.64***
Money supply	0.07***	9.72***	9.03***	73.79***
Unemployment	0.25***	131.10***	123.13***	749.50***
Change in liabilities to assets	0.09***	23.25***	23.25***	132.00***
Growth in liabilities to assets	0.11***	32.16***	32.14***	178.15***
Change in assets to capital	0.09***	22.74***	22.71***	129.07***
Growth in assets to capital	0.08***	18.18***	18.17***	104.52***
Change in pre-tax return on equity	0.06***	8.74***	8.52***	52.28***
Change in pre-tax return on assets	0.12***	37.77***	37.72***	205.09***
Change in post-tax return on equity	0.07***	12.87***	12.57***	76.78***
Change in post-tax return on assets	0.13***	45.70***	45.68***	249.07***
Growth in asset	0.15***	49.97***	43.88***	266.11***
Growth in deposit	0.14***	50.60***	45.67***	276.73***
Growth in liabilities	0.14***	45.45***	41.00***	248.26***
Growth in current asset-liability mismatch	0.12***	32.74***	30.72***	183.13***
Change in securities available for sale	0.16***	67.51***	66.81***	359.28***
Growth in securities available for sale	0.10***	25.46***	24.93***	146.45***
Change in securities to assets	0.07***	15.01***	15.01***	86.87***
Growth in securities to assets	0.08***	18.26***	18.23***	105.29***
Growth in the net interest margin	0.10***	29.42***	29.21***	165.04***
Growth in revenue to assets	0.10***	26.87***	26.81***	153.81***
Growth in interest income to assets	0.09***	26.66***	26.50***	151.65***

Notes: Null hypothesis is that the data is normally distributed.* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE B3
Descriptive statistics of data used for EFA analysis

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Change in cash to liabilities	6424	-6.91	7.15	0.00	0.97	0.29	0.03	7.10	0.06
Growth in cash to liabilities	6424	-5.90	6.12	0.00	0.98	0.12	0.03	2.90	0.06
Change in cash to total expenses	6424	-6.69	6.24	0.00	0.98	-0.65	0.03	6.63	0.06
Growth in cash to total expenses	6424	-6.10	6.44	0.00	0.98	0.15	0.03	3.21	0.06
Change in reserves	6424	-6.52	6.32	0.00	0.99	0.24	0.03	8.56	0.06
Change in cash	6424	-6.72	6.39	0.00	0.99	0.31	0.03	8.88	0.06
Growth in short term liquidity to assets	6424	-4.73	6.26	0.00	0.98	0.07	0.03	2.74	0.06
Inflation	6424	-1.75	1.62	0.02	0.99	-0.05	0.03	-1.28	0.06
Output	6424	-2.15	1.43	0.02	0.98	-0.65	0.03	-0.68	0.06
Money supply	6424	-1.46	1.99	0.02	0.99	0.29	0.03	-1.00	0.06
Unemployment	6424	-0.79	1.82	0.00	1.00	0.83	0.03	-1.08	0.06
Change in liabilities to assets	6424	-7.03	6.33	0.00	0.97	-0.15	0.03	5.43	0.06
Growth in liabilities to assets	6424	-7.18	6.58	0.00	0.97	-0.26	0.03	8.39	0.06
Change in assets to capital	6424	-6.69	5.48	0.00	0.98	-0.29	0.03	4.97	0.06
Growth in assets to capital	6424	-6.93	5.95	0.00	0.98	-0.22	0.03	4.62	0.06
Change in pre-tax return on equity	6424	-5.74	4.98	0.01	0.97	-0.36	0.03	3.30	0.06
Change in pre-tax return on assets	6424	-7.03	7.05	0.00	0.97	0.72	0.03	12.76	0.06
Change in post-tax return on equity	6424	-6.11	5.91	0.00	0.97	-0.43	0.03	4.69	0.06
Change in post-tax return on assets	6424	-7.06	7.08	0.00	0.97	0.69	0.03	13.88	0.06
Growth in asset	6424	-4.46	5.94	-0.01	0.98	1.77	0.03	6.71	0.06
Growth in deposit	6424	-5.38	6.03	-0.01	0.97	1.65	0.03	6.82	0.06
Growth in liabilities	6424	-4.82	5.94	-0.01	0.97	1.63	0.03	6.42	0.06
Growth in current asset-liability mismatch	6424	-6.18	6.03	0.00	0.98	1.05	0.03	6.03	0.06
Change in securities available for sale	6424	-6.53	6.29	0.00	0.99	0.54	0.03	8.86	0.06
Growth in securities available for sale	6424	-6.70	5.99	0.00	0.98	0.42	0.03	5.63	0.06
Change in securities to assets	6424	-5.82	6.02	0.00	0.98	-0.10	0.03	3.74	0.06
Growth in securities to assets	6424	-6.21	6.27	0.00	0.98	-0.07	0.03	4.67	0.06
Growth in the net interest margin	6424	-7.13	7.02	0.01	0.94	-0.30	0.03	6.94	0.06
Growth in revenue to assets	6424	-7.13	6.74	0.00	0.95	-0.07	0.03	6.84	0.06
Growth in interest income to assets	6424	-7.13	7.02	0.00	0.94	-0.20	0.03	6.67	0.06