Measuring the Dependency of the Banks' Assets and Liabilities in Iran

Azam Ahmadyan
Faculty member in monetary and banking research institute:
(corresponding author)
azam_ahmadyan@yahoo.com

Mohammad Vilipor Pasha
Researcher in monetary and banking research institute

ABSTRACT

Analyzing the correlation between banks' assets and liabilities after the financial crisis has been focused by many countries. As the banks in Iran have proved to be the biggest financer required for the production sector, investigating the asset and liability portfolio and their correlation appears to be very important. In this paper, there has been an attempt to patronize the Iranian banking network's balance sheets during the course of 2006-2015 and the standard methods of measuring correlation coefficient to evaluate the dependency degree among the assets and liabilities of the banks in order to scrutinize its trend. Results show some similarities between the two banking sectors. First, for two banking sectors alike, neither the asset nor the liability side of the balance sheet alone can be held responsible for the declining asset-liability dependencies. Second, all two banking sectors have experienced declining dependencies of loans to non-banks and deposits, while dependencies of the security and investment increase and the dependency of the liability from central bank did not change significantly during the period of our study.

Keywords:

asset-liability dependency, canonical correlation, balance sheets.

1. Introduction

Evaluating the dependency between assets and liabilities is highly essential for their maturity mismatches. In fact because assets and liabilities' maturity mismatches, it seems necessary for the banks' balance sheets to be well programmed so that banks could manage their assets and liabilities. The main objective of Asset/Liability Management (ALM) is to promulgate a continuous stream of profitability with the highest quality plus stability and growth. Analyzing the dependency between assets and liabilities in the banking network has been considered as utmost issue more often after the crisis.

While the crisis unfolded in several increasingly complicated stages and took over a decade to run its course, the initial cause of the crisis was quite simple: savings and loans (or thrifts) funded long-term fixed rate mortgage loans with short-term certificates of deposit and demandable deposit accounts. Under normal credit market conditions—that is, an upward sloping yield curve—this maturity mismatch was quite profitable, but it left thrifts vulnerable to interest rate risk. The thrift crisis was a wake-up call to U.S. banks and thrifts underscoring the importance of asset-liability management (ALM) for mitigating interest rate risk. In its most simple form, ALM requires banks to select a liability structure that matches the expected maturity or duration of their existing assets, thus immunizing bank earnings from interest rate movements. More recently, a variety of developments have allowed banks to mitigate interest rate risk without having to practice this strict form of ALM. Financial innovations such as interest rate derivatives, adjustable rate loans, and asset securitization have expanded the methods banks can use to manage interest rate risk both on and off the balance sheet, and have reduced the costs of doing so. Geographic deregulation has allowed banks of all sizes to grow larger, providing a wider set of investment and funding options for small banks and allowing midsized banks easier access to off-balance sheet risk-management tools and tactics. Expansion into non-traditional banking services securities brokerage and insurance sales, as well as a general shift away from portfolio lending and toward securitized lending and contingent credit contracts, have generated streams of off-balance sheet income which, in some cases, has reduced banks' reliance on interest-based income and lessened the importance of asset-liability mismatch to their overall risk positions. Because these developments have arguably reduced the need for banks to practice strict ALM, the composition of banks' assets and liabilities should have become measurably more independent over the past two decades (Deyoung and yom(2008)).

There have been no clear financial instruments as reliable ones in the international banking network and the loans are generally-simply financed by deposits absorptions and performing loans reimbursement. Henceforth, changes in the volume of liabilities will influence the volume of assets. On the other hand, volatilities in the volume of banks' liabilities are significantly affected by the monetary policies of the central bank. Therefore, regarding the dependency degree between assets and liabilities, the intensity impact of changes of liabilities on assets would be different. Thus measuring the dependency between the portfolio of assets and liabilities would be regarded as important.

On the other hand, as Deyoung and Yom (2008) proposed, in the recent decade the banks approach has shifted from loans payments to activities regarding investments and the dependency between assets and liabilities has mitigated as well. The same story matches with the Iranian banking network with respect to changes in the assets and liabilities.

What could be comprehended from the portfolio of the Iranian banks' assets portfolio is that they have moved their assets portfolio from loans to other items (interbank market, investments and securities) although this issue confronts the Iranian banks' with the diminishing credit risk in the future periods. However, because of the decreasing proportion of loans which constitutes the key part of the earning assets, banks will face profitability to dip in the next periods.

On the other hand, banks will substitute credit risk with market risk via increasing their level of investments. Also, with respect to the conditions of the Iranian economy which is experiencing recession, banks prefer to provide loans to the banking sector rather than the nonbanking institutions because the claims from the banking network are prove to be both early returning and low risk. In the liability side of the balance sheet, banks have experience a move from stable liability (time investment deposits) to the resources with lower stability such as the deposits without interest rate. Albeit the decreasing investment deposits have diminished the banks' interest cost, due to a decrease in the stable resources in banks it could be mentioned that the Iranian banks will be bound to liquidity risk in the subsequent periods.

Two main questions are obviously discussed in this paper: First, how much is the degree of dependency between assets and liabilities? Second, has the dependency between assets and liabilities decreased in the investigation period? In this paper, three methods, as in Memmel and Schertler (2009) and Deyoung and Yom (2008), are patronized to calculate the degree of dependency between the assets and liabilities item using the statistics of the Iranian banks' balance sheets during the course of 2006-15.

Our first measure is a weighted sum of all squared pairwise correlations that provides information on the overall asset-liability dependency. Our second measure is the coefficient of determination of a certain regression. This measure complements our first measure, since it gives insights into the dependency degree of single asset and liability position. Thirteen measures is canonical correlation analysis to balance sheet data. Although canonical correlation analysis is seldom used in financial or banking research, it is the most appropriate tool for our purposes. Developed by Hotelling (1935, 1936), canonical correlation is a multivariate version of the familiar linear correlation analysis—more exactly, linear correlation is a special case of canonical correlation analysis in which the two vectors being examined each contain just a single variable. The technique measures the degree to which one set of correlated variables (say, the portfolio of loans, investments, and other assets held by banks) is useful for explaining the variance in another set of correlated variables (say, the mix of liabilities and equity capital used to fund bank assets).

The remainder of the paper proceeds as follows. In Section 2 we discuss some important background issues, including the finance literature on asset-liability dependency, the asset-liabilities linkages that make financial institutions special, and how recent financial innovations and deregulations arguably make financial markets more complete and reduce asset liability linkages in financial intermediaries. In Section 3 we provide a basic outline of canonical correlation analysis, the statistical methodology we employ in this study to measure the strength of asset-liability linkages at commercial banks. In Section 4 we describe our data on Iranian between 2006 and 2015 and present the basic results of our analysis, and in Section 5 we derive some additional results regarding banks.

2. Literature Review

A number of theories have been advanced to explain why banks exist. In most of these theories, banks exist because they solve a host of problems that otherwise prevent the flow of funds from agents with excess liquidity (depositors) to agents in need of liquidity (borrowers). These problems arise because of informational asymmetries, contracting costs, and scale mismatches between liquidity suppliers and liquidity demanders. Intermediation-based theories of financial institutions see banks as the solution to these problems because: banks have a comparative advantage at gathering information on borrower creditworthiness; banks are better able than individual lenders to monitor borrowers; banks provide increased liquidity by pooling funds from many households and businesses and by issuing demandable deposits in exchange for these funds; banks diversify away idiosyncratic credit risk by holding portfolios of multiple loans; and banks are able to exploit inter-temporal production synergies that exist between deposit supply and credit demand.[1]

Banks earn a profit from the financial flows fundamental to the intermediation process (e.g., interest paid on deposits, interest received from loans and securities, and the resulting net interest margins) but the nature of these flows exposes the bank to risk. Some of these risks are associated solely or primarily with items on just one side of the balance sheet and are independent of items on the other side of the balance sheet, e.g., credit risk is associated primarily with loans, while market risk is associated primarily with investments in long-term fixed income securities. This independence suggests that a substantial amount of the risk inherent in banking is unrelated to the intermediation process. In contrast, *interest rate risk* is associated with the interaction of items on the right-hand side (e.g., the maturities of various loans and securities) and left-hand side (e.g., the maturities of various deposit accounts) of a bank's balance sheet, and as such is a direct outgrowth of the intermediation process. Thus, the value of a traditional commercial banking company will depend systematically on its financing decisions, even in a world without taxes or other frictions absent from the simplest Modigliani and Miller (1958) framework.

The degree to which commercial banking companies rely on the traditional intermediation business model has declined over time. Two decades of innovations in information processing, communications technologies, and financial markets (e.g., credit bureaus, computers, the Internet, adjustable-rate loans, credit scoring, asset securitization, financial derivatives), plus a wave of industry deregulation that abolished barriers to diversification across geographic and product market boundaries, have allowed banks to (a) expand into non-intermediation activities, (b) alter the nature of their intermediation processes, and (c) adopt new methods of managing the risks inherent in intermediation. Collectively, these changes have reduced the degree of association between assets and liabilities that has traditionally been necessary for banks to operate profitably deyoung and yom(2008).

Drechsler et al, (2017) showed that in stark contrast to conventional wisdom, maturity transformation does not expose banks to significant interest rate risk. Aggregate net interest margins have been near-constant over 1955-2013, despite substantial maturity mismatch and wide variation in interest rates. They argued that this is due to banks' market power in deposit markets. Market power allows banks to pay deposit rates that are low and therefore relatively insensitive to interest rate changes, but it also requires them to pay large operating costs. This makes deposits resemble fixed-rate liabilities. Banks hedge these liabilities by investing in long-term assets, whose interest payments were also relatively insensitive to interest rate changes. Consistent with this view, they found that banks match the interest rate sensitivities of their expenses and income one for one. Furthermore, banks with lower interest expense sensitivity hold assets with sub-stantially longer duration. They exploit cross-sectional variation in market power and showed that it generates variation in expense sensitivity that is matched one-for-one by income sensitivity. Their results provided a novel explanation for the coexistence of deposit-taking and maturity transformation.

Bai et al (2014) implemented a liquidity measure "Liquidity Mismatch Index (LMI)," to measure the mismatch between the market liquidity of assets and the funding liquidity of liabilities and they measure dependency of asset and liability. They constructed the LMI for 2870 bank holding companies during 2002 -2013 and investigated its time-series and cross-sectional patterns. The aggregate LMI worsens from less than

[negative] $1 trillion in 2002 to $3.3 trillion in 2008, before reversing back to pre-crisis level in 2009. In the cross section, They found that banks with more liquidity mismatch (i) experience more negative stock returns during the crisis, but more positive returns in non-crisis periods; (ii) experience more negative stock returns on events corresponding to a liquidity run, and more positive returns on events corresponding to government liquidity injection; (iii) borrow more from the government during the financial crisis.

Boyd and Gertler (1994) showed that although the share of U.S. financial assets held by commercial banks was in decline, the amount of intermediation in which these banks participated was not. Both of these studies suggest a different, rather than declining, role for banks in financial intermediation which features off-balance sheet activities that generate fee income rather than, or in addition to, portfolio lending that generates interest income. If intermediation has indeed remained central to the profitability of commercial banks over the past two decades, there is no doubt that the manner in which banks intermediate has changed. Perhaps the most fundamental change in the intermediation process has been the securitization of consumer loans— home mortgage loans in particular, but also credit cards, auto loans, and even more recently small business loans. Rather than holding these loans as on-balance-sheet investments, banks bundle the loans into loan pools, and sell these pools into an investment trust that is financed by the sale of securities (e.g., mortgage-backed securities). The security holders receive cash flows based on the interest generated by the pooled loans, as well as some protection from credit risk (the bank often takes a first-loss position). The bank earns fees when the loans are originated and fees for servicing the loans (or, alternatively, sells the servicing rights), but since the loans are not held on the balance sheet, the bank earns no interest income and economizes on equity capital. Securitized lending exhibits large scale economies, partly because banks use automated credit scoring models—a technology with a low ratio of variable costs to fixed costs—to evaluate loan applications. Loan securitization has led to a strategic dichotomy in the banking industry, with large banks and small banks having quite different approaches to intermediation (DeYoung, Hunter, and Udell 2004).

Correlation analysis is applied to examine how the relationship between asset liability accounts. In this regard, the Correlation Analysis of Commercial Bank Asset/Liability Structures was priory applied by Simonson, Stove and Watson (1983) for large U.S. commercial banks. On the other hand, Robert De Young and Chiwon Yom (1990-2005) utilized correlation analysis to evaluate how the relationship between asset liability accounts at US commercial banks has evolved during the period 1990 - 2005. The correlation analysis is applied for the different period of times in this study and banks are grouped according to asset size. It is anticipated that intensive users of risk mitigation strategies prove asset-liability relationships to be weaker that are described by the interest rate swaps and adjustable loans and asset-liability linkages which are probably-surprisingly stronger at large banks than at small banks, although these size-based differences have diminished over time, both because of increased asset-liability relations at small banks and decreased linkages at large banks. Furthermore, cash transactions leading to cash inflows allow banks to restructure their balance sheet (Gorton and Pennacchi (1995)). Intensive techniques using computer technologies are utilized by banks to allow developing computationally for measuring and managing the various kinds of risks they might face. Moreover, it has made it possible for banks to offer customers a wide range of online services, such as paying bills or making investments online (Pikkarainen et al. (2004)), which prove to have not changed the degree of competition and have certainly had an impact on how banks do their business. Less stable and more expensive funding sources have potentially supplemented the traditional sources with traditional deposit funding which has declined in recent years (Harvey and Spong (2001)). In this context, banks that use derivatives have higher growth rates in business lending and they hold lower levels of capital than banks that do not use derivatives (e.g. Brewer et al. (2000), Brewer et al. (2001)).

Two measures for determining dependency structure have been applied, the first of which is a weighted sum of all squared pair-wise correlations and the second one is the coefficient of determination of a regression analysis that provides an insight into how single asset (liability) positions depend on the liability (asset) structure (Memmel and Schertler, 2009). Memmel and Schertler (2009), show that, for all three sectors of German universal banks (private commercial banks, savings banks, and cooperative banks), asset-liability dependency declined over the period 1994-2007, the decline was strongest for those banks that use more than sector-average amounts of derivatives. Only in the case of private commercial banks, we do find that lower regulatory capital has coincided with higher asset-liability dependencies. Over their sample period, the difference has diminished since poorly-capitalized private commercial banks have reduced their asset-liability dependencies more intensively than their well-capitalized counterparts. Moreover, they find that profitability matters for the asset-liability dependency but not in the same way for all three sectors. Asset-liability dependency is lower for private commercial banks with higher provision income, savings banks with lower ROE volatilities and cooperative banks with higher ROEs. Canonical correlation analysis has been applied only sparingly to describe asset liability relationships. Simonson, Stowe, and Watson (1983) used it to analyze a cross section of data for large U.S. commercial banks. Similarly, Obben and Shanmugam (1993) used canonical correlation analysis to analyze the incidence of maturity matching among Malaysian commercial banks, finance companies, and merchant banks. Dash and Pathakh (2009) the canonical correlation coefficients of different set of banks indicate that different banks have different degree of association among constituents of assets and liabilities. The bank groups can be arranged in overall decreasing order of correlation: foreign banks, followed by private banks, and lastly public banks. Looking at the redundancy factors, the independent and dependent sets for different bank groups can be identified: foreign and public banks have assets as their independent set, which means that during the period 2004-2008, these banks were actively managing assets and liability was dependent upon how well the assets are managed; on the other hand, for private banks, liabilities were the independent set.

Deyong and yom (2008) Using canonical correlation analysis, they examine how the relationships between asset and liability accounts at U.S. commercial banks changed between 1990 and 2005. Importantly, we show that asset-liability linkages are weaker for banks that are intensive users of risk-mitigation strategies such as interest rate swaps and adjustable loans. Perhaps surprisingly, they find that asset-liability linkages are stronger at large banks than at small banks, although these size-based differences have diminished over time, both because of increased asset-liability linkages at small banks and decreased linkages at large banks.

3. Methodology

The literature has put forward several dependency measures, such as Pearson's correlation coefficient, regression analysis and canonical correlations as applied in a recent study by De young and Yom(2008) and formerly by Simonson et al.(1983). The starting point of all these measures is (more or less) the (matrix of) pairwise correlation coefficients.

We like Memmel and Schertler (2009) and deyiung and yom(2008), use three measures; each measures is calculated for each point in time and for each banking group. Our first measure ϕ is a weighted sum of all squared pairwise correlations that provides information on the overall asset-liability dependency. Our second measure, τ , is the coefficient of determination of a regression analysis that provides an insight into how single asset(liability) positions depend on the liability (asset) structure. Third measure is canonical measure .A canonical correlation is the maximum correlation between linear functions of two vectors of variables; where linear weights are selected that maximize the correlation. As such, canonical correlation is an especially appropriate tool for analyzing the inner workings of financial intermediaries like commercial banks that transform multiple types of liabilities with different characteristics (e.g., demand deposits, household checking and savings accounts, long-term certificates of deposit, purchased funds) into multiple types of assets with different characteristics (e.g., short-term loans, long-term loans, investment securities, cash and liquid reserves).

Let ω^A and ω^L describe the structure of a bank's assets and liabilities, respectively. ω_i^A is the share of asset position i with respect to total assets, and ω_j^L is the share of liability position j with respect to total liabilities plus equity. The Pearson correlation coefficient between ω_i^A and ω_j^L is denoted by ρ_{ij} . We define φ as the weighted sum of all pairwise correlations:

$$\phi = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} E(\omega_i^A)E(\omega_j^L)\rho_{ij}^2}{\sum_{i=1}^{n}\sum_{j=1}^{m} E(\omega_i^A)E(\omega_j^L)} \qquad (1)$$

The measure ϕ has a number of desirable features: (i) In terms of construction, it is confined to the interval between 0 and 1. (ii) It summarizes the single pairwise correlation coefficients ρ_{ij} into one figure. The pairwise correlations are weighted according to their average weight in the balance sheet. The denominator equals one, if all the assets and all the liabilities are included in the positions under consideration. (iii) Although the level of the measure is hard to interpret, it can serve as the basis for comparisons in the time dimension and in the cross section. A higher level of this measure suggests a higher dependency of assets and liabilities.

For the empirical implementation, we replace the variables from above with their empirical counterparts, i.e.

$$\phi = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} \overline{\omega}_i^{A}\overline{\omega}_j^{L}\rho_{ij}^2}{\sum_{i=1}^{n}\sum_{j=1}^{m} \overline{\omega}_i^{A}\overline{\omega}_j^{L}} \qquad (2)$$

Where $\hat{\rho}_{ij}$ is the empirical correlation coefficient of the balance sheet shares ω_i^A and ω_j^L , which is calculated from the cross section of the K banks. $\overline{\omega}_i^A$ and $\overline{\omega}_j^L$ are the averages of the K bank's asset and liability positions, i.e.

$$\overline{\omega}_i^{A} = \frac{1}{K}\sum_{k=1}^{K}\omega_{i,k}^{A} \qquad (3)$$

Our second measure gives insights into the degree of dependency between a single asset position i and the structure of the liabilities and vice versa. To determine the degree of dependency for each single asset position we run the following regression:

$$\omega^A_{i,k} = \alpha_i + \beta_{1,i}\omega^L_{1,k} + ... + \beta_{J,i}\omega^L_{J,k} + \varepsilon^A_{i,k} \quad (4)$$

We use the coefficients of determination R^2_i of these regression as the dependency measures τ^A_i. This dependency measure can be seen as the maximum squared correlation between the weight of asset i and any linear combination of the liability weights. Note the similarity to canonical correlations which are the maximum correlation of assets and liabilities when one varies both the asset and the liability structure:

$$\tau^A_i = \max_{\beta_i} corr^2(\omega^A_i, \beta'_i \omega^L_j) \quad (5)$$

For each liability position, the measure τ^L_j is estimated correspondingly using asset shares. This measure has several advantages: (i) As our first measure, it is confined to the interval between 0 and 1. (ii) It summarizes the single pairwise correlations ρ_{ij} into one figure for each asset and liability position, respectively. (iii) As the coefficient of determination is widely used, this measure is relatively easy to communicate and interpret.

Although canonical correlation analysis cannot directly consider return variances and co-variances, it considers them indirectly through the movements and co-movements in the relative levels of those balances. More explicitly, canonical correlation analysis determines linear combinations of the various asset accounts that are most highly correlated with linear combinations of the various liability accounts. Moreover, because the complex relationships between and among asset and liability accounts are unlikely to be fully captured by a single set of linear functions, multiple canonical correlations are usually considered, based on multiple pairs of linear combinations that are orthogonal to each other.

Let asset variables as a proportion of total liabilities be denoted $\omega^A_{i,k} = \left[\omega^A_{i,1}, \omega^A_{i,2}, ..., \omega^A_{i,k}\right]$ and liabilities variables as a proportion of total liabilities $\omega^L_{i,P} = \left[\omega^L_{i,1}, \omega^L_{i,2}, ..., \omega^L_{i,P}\right]$ From these variables we can construct linear combinations of $\omega^A_{i,k}$ and $\omega^L_{i,P}$:

$$A = c_1\omega^A_{i,1} + c_2\omega^A_{i,2} + ...c_p\omega^A_{i,k} \quad (6)$$

$$L = d_1\omega^L_{i,1} + d_2\omega^L_{i,2} + ...d_p\omega^L_{i,p} \quad (7)$$

The canonical coefficients are chosen to maximize the canonical correlation between the canonical variables A and L:

$$r_{AL} = \frac{\sum al}{\sqrt{(\sum a^2)(\sum l^2)}} \quad (8)$$

where a and l denote mean differences for the variables A and L, respectively. Importantly, because (assuming k≥p) there are up to p different ways to pair up each asset and liability variable, the maximization process generates p-1 separate canonical correlations, based on p-1 distinct and orthogonal linear combinations A and L.

The size and strength of the canonical correlation forms the basis for identifying relationships between specific asset and liability accounts. For example, if we observe that actual core deposits

(DCORE) are strongly correlated with the constructed canonical variable L, and we also observe that actual long term loans (CLTLOANS) are strongly correlated (in the same direction) with the constructed canonical variable A, then we can surmise that banks with high levels of core deposits will also tend to have large amounts of long term loans as long as the correlation rAL is strong. In other words, long term loans and core deposits share a common factor which is captured in rAL. This indirect relationship between YCORE and XLTLOANS is illustrated in Figure 1, and depends entirely on the direction and strength of the maximized correlation between the two canonical variables A and L.

The nature of the relationships between asset and liability accounts can be studied by examining

more detailed information from the *canonical loadings*. Canonical loadings are the correlations between the actual variables and their own canonical variables. For instance, a canonical loading of the variable $\omega^A_{i,1}$ with the first canonical variable A_1 is the simple correlation between $\omega^A_{i,1}$ and A_1:

$$Corr(\omega_{i,1}^{A}, A_1) = Corr(\omega_{i,1}^{A}, c_1\omega_{i,1}^{A} + c_2\omega_{i,2}^{A} + ..c_p\omega_{i,k}^{A}) = c_1^1\sigma_{\omega_{i,1}^{A}} + c_2^1\sigma_{\omega_{i,2}^{A}} + ... + c_p^1\sigma_{\omega_{i,k}^{A}} \quad (9)$$

where $c_1^1, c_2^1, ...c_p^1$ are the first canonical coefficients for A_1, $\sigma_{\omega_{i,1}^{A}}$ is standard deviation of $\omega_{i,1}^{A}$, $\sigma_{\omega_{i,1}^{A}}$ is the correlation between $\omega_{i,1}^{A}$ and $\omega_{i,2}^{A}$, and so on. Similarly, canonical loadings can be derived for liability variables (e.g., Corr($\omega_{i,1}^{L}, L_1$)) or for higher order ($k \succ 1$) canonical variables (e.g., Corr($\omega_{i,1}^{A}$, A_3)).

If the canonical correlation (3) between assets and liabilities is strong and the canonical loading (4) for asset *i* is strong and the canonical loading for liability *j* is strong, then we can surmise that a relationship exists between asset *i* and liability *j*. The canonical loadings also prove useful for measuring the total amount of variance in the actual data accounted for by the canonical variables:

$$R_{A,i}^2 = \sum_{i=1}^{k} \frac{(Corr(\omega_i^A, A_i))^2}{k} \quad (10)$$

where $R_{A,i}^2$ is the *proportion of variance* in the asset variables accounted for by the i^{th} asset canonical variable (i=1,…, k). This measure indicates how well a canonical variable captures the total amount of variance in the ω_i^A variables. For instance, if only one asset variable has high association with the asset canonical variable (i.e., a high canonical loading), the statistic $R_{A,i}^2$ will tend to be small. Note that the canonical correlation in (3) represents the variance shared by linear combinations of asset and liability variables, and not the shared variance of the original asset and liability variables. Hence, it is possible that a very large canonical correlation could be the result of a large correlation of just one asset variable with just one liability variable, while the other asset and liability variables are uninvolved in the canonical structure. In such a case, the canonical correlation would overstate the true relationship. The *redundancy coefficient* provides a summary measure of the average ability of asset (liability) variables taken as a set to explain variation in liability (asset) variables taken one at a time:

$$R_{A|L,i}^2 = \mu_i^2 R_{A,i}^2 \quad (11)$$

The first term of the product, μ_i^2, is the i^{th} squared canonical correlation (or the i^{th} eigenvalue) and measures the proportion of variance in i^{th} asset canonical variable predictable from the i^{th} liability canonical variable. The second term, $R_{A,i}^2$, is the proportion of asset variance accounted for by its i^{th} canonical variable. The product of these two terms measures the proportion of asset variance explained by i^{th} liability canonical variable. Summing the redundancy coefficients across all the canonical correlations provides an index, $R_{A|L,i}^2$, of the proportion of variance of asset variables predictable from liability variables, or the redundancy in asset variables given liability variables.

4. Results

We use year-end data from the Iranian's yearly balance sheet statistics for the years 2006-2015. These statistics include the balance sheet information of all banks in Iran, broken down into different asset and liability positions according to the type of the financial asset and liability (e.g. equity or debt), the type of the counterparty (e.g. bank or non-bank) and the maturity of the financial asset or liability (e.g. initial maturities up to one year (short- term) and of more than one year (long-term)). Our analysis starts in 2006 because otherwise the asset and liability structure would not be defined in a consistent manner over time.

We subdivide the banks 'assets and liabilities into eight and five accounts, respectively. The asset positions are cash, interbank loans, loans to non-banks, loans to central bank securities and other assets. Accordingly, the banks liabilities are broken down into saving accounts, interbank liabilities, liabilities from central bank, own funds and other liabilities. To avoid perfect multicollinearity among the asset and liability positions, we skip the positions other assets and other liabilities.

Table 1. structure of banks' assets and liabilities

Asset	Liability
Loan to non-banks	Saving account
Interbank loan	Own fund
Loan to central bank	Liabilities from central bank
Cash and securities	Interbank liabilities
Other assets	Other liabilities

Table (1) depicts the structure of the banks' assets and liabilities summarized across all tow banking sectors in our sample. For each asset and liability position, We present the value of the private and state of banks.

Table 2 presents the mean shares of the asset and liability positions broken down into the tow banking sectors[2]. A test of equal means across the tow banking sectors suggests some pronounced differences among these tow banking sectors.

Private Banks seem to allocate higher ratio of saving account ratio than the state banks. Henceforth, the private banks have taken hold of lower Liabilities to the banking network and Liabilities to central banks in comparison with the rest of the banks in the Iranian banking network. Although the higher proportion of the saving account in the liability portfolio of the present banking group causes an increase in their interest expenses, they will confront with lower liquidity risk in comparison with other banks. On the contrary, the banks which are faced with higher volatile saving account ratio compared to other banks, e.g. the commercial banks, though are they faced with lower interest expenses, they will confront with higher liquidity risk in the future periods compared to other banks.

Among the Iranian banks, state banks, take hold of a higher proportion of total loans to total assets ratio. Meanwhile, the state banks, the large ones in line with long-living banks have recorded a higher proportion of debts to the central banks to total liabilities. Regarding the nature of this group of banks which are more exposed to provide assigned loans rather than other banks and with respect to the short term borrowing from the central bank, the higher proportion of debt to the central bank in the liability portfolio of this group of banks depict the scarcity of liquidity and higher liquidity risk.

As it could be observed in table 2, the loans section constitutes the most significant part of the asset portfolio of the banking network in Iran in which this bundle is not far anticipated regarding the intermediary role of the banks.

Table 2. Test of equal mean shares of baking sector

Share of asset and liability	Mean		Standard deviation		Sign.
	private	State	Private	state	
Loan to non-banks	58.86	62.8	15.7	21.1	.000
Interbank loan	9.51	11.6	8.6	8.9	.000
Loan to central bank	10.2	5.3	4.4	4.3	.013
securities	2.5	6.3	5.3	17.6	.000
cash	28.8	21.5	13.6	12.8	.000
Saving account	82.6	58.4	15.2	25.2	.003
Own fund	28.7	118.3	15.8	384.7	.000
Liabilities from central bank	3.9	15.9	5.2	16.3	.000
Interbank liabilities	5.6	6.7	11.6	8.6	.000

Source: researchers' calculations

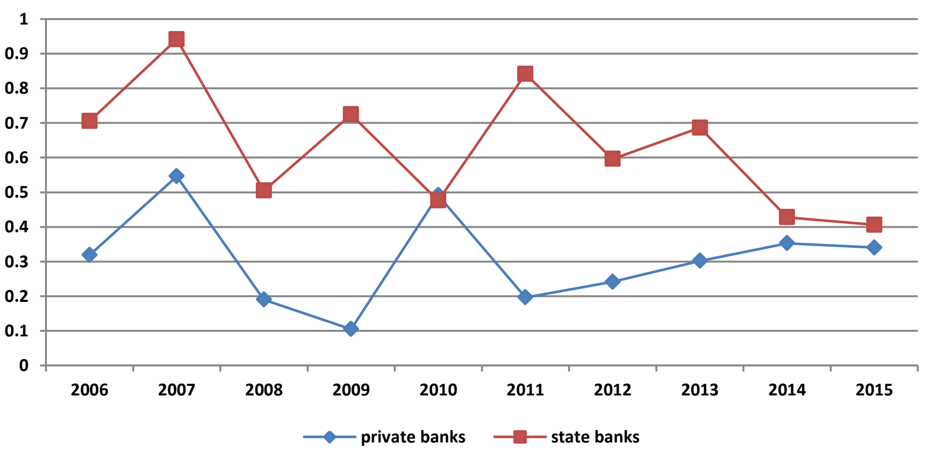
Also, according to table 2, it is observed that most of the banks are heading toward the inter banks market or other assets in which the most significant parts are investments and securities. In other words, based on the conditions which are dominant on the macroeconomic status of Iran which is experiencing the stagflation, the banks prefer to supply loans to the banking network instead of the nonbanking network because Receivables from banks seem to have early returns and low risk. On the other hand, increasing investments lead to a substitution of market risk with the credit risk.

To gain insights into the trend in the asset-liability dependency, we calculated the measure $\hat{\varphi}$ for each year and for each banking sector separately. The results presented in Figure 1 show that the dependency measure $\hat{\varphi}$ for assets and liabilities decreases in the last 9 years for all tow banking sectors Since there are 4 years in which the dependency measure $\hat{\varphi}$ rises compared to the previous year, we tested whether the dependency measure rises at least as often as it drops (compared to the previous year).For each banking sector we count 5 negative year to year changes in the dependency measure . Therefore, we can reject the null hypothesis for each sector at the 5%-level. We addition, linear regressions of $\hat{\varphi}_t$ on a linear time trend always yield significantly negative coefficients for all tow banking sectors. This last test should be interpreted with caution given the low number of observations (n=٩).

Figure 1 also reveals that the order in the asset-liability dependency of the two sectors remains the same over the 9 years of our study. More surprising is the order of the asset – liability dependency between state banks and private banks. State banks, which are on average larger than private banks, have a much higher dependency than private banks. The dependency between assets and liabilities is by far stronger among the state banks, seem to be less reluctant to use new financial instruments than private banks.

We use our second measure τ_i^A and τ_j^L, which was calculated for each year and each banking sector separately, to determine the trend in single asset and liability positions. Using this second measure in addition to our first measure is useful in two respects. First, it allows insights on whether a particular asset and/ or liability position is responsible for the decline in the asset – liability dependency. Second, it may provide insights into why the asset – liability dependency decreased more strongly for state banks than for private banks.

Figure 1. Dependency measure $\hat{\varphi}$



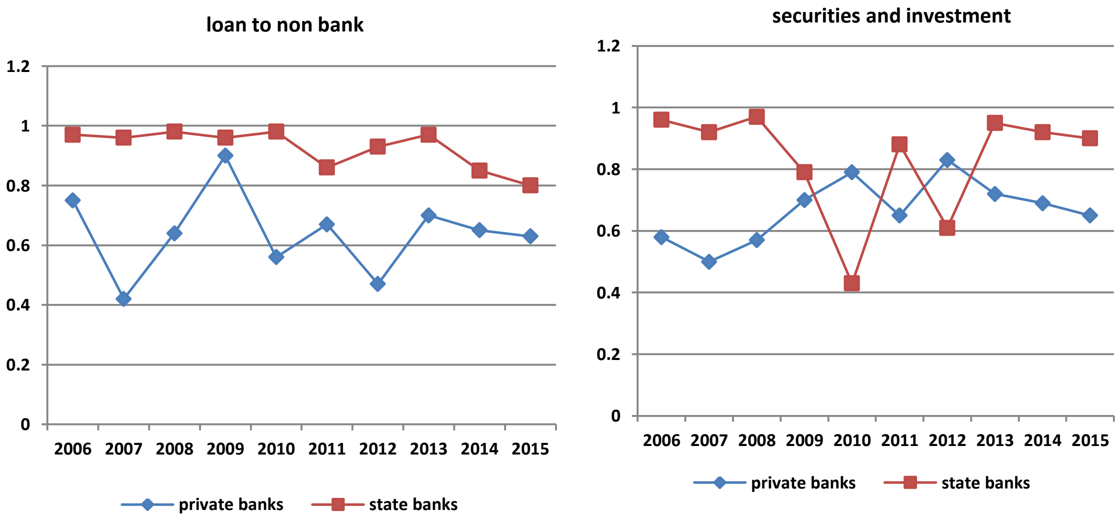
Source: researcher calculations

Figure 2 depicts exemplarily the measure $\hat{\tau}$ for the four most important balance sheets positions: the loans to non – banks, the securities and investment, the deposits and the savings accounts and the liability from central bank. The liability dependency of loans to non – banks declines for two banks. On the contrary, the dependency between bonds and investment for the public banks has proved to be diminishing vs. private banks which are increasing. Analyzing the two figures illustrate that private banks have registered a shift in their assets portfolio from loans to non-bank items such as bonds and investment. With respect to the present recession in the economy, the results are not far from expectation. The recession in the past years resulted in lack of solvency in the private sector. On the other hand, except for the two last years, the government policy was based on decreasing the interest rate that could be negatively influencing the Iranian banks incentive for lending. On the one hand, nonperforming loans accumulation has caused significant banks resources to be confusingly circulated and decrease the banks resources from loans reimbursement and on the other hand decreasing the interest rate has caused a decrease in profitability from lending to the private sector.

The asset dependency for deposits declines for state banking sectors and increases for private banking sector. Finally, the asset dependency of liability from central bank declines somewhat for private banks, it stays unchanged of state banks. Regarding the decrease in the deposit interest rate in the recent years when state banks experienced a more decrease rather than the private banks, decreasing the dependency between the assets and deposits in the state banks is evidently anticipated. On the other hand, with respect to the lack of resources of this kind of banks due to deposit decrease, the state banks had to borrow from the central bank for containing the shortage of resources.

As it can be observed, decreasing the dependency in asset and deposit in the state banks, the dependency between assets and liabilities to the central bank of this kind of banks have experienced an unchanged and high trend. On the other hand, the dependency between assets and liabilities to the central bank in state banks has recorded to be higher than private banks. With respect to the point that private banks have been more successful in collecting the deposit rather than the state banks, they borrowed less from the central bank and therefore the dependency between their assets and liabilities to the central bank is lower as well.

Figure 2. Dependency measure $\hat{\tau}$ for selected asset and liability positions



Source: researchers' calculations

With respect to the level of $\hat{\tau}$, we observe the highest values for the balance positions long – term loans to non – banks. This is not surprising as long to non – banks constitute the bank's core business (at least for traditional universal banks). Also, the dependency between the assets and liabilities items in state banks has proved to be stronger than private banks. This issue is emanated from the business model of the state banks that are significantly involved in collecting the savings and lending while the private banks have tried to record a more various assets portfolio and utilize other financial tools such as bonds for funding the required resources.

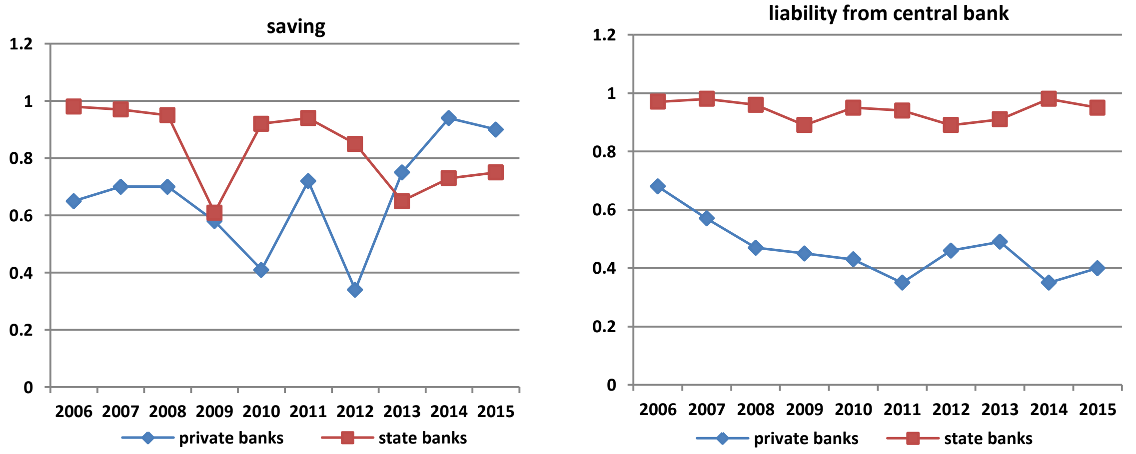
Results show some similarities between the two banking sectors. First, for two banking sectors alike, neither the asset nor the liability side of the balance sheet alone can be held responsible for the declining asset-liability dependencies. Second, all two banking sectors have experienced declining dependencies of loans to non-banks and deposits, while dependencies of the security and investment increase and the dependency of the liability from central bank did not change significantly during the period of our study.

Table 3 displays the canonical correlations (3), arrayed in 36 cells according to the two bank ownership and nine main years in our data. We calculate four canonical correlations for each of the cells, the maximum allowable given the manner in which we group the asset and liability accounts.[3] The asset and liability variables exhibit a relatively high degree of collective dependence. For example, the first canonical correlation in the table (for the state banks in 2006) is 0.98, which indicates that the first pair of canonical variables (A1 and L1), have a linear correlation of 0.98.

The second canonical correlation is 0.64, this indicate the second factor extracted from the asset accounts data and the second factor extracted from the liability accounts data (A2 and L2) have a linear correlation of 0.64. Moving down each column, the canonical correlations tend to decline in explanatory power, as well as in statistical significance. In the first column, the first approximate F-value of 6۱.۳ allows us to reject the null hypothesis that all five canonical correlations are zero; similarly, the second F-value of ۳۱.۲1 rejects the null hypothesis that second, third and fourth canonical correlations are zero.

The third F-value is also statistically significant, but the fourth F-value is not, and as such we conclude that three or fewer canonical pairs are necessary to represent the asset-liability relationship. The asset and liability canonical variables are more strongly correlated—that is, the numerical magnitudes tend to be bigger—for the state banks, a result similar to the simple pair-wise correlations displayed above in figure 1 and 2.

Figure 3. Dependency measure $\hat{\tau}$ for selected liability positions



Source: researchers' calculations

The statistics displayed in Table 3 represent relationships between linear combinations of asset variables and linear combinations of liability variables, and these canonical correlations may or may not indicate systematic relationships between or among the underlying asset and liability variables. To get at this question, we report information for the proportion of variance coefficients (1) and the redundancy coefficients(2) in Table 4.

Table 4 displays the average proportion of the variance in asset and liability variables explained by the canonical variables, for each of the four canonical loadings. The averages are un-weighted means across 18 separate calculations (tow groups by 9 time periods). To reduce the amount of space necessary to display these diagnostics, each cell in the table displays a straight-line average based on the values of (1) or (2) from each of the four bank asset quartiles and nine main years of our data. These averages are calculated separately for each of the four canonical loadings; the fifteenth column is the sum of the first four entries, and represents the total proportion of asset or liability variance explained by the canonical variables.

By construction, the proportion of variance statistics (1) in the top half of the table must sum to 100% across the four loadings. About 73 percent of the variation in the actual liabilities data is explained by the liability canonical variables in the first three loadings—in contrast, the variation in the actual assets data is explained by the asset canonical variables in a more uniform fashion in all four loadings. All else equal, this suggests that the relationships among the various asset accounts are more complex than the relationships among the various liability accounts. The redundancy coefficients (2) in the bottom half of the table sum to well less than 100% across the four loadings. The liability canonical variables explain only about 18.1% of the variation in the asset variables, while the asset canonical variables explain about 24.6% of the variation in the liability variables.

We draw two informal inferences from these results: First, the calculations suggest that causation runs more strongly from assets to liabilities (i.e., banks seek funding and/or determine funding mix only after finding investment opportunities) than from liabilities to assets (i.e., banks are pools of deposits looking for lending opportunities). Second, the relatively state banks of the redundancy coefficients, as well as the importance of the first two loadings in the calculation of these coefficients, suggests that the strong canonical correlations in Table 3 are driven by a relatively small number of relationships among individual asset and liability accounts.

Table 3. Canonical Analysis

loading	**year**									
State banks	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1	0.98 (62.2)	0.97 (76.2)	0.92 (59.8)	0.88 (50.8)	0.80 (60.5)	0.79 (68.9)	0.85 (59.08)	0.73 (49.08)	0.65 (53.9)	0.70 (51.5)
2	0.64 (27.01)	0.65 (50.6)	0.45 (39.9)	0.76 (47.9)	0.68 (51.01)	0.86 (34.09)	0.88 (58.9)	0.52 (38.07)	0.59 (44.8)	0.58 (46.2)
3	0.57 (8.4)	0.84 (7.3)	0.71 (9.4)	0.67 (9.1)	0.79 (7.1)	0.63 (16.9)	0.61 (10.6)	0.76 (9.3)	0.42 (14.2)	0.45 (10.5)
4	0.63 (6.4)	0.61 (5.1)	0.53 (7.9)	0.55 (8.7)	0.47 (13.9)	0.48 (8.4)	0.50 (8.5)	0.32 (7.6)	0.17)(9.4	0.20 (10.2)
Private banks										
1	0.81 (30.04)	0.85 (54.6)	0.79 (86.2)	0.56 (40.79)	0.58 (34.5)	0.50 (50.1)	0.61 (77.2)	0.91 (47.9)	0.74 (89.1)	0.70 (78.2)
2	0.61 (14.83)	0.58 (34.8)	0.46 (78.3)	0.35 (27.4)	0.66 (26.6)	0.31 (31.1)	0.77 (33.7)	0.79 (29.1)	0.57 (39.5)	0.68 (42.3)
3	0.91 (5.3)	0.83 (5.07)	0.70 (8.9)	0.46 (7.21)	0.94 (9.04)	0.79 (10.7)	0.67 (8.6)	0.48 (8.4)	0.45 (7.6)	0.52 (5.2)
4	0.66 (3.26)	0.96 (5.8)	0.35 (1.9)	0.97 (2.7)	0.91 (7.9)	0.52 (5.2)	0.44 (4.2)	0.51 (5.1)	0.54 (9.5)	0.53 (8.2)

Source: researchers' calculations

Table 4. Average Proportion of variance and Redundancy coefficient

Average			1th loading	2th loading	3th loading	4^{th} loading	total
Proportion of variance(1):							
Asset variables variance	Explained by:	Asset canonical variable	24.6	23.8	25.6	25	100.00
Liabilities variables variance		Liabilities canonical variable	18.9	34.2	21.5	25.4	100.00
Redundancy coefficient 2:							
Asset variables variance	Explained by:	Liabilities canonical variable	7.8	5.4	3.2	1.7	18.1
Liabilities variables variance		Asset canonical variable	9.7	6.8	4.2	3.9	24.6

Source: researchers' calculations

Finding simultaneous strong canonical loadings for asset and liability accounts implies a strong relationship between the underlying asset and liability variables, because the canonical correlations in both the first and second loadings are empirically large and statistically strong (see Table 3). As above, we use a 0.30 threshold to determine a "strong" relationship between the original variables and the canonical variables (Fornell and Larcker 1980). This results are similar results of Memmel and Schertler (2009) and deyiung and yom(2008).

5. Discussion and Conclusion

The Iranian banking network in the recent years have confronted with two main changes in its assets portfolio. Given the highest proportion of the loans in the banks' assets portfolio, due to the reasons such as the economic recession, the ratio of loans has been diminishing and on the contrary, the ratio of claims from other banks as well as investments and securities has increase. However, given the highest proportion of stable liabilities (time investment deposits) in the liabilities portfolio during the study period, but in the recent years specially 2006-11 they have faced a diminishing trend of stable liabilities and increasing trend of unstable liabilities such as no-interest deposits, liability to the central bank and liability to the banking network.

Since the assets are financed by the liabilities; therefore, any change in the liability portfolio will influence the asset portfolio. Thus, the amount of assets and liabilities dependency degree in the Iranian banking network appears to be significant. In this paper, we have tried to patronize three standard methods with respect to the theoretical and empirical literature available in the field of assets and liabilities dependency analysis to calculate the dependency degree and analyze its trend in the Iranian banking network for two groups of private and state banks during the course of 2006-15. For this purpose, we used Memmel and Schertler(2009) and Deyoung and Yom(2008 to measure the degree of dependence of assets and liabilities.

Henceforth, the items utilized from the assets portfolio comprise of loans, claims from other banks, claims from the central bank, liquid assets and investments. The same selection happens for the liability portfolio including through liability to the central bank, deposit account, capital account, liability to other banks. Other assets and liabilities are eliminating due to collinearity. Results of the study highlight that the dependency between assets and liabilities in the state banks are far more than the private banks and experienced a diminishing trend in both banking groups.

This results are similar results of Memmel and Schertler (2009) , deyiung and yom(2008) and Gorton and Pennacchi(1995).

Some justifications and interpretations in this regard could be implied as below:

1) for two banking sectors alike, neither the asset nor the liability side of the balance sheet alone can be held responsible for the declining asset-liability dependencies.
2) all two banking sectors have experienced declining dependencies of loans to non-banks and deposits,

while dependencies of the security and investment increase and the dependency of the liability from central bank did not change significantly during the period of our study.

3) State banks have registered a higher liability to the central bank compared to the private banks.
4) State banks have documented lower stable resources in comparison with the private banks.
5) Private banks prefer to promulgate more investment activities rather than lending
6) State banks have recorded weaker asset portfolio diversification than private banks.

Reference

1) Benston, G., and C.W. Smith. (1976). "A Transaction Cost Approach to the Theory of Financial Intermediation," Journal of Finance 31: 215-231.
2) Boyd, J. and E. Prescott. (1986). "Financial Intermediary-Coalitions," Journal of Economic Theory 38: 211-232.
3) Boyd, J. and M. Gertler. (1994). "Are Banks Dead? Or Are the Reports Greatly Exaggerated?" Federal Reserve Bank of Chicago, Proceedings,30th Annual Conference on Bank Structure and Competition, pp. 85-117.
4) Brewer, E., W. E. Jackson, and J. T. Moser (2001). The value of using interest rate derivatives to manage risk at U.S. banking organizations. Economic Perspectives, Federal Reserve Bank of Chicago.
5) Brewer, E., B. A. Minton, and J. T. Moser (2000). Interest rate derivatives and bank lending. Journal of Banking and Finance 24, 353–379.
6) Bia, Jennie., Krishnamurthy, Arvind and Weymuller, Charles-Henri,. (2014). Measuring liquidity mismatch in the banking sector, Federal Reserve Bank of New York
7) Dash, Mihir., & Pathak, Ravi,. (2009). Canonical correlation analysis of Asset – Liability Management of Indian Banks. http://ssrn.com/abstract=1412739.
8) DeYoung, R. and C. Yom (2008). On the independence of assets and liabilities: Evidence from U.S. commercial banks, 1990-2005. Journal of Financial Stability 4, 275–303.23
9) DeYoung, Robert, William C. Hunter, and Gregory F. Udell. (2004). "Whither the Community Bank? What We Know and What We Suspect," Journal of Financial Services Research, forthcoming.
10) Diamond, D. (1984). "Financial Intermediation and Delegated Monitoring," Review of Economic Studies 51: 393-414.
11) Diamond, D., and P. Dybvig. (1983). "Bank Runs, Deposit Insurance, and Liquidity," Journal of Political Economy 91: 401-419.
12) Drechsler, Itamar,. Savov, Alexi and Schnabl, Philipp,. (2017), Banking on Deposits: Maturity Transformation without Interest Rate Risk,New York University Stern School of Business,
13) Gorton, G. B. and G. G. Pennacchi (1995). Banks and loan sales marketing nonmarketable assets. Journal of Monetary Economics 35, 389–411.
14) Gurley, J., and E. Shaw. (1960). Money in the Theory of Finance. Washington: Brookings Institution.
15) Harvey, J. and K. Spong (2001). The decline in core deposits: What can banks do? Financial Industry Perspectives Federal Reserve Bank of Kansas City.
16) James, C. (1987). "Some Evidence on the Uniqueness of Bank Loans," Journal of Financial Economics 19(2): 217-235.
17) Kashyap, A., R.A. Rajan, and J.C. Stein. (2002). "Banks as Liquidity Providers: An Explanation for the Co-existence of Lending and Deposit-taking," Journal of Finance 57: 33-74.
18) Memmel, C. and A. Schertler. (2009). The dependency of the banks' assets and liabilities: evidence from Germany. Discussion Paper, Series 2: Banking and Financial Studies, No 14/2009
19) Modigliani, F. and M. Miller. (1958). "The Cost of Capital, Corporation Finance and the Theory of Investment," American Economic Review. 31
20) Obben, J. and B. Shanmugam. (1993). "Canonical Correlation Analysis of Asset/Liability Structures of Malaysian Financial Institutions," (Edited by Theodore Bos and Thomas A. Fetherston), Research in International Business and Finance, vol. 10. Greenwich, Conn. and London: JAI Press. Sides of the Balance Sheet: A Canonical Correlation Analysis," Journal of Finance 35: 973-980. 32
21) Pikkarainen, T., K. Pikkarainen, H. Karjaluoto, and S. Pahnila (2004). Consumer acceptance of

online banking: an extension of the technology acceptance model. Internet Research 14, 224–235.

22) Simonson, D. G., J. D. Stowe, and C. J. Watson (1983). A canonical correlation analysis of commercial bank asset and liability structures. Journal of Financial and Quantitative Analysis 18, 125–140

Note

1. Seminal theoretical studies in this area include Gurley and Shaw (1960), Pyle (1971), Benston and Smith (1976),Leland and Pyle (1977), Fama (1980), Diamond and Dybvig (1983), Diamond (1984), Boyd and Prescott (1986),James (1987), Gorton and Pennacchi (1990), and Kashyap, Rajan, and Stein (2002). See Saunders and Cornett (2006, chapter 1) and Freixas and Rochet (1999, chapter 2) for general discussions of why banks exist and overviews of the theoretical literature.
2. private banks: pasargad, eghtesad novin, saman, ansar, sina, ayandeh, sarmayeh, shahr, karafarin, ghavamin, dey, ghardeshgari, iranzamin, hekmate Iranian, mellat, saderat, tejarat, refahekargaran and state banks: sepah, melli, keshavarzi, maskan, toseesaderat, sanatomadan, tosee taavon
3. That is, P=5 Liability accounts, with one variable deleted to avoid perfect collinearity.