**Asset-liability dependency and unconventional monetary policy: evidence from Euro area banks**

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**EFM classification codes**: 510 (Depository institutions - management); 550 (Interest rates and term structure); 560 (Issues in monetary and economic policy)

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## Abstract

By focusing on a sample of Euro area commercial banks over the years 2013-2020, we provide a measure of asset-liability dependency through the application of the canonical correlation analysis. We analyse three sets of data, referred to 2013, 2016 and 2020, respectively, and study the impact of the adoption of the negative interest rates (NIRP) policy by the European Central Bank by dividing our sample in two groups of small and large banks. We contribute both to the studies dealing with the impact of unconventional monetary policy and to prior empirical research investigating the asset-liability management of commercial banks.

Based on their size, banks show different asset-liability management strategies: large credit institutions seem to decide their funding policies just after searching for good investment opportunities, which can be explained by their superior ability in collecting funds from sources different from retail depositors. On the contrary, small banks appear to get involved in lending activity only after their funding is set. Further, the intensity of the casual relations between the asset and liability side of their balance sheets changes over the years we consider, since the NIRP makes it much less clear if compared with both 2013 and 2020.



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**Keywords**: ALM, canonical correlation, NIRP, interest rates, bank deposits

## 1. Introduction

By meeting the maturity preferences expressed by those economic agents with a surplus of financial resources and of those with a fund deficit, commercial banks typically adotp a borrow short - lend long strategy, since they issue long-term loans that are financed by short term deposits. The overall maturity mismatch between bank assets and liabilities is both one of the main performance leading factors in banking activity and the material evidence of the maturity and risk transformation function. This mismatch is the source of two main risks in banking: the interest rate risk and the liquidity risk, dramatically emphasized by the 2007 financial crisis. The former was dramatically emphasized by the US Savings and Loan crisis in the '80s, which led to the failure of 563 institutions, with an overall cost of more than $160 billion; the systemic nature of the latter was highlighted by the 2007 great financial crisis. Both these risks have captured regulators', industry's and scholars' attention in the last years for tremendous changes in the financial market conditions and the emergence of new potential sources of bank instability.

Bank management requires a strong coordination between asset- and liability-related strategies and the associated issues have been studied by prior literature. Assuming both the dependence and the independence between the yields on loans and on deposits, Pyle (1971) determines the necessary and sufficient conditions for the existence of financial intermediation. In the first case, he shows that banks' decisions concerning their asset (liability) side are influenced by parameters regarding the liability (asset) accounts, including their maturity, just because of a non-zero covariance of liability and asset yields. The hedging purpose of banks' ALM is highlighted in Ho and Saunders (1981). Under an expected utility maximizing framework, they show that a hedging behaviour represents the attempt by banks to protect themselves from the risk caused by the interplay between volatile interest rates and asset and liability structural interrelations.

Banking business has dramatically changed during the last two decades, moving from the traditional intermediation model, with a strong association between assets and liabilities, towards a greater independence between the two sides of the balance sheet. Today commercial banks generate a significant part of their profit from a non-interest-income activity (DeYoung and Rice 2004, Kaufman and Mote 1994, and Choi, De Young and Hasan 2007); nevertheless, intermediation activity is not less important than it was years ago DeYoung and Rice 2004, Boyd and Gertler 1994). Banks have adapted their business models in response to the changing environment they operate in by: *i)* being increasingly involved in off-balance sheet activities; *ii)* making use of the tools that financial innovation has been producing over the past years; *iii)* facing, on the one hand, the competitive pressure exerted by non-banking firms, and, on the other hand, the easier borrowers' access to financial markets.

Considering the increasing attention to the interest rate and liquidity risk exposure, the objective of this paper is to provide a measure of asset-liability dependency for a sample of Euro area banks through the application of the canonical correlation analysis, and to investigate whether, over the period 2013-2020: banks behave differently, in terms of asset-liability management, based on their size; the adoption of the negative interest rates policy (NIRP) by the European Central Bank (ECB) has produced any change in the relations between the asset and liability items of their balance sheets.

Canonical correlation is a statistic technique able to capture in a single summary measure the ALM essence: whether the maturity mix of a bank's assets reflects the maturity mix of its liabilities. Furthermore, the canonical correlation analysis measures the correlation among and between the individual accounts of the two sides of the balance sheet, which allows us to infer which assets banks match with which liabilities. Finally, canonical correlation doesn't require any particular structure on the data and any assumption about the casual direction between assets and liabilities, this being helpful to us because funding activity is more developed than the lending business for some commercial banks, whereas the opposite is true for other commercial credit institutions.

Main findings can be summarized as follows. Large banks behave differently from small intermediaries as far as the casual relation between the asset and liability side is concerned: it seems that the former decide their funding policies after searching for good investment opportunities, whereas small banks determine their investment strategy only after seeking funding and/or deciding their funding mix. Further, the strength of these relations change over the years we take into account, showing that in 2016, due to the impact of the NIRP on the financial markets, the casual direction between assets and liabilities appears much less clear if compared with 2020.

This paper provides a contribution to two streams of literature: the first is referred to the studies dealing with the impact of unconventional monetary policy (see among the others Claessens et al., 2018 and Genay and Podjasek, 2014), the second investigates the asset-liability management of commercial banks through the canonical correlation analysis (see among the others DeYoung and Yom, 2008 and Abou-El-Sood and El-Ansary, 2017).

The rest of the paper is organized as follows: paragraph 2 presents a review of the scant literature analyzing banks' ALM through the canonical correlation analysis; paragraph 3 shows the rationale for using canonical correlation analysis and outlines its application to this research; paragraph 4 describes our bank sample and the variables we use in our work; in paragraphs 5 and 6 we present the results of our analysis and our interpretations; paragraph 7 concludes.

## 2. Studying the relationship between bank assets and liabilities based on the canonical correlation analysis: a literature review

Canonical correlation has already been used to investigate the asset and liability structure of banks' balance sheets, as well as their dependency. Simonson, Stowe and Watson (1983) study a crosssection of large U.S. commercial banks, with assets worth more than $300 million at year-end 1979, splitting the whole sample in two sub-samples: the first one ("large banks") includes banks with assets between $300 million and $1 billion; the second one ("very large banks") comprises banks with total assets greater than $1 billion. Overall, they find a strong evidence of systematic asset-liability hedging to manage interest rate risk. Particularly, "large banks" hedge interest rate risk through the matching of interest sensitive funds and assets. Furthermore, they find a strong linkage between high levels of equity capital and liquid investment, as Stowe, Watson and Robertson (1980) do for their sample of non-financial firms, and they interpret it as a rationale response to mismatched assets and liabilities. The analysis referred to the "very large banks" doesn't support the direct equity-liquidity linkage, and they argue that this is because, as the bank size increases, the equity capital proportions decline since its access to money market sources of funds becomes easier. They also focus on the indirect and negative relationship between equity capital and cash, based on their common link to the bank size, which can be explained as follows: relative to the smaller group, "very large banks" have smaller amounts of equity capital, and, at the same time, are more likely to have larger amounts of the component of the cash account made up of items in process of collection since their depositors are more involved in cash management practices which raise deposits velocities and expand items in process of collection.

DeYoung and Yom (2008) apply canonical correlation analysis to balance sheet data of a sample of U.S. commercial banks between 1990 and 2005. They find that: larger banks have a stronger linkage between assets and liabilities than smaller banks; assets and liabilities have become less dependent over time for large banks but not for small banks; a portion of this increasing independence can be explained by the stronger recourse to off-balance risk-mitigation instruments; a strong positive relationship between short-term loans and purchased funds, and between long-term loans and core deposits.

Many authors apply this kind of analysis to the Indian context. Jaswal (2010) examines a sample of commercial banks operating in India, both domestic and foreign institutions, for the period 1997-2008. He finds strong, but declining, linkage between asset and liability accounts. The decline is more pronounced in case of foreign banks as they are largely exposed to off-balance sheet activities. The Indian context was examined also by Jain and Gupta (2004). The authors examine 68 commercial banks operating in India for years 1992–2000 using canonical correlation analysis. Their study reveals that most of the banks, in general, show prudent matching of assets and liabilities. The most prominent relationship is between short term deposits and SLR securities. Karthigeyan, Mariappan and Rangaiah (2013) examine the sample of three Old & New generation Private sector Banks using the Canonical correlation technique to capture the predictor variables, liability and predictive variables assets in these banks. The finding of the paper reveals that except ICICI bank, all other banks are in safer zone and mostly the predictor variables are long-term and the predictive variables are also long-term, and short- term in nature. Similar evidence emerges with reference to Tunisian banks in the study by Ben Said and Rim (2018). The aim of their analysis is to analyze asset-liability management behaviour in Tunisian banks between 2000 and 2014. From the analysis, different degrees of the association have been found among various constituents of assets and liabilities and among banks. In most cases, there has been a poor and judicious matching of assets and liabilities in terms of their explicit cost and revenue as well as their maturity and liquidity. It is further observed that most Tunisian banks were asset-managed: these banks were actively managing assets and liabilities and were dependent on how well the assets are managed.

Abou-El-Sood and El-Ansary (2017) collect data from the financial statements of Islamic Banks (IB) in the Middle East and North Africa region and Southeast Asia during the period 2002-2012. By using canonical correlation analysis, the authors find that Islamic Banks tend to make decisions on sources of finance based on their asset portfolio choices. The interdependencies are stronger for small banks. IBs direct more of their investments to risk-mitigating instruments that share the risk with the borrower/client and are based on the purchase and sale of real goods rather than financial instruments. In add to this, they investigate how ALM models work at times of economic turmoil, showing that banks tend to rely less on equity to finance their investments during economic boom and increase their equity holdings during economic bust.

## 3. The canonical correlation analysis: mathematical framework and application to this research

This paragraph provides a description of the canonical correlation technique, developed by Hotelling (1935, 1936), to clarify the rationale for adopting it in our study. Canonical correlation is a multivariate analysis technique describing the relationships between two sets of variables, named criterion variables and predictor variables. In our case, these two sets of variables are, respectively, the asset and liability/capital accounts of a bank's balance sheet.

Let the asset and liability/capital variables be denoted, respectively, by the matrices X and Y. The number of rows of each matrix represents the n banks of our sample, while the number of columns indicates the different categories of asset ($q_1$) and liability ($q_2$) taken into account in our analysis. Consequently, X is $n \times q_1$ and Y is $n \times q_2$. The variables used are expressed as a proportion of total assets.

The canonical correlation methodology attempts to find linear combinations of X and Y so that the correlation between them is as high as possible. The linear combinations of X and Y are denoted, respectively, by $u_i$ and $v_i$:

$$u_i = Xa_i \quad (1.a) \qquad v_i = Yb_i \quad (1.b) \qquad i = 1,\ldots p \quad \text{with} \quad p = \min(q_1, q_2)$$

where $a_i$ and $b_i$ are vectors to be estimated and are, respectively, $q_1 \times 1$ e $q_2 \times 1$. We refer to the scalars that constitute the vectors as canonical coefficients, to the linear combinations of X and Y as canonical variables and to the correlations between the canonical variables as canonical correlation coefficients.

The canonical correlation coefficients and the canonical coefficients are obtained by solving the following equations[1]:

$$\begin{cases} (R_{11}^{-1} R_{12} R_{22}^{-1} R_{21} - \lambda_i I) a_i = 0 & (2.a) \\ (R_{22}^{-1} R_{21} R_{11}^{-1} R_{12} - \lambda_i I) b_i = 0 & (2.b) \end{cases}$$

where $R_{11}$ is the covariance matrix between asset variables; $R_{22}$ is the covariance matrix between liability variables; $R_{12}$ is the covariance matrix between asset and liability variables, $R_{21}$ is its transposed and I is the identity matrix.

Equations (2.a) and (2.b) can be rewritten as systems of p linear equations in p unknown coefficients. These systems of linear equations will have non-trivial solutions only if their determinants are zero.

$$\left| R_{11}^{-1} R_{12} R_{22}^{-1} R_{21} - \lambda_i I \right| = 0 \qquad (3.a)$$

$$\left| R_{22}^{-1} R_{21} R_{11}^{-1} R_{12} - \lambda_i I \right| = 0 \qquad (3.b)$$

The largest value of $\lambda$ that satisfies both equations (2.a) and (2.b) is the first characteristic root, or,

[1] For a more detailed description see Anderson (2003).

in other words, the first eigenvalue, of the following matrices:

$$R_{11}^{-1} R_{12} R_{22}^{-1} R_{21} \qquad (4.a) \qquad R_{22}^{-1} R_{21} R_{11}^{-1} R_{12} \qquad (4.b)$$

Vectors $a_1$ e $b_1$ are its corresponding eigenvectors, which constitute the weights (canonical coefficients) for the linear combinations $u_1$ and $v_1$. The first canonical correlation coefficient ($R_1$) is the square root of the first characteristic root. In symbols:

$$R_1 = \sqrt{\lambda_1} \qquad (5.)$$

Particularly, there will be a number p of canonical correlation coefficients equal to the minimum between $q_1$ and $q_2$.

Canonical correlation coefficients represent the variance shared by linear combinations of assets and liabilities. Each successive canonical correlation coefficient will be smaller than the last since each successive root will explain less and less of the data. For each canonical correlation coefficient we have different pairs of canonical variables. Each pair of canonical variables is uncorrelated with the others. In order to determine the number of statistically significant canonical correlation coefficients we use the test proposed by Bartlett (1941) which tests the null hypothesis that there is no relationship between the predictor and the criterion variables, or that there are no more than *k* significant canonical pairs, where *k* is equal to zero. When this hypothesis is rejected, *k* is set equal to 1 and Bartlett's test is performed for this new value until the significance level is exceeded and the number of statistically significant canonical pairs is determined.

Since the variables used in our study are expressed as a proportion of total asset the sum of these proportions add to unity, which makes $R_{11}$ and $R_{22}$ singular. To avoid this singularity we eliminate one variable from each set. The informational content of the remaining $q_1$-1 and $q_2$-1 variables does not change. Consequently, the number of canonical correlation can be lower than the minimum between $q_1$-1 e $q_2$-1. In symbols we can have:

$$p \leq min(q_1 - 1; q_2 - 1) \qquad (6.)$$

The nature of the relations between asset and liability can be studied by examining the canonical loadings, which are the correlation between the original variables and their own canonical variables. The canonical loadings give a measure of the total amount of variance in the actual data accounted for by the canonical variables; they are the elements of the matrices $S_1$ and $S_2$, with dimension $q_1 \times p$ and $q_2 \times p$, obtained as follows:

$$S_1 = \frac{1}{n} X'V = \frac{1}{n} X' XA = R_{11} A \qquad (7.a)$$
$$S_2 = \frac{1}{n} Y'U = \frac{1}{n} Y'YB = R_{22} B \qquad (7.b)$$

where U and V are n×p matrices whose columns contain the canonical variables obtained by solving (2.a) and (2.b). A and B are matrices with dimension, respectively, $q_1 \times p$ and $q_2 \times p$, whose columns are formed by the eigenvectors of the characteristics roots. Following Cliff and Krus (1976), we rotate simultaneously the canonical loadings using Kaiser (1958)'s normalized varimax criterion. This simplifies the interpretation of the nature of the relationships between the canonical variables without affecting the total predictable variance.

Each element $S_{jk,1}$ and $S_{jk,2}$ of matrices $S_1$ and $S_2$ is the correlation coefficient between the j-th asset/liability variable and the k-th asset/liability canonical variable (for j = 1,2… $q_1/q_2$ and K=1,2,…p). The canonical correlation coefficients and the canonical loadings can be used to study the nature of the relationship between a specific asset and a specific liability. The logic behind can be represented in the picture below and explained as follows: if the size of canonical correlation coefficient between two canonical variables is high (relation 1 in the figure), and the size of the canonical loading for a specific asset $q_1$ is high (relation 2a), and the size of the canonical loading for a specific liability $q_2$ is high (relation 2b), we can assume that the specific asset $q_1$ and the specific liability $q_2$ are interconnected (relation 3).

[Insert Figure 1 here]

Since the canonical correlation coefficients represent the variance shared by linear combinations of asset and liability/capital variables and not the variance shared by the original asset and liability accounts, it is possible that a high correlation between only one asset variable and only one liability variable could lead to a very large canonical correlation coefficient. In order to address this issue and further investigate the links between asset and liability accounts, we calculate the redundancy coefficients that provide a 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. For each canonical correlation coefficient (k=1,…p), the redundancy coefficients can be obtained as follows:

$$R_{1k} = \frac{\sum_{j=1}^{q1} s^2{}_{jk,1}}{q_1} \cdot R^2{}_k \quad (8.a) \qquad R_{2k} = \frac{\sum_{j=1}^{q2} s^2{}_{jk,2}}{q_2} \cdot R^2{}_k \quad (8.b) \qquad k = 1,....p$$

where $s^2{}_{jk,1}$ and $s^2{}_{jk,2}$ are, respectively, the elements of matrices $S_1$ and $S_2$ and $R^2$ is the canonical correlation coefficient. As shown by Stewart and Love (1968), the sum of the redundancy coefficients across all the canonical correlation coefficients represents a measure of the proportion of the variance of asset variables predictable from liability variables ($R_1$) and vice versa ($R_2$). In symbols:

$$R_1 = \sum_{k=1}^{p} R_{1k} \quad (9.a) \qquad R_2 = \sum_{k=1}^{p} R_{2k} \quad (9.b)$$

**4. Measuring asset-liability dependency: data and variables**

We use 2013, 2016 and 2020 year-end data from Moody's Analytics BankFocus database, referred to the EA banking system. By comparing these three years we aim at testing whether the relationships between banks' assets and liabilities have changed due to the adoption of the negative interest rate policy by the ECB from June 2014. To grant some homogeneity, banks included in the sample have been selected based on the type of activity they are involved in, and, in order to avoid double counting of financial institutions, our data are drawn from the consolidated balance sheets, if available, otherwise from the unconsolidated financial statements.

Five asset accounts (cash, short-term loans, long-term loans, securities, and other assets) and five liability/capital categories (equity, demand deposits, term deposits, deposits from banks, and other liabilities) are chosen. Since there is not any a priori that can be accounted for in defining these categories, we first consider the size of these balance sheet items in terms of total assets, and then account for their maturity, i.e., according to our assumption cash, short-term loans, securities and demand deposits tend to have shorter maturities than long-term loans, term deposits and of course equity.

Table 1 reports the variables used in the empirical analysis. As to the exact definitions of these balance sheet items, *cash balance* (CASH) includes cash at the bank, deposits at other banks and at the European Central Bank; *long-term loans* (LTL) comprise customer loans with maturities of more than one year, leases and mortgages; *short-term loans* (STL) are obtained by subtracting long-term loans to total customer loans; *securities* (SEC) take in all trading and investment securities, which, irrespective of their contractual maturities, can be easily negotiated on markets and/or are to be traded within a short-term horizon; all other assets not included in the previous categories are classified as *other assets* (OA); *equity* (EQ) includes all common stocks, perpetual preferred stocks and retained earnings; *demand deposits* (DD) contain all customers sight deposits accounts; *term deposits* (TD) are calculated by subtracting demand deposits to the total amount of customer deposits, and mainly include savings deposits, deposits that can be withdrawn after the term has ended or by giving a predetermined number of days of notice; *bank deposits* (BD) include funds whose holder is another bank including the ECB; *other liabilities* (OL) include all other liability accounts not described before, such as time certificates of deposits with a maturity of twelve months or less and other money market accounts. All previous variables are expressed as a percentage of total assets.

[Insert Table 1 here]

We perform canonical correlation analysis on these data where each set of annual calculation is independent from the others, taking into account only banks that appear in the three sample years since we want our results to reflect changes occurred in the financial markets during the 2013-2020 period. Particularly, we want to investigate the effects of the long-lasting negative interest rates policy, officially started in 2014, when the ECB lowered the deposit facility rate below the zero level for the first time.

To account for the influence of bank size on the relationships between the asset and liability sides of the balance sheet, starting from a whole sample of 254 banks, we decided to analyze two sub-samples consisting of the largest 25% and the smallest 25% of our sample banks. Consequently, we have 64 credit institutions with total assets equal or exceeding €12.3 billion ("Large Banks" – LB) and 64 banks with assets equal or lower than €399 million ("Small Banks" – SB). Following DeYoung and Yom (2008), each of the survivor banks is assigned to one of two asset size categories based on its average assets over the three years. Consequently, our sub-sample canonical correlation measures will be based on the same (number of) banks, making comparisons across sub-samples more valid.

Splitting the sample into two groups resulted in some differences in the balance sheet proportions, as indicated by means, standard deviations and the t-statistics that test for the difference between mean balance sheet accounts, presented in Table 2, where Panels A, B and C refer to the 2013, 2016 and the 2020 data, respectively. Overall, cash at our sample banks and their deposits at the ECB are a small portion of their total assets, and the differences between the means of the two groups of banks is statistically significant in 2016 and 2020, where larger credit institutions show a statistically higher mean value, which is almost four times larger than that of smaller banks in 2020. As to short-term loans, small banks appear to be less involved in this particular business area than larger ones in 2013 and 2016, when STL stands at around 30% for these latter and drop from 19.33% to 16.85% for the former. We find opposite evidence for the 2020, when short-term loans become 34.64% of total assets for small banks and slightly decrease to 29.09% for large intermediaries. In all the three years, the differences in the mean values of the incidence of short-term loans to total assets are statistically significant at the 1% confidence level. We find no statistically significant difference in the share of long-term loans to total assets (LTL) between the two groups of banks. LTL is around 31% for 2013, with a certain positive trend in 2016 and 2020, when it reaches 34.97% and 32.81% for small and large banks, respectively. The variable SEC includes securities that are mainly made up of government bonds and other bonds that can be easily negotiated on the markets. The share of this asset category increases from 2013 to 2016 for small banks, raising from 31.55% to 37.04% of total assets, whereas it stays stable at around 18% for large institutions. It decreases for both the two groups in 2020, when it is circa 12.5% and 11.5%, respectively, with a difference between these two mean values that is no more statistically significant.

As far as the liability side is concerned, major differences between the two groups of banks refer to the variables EQ and DD, namely the ratios of equity to total assets and that of demand deposits to total assets. On average, as expected, small banks are more capitalized than large credit institutions, and the difference remains statistically significant at the 1% level in all the three years we study, even if it shrinks from 5.55% in 2013 to 3.32% in 2020. This is consistent with the evidence, also found in prior studies, that smaller banks are generally more capitalized than larger ones. Small banks hugely rely on customer deposits to raise funds, much more than larger credit institutions, which have easier access to financial markets and wholesale funds, which nevertheless are included in the residual variable OL and are not directly observable. The difference is particularly relevant in terms of demand deposits (DD). The former are 41.61% of total assets in 2013, and raise to 49.57% in 2016 and to 59.11% in 2020. Even if the share of these deposits on total assets is much lower than that observed for small banks, DD shows a positive trend also for large credit institutions, going from 21.19% in 2013 to 34.10% in 2020. Smaller credit institutions make also more recourse to time deposits, if compared with larger ones, but the difference is statistically significant in none of the years we consider. The differences in the mean values of the ratio of time deposits to total assets (TD), which shows a decreasing trend over the three years, are definitely lower and never statistically significant. TD goes from 14.35% in 2013 to 9.67% in 2020 for small banks and from 13.52% to 7.98% for the group of the large ones. Overall, we believe that the increase in the demand deposits and the decrease in the time deposits can be a proxy for a more marked investors' risk aversion.

[Insert Table 2 here]

## 5. Results of the pair-wise correlation analysis

In this section we present the results of the pair-wise correlation analysis, which is the first leg of our empirical analysis. In paragraph 6, to achieve a deeper comprehension of the relations occurring both within and across the asset and liability sides of our banks' balance sheets, we present and discuss the results of the canonical correlation analysis.

Panels A, B and C of Table 3 show the pair-wise correlations between the asset and liability items we have used to break the bank balance sheet down for the 2013, 2016 and 2020, respectively. The correlation matrices of the two groups of banks differ: particularly, strong asset-liability correlations happen more often at large banks than at the small banks. This would entail that smaller banks are less able and/or less likely to practice on-balance sheet ALM than larger credit institutions. Nevertheless, this could also depend on within-group heterogeneity among smaller banks that introduces noise into the correlation measures or may indicate that the asset and liability categories that we impose on the data reflect larger banks' business models better than those of smaller credit institutions.

For both small and large banks, CASH is negatively correlated with EQ for all the three years considered, even if this correlation is statistically significant (always at the 1% confidence level) only for large banks, being marginally significant (at the 10% confidence level) for small banks only in 2013. Further, the magnitude of the relationship is higher for large banks relative to small intermediaries. Overall, this negative relationship is consistent with the idea that banks with large amounts of equity to total assets are less likely to need high balances of liquidity, both at the bank itself and at the ECB, and have higher incentives to get involved into more profitable activities, which is proved by the positive correlation between EQ and LTL for the years 2016 and 2020, again only for large intermediaries.

The negative CASH-EQ relationship can be also read from a capital adequacy perspective: the lower is CASH, the higher might be the liquidity risk a that a bank faces; the higher is the risk, the higher is the capital that a bank decides to hold, though capital buffers are not the most well-suited instruments to keep the bank safe from liquidity risk. This correlation could even represent the evidence of a certain concern at large banks for their liquidity position, which is something we do not find at small banks probably because of their typically higher capital endowment.

Equity endowment appears to be negatively correlated with short-term loans at small banks: the correlation coefficient is marginally significant in 2013 and significant at the 1% and 5% confidence level in 2016 and 2020, respectively. Long-term loans are positively and significantly correlated with equity at large intermediaries for 2016 and 2020, whereas at small banks the correlation coefficient is never statistically significant.

STL is positively correlated with DD and TD at large banks in the three years considered, with pair-wise correlation coefficients statistically significant at the 1% level. This would suggest that short-term loans are mainly funded by demand and time deposits, probably because of their long-term stability, if compared with other non-retail sources of funds.

[Insert Table 3 here]

**6. Results of the canonical correlation analysis**

Four canonical variate pairs were derived for each group of banks, since we had five variables on both the asset and the liability side of the balance sheet and one was dropped to avoid the singularity problem.[2] As shown in Table 4, in 2013, one canonical variate pair is significant below the 5% level for both groups of banks, as determined by Bartlett's Chi-square test. In 2016, two canonical variate pairs are significant at the 5% confidence level for both small and large banks, whereas in 2020, there is only one for small banks and still two for large credit institutions.

[Insert Table 4 here]

To better investigate the relationships between assets and liabilities, in Table 5 we analyze the proportion of the variance in the asset (liability) variables predictable from the liability (asset) variables, using Stewart and Love's redundancy indexes. Panels A, B and C of the Table 5 present the results of the analysis run on 2013, 2016 and 2020 year-end data, respectively. In 2013 the proportion of the variance in the asset variables shared with the liability variables is 16.93% for the bottom 25% banks, higher than the 11.11% of the variation in the liability variables predictable from the asset canonical variables. The same redundancy indexes for the group of large banks are circa 11.30% and 19.87%, respectively. Therefore, causation seems to run more from assets to liabilities for large banks (it is just after finding investment opportunities that they decide their funding strategies) than from liabilities to assets (banks would decide their investment strategy only after seeking funding and/or determining their funding mix), whereas for small banks the direction is opposite.

In 2016, the redundancy coefficients are higher if compared to those of 2013 for both the two groups of banks, meaning that the relationships between assets and liabilities are stronger. Particularly, for the small banks group, the proportion of the variance in the asset predictable from

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[2] See section 3.

the liability variables is 20.52%, and that of the liability variables extracted by the asset variables stands at 18.92%. For the top 25% banks, the former coefficient is slightly lower than the latter, 25.0% vs. 25.91%. Overall, the difference we find relative to the 2013 data is that both for small and large banks, the distance between the redundancy coefficients has shrunk, going from 5.82% to 1.60% for smaller banks and from 8.57% to 0.91% for the top 25% banks in our sample. We argue that the greater proximity in the redundancy coefficients can be to some extent due to the new financial conditions in which banks run their intermediation activity more than two years after the adoption of the NIRP by the ECB.

If compared with 2016, the results we find for 2020 show some interesting differences, even if the overall behaviour in terms of the proportion of the variance of one side of the balance sheet explained by the variance of the other one is confirmed. Being verified that the liability side has a higher predictive power on the asset side than the other way around for small banks, we observe that the redundancy coefficients decrease to 17.85% and 9.84%, with an increase in their difference, which stands at 8.01%. It seems that five years later, the situation has returned to that shown in 2013. This is not what we find for larger banks. Redundancy coefficients are higher than 2016, being 28.47% for the share of the asset variance explained by the liability side and 35.72% for the proportion of the liability variance shared by the asset side, with a difference of 7.25%, which is significantly higher than that observed in 2013.

[Insert Table 5 here]

Tables 6, 7 and 8 focus on the individual asset-liability relations in the canonical loadings, based on the 2013, 2016 and 2020 year-end data, respectively. Particularly, the canonical loadings have been rotated simultaneously using Kaiser (1958)'s normalized varimax criterion, and then sorted by descending size of their absolute values for each canonical variate pair. Panel A and Panel B show these varimax rotated canonical loadings for the group of small banks and large banks, respectively. Following DeYoung and Yom (2008), we set a 0.30 threshold to determine a strong relationship between the original variables and the canonical variables.

We first consider the results referred to the 2013 year-end balance sheets for the small banks and then move to the group of large intermediaries. The canonical variable 1R for the smallest 25% banks (Panel A in Table 6) has very large negative loadings for STL, TD and CASH, whereas both SEC and BD load with the same positive sign. Large banks show positive loadings for EQ, on the liability side, and LTL on the asset side, with STL having a canonical loading very close to the 0.30% threshold.

Evidence referred to the year 2016 shows that, as far as the small banks are concerned, LTL and DD have large positive loadings, whereas STL and TD load with the same negative sign (see canonical variable 1R in Panel A of Table 7). Furthermore, also in 2016, the second canonical variable 2R confirms that there is a strong direct relation between SEC and BD. The analysis of the top 25% largest banks shows a strong direct relation between LTL and EQ (see canonical variable 1R in Panel B of Table 7) and between STL and TD (see canonical variable 2R in Panel B of Table 7).

Finally, 2020 results confirm both the LTL-DD and the STL-TD relationships pointed out in 2016 (see canonical variable 1R in Panel A of Table 8). As concerns large intermediaries, even in the last year of our sample period, we find a strong direct relationship between EQ and LTL (see canonical variable 1R in Panel B of Table 8) and between STL and TD (see canonical variable 2R in Panel B of Table 8). Relative to the last year before the NIRP was introduced, we observe that the direct relationship between SEC and BD has been replaced by strong and direct link between deposits from other banks, including those from ECB, and the cash balance at the bank itself and at other banks, including ECB.

Overall, the results seem to suggest that there is a strong direct relationship between capital endowment and long-term lending activity for large banks, which is something we find irrespective of the year examined. Further, if compared with the evidence of 2013, in 2016 and 2020, during the years of long-lasting, unconventional monetary policy, a new STL-TD relationship emerges. As for small banks, relative to the 2013 results, balance sheets referred to 2016 and 2020 show that long-term lending is significantly linked with the availability of retail demand deposits and short-term loans are directly associated with time deposits.

[Insert Table 6 here]

[Insert Table 7 here]

[Insert Table 8 here]

## 7. Concluding remarks

The interdependence of assets and liabilities for a sample of EA commercial banks, at both small and large intermediaries, has changed during the 2013-2020 years. Through the canonical correlation technique, we analyze three sets of year-end data, referred to 2013, 2016 and 2020, respectively, finding that in all the three years large banks run their business as if they decided their funding policies after identifying good investment opportunities, which is something a bank can do when there are no issues in raising additional liquidity in the market. On the contrary, small intermediaries are systematically characterized by opposite evidence in terms of the variance of one side of the balance sheet explained by the other side, since it seems that they determine their investment strategy only after seeking funding and/or deciding their funding mix. The strength of these relations change over the years: in 2016, the casual direction between assets and liabilities appears much less clear, whereas the 2020 evidence basically restores the results found before the beginning of the ECB's negative interest rates monetary policy, thus suggesting a sort of adaptation from our sample banks to the new financial markets conditions.

From both a regulators' and industry's perspective, further investigation and deeper comprehension of the relations between bank assets and liabilities can help to define new approaches to measure and monitor banks' exposure to both liquidity and interest rates risks that are more consistent with banks' actual behaviour, during both benign market conditions and never experienced financial environment.

**References**


Abou-El-Sood, H., El-Ansary, O. (2017), Asset-liability management in Islamic banks: evidence from emerging markets. *Pacific Accounting Review*, Vol. 29 No. 1, pp. 55-78. https://doi.org/10.1108/PAR-04-2016-0050

Anderson, Theodore Wilbur 2003. *An Introduction to Multivariate Statistical Analysis*. Hoboken: John Wiley & Sons, Inc.

Bartlett, M.S. 1941. The statistical significance of canonical correlations. *Biometrika* no 32: 29-38.

Ben Said, H., Rim, Z.-H. (2018). Tunisian bank assetliability management: A canonical correlation analysis. Corporate Ownership & Control, 15(3-1), 230-238. http://doi.org/10.22495/cocv15i3c1p7

Boyd, John., Gertler, Mark. 1994. Are banks dead? Or are the reports greatly exaggerated? Federal Reserve Bank of Chicago. In: Proceedings of the 30th Annual Conference on Bank Structure and Competition, 85-117.

Choi, S., De Young, R., Hasan, I. 2007. Risk, return, and non-interest income at commercial banks: a cross-country analysis. *Unpublished working papers.*

Claessens S., Coleman N. and Donnelly M. (2018), *"Low-for-long" interest rates and banks' interest margins and profitability: cross-country evidence*, Journal of Financial Intermediation, Vol. 35, pp. 1-16

Cliff, N., Krus, D.J. 1976. Interpretations of canonical analysis: rotated vs. unrotated solutions. *Psychometrika*, March.

DeYoung, R., Rice, T. 2004. Non-interest income and financial performance at U.S. commercial banks. *Financial Review* no 39: 101-127.

DeYoung, R., Yom, C. 2008. On the independence of assets and liabilities: Evidence from U.S. commercial banks, 1990-2005, no 4: 275-303.

Genay H. and Podjasek R. (2014), *What is the impact of a low interest rate environment on bank profitability?* Chicago Fed. Lett. 324, pp. 1-4

Ho, T.S.Y., Saunders, A. 1981. The determinants of bank interest margins: theory and empirical evidence. *Journal of Financial and Quantitative Analysis* XVI, no 4: 581-600.

Jain, P. K., & Gupta, V. 2004. Asset-Liability management among commercial banks in India—A canonical correlation analysis. *Vision*, 8(1), 25-40.

Jaiswal, S. 2010. Relationship between Asset and Liability of Commercial Banks in India, 1997-2008. *International Research Journal of Finance and Economics*, no 49: 43-58.

Kaiser, H. F. 1958. An index of Factorial Simplicity. *Psychometrika* 23, 187-200.

Karthigeyan, A., Mariappan, V., & Rangaiah, B. 2013. Asset-liability management in Indian private sector banks-a canonical correlation analysis. Journal Impact Factor, 4(5), 06-13.

Kaufman, G., Mote, L., 1994. Is Banking a Declining Industry? An Historical Perspective. *Federal Reserve Bank of Chicago Economic Perspectives*: 2-21.

Pyle, D.H. 1971. On the theory of financial intermediation. *Journal of Finance* 26, no 3: 737-747.

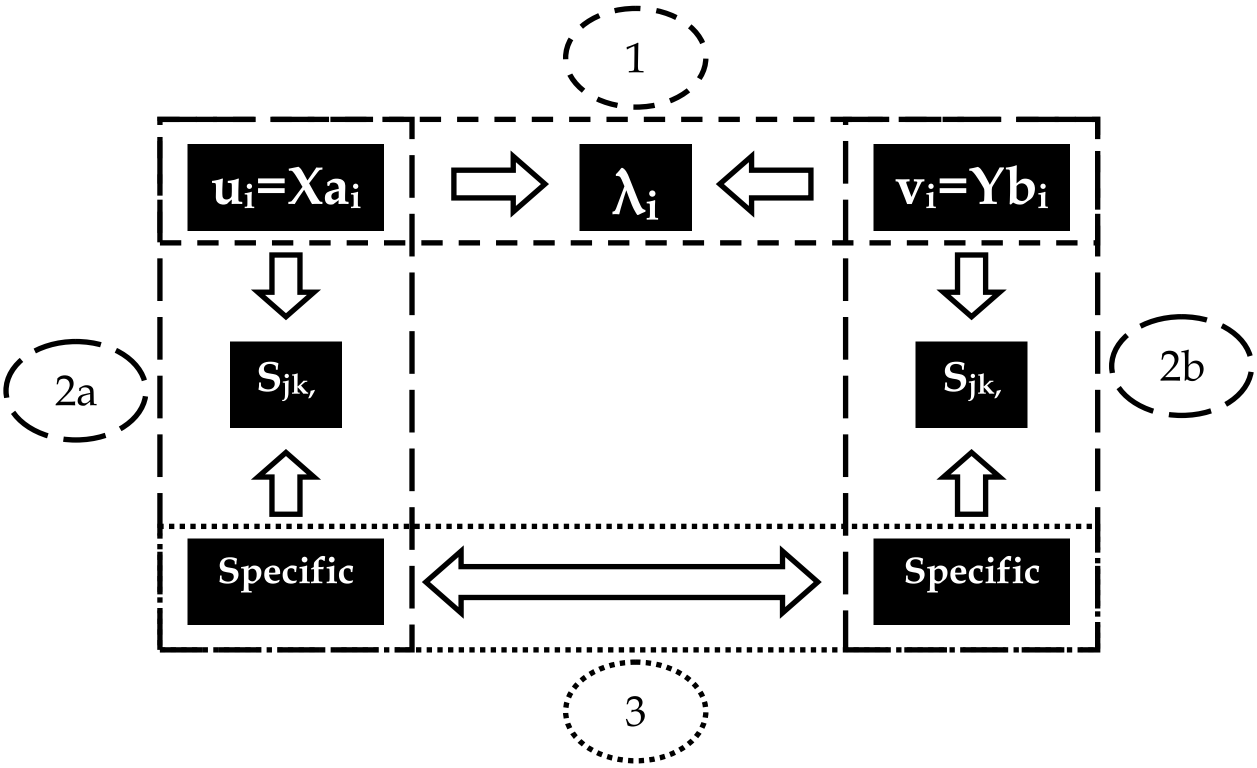
Simonson, D., Stowe, J., Watson, C. 1983. A canonical correlation analysis of commercial bank asset/liability structures. *Journal of Financial & Quantitative Analysis* 18: 125-140.

Stewart, D., Love, W. 1968. A general canonical correlation index. *Psychological Bulletin* 70: 160-163.

Stowe, J., Watson, C., Robertson, T. 1980. Relationships between the two sides of the balance sheet: a canonical correlation analysis. *Journal of Finance* 35: 973-980.

## Tables and Figures

Figure 1. Relationship between a specific asset and a specific liability




a. Relation 1 represents the size of the canonical correlation coefficient between two canonical variables

b. Relation 2a represents the size of the canonical loading for a specific asset $q_1$

c. Relation 2b represents the size of the canonical loading for a specific liability $q_2$

d. Relation 3 represents the interconnection between the specific asset $q_1$ and the specific liability $q_2$

Table 1: List of variables. It presents description, and source of the bank-specific variables used in the empirical analysis

| Variable | Description | Source |
|---|---|---|
| CASH | *Cash balance.* Ratio of cash at the bank, deposits at other banks (mainly at the European Central Bank) to total assets | Moody's Analytics BankFocus and authors' computation |
| STL | *Short-term loans.* Ratio of customer loans with maturities of less than one year (mainly consumer loans) to total assets | Moody's Analytics BankFocus and authors' computation |

| | | |
|---|---|---|
| LTL | *Long-term loans*. Ratio of customer loans with maturities of more than one year (mainly leases and mortgages) to total assets | Moody's Analytics BankFocus and authors' computation |
| SEC | *Securities*. Ratio of trading and investment securities, easily negotiated on markets and/or to be traded within a short-term horizon, to total assets | Moody's Analytics BankFocus and authors' computation |
| OA | *Other assets*. Ratio of all other assets not included in previous categories to total assets | Moody's Analytics BankFocus and authors' computation |
| EQ | *Equity*. Ratio of common stocks, perpetual preferred stocks and retained earnings to total assets | Moody's Analytics BankFocus and authors' computation |
| DD | *Demand deposits*. Ratio of customers sight deposits accounts to total assets | Moody's Analytics BankFocus and authors' computation |
| TD | *Time deposits*. Ratio of savings deposits, deposits that can be withdrawn after the term has ended or by giving a predetermined number of days of notice, to total assets | Moody's Analytics BankFocus and authors' computation |
| BD | *Bank deposits*. Ratio of *funds* provided by other banks (mainly European Central Bank) to total assets | Moody's Analytics BankFocus and authors' computation |
| OL | *Other liabilities*. Ratio of all other liabilities not included in previous categories | Moody's Analytics BankFocus and authors' computation |

Table 2: Balance sheet proportions: small banks (SB) vs. large banks (LB). It presents the means of the variables used in the empirical analysis calculated on 2013, 2016 and 2020 year-end balance sheet data)

| | Panel A: 2013 | | | Panel B: 2016 | | | Panel C: 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| | SB Mean (Std. Dev.) | LB Mean (Std. Dev.) | Differences in means | SB Mean (Std. Dev.) | LB Mean (Std. Dev.) | Differences in means | SB Mean (Std. Dev.) | LB Mean (Std. Dev.) | Differences in means |
| CASH | 0.0204 (0.0581) | 0.0227 (0.0197) | -0.0024 | 0.0121 (0.0300) | 0.0331 (0.0345) | -0.0210*** | 0.0191 (0.0591) | 0.0802 (0.0663) | -0.0611*** |
| STL | 0.1933 (0.0959) | 0.3109 (0.1365) | -0.1175*** | 0.1685 (0.0739) | 0.3020 (0.1192) | -0.1335*** | 0.3464 (0.1059) | 0.2909 (0.1037) | +0.0555*** |
| LTL | 0.3129 (0.1357) | 0.3132 (0.1550) | -0.0003 | 0.3286 (0.1358) | 0.3239 (0.1602) | +0.0047 | 0.3497 (0.1293) | 0.3281 (0.1551) | +0.0216 |
| SEC | 0.3155 (0.1404) | 0.1786 (0.1230) | +0.1369*** | 0.3704 (0.1349) | 0.1789 (0.1387) | +0.1915*** | 0.1251 (0.0899) | 0.1150 (0.0873) | +0.0100 |
| OA | 0.1579 (0.1370) | 0.1747 (0.1298) | -0.0511** | 0.1205 (0.1144) | 0.1620 (0.1142) | -0.0416** | 0.1598 (0.1085) | 0.1858 (0.1412) | -0.0261 |
| EQ | 0.1245 (0.0451) | 0.0691 (0.0248) | +0.0555*** | 0.1228 (0.0427) | 0.0766 (0.0243) | +0.0462*** | 0.1043 (0.0409) | 0.0711 (0.0239) | +0.0332*** |
| DD | 0.4161 (0.1122) | 0.2119 (0.1264) | +0.2042*** | 0.4957 (0.1159) | 0.2691 (0.1526) | +0.22667*** | 0.5911 (0.1193) | 0.3410 (0.1651) | +0.2501*** |
| TD | 0.1435 (0.1242) | 0.1352 (0.1109) | +0.0083 | 0.1253 (0.1283) | 0.1008 (0.0817) | +0.0245 | 0.0967 (0.0982) | 0.0798 (0.0799) | +0.0168 |
| BD | 0.1284 (0.0777) | 0.1743 (0.1323) | -0.0459** | 0.1285 (0.0889) | 0.1577 (0.1172) | -0.0292 | 0.1374 (0.0713) | 0.1161 (0.1352) | +0.0213 |
| OL | 0.1832 (0.1139) | 0.2343 (0.1638) | -0.0511** | 0.1245 (0.0859 | 0.2104 (0.1597) | -0.0859*** | 0.0701 (0.0744) | 0.2228 (0.1420) | -0.1526*** |

Note: ***, **, * = significance level of 1%, 5%, and 10%, respectively. See Table 1 for variables definitions.

Table 3: Pair-wise correlations between asset and liability proportions: small banks (SB) vs large banks (LB). It presents the pair-wise correlation coefficients between the variables used in the empirical analysis, calculated on 2013 (Panel A), 2016 (Panel B) and 2020 (Panel C).

Panel A: Correlations calculated based on 2013 year-end data

| | CASH | STL | LTL | SEC | OA |
|---|---|---|---|---|---|
| **Small banks** | | | | | |
| EQ | -0.2105* | -0.2109* | 0.0188 | 0.0317 | 0.1859 |
| DD | 0.0412 | -0.1234 | 0.0888 | -0.1724 | 0.1577 |
| TD | 0.3699*** | 0.2880** | -0.3669*** | -0.3314** | 0.3098** |
| BD | -0.1795 | -0.1107 | -0.0535 | 0.5306*** | -0.3372*** |
| OL | -0.3117** | -0.2111* | 0.2078* | 0.2370* | -0.1688 |
| **Large banks** | | | | | |
| | CASH | STL | LTL | SEC | OA |
| EQ | -0.3393*** | 0.2404 | 0.3087 | -0.3049 | -0.281 |
| DD | -0.0369 | 0.3679*** | 0.1578 | -0.1064 | -0.4690*** |
| TD | 0.0598 | 0.4018*** | -0.0356 | -0.0204 | -0.3486*** |
| BD | -0.0161 | -0.1456 | -0.2782** | 0.0707 | 0.4208*** |
| OL | 0.4218*** | -0.1103 | -0.4278*** | 0.3587*** | 0.2228 |

Panel B Correlations calculated based on 2016 year-end data

| | CASH | STL | LTL | SEC | OA |
|---|---|---|---|---|---|
| **Small banks** | | | | | |
| EQ | -0.1151 | -0.3766*** | 0.1559 | -0.0464 | 0.143 |
| DD | 0.0210 | -0.2006 | 0.2317* | -0.1847 | 0.0668 |
| TD | 0.1340 | 0.3455*** | -0.2162 | -0.1415 | 0.1092 |
| BD | -0.1312 | -0.1386 | -0.2228* | 0.4832*** | -0.1815 |
| OL | -0.1156 | -0.0439 | 0.0067 | 0.0472 | -0.005 |
| **Large banks** | | | | | |
| | CASH | STL | LTL | SEC | OA |
| EQ | -0.5038*** | 0.0449 | 0.4241*** | -0.3126** | -0.1098 |
| DD | 0.0493 | 0.3235*** | 0.2153* | -0.1356 | -0.4900*** |
| TD | -0.0232 | 0.4360*** | -0.049 | -0.1423 | -0.1795 |
| BD | 0.0647 | -0.0587 | -0.2994** | 0.1093 | 0.3291*** |
| OL | 0.3881*** | -0.1570 | -0.5653*** | 0.4514*** | 0.2913** |

Panel C: Correlations calculated based on 2020 year-end data

| | CASH | STL | LTL | SEC | OA |
|---|---|---|---|---|---|
| **Small banks** | | | | | |
| EQ | -0.0575 | -0.2914** | -0.0902 | 0.3812*** | 0.1076 |
| DD | 0.0259 | -0.1201 | 0.2295* | -0.2382* | 0.0269 |
| TD | 0.1176 | 0.1345 | -0.1665 | -0.0917 | 0.059 |
| BD | -0.2279* | 0.3596*** | 0.0055 | -0.1938 | -0.0727 |
| OL | -0.0716 | -0.1988 | -0.0666 | 0.5561*** | -0.1483 |
| **Large banks** | | | | | |
| | CASH | STL | LTL | SEC | OA |
| EQ | -0.4901*** | 0.0647 | 0.4194*** | -0.1132 | -0.2079 |
| DD | 0.2155 | 0.4151*** | 0.2438 | -0.0005 | -0.6735*** |
| TD | 0.0673 | 0.3529*** | -0.127 | 0.0206 | -0.1621 |
| BD | 0.4486*** | -0.1378 | -0.4733*** | 0.0533 | 0.3772*** |
| OL | 0.018 | -0.1446 | -0.4538*** | 0.1372 | 0.5112*** |

Note: ***, **, * = significance level of 1%, 5%, and 10%, respectively. See Table 1 for variables definitions.

Table 4: Canonical correlations. It presents the canonical correlation coefficients calculated for 2013, 2016 and 2020, referred to small banks (Panel A) and large banks (Panel B)

| | 2013 data | 2016 data | 2020 data |
|---|---|---|---|
| Panel A: small banks | | | |
| 1 through 4 | 0.5998*** | 0.6593*** | 0.7633*** |
| 2 through 4 | 0.4126 | 0.5604** | 0.3738 |
| 3 through 4 | 0.2342 | 0.2859 | 0.2479 |
| 4 through 4 | 0.1687 | 0.1202 | 0.1972 |
| Panel B: large banks | | | |
| 1 through 4 | 0.7878*** | 0.7397*** | 0.8683*** |
| 2 through 4 | 0.4472* | 0.6293*** | 0.6868*** |
| 3 through 4 | 0.2323 | 0.2806 | 0.2090 |
| 4 through 4 | 0.0492 | 0.0012 | 0.0195 |

Note: ***, **, * = significance level of 1%, 5%, and 10%, respectively, using Bartlett's Chi-square test

Table 5: Redundancy coefficients: small banks (SB) vs large banks (LB). It presents the redundancy coefficients based on the canonical correlation run on data referred to year-end 2013 (Panel A), 2016 (Panel B) and 2020 (Panel C).

| Panel A: redundancy coefficients for data of year-end 2013 | | | | | | |
|---|---|---|---|---|---|---|
| | | | | 1st loading | 2nd loading | Total |
| SB | Asset variables variance | explained by | Liabilities canonical variable | 16.93% | Not significant | 16.93% |
| | Liabilities variables variance | | Asset canonical variable | 11.11% | Not significant | 11.11% |
| LB | Asset variables variance | explained by | Liabilities canonical variable | 11.30% | Not significant | 11.30% |
| | Liabilities variables variance | | Asset canonical variable | 19.87% | Not significant | 19.87% |

| Panel B: redundancy coefficients for data of year-end 2016 | | | | | | |
|---|---|---|---|---|---|---|
| | | | | 1st loading | 2nd loading | Total |
| SB | Asset variables variance | explained by | Liabilities canonical variable | 13.70% | 6.82% | 20.52% |
| | Liabilities variables variance | | Asset canonical variable | 9.02% | 9.90% | 18.92% |
| LB | Asset variables variance | explained by | Liabilities canonical variable | 11.61% | 13.39% | 25.00% |
| | Liabilities variables variance | | Asset canonical variable | 16.58% | 9.33% | 25.91% |

| Panel C: redundancy coefficients for data of year-end 2020 | | | | | | |
|---|---|---|---|---|---|---|
| | | | | 1st loading | 2nd loading | Total |
| SB | Asset variables variance | explained by | Liabilities canonical variable | 17.85% | Not significant | 17.85% |
| | Liabilities variables variance | | Asset canonical variable | 9.84% | Not significant | 9.84% |
| LB | Asset variables variance | explained by | Liabilities canonical variable | 12.24% | 16.23% | 28.47% |
| | Liabilities variables variance | | Asset canonical variable | 21.71% | 14.01% | 35.72% |

Table 6: Correlations of original variables with canonical variables (2013 year-end data). Sorted varimax rotated canonical loadings. Results are referred to small banks (Panel A) and large banks (Panel B)

| Panel A: Small banks | | | |
|---|---|---|---|
| Assets | | Liabilities and capital | |
| Canonical variable 1R | | | |
| SEC | 0.9778 | BD | 0.9836 |
| STL | -0.3727 | TD | -0.3219 |
| CASH | -0.3167 | DD | -0.2409 |
| LTL | -0.0601 | EQ | -0.0387 |

| Panel B: Large banks | | | |
|---|---|---|---|
| Assets | | Liabilities and capital | |
| Canonical variable 1R | | | |
| SEC | -0.9061 | EQ | 0.9669 |
| LTL | 0.5635 | DD | -0.1625 |
| CASH | -0.524 | TD | 0.0281 |
| STL | 0.2962 | BD | 0.0106 |

See Table 1 for variables definitions.

Table 7: Correlations of original variables with canonical variables (2016 year-end data). Sorted varimax rotated canonical loadings. Results are referred to small banks (Panel A) and large banks (Panel B)

| Panel A: Small banks | | | |
|---|---|---|---|
| Assets | | Liabilities and capital | |
| Canonical variable 1R | | | |
| LTL | 0.8506 | DD | 0.963 |
| STL | -0.3366 | TD | -0.7822 |
| CASH | -0.0725 | BD | -0.246 |
| SEC | 0.0282 | EQ | -0.132 |
| Canonical variable 2R | | | |
| SEC | 0.9964 | BD | 0.8756 |
| STL | -0.6509 | TD | -0.2724 |
| LTL | -0.3178 | EQ | -0.2047 |
| CASH | -0.1358 | DD | -0.0019 |

| Panel B: Large banks | | | |
|---|---|---|---|
| Assets | | Liabilities and capital | |
| Canonical variable 1R | | | |
| CASH | -0.8872 | EQ | 0.9881 |
| LTL | 0.6774 | BD | -0.1901 |
| SEC | -0.465 | DD | -0.1131 |
| STL | 0.0381 | TD | 0.1013 |
| Canonical variable 2R | | | |
| STL | 0.8438 | TD | 0.9624 |
| LTL | -0.4709 | DD | 0.1279 |
| CASH | -0.2454 | BD | -0.0327 |
| SEC | -0.0414 | EQ | 0.0311 |

See Table 1 for variables definitions.

Table 8: Correlations of original variables with canonical variables (2020 year-end data). Sorted varimax rotated canonical loadings. Results are referred to small banks (Panel A) and large banks (Panel B)

| Panel A: Small banks | | | |
|---|---|---|---|
| Assets | | Liabilities and capital | |
| Canonical variable 1R | | | |
| LTL | -0.8800 | TD | 0.9476 |
| CASH | 0.2477 | DD | -0.8425 |
| STL | 0.3783 | EQ | 0.2281 |
| SEC | 0.0501 | BD | -0.0225 |

| Panel B: Large banks | | | |
|---|---|---|---|
| Assets | | Liabilities and capital | |
| Canonical variable 1R | | | |
| CASH | 0.863 | TD | 0.9233 |
| LTL | -0.4829 | DD | -0.5389 |
| SEC | -0.2429 | EQ | -0.159 |
| STL | -0.1313 | BD | -0.0404 |
| Canonical variable 2R | | | |
| BD | 0.9787 | TD | 0.9938 |
| EQ | -0.4727 | BD | -0.1224 |
| DD | 0.0821 | DD | 0.1092 |
| TD | -0.0515 | EQ | -0.0063 |

See Table 1 for variables definitions.