On the Independence of Assets and Liabilities: Evidence from U.S. Commercial Banks, 1990-2005

June 7, 2007
Helsinki, Finland

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*** This presentation does not necessarily reflect the views or opinions of the FDIC.**

Motivation (1)

- In a strict Modigliani and Miller world, firm value is unaffected by <u>amount</u> of debt financing.
- But frictions create optimal debt-to-equity:
  - Tax code; bankruptcy costs; incomplete markets.
- Banks are special case:
  - Additional frictions: Deposit insurance encourages debt, while capital regulation limits debt.
  - Traditional model: Bank intermediation earnings depend on the <u>structure</u> of bank liabilities.
- Traditionally, banks manage risk-return tradeoff:
  - Higher expected return from maturity mismatch.
  - Use on-balance sheet methods to limit interest rate risk.

Motivation (2)

- Innovations have likely reduced need for banks to manage interest rate risk on-balance sheet.
- We test two basic questions:
  - Have bank assets and liabilities become more independent over time?
  - Are new risk mitigation tools associated with greater asset-liability independence (i.e., are financial markets becoming more complete)?
- We examine balance sheet data from all U.S. commercial banks between 1990 and 2005.
- We analyze these data using <u>canonical correlation</u> analysis.

A preview of our methodology…

- Canonical correlation analyzes the relationships between and among two vectors of variables.
  - NOTE: Pair-wise correlation is the special case in which each vector contains only a single variable.
- Technique invented by Hotelling (1935) but has been used only sparingly in finance research.
  - Assets <u>and</u> Liabilities:
    - Stowe, Watson, and Robertson (1980), Simonson, Stowe, and Watson (1983), Obben and Shanmugam (1993).
  - CEO compensation <u>and</u> Firm performance:
    - Duru and Iyengar (2001).
  - Stock order flows <u>and</u> Stock returns
    - Hasbrouck and Seppi (2001).

A preview of our findings…

- Bank assets and bank liabilities have systematically become more independent since 1990.
- Perhaps surprisingly, asset-liability linkages are <u>stronger</u> for large banks. However, size-based differences are shrinking over time.
- Reduced asset-liability dependence is associated with banks using risk mitigation techniques (e.g., derivatives, adjustable rate loans).
- Banks with strong supervisory ratings have <u>weaker</u> asset-liability links.

Statistical Methodology

Canonical Correlation Analysis (1)

- We have two vectors: assets X and liabilities Y.
- We define "canonical variables" A and L that are linear combinations of X and Y, respectively:

$$A = B^{'}X = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_p X_p$$

$$L = C^{'}Y = \gamma_1 Y_1 + \gamma_2 Y_2 + \gamma_3 Y_3 + \ldots + \gamma_q Y_q$$

- We choose values for B' and C' that maximize the "canonical correlation" between A and L:

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

Canonical Correlation Analysis (2)

- Each asset account X can be paired up with multiple liability accounts Y.
  - We have p asset accounts X.
  - We have q liability accounts Y.

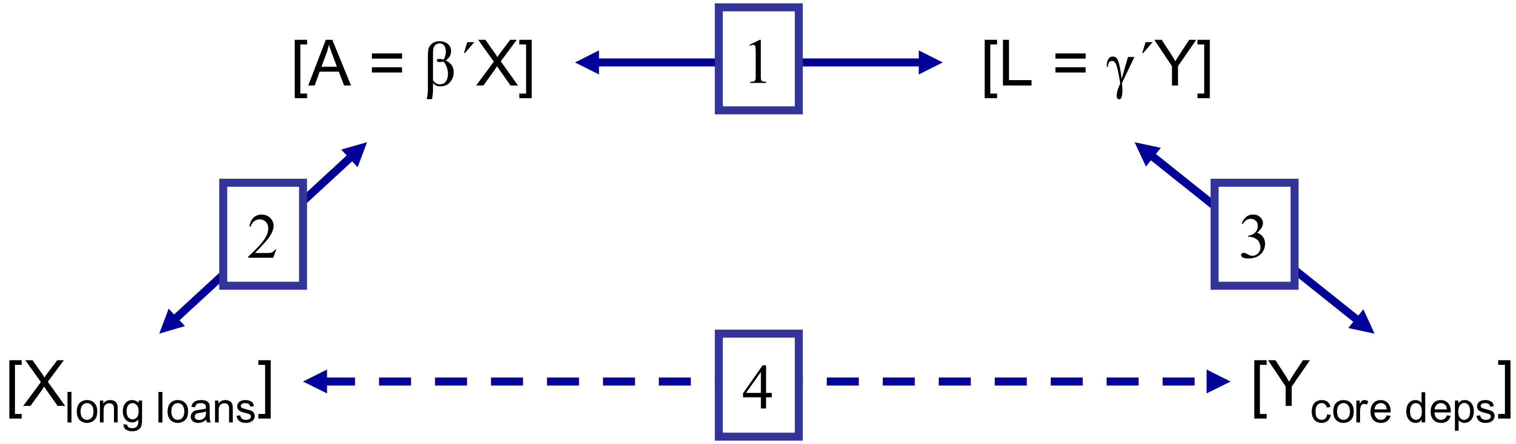
- The maximization produces MIN(q,p) – 1 sets of parameters B' and C'.
  - Each set of these parameters generates <u>separate and orthogonal</u> canonical variables A and L.
  - Multiple sets of all statistics.

Canonical Correlation Diagnostics

- How strongly is variable X_1 correlated with its canonical variable A?

$$Corr\left(X_1, A\right) = Corr\left(X_1\ ,\ \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p\right)$$

- This correlation is sometimes referred to as the "canonical loading" of variable X_1 on A.



The following three conditions:

1. A strong canonical correlation between Assets and Liabilities (equation 3, Table 3).
2. A strong canonical loading between Long-term Loans and Assets (equation 4, Table 5).
3. A strong canonical loading between Core Deposits and Liabilities (equation 4, Table 5).

Imply the following fourth condition:

4. There is a strong relationship between Long-term Loans and Core Deposits, after considering the correlations among all of the other asset and liability accounts.

Canonical Correlation Diagnostics

- How much of the variation in the asset vector ***X*** is explained by the asset canonical variable A?

$$R_A^2 = \sum_{i=1}^{p} \frac{\left(Corr\left(X_i, A\right)\right)^2}{p}$$

- How much of the variation in ***X*** is explained by the liability canonical variable L? (Redundancy Coefficient)

$$R_{A|L}^2 = r_{AL}^2 R_A^2$$

where r_{AL} is the canonical correlation.

Data

Banks organized into five asset size groups (data in 2004 dollars)

asset size	# in 1990	# in 2005
less than $100 million	8,373	2,754
$100 to $500 million	1,484	2,545
$500 million to $2 billion	255	634
$2 billion to $10 billion	132	159
more than $10 billion	17	58

Assets and liability accounts selected in *ad hoc* fashion, using own judgement.

asset accounts	**liability accounts**
Cash	Demand deposits
Short-term securities	Core deposits
Long-term securities	Purchased funds
Short-term loans	Equity
Long-term loans	Other liabilities
Other assets	

All asset and liability accounts are normalized by total assets (Table 1).

	1990 data				
asset accounts	**Small**	**.**	**.**	**.**	**Large**
Cash	.07	.06	.08	.10	.13
Short-term securities	.10	.08	.05	.04	.02
Long-term securities	.22	.18	.15	.14	.14
Short-term loans	.37	.42	.43	.46	.46
Long-term loans	.20	.23	.24	.22	.19
Other assets	.03	.03	.03	.04	.06

All asset and liability accounts are normalized by total assets (Table 1).

	1990 data				
liability accounts	**Small**	**.**	**.**	**.**	**Large**
Demand deposits	.12	.13	.15	.16	.16
Core deposits	.68	.65	.59	.51	.41
Purchased funds	.08	.12	.12	.20	.21
Other liabilities	.02	.02	.02	.06	.16
Equity	.09	.08	.07	.06	.06

Benchmark:
Simple pair-wise correlations

of asset-liability pairs for which the simple linear correlation exceeds 0.30 (Table 2).

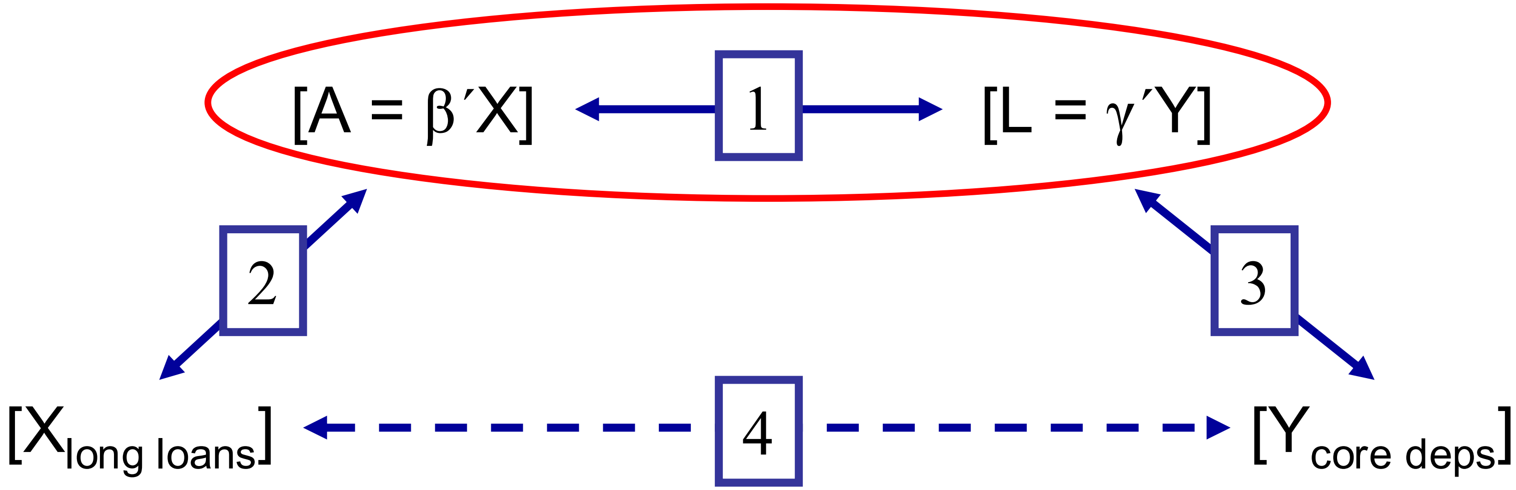
asset size	**1990**	**1995**	**2000**	**2005**
less than $100 million	0	1	1	3
$100 to $500 million	4	3	2	2
$500 million to $2 billion	4	6	4	3
$2 billion to $10 billion	4	8	9	5
more than $10 billion	18	13	5	5

Which asset-liability pairs have strong simple linear correlations?

- Only a few correlations are strong in over half the cells:
  - ρ(Cash, Demand Deposits) > 0 in 11 cells.
  - ρ(Cash, Core Deposits) < 0 in 13 cells.
  - ρ(Long-term Loans, Core Deposits) > 0 in 13 cells.

- Some of the strong correlations are non-intuitive. For example, regarding purchased funds:
  - ρ(Purchased funds, Long-term Loans) > 0 one time.
  - ρ(Purchased funds, Long-term Securities) > 0 two times.
  - ρ(Purchased funds, Short-term Securities) > 0 three times.

Main Results:
Canonical correlation analysis



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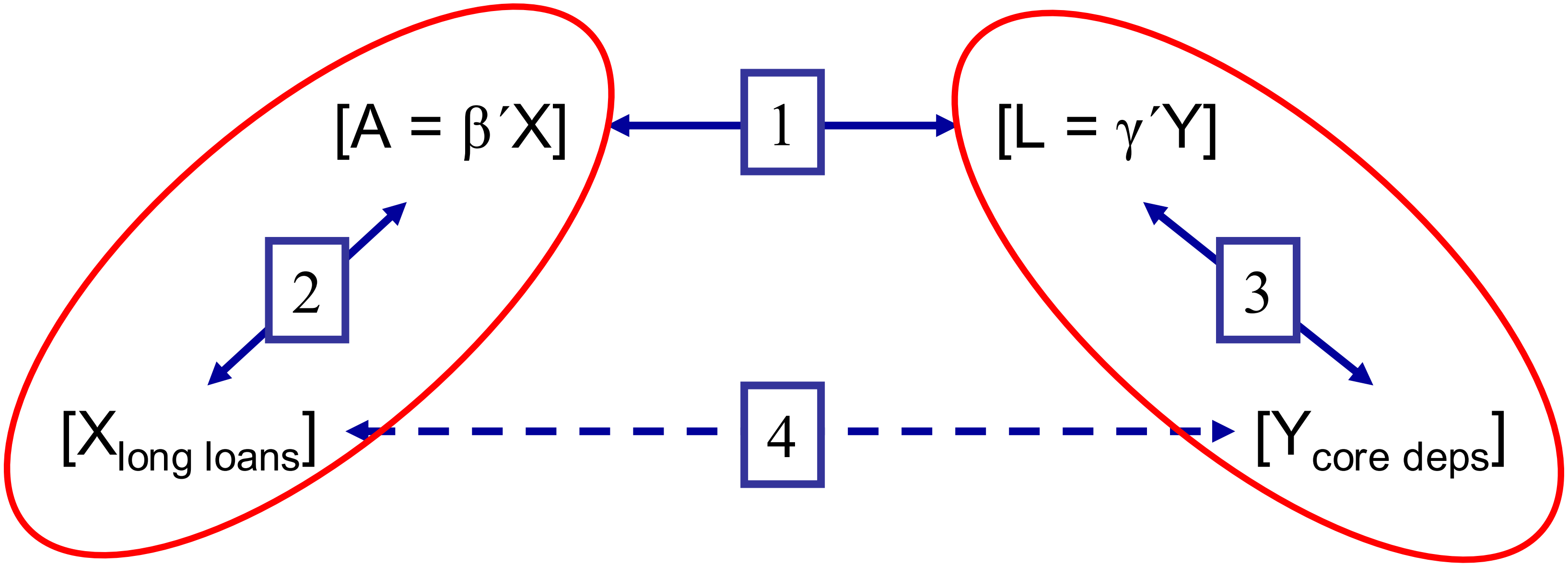
Canonical correlation coefficients (Table 3).

	1990 data				
	Small				**Large**
First loading	.41***	.58***	.70***	.85***	.98***
Second loading	.23***	.32***	.40***	.28**	.77*
Third loading	.16***	.23***	.29***	.26*	.74
Fourth loading	.06***	.13***	.09	.15	.38

Why would asset-liability linkages be weaker at the smallest banks?

- Small banks hold more equity than large banks:
  - A substitute for asset-liability management.
- Small loan-numbers problem at small banks:
  - Investments are granular.
  - New investment opportunities occur randomly.
- Deposit structure at small banks is static.



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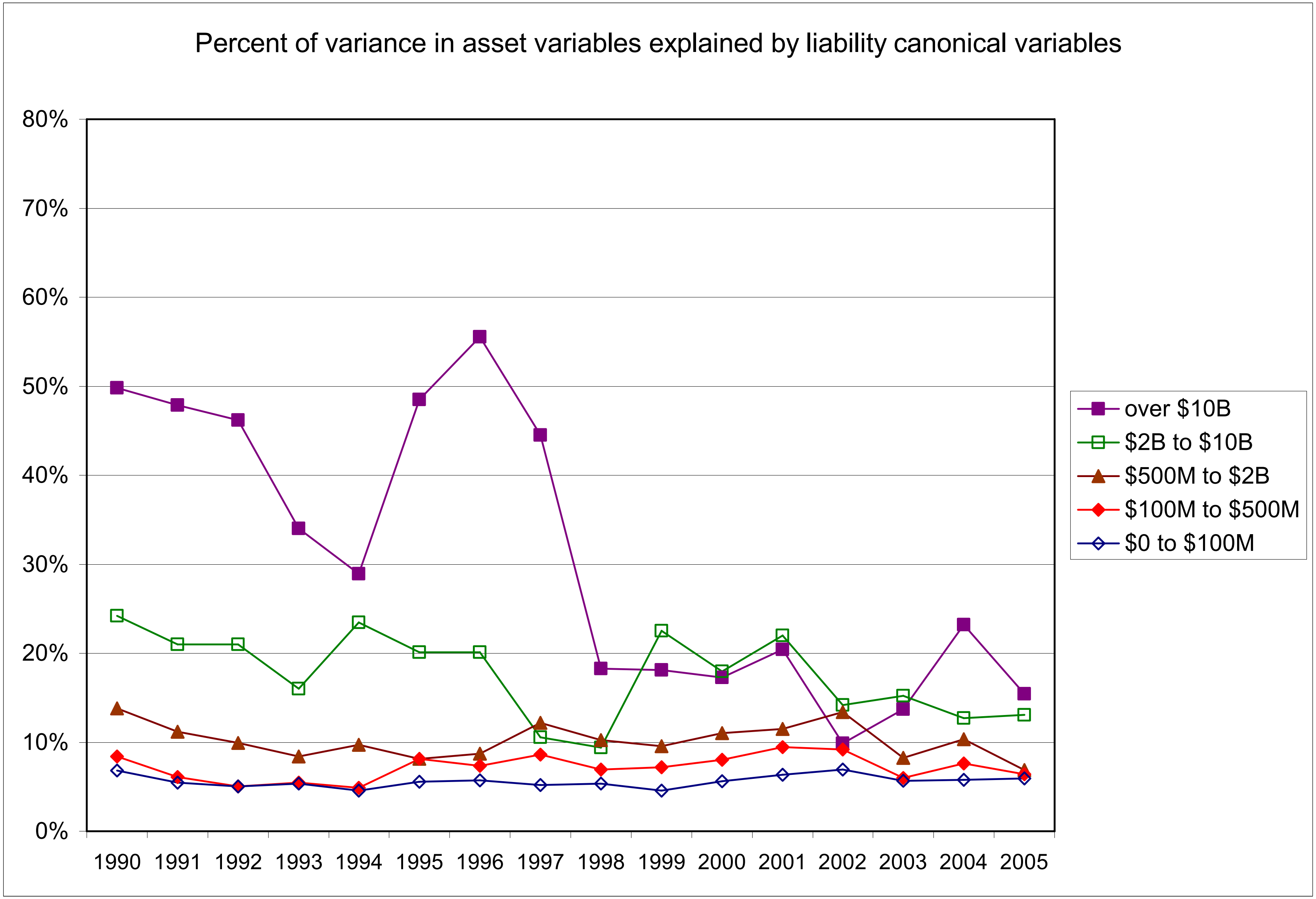
Correlations of variables with their canonical variables imply sensible relationships (Table 5).

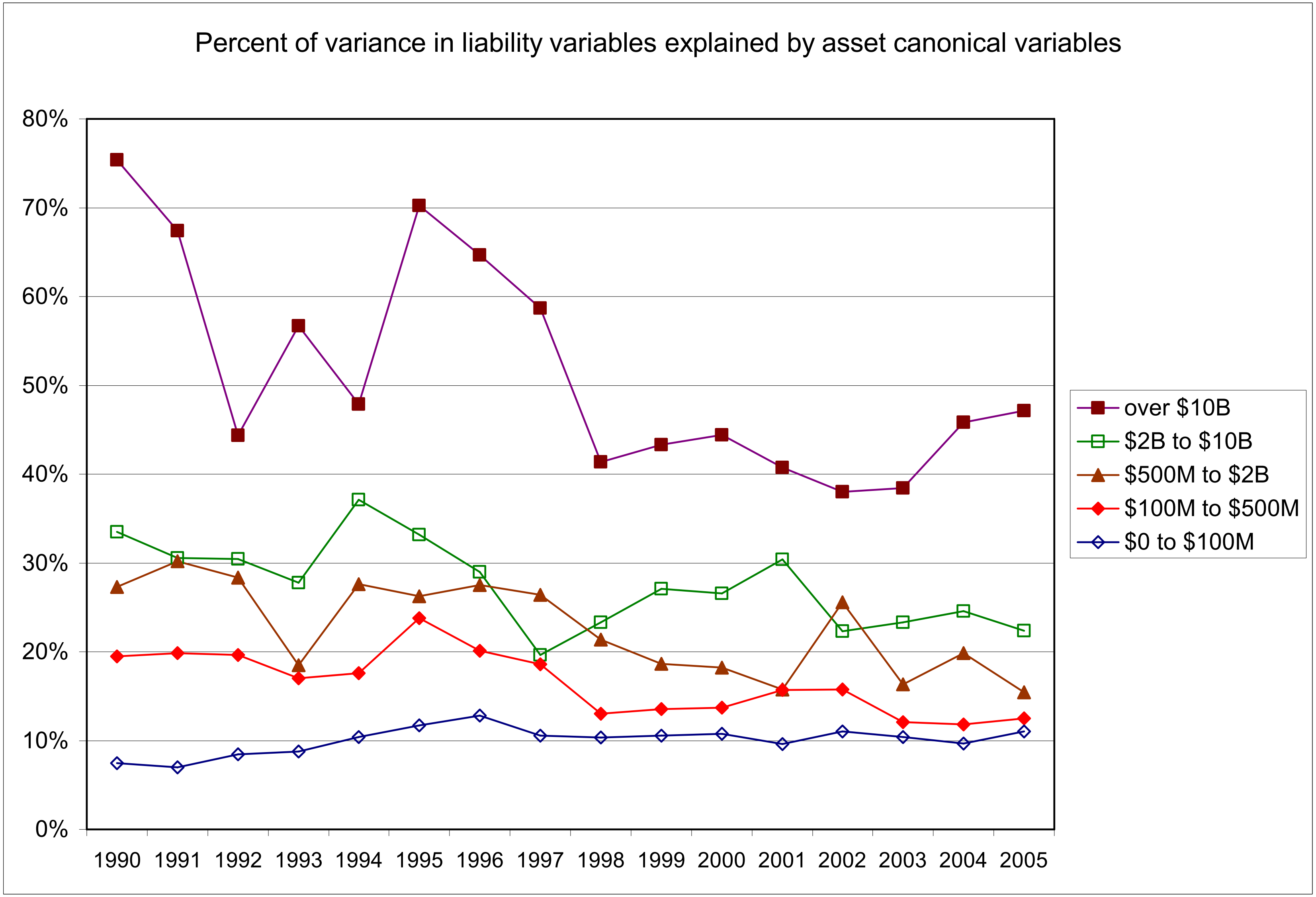
- First Loading:
  - Positive: Long-term loans with Core deposits (18/20).
  - Positive: Short-term loans with Purchased funds (13/20).
    - Limited to smaller banks.
  - Negative: Core deposits with Purchased funds (14/20).
    - Limited to smaller banks.

- Second Loading:
  - Positive: Cash with Demand deposits (6/20).
    - Limited to smaller banks.
  - Negative: Long-term securities with Loans (9/20).

Redundancy: % of asset variance explained by liability canonical variables (Figure 2).



<u>Redundancy</u>: % of liability variance explained by asset canonical variables (Figure 3).



Implications

Implications for Financial Stability?

- We find the largest declines in Asset-Liability linkages at large banks – the banks most capable of causing financial instability.
- What are the implications of reduced Asset-Liability dependence?
  - Presumably greater risk if un-hedged.
  - Lesser risk if hedged, which our findings suggest.
    - Heavy users of interest rate swaps and adjustable rate loans have more Asset-Liability independence.

Implications for Bank Supervision?

- Risk mitigation tools (swaps, adjustable rates) associated with asset-liability independence.
- Banks with strong supervisory ratings exhibit a higher degree of Asset-Liability independence.
  - DeYoung, Hughes and Moon (2001) conclude that well-run banks are given greater risk-taking freedom by supervisors.
  - Demsetz and Strahan (1997), Schrand and Unal (1998), and Hughes, et al (1999) conclude that banks that reduce risk in one area tend to "spend" the gain by increasing risk in other areas.

Implications for other research

- Typical bank cost function models impose an intermediation approach, i.e., assets are a function of liabilities.
- We find that relationships between assets and liabilities are very different for different size banks.
  - If production function differs, then cost specifications may need to differ as well.
  - However, we find convergence over time.

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