

Factor Model for Stress-testing with a Contingent Claims Model of the Chilean Banking System

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Outline

- 1. Contingent claims concepts and risk indicators**
- 2. Application of CCA to the Chilean banking system**
- 3. Factor model VARs to distance to distress**
- 4. Stress testing scenarios**
- 5. Conclusions and further work**

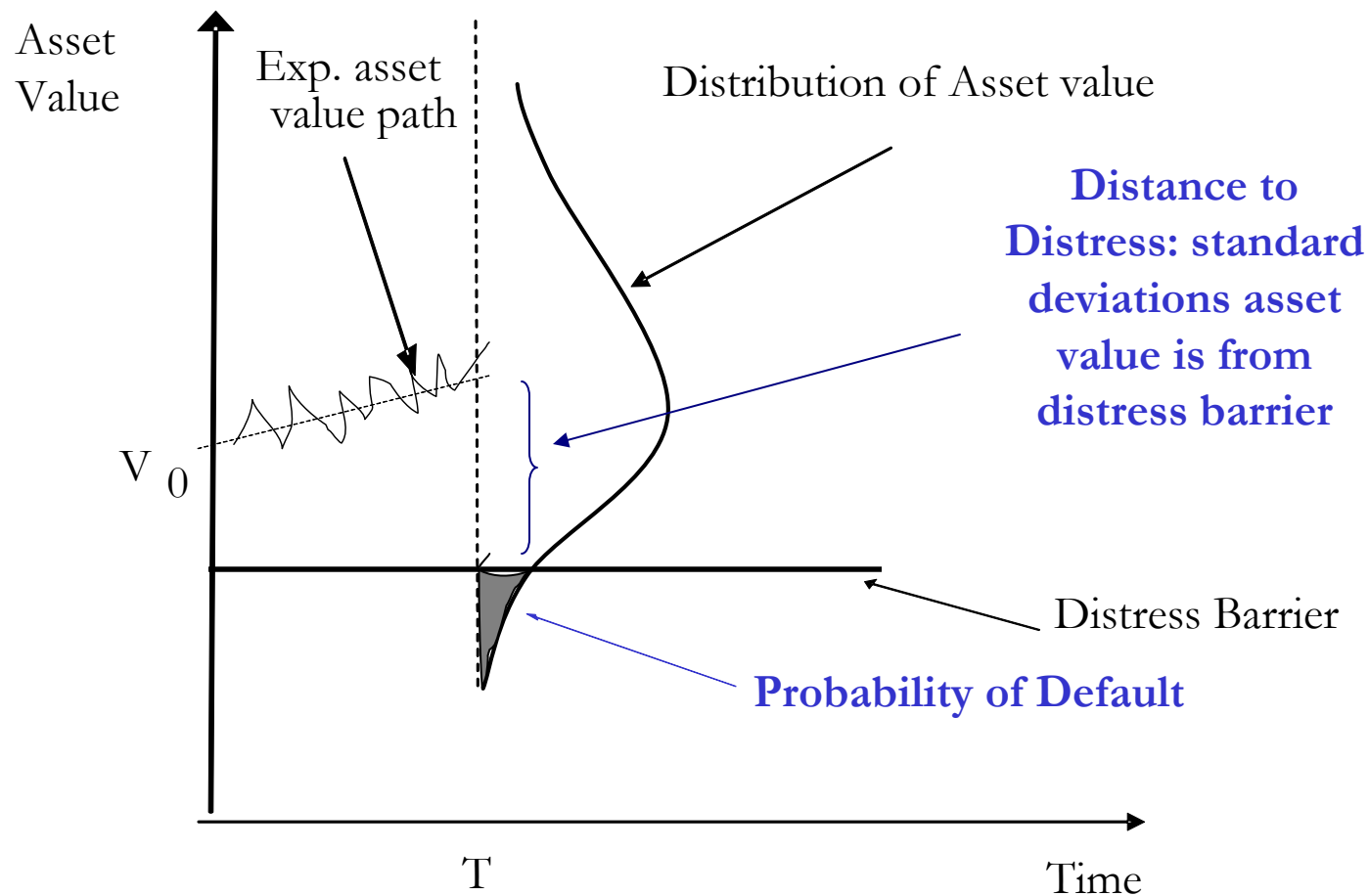


What are the main objectives of CCA?

- **Apply modern risk management and finance techniques** to assess country vulnerability and valuation of debt and contingent liabilities.
- **Measure risk** for the financial sector and sovereign, and risk transmission from other sectors
- **Analyze impact of shocks**, both domestic and external
 - factors affecting bank assets and bank risk
 - principle components
- **Policy analysis** using quantitative risk-based tool for :
 - key factors driving risk bank by bank
 - financial system risk
 - economic capital adequacy

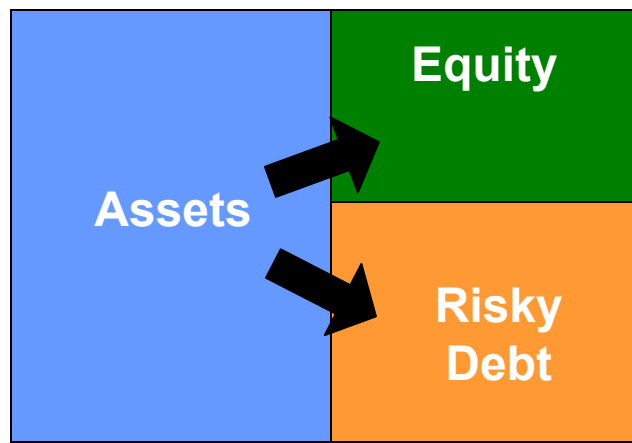


The Risk Measures We Need



CCA Applied to Firms or to Banks: Value of Equity and Risky Debt Depend on Assets

Begin with a simplified balance sheet with debt and equity.



- Value of liabilities depend, i.e. are contingent, on value of assets.
- Liabilities have different seniority.
- Randomness in asset value.

$$\begin{aligned}
 \text{Assets} &= \text{Equity} + \text{Risky Debt} \\
 &= \text{Equity} + \text{Default-Free Debt} - \text{Expected Loss} \\
 &= \text{Impl. Call Option} + \text{Default-Free Debt} - \text{Impl. Put option}
 \end{aligned}$$



$$\text{Distress Barrier} = \text{Default-Free Value of Debt} (\approx ST + 1/2LT)$$

How to Measure the Market Value of Assets?

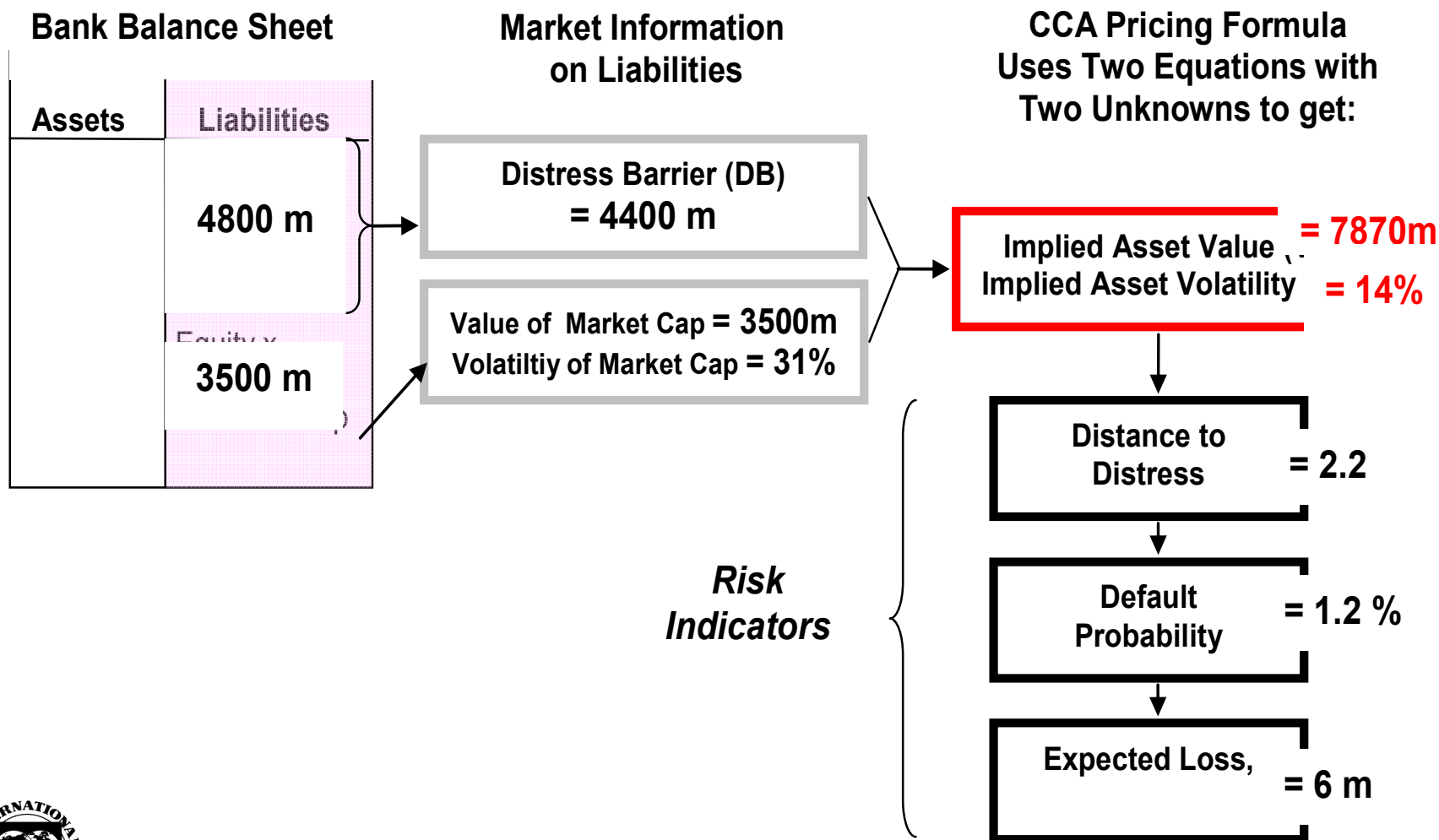
Three ways to get asset value:

1. Observe market value (only part of assets' market value is observable)
2. Estimate comparable, e.g. PV of future net cash flows (inaccurate projections, may miss some assets)
3. Implied asset value and implied asset volatility from contingent claims analysis*

***Application of Merton Model/CCA to Firms and Financial Institutions** - CCA has already been applied to over 100,000 firms and financial institutions around the world (by MKMV and others) and it is used by >2500 banks and financial institutions. Tools and techniques are well established.



CCA Can Be Used to Estimate Implied “Market Value” of Assets, its Volatility and Risk Indicators -EXAMPLE



After Calibration Several Types of Risk Indicators are Derived

(1) Credit Risk Indicators

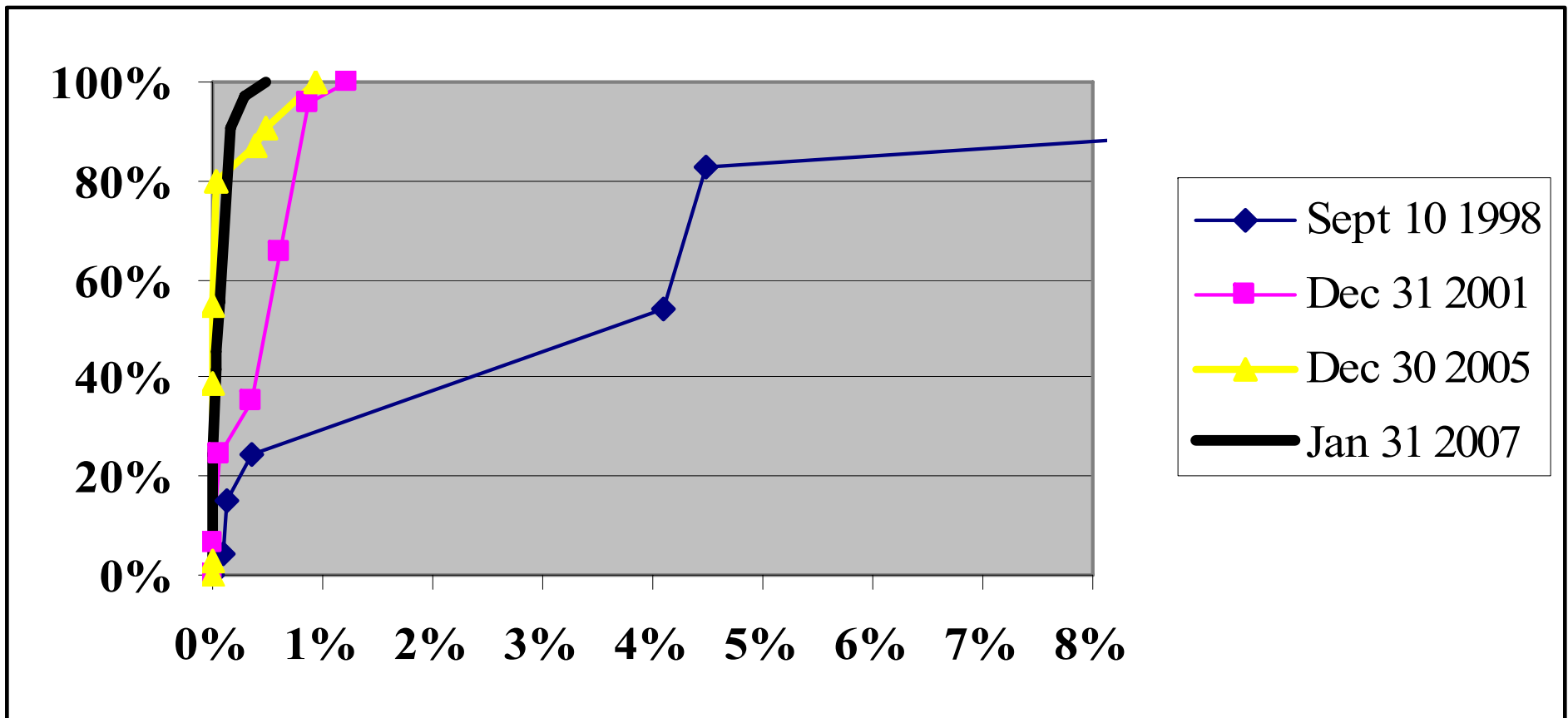
- **Distance to Distress** (number of standard deviations of asset value from distress = d_2 from Black-Scholes)
- **Default Probability**
 - Risk Neutral Default Probability = $N(-d_2)$
 - Estimated Actual Default Probability = $N(-d_2 - \text{MPR})$
- **Model Spread, s , in basis points**
- **Implicit Put Option (Expected Loss) and Value of Risky Debt (Default-free value of debt – expected loss)**

(2) Sensitivity Measures

- **Sensitivity of risk indicators to changes in underlying asset value, volatility or distress barrier, or other factors**



Changing pattern of Banking System Risk Cumulative Banking Sector Assets (%) vs. Approximate Probability of Default in One-Year



Macroeconomic Variables

How does banking risk relate to macroeconomic variables?

- ***Which indicator to use?***
- ***Which macro variables to use?***
- ***How can we stress-test?***
- ***Do all banks react similarly?***

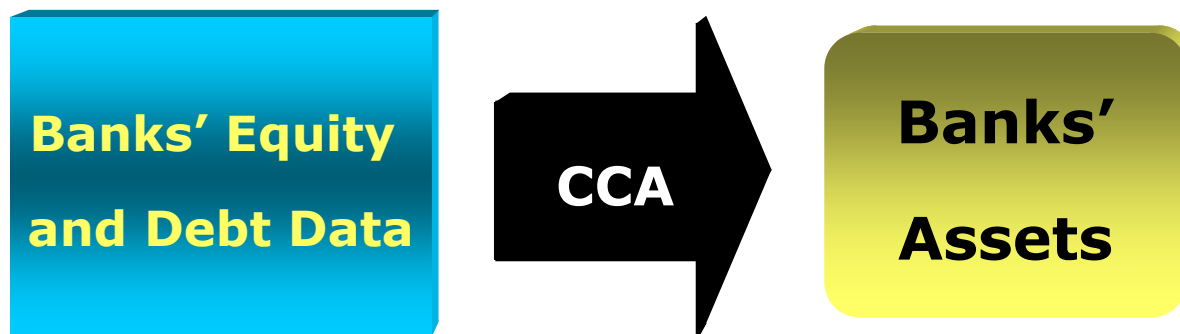


Macroeconomic Variables: Which measure to use?

We use implied assets

- Seems to have a closer relationship to macro variables
- Can derive risk measures from asset data.

Derived from CCA:



Macroeconomic Variables: Which should we look at?

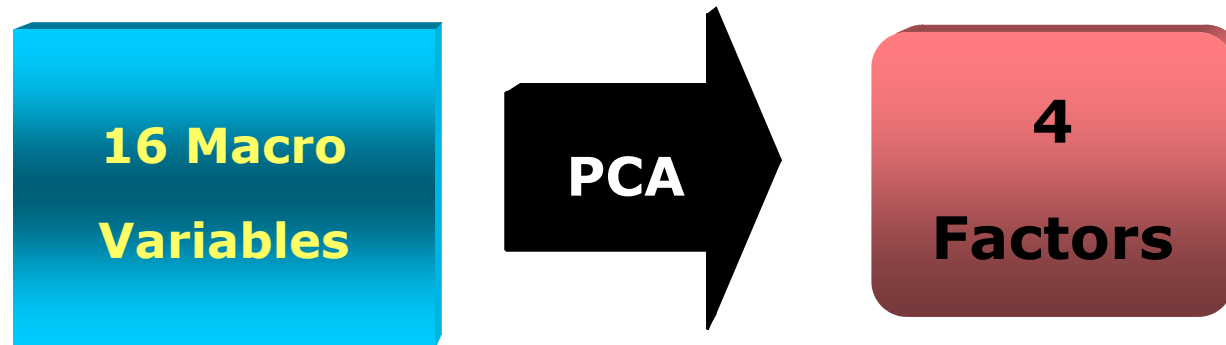
	Chile	United States	Int'l
Financial	IPSA	S&P VIX	
Prices & Interest Rates	CPI	1-Year T-Bill (chg) 10-Year T-Bill (chg) Difference (yld curve) CPI	Dollar-peso exchange rate BRA real-peso exchange rate
Real	IMACEC Unemployment		Oil Price Copper Price



Reducing state space

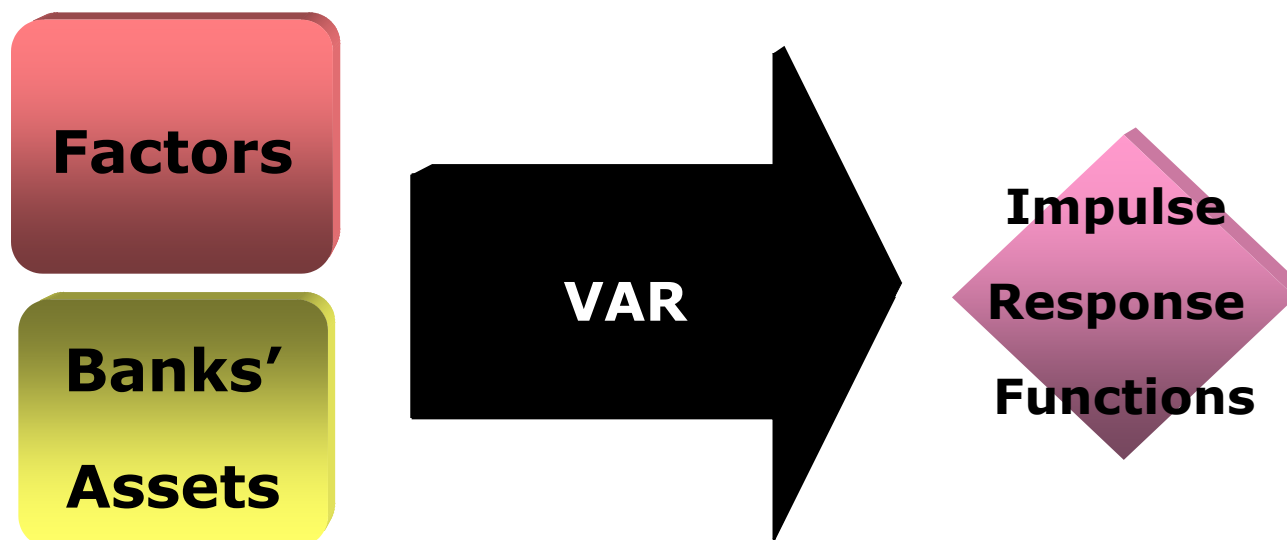
Given heterogeneity of variables and response, we can reduce number of variables through **principal-component analysis**.

Also allows easier interpretation of results across different banks.

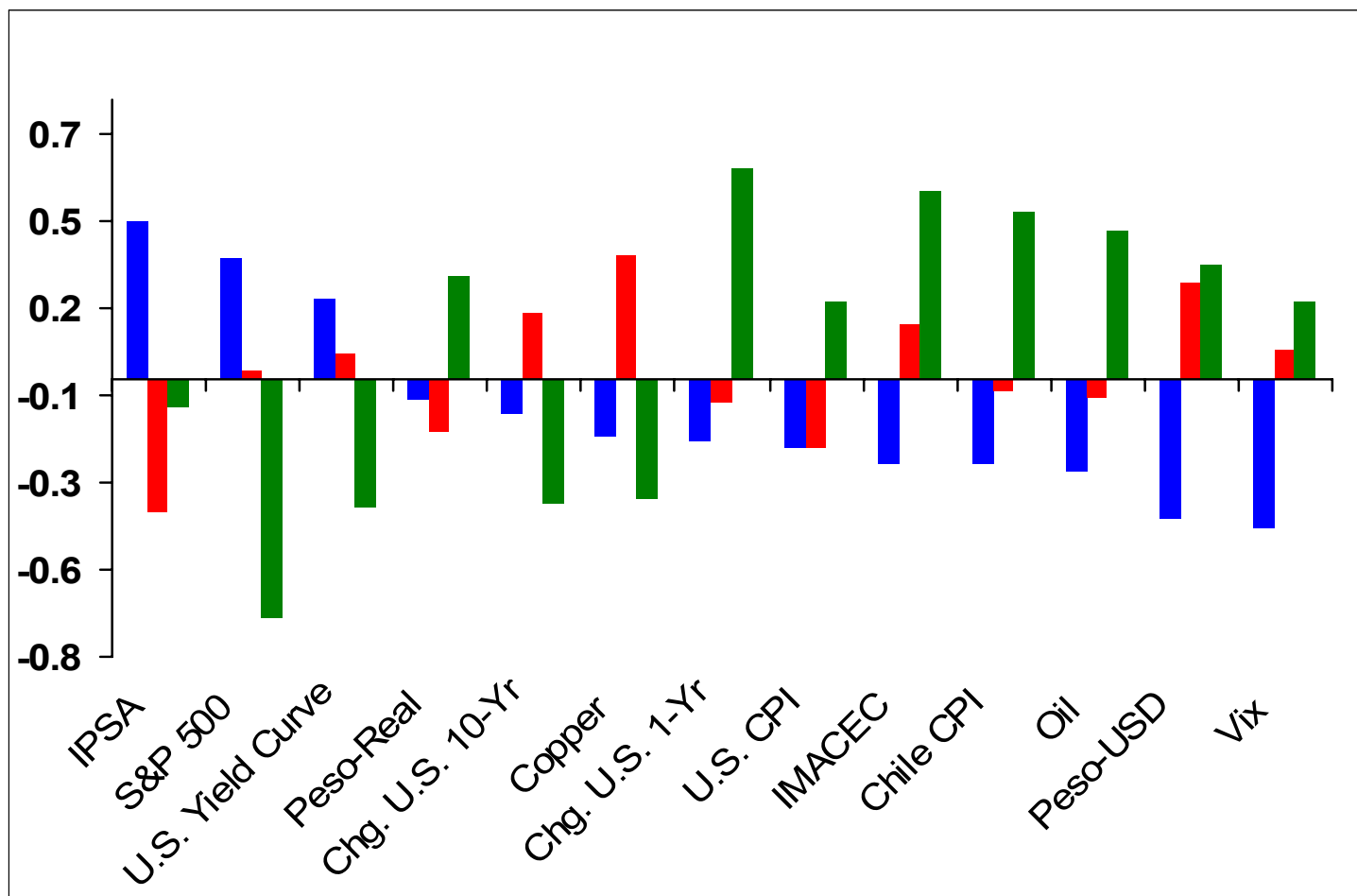


Macroeconomic Variables: How can we stress test?

1. Estimate vector autoregressions for factors and asset returns.
2. Derive impulse-responses to see how assets are affected by factor shocks.



Macroeconomic Variables: Do all banks react similarly?



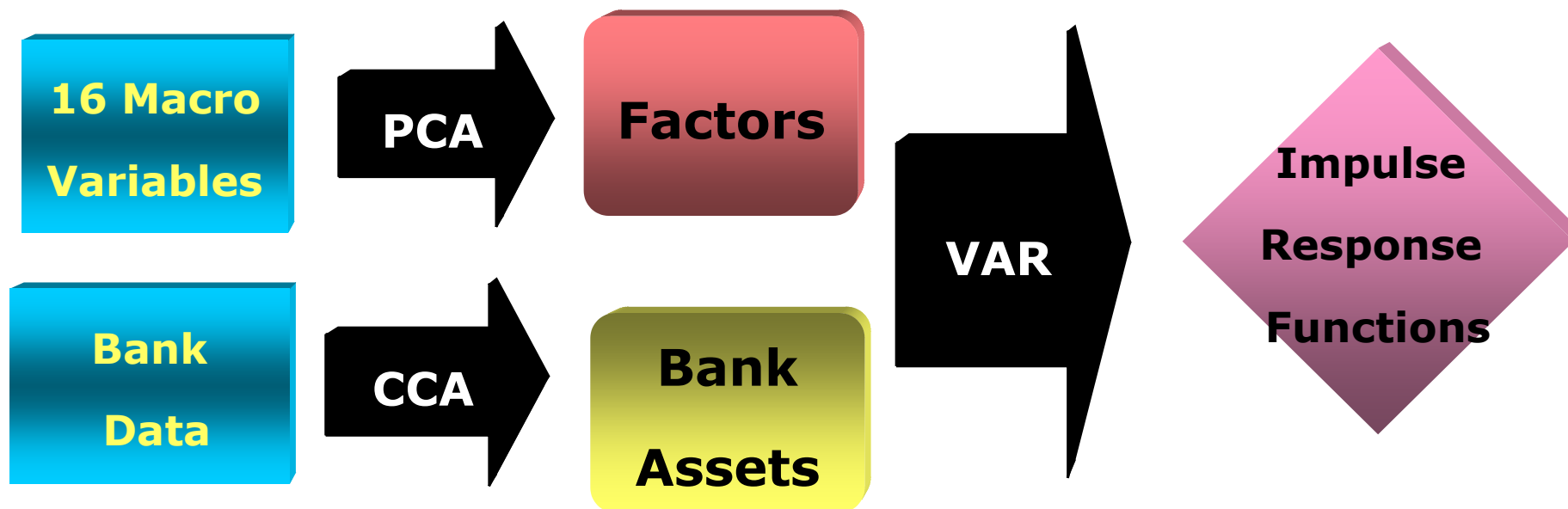
Annual asset-return correlations of three largest banks with macroeconomic variables.



Do banks react similarly to shocks?

Since banks have heterogeneous responses, we estimate IRFs for each bank.

Procedure:



Principal Component Output

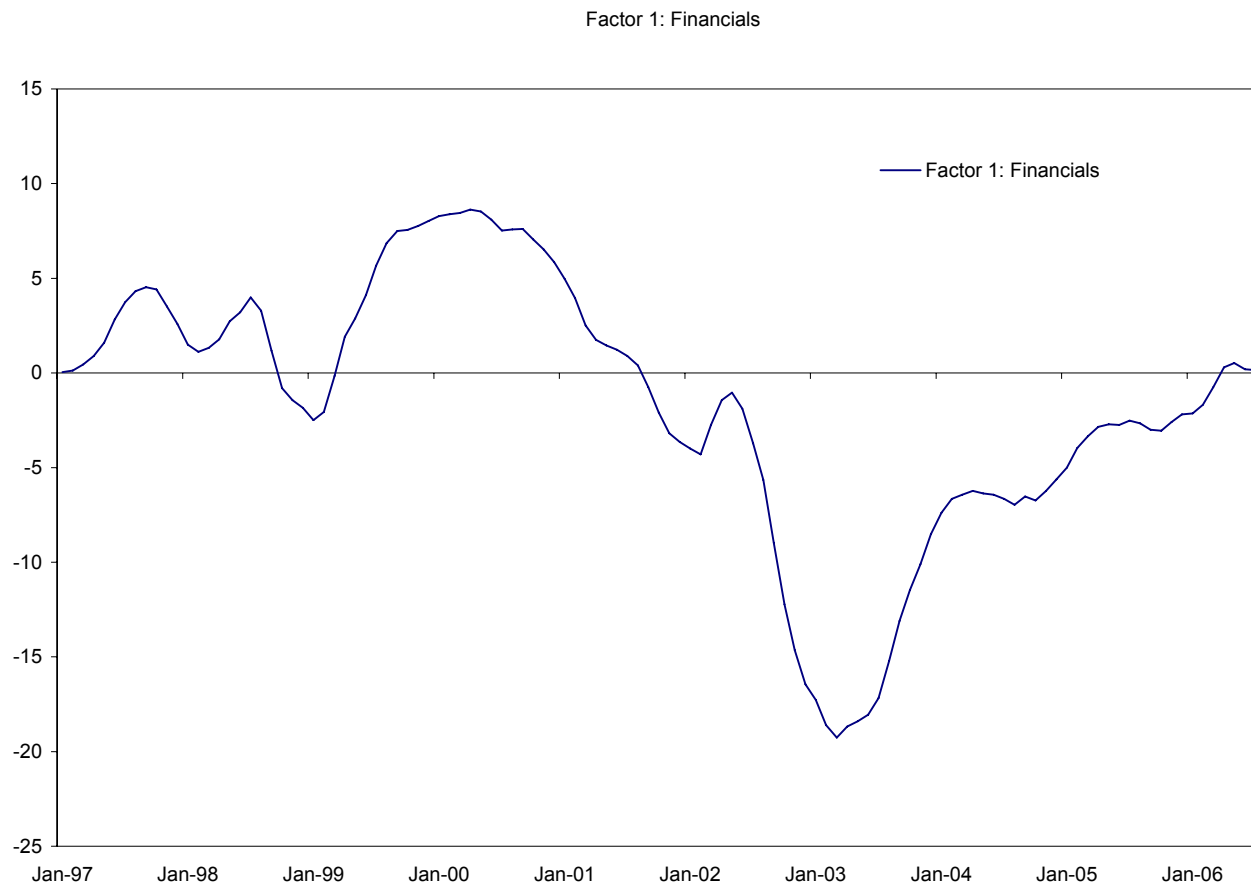
Factors associated with different components of asset returns by which variables they load most strongly:

Factor1	Factor2	Factor3	Factor4
VIX S&P 500 US 10Yr (Chg) US 1Yr (Chg) IPSA CLP-USD	U.S. Yield US 1Yr (Lvl) CPI Chile	Copper Price Oil Price CPI USA US 1Yr (Chg)	IMACEC Unemp. CLP-BRL
Financials	Interest Rates	Cyclicals	Domestic



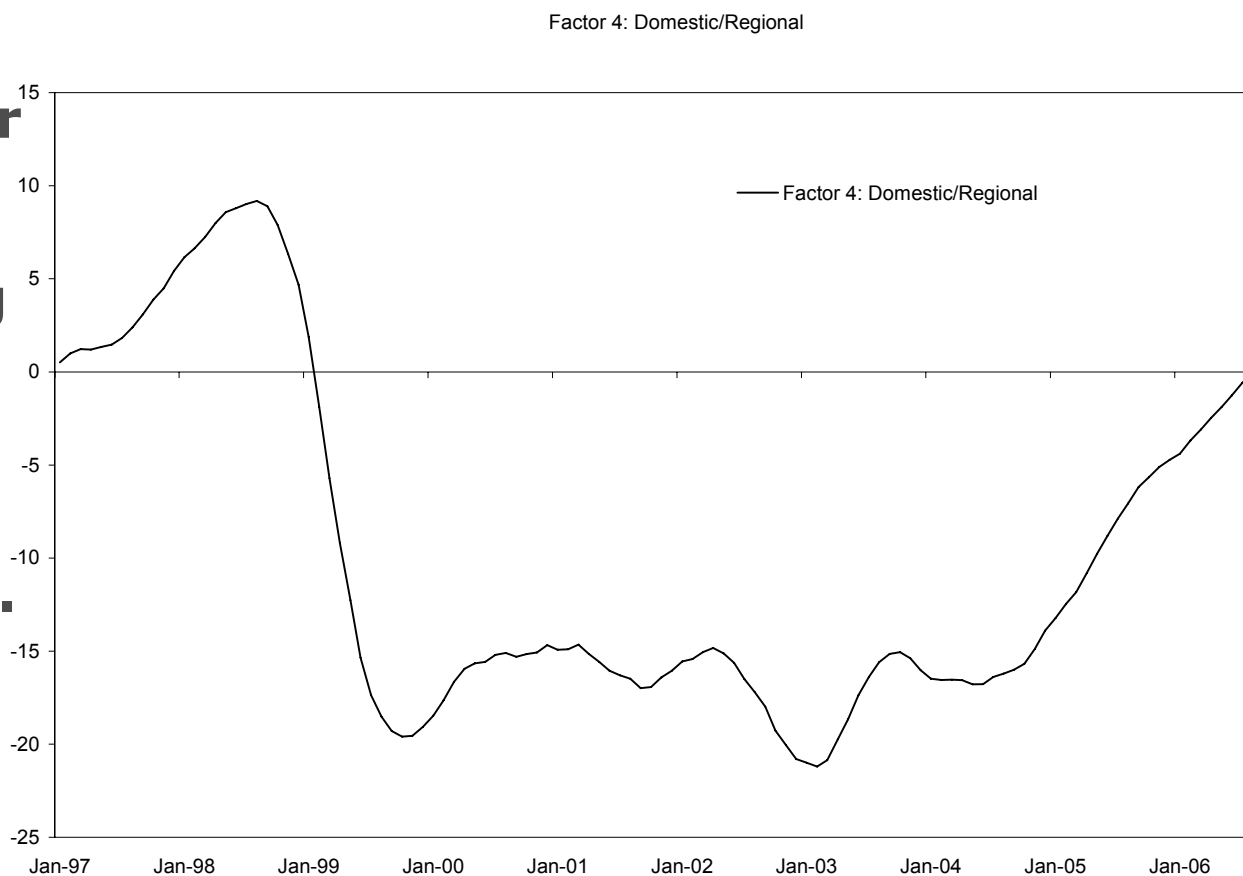
Factors: Factor 1

- **Log of financials factor.**
- **Low levels during 1998-1999, but larger during 2003 around Brazilian election**



Factors: Factor 4

- **Log of first regional factor**
- **Much larger decline during 1998; smaller during 2003 and recovery more recently.**
- **More closely tied to LatAm uncertainty**



VARs

- **VARs are for monthly log changes in asset returns and monthly log changes in factor returns.**
- **Two lags used.**
- **No contemporaneous correlation btw factors, but leads and lags may be significant.**



VAR Output

- R^2 in .3-.7 range.
- Persistence in asset returns: first lag always significant
- Factor 1 (financials) significant for almost all banks: generally positive (better financial conditions -> higher asset returns and lower risk.)
- Other results vary: different factors matter.



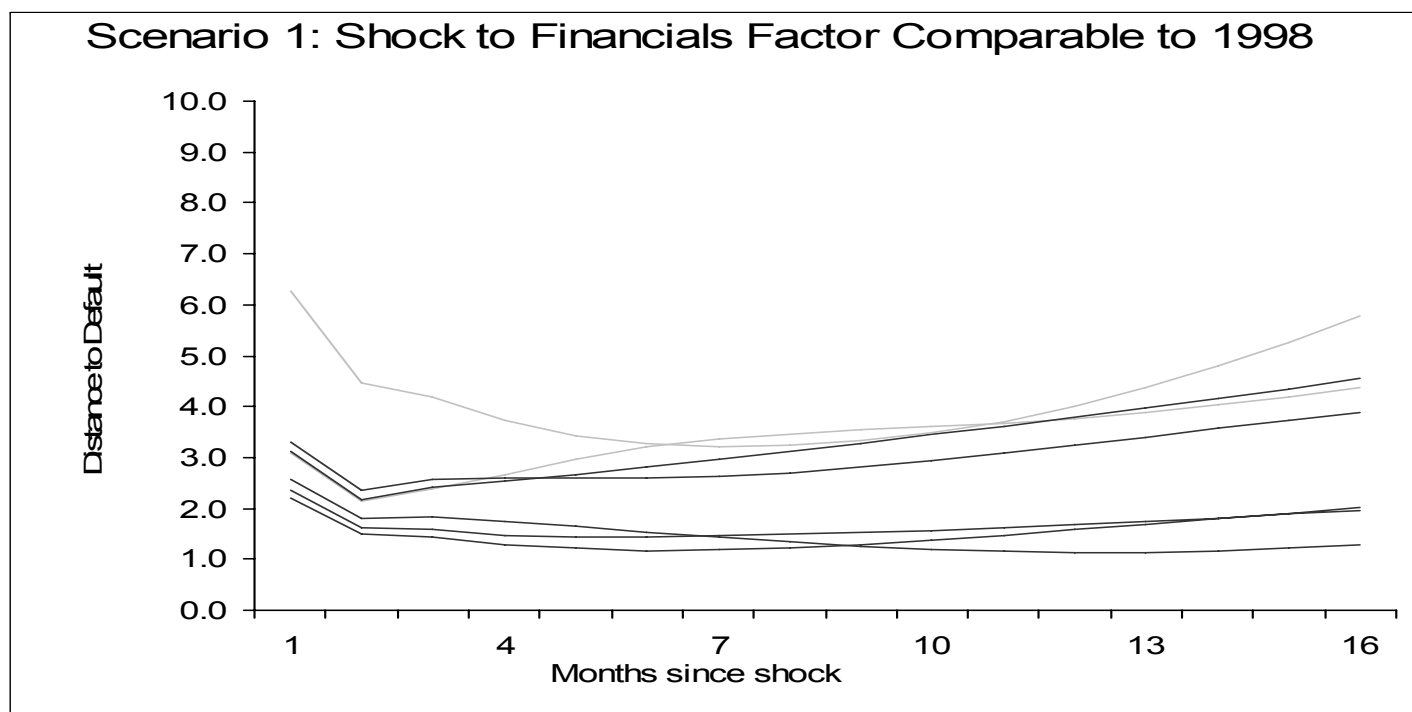
Shocks and Stress Testing

- **Can assess impact of shifts in macro situation by shocking factors**
- **The factors are orthogonal, so can isolate individual shocks**
- **But some crises (e.g., 1998, election of Lula) may involve shocks to more than one factor**
- **Can also stress test: how far must a factor (and thus a macro variable) be shocked before banks approach distress?**



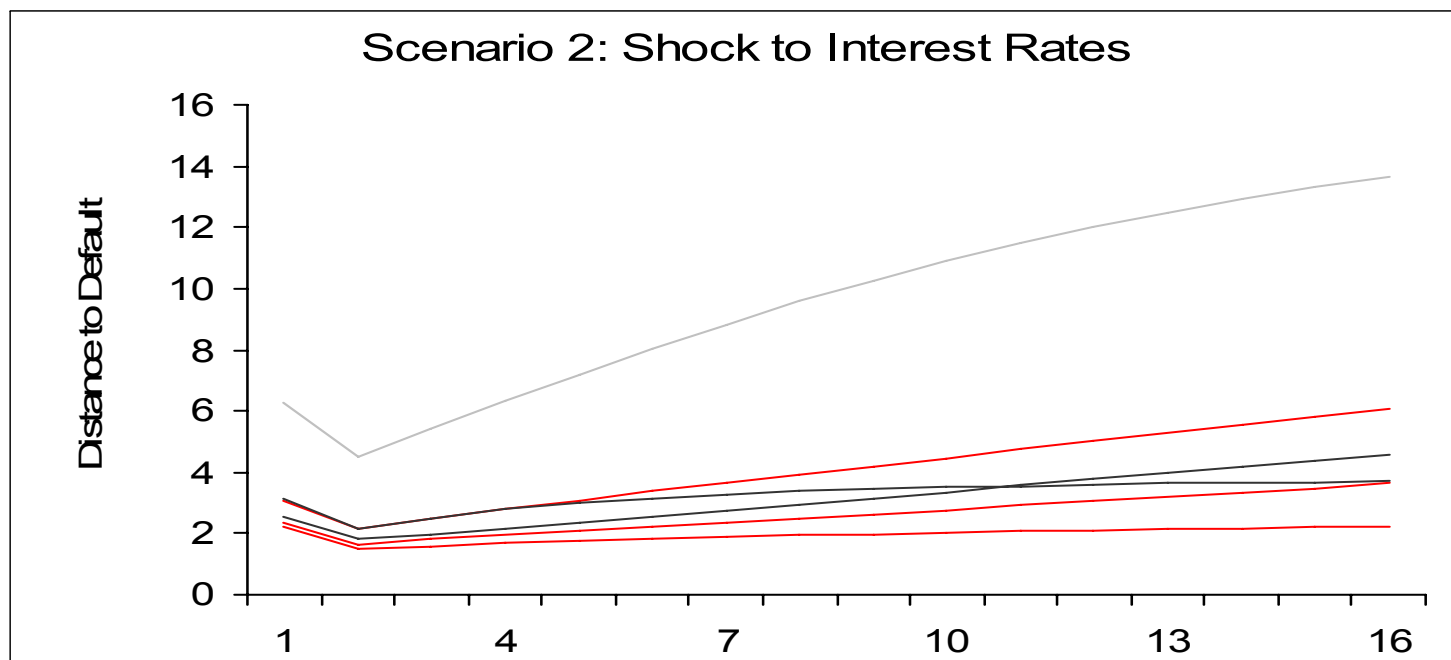
Shock to financials factor

- Shock to factor brings it close to 2003 levels (greater than 1998). Distance to default remains below 1998 levels, however.
- ***Shocks take a long time to bottom out: in most cases ~six months.***
- ***Persistence and recovery vary across banks.***



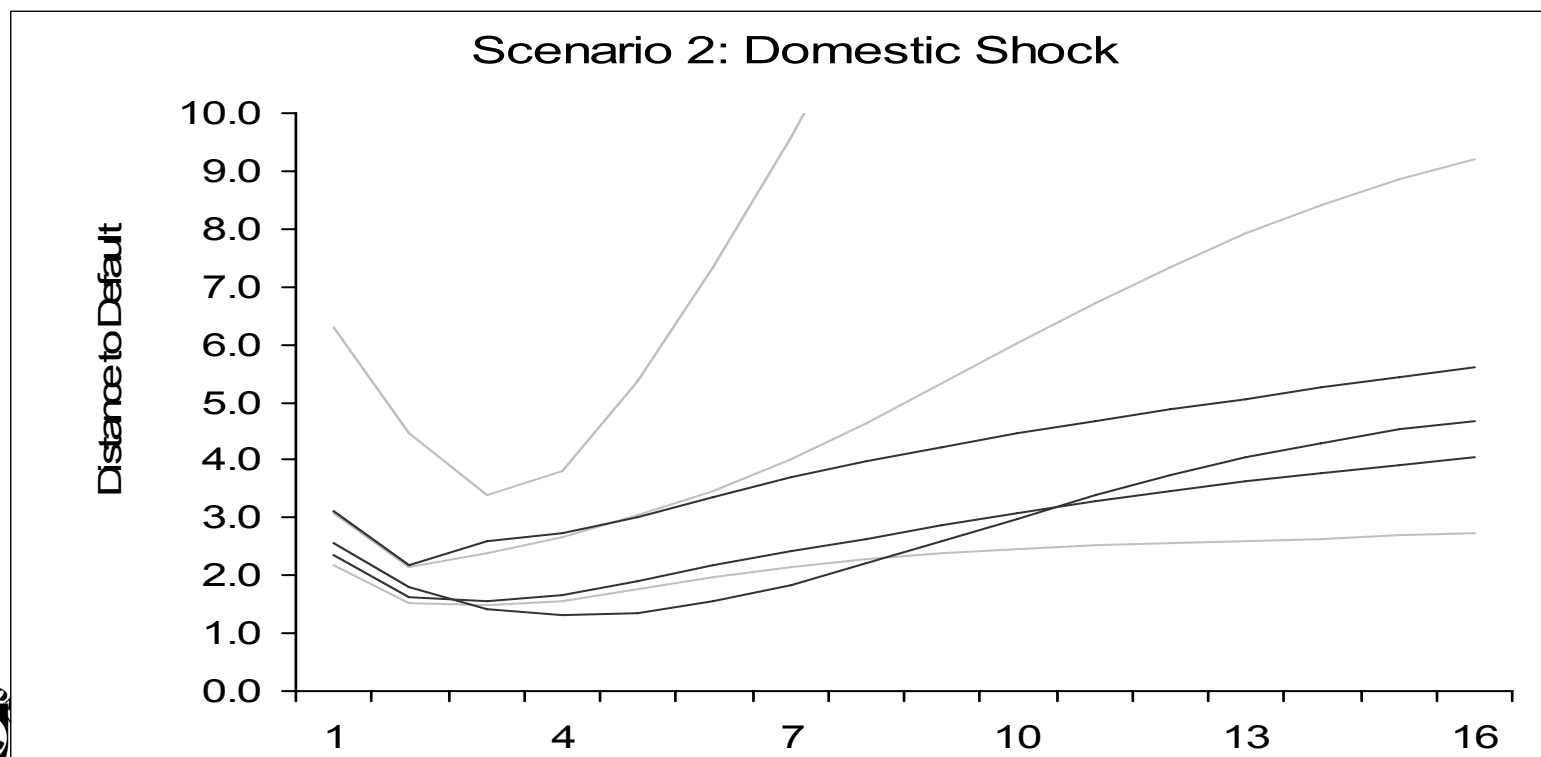
Shock to interest-rates factor

- Similar magnitude to 1-point increase in US 10 Yr rate with 1-yr rate fixed
- All banks affected negatively, but some faster than others.
- ***Future tightening in the U.S. might have a serious impact on Chilean banks, including the larger, systemically important ones (red lines).***



Shock to domestics: comparable to 2- σ fall in IMACEC

- Shock affects banks more quickly than interest-rate shock.
- ***Shock takes longer to affect some banks than others***
- ***Recovery speed again is quite heterogeneous.***



Conclusions

- **The CCA is extensively used in the private sector to assess riskiness of corporations: why not use in public sector?**
- **In application to banking, relatively straightforward to extend analysis to dynamic relationships with macro variables.**
- **This can be used in a variety of ways to assess risk under different scenarios, and see how banks react differently to changes in economy.**



Further work

- **Different frequencies might be useful: barrier data not updated daily, and GDP or other data might be available quarterly.**
- **Running model with only a small number of macro variables may produce similar effects to those here, though variables may be difficult to choose.**
- **Compare results to accounting ratios: are results similar, do they lead/lag accounting forecasts?**

