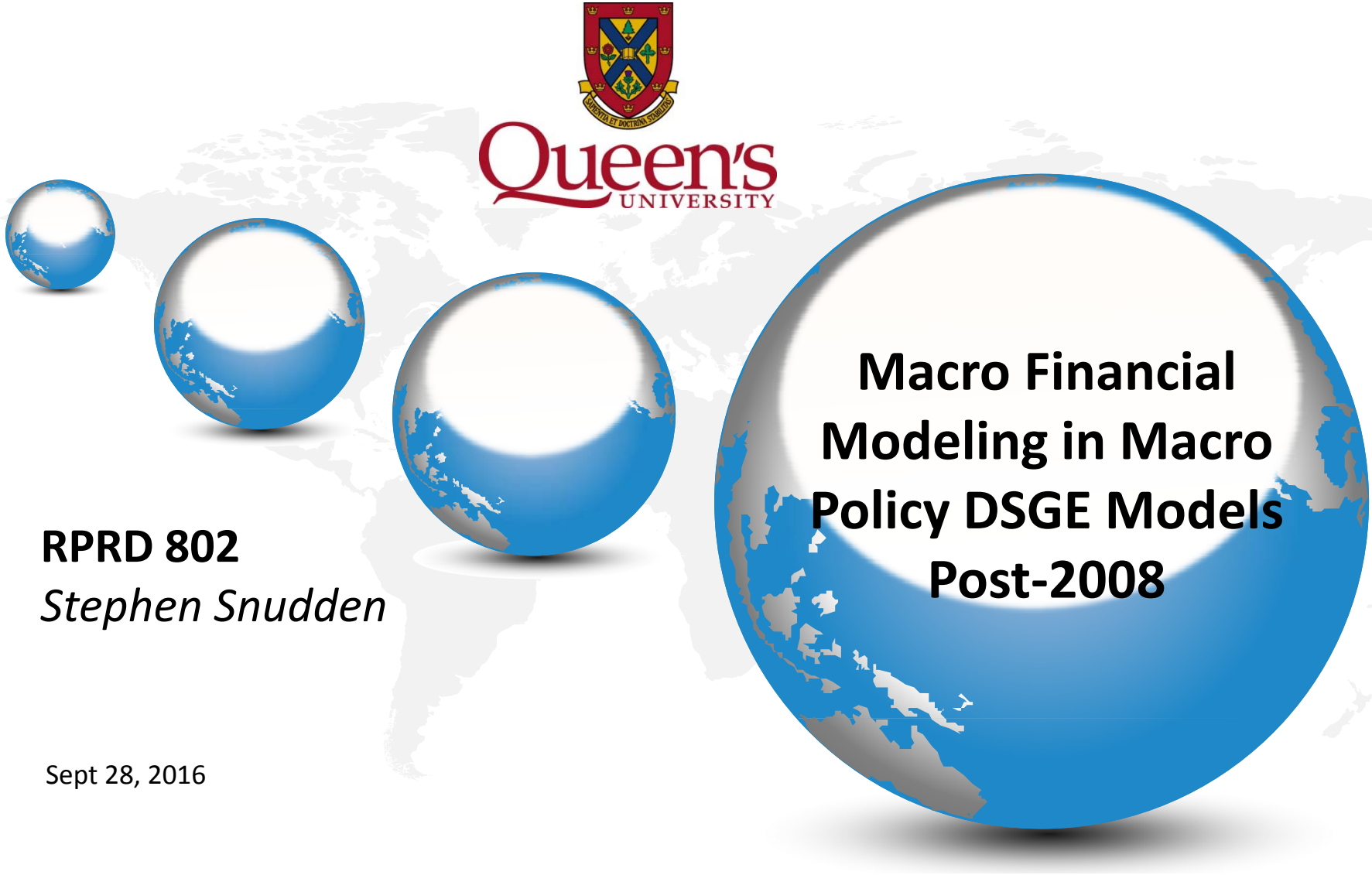

Macro Financial Modeling in Macro Policy DSGE Models Post-2008

RPRD 802

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Sept 28, 2016

Objectives

- Overview of the types of models used at policy institutions
- History of financial frictions in **macroeconomic policy DSGE** models post 2008
- The financial crisis resulted in a shift in mentality:
  - Financial markets now matter for the economy!
  - Policy models were seen to be severely misspecified
- An insiders scoop:
  - Why were certain models that were tried, discarded?
  - Which models are currently in use, and how are they lacking?
  - What properties do central bankers want in their financial sector models?

What are Macro-Policy DSGE Models?

- All models are a simplification of reality
  - *What should be in the core of the model versus kept in a satellite model?*
- Macro-Policy DSGE Models:
  - are sometimes used for forecasting
  - are structural and micro-founded
  - used extensively for policy and scenario analysis
  - contain important sources of shocks/ mechanisms (**what is *important?***)
- Pros:
  - GE interactions of theories, quantitative rigor
  - Concentration of resources, ability to pull from academic circles
  - A ready to use model for a variety of potential policy questions
- Con:
  - Difficult to change structure, large in size
  - Limited in the amount of detail

What Makes Macro-Policy-DSGE Models Special?

Other Types of Models Used in Policy:

1. Semi-Structural (or Non-Structural) Empirical
   - Used for forecasting/ projections, empirical validations
   - Pros: easy to change, better forecasts
   - Cons: hard to interpret, subject to Lucas critique
   - Example: PAC models such as MUSE, FRB-US, VARs, DFMs
2. Specialized Policy Models
   - Useful for specific questions
   - Pros: Better when acute detail needed
   - Cons: Resource consuming, few macro. GE effects (no open economy, *etc*)
   - Example: Models of the Canadian Banking Sector for FSAPs
3. Toy Theoretical
   - Useful for developing underlying theory, isolating key channels
   - Pros: Possibility to work with academic literature
   - Cons: Resource consuming, few macro. GE effects, limited in policy usefulness
   - Example: Most academic models which propose a theory

Examples of Macro Policy-DSGE Models: 2008

Models	Institutions	Features	Financial Frictions
BoC-GEM/ GEM	Bank of Canada / IMF	Global, INF+LIQ, commodities, quarterly	Exog. risk premiums: NFA, sovereign debt.
Totem	Bank of Canada	SOE, INF, sector details, quarterly	-
GIMF	IMF	Global, OLG+LIQ, detailed fiscal block, annual	Exog. risk premiums: NFA, sovereign debt.
QUEST	European Commission	Euro area – ROW, INF-LIQ, fiscal, quarterly	Exog. risk premium NFA

Others: ECB, NAWM; FED, SIGMA

Questions to Begin

- Why do we care about financial frictions now?
  - versus the tech bubble
  - versus the east Asian crisis
  - versus a entire human history of financial related crises

- What would you devote your limited resources to have?
  - type of financial channels to include
  - other important features: primary commodities, international linkages, labor

- A need to take stock
  - look at the whole system/ history
  - identify key shocks/ propagation channels
  - remain flexible/ forward looking as the system evolves

I. Modeling the Demand for Credit

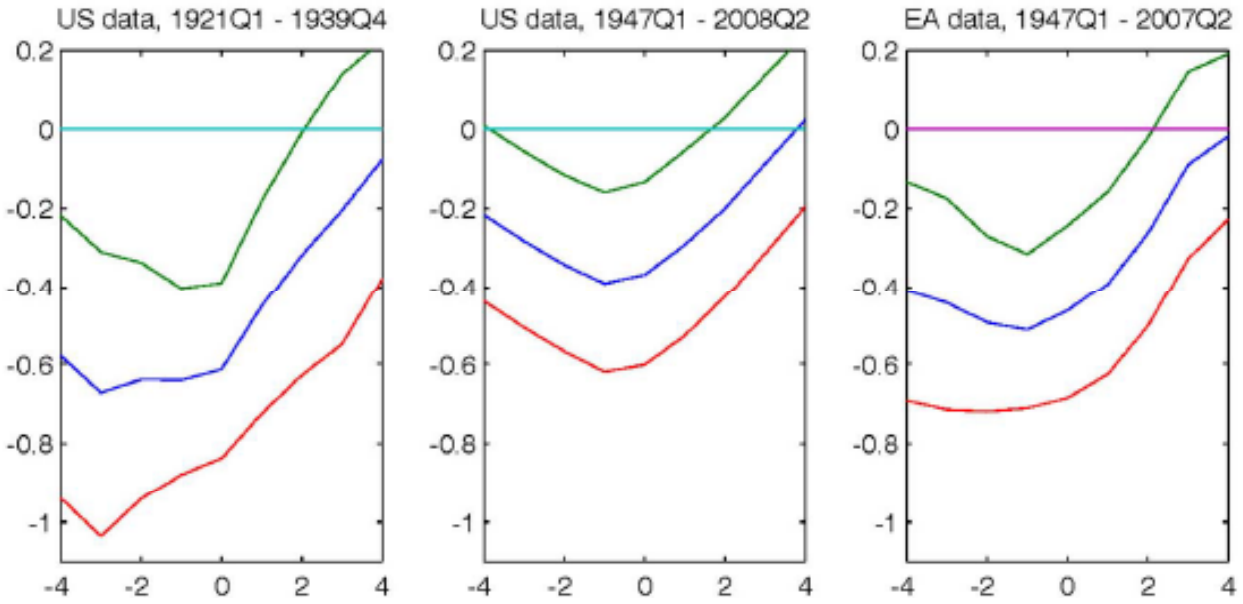
I. The Financial Accelerator à la BGG

- Been **around** for a while – well understood?
  - Bernanke and Gertler (1989)
  - Carlstrom and Fuerst (1997)
  - Bernanke, Gertler, and Gilchrist (1999)
  - Dib and Christensen (2005)

- Adapted quickly into most macro-policy models:
  - IMF, GIMF; BoC, GEM; FED, SIGMA; EC, QUEST; ECB, EAGLE.

I. Risk Spread Sign. Neg. Correl. with Output

Correlation of risk spread(t), output(t+j), HP filtered data, 95% CI



- Notes: Risk spread is measured by the difference between the yield on the lowest rated corporate bond (Baa) and the highest rated corporate bond (Aaa). Bond data were obtained from the St. Louis Fed website.

Christiano et al. 2010

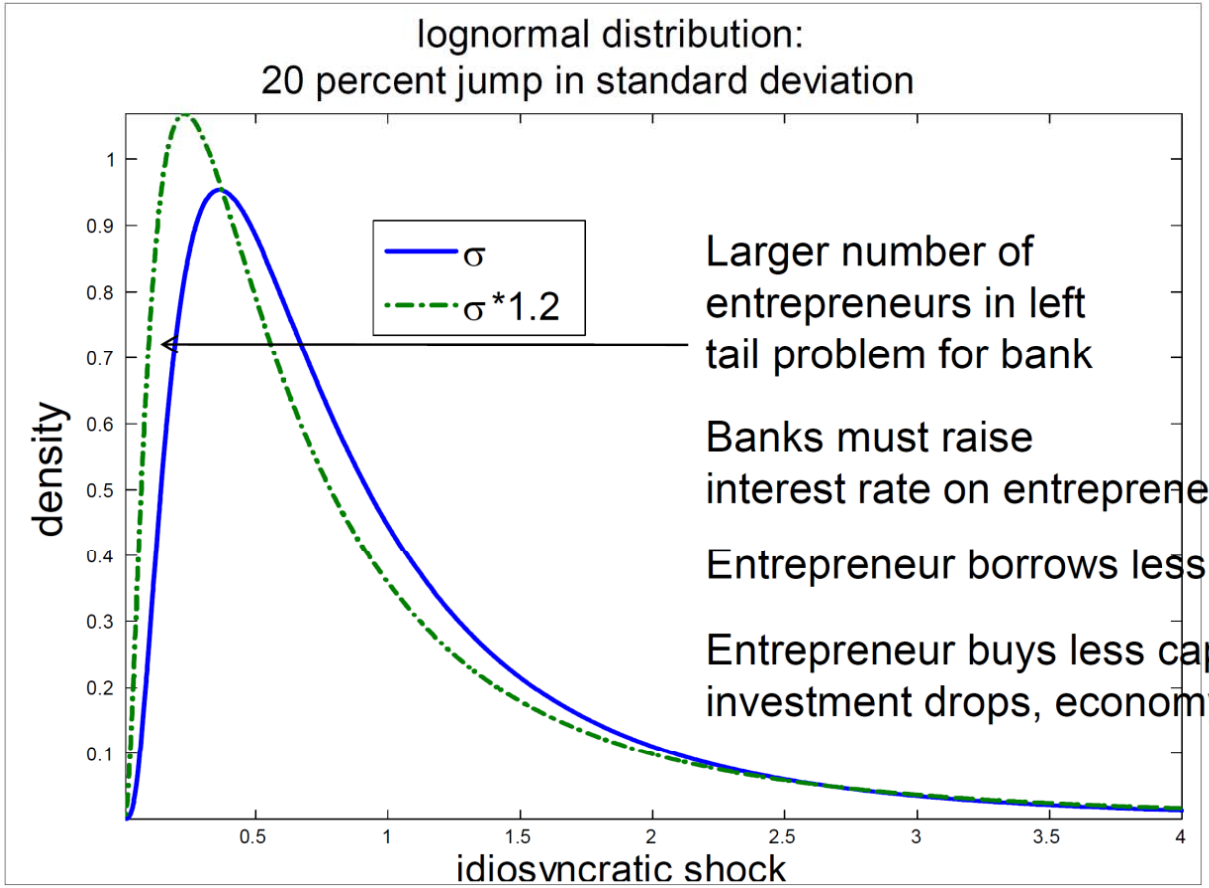
I. BGG (1999) Overview

- Capital acquisition financed via **net worth and "bank" loans**
  - CSV: asymmetric information about the payoff from capital

- Some firms default in any given period after shock realized
  - only partially recoverable to "banks"

- Borrowers compensate "banks" for the risk by paying an external finance premium
  - depends inversely on entrepreneurs' aggregate net worth

I. The Risk Shock in the BGG



Christiano et al. 2010

I. CSV Details – desirable or undesirable?

- A set of **NONLINEAR** optimality conditions
- **Entrepreneurs absorb all risks**
- **Bank have zero profit condition**
- Defaulted capital lost to the bank is **distributed back to households**
  - Results in higher household income
- When riskiness increases some firms (right tail) are **more profitable.**

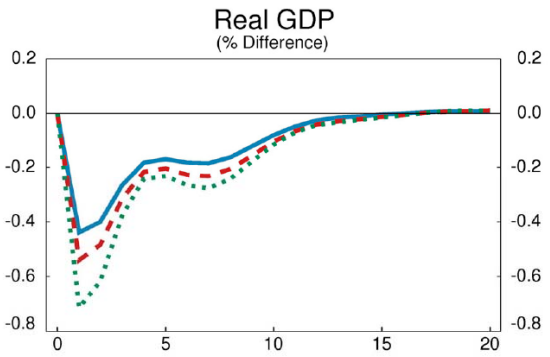
I. Impact of Leverage under an Increase in Borrower Riskiness

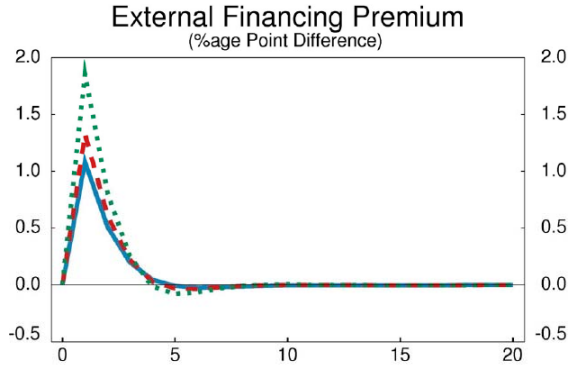
Andersen and others (2013)

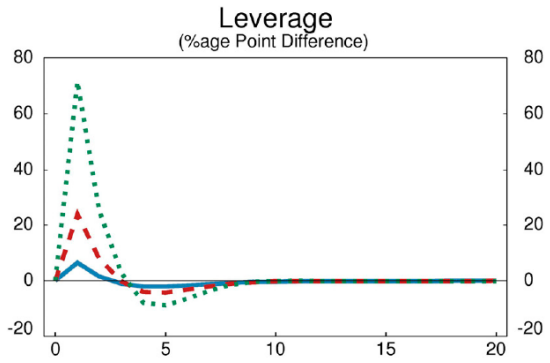
Percent or percentage point deviation from steady-state baseline

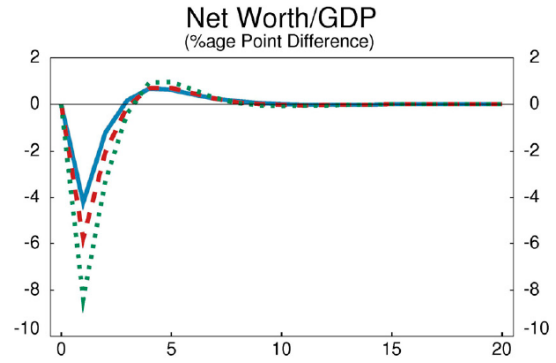
(Horizontal axis is in years)

___ Leverage of 1 _ _ Leverage of 1.75 ... Leverage of 2.5









I. Impact of Leverage under an Increase in Borrower Riskiness

Andersen and others (2013)

- The amount of leverage is altered in the U.S. economy – a ratio of corporate debt relative to firms' net worth of either 1, 1.75, or 2.5.

- Because entrepreneurs must pay their interest obligations on debt to avoid bankruptcy, an increase in leverage increases the cutoff rate for profitability that the entrepreneur has to achieve to avoid bankruptcy.

- Thus, the higher leverage is in the steady state, the more likely that the entrepreneur will default for a given increase in risk.

- Thus, higher leverage ratios make the user cost of capital more sensitive and business investment more volatile in the presence of other shocks to the economy.

I. The Approximation

Christiano et al (2010)

- If the model is log linearized, the a parameter (v) is introduced: the time-varying elasticity of the external finance premium with respect to the entrepreneurs' leverage ratio:

$$E_t\left\{\tilde{r}^{k}_{t+1}\right\} - \tilde{r}_{t+1} = -v\left[\tilde{n}_{t+1} - (\tilde{q}_t + \tilde{k}_{t+1})\right]$$

- This governs the risk shock.

- All **nonlinearities are lost.**

I. The Approximation

Christiano et al (2010)

Percent Variance in Business Cycle Frequencies Accounted for by Risk Shock	
variable	*Risk*, σ_t
GDP	62
Investment	73
Consumption	16
Credit	64
Premium (Z – R)	95
Equity	69
$R^{10\text{ year}} - R^{1\text{ quarter}}$	56

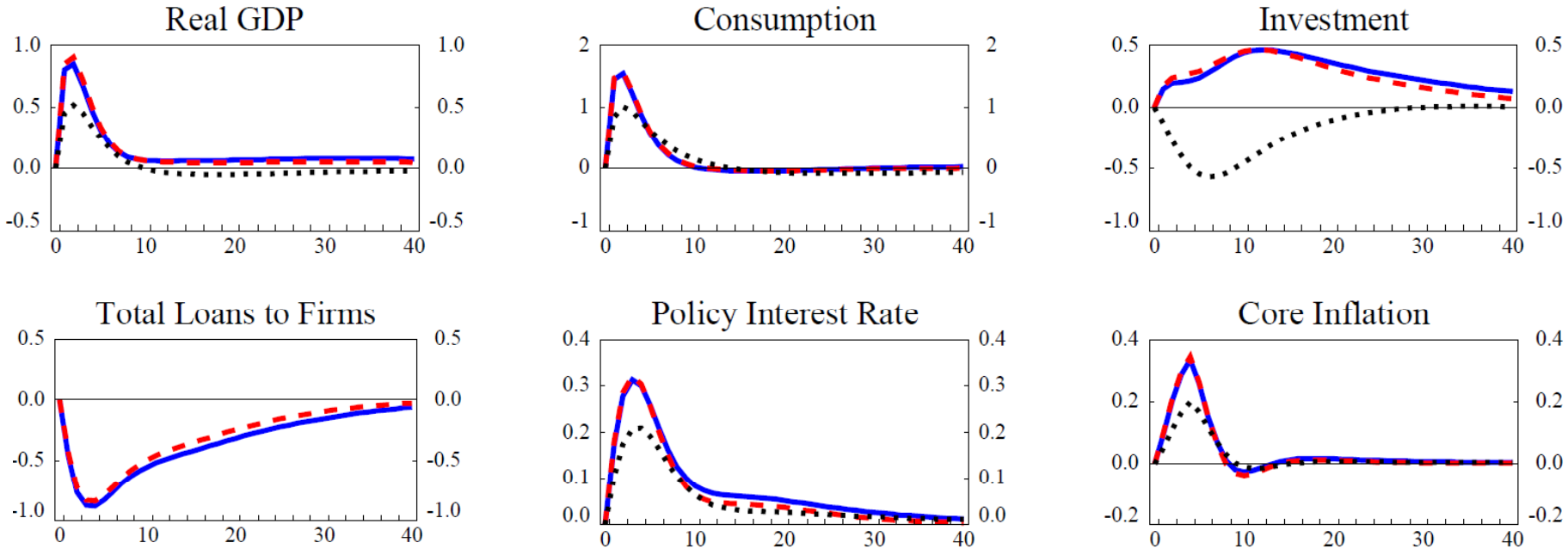
Note: 'business cycle frequencies means' Hodrick-Prescott filtered data.

I. An Increase in U.S. Consumption– U.S. Effects

Beaton and others (2014)

(Deviation from Steady State)

Solid = BoC-GEM-Fin; Dashed = BoC-GEM-BGG; Dotted = BoC-GEM



I. Key Mechanisms of Financial Accelerator

BGG (1999)

- **Inverse relationship between the external finance premium and net worth**
  - Lower levels of borrowers net wealth increase the divergence of borrower and lender interests
  - Implies greater agency costs
  - Lenders demand a higher risk premium
- Introduces the "**financial accelerator** effect"
  - Shocks that raise output tend to be amplified if the shock also raises capital values and entrepreneurial income
  - Helps create a positive correlation between consumption and investment
  - Increases the persistence of shocks
- Introduces the "**Fisher debt deflation** effect"
  - Contracts are in nominal terms: unexpected changes in the price level result in a reallocation of wealth between entrepreneurs and lenders
  - Shocks that reduce the price level hurt entrepreneurial net worth and depress output

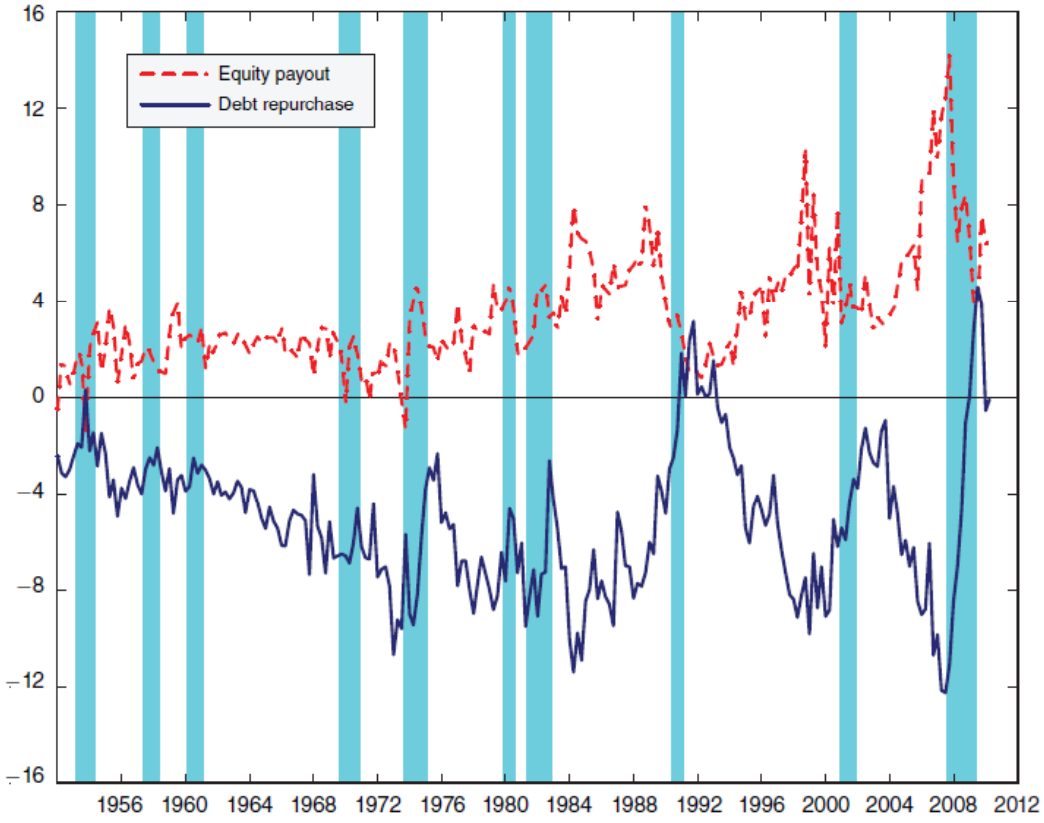
Question: Limitations of the Financial Accelerator Framework?

I. Key Limitations of BGG (1999)

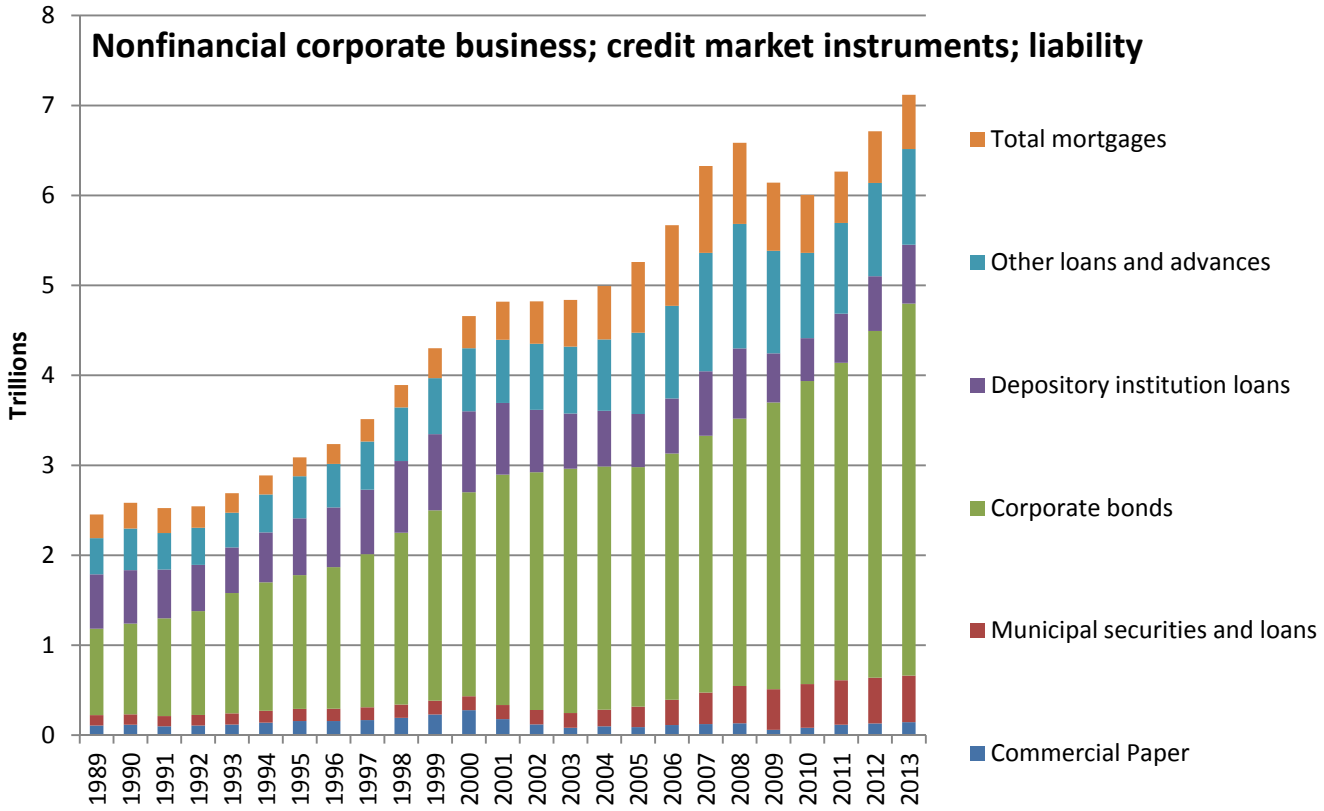
- Models only the demand side of credit
  - Loan dynamics are often undesirable for non-financial shocks
  - Causes over specification of the risk shock
  - Deposits are fully flexible
- Ignores alternative sources of risk spread (risk aversion, liquidity)
- Applies only to 'mom and pop grocery stores:
  - bank dependent for outside finance
  - no access to equity, bond markets, etc
- Retained earnings – for CSV net worth is paid out slowly and exogenously to keep it from accumulating above steady state
- Does not explicitly model banks

I. Financial Flows in Non-Financial Sector

Jermann and Quadrini (2012)

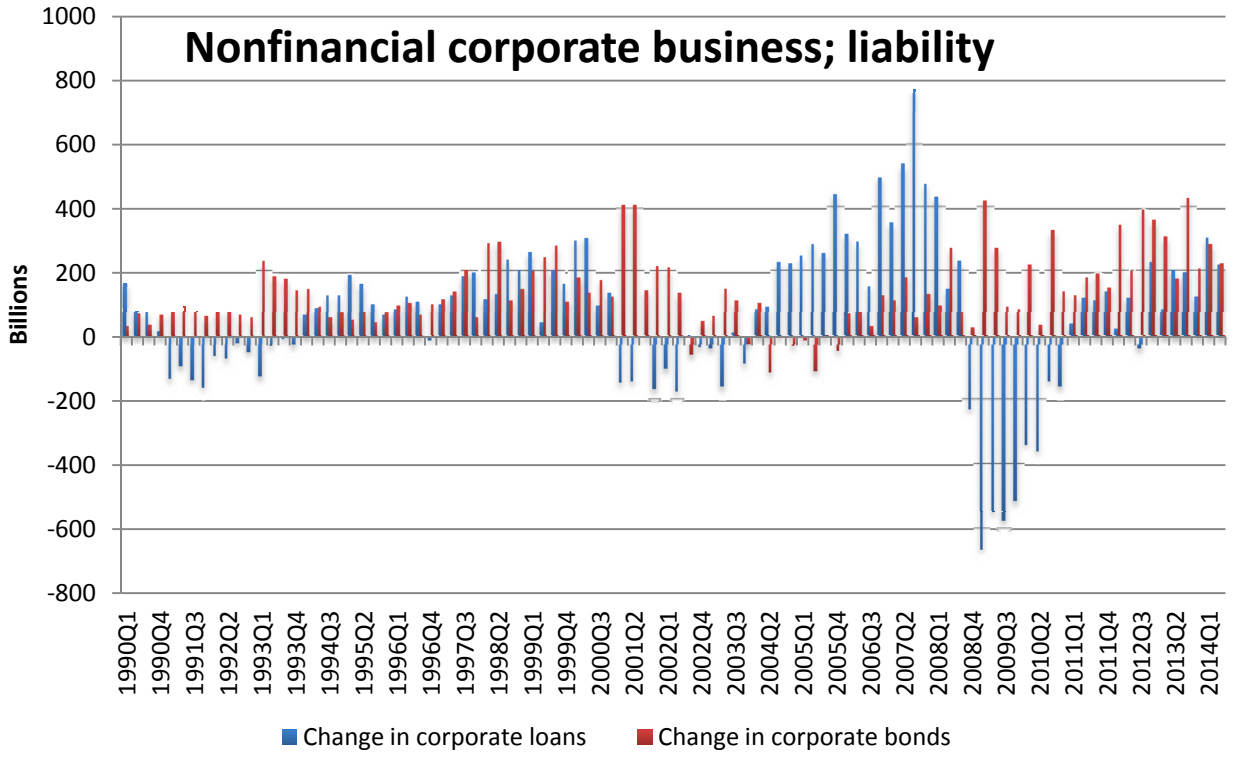


I. How Do Firms Finance?



US Flow of Funds, table L102.

I. How Important are Loans for Firms Financing?



US Flow of Funds, table F102.

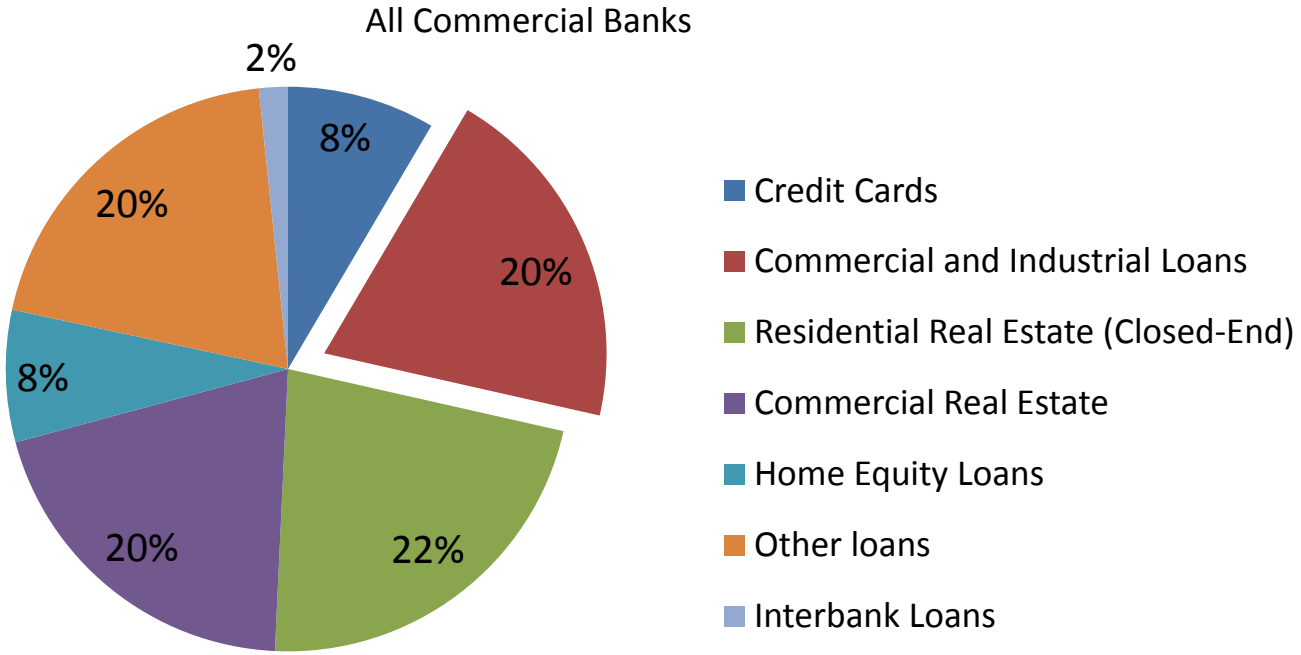
I. Understanding Firm Financing: The Future

- Need to understand importance of mechanisms for firm financing:
  - Internal versus external financing (Jermann and Quadrini, 2012)
  - Dependency of firms on direct loans versus bonds (Adrian et al., 2012)
  - How does this depend on firm size? (Begenau Salomao, 2015)
  - Frictions in raising firm capital?
  - Non-depository-institutions-loan financing?

- But…. why so much focus on firms?
  - What about Households, Government debt, Trade financing, etc.

I. What Loans are on Bank Balance Sheets?

U.S. Loans and Leases in Bank Credit (2012)



Source: FRED database, authors estimates

I. Demand for Credit Models: Housing

- Iacoviello (2005)
  - Models the **housing demand for credit**
  - Based on **collateral constraint frameworks** Kiyotaki and Moore (1997)
  - Key disturbance: **housing demand shock**
- Pataracchia et al (2013)
  - Models housing building on Iacoviello (2005).
  - **Adds Endogenous leverage constraints**
  - Incorporated into EC Quest Model

- Less central banks have incorporated housing into their work horse policy models compared to the CSV framework
  - Focus remains on labor sector, banking and financial frictions

I. Demand for Credit Models: Housing

- Key Gains of Modeling Housing
  - Helps explain the **movement in consumption** over the business cycle
  - Able to look at impact of housing as a **source of shocks**
  - Helps capture the actual holdings on **bank balance sheets**
- Key Channels Missing from Modeling Housing in Policy Models
  - Speculative bubbles, IO mortgages, investment asset (Barlevy and Fisher, 2010)
  - Ex-post default – idiosyncratic risk (Forlati and Lambertini, 2011)
  - Alternative mortgage contracts, and default risk (Corbae and Quintin, 2010).
  - Housing Illiquidity and Search friction (Hedlund, 2013)

I. Demand for Credit Models: Take Aways

- What we have seen:
  - A focus on firm financing from loans via CSV models
  - Less role for non-loan credit instruments
  - Less focus on housing – other credit demand
  - Few models of ex-post default in housing
- What other loan channels are missing? - Needed?
  - Student debt
  - Trade financing
  - Corporate real estate
  - International Financial Linkages
- What other credit channels are missing? - Needed?
  - Securities, bonds, etc
  - Role for sovereign debt

II. The Quest for the Supply Side of Credit

II. Credit Supply Models

1. The financial accelerator framework
   - Ex-post informational asymmetry
   - External finance premium

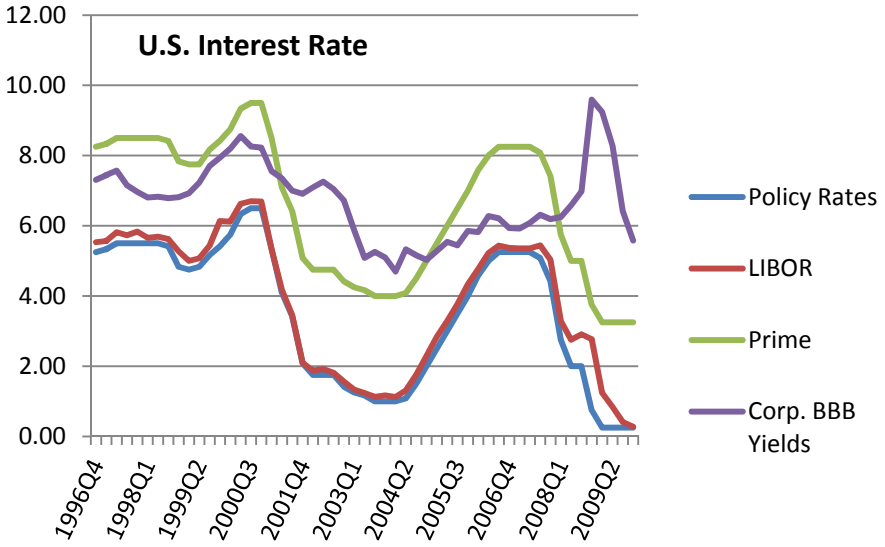
2. Collateral constraints framework
   - Limited contract enforcement environment

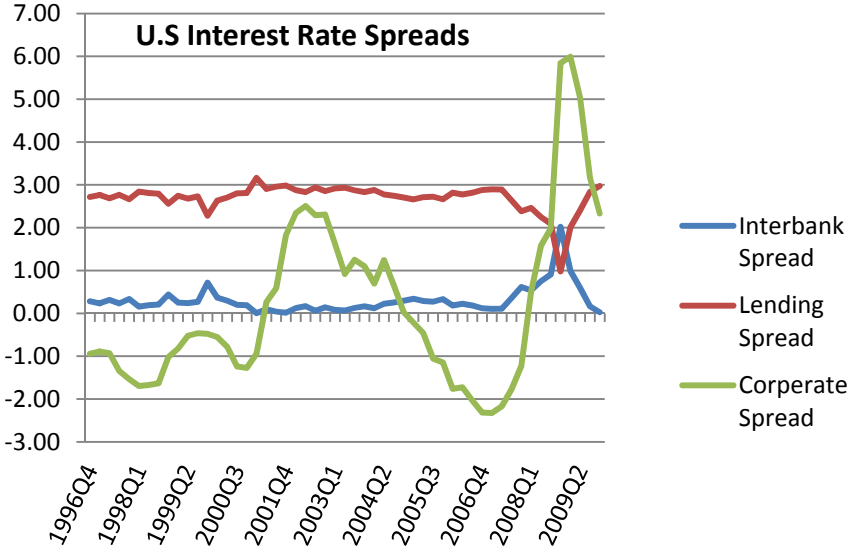
3. Costly banking framework
   - Non-convex production technology

- Most frameworks imply that intermediation costs are positively related to volume of intermediation and are always procyclical over the business cycle – **at odds with the empirical evidence**. Borio et al. (2001)

II. Where Are the Frictions?

Beaton and others (2014)

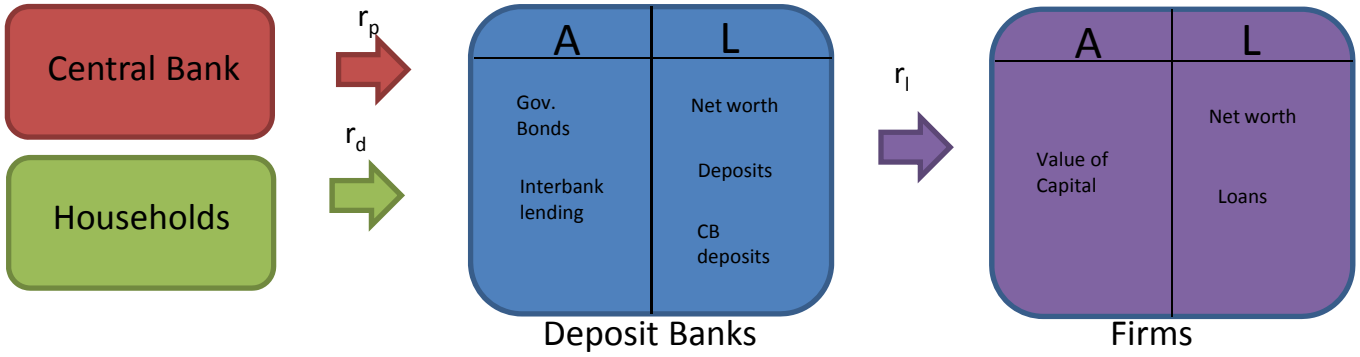




Board of Governors of the Federal Reserve System, table H15

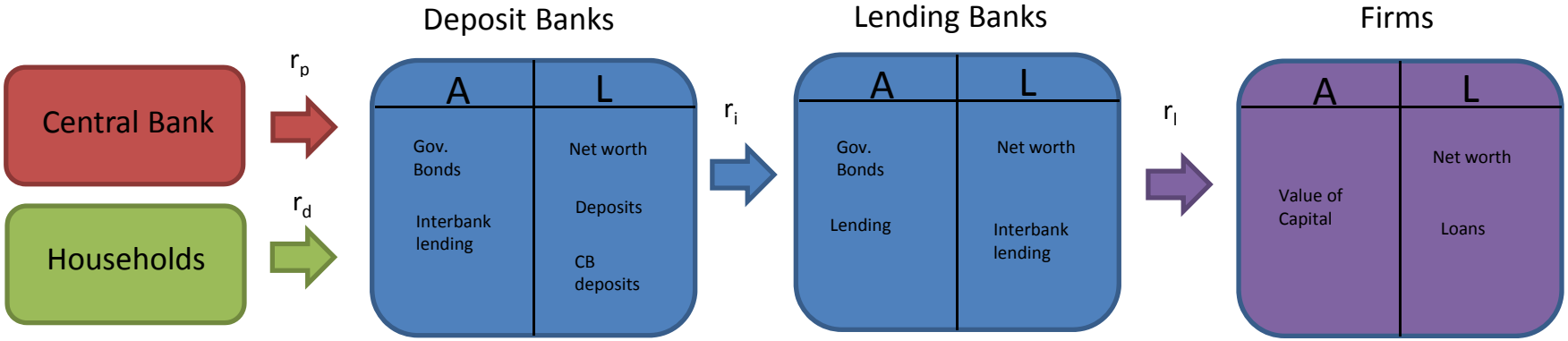
II. Early Models of the Supply Side of Credit

- Markovic (2006)
  - Looks at the role of bank capital, and the effect of bank capital requirements.
  - The sector is **driven by the demand for credit** – a higher demand for credit is met with higher savings of households.
  - A **double moral hazard framework** between banks and depositors and banks and entrepreneurs
  - Still only **intermediation** – still driven by the **demand for credi**t.
- Meh and Moran (2008) ; Gertler and Kiyotaki (2010)
  - Bank net worth directly effects lending limits due to **collateral constraints**.
  - Banks are at the limit of their bank capital requirement – **no buffer**.
  - Lending pinned down by **exogenous leverage** requirement.



II. Early Models of the Supply Side of Credit

- Dib (2010)
  - Looks at the role of bank capital, and develops a theory on interbank lending, and quantitative easing.
  - Banks have **Leontief lending technology** for deposits and capital – causes problems.
  - Shocks to the technology of lending and interbank monitoring
  - Still only **intermediation** – still driven by the **demand for credit.**



II. Current Models of the Supply Side of Credit

- Benes and Kumhof (2011); Van Den Heuvel (2009)
  - Banks optimally choose a **capital buffer** against hitting requirements.
  - A financial **accelerator mechanism for banks** similar to BGG (1999) allowing for a s.d. of bank riskiness shock – **ex-post heterogeneity**.
  - Begins to develop a **theory of aggregate credit creation** – not just intermediation.
- Adrian et al. (2012)
  - In addition to net worth, **leverage is endogenous** affecting bank lending.
  - Total credit stable - firms shifted from **bank loans to bond financing**.
  - Total lending by banks instable – **reflected in risk premiums**.

III. Policy Models: Current Trends

III. Financial Frictions Policy Models: post 2008

Models	Institutions	Other New Features	Financial Frictions
BoC-GEM/ GEM	Bank of Canada / IMF	Fiscal details	Supply: Deposit and lending banks with interbank market Demand: Financial accelerator, international loans from banks to foreign firms
FSGM	IMF (2015)	Remittances, oil	Risk premiums: Corporate (Output gap), Sovereign, External, Economy Wide, Household
GIMF	IMF	Labor search, remittances, oil	Supply: Heterogeneous banks, endogenous leverage constraints, capital buffers, ex-post losses Demand: Financial accelerator
QUEST	European Commission	Credit constrained HHs	Supply: Heterogeneous banks, endogenous leverage constraints, capital buffers, ex-post losses Demand: financial accelerator, Iacoviello housing

III. What is Happening to Policy DGSE Models?

- Macro-financial theory continues to be developed
  - Mainly in academic toy models
  - Some institutions are including more advanced general mechanisms (IMF, EC)

- There has been a move to semi-structural policy models
  - Allowing for greater flexibility (quantitative accuracy)
  - Example: FSGM (IMF), LAN (BoC), G-MUSE (BoC)

- Detailed financial models remain satellite models
  - Generally not kept in day-to-day workhorse models
  - Only the key exogenous mechanisms for financial shocks are kept in workhorse

IV. Current Debates in Macro-Finance

IV. The Quest for a Decent Supply Side of Credit

A model of the supply side of credit has not yet been satisfactorily developed. **Why?**

- Disagreement on the key mechanisms of the sector
  - Which sectors of the financial market matter?
  - What are the key frictions?

- Disagreement on the key sources of shocks
  - What makes banks/financial firms risky?
  - Where in the process do shocks originate?

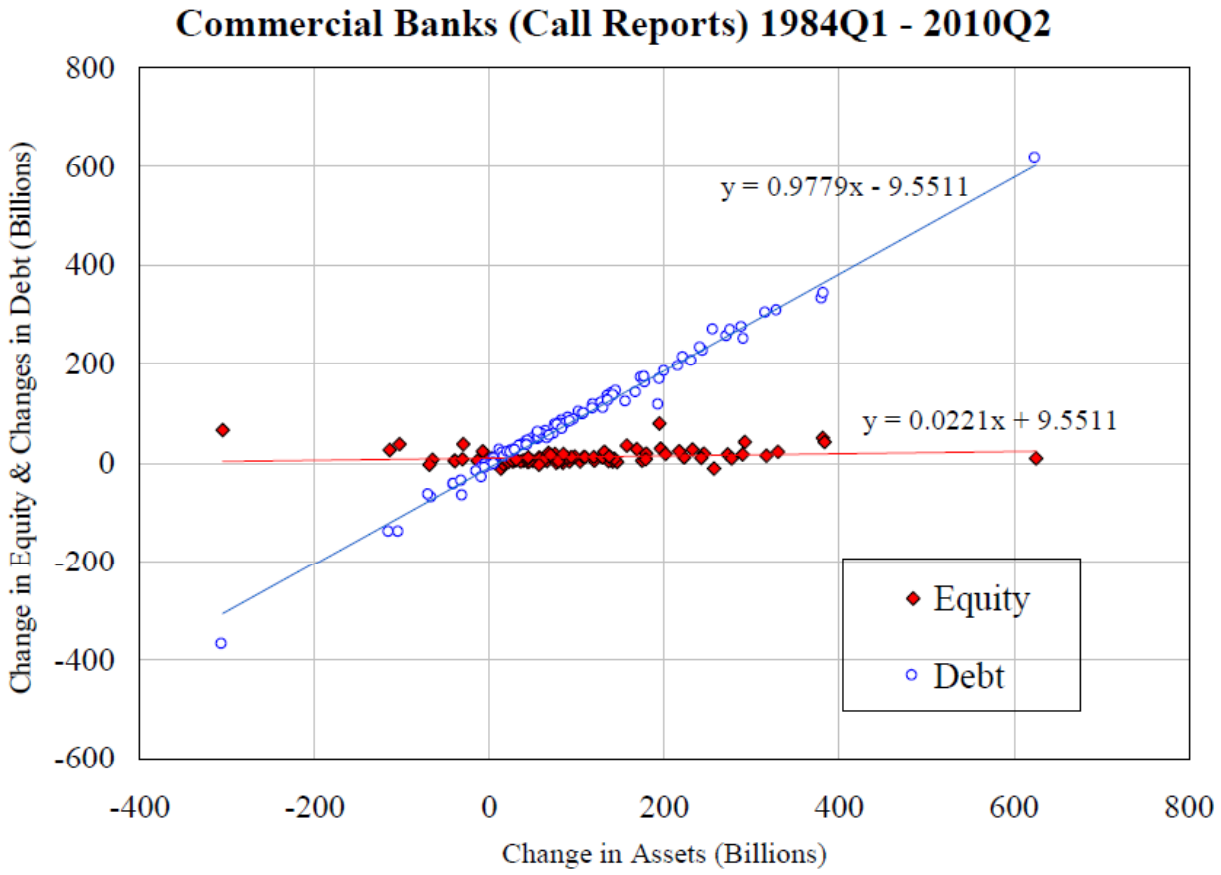
- Disagreement on stylized facts/ calibrations
  - Few estimations/ empirical studies of new mechanisms
  - Lack of mapping to observed balance sheets

IV. Basic Disagreement on the Role of Banks

Are banks sources of shocks, accelerators of shocks, or absorbers of shocks?

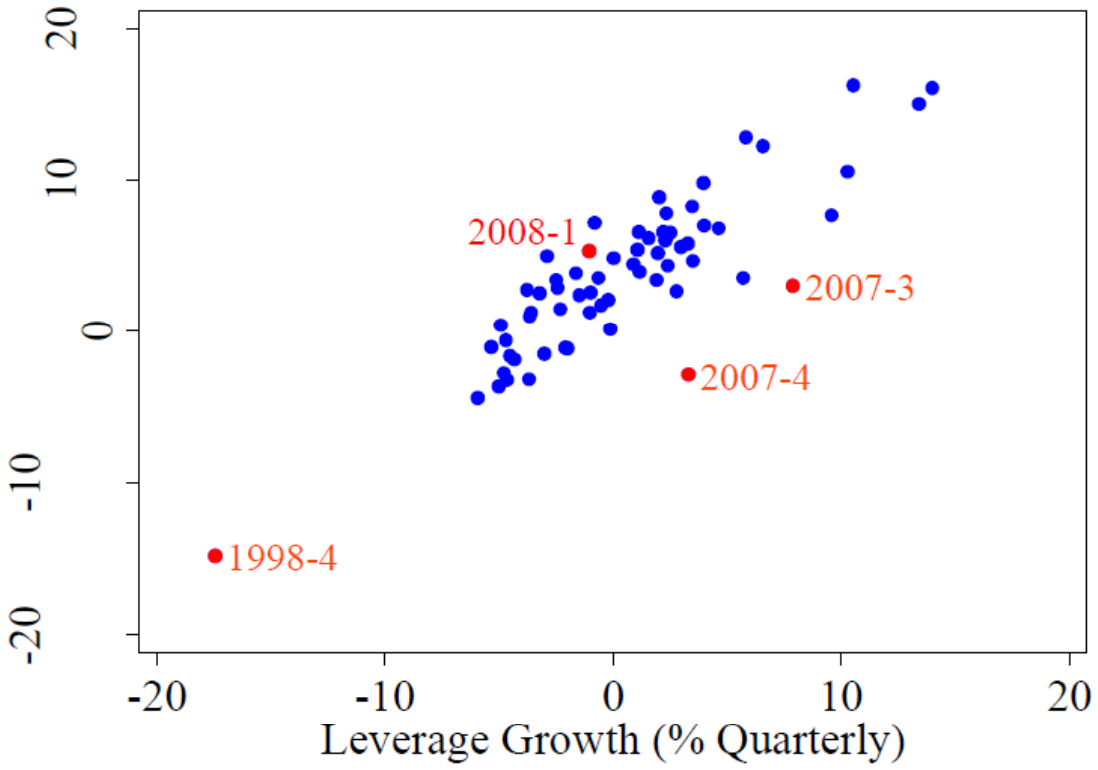
- Most models are procyclical to aggregate demand movements.
- Is this even correct?
- Prior to crisis bank lending channel found to play a limited role in cyclical fluctuations
  - may even dampen shocks during normal periods.
- Gambacorta and Marques-Ibanez (2011) depends on:
  - Core capital positions
  - Dependency on market funding
  - Dependency on non-interest sources of income
  - Degree of securitisation activity

IV. Changes in Commercial Bank Balance Sheets?



Adrian et al. (2012)

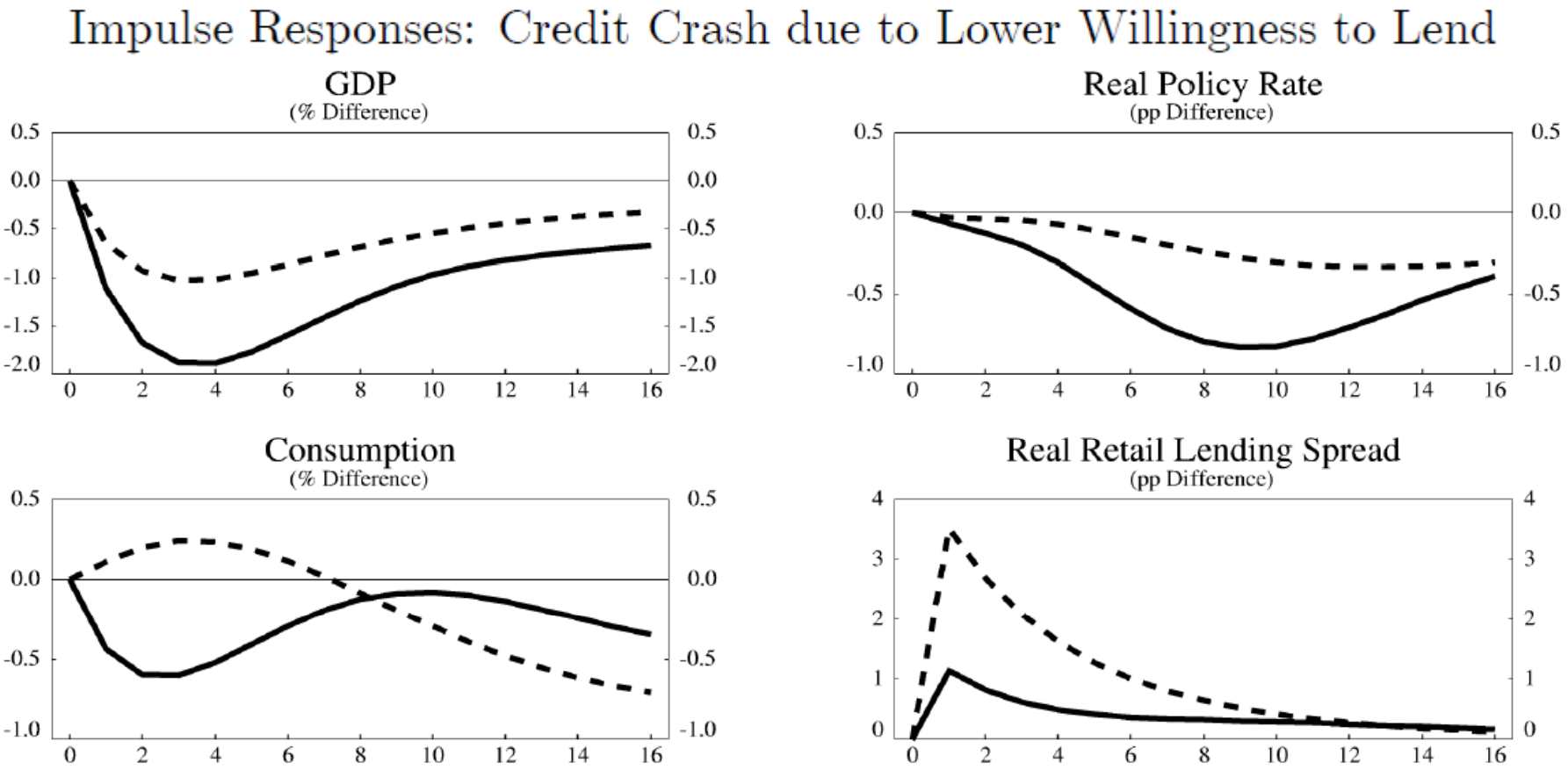
IV. Leverage Growth and Asset Growth of US Investment Banks



Adrian and Shin (2007); Source: SEC

IV. Intermediation versus Credit Creation

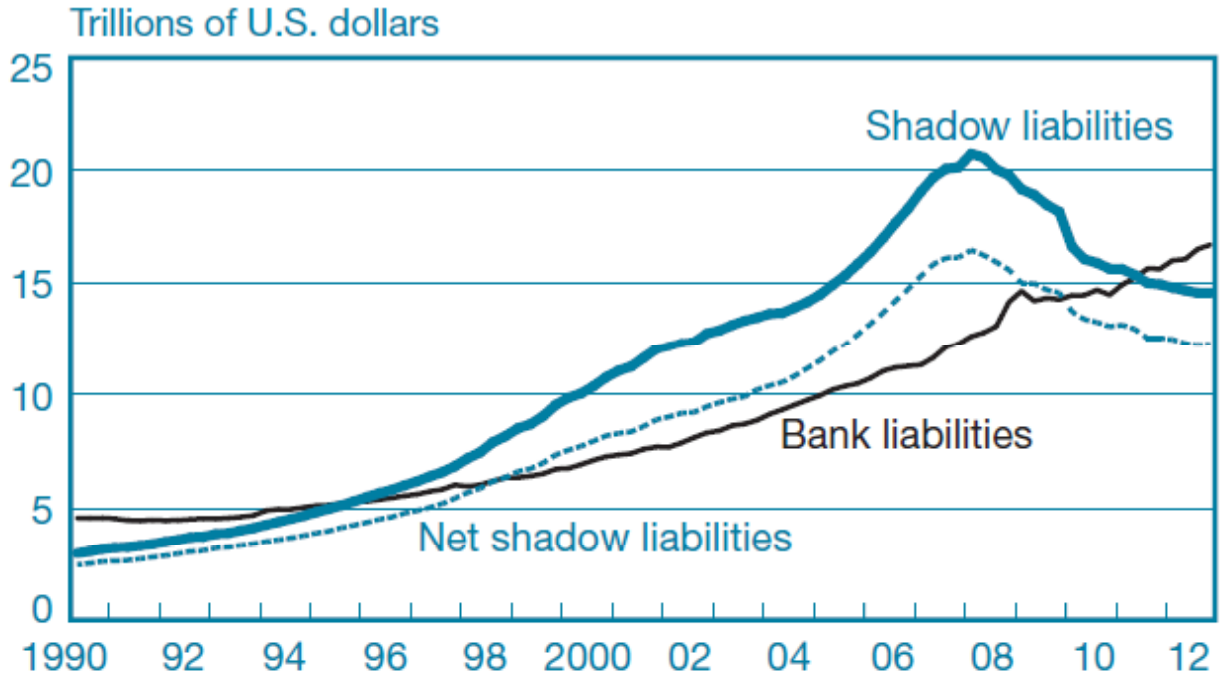
Jakab and Kumhof (2015)



IV. Intermediation versus Credit Creation

- Liabilities are **created and destroyed** anytime credit is extended withdrawn
- Banks alter liability side of balance sheet to expand collateral and assets
- **Risk weighted balance sheet stable** relative to actual size of balance sheet
- **Leverage is counter cyclical** over business cycle because collateral increases in good times even though leverage does not change

IV. Shadow Bank Liabilities versus Traditional Bank Liabilities

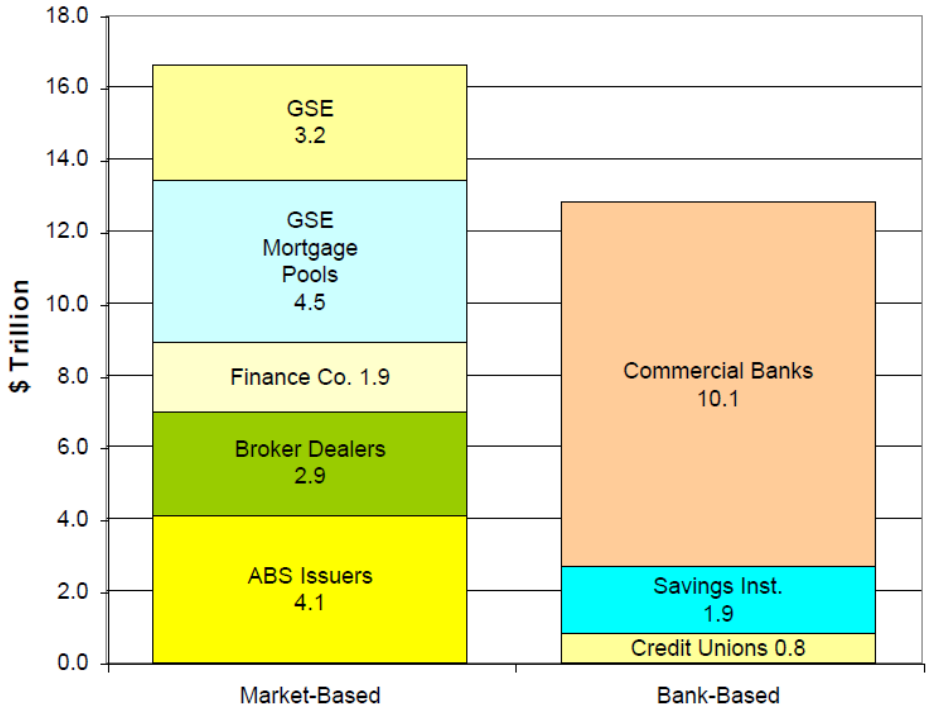


Sources: Board of Governors of the Federal Reserve System, "Flow of Funds Accounts of the United States" (as of 2011:Q3); Federal Reserve Bank of New York.

Source: Pozsar et al. (2012)

IV. Bank versus Non-Bank Financial Instutions

Figure 1. Total Assets at 2007Q2 (Source: US Flow of Funds, Federal Reserve)



Source: Adrian and Shin (2009)

IV. Which frictions matter?

- Which sectors of the financial market matter?
  - Commercial versus financial firms
  - Shadow banks versus commercial banks
  - Interbank markets versus final lending
  - OTC trading versus general assets
- Quantities or prices?
  - The quantities in the balance sheet of banks
  - Maturity mismatch - liquidity risk
  - Information asymmetries – risk mispricing
  - Solvency risk
- Spillover channels?
  - Direct exposure
  - Bank runs
  - Information contagion
  - Fire sales contagion
  - Risk aversion

IV. What is needed?

- Going forward we will need a **general theory**
- Flexible enough to capture **future shocks**
- Captures key **macro linkages**
- Useful for evaluating **policy tools**:
  - Loan-to-value
  - Leverage requirements
  - Capital requirements
  - Risk weights
  - etc?

V. Conclusions

V. Conclusions

- Policy makers have focused on firms demand for credit
  - **Simplistic** in design
  - **Limited** in helpfulness

- The supply side of credit has not yet been satisfactorily developed
  - Focus on financial **intermediation** – commercial banks
  - Disagreement on the **source of shocks**
  - Disagreement on **key channels**

- Going forward we will need a model **flexible** enough to capture future shocks, their key **macro linkages**, and use **policy instruments**

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