DSGE Models and the Role of Finance

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Finance in Macro Models

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Does finance matter?

• Not much?

“Where enterprise leads finance follows.”

Joan Robinson (1952)

• A lot?

“.that financial markets contribute to economic growth is a proposition too obvious for serious discussion.”

Merton Miller (1988)
Some (Contradictory) Views about Finance

- Financial Regulation
  - Deregulation was responsible for the crisis; regulations should be tightened
  - Finance is over-regulated and credit supply is impaired

- Finance and Growth
  - Financial development is important for growth
  - The last useful financial innovation was the ATM

- Finance and Inequality
  - Lack of access to finance creates poverty traps
  - Finance increases income inequality

- Fin-tech and Bitcoins
Financial Contracts

Fundamentals of Financial Contracting
Three Financial Frictions

- Debt overhang, Myers (1977)
- Monitoring & Moral hazard
- Screening & Adverse Selection
Basic Setup

Risk neutral investors, two periods $t = 0, 1$, limited liability

- Legacy assets & liabilities
  - liquidity $m$, assets $a$ with $p \equiv \Pr(a = A^H)$, (long term) debt $D$

- New Investment
  - Invest $k$ to generate *additional* $v = V$ with prob. $q$, otherwise $v = 0$

- Total income at $t = 1$
  $$y = a + v$$

- Borrowing $b$ to close funding gap
  $$b = k - m$$
Moral Hazard: Endogenous $q$

- Ignore existing assets and liabilities ($a = D = 0$): $q$ is $q^H$, or $q^L$ with private benefit $\psi$. Incentive constraint with $y^e$ payment to entrepreneur

$$y^e > y_{\text{min}}^e \equiv \frac{\psi}{q^H - q^L}$$

- Therefore pledgeable income is $q^H (V - y_{\text{min}}^e)$

- Financing constraint is $q^H \left( V - \frac{\psi}{q^H - q^L} \right) > k - m$ and investment condition is

$$m > \hat{m} \equiv k - q^H \left( V - \frac{\psi}{q^H - q^L} \right)$$

- Existing assets can be used as collateral to increase pledgeable income
Adverse Selection

- Quality of existing assets privately known: bad types $a = A^b$, good types $a = A^g$
  - Good types safe, bad types risky

\[ A^b < D < A^g - \frac{k}{q} \]

- Issuance game & security design
  - Myers and Majluf (1984), Nachman and Noe (1994)

- Pooling rate given perceived quality $z$ (fraction of good types)

\[ r(z) = \frac{1}{q + z(1 - q)} \]

- Good types refuses to invest if

\[ rk > qV \]
**Time 1: Credit Market**

![Graph showing the relationship between perceived quality and rate]

- **Perceived Quality ($z$)**: horizontal axis
- **Rate ($r$)**: vertical axis

- **Pooling Rate**: represented by a red line descending from left to right.
- **Limit Rate For Strong Types**: represented by a blue horizontal line.

The graph illustrates the concept of pooling rates and limit rates in a credit market context.
Time 1: Credit Market Equilibrium

Equilibrium Rate

Limit Rate For Strong Types

Perceived Quality $z$
Taking Stock

- Debt overhang: legacy debt can limit/distort investment
- Moral Hazard & Adverse Selection: inside liquidity is important
  - Role for intermediation: monitoring (lower private benefit $\psi$) and screening (acquire information about types)
- Collateralized borrowing: pledging existing assets to fund new investment
  - financial sophistication determines what can be collateralized (e.g., patents in the US)
  - adverse selection can limit pledgeability of existing assets
- How much are agents willing to pay for intermediation?
Measuring Financial Intermediation

Philippon (2015)
Price and Quantity of Financial Intermediation

• Price

\[ u = r + \psi \]

- User cost of borrowers, expected return of savers
- Unit cost of intermediation: \( \psi \)

• Quantity

- Household finance \( b_c \)
- Corporate finance \( b_k, e_k \)
- Liquidity services \( m \)
Traditional Banking

Quantity Intermediated = 100
Net interest income = 2
Unit cost = 2%
Modern Finance

A new division of labor:
- Monitoring and screening fee = 1
- Asset management fee = 0.5
- Credit risk hedging cost = 0.5

Sum all wages and profits = 2
Income Share of Finance Industry
Neoclassical Growth with Intermediation

- Households’ consumption and liquidity services: $u(c_t, m_t)$, life cycle borrowing/lending
- Costs of intermediation services
  - $\psi_m$ for liquid assets, $\psi_c$ for households credit, $\psi_k$ for firm credit
- Non financial businesses
  - User cost
    $$k^\alpha = \frac{1 - \alpha}{r + \delta + \psi_k},$$
- Financial intermediation income
  $$y^f_t = \psi_c b_{c,t} + \psi_m m_t + \psi_k k_t,$$
Aggregation

- **Assumption: Constant Relative Costs**: \( \psi_{i,t} = \mu_i \psi_t \), with the normalization \( \mu_c = 1 \).
- Quantity of assets

\[
q_t \equiv b_{c,t} + \mu_m m_t + \mu_k k_t,
\]

- Estimate the \( \mu' \)'s with micro data on rates, returns and issuance costs
Intermediated Assets & Services

- Business Credit & Equity
- Household Credit
- Liquidity Services
- M&As
Financial Intermediation (in the U.S.)

Source: Philippon (AER, 2015)
Unit Cost in the U.S.

Raw Unit Costs

Source: Philippon (AER, 2015)
Unit Costs, Global Comparison

Figure 2.5.1: National unit cost (4-year moving average)

Source: Bazot (2013)

Note: US unit cost from Philippon (2012), level estimation. The US series does not use bank capital gains. Unit costs calculation details for Germany, France and the UK are provided in the preceding paragraphs of this section.
Constant Returns to Scale

More Intermediation

Quantity Intermediated = 200
Intermediation cost = 4
Unit cost = 2%
Evidence of Constant Returns to Scale

Notes: Series normalized to one in 1950
Quality Adjustments with Heterogenous Borrowers

Intermediate cost = 6
Intermediated Quantities? 100 + 100 + 100 = 300
Unit Cost? 6/300 = 2%
Corporate Finance

- Heterogenous inside equity (retained earnings) $x$. Monitoring $\mu$ to prevent cash flow diversion.
  - IC constraint, etc.
- Aggregate monitoring

$$\bar{\mu}_t = \mu_h + (1 + r)(x_h - x_l)s_t,$$

where $s \equiv \frac{k_l}{k_l + k_h}$

- Income from corporate finance intermediation

$$y_{k,t}^f = \phi_t k_t + \zeta_t \bar{\mu}_t.$$

where $\phi$ is an asset management fee
Household Finance

- Heterogenous labor endowment $\eta \sim F(.)$
- Credit: marginal cost $\varphi$, fixed cost $\kappa w$
  - Participation for $\eta > \hat{\eta}$
  - Household debt market
    \[
    \bar{b}_c \frac{1}{w} = \frac{1}{2 + r} \int_{\eta > \hat{\eta}} \left( \left( \lambda - (1 - \varphi)^{-1} \right) \eta - \kappa \right) dF(\eta)
    \]
  - Income
    \[
    y_{c,t}^f = \varphi \bar{b}_{c,t} + \kappa_t w (1 - F(\hat{\eta}_t)).
    \]
## Calibration

<table>
<thead>
<tr>
<th></th>
<th>Rate</th>
<th>Deprec.</th>
<th>Growth</th>
<th>Labor Sh.</th>
<th>CRRA</th>
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<table>
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<th>Low cash</th>
<th>Asset Mgt Fee</th>
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<td>( x_h )</td>
<td>0.62</td>
<td>0.1</td>
<td>0.01</td>
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<tr>
<td>( x_l )</td>
<td>0.1</td>
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## Calibration

### Moments

<table>
<thead>
<tr>
<th>B</th>
<th>Cost share</th>
<th>HH D</th>
<th>Frac</th>
<th>Top 20</th>
<th>Liquid</th>
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<tr>
<td>$\bar{b}_k/y$</td>
<td>$\varphi + \zeta \frac{\bar{b}_k}{b}$</td>
<td>s</td>
<td>$\bar{c}_k/y$</td>
<td>$1 - F(\hat{\eta})$</td>
<td>...</td>
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<tr>
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<td>0.0205</td>
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<td>0.84</td>
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<td>0.0208</td>
<td>0.199</td>
<td>0.73</td>
<td>0.84</td>
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### Implied Parameters

<table>
<thead>
<tr>
<th>Monit</th>
<th>Firms</th>
<th>Slope</th>
<th>Ineq.</th>
<th>Fix</th>
<th>Liq D</th>
<th>Liq S</th>
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<tbody>
<tr>
<td>$\zeta = \frac{r}{3.3}$</td>
<td>$\frac{k_h}{k^*} = 0.622$</td>
<td>$\lambda = 2.07$</td>
<td>$H = 0.875$</td>
<td>$\kappa = 0.023$</td>
<td>$v = 0.0181$</td>
<td>$\psi_m = 0.019$</td>
</tr>
</tbody>
</table>
Calibrated Model

A. Corp. Finance Income Share

B. Corporate Debt / GDP

C. Corporate Adjustment

D. Participation

E. Household Debt / GDP

F. Household Adjustment Factor
Quality-Adjusted Quantity of Intermediation

The graph shows the quality-adjusted quantity of intermediation over time, from 1880 to 2000. The data is represented by different lines:

- **Assets** (green line)
- **Firm Adj.** (red line)
- **Firm & HH. Adj.** (blue line)

The x-axis represents the years, while the y-axis measures the quantity of intermediation.
Adjusted Unit Cost

![Graph of Adjusted Unit Cost over time showing trends from 1880 to 2000. The graph includes lines for Raw, Firm Adj., and Firm & HH Adj. costs.](image-url)
Dynamics

Macro-Finance Dynamics
Asset Pricing, Cochrane (2017)

- Equity premium 6%
  - Just as likely to be 1% (in good times) or 11% (in bad times)
- Pricing kernel

\[ \Lambda_{t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} \Xi_{t+1} \]

- Aggregate consumption growth not volatile enough, \( \gamma = 25 \) is just silly.
- \( \Xi_{t+1} \) needed. Cochrane (2017) reviews 10 models, including: Habits, LR risk with EZ preferences, disasters, ambiguity aversion, behavioral biases
Epstein-Zin Recursive Utility

- An important class of recursive utility function uses a CES aggregator ($\varepsilon$) where risk aversion is $\gamma$

$$U_t = \left( (1 - \beta) C^{1-\varepsilon} + \beta \left( \mathbb{E}_t \left[ U_{t+1}^{1-\gamma} \right] \right)^{\frac{1-\varepsilon}{1-\gamma}} \right)^{\frac{1}{1-\varepsilon}}$$

- This leads to a pricing kernel

$$\Lambda_{t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{-\varepsilon} \left( \frac{U_{t+1}}{\left( \mathbb{E}_t \left[ U_{t+1}^{1-\gamma} \right] \right)^{\frac{1}{1-\gamma}}} \right)^{\varepsilon-\gamma}$$

- Typical calibration of long run risk model à la Bansal and Yaron (2002) has $\varepsilon$ close to 1 and $\gamma > 1$
- Household worried not only about bad news to consumption but also to future utility
- See also Cochrane’s discussion of disaster risk
Friction-less Benchmark: Q-Theory

- Firm value
  \[ V_t = \mathbb{E}_t \left[ \sum_{j=0}^{\infty} \Lambda_{t,t+j} \Pi_{t+j} \right] \]

- Capital accumulation
  \[ K_{t+1} = (1 - \delta_t) K_t + I_t \]

- Dividends & Adjustment Costs
  \[ \Pi_t = R_{k,t} K_t - P_{k,t} I_t - \frac{\varphi_k}{2} P_{k,t} K_t \left( \frac{I_t}{K_t} - \delta_t \right)^2 \]
Friction-less Benchmark: Q-Theory

- Recursive

\[ V_t(K_t) = \max_{l_t} \Pi_t + \mathbb{E}_t [\Lambda_{t+1} V_{t+1}(K_{t+1})] \]

- Define \( \mathcal{V}_t \equiv \frac{V_t}{K_t} \) and net investment \( x_t \equiv \frac{l_t}{K_t} - \delta \):

\[ \mathcal{V}_t = \max_x R_{k,t} - P_{k,t} (x_t + \delta_t) - \frac{\phi_k}{2} P_{k,t} x_t^2 + (1 + x_t) \mathbb{E}_t [\Lambda_{t+1} \mathcal{V}_{t+1}] \]

- FOC \( P_{k,t} (1 + \phi_k x_t) = \mathbb{E}_t [\Lambda_{t+1} \mathcal{V}_{t+1}] \) can be written as

\[ x_t = \frac{1}{\phi_k} \left( Q^k_t - 1 \right) \]

where

\[ Q^k_t \equiv \frac{\mathbb{E}_t [\Lambda_{t+1} \mathcal{V}_{t+1}]}{P^k_t} = \frac{\mathbb{E}_t [\Lambda_{t+1} V_{t+1}]}{P^k_t K_{t+1}} \]
Tobin’s $q$ and Investment
Q-Theory: Bonds vs Stocks, Philippon (2009)

- Let $e_t = \frac{\mathbb{E}_t[\Lambda_{t+1} V_{t+1}^e]}{P_t^k K_{t+1}}$ and $b_t = \frac{\mathbb{E}_t[\Lambda_{t+1} V_{t+1}^b]}{P_t^k K_{t+1}}$ for equity and bonds

$$q_t = e_t + b_t$$

- Suppose you observe $b_t$: can you re-construct $q_t$? Leland (1994) and Leland (1998): debt with coupon $c$ and average maturity $1/\phi$. One unit of principal at $t$ repays

$$c + \phi \quad (1 - \phi)(c + \phi) \quad \ldots \quad (1 - \phi)^{\tau-t-1}(c + \phi) \quad \ldots$$

- Risk “neutral” debt pricing, with book leverage $l$, in state $\omega$:

$$b(\omega) = \frac{1}{1 + r(\omega)} E^{\pi} \left[ \min \left\{ (c + \phi) l + (1 - \phi) b(\omega'); \mathcal{V}(\omega') \right\} \right] | \omega$$
Bond \( q \) and Investment, Philippon (2009)

Figure 1: Tobin's \( q \) and the price of corporate bonds relative to treasuries.
Bond $q$ and Investment, Philippon (2009)
Models with Financial Frictions

- **Financial Accelerator**
  - Financial frictions can amplify and propagate macroeconomic shocks

- **First generation:** Backward loop, Bernanke and Gertler (1989); Bernanke et al. (1999)
  - Based on simple moral hazard model: dynamics of cash on hand
  - Bad shock: \( m_t \downarrow \rightarrow K_{t+1} \downarrow \rightarrow m_{t+1} \downarrow \)

- **Second generation:** Forward loop, Kiyotaki and Moore (1997)
  - Collateralized borrowing by “specialists”
    \[
    B_t \leq \theta_t Q_t K_{t+1}
    \]
  - Second best use of capital and fire sales: if constraint binds, \( K \) needs to be operated by non-specialists, and \( Q \) goes down
  - Bad shock: \( Q_t \downarrow \rightarrow K_{t+1} \downarrow \rightarrow Q_{t+1} \downarrow \)
  - But \( Q \) is forward looking \( Q_t \downarrow \leftarrow E_t [Q_{t+1}] \downarrow \)
Intermediary-Driven Crisis

- The 2008-2009 crisis centered around financial intermediaries
Intermediary-Driven Crisis
Intermediary-Driven Crisis

- New models focused on financial intermediaries, such as He and Krishnamurthy (2012) and Gertler and Kiyotaki (2013).
  - Banker with survival probability $\sigma$ maximizes
    \[ V_t = \mathbb{E}_t [\Lambda_{t+1} ((1 - \sigma) n_{t+1} + \sigma V_{t+1})] \]
    subject to budget constraint
    \[ Q_t k_t = d_t + n_t \]
    and incentive/collateral constraint
    \[ \theta Q_t k_t \leq V_t \]
  
- Promised rate on deposits is $R_t$ so
  \[ n_t = (Z_t + Q_t) k_{t-1} - R_t d_{t-1} \]
Discussion

• What we get from Gertler and Kiyotaki (2013)
  - value function is linear in net worth $V_t = \nu_t n_t$, so aggregation is straightforward
  - key choice for intermediary is leverage $\frac{Q_t k_t}{n_t}$
  - recessions driven by liquidity and intermediation risk

• Notes
  - What is missing from Fig 1 in GG?
  - What is the link between $\Xi$, time varying risk aversion, and the Gilchrist-Zakrajsek EBP (excess bond premium)?
A Prototypical Crisis Model

- The basic elements of a modern financial crisis model are:
  - Output depends on asset price
    \[ Y = Y(Q) \leq Y^* \]
  - Asset price is forward looking
    \[ Q = \frac{\mathbb{E}[Z' + Q']}{{R_k}} \]
  - Risk spread increases with intermediary distress
    \[ s = R_k - r \]
  - Monetary policy is constrained
    \[ r \geq 0 \]
Intermediary-Driven Crisis

![Graph showing excess bond premium and GDP over time](image)
• Most macro finance of the 1990’s models had representative agent. Action was on firm side
• Household balance sheet were important in the crisis. Two classes of models
  - Two agents with different $\beta$ Eggertsson and Krugman (2012)
  - Bewley-style models Kaplan and Violante (2011)
Greece: A Macro-Financial Tragedy
Three Financial Frictions

• In 2007, Greek GDP per capita was around 22,600 euros and the unemployment rate was 8.4%.

• In 2014, Greek GDP per capita was around 17,000 euros and the unemployment rate was 26.6%

• What happened?
Benchmarking: the Comparison Group

- **Sudden Stops**
  - Combination of capital flow reversal & large drop in domestic output
  - 49 sudden stops

- **Sovereign Defaults**
  - from Gourinchas & Obstfeld (2012) based on literature
  - default on domestic or external debt
  - 65 default episodes

- **Lending booms/busts**
  - defined as in Gourinchas et al (2001)
  - deviation of credit/output from trend
  - 114 boom/busts
# The Incidence of Crises

<table>
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<tr>
<th>Sudden Stop</th>
<th>Defaults</th>
<th>Credit Booms</th>
<th>‘Trifecta’</th>
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<tbody>
<tr>
<td>AE</td>
<td>13</td>
<td>18</td>
<td>Greece</td>
<td>22</td>
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<tr>
<td>EM</td>
<td>36</td>
<td>96</td>
<td>Greece</td>
<td>57</td>
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<tr>
<td>Total</td>
<td>49</td>
<td>114</td>
<td>10</td>
<td>79</td>
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Benchmarking 1: GDP Relative to All Sudden Stops

**Real Output per capita relative to t-2 (100-log points)**

- **Sudden Stop**
- **Greece (2010)**
Benchmarks 1: Aggregate Domestic Investment/Output

Investment/Output relative to t-2 (100-log points)

Sudden Stop vs. Greece (2010)
Benchmarking 2: Other Crises

Output per capita relative to t-2 (log points)

Sovereign Default? Credit Bust?... Trifecta
Benchmarking 3: Compared to EM Floaters & Peggers
Benchmarking 4: Endogenous Peg?

Output per capita relative to $t-2$, EME sudden stops (log points)
Empirical Lessons

1. Greek crisis significantly more severe persistent and backloaded than typical sudden stop
2. Greek crisis significantly more severe persistent and backloaded than ‘Trifecta’ episodes
3. Greek crisis more severe than for peggers (even Estonia or Latvia)
4. Collapse in aggregate investment unprecedented in its persistence and magnitude
Model

- Small Open Economy in a currency union \((r, \pi^F)\) exogenous
- Standard NK DSGE à la Galì (2011) with financial frictions
  - Government \((B^g, T, G, r^g)\)
  - Banks \((V, r^d)\)
  - Households \((B^h, C, r^h)\)
  - Firms \((I, K, r^k)\)
- Various shocks
  \[ \zeta_t^# = \rho^# \zeta_{t-1}^# + \sigma^# \varepsilon_t^# \]
Government

- Budget constraint

\[
\frac{B_t^g}{R_t^g} + \tau_t Y_t = G_t + T_t + \frac{B_{t-1}^g}{\Pi_t^H}
\]

- Fiscal rule (spending and social transfers)

\[
g_t = F_l g_{t-1} - F_n n_t - F_r r_t^g - F_b b_t^g + \zeta^{\text{spend}}_t
\]

- Tax rate

\[
\tau_t = \bar{\tau} + \zeta^{\text{tax}}_t
\]

- Government funding cost

\[
\begin{align*}
r_t^g &= r_t + d_t^g \\
d_t^g &= \bar{d}_t \frac{B_t^g}{Y} \left( b_t^g - \mathbb{E}_t [y_{t+1}] - \mathbb{E}_t \left[ \pi_{t+1}^h \right] \right) + \zeta_{tg}
\end{align*}
\]
Households

\[ U^i = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_t^i \left( \frac{(C_t)^{1-\gamma}}{1-\gamma} - \frac{(N_t)^{1+\phi}}{1+\phi} \right) \quad ; \quad C_t^i \equiv \left[ (1-\omega)^{\frac{1}{\epsilon_h}} C_{H,t}^{\frac{i}{\epsilon_h}} + \omega^{\frac{1}{\epsilon_h}} C_{F,t}^{\frac{i}{\epsilon_h}} \right]^{\frac{\epsilon_h}{\epsilon_h-1}} \]

- **Borrowers**, mass \( \chi \), \( B_t^h \leq \bar{B}_t^h \),

\[
P_t C_t^b = (1 - \tau_t) W_t N_t^b + \frac{P_{H,t} B_t^h}{R_t^h} - (1 - d_t^p) P_{H,t-1} B_{t-1}^h + P_{H,t} T_t^b
\]

\[
d_t^p = -\bar{d}_y y_t + \bar{d}_b b_t^h + \zeta_t^{\text{def}}
\]

\[
\bar{b}_t^h = \psi_{bh} \bar{b}_{t-1}^h - \xi^{bh} r_t + \zeta_t^{bh}
\]

- **Savers**, \( \beta > \beta_b \) (mass \( 1 - \chi \)),

\[
P_t C_t^s = (1 - \tau_t) W_t N_t^s + \tilde{R}_t P_{H,t-1} S_{t-1} - P_{H,t} S_t + P_{H,t} T_t^s
\]
Non-Financial Firms

- Capital-producing firms:
  - Q theory
- Goods-producing firms:
  - Convert capital and labor into goods.
  - Cobb-Douglas with constant TFP.
  - Financing friction: pay part of wage bill in advance.
    Intra-period loan with funding cost $r^k$. 
Price and Wage Rigidity

- Wage-calvo process yields a Phillips curve for wages
  \[ \pi_w^t = \beta E_t \pi_{t+1}^w - \lambda_w (w_t - \gamma c_t - \varphi n_t) + \zeta_w^t \]

- Price-calvo process yields a Phillips curve for domestic prices
  \[ \pi_h^t = \beta E_t \pi_{t+1}^h + \lambda_p m c_t + \zeta_{\pi h}^t, \]
  where \( m c_t \) is log real marginal cost in terms of domestic goods.
- \( \zeta_w^t : \) wage markup shock, \( \zeta_{\pi h}^t : \) domestic price markup shock
Banks

- Domestic deposits and foreign loans
- Lend to households, firms and government
- Subject to capital requirement

\[ V_t \geq \kappa \left( \frac{B^k_t}{R^k_t} + \frac{B^h_t}{R^h_t} \right) \]

where \( V_t \) is franchise value.

- No capital requirement for sovereign exposure
- Bank funding costs

\[ r^d_t = r_t + \zeta^r t + \xi^d L_{t} [d^p_{t+1}] \]
Summary of Funding Costs

- Key equations
  - Funding cost: banks $\rightarrow$ households & firms
    \[ r_t^k = r_t^d \]
  - Banks: sudden stop and capital loss
    \[ r_t^d = r_t + \zeta_t^{rd} + \xi_t^d L \mathbb{E}_t \left[ d_{t+1}^p \right] \]
    \[ d_t^p = -\bar{d}_y y_t + \bar{d}_b b_{t-1} + \zeta_t^{def} \]
  - Government
    \[ r_t^g = r_t + d_t^g \]
    \[ d_t^g = \bar{d}_g \frac{B^g}{\Upsilon} \left( b_t^g - \mathbb{E}_t [ y_{t+1} ] - \mathbb{E}_t \left[ \pi_{t+1}^h \right] + \zeta_t^{dg} \right) \]
  - Households
    \[ r_t^h = r_t^d + \mathbb{E}_t \left[ d_{t+1}^p \right] \]
No direct doom loop, but indirect GE feedback loops:

- **Sovereign risk shock** $\zeta^{dg}_t$:
  - Government funding costs increase $\rightarrow$ Government raises taxes and reduces expenditure $\rightarrow$ Output declines $\rightarrow$ Expected costs of default on private-sector loans increase $\rightarrow$ Funding costs for private sector increase and investment drops.

- **Sudden stop** $\zeta^{rd}_t$:
  - Funding costs for private sector increase $\rightarrow$ Output and investment drop $\rightarrow$ Fiscal revenues drop $\rightarrow$ Expected costs of default on sovereign loans increase $\rightarrow$ Government funding costs increase.
Impulse Response: Sovereign Risk Shock

Sov Risk

Output: Saver vs Borrower

Consumption: Saver vs Borrower

Investment

Employment

Funding Cost: rk vs zrd

Sovereign Yield

NPL/Total Loans

Inflation

Govt Finance: Rev. vs Spend.

Govt Debt

Household Debt

Current Account/GDP

Years

Years

Years

Years
Impulse Response: Sudden Stop

- Output
- Consumption
- Investment
- Employment
- Funding Cost
- Sovereign Yield
- NPL/Total Loans
- Inflation
- Govt Finance
- Govt Debt
- Household Debt
- Current Account/GDP
Bayesian Estimation of the Model

- Standard techniques (Herbst & Schorfheide (2015))
- Period: 1999 to 2015
- Calibrate steady state parameters
- Estimate dynamic parameters

<table>
<thead>
<tr>
<th>Observable</th>
<th>Description</th>
<th>Shock</th>
<th>Shock Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G_t + T_t$</td>
<td>Government spending</td>
<td>$\zeta_t^{spend}$</td>
<td>Govt. spending shock</td>
</tr>
<tr>
<td>$t_t Y_t$</td>
<td>Government revenues</td>
<td>$\zeta_t^{tax}$</td>
<td>Tax rate shock</td>
</tr>
<tr>
<td>$R_t^g$</td>
<td>Greek government spread over EZ average</td>
<td>$\zeta_t^{dg}$</td>
<td>Sovereign risk shock</td>
</tr>
<tr>
<td>$R_t^k$</td>
<td>SME spread over EZ average</td>
<td>$\zeta_t^{r}$</td>
<td>Funding cost shock</td>
</tr>
<tr>
<td>$\exp(d_t^p)$</td>
<td>Non-performing loans/total loans, $def = npl$</td>
<td>$\zeta_t^{def}$</td>
<td>Private default shock</td>
</tr>
<tr>
<td>$\Pi_t$</td>
<td>Greece CPI - EZ CPI</td>
<td>$\zeta_t^{\pi h}$</td>
<td>PPI cost push shock</td>
</tr>
<tr>
<td>$B_t^h$</td>
<td>Household debt</td>
<td>$\zeta_t^{bh}$</td>
<td>Household credit shock</td>
</tr>
<tr>
<td>$\Pi_t^w$</td>
<td>Greek Wage Inflation - EZ Wage Inflation</td>
<td>$\zeta_t^{w}$</td>
<td>Wage inflation shock</td>
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</tbody>
</table>

Table: Observables and Shocks
### Calibrated Parameters-I

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>Discount Factor</td>
<td>0.97</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Capital Share</td>
<td>1/3</td>
</tr>
<tr>
<td>$\varepsilon_h$</td>
<td>Elasticity between H and F</td>
<td>1</td>
</tr>
<tr>
<td>$\varepsilon_f$</td>
<td>Elasticity between exports</td>
<td>1</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>Inverse labor supply elasticity</td>
<td>1</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Risk Aversion</td>
<td>1</td>
</tr>
<tr>
<td>$\vartheta$</td>
<td>Price Stickiness</td>
<td>0.5</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>Elasticity of Substitution Goods</td>
<td>6</td>
</tr>
<tr>
<td>$\vartheta_w$</td>
<td>Wage Stickiness</td>
<td>0.5</td>
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<tr>
<td>$\varepsilon_w$</td>
<td>Elasticity of Substitution Labor</td>
<td>6</td>
</tr>
<tr>
<td>$\varepsilon_r$</td>
<td>Elasticity of R to NFA</td>
<td>0.0001</td>
</tr>
<tr>
<td>$\varphi_k$</td>
<td>Adjustment Cost</td>
<td>1</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation</td>
<td>0.07</td>
</tr>
<tr>
<td>$FC$</td>
<td>Fixed cost of production, 10% of Y</td>
<td>0.0955</td>
</tr>
</tbody>
</table>
## Calibrated Parameters-II

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>$\varpi$</td>
<td>Openness (Martin and Philippon (2014))</td>
<td>0.3</td>
</tr>
<tr>
<td>$\chi$</td>
<td>Fraction of Impatient (Martin and Philippon (2014))</td>
<td>0.65</td>
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<tr>
<td>$\Delta$</td>
<td>Annual lending spread of 2%</td>
<td>1.02</td>
</tr>
<tr>
<td>$\bar{B}^h_Y$</td>
<td>Household debt to GDP of 50%</td>
<td>0.5</td>
</tr>
<tr>
<td>$B^g_Y$</td>
<td>Government debt to GDP of 120%</td>
<td>1.2</td>
</tr>
<tr>
<td>$G_Y$</td>
<td>Government consumption to GDP of 20%</td>
<td>0.2</td>
</tr>
<tr>
<td>$T_Y$</td>
<td>Public social expenditure to GDP of 20%</td>
<td>0.2</td>
</tr>
<tr>
<td>$\bar{d}^h$</td>
<td>Steady state default rate for Households</td>
<td>5.4%</td>
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<tr>
<td>$\bar{d}^k$</td>
<td>Steady state default rate for Corporates</td>
<td>5.4%</td>
</tr>
<tr>
<td>$B^k_Y$</td>
<td>Corporate debt to GDP of 50%</td>
<td>0.5</td>
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<tr>
<td>$\psi_{sk}$</td>
<td>Working Capital Constraint</td>
<td>1</td>
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<tr>
<td>$\tau$</td>
<td>Tax rate, budget balance in SS</td>
<td>0.436</td>
</tr>
<tr>
<td>$L$</td>
<td>Leverage scaling</td>
<td>1</td>
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</table>
### Calibrated Parameters-III

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>$F_b$</td>
<td>Elasticity of govt. spending to public debt</td>
<td>0.05</td>
</tr>
<tr>
<td>$F_n$</td>
<td>Elasticity of govt. spending to employment</td>
<td>0.025</td>
</tr>
<tr>
<td>$F_r$</td>
<td>Elasticity of govt. spending to the int. rate</td>
<td>0.5</td>
</tr>
<tr>
<td>$F_l$</td>
<td>Persistence of govt. spending</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Data Inputs
Decomposition of Output and Investment
Decomposition of Sovereign Debt

Govt. Debt

- Spending
- Tax
- Credit Demand
- Sudden Stop
- Priv. Def.
- Sov. Risk
- Markup
- Wage Markup

Decomposition of Private Default

Chart showing the decomposition of private default over the years 2000 to 2015. The chart includes categories such as spending, tax, credit demand, sudden stop, private default, sovereign risk, markup, and wage markup.
Decomposition of Government Spending

Govt. Spending

- Spending
- Tax
- Credit Demand
- Sudden Stop
- Priv. Def.
- Sov. Risk
- Markup
- Wage Markup


Spending range: -0.2 to 0.4
Key Lessons

• Fiscal trajectory prior to 2009 unsustainable. Stimulates output initially, but depresses it later on.
• First phase of the crisis (2009-2013)
  - Sovereign risk
  - Sudden stop
• Second phase of the crisis (2013-..)
  - Non-performing loans
  - Price markups.
4 Counterfactual Exercises

1. Low leverage (EME leverage)
2. Banking union
3. Fiscal discipline
4. Price flexibility (Latvia)
## Counterfactual I: EME Leverage

<table>
<thead>
<tr>
<th></th>
<th>Greece</th>
<th>Typical EME</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit / GDP</td>
<td>1.01</td>
<td>0.46</td>
<td>0.025</td>
<td>1.46</td>
</tr>
<tr>
<td>Sovereign Debt / GDP</td>
<td>1.38</td>
<td>0.343</td>
<td>0.063</td>
<td>0.68</td>
</tr>
<tr>
<td>Current Account / GDP</td>
<td>-0.083</td>
<td>-0.039</td>
<td>-0.10</td>
<td>+0.17</td>
</tr>
</tbody>
</table>

**Table:** Leverage and Imbalances Before Sudden Stop

**Notes:** Average from t-6 to t-2 where t is sudden stop.
Counterfactual I: EME Leverage

GDP

Investment

Current Account/GDP

Govt. Spending

Data
CFact
Model
Counterfactual II: Banking Union

GDP

Investment

Current Account/GDP

Govt. Spending

Data
CFact
Model
Counterfactual III: No Discretionary Spending

GDP

Investment

Current Account/GDP

Govt. Spending
Counterfactual V: Low Price Stickiness

GDP

Investment

Current Account/GDP

Govt. Spending

Data
CFact
Model
Greece, Conclusion: What Would Have Helped?

- What we can say
  - Exposure Y+10%, I+15%
  - Banking union Y+10%, I+30%
  - Sound fiscal Y+15%, I+20%
  - More flexible prices Y+15%, I+20%

- Open issues
  - Uncertainty (political, EZ risk)?
  - Early sovereign default?
  - Devaluation?
Systemic Risk
Systemic Risk (with Acharya, Pedersen, and Richardson)

- Need to avoid two pitfalls
  - Too narrow: only leveraged, short-term wholesale-funded banks are systemic
  - Too broad: “Everything is systemic”

- Not much consensus beyond banking
  - Are insurance companies systemic?
  - Asset managers?

- Regulatory approach
  - Size + Interconnectedness + Substitutability

- Our initial approach (2010)
  - Systemic risk when aggregate capital shortfall
  - Tax/regulate contribution to shortfall → SES
Basic Model of Systemic Risk

- $J$ financial firms, $i = 1, \ldots, J$, two dates $t = 0, 1$, normalize $r^f = 0$
- Time 0
  $$a_i = w_{i,0} + b_i$$
- Time 1, random gross return $q$
  $$w_i = q_i a_i - d_i$$
- Debt priced fairly
  $$b_i = \mathbb{E}[\min(q_i a_i, d_i)]$$
Basic Model of Systemic Risk

- Firm $i$’s problem

$$U_i = \max_{d_i, q_i} \mathbb{E}[\max(q_i a_i - d_i; 0) - w_i, 0 - \tau_i]$$

- Regulator cares about aggregate externality:

$$\max_{\{\tau_i\}_{i=1}^J} \sum_{i=1}^J U_i + \mathcal{E}$$

s.t.

$$\mathcal{E} \equiv -e\mathbb{E}[1_{W - \kappa A}(\kappa A - W)].$$
Reduced Form Externality

\[ A = \sum_{i=1}^{N} a^i \]

\[ W^* = kA \]

Externality \( e(W^* - W) \)

k? more later.
Optimal Pigouvian tax

Proposition
In the simple model with exogenous externality, the efficient outcome is obtained by a tax

$$\tau_i = e \times \Pr(W < \kappa A) \times MES_i + \tau_0$$

where the **systemic expected shortfall** is defined by

$$MES_i \equiv \mathbb{E} [\kappa a_i - w_i | W < \kappa A]$$

- Look for MES at https://vlab.stern.nyu.edu
BAC MES
MES & SCAP
Measuring Leverage Not Easy
Liquidity & Maturity

Source: Hanson, Shleifer, Stein, Vishny, 2014
Bank Capital Regulations

- Identify four constraints on bank equity
- Equity per $1 of asset
  - Risk based capital (RBC): $k_{RBC} \times w_i$, capital requirement * risk weight
  - Supplementary leverage ratio (SLR): $k_{SLR}$
  - Post stress RBC: $k_{RBC,STRESS} \times w_i + NLR_i$, RBC + net loss rate
  - Post stress SLR: $k_{SLR,STRESS} \times w_i + NLR_i$
- GS more likely to be bound by SLR, while WF bound by RBC
## Required Capital Ratios

<table>
<thead>
<tr>
<th>G-SIBs:</th>
<th>Tier 1 Ratio</th>
<th>SLR</th>
<th>CCAR Tier 1 Ratio</th>
<th>CCAR SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPMorgan Chase</td>
<td>12.0</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Bank of America</td>
<td>11.5</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Citigroup Inc.</td>
<td>11.5</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>11.5</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Goldman Sachs</td>
<td>11.0</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Wells Fargo</td>
<td>10.5</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Bank of New York Mellon</td>
<td>10.0</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>State Street</td>
<td>10.0</td>
<td>5.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Large BHCs:</th>
<th>Tier 1 Ratio</th>
<th>SLR</th>
<th>CCAR Tier 1 Ratio</th>
<th>CCAR SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Bancorp</td>
<td>8.5</td>
<td>3.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>PNC Financial Services</td>
<td>8.5</td>
<td>3.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Capital One Financial</td>
<td>8.5</td>
<td>3.0</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>HSBC North America</td>
<td>8.5</td>
<td>3.0</td>
<td>6.0</td>
<td>3.0</td>
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<tr>
<td>TD Group US</td>
<td>8.5</td>
<td>3.0</td>
<td>6.0</td>
<td>3.0</td>
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</table>
## Distance from Requirements

<table>
<thead>
<tr>
<th></th>
<th>Distance from Requirement (%)</th>
<th>Tier 1 Ratio</th>
<th>SLR</th>
<th>CCAR Tier 1 Ratio</th>
<th>CCAR SLR</th>
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<tbody>
<tr>
<td><strong>G-SIBs:</strong></td>
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<td>JPMorgan Chase</td>
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<td>1.5</td>
<td>2.4</td>
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<td>2.0</td>
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<td>1.3</td>
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<td>4.3</td>
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<td>1.5</td>
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<td>Morgan Stanley</td>
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<td>8.5</td>
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<td>4.3</td>
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<td>Goldman Sachs</td>
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<td>1.5</td>
<td>2.2</td>
<td>0.1</td>
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<tr>
<td>Wells Fargo</td>
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<td>2.3</td>
<td>2.6</td>
<td>3.0</td>
<td>2.3</td>
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<tr>
<td>Bank of New York Mellon</td>
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<td>1.8</td>
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<td>4.7</td>
<td>0.9</td>
<td>3.1</td>
<td>0.6</td>
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<td><strong>Other Large BHCs:</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>U.S. Bancorp</td>
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<td>2.5</td>
<td>4.3</td>
<td>1.9</td>
<td>2.2</td>
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<td>PNC Financial Services</td>
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<td>1.1</td>
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<tr>
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<td>4.3</td>
<td>5.6</td>
<td>1.0</td>
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<tr>
<td>TD Group US</td>
<td></td>
<td>5.2</td>
<td>4.1</td>
<td>5.3</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Estimated Capital Charges

- Compute capital charge for bank $j$ under $j$’s most binding constraint

<table>
<thead>
<tr>
<th>G-SIB Banks:</th>
<th>Tightest constraint</th>
<th>Residential C&amp;I Mortgages</th>
<th>Residential Other Mortgages</th>
<th>Credit Cards</th>
<th>Other Consumer Treasuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPMorgan Chase &amp; Co.</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
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<tr>
<td>Bank of America Corporation</td>
<td>CCAR SLR</td>
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<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
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<td>Citigroup Inc.</td>
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<td>1.1</td>
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<td>2.8</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>CCAR SLR</td>
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<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
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<tr>
<td>Goldman Sachs Group, Inc.</td>
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<tr>
<td>Wells Fargo &amp; Company</td>
<td>Tier 1 Ratio</td>
<td>10.5</td>
<td>5.3</td>
<td>10.5</td>
<td>10.5</td>
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<tr>
<td>Bank of New York Mellon Corporation</td>
<td>SLR</td>
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<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
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<tr>
<td>State Street Corporation</td>
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<td>1.1</td>
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<td>2.8</td>
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<td>Other Large BHCS:</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>U.S. Bancorp</td>
<td>CCAR Tier 1 Ratio</td>
<td>8.7</td>
<td>1.1</td>
<td>8.7</td>
<td>5.8</td>
</tr>
<tr>
<td>PNC Financial Services Group, Inc.</td>
<td>CCAR Tier 1 Ratio</td>
<td>8.7</td>
<td>1.1</td>
<td>8.7</td>
<td>5.8</td>
</tr>
<tr>
<td>Capital One Financial Corporation</td>
<td>CCAR Tier 1 Ratio</td>
<td>8.7</td>
<td>1.1</td>
<td>8.7</td>
<td>5.8</td>
</tr>
<tr>
<td>HSBC North America Holdings Inc.</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
</tr>
<tr>
<td>TD Group US Holdings LLC</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Banks vs Non-Banks

- Agreement that banks (and shadow banks) can create systemic risk
- Much more controversial for non-banks
  - MetLife sued FSOC January 2015 over their decision to designate MetLife as a SIFI
- Insurance Companies play important role in financial system
  - 30%–35% of bonds issued by European financial firms
  - Fire sales can happen (Dick-Nielsen-Feldhutter-Lando, Ellul-Jotikasthira-Lunblad, Manconi-Massa-Yasuda)
Are Financial Innovations Useful?
What did NOT happen in Finance

Retail Trade: Relative Price

Year

1960 1975 1990 2005
Relative Wage & Education in Finance

Source: Philippon & Reshef (QJE, 2012)
Relative Wage: Financiers vs Engineers

Source: Philippon & Reshef (QJE, 2012)
Employment Shares & Relative Wages

Source: Philippon & Reshef (QJE, 2012)
Pay & Regulation

Source: Philippon & Reshef (QJE, 2012)
Regulation: Where We Are & Where We Want To Be

Current System:
- Expensive
- Levered
- Too big to fail

Desired System

FinTech
Current Strategy Has Run Its Course

Will not work: entrenched interests, coordination costs, intractable design problem
My Proposal: Strategy 2
My Proposal: Strategy 2

Containment + Regulated Evolution

Entry
This Will Not Happen Automatically

Lack of Strategic Regulation
This Will Not Happen Automatically
Finance and Climate Change

- **New risks**
- **Insurance**
  - impact on insurance liabilities from climate- and weather-related events, such as floods and storms that damage property or disrupt trade
- **Asset management**
  - Revaluation risks from adjustment towards a lower-carbon economy
  - Stranded assets: Fossil fuels companies: mainly valued on their reserves. But reserves exceed the budget of the planet: 2,795 GtCO2, but budget: 1,437 GtCO2
Low Carbon Indices

• How would you go about providing financial incentives for reducing carbon footprint

• Option 1: exclude polluters from portfolio and/or bet on replacements
  - very costly and complicated

• How do you build an investment strategy when you think there is a risk in the long run but you have no idea when risk might materialize?

• Option 2: start from existing indexes and reduce footprint
  - start from MSCI index & match with carbon emission data
  - choose portfolio that achieves X% reduction of Emission Intensity and Z% reduction in exposure to stranded assets
  - optimize and re-balance regularly: low tracking error
Low Carbon Indices: Theory
Low Carbon Indices: Historical Performance
References I


References II


References III


