AEA Continuing Education Program

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**
  \[ b = k - m \]
### Debt Overhang

<table>
<thead>
<tr>
<th>Total</th>
<th>Senior Debt</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A^H$</td>
<td>$D$</td>
<td>$A^H\cdot D$</td>
</tr>
<tr>
<td>$A^L$</td>
<td>$A^L$</td>
<td>0</td>
</tr>
</tbody>
</table>

Key Friction: Difficult to Renegotiate Senior Debt

- Free riding among dispersed creditors
- Risk of runs
# How New Projects Are Evaluated

<table>
<thead>
<tr>
<th>Total</th>
<th>Senior Debt</th>
<th>Junior Debt</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A^H + v^H$</td>
<td>$D$</td>
<td>$Rk$</td>
<td>$A^H - D + v^H - Rk$</td>
</tr>
</tbody>
</table>

New lenders break even

1. Risk shifting: $v^L$ irrelevant
2. Underinvestment: $R > 1$

Shareholder Value: $v^H - Rk$
Underinvestment in Safe Projects

<table>
<thead>
<tr>
<th>Total</th>
<th>Senior Debt</th>
<th>Junior Debt</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A^H + v$</td>
<td>$D$</td>
<td>$k/p$</td>
<td>$A^H - D + v - k/p$</td>
</tr>
</tbody>
</table>

\[
\begin{array}{l}
\text{Underinvestment Model}
\end{array}
\]

\[
\begin{array}{l}
p \rightarrow A^H + v \\
-k \rightarrow A^L + v \\
1-p \rightarrow A^L + v
\end{array}
\]

- Myers (1977)
  - Philippon-Schnabl (2009): \((p,v)\) unknown to government
- Philippon (2010): bailouts in open economy
Philippon-Schnabl (2009)

Diagram illustrating the concept of Debt Overhang and Invest.
Risk Shifting

<table>
<thead>
<tr>
<th>Total</th>
<th>Senior Debt</th>
<th>Junior Debt</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A^H + v$</td>
<td>$D$</td>
<td>$k/p$</td>
<td>$A^H - D + v - k/p$</td>
</tr>
</tbody>
</table>

- $p$
- $1-p$

NPV = $(2p-1)v-k$ can be negative, e.g. when $p<0.5$

But if $v > k/p$, shareholders like the project
Reluctance to Sell Assets

<table>
<thead>
<tr>
<th>Total</th>
<th>Senior Debt</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(1-z)A^H + m$</td>
<td>$D$</td>
<td>$(1-z)A^H - D + m$</td>
</tr>
</tbody>
</table>

$-m$

$p$

$(1-z)A^H + m$

$D$

$(1-z)A^H - D + m$

$1-p$

$(1-z)A^L + m$

$(1-z)A^L + m$

$0$

- Buyers: $m = zE[A]$

- Equity: $A^H - D - z(1-p)(A^H - A^L)$

Papers

- Philippon-Schnabl (2009)
- Landier-Ueda (2009)
- Diamond-Rajan (2010)
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

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

- Therefore pledgeable income is $q^H (V - y^e_{min})$

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

Rate $r$

$\frac{1}{q}$

$\frac{qV}{k}$

Perceived Quality $z$

Limit Rate For Strong Types

Pooling Rate
Time 1: Credit Market Equilibrium

![Graph showing credit market equilibrium with variables and rates]

- Equilibrium Rate: $\frac{1}{q}$
- Limit Rate for Strong Types: $\frac{qV}{k}$
- 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%
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
Outstanding Credit / GDP

- Farm, Hist
- Household, Hist
- Nonfarm Business, Hist
- Farm, FoF
- Household, FoF
- Nonfarm Business, FoF
Neoclassical Growth with Intermediation

- Households’ consumption and liquidity services: $u(c_t, m_t)$, lifecycle 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
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)

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.

Source: Bazot (2013)
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

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

- Heterogeneous 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

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

where $\varphi$ 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
    \[
    \bar{b}_c = \frac{1}{2 + r} \int_{\eta > \hat{\eta}} \left( \left( \lambda - (1 - \varphi)^{-1} \right) \eta - \kappa \right) dF(\eta)
    \]
  - Income
    \[
    y_{c,t}^f = \varphi \bar{b}_{c,t} + \kappa_t w (1 - F(\hat{\eta}_t)).
    \]
## Calibration

<table>
<thead>
<tr>
<th>Rate</th>
<th>Deprec.</th>
<th>Growth</th>
<th>Labor Sh.</th>
<th>CRRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r = 0.05$</td>
<td>$\delta = 0.1$</td>
<td>$\gamma = 0.02$</td>
<td>$\alpha = 0.7$</td>
<td>$\rho = 1$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High cash</th>
<th>Low cash</th>
<th>Asset Mgt Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_h = 0.62$</td>
<td>$x_l = 0.1$</td>
<td>$\phi = 0.01$</td>
</tr>
</tbody>
</table>
Calibration

Moments

<table>
<thead>
<tr>
<th>B</th>
<th>Cost share</th>
<th>HH D Frac</th>
<th>Top 20</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \overline{b}_k / y )</td>
<td>( \phi + \zeta \frac{\overline{\mu}_k}{b_k} )</td>
<td>( s )</td>
<td>( \overline{b}_c / y )</td>
<td>( 1 - F(\hat{\eta}) )</td>
</tr>
<tr>
<td>data</td>
<td>0.806</td>
<td>0.0205</td>
<td>0.20</td>
<td>0.73</td>
</tr>
<tr>
<td>model</td>
<td>0.811</td>
<td>0.0208</td>
<td>0.199</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Implied Parameters

| Monit Firms Slope Ineq. Fix Liq D Liq S |
|----|----------|--------|-----|-----|---|---|
| \( \zeta = \frac{r}{3.3} \) | \( \frac{k_h}{k^4} = 0.622 \) | \( \lambda = 2.07 \) | \( H = 0.875 \) | \( \kappa = 0.023 \) | \( \nu = 0.0181 \) | \( \psi_m = 0.019 \) |
Calibrated Model

A. CORP. FINANCE INCOME SHARE

B. CORPORATE DEBT / GDP

C. CORPORATE ADJUSTMENT

D. PARTICIPATION

E. HOUSEHOLD DEBT / GDP

F. HH ADJUST. FACTOR
Quality-Adjusted Quantity of Intermediation

[Graph showing the quality-adjusted quantity of intermediaion over time, with three lines representing different adjusted quantities: Assets, Firm Adj., and Firm & HH. Adj.]

- Quality-Adjusted Quantity: 1, 2, 3, 4, 5
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

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

- 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

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

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

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

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

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

where

\[ Q_t^k \equiv \frac{\mathbb{E}_t [\Lambda_{t+1} \mathcal{V}_{t+1}]}{P_t^k} = \frac{\mathbb{E}_t [\Lambda_{t+1} V_{t+1}]}{P_t^k K_{t+1}} \]
Q-Theory: Bonds vs Stocks, Philippon (2009)

- Let \( e_t = \frac{E_t[\Lambda_{t+1} V_{t+1}^e]}{P_t^k K_{t+1}} \) and \( b_t = \frac{E_t[\Lambda_{t+1} V_{t+1}^b]}{P_t^k K_{t+1}} \) 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
  \[
  \begin{align*}
  &t+1 \quad t+2 \quad \ldots \quad \tau \quad \ldots \\
  &c + \phi \quad (1-\phi)(c+\phi) \quad \ldots \quad (1-\phi)^{\tau-t-1}(c+\phi) \quad \ldots
  \end{align*}
  \]

- Risk “neutral” debt pricing, with book leverage \( l \), in state \( \omega \):
  \[
  b(\omega) = \frac{1}{1 + r(\omega)} E^\pi \left[ \min \left\{ (c + \phi) l + (1 - \phi) b(\omega') ; \forall(\omega') \right\} \right] | \omega
  \]
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: \( m_t \downarrow \implies K_{t+1} \downarrow \implies m_{t+1} \downarrow \)
  - 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: \( Q_t \downarrow \implies K_{t+1} \downarrow \implies Q_{t+1} \downarrow \)
  - But \( Q \) is forward looking \( Q_t \downarrow \iff \mathbb{E}_t [Q_{t+1}] \downarrow \)
The 2008-2009 crisis centered around financial intermediaries.
Intermediary-Driven Crisis

Excess Bond Premium and Commercial Bank Lending Standards
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
• 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>
<thead>
<tr>
<th></th>
<th>Sudden Stop</th>
<th>Defaults</th>
<th>Credit Booms</th>
<th>‘Trifecta’</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>13</td>
<td>Greece</td>
<td>18</td>
<td>Greece</td>
<td>22</td>
</tr>
<tr>
<td>EM</td>
<td>36</td>
<td>64</td>
<td>96</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>65</td>
<td>114</td>
<td>10</td>
<td>79</td>
</tr>
</tbody>
</table>
Benchmarking 1: GDP Relative to All Sudden Stops

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

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

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

- Sudden Stop
- Greece (2010)
Benchmarking 2: Other Crises

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

- Default
- Lending Boom
- Trifecta
- IIPS (2010)
- Greece (2010)
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)

- strict peggers
- Estonia (2009)
- Latvia (2009)
- Greece (2010)
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
  \[\zeta_t^\# = \rho^\# \zeta_{t-1}^\# + \sigma^\# \epsilon_t^\#\]
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)

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

- Tax rate

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

- Government funding cost

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

\[ U^i = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^i_t \left( \frac{(C^i_t)^{1-\gamma}}{1-\gamma} - \frac{(N^i_t)^{1+\phi}}{1+\phi} \right) ; \quad C^i_t \equiv \left[ (1-\omega)^{\frac{1}{\epsilon_h}} C^i_{H,t}^{\frac{1-\epsilon_h}{\epsilon_h}} + \omega^{\frac{1}{\epsilon_h}} C^i_{F,t}^{\frac{1-\epsilon_h}{\epsilon_h}} \right]^{\frac{1}{\epsilon_h-1}} \]

- **Borrowers**, mass \( \chi \), \( B^h_t \leq \bar{B}^h_t \),

\[ P_t C^b_t = (1-\tau_t) W_t N^b_t + \frac{P_{H,t} B^h_t}{R^h_t} - (1-d^p_t) P_{H,t-1} B^h_{t-1} + P_{H,t} T^b_t \]

\[ d^p_t = -\bar{d}_y y_t + \bar{d}_b b^h_t + \zeta^{\text{def}}_t \]

\[ \bar{b}^h_t = \psi_{bh} b^h_{t-1} - \xi^{\text{bh}} r^d_t + \zeta^{\text{bh}}_t \]

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

\[ P_t C^s_t = (1-\tau_t) W_t N^s_t + \tilde{R}_t P_{H,t-1} S_{t-1} - P_{H,t} S_t + P_{H,t} T^s_t \]
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
  \[ \pi_t^w = \beta E_t \pi_{t+1}^w - \lambda_w (w_t - \gamma c_t - \phi n_t) + \zeta_t^w \]

- Price-calvo process yields a Phillips curve for domestic prices
  \[ \pi_t^h = \beta E_t \pi_{t+1}^h + \lambda_p m c_t + \zeta_t^{\pi h} \]
  where \( m c_t \) is log real marginal cost in terms of domestic goods.

- \( \zeta_t^w \): wage markup shock, \( \zeta_t^{\pi h} \): domestic price markup shock
Banks

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

\[ V_t \geq \kappa \left( \frac{B_t^k}{R_t^k} + \frac{B_t^h}{R_t^h} \right) \]

where \( V_t \) is franchise value.
• No capital requirement for sovereign exposure
• Bank funding costs

\[ r_t^d = r_t + \zeta_t^{rd} + \xi^d L^t E [d_{t+1}^p] \]
Summary of Funding Costs

• Key equations

  - Funding cost: banks $\rightarrow$ households & firms
    \[ r_t^k = r_t^d \]

  - Banks: sudden stop and capital loss
    \[ r_t^d = r_t + \zeta_t + \xi_t + \bar{\delta}y_t + \bar{d}_t b_{t-1} + \zeta_t^{def} \]
    \[ d_t^p = -\bar{d}_y y_t + \bar{d}_b b_{t-1} + \zeta_t^{def} \]

  - Government
    \[ r_t^g = r_t + d_t^g \]
    \[ d_t^g = \bar{d}_g \frac{B^g}{\gamma} \left( b_t^g - \mathbb{E}_t [y_{t+1}] - \mathbb{E}_t [\pi_{t+1}] + \zeta_t^{dg} \right) \]

  - Households
    \[ r_t^h = r_t^d + \mathbb{E}_t [d_{t+1}^p] \]
Doom Loops

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

Sovereign Risk Impulse Response:
- Output
- Consumption
- Investment
- Employment
- Funding Cost
- Sovereign Yield
- NPL/Total Loans
- Inflation
- Govt Finance
- Govt Debt
- Household Debt
- Current Account/GDP

Years: 5 10 15
Impulse: -0.05 0 0.05
Sovereign Risk Shock

Output, Consumption, Investment, Employment, Funding Cost, Sovereign Yield, NPL/Total Loans, Inflation, Govt Finance, Govt Debt, Household Debt, Current Account/GDP

Graphs show the impact of a Sovereign Risk Shock on various economic indicators over a 15-year period.
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

Years

Output
Consumption
Investment
Employment
Funding Cost
Sovereign Yield
NPL/Total Loans
Inflation
Govt Finance
Govt Debt
Household Debt
Current Account/GDP

Years

Years

Years

Years

Years
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>
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<tbody>
<tr>
<td>$G_t + T_t$</td>
<td>Government spending</td>
<td>$\zeta_{t}^{\text{spend}}$</td>
<td>Govt. spending shock</td>
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<tr>
<td>$\tau_t Y_t$</td>
<td>Government revenues</td>
<td>$\zeta_{t}^{\text{tax}}$</td>
<td>Tax rate shock</td>
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<tr>
<td>$R_t^g$</td>
<td>Greek government spread over EZ average</td>
<td>$\zeta_{t}^{\text{dg}}$</td>
<td>Sovereign risk shock</td>
</tr>
<tr>
<td>$R_t^k$</td>
<td>SME spread over EZ average</td>
<td>$\zeta_{t}^{\text{f}}$</td>
<td>Funding cost shock</td>
</tr>
<tr>
<td>$\exp(d_t^p)$</td>
<td>Non-performing loans/total loans, $\text{def} = \text{npl}$</td>
<td>$\zeta_{t}^{\text{def}}$</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>$\zeta_{t}^{\text{bh}}$</td>
<td>Household credit shock</td>
</tr>
<tr>
<td>$\Pi_t^w$</td>
<td>Greek Wage Inflation - EZ Wage Inflation</td>
<td>$\zeta_{t}^{\text{w}}$</td>
<td>Wage inflation shock</td>
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Table: Observables and Shocks
Calibrated Parameters-I

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>$\beta$</td>
<td>Discount Factor</td>
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<tr>
<td>$\alpha$</td>
<td>Capital Share</td>
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<tr>
<td>$\varepsilon_h$</td>
<td>Elasticity between H and F</td>
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<tr>
<td>$\varepsilon_f$</td>
<td>Elasticity between exports</td>
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<tr>
<td>$\phi$</td>
<td>Inverse labor supply elasticity</td>
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<tr>
<td>$\gamma$</td>
<td>Risk Aversion</td>
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<tr>
<td>$\vartheta$</td>
<td>Price Stickiness</td>
<td>0.5</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>Elasticity of Substitution Goods</td>
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<tr>
<td>$\vartheta_w$</td>
<td>Wage Stickiness</td>
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<td>Elasticity of Substitution Labor</td>
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<tr>
<td>$\varepsilon_r$</td>
<td>Elasticity of $R$ to $NFA$</td>
<td>0.0001</td>
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<tr>
<td>$\phi_k$</td>
<td>Adjustment Cost</td>
<td>1</td>
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<tr>
<td>$\delta$</td>
<td>Depreciation</td>
<td>0.07</td>
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<tr>
<td>$FC$</td>
<td>Fixed cost of production, 10% of $Y$</td>
<td>0.0955</td>
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# 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>
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<tr>
<td>$\chi$</td>
<td>Fraction of Impatient (Martin and Philippon (2014))</td>
<td>0.65</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>Annual lending spread of 2%</td>
<td>1.02</td>
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<tr>
<td>$\frac{\bar{B}_h}{Y}$</td>
<td>Household debt to GDP of 50%</td>
<td>0.5</td>
</tr>
<tr>
<td>$\frac{B_g}{Y}$</td>
<td>Government debt to GDP of 120%</td>
<td>1.2</td>
</tr>
<tr>
<td>$\frac{G}{Y}$</td>
<td>Government consumption to GDP of 20%</td>
<td>0.2</td>
</tr>
<tr>
<td>$\frac{T}{Y}$</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>
</tr>
<tr>
<td>$\bar{d}^k$</td>
<td>Steady state default rate for Corporates</td>
<td>5.4%</td>
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<tr>
<td>$\frac{B^k}{Y}$</td>
<td>Corporate debt to GDP of 50%</td>
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<tr>
<td>$\Psi_{sk}$</td>
<td>Working Capital Constraint</td>
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<td>$\tau$</td>
<td>Tax rate, budget balance in SS</td>
<td>0.436</td>
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<tr>
<td>$L$</td>
<td>Leverage scaling</td>
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## Calibrated Parameters-III

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$F_b$</td>
<td>Elasticity of govt. spending to public debt</td>
<td>0.05</td>
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<tr>
<td>$F_n$</td>
<td>Elasticity of govt. spending to employment</td>
<td>0.025</td>
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<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

- **Govt. Revenue**: Graph showing trends from 2000 to 2015.
- **Govt. Spending**: Graph showing trends from 2000 to 2015.
- **Govt. Yield**: Graph showing trends from 2000 to 2015.
- **Private Funding Cost**: Graph showing trends from 2000 to 2015.
- **NPL/Total Loans (Obs.)**: Graph showing trends from 2000 to 2015.
- **dlog GDP Deflator (Obs.)**: Graph showing trends from 2000 to 2015.
- **Household Debt**: Graph showing trends from 2000 to 2015.
- **Wage Inflation (Obs.)**: Graph showing trends from 2000 to 2015.
Fit of the Model

**Output**

**Investment**

**PPI Inflation**

**Current Account/GDP**

**Wage Inflation**

<table>
<thead>
<tr>
<th>Year</th>
<th>Data</th>
<th>Model</th>
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<tbody>
<tr>
<td>2000</td>
<td></td>
<td></td>
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<tr>
<td>2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Data: Line graph showing actual data points.
- Model: Line graph showing model predictions.

**Notes:**
- The graphs illustrate the fit of the model to various macroeconomic indicators over time from 2000 to 2015.
- The y-axis represents the values of the indicators, while the x-axis represents the years.

**References:**

Greece Regulation FinTech

**Data Sources:**

- Fit of the Model
- Greece Regulation
- FinTech
Decomposition of Output and Investment
Decomposition of Sovereign Debt
Decomposition of Government Spending

Govt. Spending

Spending
Tax
Credit Demand
Sudden Stop
Priv. Def.
Sov. Risk
Markup
Wage Markup
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>
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</thead>
<tbody>
<tr>
<td>Credit / GDP</td>
<td>1.01</td>
<td>0.46</td>
<td>0.025</td>
<td>1.46</td>
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<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
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
  \[ b_i = \mathbb{E} \left[ \min (q_i a_i, d_i) \right]. \]
Basic Model of Systemic Risk

- Firm $i$'s problem

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

- Regulator cares about aggregate externality:

$$\max \sum_{i=1}^{J} U_i + \mathcal{E}$$

s.t.

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

$$A = \sum_{i=1}^{N} a^i$$

$$W^* = k A$$

$e(W^* - W)$

$k?\text{ more later.}$

Aggregate net worth
Optimal Pigouvian tax

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

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

where the systemic expected shortfall is defined by

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

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

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

• identify four constraints on bank equity
• $\text{equity per }$ $1$ 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></th>
<th>Required ratios (%)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Tier 1 Ratio</td>
<td>SLR</td>
<td>CCAR Tier 1</td>
<td>CCAR SLR</td>
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<tr>
<td><strong>G-SIBs:</strong></td>
<td></td>
<td></td>
<td>Ratio</td>
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<tr>
<td>JPMorgan Chase</td>
<td>12.0</td>
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<tr>
<td>Bank of America</td>
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<td>5.0</td>
<td>6.0</td>
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<td><strong>Other Large BHCs:</strong></td>
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<td></td>
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<td>6.0</td>
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## Distance from Requirements

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<th>CCAR Tier 1 Ratio</th>
<th>CCAR SLR</th>
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<tr>
<td><strong>G-SIBs:</strong></td>
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<td></td>
<td></td>
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<thead>
<tr>
<th><strong>Other Large BHCs:</strong></th>
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</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>Other Mortgages</th>
<th>Credit Cards</th>
<th>Other Consumer</th>
<th>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>
<td>2.4</td>
</tr>
<tr>
<td>Bank of America Corporation</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Citigroup Inc.</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Goldman Sachs Group, Inc.</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<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>
<td>10.5</td>
</tr>
<tr>
<td>Bank of New York Mellon Corp.</td>
<td>SLR</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>State Street Corporation</td>
<td>CCAR SLR</td>
<td>5.7</td>
<td>1.1</td>
<td>5.7</td>
<td>2.8</td>
<td>2.4</td>
</tr>
</tbody>
</table>

| Other Large BHCs:             |                     |                           |                 |              |                |            |
| U.S. Bancorp                  | CCAR Tier 1 Ratio   | 8.7                       | 1.1             | 8.7          | 5.8            | 5.4        | -1.7       |
| PNC Financial Services Group, Inc. | CCAR Tier 1 Ratio | 8.7                       | 1.1             | 8.7          | 5.8            | 5.4        | -1.7       |
| Capital One Financial Corporation | CCAR Tier 1 Ratio | 8.7                       | 1.1             | 8.7          | 5.8            | 5.4        | -1.7       |
| HSBC North America Holdings Inc. | CCAR SLR           | 5.7                       | 1.1             | 5.7          | 2.8            | 2.4        | 1.3        |
| TD Group US Holdings LLC      | CCAR SLR            | 5.7                       | 1.1             | 5.7          | 2.8            | 2.4        | 1.3        |
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

- Relative Price: 1, 1.1, 1.2, 1.3, 1.4, 1.5
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
This Will Not Happen Automatically
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

No Carbon Repricing

Repricing
Low Carbon Indices: Historical Performance

CUMULATIVE INDEX PERFORMANCE - NET RETURNS (EUR) (NOV 2010 – MAY 2017)

- MSCI Europe Low Carbon Leaders
- MSCI Europe


50  |  100  |  150  |  200  |  176.30 |  182.82
References I


References III


