Efficient Bailouts?

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Motivation

- Large interventions in credit markets during **financial crises**

- Fierce debate about desirability of **bailouts**
  
  - Supporters: salvation from a deeper credit crunch
  
  - Critics: sowing the seeds of future financial crises

- Frank-Dodd act attempts to end bailouts
Questions

- What are the implications of bailouts for the stability of the financial sector?

- Is it desirable to prohibit government bailouts?

- Quantitatively:
  - What are the effects over risk-taking and the severity of crises?
  - What is the optimal size of government intervention?
  - What are the features of policies to prevent excessive risk taking?
What I do

Propose a **quantitative** equilibrium model:

- Liquidity constraints generate “occasional credit crunches”
- This leads to **precautionary behavior** during normal times

**Inefficiency and Policy Response:**

- Collective transfer to firms increase dividend payments and wages
- But households do not internalize these GE effects

⇒ Ex-post: welfare improving bailouts
⇒ Ex-ante: insurance and moral hazard effects

Solve for optimal intervention
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**Solve for optimal intervention**
What I find

- Bailouts are ex-ante welfare improving
- Optimal bailout: 2% points of GDP on average and increasing in leverage
- Severity of recession falls by 40% with the optimal intervention
- Role for macro-prudential policy to correct private cost of borrowing
- Size of optimal bailout is reduced by half when bailout is not anticipated
Relationship to the Literature

- Credit crunches and credit policy in DSGE models:
  (Gertler-Karadi (JME, 2011); Del Negro et al. (2010); Gertler-Kiyotaki-Queralto (2011))
  They mostly focus on policy response to unanticipated credit crunches or log-linear dynamics. I analyze moral hazard effects.

- Moral hazard and incentive effects of bailouts:
  (Schneider-Tornell (RES, 2004); Farhi-Tirole (AER, 2012); Chari-Kehoe (2010), Keister (2010))
  They study theoretically how bailouts increase risk-taking and moral hazard. I conduct a quantitative assessment.

- Externalities and macro-prudential regulation
  (Lorenzoni (RES, 2008); Bianchi (AER, 2011); Bianchi-Mendoza (2010); Jeanne-Korinek (2010))
  They study prudential measures to address systemic risk. I study the role of bailouts and the implications for prudential regulation.
Households

Government

External Creditors

Households

Firms

Households

Firms
Households

Limited enforcement

Credit flows

External Creditors

Firms

Labor-Wages

Equity payouts

Households

Agency Problems
Households

Preferences:

\[ E_0 \sum_{t=0}^{\infty} \beta^t u(c_t - G(n_t)) \]

Budget constraint:

\[ s_{t+1} p_t + c_t = w_t n_t + s_t (d_t + p_t) \]

d_t dividends, s_t equity shares, p_t price of shares

FOC:

\[ w_t = G'(n_t) \]
\[ p_t = E_t m_{t+1}(d_{t+1} + p_{t+1}) \]

where \( m_{t+j} \equiv \beta^j u'(c_{t+j} - G'(n_{t+j}))/u'(c_t - G'(n_t)) \)
Continuum of firms with revenue given by

\[ F(z, k, h) = zk^\alpha h^{1-\alpha} \]

\( z_t \) is an exogenous aggregate productivity shock

Flow-of-funds constraint:

\[
  b_t + d_t + k_{t+1} + \phi(k_t, k_{t+1}) \leq k_t(1 - \delta) + F(z_t, k_t, h_t) - w_th_t + \frac{b_{t+1}}{R}
\]

\( \phi(\cdot) \) capital adjustment costs

\( b_t \) non-state contingent one-period debt

Remark: stock of shares is fixed and normalized to 1
Financial constraints

- Collateral constraint on debt financing:
  \[ b_{t+1} \leq \kappa_t k_{t+1} \]

- Equity constraint:
  \[ d_t \geq \bar{d} \]

Investment is constrained by internal and external funds:

\[
\boxed{\begin{align*}
\underbrace{k_{t+1} - k_t (1 - \delta) + \psi(k_t, k_{t+1})}_{\text{Investment}} &= \underbrace{F(z_t, k_t, h_t) - w_h - b_t + \frac{b_{t+1}}{R} - d_t}_{\text{new ext. funds}} \\
\end{align*}}
\]

\[ i_t \leq F(z_t, k_t, h_t) - w_h - b_t + \frac{\kappa_t k_{t+1}}{R} - \bar{d} \]
Recursive Problem

\[ V(k, b, X) = \max_{d, h, k', b'} \left\{ d + \mathbb{E}m'(X, X')V(k', b', X') \mid X \right\} \]

s.t. \[ b + d + k' + \psi(k, k') \leq (1 - \delta)k + F(z, k, h) - w(X)h + \frac{b'}{R} \]

\[ b' \leq \kappa k' \quad (\mu) \]

\[ d \geq \bar{d} \quad (\eta) \]

\[ X \equiv (K, B, \kappa, z) \]
(Labor demand) \[ F_h(z_t, k_t, h_t) = w_t \]

(EE for bonds) \[ 1 + \eta_t = R \mathbb{E}_t m_{t+1}(1 + \eta_{t+1}) + R \mu_t \]

(EE for capital) \[ 1 + \eta_t = \mathbb{E}_t m_{t+1} R^k_{t+1}(1 + \eta_{t+1}) + \kappa_t \mu_t \]

\[ R^k_{t+1} \equiv \frac{1 - \delta + F_k(z_{t+1}, k_{t+1}, h_{t+1}) - \psi_{1,t+1}}{1 + \psi_{2,t}} \]
Competitive Equilibrium Definition

Given an interest rate $R$ and stochastic processes for $z_t$ and $\kappa_t$, a competitive equilibrium is defined by a set of prices $\{w_t, p_t\}_{t \geq 0}$, allocations $\{c_t, k_{t+1}, b_{t+1}, d_t, h_t, n_t, s_t\}_{t \geq 0}$ and a SDF $\{m_t\}_{t \geq 0}$:

1. Households maximize utility

2. Firms optimize and discount dividends at $\beta^j u'(t + j)) / (u'(t))$

3. All market clears:
   - Equity markets: $s_t = 1$
   - Labor markets: $h_t = n_t$
   - Resource constraint:
     
     $$b_t + c_t + k_{t+1} + \psi(k_t, k_{t+1}) = k_t(1 - \delta) + F(z_t, k_t, n_t) + \frac{b_{t+1}}{R}$$
Coordination Problem

- During a credit crunch, funds are more valuable inside firms
- Households do not internalize benefits of unilateral transfers to firms \( \Rightarrow \text{Free-rider problem} \Rightarrow \text{inefficient level of investment} \)
- Bailouts force households to transfer funds to firms \( \Rightarrow \text{solve free-rider problem and improve welfare } \text{ex-post} \)
- Bailouts reduce perceived cost of borrowing \( \Rightarrow \text{Need for tax on debt } \text{ex-ante} \)
Limited enforcement

Credit flows

Creditors

Firms

Labor-Wages

Equity payouts

Households
Normative Analysis

1. Set-up a constrained social planner’s problem

2. Identify possible instruments that decentralize optimal allocations (debt-relief, equity injections, lump-sum transfers)

3. Quantitative analysis
Constrained Social Planner Problem

- Chooses investment, borrowing and dividends subject to liquidity constraints
- Choose transfers between firms and households subject to iceberg costs
- Lets labor markets, equity markets, and goods market clear competitively
Admissible Allocations

(Resource Const.) \( b_t + c_t + k_{t+1} + \varphi \Upsilon_t = (1 - \delta)k_t + F(z, k_t, h_t) + \frac{b_{t+1}}{R} \)

(Equity Const.) \( (1 - \delta)k_t + F(z_t, k_t, h_t) - w_t h_t + \frac{b_{t+1}}{R} + \Upsilon_t - b_t - k_{t+1} \geq \bar{d} \)

\( \Upsilon_t \) are transfers from households to firms, \( \varphi \) is iceberg cost of transfers

(Collateral Constraint) \( b_{t+1} \leq \kappa_t k_{t+1} \)

(Stock market clearing) \( p_t = \mathbb{E}_t m_{t+1}(d_{t+1} + p_{t+1}), \ s_t = 1 \)

(Labor Market clearing) \( w_t = G'(n_t) = F_h(k_t, h_t) \)
Some characterization

\[ \eta_t - \varphi u'(t) \leq 0 \text{ with equality if } \Upsilon_t > 0 \]

Remarks:

- If \( \varphi = 0 \), \( d \geq \bar{d} \) does not bind.

- If \( \bar{d} = -\infty \), the competitive equilibrium and the social planner’s solution coincide.
Decentralization I: Debt relief

Households finance bailout with lump-sum tax:

\[ s_{t+1}p_t + c_t \leq w_t n_t + s_t(d_t + p_t) - T_t \]

Firms receive debt relief:

\[ (1 - \gamma_t)b_t + d_t + i_t \leq F(z_t, k_t, h_t) - w_t n_t + \frac{b_{t+1}}{R}(1 - \tau_t) + T_f \]

**Remark:** Debt relief is executed *only* if equity constraint binds
Decentralization I: Debt relief, debt-tax

Households finance bailout with lump-sum tax:

$$s_{t+1}p_t + c_t \leq w_t n_t + s_t (d_t + p_t) - T_t$$

Firms receive debt relief and pay tax on debt:

$$(1 - \gamma_t)b_t + d_t + i_t \leq F(z_t, k_t, h_t) - w_t n_t + \frac{b_{t+1}}{R} (1 - \tau_t) + T_t^f$$

Remark: Debt relief is executed only if equity constraint binds

Remark: Tax on debt is set when debt relief only if equity constraint is expected to bind
Decentralization II: Equity injections

Government purchases equity and transfer them to households:

\[ s_{t+1}p_t + c_t \leq w_t n_t + (s_t + s^g_t)(d_t + p_t) - T_t \]

Firms’s problem is:

\[
\mathbb{E}_t \sum_{j=0}^{\infty} m_{t+j}(d_{t+j} - e_t b_t)
\]

s.t. \[ b_t + d_t + i_t \leq F(z_t, k_t, h_t) - w_t n_t + e_t b_t + \frac{b_{t+1}}{R}(1 - \tau_t) + T_t^f \]

\[ d_t \leq \bar{d}, \quad b_{t+1} \leq \kappa_t k_{t+1} \]

where number of shares are re-normalized to one and equity injections are set to a fraction of debt.
Decentralization II: Equity injections, debt-tax

Government purchases equity and transfer them to households:

\[ s_{t+1}p_t + c_t \leq w_t n_t + (s_t + s^g_t)(d_t + p_t) - T_t \]

Firms’s problem is:

\[
\mathbb{E}_t \sum_{j=0}^{\infty} m_{t+j}(d_{t+j} - e_t b_t)
\]

s.t.  \[ b_t + d_t + i_t \leq F(z_t, k_t, h_t) - w_t n_t + e_t b_t + \frac{b_{t+1}}{R}(1 - \tau_t) + T^f_t \]

\[ d_t \leq \bar{d}, \quad b_{t+1} \leq \kappa_t k_{t+1} \]

where number of shares are re-normalized to one and equity injections are set to a fraction of debt

**Remark:** Prudential tax on debt is strictly smaller than debt relief
Decentralization III: Helicopter Drop

Bailout implemented through lump sum transfers conditional on aggregate variables

First-order conditions remain unaffected

→ No tax on debt is required to implement planner’s allocations

Best case to prevent moral hazard as individual outcomes are independent of individual choices
Quantitative Analysis
Numerical Method

- Challenges
  - Financial constraints impose significant non-linearities
  - State variables are not confined to a small region
  - Changes in consumption lead to large changes in firms’s choices

- Approach:
  - Iterates jointly on equilibrium policy functions on entire state space
  - Allows for occasionally binding liquidity constraints
  - Full-equilibrium dynamics
Functional Forms and Distribution Assumptions

\[ u(c - G(n)) = \left( c - \chi \frac{n^{1 + \frac{1}{\omega}}}{1 + \frac{1}{\omega}} \right)^{1 - \sigma} - 1, \quad F(z, k, h) = zk^\alpha h^{1 - \alpha} \]

\[ \psi(k_t, k_{t+1}) = \frac{\phi_k}{2} \left( \frac{k_{t+1} - k_t}{k_t} \right)^2 k_t \]

TFP shocks and financial shocks are independent processes:

\[ \log(z_t) = \rho \log(z_{t-1}) + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon) \]

Financial shocks follow a two-state Markov chain with values given by \( \{\kappa_L, \kappa_H\} \) and transition matrix:

\[
P = \begin{bmatrix}
P_{L,L} & 1 - P_{L,L} \\
1 - P_{H,H} & P_{H,H}
\end{bmatrix}
\]
## Calibration

<table>
<thead>
<tr>
<th>Parameters set independently</th>
<th>Value</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>$R - 1 = 0.02$</td>
<td>Interest rate mid 2000</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta = 0.97$</td>
<td>Capital-output = 2.5</td>
</tr>
<tr>
<td>Share of capital</td>
<td>$\alpha_K = 0.33$</td>
<td>Average Labor Share</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta = 0.1$</td>
<td>Standard value</td>
</tr>
<tr>
<td>Labor disutility coefficient</td>
<td>$\chi = 0.67$</td>
<td>Normalization</td>
</tr>
<tr>
<td>Risk aversion</td>
<td>$\sigma = 1.5$</td>
<td>Benchmark value</td>
</tr>
<tr>
<td>Frisch elasticity parameter</td>
<td>$\omega = 2.0$</td>
<td>Benchmark value</td>
</tr>
<tr>
<td>Efficiency cost</td>
<td>$\varphi = 10bps$</td>
<td>Benchmark value</td>
</tr>
</tbody>
</table>
## Calibration

<table>
<thead>
<tr>
<th>Parameters set by simulation</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TFP shock</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_\epsilon = 0.01$</td>
<td></td>
<td>SD of GDP=2.0</td>
</tr>
<tr>
<td>$\rho = 0.24$</td>
<td></td>
<td>Autocorrelation of GDP=0.45</td>
</tr>
<tr>
<td><strong>Financial shock</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\kappa_L = 0.43$</td>
<td></td>
<td>Average leverage =45 percent</td>
</tr>
<tr>
<td>$\kappa_H = 0.54$</td>
<td></td>
<td>Non-binding collateral constraint</td>
</tr>
<tr>
<td>$P_{HH} = 0.9$</td>
<td></td>
<td>Probability of credit crunch=4 percent</td>
</tr>
<tr>
<td>$P_{LL} = 0.1$</td>
<td></td>
<td>Duration of credit crunch=3 years</td>
</tr>
<tr>
<td><strong>Adjustment cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_k = 2.0$</td>
<td></td>
<td>SD of investment =9 percent</td>
</tr>
<tr>
<td><strong>Dividend threshold</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{d} = 0.05$</td>
<td></td>
<td>Equalize prob. binding constraints</td>
</tr>
</tbody>
</table>

**Definition of credit crunch:** Fall in credit of more than 2SD
How does a typical crisis look like in the decentralized equilibrium without intervention?
## Comparison with Data

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data 2008-2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>-1.5%</td>
<td>-2.6%</td>
</tr>
<tr>
<td>Consumption</td>
<td>-1.1%</td>
<td>-1.2%</td>
</tr>
<tr>
<td>Investment</td>
<td>-27.0%</td>
<td>-22.6%</td>
</tr>
<tr>
<td>Debt-repurchase/GDP</td>
<td>6.6%</td>
<td>8.1%</td>
</tr>
<tr>
<td>Hours</td>
<td>-1.0%</td>
<td>-6.7%</td>
</tr>
</tbody>
</table>

Note: Data corresponds to US data 2008-2009. Model corresponds to average crisis in decentralized equilibrium.
Ergodic Distribution of Bailouts
Laws of motion for leverage \( \left( \frac{B_{t+1}}{K_{t+1}} \right) \), borrowing and capital as a function of current debt, for mean values of productivity and mean value of capital

OBP denote optimal bailout policy

NBP denote no bailout policy
Current Debt
Leverage ($\kappa_H$)

Next Period Debt ($\kappa_L$)
Current Debt
Leverage ($\kappa^H$)

Next Period Debt ($\kappa^H$)

Next Period Capital ($\kappa^H$)

Current Debt
Leverage ($\kappa^L$)

Next Period Debt ($\kappa^L$)

Next Period Capital ($\kappa^L$)

NBP  BP
1 1.1 1.2 1.3 1.4
0.35 0.4 0.45 0.5

Current Debt
NBP  BP
1 1.1 1.2 1.3 1.4
2.5 2.75 3

Current Debt
NBP  BP
1 1.1 1.2 1.3 1.4
2.5 2.75 3
Leverage ($\kappa^H$)

Current Debt

Next Period Debt ($\kappa^H$)

Next Period Capital ($\kappa^H$)

Current Debt

Next Period Debt ($\kappa^L$)

Next Period Capital ($\kappa^L$)

Leverage ($\kappa^L$)

Current Debt

Next Period Debt ($\kappa^L$)

Next Period Capital ($\kappa^L$)
Current Debt Consumption ($\kappa^H$)

Current Debt Dividends ($\kappa^H$)

Current Debt Investment ($\kappa^H$)

Current Debt Consumption ($\kappa^L$)

Current Debt Dividends ($\kappa^L$)

Current Debt Investment ($\kappa^L$)
Current Debt

Consumption ($\kappa_H$)

NBP

OBP

Current Debt

Dividends ($\kappa_H$)

Current Debt

Investment ($\kappa_H$)

Current Debt

Dividends ($\kappa_L$)

Current Debt

Investment ($\kappa_L$)
Ergodic Distribution Leverage

NBP

OBP
Non-linear impulse response

What is the economy’s response to a negative financial shock?

- Simulate economy for a long period of time for a sequence of TFP shocks equal to the average and positive financial shocks
- Hit the economy with a one-time negative financial shock
- Compare economy without intervention to economy with anticipated and unanticipated bailouts
- Role for macro-prudential policy
No Prudential Tax on Debt

Leverage

Investment

Output

Employment

NBP  BP (no-debt-tax)
Prudential Tax on Debt

Leverage

Investment

Output

Employment

NBP  OBP
Welfare Gains of Optimal Policy
Conclusions

- Substantial effects of bailouts on risk-taking and on recovery from recession

- Part of the increase in leverage is socially desirable (insurance effects)

- Best approach is to complement bailouts with prudential policy
  - This offsets moral hazard effects
  - Delivers time-consistent policy

- Moving forward: foundations for financial shocks and equity constraint, crowding-out effects of bailouts
Extra Slides
Equity payout and debt repurchases in the nonfinancial business sector (corporate and noncorporate), 1952.I-2010.II. See the online appendix for data sources.

Figure 1. Financial flows in the nonfinancial business sector (corporate and noncorporate), 1952.I-2010.II. See the online appendix for data sources.

Source: Jermann and Quadrini (AER, 2012) from Flow of Funds
Equity Injections

\[ e_t b_t = \Upsilon_t \]

\[ T_t = \Upsilon_t (1 + \varphi) \]

\[ \tau_t = \frac{\mathbb{E}_t m_{t+1} (1 + \eta_{t+1}) + \mu_t}{\mathbb{E}_t m_{t+1} (1 + \eta_{t+1} (1 - e_{t+1})) + \mu_t} - 1 \]

\[ T_t^f = \frac{b_{t+1} \tau_t}{R} \]
\[ \gamma_t b_t = \Upsilon_t \]

\[ T_t = \Upsilon_t (1 + \varphi) \]

\[ \tau_t = \frac{\mathbb{E}_t m_{t+1}(1 + \eta_{t+1}) + \mu_t}{\mathbb{E}_t m_{t+1}(1 + \eta_{t+1})(1 - \gamma_{t+1}) + \mu_t} - 1 \]

\[ T_t^f = \frac{b_{t+1}\tau_t}{R} \]
Recursive Competitive Equilibrium

- firms’ policies \( \{ \hat{d}(k, b, X), \hat{h}(k, b, X), \hat{k}(k, b, X), \hat{b}(k, b, X) \} \) and firm’s value \( V(k, b, X) \)
- households’ policies \( \{ \hat{s}(s, X), \hat{n}(s, X) \} \) and SDF \( m(X, X') \)
- prices for labor and stocks \( w(X), p(X) \)
- a law of motion of aggregate variables \( X' = \Gamma(X) \)

1. Households solve their optimization problem
2. Firms’s policies and firm value solve their Bellman equation
3. Markets clear in equity and labor market \((\hat{s}(1, X) = 1), (\hat{h}(K, B, X) = \hat{n}(1, X))\)
4. The law of motion is \( \Gamma(\cdot) \) is consistent with individual policy functions and stochastic processes for \( \kappa \) and \( z \).
Binding Region

- Both constraint bind
- Dividend constraint bind
- None binding
- Not feasible
Planner’s problem

\[
\max_{k_{t+1}, b_{t+1}, d_t, c_t, \gamma_t, h_t, p_t} \quad E_0 \sum_{t=0}^{\infty} \beta^t u(c_t - G(h_t))
\]

\[
b_t + c_t + k_{t+1} + \gamma_t \varphi = (1 - \delta) k_t + F(z_t, k_t, h_t) + \frac{b_{t+1}}{R}
\]

\[
\bar{d} \geq (1 - \delta) k_t + F(z, k_t, h_t) - w^*_t h^*_t + \frac{b_{t+1}}{R} + \gamma_t - b_t - k_{t+1}
\]

\[
b_{t+1} \leq \kappa k_{t+1}
\]

where \( h^*_t, w^*_t, w^*_t = G'(h^*_t) = F_L(z_t, k^*_t, h^*_t) \)

\[
p_t u'(t) = \beta \mathbb{E}_t u'(t + 1)(d_t + p_{t+1})
\]

Remark: similar results if planner internalizes wage effects
“The nation must work together to strike the right balance between our need to promote the public trust and using taxpayer money prudently to strengthen the financial system...to get credit flowing to working families and businesses.”

### Table: Second Moments

<table>
<thead>
<tr>
<th></th>
<th>No Bailout Policy</th>
<th>Optimal Bailout Policy</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>2.3</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Consumption</td>
<td>2.0</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Employment</td>
<td>1.5</td>
<td>1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Investment</td>
<td>9.9</td>
<td>9.6</td>
<td>9.0</td>
</tr>
</tbody>
</table>

Note: Moments in the model correspond to the stochastic steady state. Moments in the data correspond to annual data from 1950-2010.