Financial Frictions, Financial Shocks and Unemployment Volatility: Lessons from the Great Recession

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Financial recessions are deeper and last longer than ordinary recessions. (IMF, 2010; Carmen and Rogoff, 2008; Boeri et al. 2013; Boissay et al. 2013)

Financial recessions, or banking crises during recessions, are rare events. Boissay et al. (2013): once every 40 years.

Not only job destruction: the 2007-2009 recession features an un-precedented decline in vacancies and firm entry (Siemer 2014)
### Table: Unemployment and GDP during financial recessions

<table>
<thead>
<tr>
<th>Country</th>
<th>Type of recession</th>
<th>$du$</th>
<th>$du/u$</th>
<th>$dy/y$</th>
<th>$\epsilon^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>Financial rec</td>
<td>2.65</td>
<td>50%</td>
<td>-3.0%</td>
<td>16.66</td>
</tr>
<tr>
<td></td>
<td>Other rec</td>
<td>1.93</td>
<td>33%</td>
<td>-2.6%</td>
<td>12.69</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.72</td>
<td>17%</td>
<td>-0.4%</td>
<td>3.97</td>
</tr>
<tr>
<td>UK</td>
<td>Financial rec</td>
<td>2.10</td>
<td>36%</td>
<td>-3.2%</td>
<td>11.25</td>
</tr>
<tr>
<td></td>
<td>Other rec</td>
<td>0.50</td>
<td>7%</td>
<td>-3.1%</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>1.60</td>
<td>28%</td>
<td>0.0%</td>
<td>9.00</td>
</tr>
</tbody>
</table>

$^a$ Apparent elasticity of unemployment with respect to GDP.


JC and JD in young and old US firms during GR
JC and vacancies in the US during the GR
Two interlinks between labor and finance:

1. Financial frictions may propagate and *amplify* standard (productivity) fluctuations.
   - Negative productivity shocks may increase financial frictions and exacerbate their adverse effects on unemployment

2. *Pure financial shocks* may influence aggregate labor market conditions.

This paper addresses both channels in a tractable DSGEM with frictions in *both* labor and finance.
This Paper (I): A model of labor and finance

- Firms operate in a Diamond-Mortensen-Pissarides (DMP) labor market
  - Simple matching model (Pissarides 1985) with competitive search (Moen, 1997)
- Firms obtain funding in an imperfect financial market
  - Firms borrow to finance investments in capital and search
  - Limited pledgeability of future income flows: investors need to share part of firm’s income with insiders. Holmstrom and Tirole (2011)
Amplification effects of pure productivity shocks induced by limited pledgeability

- Amplification effects do exist
- Only the effects of productivity shocks on financial frictions are quantitatively important (pledgeability effect).
- Financial frictions by themselves have small amplification effects (collateral effect)

Real effects of financial shocks

- A very adverse (and unlikely) financial shock can have a strong adverse impact on the aggregate labor market.
Macro labor and finance: A Vibrant Research Area

1 Early literature
   (i) risk adjustment effect: Greenwald and Stiglitz, 1993;
   ii) financing of quasi-fixed costs (Oi, 1962; Farmer, 1985);
   iii) sticky bank/firm relationship (Sharpe, 1990; Homstrom and Tirole, 1987);

2 Post Great recession research:
   Labor impact of shocks to consumers and firms’ discount rate (Hall, 2014, Keho et al. 2014)
   Real Effects of financial shocks as (borrowing spreads) (Christiano et al., 2015)
   Search and asset price theory (Kuhen et al. 2014)

3 Search with financial imperfections
   Double friction (Wasmer and Weil, 2005)
   Wage setting with financial imperfections Quadrini and Trigari, 2013; Michelacci and Quadrini, 2009
   Job Composition effect (Petroksy-Nadeu, 2013)
   Liquidity as war chest, Boeri Garibaldi and Moen, 2014
Volatility and DMP framework

- Real effects of borrowing spreads. (Eckstein et al., 2014)
- Double search frictions (Wasmer and Petrosky-Nadeu, 2013)
- Financing of vacancy costs (Petrosky-Nadeu, 2013)
- Shocks to collateral and Kiotaky and Moore (Garin, 2015; Iliopolus et al. 2014)
Our model

- **Basics**
  - Discrete time. Risk neutral firms and workers, discount rate $\beta$
  - Workers infinitely lived.
  - Firms die at rate $\lambda$, in which case the employees become unemployed and earn $z$.
  - Cobb-Douglas matching function. The probability of job filling in a period is $q(\theta) = M\theta^{-\alpha}$, where $\theta$ is vacancy/unemployment ratio.

- **Production technology: Leontief in Labor and Capital**
  - Entrepreneurs pay an entry cost $K$ as effort. Then they invest $A$ units in *physical capital*.
  - Price of capital is $\phi$
  - $A$ is measure of jobs.

- **Output** is $y_tA_t$. Productivity is stochastic $y_t = ye^{\epsilon_t}$.
  - $\epsilon_t = \rho \epsilon_{t-1} + u_t$. Discrete approximation to $N$ states
  - stochastic matrix $P$: $p_{ij} = \text{prob} [y_t = i | y_{t-1} = j]$
**Model**

- **Matching.**
  - Firms post vacancies with wages attached to them (rents over unemployment) at cost $c$.
  - Firms pay $c/q$ in search cost per worker hired, and get workers immediately.

- **Funding and Borrowing Constraint**
  - Upfront investments in machines and search have to be financed.
  - Set-up cost $K$ is an effort cost, and is not financed.
  - Two sources of income
    - External liquidity: exogenous income flow originated outside the corporate sector $y_o(y_t)$ - fully pledgeable.
    - Internal liquidity: income from production - limited pledgeability à la Holmstrom and Tirole.
Asset Values and Profits

**Joint Income** $M(y)$:

$$M(y) = yA + \beta \{ (1 - \lambda)M(y'|y) + \lambda AU(y'|y) \}$$

**Joint surplus**: $S(y) = M(y) - AU$

$$S(y) = (y - \rho U)A + \beta (1 - \lambda) S(y'|y)$$

$$\rho(y) = \frac{U(y) - \beta U(y|y')}{U(y)}$$

**Profits** $V$:

$$V(U(y), y) = [S(y) - \phi - C(U(y))] A$$

where $C(U)$ are all labor related costs.
Search and Worker’s Rent (I)

- Competitive Search: Firms choose wages (rents $R$) to speed up hiring.
- Firms trade-off optimal wage and search costs.
- Minimize total labor related costs

$$C = \min \left[ c\theta(U)^{\alpha} + R \right] \quad \text{S.T.} \quad \rho(y)U = z + p(\theta)R$$

- Total Labor Cost per Worker:

$$C = \frac{c\theta^{\alpha}}{1 - \alpha}; \quad C(U) = \kappa \left[ \rho(y)U - z \right]^{\alpha}$$

$\kappa$ is a constant
Finance (I): The financial structure

- Start-up cost $K$ is effort and needs not be financed.
- External liquidity
  - External liquidity: flow $y_t y_o$ fully pledgeable
  - External liquidity depends on output - the *collateral effect* of productivity
- Internal liquidity
  - Internal liquidity: net revenues from the investment can be borrowed upon
  - Not fully pledgeable (Holmstrom and Tirole 2011)
  - Part of total income $x(y)A$ is not pledgeable
  - $x'(y) \leq 0$, the *pledgeability effect* of productivity
  - Idea: Geneakoplos, the Leverage Cycle, 2010.
- No savings of non-pledgeable income
The NPV of pledgeable income:

\[
\bar{P}(y) = y_0y + (y - w)A_t - x(y)A + (1 - \lambda)\beta P(y'|y) \\
= Y_0(y) + A(S(y) - R - X(y))
\]

(1)

where

\[
X(y) = x(y) + (1 - \lambda)\beta X(y'|y)
\]

(2)

\[
Y_0(y) = yy_0 + \beta Y_0(y'|y)
\]
Borrowing constraint: financing machines and search costs

\[ \tilde{P} = A(\phi + c/q) \]

Firm Size:

\[ A(y) = \frac{Y_0(y)}{\phi + C + X(y) - S}; \quad A(y) = k(y) Y_0(y) \]  \hspace{1cm} (3)

\( k(y) \) is the financial multiplier (units of worker-machine the firm can invest in per unit of external liquidity).
General equilibrium is a set of value functions $U(y)$, $C(U)$, $V(U, y)$, a firm size $A(y, U)$ such that

1. $C(U)$ minimizes total labor costs
2. $A(y, U)$ satisfies the borrowing constraint without slack
3. $V(U(y), y) = K$ for all $y$.

Equilibrium unemployment

$$u_{t+1} = \lambda (1 - u_t) - \theta(U)^{1-\alpha} u_t$$  \hspace{1cm} (4)
Deterministic Equilibrium (I)

\( y' | y \) is degenerate, so that \( y' | y = y \) with probability 1.

- **Free Entry**

\[
K = \left[ \frac{y - (1 - \beta)U}{1 - \beta(1 - \lambda)} - \phi - C(U) \right] A
\]

- **Optimal Size**

\[
A = \frac{\frac{y_0 y}{1 - \beta(1 - \lambda)}}{\phi + C(U) - \frac{y - x(y) - (1 - \beta)U}{1 - \beta(1 - \lambda)}}
\]

- **Search Capital**

\[
C(U) = \kappa [\rho(y)U - z]^\alpha
\]
Deterministic Equilibrium (II): Results

Result

The following holds:

- If the economy is sufficiently productive, the equilibrium exists and it is unique.
- Financial frictions reduce the value of unemployment and increase the unemployment rate.
- An increase in productivity increases firm size A (and reduces profit per worker)
Deterministic Equilibrium (II): unemployment volatility and financial frictions

We compare our model with a benchmark model with constant firm size $A = \bar{A}$

**Result**

- *Compared with the fixed-size case, our model exhibits excess volatility*
- *The excess volatility of financial frictions is the sum of two effects, the pledgeability effect and the collateral effect*

Intuition: An increase in $y$ increases firm size in our model. Financial frictions become less important. Hence unemployment responds more.
Calibration: 10 steady-state parameters + productivity shocks

- **Basic Values** $\beta, y, z, \alpha$ Set from literature
  - unemployed income $z = 0.5$ (Shimer versus Hagedorn Manovski)
  - matching elasticity $\alpha = 0.5$

- **Key Labor Market Moments matched** $m, c, \lambda$
  - i) job finding probability; ii) market tightness; iii) average unemployment

- **Leverage** $K / y_0, x, \phi$
  - $lev = \frac{\text{Total Asset}}{\text{equity}} = \frac{(C(U)+\phi)A+K}{K}$
  - Kalemili-Ozcan (2013), leverage in non-listed non-financial firms in 2006
Productivity, Pledgeability and Collateral Effects

- Pure productivity $y e^{\epsilon_t}$: Standard BC literature $\rho, \sigma^2$
- Pledgeability effect $x(y_t) = xye^{-\gamma\epsilon_t}$
  - $\gamma$ is the elasticity of $x$ wrt $y$, $\eta(y)$.
- How large is the change in pledgeability?
  - Relative pledgeable income $\nu(y = 1) = \frac{y-x(y)}{y} = .9$ in s.s.
  - $\nu(y = 0.96, \gamma = 6) = \frac{0.96-0.13}{0.96} = 0.87$
- Collateral effect $\frac{y\nu ye^{\epsilon_t}}{1-\beta} = ye^{\epsilon_t}$
  - Pure productivity effect on collateral
### Table: Matching the Calibration Target

<table>
<thead>
<tr>
<th>Target</th>
<th>Source</th>
<th>Value</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average Job Finding Rate, $</td>
<td>\text{Shimer (2005)}</td>
<td>0.8336</td>
<td>0.8366</td>
<td></td>
</tr>
<tr>
<td>2. Average Market tightness, $\theta$</td>
<td>Hagedorn Manovski (2008)</td>
<td>0.634</td>
<td>0.6634</td>
<td></td>
</tr>
<tr>
<td>3. Firm Leverage, $lev$</td>
<td>Kalemli-Ozcan et al. (2011)</td>
<td>2.4</td>
<td>2.3990</td>
<td></td>
</tr>
</tbody>
</table>

Based on Shimer (2005) monthly probability of not finding a job set at 0.55

*Source: Authors' calculation*
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure Discount Rate</td>
<td>$\beta$</td>
<td>0.990</td>
</tr>
<tr>
<td>Baseline productivity</td>
<td>$y$</td>
<td>1.000</td>
</tr>
<tr>
<td>Unemployed income</td>
<td>$z$</td>
<td>0.500</td>
</tr>
<tr>
<td>Exit rate</td>
<td>$\lambda$</td>
<td>0.053</td>
</tr>
<tr>
<td>Matching function elasticity</td>
<td>$\alpha$</td>
<td>0.500</td>
</tr>
<tr>
<td>Matching function parameter</td>
<td>$m$</td>
<td>1.027</td>
</tr>
<tr>
<td>Search cost parameter</td>
<td>$c$</td>
<td>0.457</td>
</tr>
<tr>
<td>Own income flow</td>
<td>$y_o$</td>
<td>0.010</td>
</tr>
<tr>
<td>Financial friction</td>
<td>$x$</td>
<td>0.100</td>
</tr>
<tr>
<td>Entry cost</td>
<td>$k$</td>
<td>4.878</td>
</tr>
<tr>
<td>Price of capital</td>
<td>$\phi$</td>
<td>1.137</td>
</tr>
</tbody>
</table>

**Productivity Values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\rho$</th>
<th>0.970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence of productivity process</td>
<td>$\sigma$</td>
<td>0.007</td>
</tr>
<tr>
<td>Variance of innovation in productivity process</td>
<td>$n$</td>
<td>3.000</td>
</tr>
<tr>
<td>Number of states</td>
<td>$b$</td>
<td>1.200</td>
</tr>
<tr>
<td>Withd of the state space</td>
<td>$\gamma(max)$</td>
<td>6.000</td>
</tr>
</tbody>
</table>

**Equilibrium Values**

| Parameter                                                      | $U$    | 80.000 |
|                                                               | $A$    | 3.695  |
|                                                               | $C(U)$ | 0.724  |
|                                                               | $p(\theta(U))$ | 0.837 |
|                                                               | $\theta(U)$ | 0.663 |
|                                                               | $u$    | 0.060  |
|                                                               | $lev$  | 2.410  |

Source: Authors' calculation
## Table: Amplification with Endogenous Leverage

<table>
<thead>
<tr>
<th>Model</th>
<th>Effect</th>
<th>$\Psi_{U,Y}$ (Welfare vs Productivity)</th>
<th>$\Psi_{U,Y}$ (Unemployment Rate vs productivity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Fixed Size $^a$</td>
<td>$\frac{1}{1-\beta}$</td>
<td>1.25</td>
<td>1.01</td>
</tr>
<tr>
<td>(2) Endog. Lev $^b$</td>
<td>$\frac{\tilde{K}}{(y+\tilde{K})^2} y^2 x$</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>(3) Endog. Lev $^c$</td>
<td>$\frac{\tilde{K}}{(y+\tilde{K})} \gamma_{xy} (1-\beta)$</td>
<td>0.62</td>
<td>0.50</td>
</tr>
</tbody>
</table>

| Total Effect | 1.872                                      | 1.521                                  |

$^a$ Model with fixed and maximum capacity of new firms $A = \bar{A}$

$^b$ Model with endogenous leverage and and capacity of new firms $A = A(U)$ and fixed non pledgeable income $x$. Pure collateral effect

$^c$ Model with endogenous leverage and and capacity of new firms $A = A(U)$ and non pledgeable income $x$. Collateral effect and pledgeability effect

**Sources:** Author's calculation.
Figure: Decomposition of Productivity Effects: Steady State
Financial Shocks and Unemployment

- Productivity is constant at its steady state value $y$.
- Financial shocks in the form of pledgeability shock.
  
  $$x_t = xe^{z_t}$$
  
  $$z_t = \rho z_t + \omega_t$$

- A discrete approximation of $x_t$; $x_1, \ldots, x_n$ and a stochastic matrix $P^x$
  
  $$p_{ij}^x = \text{prob}[x_t = i | x_{t-1} = j]$$

- Financial shocks affect directly the financial multiplier and the firm size (and indirectly $U$ and $S$).
Calibrating Financial Shocks

- $\rho_z$, the persistence of the liquidity shock
  - Most severe adverse financial conditions take place at very low frequencies. Systemic financial crises take place every 45 years.

- $\sigma^2_\omega$, the variance of the innovation of the financial shock.
  - A firm (and the economy) is in financial distress when internal funding completely dries up.
  - There exist a distress level of pledgeability $x_d$ such that internal liquidity is zero

\[
x_d : \frac{y - (1 - \beta) U - x_d}{1 - \beta(1 - \lambda)} \approx 0
\]  

(6)
**Table:** Steady States with average liquidity and with Financial Distress

<table>
<thead>
<tr>
<th>Model</th>
<th>Plead. income</th>
<th>profits</th>
<th>Size</th>
<th>Welfare</th>
<th>Int Liq</th>
<th>Mkt Tightness</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4) Average liquidity</td>
<td>v(x)</td>
<td>π</td>
<td>A</td>
<td>U</td>
<td>θ</td>
<td></td>
</tr>
<tr>
<td>0.90</td>
<td>1.320</td>
<td>3.69</td>
<td>80</td>
<td>0.10</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>(5) Financial Distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.57</td>
<td>5.62</td>
<td>0.86</td>
<td>55.51</td>
<td>0.01</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Model with endogenous leverage and pledgeable income calibrated as in the baseline model of Table ??

\(^b\) Model with endogenous leverage and a pledgeable income to distress level.

See main text for steady state equations.

Sources: Author’s calculation.
Impulse Response Function to an Extreme Financial Shock

Figure: One Time Financial Shock
Figure: One Time Productivity Shock
We introduced financial frictions a-lá Holmstrom and Tirole into a DMP model.

Financial frictions increase unemployment volatility, through two channels
- The collateral channel
- The pledgeability channel
- Only the second one is important quantitatively

Financial frictions shocks increase unemployment dramatically

Many issues to be explored
- Calibration of financial shocks
- Calibration to Europe
## Model with Endogenous Size

### Table: Simulation Statistics: Baseline Model

<table>
<thead>
<tr>
<th></th>
<th>y</th>
<th>U</th>
<th>C(..)</th>
<th>A</th>
<th>k</th>
<th>v</th>
<th>θ</th>
<th>u</th>
<th>p(θ)</th>
<th>lev</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.86</td>
<td>-0.75</td>
<td>0.90</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>U</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.85</td>
<td>-0.77</td>
<td>0.90</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>C</td>
<td>1.00</td>
<td>1.00</td>
<td>0.85</td>
<td>-0.76</td>
<td>0.90</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>0.99</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1.00</td>
<td>1.00</td>
<td>-0.31</td>
<td>0.76</td>
<td>0.85</td>
<td>-0.61</td>
<td>0.85</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>-0.69</td>
<td>-0.76</td>
<td>0.55</td>
<td>-0.76</td>
<td>-0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.90</td>
<td>-0.35</td>
<td>0.90</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>θ</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>0.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>-0.71</td>
<td>-0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p(θ)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Standard Deviations (%)**

|       | 0.99 | 0.34 | 1.52 | 0.19 | 0.16 | 2.23 | 3.04 | 1.38 | 0.99 | 0.19 |

**Source:** Authors’ calculation
### Table: Simulation Statistics: Baseline Model with Fixed Size

<table>
<thead>
<tr>
<th></th>
<th>y</th>
<th>U</th>
<th>C(.)</th>
<th>A</th>
<th>k</th>
<th>v</th>
<th>θ</th>
<th>u</th>
<th>p(θ)</th>
<th>lev</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>-0.02</td>
<td>.</td>
<td>0.90</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>U</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>-0.02</td>
<td>.</td>
<td>0.90</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>C</td>
<td>1.00</td>
<td>-0.02</td>
<td>.</td>
<td>0.90</td>
<td>1.00</td>
<td>-0.71</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1.00</td>
<td>-0.02</td>
<td>-0.02</td>
<td>0.01</td>
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**Standard Deviations (%)**

| 0.99 | 0.33 | 1.51 | 0.00 | . | 2.24 | 3.02 | 1.38 | 0.99 | 0.00 |

*Source: Authors’ calculation*
Job openings: fell from 3.2 percent in 2007(II) to 1.8 percent in 2009.

Unemployment: rose from 5.2 in 2007(II) to 9% in 2009 and 10% in 2010.

Productivity: did not fall;

Financial crisis time line starts in 2007(I)
- February 2007: Freddie Mac announced that was no longer buying sub-prime mortgages
- April 2007 New Century Financial Corporation, a leading sub-prime lender, filed for Chapter 11.
- June 2007 Bear Stearns suspended redemptions from one of its Structured Leveraged Funds.