The Interaction between Household and Firm Dynamics and the Amplification of Financial Shocks*

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Motivation and Questions

Interaction of households’ and firms’ credit constraints

- Recessions caused by financial crises typically feature tightening credit constraints for both households and firms, and large and persistent increases in unemployment.

Empirical Evidence from the recent 2007-2009 great recession (among many others):

- Firm financing constraints. Chodorow-Reich (2014): credit constraints account for 1/3 employment loss in small/medium firms in the U.S.

- Household credit constraints: Household deleveraging main force behind depth and length of downturn (Mian, Rao, and Su (2013), Mian and Su (2014))
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- **Answer to both questions: yes**
This Paper

- GE model with heterogeneous firms and households, financial frictions and labour market frictions.
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- Firms also face credit frictions and costly bankruptcy:
  - Collateralized long term debt fixed in nominal terms: key nominal rigidity for demand shocks to matter.
  - Price fluctuations have real effects. Expected decline in nominal revenues reduce job creation and increase job destruction (both because of bankruptcies and voluntary liquidations).
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- The Bad effect slightly prevails but only for 6 quarters; unemployment increases by a maximum of 0.3% in the short term, and then decreases below the steady state in the medium term.
Finally, we consider both a deleveraging shock to households and a credit shock to firms.

Unemployment increases from 5.7% to a peak of 9.5%

Compare it to:

Only firms shock:

\[ u \] increases from 5.7% to 7.4%

Only households shock:

\[ u \] increases from 5.7% to 6% (and then goes as low as 5%).

Faced with a credit crunch and an expected decline in prices and nominal revenues, many firms choose to voluntarily liquidate and destroy jobs to reduce future expected bankruptcy costs.

The price decline caused by deleveraging is slower but it lasts longer. Higher unemployment implies that:

Households want to precautionary save more.

On average it takes them longer to deleverage.

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Financial shock, wealth shock → Prices fall → Collateral value of capital falls
- Debt deflation
- Tightening of collateral constraints

HOUSEHOLDS
Consumption spending decreases

Unemployment risk increases
Precautionary behavior

FIRMS
Increase in job destruction and liquidation of capital

FIRMS
Decrease in job creation
Related Literature

- Precautionary savings and endogenous unemployment risk
  - Krusell, Mukoyama and Sahin (2010), Ravn and Sterk (2013), Challe, Matheron, Ragot, Rubio-Ramirez (2014), and Bayer, Lütticke, Pham-Daoz and Tjadenz (2014)).

- Household behavior and financial shocks

- Firm financing frictions and labor market frictions
  - Chug (2009) and Petrosky-Nadeau (2009): no precautionary behavior in households or firms
  - Monacelli, Quadrini and Trigari (2012); transmission channel through wage bargaining process

- Firms’ credit tightening and balance-sheet effects:
The Model

- **Firms**
  - Produce a consumption good using capital and labor
  - Face borrowing constraints and costly bankruptcy
  - Owned by industrial conglomerates
  - Created when vacancy matched with worker

- **Households**
  - Risk-averse
  - Face borrowing constraints and uninsurable unemployment risk
  - Self-insure by holding shares in conglomerates
  - Inelastic labor supply

- **Industrial conglomerates**
  - Each owns multiple firms
  - Shares in conglomerates: only means of saving used by households and firms to self-insure
  - Medium of exchange and numeraire ($P = \text{price of consumption good}$)
  - In fixed aggregate supply

- **Dividend payout rule** determines interest rate
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Model Ingredients (2)

Frictions

1. Uninsurable idiosyncratic shocks
   - Workers cannot insure directly against unemployment risk
   - Firms face idiosyncratic productivity shocks and may realize negative profits
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2. Labor market frictions (Diamond-Mortensen-Pissarides)

3. Borrowing constraints
   - Households cannot borrow
   - Firms can only borrow nominal long term debt to finance initial investment in equipment
     - Need enough financial assets to guarantee debt, otherwise costly bankruptcy
The Firms

Operating firms generate profits:

\[ \pi_{i,t}(\varepsilon_{i,t}) \equiv P_t(z + \varepsilon_{i,t}) - w_t, \]  

(1)

\[ w_t = \varphi P_t z, \]  

(2)

\( \varepsilon_{i,t} \) is an i.i.d. profits shock (sometimes profits are negative).
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\( \epsilon_{i,t} \) is an i.i.d. profits shock (sometimes profits are negative).

The budget constraint is:

\[ n_{t+1}^F = n_t^F (1 + r_t) + \pi_t(\epsilon_t) - d_t. \]  

(3)

\( n_t^F = a_t^F - D \) is net financial wealth, where \( D \) is long term nominal debt contracted when the firm is created. \( d_t = \text{dividends} \).
The Firms (2)

Financial constraints:

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2. With probability $\alpha$ long term debt $D$ needs to be "rolled over" and the following condition needs to be satisfied:

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rearranging:

$$a_t^F + P_t k \geq D$$

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2. With probability \( \alpha \) long term debt \( D \) needs to be "rolled over" and the following condition needs to be satisfied:

\[
\left\{ \frac{n_t^F}{a_t^F} \right\} - D + P_t k \geq 0
\]

rearranging:

\[
\text{financial wealth} + \text{collateral value of capital} \geq D \quad (4)
\]

If it is not satisfied, the firm is liquidated and the fire sale value of capital is \( \chi P_t k \), where \( (1 - \chi) P_t k \) are therefore bankruptcy costs.
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Note 1: \( D \) is long term debt with average maturity \( \frac{1}{\alpha} \) periods.
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\begin{align*}
\sum_{t=0}^{n_t^F} a_t^F - D + P_t k & \geq 0 \\
\text{financial wealth} + \text{collateral value of capital} & \geq D \quad (4)
\end{align*}
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Note 1: \( D \) is long term debt with average maturity \( \frac{1}{\alpha} \) periods.

Note 2: the expected path of prices affects the probability that condition 4 will bind in the future.
Firm Exit

- A firm may cease to operate for 3 reasons:

1. **Forced** liquidation with probability $\alpha$ when:

$$a_t^F + P_t k < D$$

2. **Voluntary** exit when

$$J_t(n_Ft) = \text{continuation value of the firm (NPV of future profits)} < d_{exit_t},$$

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3. **Exogenous** exit: probability $\eta$
Firm Exit

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   Where $J_t(n^F_t) =$ continuation value of the firm (NPV of future profits)
   $d_t^{\text{exit}} =$ liquidation value of the firm.
Firm Exit

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   Where $J_t(n_t^F) =$ continuation value of the firm (NPV of future profits)
   $d_t^{exit} =$ liquidation value of the firm.

   Voluntary exit is an equilibrium outcome if bankruptcy costs 
   $(1 - \chi) P_t k$ are relatively large.

3. **Exogenous** exit: probability $\eta$
Value function of firms

The value function of a firm with net asset holdings $n^F_t$ in period $t$, which we denote by $J_t(n^F_t)$, is derived conditional on not exiting for voluntary reasons in period $t$, but before suffering the possibility of a collateral constraint examination, and is given by:

$$J_t(n^F_t) = \max_{d_t} \varphi_t(n^F_t) d_t^{\text{exit}}(n^F_t) + \left(1 - \varphi_t(n^F_t)\right) d_t + \frac{1 - \varphi_t(n^F_t)}{1 + r_{t+1}} E_t \left[J_t+1(n^F_{t+1})\right]$$

(6)

$\varphi_t(n^F_t)$ is the probability that the firm exits conditional on having decided not to exit voluntarily, and is given by

$$\varphi_t(n^F_t) = \alpha_t I_{\text{bankr},t} + \left(1 - \alpha_t I_{\text{bankr},t}\right) \eta.$$
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(7)

The voluntary exit decision is taken by the firm in order to maximize the beginning of period value $\bar{J}_t(n^F_t)$:

$$\bar{J}_t(n^F_t) = \max_{l_{vol,t} \in \{0,1\}} l_{vol,t} d_t \cdot d_{exit}(n^F_t) + (1 - l_{vol,t}) J_t(n^F_t)$$

(8)
Industrial Conglomerates, Household Sector, Labor Market and Goods Market Equilibrium

- **Industrial conglomerates:**
  - Post vacancies, own firms, lend to firms in other conglomerates
  - Collect dividends from firms and pay them as return on shares owners. nominal interest rate $r$ satisfies:
    \[ 1 + r = 1 + \frac{DIV}{M}. \]
  - Where $DIV$ is total dividends distributed by conglomerates to households and $M$ is the number of shares
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- **Household sector** modeled as in Bewley-Huggett-Aiyagari framework

- **Labor market:** vacancies and unemployed matched randomly each period

- Goods market equilibrium condition
Vacancies and Matching

- There is a large number of unemployed managers available to run firms, a number in excess of the number of unemployed consumers $N_{u,t}$, and a continuum of mass 1 of identical industrial conglomerates.
Vacancies and Matching

- There is a large number of unemployed managers available to run firms, a number in excess of the number of unemployed consumers $N_{u,t}$, and a continuum of mass 1 of identical industrial conglomerates.
- Vacancies and unemployed workers are randomly matched each period and an aggregate constant returns-to-scale matching function specifies that $M(N_{u,t}, N_{v,t})$.

The probability that this vacancy is filled in the current period is $\lambda f_t = \frac{M(N_{u,t}, N_{v,t})}{N_{v,t}}$.

The probability that an unemployed worker finds a job is $\lambda w_t = \frac{M(N_{u,t}, N_{v,t})}{N_{u,t}}$.

The optimal number of vacancies solves:

$$\frac{\partial \Omega(I, K)}{\partial I} = P_t \xi, \quad (9)$$

Marginal capital adjustment costs
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- The probability that this vacancy is filled in the current period is $\lambda_{f,t} = M(N_{u,t}, N_{v,t}) / N_{v,t}$.
- The probability that an unemployed worker finds a job is $\lambda_{w,t} = M(N_{u,t}, N_{v,t}) / N_{u,t}$.
- The optimal number of vacancies solves:

$$
J_t(n^F = -P_t k) - P_t k \frac{\partial \Omega(I, K)}{\partial I} \begin{bmatrix} \frac{\partial M(N_{u,t}, N_{v,t})}{\partial N_{v,t}} \end{bmatrix} = P_t \xi,
$$

(9)
The model

- Employed households:

\[
W_t(a_t, n_t^F) = \max_{c_t, a_{t+1}} \left\{ u(c_t) + \beta E \varepsilon_t \left[ \sigma_{t+1}(n_{t+1}^F) U_{t+1}(a_{t+1}) + (1 - \sigma_{t+1}(n_{t+1}^F)) W_{t+1}(a_{t+1}, n_{t+1}^F) \right] \right\}
\]

(10)

\[
P_t c_t + a_{t+1} = a_t (1 + r_t) + w_t.
\]

(11)
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\[ P_t c_t + a_{t+1} = a_t (1 + r_t) + w_t. \]  

(11)

- Unemployed households

\[ U_t(a_t) = \max_{c_t, a_{t+1}} \left\{ u(c_t) + \beta [(1 - \lambda_{w,t+1}) U_{t+1}(a_{t+1}) + \lambda_{w,t+1} W_{t+1}(a_{t+1}, -P_{t+1} k)] \right\} \]  

(12)

\[ P_t c_t + a_{t+1} = a_t (1 + r_t), \]  

(13)
The model

- Employed households:

\[
W_t(a_t, n^F_t) = \max_{c_t, a_{t+1}} \left\{ u(c_t) + \beta E_{\varepsilon_t} \left[ (1 - \sigma_{t+1}(n^F_{t+1})) W_{t+1}(a_{t+1}, n^F_{t+1}) \right] \right\}
\]

\[P_t c_t + a_{t+1} = a_t (1 + r_t) + w_t. \tag{11}\]

- Unemployed households

\[
U_t(a_t) = \max_{c_t, a_{t+1}} \left\{ u(c_t) + \beta [(1 - \lambda_{w,t+1}) U_{t+1}(a_{t+1}) + \lambda_{w,t+1} W_{t+1}(a_{t+1}, -P_{t+1} k)] \right\}
\]

\[P_t c_t + a_{t+1} = a_t (1 + r_t), \tag{12}\]

Borrowing penalty function (for both employed and unemployed):

\[
u(c_t, a_{t+1}) = \frac{c_t^{1-\gamma}}{1 - \gamma} - \frac{\tau}{a_{t+1}^2}.\]
Panel A: Main Calibration Targets

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workers’ job finding rate</td>
<td>0.37</td>
<td>0.33-0.54</td>
</tr>
<tr>
<td>Vacancy-unemployment ratio</td>
<td>0.62</td>
<td>0.50-0.72</td>
</tr>
<tr>
<td>Operating income/Sales: mean (median)</td>
<td>0.09 (0.20)</td>
<td>0.02 (0.08)</td>
</tr>
<tr>
<td>Probability of negative profits</td>
<td>30.2%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Aggregate adj. costs over total stock of capital</td>
<td>0.91%</td>
<td>0.91%</td>
</tr>
<tr>
<td>Annual rate of firm bankruptcies</td>
<td>0.19%</td>
<td>0.48%</td>
</tr>
<tr>
<td>Average maturity of firm debt</td>
<td>8.69</td>
<td>8.68</td>
</tr>
<tr>
<td>Costs of bankruptcy as a share of firm assets</td>
<td>26%</td>
<td>20-36%</td>
</tr>
<tr>
<td>Annual job destruction</td>
<td>9.2%</td>
<td>8-11%</td>
</tr>
<tr>
<td>Households’ net worth as a % of total net worth</td>
<td>84%</td>
<td>80%</td>
</tr>
</tbody>
</table>
Value function

Figure: Firm’s Optimal Voluntary Exit Decision
Steady state distributions

Figure: Household and Firm Real Net Asset Distributions
Transition dynamics

- We assume that the economy is in steady state in period $t = 0$.
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- In period $t = 1$ agents learn about a sequence of unexpected aggregate shocks that take place between $t = 1$ and $t = J > 1$, $\{\Psi\}_1^J$.

Shock to households: quarterly shock $h_d$, so that in the first 8 quarters of the transition period, from $t = 1$ to $t = 8$, the wealth of household $i$ in decile $d = 1, \ldots, 9$, at $t$, is unexpectedly reduced to $a_d i_t (1 + h_d)$. (transfer to the richest decile)

Shock to firms: probability to face a "roll over" shock $\alpha$ increases to 50% for periods $t = 1, \ldots, 8$. 

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Transition dynamics (2)

**Figure:** Transition Dynamics - Individual Shocks to Households and Firms
Transition dynamics (2a)
Transition dynamics (2b)

Bankruptcies (% of SS hires)

Hirings (% of SS hires)

- Only Firm Sector Shock
- Only Household Sector Shock
Transition dynamics (3)

Figure: Transition Dynamics - Joint and Individual Shocks to Households and Firms
Transition dynamics (3b)

Unemployment Rate

Price (relative to SS)

- Red: Only Firm Sector Shock
- Blue: Only Household Sector Shock
- Black: Both Shocks
Transition dynamics (3c)

Voluntary Exits (% of SS hires)

Bankruptcies (% of SS hires)

- -- Only Firm Sector Shock
- Only Household Sector Shock
- - Both Shocks
Intuition

Negative feedback effect:

- Household "deleveraging" generates future expected declines in revenues and collateral value of assets.
  - Increases voluntary liquidations by firms.

- Reduction in employment prolongs the decline in prices:
  - The initial sharp drop in supply slows down the initial price decline.
  - It takes longer on average for households to reach their desired savings.

- Higher unemployment risk increases ex ante precautionary saving (but this channel is weak for our calibration).
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Transition dynamics (4)
Small shocks (50% of benchmark)

Figure: Transition Dynamics - Joint Shocks to Households and Firms of a Small Magnitude
Transition dynamics (5)
Large shocks

Figure: Transition Dynamics - Joint Shocks to Households and Firms of a Large Magnitude
Precautionary saving feedback effect

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Precautionary saving feedback effect

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- Following a shock that increases unemployment risk, households might react by reducing consumption and increasing savings, which would in turn depress goods prices and induce more job destruction.
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- Following a shock that increases unemployment risk, households might react by reducing consumption and increasing savings, which would in turn depress goods prices and induce more job destruction.
- This effect is not strong in our base calibration:
Precautionary saving feedback effect (2)

It becomes strong if we increase the financing frictions of the unemployed.

Figure: Transition Dynamics in Models with Tighter Credit Constraints for Unemployed Households - Joint Shocks to Households and Firms With and Without Household Precautionary Motives
Nominal wage rigidity

We consider fully rigid nominal wages, fixed at the steady state level.

- Price declines hurt firms' profits and reduce job creation, but:
  - Higher real wages sustain consumption and prevent price declines in the first place.
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Figure: Transition Dynamics - Joint Shocks to Households and Firms in the Benchmark Model and in a Model With Nominally Rigid Wages
Conclusions

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- Results obtained in the absence of wage and price rigidities - Emphasize the role of nominal debt rigidity.
- Framework can be used to study effects of different policies:
  - Fiscal/Monetary policy
  - labor market reform (firing costs,...)
  - unemployment benefits
  - subsidies to firms