Liquidity Traps and Monetary Policy: Managing a Credit Crunch

PRELIMINARY

FRANCISCO BUEA
UCLA

JUAN PABLO NICOLINI
Minneapolis Fed and Di Tella

Boston Fed, December, 2012
Motivation & Question

- Important economic contractions are often associated with large banking/financial crisis:
  - great depression, 1929-33
  - great recession, 2007-08
- Monetary policy (or the lack of it) is attributed a prominent role in ameliorating or exacerbating these contractions.
Motivation & Question

• Important economic contractions are often associated with large banking/financial crisis:
  • great depression, 1929-33
  • great recession, 2007-08

• Monetary policy (or the lack of it) is attributed a prominent role in ameliorating or exacerbating these contractions.

• What are the effects of alternative monetary policy during a credit crunch?
Motivation & Question (cont’d)

• **great depression, 1929-33:** unresponsive monetary policy, large deflation, pronounce recession, large drop in TFP, ..., nominal interest rate near zero

• **great recession, 2007-08:** large increase in government liabilities, low and stable inflation, less pronounce recession but slow recovery, large drop in investment, ..., nominal interest rate near zero
This Paper

Studies the effects of alternative monetary policies in an economy with heterogeneous producers during a credit crunch, i.e., a tightening of collateral constraints:

0. real benchmark, no government
1. unresponsive money supply
2. constant inflation target
3. distribution of welfare consequences
Preview of Results

0. real benchmark, no government
   • drop in TFP, sharp drop in the real interest rate

1. unresponsive monetary policy
   • deflation, larger drop in TFP, particularly so if debts are nominal

2. constant inflation target
   • requires a large increase in money supply/government debt, leads to an initially less severe, but more persistent contraction

3. distribution of welfare consequences (see paper)
Model Economy

- Entrepreneurs w/ heterogenous productivity, $z \sim \Psi(z)$, and workers.


- Money: cash-in-advance constraint, potential “store of value”.
Model Economy

- Entrepreneurs with heterogeneous productivity, \( z \sim \Psi(z) \), and workers.


- Money: cash-in-advance constraint, potential “store of value”.

- No aggregate uncertainty, study response to unanticipated shocks

- Flexible prices.
Entrepreneurs’ Problem

\[
\max_{\{c_t,m_{t+1},l_t,k_{t+1},b_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \left[ \nu \log c_{1t} + (1 - \nu) \log c_{2,t} \right],
\]

s.t.

\[
k_{t+1} + \frac{m_{t+1}}{p_t} + c_{1t} + c_{2t} + T_t(z)
= (z_t k_t)^{1-\alpha} l_t^{1-\alpha} - w_t l + (1 + r_t) b_t + (1 - \delta) k_t + \frac{m_t}{p_t} - b_{t+1},
\]

\[-b_{t+1} \leq \theta_t k_{t+1}, \quad \theta_t \in [0, 1], \quad \text{(borrowing constraint)}\]

\[c_{1,t} \leq \frac{m_t}{p_t}. \quad \text{(cash-in-advance)}\]
(Simplified) Entrepreneurs’ Problem

\[
\max_{\{c_t, m_{t+1}, a_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t [\nu \log c_{1t} + (1 - \nu) \log c_{2t}]
\]

s.t.

\[
a_{t+1} + \frac{m_{t+1}}{p_t} + c_{1t} + c_{2t} + T_t(z) = R_t(z)a_t + \frac{m_t}{p_t},
\]

\[
k_{t+1} \leq \lambda_t a_{t+1}, \quad \lambda_t \equiv \frac{1}{1 - \theta_t} \in [1, \infty], \quad \text{(borrowing constraint)}
\]

\[
c_{1,t} \leq \frac{m_t}{p_t}. \quad \text{(cash-in-advance)}
\]
Optimal Portfolio Choice

Capital and bond demand (supply if $b_t < 0$)

$$k_t = \begin{cases} 
\lambda_{t-1} a_t, & z \geq \hat{z}_t \\
0, & z < \hat{z}_t
\end{cases}, \quad b_t = \begin{cases} 
-(\lambda_{t-1} - 1) a_t, & z \geq \hat{z}_t \\
a_t, & z < \hat{z}_t
\end{cases}.$$ 

Gross return of net-worth

$$R_t(z) = \begin{cases} 
\lambda_{t-1}(\varrho_t z - r_t - \delta) + 1 + r_t, & z \geq \hat{z}_t \\
1 + r_t, & z < \hat{z}_t
\end{cases}$$

Marginal entrepreneur

$$\varrho_t \hat{z}_t = r_t + \delta$$

where $\varrho_t \equiv \alpha \left( (1 - \alpha) / w_t \right)^{(1-\alpha)/\alpha}$.
Workers’ Problem

\[
\max \left\{ c_t, m_{t+1}, a_{t+1} \right\}_{t=0}^{\infty} \sum_{t=0}^{\infty} \beta^t \left[ \nu \log c_{1t} + (1 - \nu) \log c_{2,t} \right]
\]

s.t.

\[
a_{t+1} + \frac{m_{t+1}}{p_t} + c_{1t} + c_{2t} + T_t^W = (1 + r_t)a_t + \frac{m_t}{p_t},
\]

\[
a_{t+1} \geq 0, \quad \text{(borrowing constraint)}
\]

\[
c_{1,t} \leq \frac{m_t}{p_t}. \quad \text{(cash-in-advance)}
\]

To derive analytical expressions we assume that for workers \( \nu = 0 \) and \( a_t = 0 \), but in the numerical example we treat workers and entrepreneurs symmetrically.
Budget constraint

\[
\frac{M_{t+1}}{p_t} - \frac{M_t}{p_t} + B_{t+1} + \int T_t(z)\psi(dz) + T_t^W = (1 + r_t)B_t.
\]
Demographics & Mixing of Wealth

- A fraction $1 - \gamma$ of entrepreneurs (workers) die and are replaced by equal number of new entrepreneurs (workers).

- Productivity $z$ of new entrepreneurs drawn from $\Psi(z)$, iid across entrepreneurs and over time.

- Each new entrepreneur (worker) inherits the assets of a randomly drawn dying entrepreneur (worker).

- These assumptions guarantee a non-degenerated distribution of net-wealth across types.
Equilibrium

Given policies $\{M_{t+1}, B_{t+1}, T_t(z), T_t^W\}_{t=0}^\infty$ and $\{\theta_t\}_{t=0}^\infty$, an equilibrium is given by sequences of prices $\{r_t, w_t, p_t\}_{t=0}^\infty$, and corresponding quantities such that:

(i) Entrepreneurs and workers maximize, taking as given $\{r_t, w_t, p_t\}_{t=0}^\infty$ and policies.

(ii) Government budget constraint is satisfied.

(iii) Markets clear

\[ B_{t+1} + \int b_{t+1}^i di = 0, \quad \int l_t^i di = L, \quad \int m_{t+1}^i = M_{t+1}, \quad \text{for all } t. \]
Aggregate output is given by a simple Cobb-Douglas function of aggregate TFP and capital

\[ Y_t = Z_t K_t^\alpha \]

where aggregate TFP is

\[ Z_t = \left( \frac{\int_{z \geq \hat{z}_t} z \Phi_t(dz)}{\int_{z \geq \hat{z}_t} \Phi_t(dz)} \right)^\alpha. \]

and \( \Phi_t(z) \) is the (endogenous) distribution of net-worth.
The bond market clearing condition is

\[
\int_0^{\hat{z}_{t+1}} \Phi_{t+1}(dz) = (\lambda_t - 1) \int_{\hat{z}_{t+1}}^{\infty} \Phi_{t+1}(dz) + B_{t+1}.
\]

and the marginal entrepreneur solve

\[
\alpha \left( \frac{1 - \alpha}{w_{t+1}} \right)^{(1-\alpha)/\alpha} \hat{z}_{t+1} = r_{t+1} + \delta.
\]

Given \( w_{t+1} \) and \( \Phi_{t+1}(z) \), there is a positive relationship between \( \lambda_t \) and \( r_{t+1} \).
Abstracting from the seigniorage, the evolution of aggregate capital is given by

\[ K_{t+1} = \beta [\alpha Y_t + (1 - \delta)K_t] + (1 - \beta) \sum_{j=1}^{\infty} \int_0^{\infty} \frac{T_{t+j}(z)}{\prod_{s=1}^{j} R_{t+s}(z)} \psi(dz) \]

\[ - (1 - \beta) \sum_{j=1}^{\infty} \int T_{t+j}(z) \psi(dz) + T_{t+j}^{W} \frac{\prod_{s=1}^{j} (1 + r_{t+s})}{\prod_{s=1}^{j}} \]

The path of **lump-sum** taxes affects capital accumulation. Ricardian equivalence does not hold!
Money Market

If \((1 + r_{t+1})p_{t+1}/p_t > 0\), then the price level at \(t\) is determined by

\[
\frac{\hat{M}_{t+1}}{p_t} = \frac{\nu(1-\beta)\beta}{1-\nu(1-\beta)} \left[ \int R_{t+1}(z)\Phi_{t+1}(dz) \right. \\
\left. \quad - \sum_{j=0}^{\infty} \int_0^\infty \frac{T_{t+j}(z)}{\prod_{s=1}^{j} R_{t+s}(z)} \Psi(dz) \right].
\]

At the ZLB, when monetary policy is unresponsive, the sequence of price levels must satisfy

\[p_t = (1 + r_{t+1})p_{t+1}\]

If policy implements an inflation target, this equation determines the real interest rate (and the supply of government liabilities must respond accordingly).
Simulate the effect of a credit crunch, i.e., an unanticipated shock to $\theta_t$, under alternative three scenarios:

0. benchmark real economy, no government

1. monetary economy, unresponsive monetary policy

2. monetary economy, constant inflation target
debt to capital ratio, $\theta_t = 1 - 1/\lambda_t$
Simulate the effect of a credit crunch, i.e., an unanticipated shock to $\theta_t$, under alternative three scenarios:

0. benchmark real economy, no government

1. monetary economy, unresponsive monetary policy

2. monetary economy, constant inflation target
Benchmark Real Economy, No Government
**Intuition: Bond Market**

The bond market clearing condition is

\[
\int_{0}^{\hat{z}_{t+1}} \Phi_{t+1}(dz) = (\lambda_{t} - 1) \int_{\hat{z}_{t+1}}^{\infty} \Phi_{t+1}(dz) + B_{t+1}.
\]

and the marginal entrepreneur solve

\[
\alpha \left( \frac{1 - \alpha}{w_{t+1}} \right)^{(1-\alpha)/\alpha} \hat{z}_{t+1} = r_{t+1} + \delta.
\]

Given \( w_{t+1} \) and \( \Phi_{t+1}(z) \), there is a positive relationship between \( \lambda_{t} \) and \( r_{t+1} \).
Comparison with Exogenous TFP Shock

![Graphs showing the effects of credit crunch and TFP shock on output, TFP, capital, and real interest rate over quarters.](attachment:image.png)
Simulate the effect of a credit crunch, i.e., an unanticipated shock to $\theta_t$, under alternative three scenarios:

0. benchmark real economy, no government

1. monetary economy, unresponsive monetary policy

2. monetary economy, constant inflation target
Monetary Economy: Unresponsive Policy

Indexed Bonds

output

TPF

capital

price level

real bmk
indexed debt

quarters

quarters
Monetary Economy: Unresponsive Policy
Indexed Bonds (cont’d)

![Charts showing real and nominal interest rates over time. The charts display the relationship between real bmk and indexed debt across different quarters, illustrating the responsiveness of the economy to policy changes.]
Intuition for the Deflation

- the credit crunch generates a large drop in the real return of bonds, i.e., the real interest rate
- if the price level remains constant, excess demand for real cash balances, i.e., “store of value”
- since the supply of money is fixed, the price level must decline to clear the money market
- ... and the return of money must drop in the future, the inflation increase, so that money and bonds have the same real return
Monetary Economy: Unresponsive Policy
Nominal Bonds, Debt Deflation
Monetary Economy: Unresponsive Policy
Nominal Bonds, Debt Deflation (cont’d)

- Real interest rate
- Nominal interest rate
- Real benchmark
- Indexed debt
- Nominal debt
Numerical Examples

Simulate the effect of a credit crunch, i.e., an unanticipated shock to $\theta_t$, under alternative three scenarios:

0. benchmark real economy, no government

1. monetary economy, unresponsive monetary policy

2. monetary economy, constant inflation target
Monetary Economy: Constant Inflation Target

Policy Rules

Government liabilities adjust to attain price stability

\[ B_{t+1} = \begin{cases} \int_{0}^{\hat{z}_{t+1}} \Phi_{t+1}(dz) \\
- (\lambda_{t+1} - 1) \int_{\hat{z}_{t+1}}^{\infty} \Phi_{t+1}(dz) & \text{if } r_{t+1} = \frac{p_t}{p_{t+1}} - 1 \\
B_t & \text{if } r_{t+1} > \frac{p_t}{p_{t+1}} - 1 \end{cases} \]

and

\[ M_{t+1} = p_t \frac{\nu(1 - \beta)\beta}{1 - \nu(1 - \beta)} \left[ \int R_{t+1}(z) \Phi_{t+1}(dz) \\
- \sum_{j=0}^{\infty} \int_{0}^{\infty} \frac{T_{t+j}(z)}{\prod_{s=1}^{j} R_{t+s}(z)} \psi(dz) \right] \]
Monetary Economy: Constant Inflation Target
Policy Rules (cont’d)

1. lump-sum case:
   - pure lump-sum taxes (transfers), $T_t(z) = T_t^W = T_t,$
   
   $$T_t = \frac{M_t - M_{t+1}}{p_t} + (1 + r_t)B_t - B_{t+1}.$$ 

2. bailout case:
   - entrepreneurs receive proceeds of new bond issues,
   
   $$\int T_t(z)\psi(dz) = \frac{M_t - M_{t+1}}{p_t} + (1 + r_t)B_t - B_{t+1}, \text{ if } B_{t+1} > B_t$$
   
   - lump-sum taxes (transfers) otherwise, $T_t(z) = T_t^W = T_t,$
   
   $$T_t = \frac{M_t - M_{t+1}}{p_t} + (1 + r_t)B_t - B_{t+1}.$$
Monetary Economy: Constant Inflation Target
Lump-Sum Case
Constant Inflation Target
Lump-Sum Case (cont’d)

![Graph showing real interest rate and nominal interest rate over time.](image)
Intuition: Government Liabilities

- The credit crunch results in an excess demand for bonds.
- To maintain price stability, the government must increase the supply of "store of value", money or bonds.
- Higher government liabilities imply higher future taxes.
- Unconstrained individuals further increase their savings, i.e., their demand for bonds, in anticipation of future taxes.
Intuition: Non-Ricardian Model

Again, assuming workers are hand-to-mouth, the evolution of aggregate capital is given by

\[
K_{t+1} = \beta [\alpha Y_t + (1 - \delta)K_t] + (1 - \beta) \sum_{j=1}^{\infty} \int_0^\infty \frac{T_{t+j}(z)}{\prod_{s=1}^{j} R_{t+s}(z)} \psi(dz)
\]

\[-(1 - \beta) \sum_{j=1}^{\infty} \int T_{t+j}(z) \psi(dz) + T^W_{t+j} \]

\[\prod_{s=1}^{j} (1 + r_{t+s})\]
Again, assuming workers are hand-to-mouth, the evolution of aggregate capital is given by

\[
K_{t+1} = \beta [\alpha Y_t + (1 - \delta)K_t] + (1 - \beta) \sum_{j=1}^{\infty} \int_0^\infty \frac{T_{t+j}(z)}{\prod_{s=1}^j R_{t+s}(z)} \psi(dz) \\
- (1 - \beta) \sum_{j=1}^{\infty} \int \frac{T_{t+j}(z)\psi(dz)}{\prod_{s=1}^j (1 + r_{t+s})} - (1 - \beta) \sum_{j=1}^{\infty} \frac{T_{t+j}^{\mathcal{W}}}{\prod_{s=1}^j (1 + r_{t+s})}
\]

- productive entrepreneurs are constrained, i.e., for \( z > \hat{z}_{t+s} \), \( R_{t+s}(z) > 1 + r_{t+s} \)
Intuition: Non-Ricardian Model

Again, assuming workers are hand-to-mouth, the evolution of aggregate capital is given by

\[ K_{t+1} = \beta [\alpha Y_t + (1 - \delta)K_t] + (1 - \beta) \sum_{j=1}^{\infty} \int_0^{\infty} \frac{T_{t+j}(z)}{\prod_{s=1}^{j} R_{t+s}(z)} \psi(dz) \]

\[-(1 - \beta) \sum_{j=1}^{\infty} \int \frac{T_{t+j}(z)\psi(dz)}{\prod_{s=1}^{j} (1 + r_{t+s})} - (1 - \beta) \sum_{j=1}^{\infty} \frac{T_{t+j}^{W}}{\prod_{s=1}^{j} (1 + r_{t+s})}\]

- productive entrepreneurs are constrained, i.e., for \( z > \hat{z}_{t+s} \), \( R_{t+s}(z) > 1 + r_{t+s} \)
- transfers to workers are consumed
Monetary Economy: Constant Inflation Target

Bailout Case

![Graphs showing output, TFP, capital, and debt to GDP over quarters. The graphs illustrate the paths under real benchmark (blue), lump-sum bailout (green), and bailout (red) scenarios.](image-url)
Monetary Economy: Constant Inflation Target

Bailout Case (cont’d)

![Graph showing real and nominal interest rates over quarters.](image)
Monetary Economy: Constant Inflation Target

Bailout Case, Alternative Inflation Targets

![Graphs showing output, TFP, capital, and debt to GDP over quarters for different inflation targets.]

- **Output**: Shows different trajectories for output over quarters with varying inflation targets. The output stabilizes over time for all inflation targets.
- **TFP**: Similar to output, TFP also stabilizes over time with different inflation targets. The graphs show a slight upward trend as time progresses.
- **Capital**: The capital levels decrease initially and then stabilize. For higher inflation targets, the capital levels are lower compared to lower inflation targets.
- **Debt to GDP**: The debt to GDP ratio increases sharply at the beginning and then stabilizes at different levels for different inflation targets. Higher inflation targets lead to higher debt levels.

The graphs illustrate the impact of different inflation targets on the economy's output, TFP, capital, and debt to GDP over time.
Monetary Economy: Constant Inflation Target
Bailout Case, Alternative Inflation Targets
Welfare Gains of a Credit Crunch
Welfare Gains of a Credit Crunch

Alternative Tax Schemes

W = −0.006
lump−sum, wg
W = −0.013
bailout, wg
W = −0.02

real bmk, wg
W = −0.006
lump−sum, wg
W = −0.013
bailout, wg
W = −0.02
Welfare Gains of a Credit Crunch
Alternative Inflation Targets, Bailout Case

\[
\begin{align*}
\pi = 0.01, \quad w_g^W &= -0.044 \\
\pi = 0.02, \quad w_g^W &= -0.02 \\
\pi = 0.03, \quad w_g^W &= -0.0056
\end{align*}
\]
Conclusions

- credit contractions lead to a large drop in the return of safe assets

- money offers an alternative “store of value”, thus the zero lower bound

- what is the role of (lack of) monetary policy?
  - an unresponsive monetary policy leads to a deflation, and debt deflation if debts are not indexed (Fisher, 1933)
  - monetary/debt policy needs to be very expansionary to stabilize prices, and output, at the cost of crowding out private investment and generating a slow recovery
\[ \Phi_{t+1}(z) = \gamma \beta R_t(z) \Phi_t(z) + (1 - \gamma) \Psi(z) \beta \int R_t(\tilde{z}) \Phi_t(d\tilde{z}) \]
\[
= \gamma \beta R_t(z) \Phi_t(z) + (1 - \gamma) \Psi(z) K_{t+1}
\]
Comparison with exogenous TFP shock
Comparison with exogenous TFP shock (cont’d)

debt to capital ratio, $\theta_t = 1 - 1/\lambda_t$

credit crunch
TFP shock

quarters
Aggregate Debt to Non-financial Assets in the Great Recession

![Graph showing the aggregate debt to non-financial assets over years 2006 to 2012. The graph includes lines for total, corporate, and non-corporate debt, with a peak around 2008 and a decline thereafter.](image-url)
First Order Conditions

Euler equation (credit goods):

\[ \frac{1}{\beta} \frac{c_{2t+1}}{c_{2t}} = R_{t+1}(z) \]

and, cash and credit goods margin tomorrow

\[ \frac{1 - \nu}{\nu} \frac{c_{1t+1}}{c_{2t+1}} = \frac{1}{R_{t+1}(z) \frac{p_{t+1}}{p_t}} \]