The Great Escape?

A Quantitative Evaluation of the Fed’s Non-Standard Policies

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Disclaimer: The views expressed are mine and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System
The Fed’s Response to a Black Swan

Source: Board of Governors of the Federal Reserve System, Release H.4.1

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The Great Escape?
Questions

• We incorporate the financial friction proposed by Kiyotaki and Moore (2008) – differences in liquidity across assets – into a DSGE model with standard real and nominal rigidities and ask:

   1. Can a KM-type liquidity shock quantitatively generate the crisis?

   • Large response of macro and financial variables.
Questions

• We incorporate the financial friction proposed by Kiyotaki and Moore (2008) – differences in liquidity across assets – into a DSGE model with standard real and nominal rigidities and ask:

1. Can a KM-type liquidity shock quantitatively generate the crisis?
   - Large response of macro and financial variables.

2. What is the quantitative effect of unconventional monetary policy in such a setting?
   - In an environment where standard monetary policy no longer works (the “great escape” from the liquidity trap)
Main results

![Graphs showing output and inflation over quarters.](image)
The model: Kiyotaki-Moore (Shi version)

1. Households \(=\) \{ entrepreneurs with probability \(\kappa\) \\
   \text{(investment opportunity)} \\
   workers with probability \(1 - \kappa\) \}

2. Government
The model: Kiyotaki-Moore (Shi version) + a few more actors and a few more rigidities

1. Households = \{ entrepreneurs with probability $\kappa$ \\
   \hspace{1cm} (investment opportunity) \\
   workers with probability $1 - \kappa$

2. Government

3. Intermediate firms \Rightarrow sticky prices

4. Final good producing firms

5. Labor packers \Rightarrow sticky wages

6. Capital producing firms \Rightarrow investment adjustment cost

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Households

• Balance sheet:

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>nominal bonds</td>
<td>own equity issued</td>
</tr>
<tr>
<td>( b_{t+1}/P_t )</td>
<td>( q_t n_{t+1}^I )</td>
</tr>
<tr>
<td>equity of other households</td>
<td>net worth</td>
</tr>
<tr>
<td>( q_t n_{t+1}^O )</td>
<td>( q_t n_{t+1} )</td>
</tr>
<tr>
<td>capital stock</td>
<td>( + b_{t+1}/P_t )</td>
</tr>
<tr>
<td>( q_t k_{t+1} )</td>
<td></td>
</tr>
</tbody>
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where \( n_t \equiv n_t^O + (k_t - n_t^I) \).
Households

- Balance sheet:

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<td>nominal bonds $b_{t+1}/P_t$</td>
<td>own equity issued $q_t n_{t+1}$</td>
</tr>
<tr>
<td>equity of other households $q_t n^O_{t+1}$</td>
<td>net worth $q_t n_{t+1}$ + $b_{t+1}/P_t$</td>
</tr>
<tr>
<td>capital stock $q_t k_{t+1}$</td>
<td></td>
</tr>
</tbody>
</table>

where $n_t \equiv n^O_t + (k_t - n^I_t)$.

- Income: $r_t^k n_t$, transfers $\tau_t$, profits $\int \mathcal{P}_t(i) di$ and $C(i_t)$
Households

- **Balance sheet:**

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<td>nominal bonds ( b_{t+1}/P_t )</td>
<td>own equity ( q_t n_{t+1}^l )</td>
</tr>
<tr>
<td>equity of other households ( q_t n_{t+1}^O )</td>
<td>net worth ( q_t n_{t+1}^1 + b_{t+1}/P_t )</td>
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where \( n_t \equiv n_t^O + (k_t - n_t^l) \).

- **Income:** \( r^k_t n_t \), transfers \( \tau_t \), profits \( \int P_t(i) di \) and \( C(i_t) \)

- **Utility** \( E_0 \sum_t u(c_t, h_t) \), where \( c_t = \kappa c_t^e + (1 - \kappa)c_t^w \), \( h_t = (1 - \kappa)h_t^w \)

\[
\begin{align*}
k_{t+1} &= \lambda k_t + \kappa i_t^e \\
n_{t+1} &= \kappa n_{t+1}^e + (1 - \kappa)n_{t+1}^w \\
b_{t+1} &= \kappa b_{t+1}^e + (1 - \kappa)b_{t+1}^w
\end{align*}
\]
Entrepreneurs & Frictions

\[ c_t^e + p_t i_t^e + q_t (n_{t+1}^e - i_t^e) + \frac{b_{t+1}^e}{P_t} = (r_t^k + \lambda)n_t + \frac{R_{t-1}b_t}{P_t} + \tau_t + \int P_t(i) dP_t + C(i_t) \]
Entrepreneurs & Frictions

\[ \begin{align*}
    c^e_t + p^l_t i^e_t + q_t (n^e_{t+1} - i^e_t) + \frac{b^e_{t+1}}{P_t} &= (r^k_t + \lambda) n_t + \frac{R_{t-1} b_t}{P_t} + r_t + \int P_t(i) di + C(i_t) 
\end{align*} \]
\[ c_t^e + p_t^e i_t^e + q_t (n_{t+1}^e - i_t^e) + \frac{b_{t+1}^e}{P_t} = (r_t^k + \lambda) n_t + \frac{R_{t-1} b_t}{P_t} + \tau_t + \int P_t(i) d_i + C(i_t) \]

\[ n_{t+1} \geq (1 - \phi_t) \lambda n_t^e + (1 - \theta)i_t^e \]

Borrowing Constraint
Entrepreneurs & Frictions

\[ c_t^e + p_t^e i_t^e + q_t (n_{t+1}^e - i_t^e) + \frac{b_{t+1}^e}{P_t} = (r_t^k + \lambda)n_t + \frac{R_{t-1}b_t}{P_t} + \tau_t + \int P_t(i)di + C(i_t) \]

\*\( n_{t+1} \geq \frac{(1 - \phi_t) \lambda n_t}{(1 - \theta)i_t^e} \)  
\text{Resaleability Constraint}
Entrepreneurs & Frictions

\[ c_t^e + p_t^l i_t^e + q_t(n_{t+1}^e - i_t^e) + \frac{b_{t+1}^e}{P_t} = (r_t^k + \lambda)n_t + \frac{R_{t-1}b_t}{P_t} + \tau_t + \int P_t(i)di + C(i_t) \]

- \[ n_{t+1} \geq (1 - \phi_t)\lambda n_t^e + (1 - \theta)i_t^e \]
- \[ b_{t+1}^e \geq 0 \]
Entrepreneurs & Frictions

\[ c_t^e + p_t^li_t^e + q_t(n_{t+1}^e - i_t^e) + \frac{b_{t+1}^e}{P_t} = (r_t^k + \lambda)n_t + \frac{R_{t-1}b_t}{P_t} + \tau_t + \int P_t(i)di + C(i_t) \]

- \[ n_{t+1} \geq (1 - \phi_t)\lambda n_t^e + (1 - \theta)i_t^e \]
- \[ b_{t+1}^e \geq 0 \]
- Solution: \[ b_{t+1}^e = 0, c_t^e = 0, n_{t+1}^e = \lambda n_t + (1 - \theta)i_t^e \]

\[ i_t^e = \frac{(r_t^k + \lambda\phi_tq_t)n_t + \frac{R_{t-1}b_t}{P_t} + \int P_t(i)di + C(i_t)}{p_t^l - \theta_tq_t} \]
Households’ FOCs

- Choose $n_{t+1}$, $b_{t+1}$, and $c_t$, subject to solution for $i_t^e$ and hh’s level budget constraint:

$$c_t + p_t \kappa i_t^e + q_t(n_{t+1} - \kappa i_t^e) + \frac{b_{t+1}}{P_t} = (r_t^k + \lambda)n_t + \frac{R_{t-1}b_t}{P_t} + \int P_t(i)d\ i + C(i_t)$$
Households’ FOCs

- Choose \( n_{t+1}, b_{t+1}, \) and \( c_t \), subject to solution for \( i_t^e \) and hh’s level budget constraint:

\[
c_t + p_t^I \kappa i_t^e + q_t(n_{t+1} - \kappa i_t^e) + \frac{b_{t+1}}{P_t} = (r_t^k + \lambda)n_t + \frac{R_{t-1}b_t}{P_t} + \int P_t(i)di + C(i_t)
\]

- Euler:

\[
u_c(c_t, h_t) = \beta E_t \left[ u_c(c_{t+1}, h_{t+1}) \left\{ \frac{R_t}{\pi_{t+1}} + \frac{\kappa(q_{t+1} - p_{t+1}^I)}{p_{t+1}^I - \theta_{t+1}q_{t+1}} \frac{R_t}{\pi_{t+1}} \right\} \right]
\]
Households’ FOCs

- Choose \(n_{t+1}, b_{t+1}, \text{and } c_t\), subject to solution for \(i_t^e\) and hh’s level budget constraint:

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\]

- Arbitrage:

\[E_t \left[u_c(c_{t+1}, h_{t+1}) \left\{ \frac{R_t}{\pi_{t+1}} \left(1 + \frac{\kappa(q_{t+1} - p_{t+1}^l)}{p_{t+1} - \theta_{t+1}q_{t+1}} \right)ight.\right.
\[
- \frac{r^k_{t+1} + \lambda q_{t+1}}{q_t} \left(1 + \frac{\kappa(q_{t+1} - p_{t+1}^l)}{p_{t+1} - \theta_{t+1}q_{t+1}} \frac{r^k_{t+1} + \lambda q_{t+1}}{q_t} \right)\left\} \right\} = 0
\]
Households’ FOCs

- Choose $n_{t+1}$, $b_{t+1}$, and $c_t$, subject to solution for $i_t^e$ and hh’s level budget constraint:

$$c_t + p_t^l \varepsilon i_t^e + q_t (n_{t+1} - \varepsilon i_t^e) + \frac{b_{t+1}}{P_t} = (r_t^k + \lambda) n_t + \frac{R_{t-1} b_t}{P_t} + \int P_t(i) di + C(i_t)$$

- Euler:

$$u_c(c_t, h_t) = \beta E_t \left[ u_c(c_{t+1}, h_{t+1}) \left\{ \frac{R_t}{\pi_{t+1}} + \frac{\varepsilon(q_{t+1} - p_{t+1}^l)}{p_{t+1}^l - \theta_{t+1} q_{t+1}} \frac{R_t}{\pi_{t+1}} \right\} \right]$$

- Arbitrage:

$$E_t \left[ u_c(c_{t+1}, h_{t+1}) \left\{ \frac{R_t}{\pi_{t+1}} (1 + \frac{\varepsilon(q_{t+1} - p_{t+1}^l)}{p_{t+1}^l - \theta_{t+1} q_{t+1}}) \right. \right.$$

$$- \frac{r_{t+1}^k + \lambda q_{t+1}}{q_t} (1 + \frac{\varepsilon(q_{t+1} - p_{t+1}^l)}{p_{t+1}^l - \theta_{t+1} q_{t+1}} \frac{r_{t+1}^k + \lambda \phi_{t+1} q_{t+1}}{r_{t+1}^k + \lambda q_{t+1}} \left. \right) \right] = 0$$

- Wage setting decision
The Role of Nominal Rigidities

\[ y_t = i_t [1 + S \left( \frac{i_t}{i^*} \right)] + c_t \]
The Role of Nominal Rigidities

\[ y_t = i_t [1 + S\left(\frac{i_t}{i^*}\right)] + c_t \]
Government

- Taylor rule:
  \[ R_t = \max\{R_* (\pi_t / \pi_*)^{\psi_1}, 0\} \]

- Unconventional monetary policy:
  \[ N^g_t = K_* \xi (\frac{\phi_t}{\phi_*} - 1) \]

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Government

• Taylor rule:

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• **Chicken**: Gvmt intervenes on the open market (does not relax individual agents constraints) ... but does have the power to issue liquid assets.
Government

• Taylor rule:

\[ R_t = \max \{ R_* \left( \frac{\pi_t}{\pi_*} \right)^{\psi_1}, 0 \} \]

• Unconventional monetary policy:

\[ N^g_t = K_* \xi \left( \frac{\phi_t}{\phi_*} - 1 \right) \]

• Chicken: Gvmt intervenes on the open market (does not relax individual agents constraints) ... but does have the power to issue liquid assets.

• Gvmt budget constraint, taxes:

\[ \tau_t - B_{t+1} \frac{B_t}{P_t} + q_t N^g_{t+1} = (r^k_t + q_t \lambda) N^g_t - \frac{R_{t-1} B_t}{P_t} \]

\[ \tau_t - \tau_* = \psi_3 \left( \left( \frac{R_{t-1} B_t}{P_t} - \frac{R_* B_*}{P_*} \right) - q_t N^g_t \right) \]
Equilibrium and solution of the Model

- All agents maximize subject to their constraints and markets clear

- Linearize model about constrained steady state

- Liquidity shock follows two-state Markov process (s.s. vs crisis)

- Explicitly take into account zero bound (Eggertsson and Woodford, 2002)
Liquidity Share: \[ \frac{L}{L+qK} \]
Steady State as a Function of $\phi_*$

(for $L_*/Y_* = .40$)

Liquidity share

Real return on liquid asset

Equity premium

$q$

% annualized

% annualized

% annualized

% annualized

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Calibration

• Impose $\phi = 18\%$ ($\theta = 20\%$) to obtain:
  1. steady state liquidity share of 13%
  2. real return on liquid assets of 1.75% (1952Q1:2008Q4)

• Probability of receiving investment opportunity: $\kappa = 5\%$
  Doms and Dunne (1998) and Cooper, Haltiwanger and Power (1999)

• Standard preferences: $u(c_t, h_t) = \frac{1}{1-\sigma} c_t^{1-\sigma} - \frac{\omega}{1+\nu} h_t^{1+\nu}$
  • Nominal rigidities: $\zeta_p = \zeta_w = .75$
  • Discount factor: $\beta = 0.99$
  • Intertemporal elasticity: $\sigma = 1$
  • Depreciation rate: $\lambda = 0.975$ (Annual depreciation = 10%)
  • Capital share: $\gamma = 0.4$
  • Taylor rule response to inflation: $\psi_1 = 1.5$
  • Inverse Frisch elasticity: $\nu = 1$
  • Investment adjustment costs: $S''(1) = 1$
Response of Macro Variables to a liquidity shock (with intervention)

- **Output**: % change from steady state over time (2006 to 2010)
- **Inflation**: Annualized % points over time (2006 to 2010)
- **Nominal Interest Rate**: Over time (2006 to 2010)
- **GDP**: Log-level (2008Q2 = 0) over time (2006 to 2010)
- **GDP Deflator**: Annualized % points over time (2006 to 2010)
- **FFR**: Over time (2006 to 2010)

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Calibration of the $\phi_t$ Shock and the Fed’s Response

Liquidity Share

Government Purchase of Private Equity

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Response of C, I, Spreads, q to a liquidity shock (with intervention)

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Data: C, I, Spreads, q

Consumption

Investment

Empirical Spreads (1\textsuperscript{st} P.C.)

Value of Capital

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The Effect of Policy Intervention

Output

% Δ from steady state

Quarters

Inflation

Annualized % points

% Δ from steady state

Quarters

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The Great Escape?

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Multipliers

\[
E_0 \sum_{t=0}^{\infty} (\hat{Y}_t^I - \hat{Y}_t^N) \\
E_0 \sum_{t=0}^{\infty} \hat{N}_{t+1}^g
\]

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Great Escape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full model</td>
<td>0.55</td>
<td>3.85</td>
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Baseline vs Great Escape
The Role of the Zero Bound

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The Great Escape?
The Role of the Nominal Rigidities

Output

Real Interest Rate

Investment

Consumption

% Δ from steady state

% Δ from steady state

Annualized % points

Quarters

Quarters

% Δ from steady state

% Δ from steady state

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Conclusions

1. Liquidity shocks as in Kiyotaki-Moore model can generate quantitatively large movements in real and financial variables → can explain some features of the crisis

2. Swap of liquid for illiquid assets (unconventional policy) is effective in reducing impact on spreads and real variables
   - How much should the central bank intervene via unconventional policy?
   - “Great escape” or “Great moral hazard”?

• Caveat: This is not a model for normative analysis!!!
Robustness to nominal rigidities

\[ ZB-\text{model-LY0}_{\text{hi a f-calibshi a f}} \]

- [Graphs showing time series of economic variables like output ($Y$), inflation ($\pi$), and other indicators with different levels of rigidity ($\zeta$).]

- A multiplier graph showing the effect of varying $\zeta$ from 0.66 to 0.85 on the multiplier.

- The graphs illustrate the impact of nominal rigidities on macroeconomic variables over time.
Investment Adjustment Costs

- Capital producers:

\[
\max_{l_t} C(l_t) = p_t l_t - l_t \left[1 + S\left(\frac{l_t}{l_*}\right)\right]
\]

with \( S(1) = S'(1) = 0, S''(1) > 0 \)

\[
\Rightarrow p_t = 1 + S\left(\frac{l_t}{l_*}\right) + S'\left(\frac{l_t}{l_*}\right) \frac{l_t}{l_*}
\]
Sticky Prices

- Monopolistic competitors produce intermediate goods with technology:

\[ y_t(i) = A_t k_t(i) \gamma l_t(i)^{1-\gamma}, \]

subject to Calvo price rigidity \((\zeta_p)\).

- Final goods producers aggregate:

\[ y_t = \left[ \int_0^1 y_t(i) \frac{1}{1+\lambda_{f,t}} \, di \right]^{1+\lambda_{f,t}} \]

- Inflation determined by New-Keynesian Phillips curve
Paths for the Nominal Interest Rate

Nominal Interest Rate

- IRF
- Contingency

Quarters

Annualized % points

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