A model of unconventional monetary policy

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Presenter

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Motivation

- **Aim of the paper**
  - Develop a monetary DSGE model to account for the effects of unconventional monetary policy

- **Conventional** monetary policy
  - Post war period, FED manipulated Funds rate in order to affect market interest rates.
  - FED avoided lending directly in private credit markets.

- **Unconventional** monetary policy
  - After subprime crisis, situation change dramatically.
  - FED directly injected credit into private markets.
  - It provided backstop funding to help revive the commercial paper market, also intervened heavily in the mortgage markets...
  - Evidence suggest that it has been effective in reducing credit costs
Motivation

- Motivation for unconventional monetary policy
  - Sharp deterioration in balance sheet of financial intermediaries
  - This disrupts the flow of funds between borrowers and lenders
  - Tightening of credit raise cost of borrowing
  - Contraction in the real activity reduces asset values
  - This reduces further intermediaries balance sheet

- They do not try to model the sub prime crisis explicitly
  - They want to capture the key elements relevant to analyzing the Fed’s credit market interventions
Ingredients

- **Standard quantitative monetary DSGE model**
  - Nominal rigidities
  - Financial intermediaries

- **Financial intermediaries**
  - Financial intermediaries that borrow from depositors and lend to firms
  - Agency problem between the intermediaries and depositors
  - Deterioration of intermediary capital: disrupt lending and borrowing, raising credit costs

- **Central bank**
  - Unconventional monetary policy == Central bank that borrow from savers and lend to investors
  - No agency problem between central bank and creditors
  - Central bank is less efficient
Large literature on conventional monetary policy:
- Cristiano et al (2005), Smets and Wouters (2007)
- They can not account for the dramatic changes in actual practice
- Many of these models assume frictionless financial markets
- Bernanke (1999) consider financial frictions, but not explicitly considered direct central bank intermediation

Until now:
- Models were unable to capture financial market disruptions that could motivate unconventional central bank interventions

Contribution:
- Macro model that analyze the effects of unconventional monetary policy as existing frameworks study conventional monetary policy
Households I

- Continuum of identical households of measure unity
- Within each household, two types of members
  - Workers: Supply labor and return wages to household
  - Bankers: Manage a financial intermediary, transfer any earning back to household
- Within the family, perfect consumption insurance
  - Representative agent model
- Deposits of households in financial intermediaries that is does not own.
- At any moment
  - \((1-f)\) of households are workers
  - \(f\) of households are bankers
  - Every period, \((1-\theta)f\) of bankers exit and become workers
  - Relative portion fixed
Households II

\[
\max \mathbb{E}_t \sum_{i=0}^{\infty} \beta^i \left[ \ln(C_{t+i} - hC_{t+i-1} - \frac{\chi}{1+\varphi} L_{t+i}^{1+\varphi}) \right]
\]

\[
C_t = W_t L_t + \prod_t + T_t + R_t B_t - B_{t+1}
\]

\[
0 < \beta < 1, 0 < h < 1, \chi, \varphi > 0
\]

- \( B_{t+1} \) is the total quantity of short term debt household acquires
  - \( B_{t+1} \) could be intermediary deposits or government debt
  - Both are one period real bonds that pay the gross return \( R_t \) from \( t-1 \) to \( t \).
  - In equilibrium we both instruments are riskless and perfect substitutes.

- Household first order conditions

\[
\varrho W_t = \chi L_t^\varphi
\]

where \( \varrho = (C_t - hC_{t-1})^{-1} - \beta h \mathbb{E}_t (C_{t+1} - hC_t)^{-1} \)

\[
\mathbb{E}/\beta \Lambda_{t,t+1} R_{t+1} = 1
\]

\[
\Lambda_{t,t+1} = \frac{\varrho_{t+1}}{\varrho_t}
\]
Financial intermediaries I (or banks)

- Financial intermediary lend funds obtained from households to firms

**Financial intermediary balance sheet:** \( Q_t S_{jt} = N_{jt} + B_{jt+1} \)

- \( N_{jt} \): The amount of wealth (equity)
- \( B_{jt+1} \): Deposits the intermediary obtains from households
- \( S_{jt} \): Financial claims on non-financial firms that intermediary holds
- \( Q_t \): Relative price of each claim

**Banker’s equity evolution:**
\[
N_{jt+1} = R_{kt+1}Q_t S_{jt} - R_{t+1}B_{jt+1} = (R_{kt+1} - R_{t+1})Q_t S_{jt} + R_{t+1}N_{jt}
\]

- Any raise in equity above the riskless return depends on the premium

\[ R_{kt+1} - R_{t+1} \]

**Condition for the intermediary to operate**
\[
\max_{E_t} \beta_t \Lambda_{t,t+1+i}(R_{kt+1+i} - R_{t+1+i}) \geq 0, \ i \geq 0
\]
Financial intermediaries II

- **Agency problem** that limits intermediaries’ ability of borrowing
  - Banker can divert a fraction $\lambda$ of available funds

- **Incentive constraint**: $V_{jt} \geq \lambda Q_t S_{jt}$
  - $V_{jt} = v_t \cdot Q_t S_{jt} + \eta_t N$ is expected terminal wealth
  - $v_t = E_t \left\{ (1 - \theta) \beta \Lambda_{t,t+1} (R_{kt+1} - R_{t+1}) + \beta \Lambda_{t,t+1} \theta x_{t,t+1} v_{t,t+1} \right\}$
  - Expected discounted mg gain of $\triangle Q_t S_{jt}$, keeping $N_{jt}$ cte
  - $\eta = E_t \left\{ (1 - \theta) + \beta \Lambda_{t,t+1} \theta z_{t,t+1} \eta_{t+1} \right\}$
  - Expected discounted mg gain of $\triangle N_{jt}$, keeping $Q_t S_{jt}$ cte

- $x_{t,t+1} = \frac{Q_{t+i} S_{jt+i}}{Q_t S_{jt}}$
- $z_{t,t+i} = \frac{N_{jt+i}}{N_{jt}}$

- With frictionless competitive markets, intermediaries will expand borrowing to the point where $v_t = 0$
**Incentive constraint II:** \( \eta N_{jt} + \nu_t Q_t S_{jt} \geq \lambda Q_t S_{jt} \)

**Assets that banker can acquire:** \( Q_t S_{jt} = \frac{\eta_t}{\lambda - \nu_t} N_{jt} = \phi_t N_{jt} \)

- \( \phi_t \): ratio of privately intermediated assets to equity (private leverage ratio)
- Assets will depend positively on equity capital

**The agency problem leads to an endogenous capital constraint on the intermediary’s ability to acquire assets**

- Given \( N_{jt} > 0 \), the constraint binds only if \( 0 < \nu_t < \lambda \).

- Holding constant \( N_{jt} \), expanding \( S_{jt} \) raises bankers’ incentive to divert
  - The larger is \( \nu_t \), the greater is the opportunity cost to the banker from being forced into bankruptcy

**Total demand of assets:** \( Q_t S_t = \phi_t N_t \)
Credit policy

- Now suppose the Central bank is willing to facilitate lending

- **Total value of intermediated assets**: \( Q_t S_t = Q_t S_{pt} + Q_t S_{gt} \)

- **Credit policy**
  - Central bank issues gov. debt to households that pays riskless rate \( R_{t+1} \)
  - Lends funds to non-financial firms at the market lending rate \( R_{kt+1} \)
  - Involves efficiency cost of \( \tau \) per unit supplied
  - Government always honor its debt: No agency conflict
  - \( Q_t S_{gt} = \psi Q_t S_t \) Central bank is willing to fund a fraction \( \psi \) of intermediated assets

- **Total value of intermediated assets**: \( Q_t S_t = \phi_t N_t + \psi Q_t S_t = \phi_{ct} N_t \)
  - \( \phi_{ct} = \frac{1}{1-\psi} \phi_t \)
  - \( \phi_{ct} \) is leverage for total intermediated funds, depends positively on \( \psi \)
Intermediate good firms I

- Competitive non financial firms produce intermediate goods
  - Goods eventually sold to retail firms
  - Retail firms needed to introduce nominal rigidities

- Timing:
  - At the end of t, an intermediate goods producer acquires capital $K_{t+1}$
  - After production in t+1, firms can sell the capital.
  - No adjustment cost at the firm level
  - Firm finance its capital acquisition each period by obtaining funds from intermediaries $Q_t K_{t+1} = Q_t S_t$

- No frictions in the process of non financial firms obtaining funding.
  - Still, financial intermediaries face capital constraints on obtaining funds.
  - These constraints affect supply of funds available to non financial firms.
Intermediate good firms II

- $Y_t = A_t(U_t \xi_t K_t)^\alpha L_t^{1-\alpha}$
  - $\xi$ denote the quality capital
  - Provide a source of exogenous variation in the value of capital
  - Utilization rate of capital $U_{t+1}$

- $P_{mt}$ is the price of the intermediate good output.

- Firm chooses the utilization rate and labor demand as follows
  \[
P_{mt} \alpha \frac{Y_t}{U_t} = \delta' (U_t) \xi_t K_t
  \]
  \[
P_{mt} (1-\alpha) \frac{Y_t}{U_t} = W_t
  \]

- Firm earns zero profits in the steady state
  - it simply pays out the ex post return to capital to the intermediary.
  - Accordingly $R_{kt+1}$ is given by
  \[
  R_{kt+1} = \left[ P_{mt+1} \alpha \frac{Y_{t+1}}{\xi_{t+1} K_{t+1}} + Q_{t+1} - \delta(U_{t+1}) \right] \xi_{t+1} K_t
  \]
Capital producing firms/ Retail firms

Capital producing firms

- At the end of period $t$, competitive capital producing firms
  - Buy capital from intermediate goods producing firms.
  - Repair depreciated capital and build new capital.

- Discounted profit for capital producers is given by:
  \[ \max E_t \sum_{\tau=t}^{\infty} \beta^{T-t} \Lambda_{t,\tau} \left\{ (Q_\tau - 1) I_{n\tau} - f \left( \frac{I_{nt} + I_{ss}}{I_{nt} + I_{SS}} \right) (I_{nt} + I_{ss}) \right\} \]
  \[ I_{nt} = I_t - \delta(U_t) \xi_t K_t. \]

Retailers

- Final output is given by: $Y_t = \left[ \int_0^1 Y_{ft} \left( \frac{\epsilon - 1}{\epsilon} \right) df \right]^{\epsilon/(\epsilon-1)}$
  - $Y_{ft} = \frac{P_{ft}}{P_t}^{-\epsilon} Y_t$, output by retailer $f$
  - CES composite of a continuum of differentiated retail firms
  - They use intermediate output as the sole input.
Retailers and government resource constraint

Retailers (continuation)

- Nominal rigidities:
  - Firm can freely adjust its price with probability \((1 - \gamma)\)
  - Firm is able to index its price to the lagged rate of inflation.

- Pricing problem is to choose the optimal reset price \(P^*_t\) that solves:
  \[
  \max \mathbb{E} \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,i} \left[ \frac{P^*_t}{P_{t+i}} \prod_{k=1}^{i} (1 + \pi_{t+k-1})^{\gamma_p} - P_{mt+i} \right] Y_{f,t+i}
  \]

- Evolution of price level
  \[
  P_t = \left[ (1 - \gamma)(P^*_t)^{1-\epsilon} + \gamma(\pi_{t-1}^{\gamma_p}P_{t-1})^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}
  \]

- Economy wide resource constraint
  \[
  Y_t = C_t + I_t + f \left( \frac{l_{nt} + l_{ss}}{l_{nt-1} + l_{ss}} \right) (l_{nt} + l_{ss}) + G + \tau \psi_t Q_t K_{t+1}
  \]
  \[\tau \psi_t Q_t K_{t+1}\] are expenditures in government intermediation.

- Capital evolution
  \[
  K_{t+1} = \xi_t K_t + I_{nt}; \quad I_{nt} = l_t - \delta(U_t) \xi_t K_t.
  \]
Government policy

- **Financing government expenditures**
  \[ G + \tau \psi_t Q_t K_{t+1} = T_t + (R_{kt} - R_t) B_{gt-1} \]

- **Taylor rule**
  \[ i_t = (1 - \rho) \left[ i + \kappa_{\pi} \pi_t + \kappa_{\gamma} (\log Y_t - \log Y^*_t) \right] + \rho i_{t-1} + \epsilon_t \]
  - \( \rho \in [0, 1] \): smoothing parameter
  - \( \epsilon_t \): exogenous shock to monetary policy

- **Feedback rule**
  \[ \psi_t = \psi + \nu \mathbb{E} \left[ (\log R_{kt+1} - \log R_{t+1}) - (\log R_k - \log R) \right] \]
  - \( \psi \) is the steady state fraction of publicly intermediated assets
  - \( \log R_k - \log R \) is the steady state premium

Central bank expands credit as the spread increase relative to its steady state value.

In crisis, Central bank abandons its proclivity to smooth \( i \).

- Sets the smoothing parameter \( \rho = 0 \).
Calibration

- 18 parameters. 15 are standards, 3 are specific: $\lambda, \theta, \xi$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.990</td>
<td>Discount rate</td>
</tr>
<tr>
<td>$h$</td>
<td>0.815</td>
<td>Habit parameter</td>
</tr>
<tr>
<td>$\chi$</td>
<td>3.409</td>
<td>Relative utility weight of labor</td>
</tr>
<tr>
<td>$\phi$</td>
<td>0.276</td>
<td>Inverse Frisch elasticity of labor supply</td>
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<tr>
<td><strong>Financial Intermediaries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.381</td>
<td>Fraction of capital that can be diverted</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.002</td>
<td>Proportional transfer to the entering bankers</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.972</td>
<td>Survival rate of the bankers</td>
</tr>
<tr>
<td><strong>Intermediate good firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.330</td>
<td>Effective capital share</td>
</tr>
<tr>
<td>$U$</td>
<td>1.000</td>
<td>Steady state capital utilization rate</td>
</tr>
<tr>
<td>$\delta(U)$</td>
<td>0.025</td>
<td>Steady state depreciation rate</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>7.200</td>
<td>Elasticity of marginal depreciation with respect to utilization rate</td>
</tr>
<tr>
<td><strong>Capital Producing Firms</strong></td>
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<td></td>
</tr>
<tr>
<td>$\eta_i$</td>
<td>1.728</td>
<td>Inverse elasticity of net investment to the price of capital</td>
</tr>
<tr>
<td><strong>Retail firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>4.167</td>
<td>Elasticity of substitution</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.779</td>
<td>Probability of keeping prices fixed</td>
</tr>
<tr>
<td>$\gamma_p$</td>
<td>0.241</td>
<td>Measure of price indexation</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\kappa_n$</td>
<td>1.5</td>
<td>Inflation coefficient of the Taylor rule</td>
</tr>
<tr>
<td>$\kappa_y$</td>
<td>0.50/4</td>
<td>Output gap coefficient of the Taylor rule</td>
</tr>
<tr>
<td>$\rho_l$</td>
<td>0.8</td>
<td>Smoothing parameter of the Taylor rule</td>
</tr>
<tr>
<td>$G$</td>
<td>0.200</td>
<td>Steady state proportion of government expenditures</td>
</tr>
</tbody>
</table>
Experiments

- Tech shock: 1% innovation in TFP, quarterly autoregressive factor of 0.95
- Mon shock: Unanticipated 25 basis point increase in short term $i_t$
- Intermediary shock: Net worth declines by 1%
Crisis experiment I

- Shock to the quality of intermediary assets
  - 5% decline in capital quality $\xi$, with quarterly autoregressive factor 0.66

- An exogenous and an endogenous component to the decline in assets
  - 1-Initial decline in capital reduces asset value by reducing the effective quantity of capital
  - 2-Due to leverage ratio constraint, the weakening of intermediary balance sheets induces a drop in asset demand, reducing the asset price $Q_t$, and investment
  - The endogenous fall in $Q_t$ further shrinks intermediary balance sheets.
  
The overall contraction is magnified by the degree of leverage
Let's see how the economy reacts without credit policy response.
Credit policy response

- We now consider different intervention intensities
  - \( \nu = 10 \), closer to real life. Increase in bank balance sheet of 7%
  - \( \nu = 100 \), closer to the optimum. Increase in bank balance sheet of 15%
Credit policy response

- In each instance, the credit policy significantly moderates the contraction

- Main reason is that central intermediation dampens the rise in the spread, which in turn dampens the investment decline

- Other things worth noting
  - Central bank exits from its balance sheet slowly over time.
  - Exit is associated with private financial intermediaries re-capitalizing
  - Inflation remains under control
Impact on the lower zero bound

- The steady state value of interest rates is four hundred basic points.
  - In the baseline experiment, I dropped 500 basic points.
  - That's not possible! Let's impose a constraint.
News as a source of asset price variation

- Effect of $\nabla$ in asset value VS effect of $\nabla$ of physical capital
- Economy is hit by news that a capital shock is likely to hit the economy in the subsequent period with probability $\sigma$
- The shock is never realized but that for a number of periods the private sector continues to believe it will arise with probability $\sigma$
- The experiment proceeds as follows:
  - Economy begins with the capital stock 5% above stst (overoptimism)
  - A wave of pessimism then sets in
  - Collapse in output very similar to previous section
  - Assets value collapse and the spread increases, which leads to the fall in output and investment
  - News shock does not affect directly the stock of capital
News as a source of asset price variation
Concluding remarks

- Quantitative monetary DSGE model with financial intermediaries that face endogenously determined balance sheet constraints

- Model can evaluate the effects of expanding central bank credit
  - Central bank is less efficient than intermediaries
  - It can elastically provide funds

- During crisis, balance sheet of intermediaries shrink
  - Net benefits of central bank intermediation
  - In the case of the zero lower bound, benefits of credit policy might be significantly enhanced
  - Unconventional monetary policy should be used only during crisis times