Liquidity Trap and Unconventional Policy

Johannes Wieland
jfwieland@ucsd.edu

Spring 2024

The Intuition of Sticky Prices and Monetary Policy

- In theory, prices should adjust a lot, quantities relatively little.
- Sticky prices: If limit price movement, quantities adjust more.
- Example: Surprise money expansion.
  - Wages and prices should all double, with no effect.
  - If prices and wages are sticky, output rises in short run.
- However, always one price that can adjust.
  - Interest rate: Price of consumption today vs. tomorrow.
  - Interest rates act as a stabilizer, making sure sticky prices do not do "too much" because this key price is flexible.
- This is how monetary policy stabilizes economy:
  - Moving $\hat{i}_t$ adjusts $\hat{r}_{t+1}$ relative to $\hat{r}^n_{t+1}$, which through intertemporal substitution along Euler equation expands or contracts aggregate demand.
  - Demand side instrument: no tradeoff for demand shocks, only for supply shocks.

The Liquidity Trap

- But what if interest rates are *also* stuck?
  - Then quantities will adjust *a lot* because this key intertemporal price fails to fully adjust.
- We call this situation a liquidity trap.
  - Topsy-turvy world in which most conventional intuition is flipped on its head.
- How could a liquidity trap occur?
  - Central bank hits *zero lower bound* on nominal interest rates.
  - At $i = 0$, money and bonds become perfect substitutes. Open market operations useless; cannot push interest rate below $i = 0$.
  - Because $E_t\{r_{t+1}\} = i_t - E_t\{\pi_{t+1}\}$, happens when full employment real interest rate falls below $-E_t\{\pi_{t+1}\}$.
- Keynes described liquidity trap, but until late 1990s, seen as a theoretical curiosity.

This Class' Approach to the Liquidity Trap

- Since 2008, burgeoning literature.
  - Too much to cover, very technical.
  - Ignore complications: multiple equilibria, non-linearities.
- I will try to give you broad outlines of what NK model tells us about a liquidity trap, focusing on policy.
- Will primarily use a simple NK model with a deterministic liquidity trap (as in Werning, 2012).
  - *Exogenous* liquidity trap where the real rate is negative.
  - Questions: Why is a liquidity trap so destructive? What is best set of policies given liquidity trap?
- Will not cover where liquidity trap comes from.
  - Key idea: Deleveraging by indebted can force savings enough to drive interest rate determined by saver Euler negative.
  - See Eggertson and Krugman (2012) for simple treatment of endogenous liquidity trap, Simsek and Korinek (2016) for application to macroprudential policy.

Outline: Questions on the Liquidity Trap

1. What Is the Effect of a Liquidity Trap in the NK Model?
2. What Is Optimal Monetary Policy in a Liquidity Trap?
   - 2.1 Forward Guidance (Gali 5.4)
   - 2.2 Other Unconventional Policies
   - 2.3 Is Zero the Lower Bound?
3. What Is the Role of Fiscal Policy in a Liquidity Trap?

What Is the Effect of a Liquidity Trap in the NK Model?

- Start with standard NK model with no cost-push shocks:

$$\hat{\pi}_t = \beta E_t\{\hat{\pi}_{t+1}\} + \kappa \hat{x}_t$$
$$\hat{x}_t = E_t\{\hat{x}_{t+1}\} - \sigma E_t\{\hat{i}_t - \hat{\pi}_{t+1} - r^n_{t+1}\}$$

- Optimal monetary policy is to set $\hat{i}_t = E_t\{\hat{r}^n_{t+1}\}$ so $\hat{x}_t = 0$ and $\hat{\pi}_t = 0$ (divine coincidence).

What Is the Effect of a Liquidity Trap in the NK Model?

- Thought experiment we will use repeatedly today:
  - The natural rate is at its steady state of ρ until period $t-1$.
  - At period t, learn $\hat{r}^n_{t+1}$ will follow deterministic path:

$$\hat{r}^n_{t+1} = \begin{cases} -\rho - \Delta < 0 & \text{from } t \text{ to } t+T \\ 0 & \text{from } t+T+1 \text{ onwards} \end{cases}$$

- For now, Central Bank pursues optimal discretionary policy
  - Prior to t and from $t+T+1$ onwards, set $\hat{x}_t = -\frac{\kappa}{\vartheta}\hat{\pi}_t \Rightarrow \hat{i}_t = 0,\ i_t = \rho \Rightarrow \hat{\pi}_t = 0$.
  - From t to $t+T$, lower i_t to ZLB so $i_t = 0$ and $\hat{i}_t = -\rho$.

What Is the Effect of a Liquidity Trap in the NK Model?

- Iterating forward and setting optimal policy from $t+T+1$ onward, in period t we have:

$$\hat{x}_t = -\sigma \sum_{s=0}^{T} (\Delta - \hat{\pi}_{t+s+1})$$

$$\hat{\pi}_t = \sum_{s=0}^{T} \beta^s \kappa \hat{x}_{t+s}$$

- This implies persistent slump with $\hat{x}_t < 0$ and $\hat{\pi}_t < 0$!
  - Start in period $t+T$. Know $\hat{\pi}_{t+T+1} = 0$ and $\Delta > 0$, so $\hat{x}_{t+T} < 0$ and $\hat{\pi}_{t+T} < 0$.
  - In period $t+T-1$, $\hat{\pi}_{t+T} < 0$ and $\Delta > 0$, so $\hat{x}_{t+T-1} < \hat{x}_{t+T} < 0$ and $\hat{\pi}_{t+T-1} < \hat{\pi}_{t+T} < 0$.
  - Working backward, $\hat{x} < 0$ and $\hat{\pi}$ all the way back to period t, with bigger output gaps and deflation farther back.

Central Bank Discretion Solution

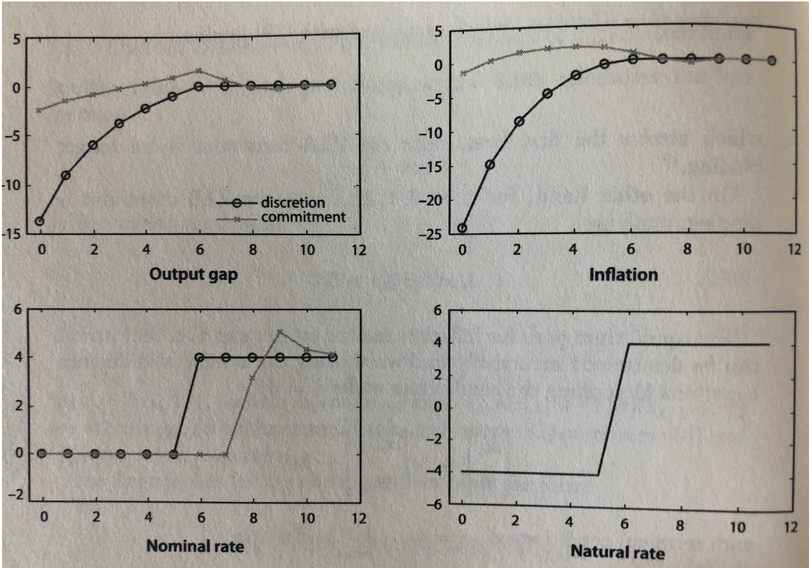

Figure 5.3. Discretion vs. Commitment in the Presence of a ZLB.

What Is the Effect of a Liquidity Trap in the NK Model?

- Why the big slump?
- Even if inflation were zero, consumption would be depressed by

$$\hat{x}_t = -\sigma \sum_{s=0}^{T} \Delta$$

  - Households desired savings too high because $\hat{r}_{t+1}$ is too high.
- Key Idea: Deflation exacerbates the ZLB.
  - Deflation occurs because negative output gaps push down MC.
  - This pushes $\hat{r}_{t+1}$ higher as $\hat{r}_{t+1} = -E_t\{\hat{\pi}_{t+1}\}$, which makes $\hat{x}_t$ lower, leading to more deflation....

$$\hat{x}_t = -\sigma \sum_{s=0}^{T} (\Delta - \hat{\pi}_{t+s+1})$$

  - Inflation is forward looking, so deflation is worst at the beginning and then gets better.

The Paradox of Flexibility

- Would more flexible prices make things better?
  - NO! Surprisingly, they make things worse!
- Output gap with perfectly sticky prices is:

$$\hat{x}_t = -\sigma \sum_{s=0}^{T} \Delta$$

- Output gap with flexible prices (larger κ) is:

$$\hat{x}_t = -\sigma \sum_{s=0}^{T} (\Delta - \hat{\pi}_{t+s+1})$$

  with $\hat{\pi}_{t+s+1}$ increasing as $\kappa \to \infty$.
- Intuition: Deflation is what turbocharges liquidity trap.
  - More flexibility $\Rightarrow$ more deflation $\Rightarrow$ worse spiral.

What Is Optimal Monetary Policy in a Liquidity Trap?

- What does monetary policy want to do in a liquidity trap?
  - $i_t = 0 \Rightarrow$ It can't do anything!
- But, as with optimal monetary policy, can gain from committing self to non-discretionary solution.
  - This time with respect to policy *after* the liquidity trap.
  - In particular, it wants to *commit to inflating*!

What Is Optimal Monetary Policy in a Liquidity Trap?

- In T period liquidity trap with commitment:

$$\hat{x}_t = -\sigma \sum_{s=0}^{T} (\Delta - \hat{\pi}_{t+s+1}) - \sigma \sum_{s=T+1}^{\infty} (\hat{i}_{t+s} - \hat{\pi}_{t+s+1})$$

$$\hat{\pi}_t = \sum_{s=0}^{\infty} \beta^s \kappa \hat{x}_{t+s}$$

- Causing an inflationary boom when the liquidity trap is over:
  1. Reduces "over saving" problem causing the trap.
     - ★ Boom in future, so less reason to save.
     - ★ This is the root cause. It would help even with fixed prices.
  2. Reduces deflation ⇒ mitigates deflationary spiral.
     - ★ Inflation today pushes r_t down towards r_t^n.

Central Bank Problem

$$
\begin{aligned}
\min_{\hat{x}_{t+s},\hat{\pi}_{t+s}} \ & \frac{1}{2}\sum_{s=0}^{\infty}\beta^s\left(\hat{\pi}_{t+s}^2+\vartheta\hat{x}_{t+s}^2\right)\\
\text{s.t. } \ & \hat{\pi}_t=\beta\hat{\pi}_{t+1}+\kappa\hat{x}_t\\
& \hat{x}_t\leq\hat{x}_{t+1}-\sigma(-\rho-\hat{\pi}_{t+1}-\hat{r}_{t+1}^n)
\end{aligned}
$$

- Second constraint combines IS and ZLB ($i_t \geq 0 \Rightarrow \hat{i}_t \geq -\rho$)
- T-period liquidity trap as before:

$$
\hat{r}_{t+1}^n=\begin{cases}-\rho-\Delta<0 & \text{from } t \text{ to } t+T\\ 0 & \text{from } t+T+1 \text{ onwards}\end{cases}
$$

Central Bank Lagrangian

$$\mathscr{L} = \frac{1}{2}\sum_{s=0}^{\infty}\beta^s \begin{bmatrix} \left(\hat{\pi}_{t+s}^2 + \vartheta \hat{x}_{t+s}^2\right) + \xi_{1,t+s}\left(\hat{\pi}_{t+s} - \beta\hat{\pi}_{t+s+1} - \kappa\hat{x}_{t+s}\right) \\ +\xi_{2,t+s}\left(\hat{x}_{t+s} - \hat{x}_{t+s+1} + \sigma(-\rho - \hat{\pi}_{t+s+1} - \hat{r}^n_{t+s+1})\right) \end{bmatrix}$$

- FOCs:

$$\hat{\pi}_t + \xi_{1,t} - \xi_{1,t-1} - \frac{\sigma}{\beta}\xi_{2,t-1} = 0 \qquad (\hat{\pi}_t)$$

$$\vartheta\hat{x}_t - \kappa\xi_{1,t} + \xi_{2,t} - \frac{1}{\beta}\xi_{2,t-1} = 0 \qquad (\hat{x}_t)$$

- Complementary slackness conditions:

$$\xi_{2,t} \geq 0, \hat{i}_t \geq -\rho, \xi_{2,t}(\hat{i}_t + \rho) = \xi_{2,t} i_t = 0$$

Central Bank Commitment Solution

- Show positive output gap and inflation at $T+1$ by differencing FOCs for between $T+1$ and T and using $\xi_{2,T+1}=0$:

$$\hat{x}_{T+1}-\hat{x}_T=-\frac{\kappa}{\vartheta}\hat{\pi}_{T+1}+\frac{\beta+\sigma\kappa}{\vartheta\beta}\xi_{2,T}+\frac{1}{\vartheta\beta}(\xi_{2,T}-\xi_{2,T-1})$$

  - First term is standard leaning against the wind effect. If this alone, $\hat{x}_{T+1}=\hat{x}_T=\hat{\pi}_{T+1}=0$.
  - Second two terms push towards positive growth since marginal value of relaxing constraint positive, $\xi_{2,T}>0$, which make you want to set $\hat{x}_{T+1}>0$.
  - Asymptotically returns to $\hat{x}_t=\hat{\pi}_t=0$.
- Intuition: Second order inflation and output gap loss in future, first order output gap and deflation gain today.
- Werning (2012) solves full dynamic path using continuous time methods, shows $\hat{i}_t=-\rho$ for $t\in[t,T_c]$ for $T_c>0$ and then jumps discretely.

Central Bank Commitment Solution

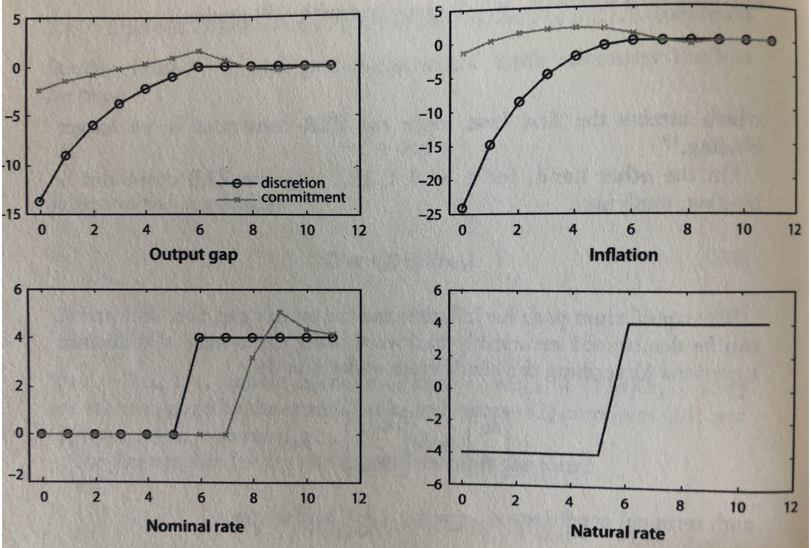

Figure 5.3. Discretion vs. Commitment in the Presence of a ZLB.

Central Bank Commitment Solution

- This commitment solution motivates *forward guidance*.
  - Announce you are going to keep your rate low for a long time, unconditional on market conditions.
  - Idea: Get people to believe that you will keep rates low after the ZLB does not bind.
  - Problem: Not a time consistent commitment.
  - Also when do you know you are out? $T-$period trap is stylized and period of ending is endogenous.
- Fed used forward guidance:
  - In December 2008 says "likely to warrant exceptionally low levels of the federal funds rate for some time."
  - In August 2011, introduce specific date stating that will be low through mid 2013.
  - Pushed that out twice to late 2014 and mid-2015 in 2012.
- Key empirical question: is the Fed following a commitment strategy or simply providing forecasts?

Forward Guidance Puzzle

- Promises of low future interest rates very effective in new Keynesian model at ZLB.
  - Probably too effective.
  - This is known as the "forward guidance puzzle."
- Simple example:
  - Promise low real rate $\hat{r}_{t+T} < 0$, T periods in the future.
  - Fix nominal rate until then.

Forward Guidance Puzzle

- No further shocks, so return to steady state at $t+T+1$.

$$\hat{x}_t = \sigma \sum_{s=0}^{T} \hat{\pi}_{t+s+1} - \sigma \hat{r}_{t+T}$$

$$\hat{\pi}_t = \sum_{s=0}^{T} \beta^s \kappa \hat{x}_{t+s}$$

  - Low real rate raises all output gaps from t to $t+T$ by $-\sigma \hat{r}_{t+T}$.
  - Higher output gap means higher inflation.
  - Real rate drops even more, further stimulating output.
  - $\Rightarrow$ "Virtuous cycle" of higher output and higher inflation.
- Effect *increases* the further away the promise is (higher T).
  - Generally viewed as unreasonable.
  - But difficult to test in practice.
  - Key issue: is central bank able to commit to such a policy?

Other Unconventional Policies

- Fed also pursued *Large-Scale Asset Purchases* (also known as "quantitative easing").
- There is not just one short term rate.
  - Fed Funds Rate
  - Longer-maturity treasury rates.
  - Checking interest / certificate of deposit rate.
  - Mortgage rates.
  - Business loan rates.
- Other rates are usually spreads over FFR.
- By buying treasuries and GSE mortgage-backed securities, reduce spreads and interest rates for consumers and businesses.
  - Much more difficult to assess these policies.
  - Very few models are able to match macro data and term premia.
  - And even fewer allow the Fed to influence these prices. Generally requires some limits to arbitrage.

Optimal Inflation Rate?

- Many of these policies are controversial.
- Most controversial: raise the inflation target above 2%.
  - Benefits:
    1. Helps us get out of liquidity trap now.
    2. In future, need $r_t^n < -\pi_t$ to fall in, so fall in less frequently.
  - Olivier Blanchard floated 4%. Nobody has yet adopted.
  - In macro-models low inflation rates tend to be optimal (Coibion, Gorodnichenko, Wieland, 2012).
    - ⋆ Pay cost of higher inflation every period, but gain benefit only in periods of ZLB.
    - ⋆ Suggest that more aggressive state-contingent policies, such as PLT, is preferred.
  - Practical circles worry about runaway inflation and that inflation expectations will become "unanchored."
  - Unclear to what extent the Fed would even be able to raise the inflation rate (see Abenomics in Japan, U.S. after lift-off in 2015).

Is Zero the Lower Bound?

- Recently, moved into a world of negative interest rates.
  - Swiss, Swedes, Danish, ECB, and Japanese all have negative rates (for banks, not people).
  - Get banks to lend money by taxing reserves and reducing other rates to zero.
- Money demand has not exploded up yet.
  - Clearly would if you go negative enough.
  - But what is "negative enough"? We really do not know..
- See Rognlie (2016) for model where money demand explodes at negative rate rather than zero, but negative rates cause costly distortions.
- See Eggertsson et al. (2019) for evidence that the pass-through of policy rates to deposit rates breaks down when the policy rate becomes negative.

Fiscal Policy in a Liquidity Trap

- In 2009, passed ARRA (e.g., the "Stimulus Act").
- In there a stronger case for fiscal stimulus at the ZLB?
  - Is the multiplier higher?
  - Other justification: $\hat{x}_t < 0 \Rightarrow$ marginal costs are low, so cheap for government to buy its goods now, and it is low so cheap for it to finance with bonds.
- To answer multiplier question, first look at multiplier in normal times in standard NK model, then consider ZLB.
- Relatively little work on optimal monetary policy. Werning (2012) a rare and very useful exception.

Government Spending in New Keynesian Model

- Assume government consumes G_t and finances with lump sum taxes T_t and bonds B_t:

$$\frac{1}{R_{t+1}} B_{t+1} = B_t + G_t - T_t$$

- With perfect capital markets and no default

$$B_t + \sum_{s=0}^{\infty} \frac{G_{t+s}}{\prod_{j=0}^{s} R_{t+1+j}} = \sum_{s=0}^{\infty} \frac{T_{t+s}}{\prod_{j=0}^{s} R_{t+1+j}}$$

- Assume G_t follows exogenous process.

Government Spending in New Keynesian Model

- Household BC

$$C_t = \frac{W_t}{P_t} N_t + TR_t + PR_t - T_t - \frac{B_t - Q_{t-1} B_{t-1}}{P_t} - \frac{M_t - M_{t-1}}{P_t}$$
$$= \text{Income}_t - T_t - \frac{B_t - Q_{t-1} B_{t-1}}{P_t} - \frac{M_t - M_{t-1}}{P_t}$$

where $\text{Income}_t = \frac{W_t}{P_t} N_t + TR_t + PR_t$.

- Then present value BC is:

$$B_t + M_t + \sum_{s=0}^{\infty} \frac{\text{Income}_{t+s} - T_{t+s}}{\prod_{j=0}^{s} R_{t+1+j}} = \sum_{s=0}^{\infty} \frac{C_{t+s}}{\prod_{j=0}^{s} R_{t+1+j}}$$

and substituting government BC, Ricardian equivalence holds.

  - Timing of taxes does not matter.
  - But changes in G_t matter.

EQUILIBRIUM

$$\frac{W_t}{P_t} = \frac{\chi N_t^{\varphi}}{C_t^{-\gamma}}$$

$$1 = \beta E_t \left\{ Q_t \frac{P_t}{P_{t+1}} \frac{C_{t+1}^{-\gamma}}{C_t^{-\gamma}} \right\} = E_t \{ \Lambda_{t,t+1} R_{t+1} \}$$

$$P_t = \left[\theta P_{t-1}^{1-\varepsilon} + (1-\theta) P_t^{*1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}$$

$$P_t^* = (1+\mu) E_t \left\{ \sum_{s=0}^{\infty} \frac{\theta^s \Lambda_{t,t+s} Y_{t+s} P_{t+s}^{\varepsilon-1}}{\sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} Y_{t+k} P_{t+k}^{\varepsilon-1}} \frac{W_{t+s}}{A_{t+s}} \right\}$$

$$Y_t = C_t + G_t$$

$$Y_t = A_t N_t \left[\int_0^1 \left(\frac{N_t(i)}{N_t} \right)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

$$Q_t = \beta^{-1} \left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} \left(\frac{Y_t}{Y_t^{flex}} \right)^{\phi_y} e^{v_t}$$

Log Linearized IS and Natural Rate

- Log-linearizing resource constraint gives

$$\hat{y}_t = (1 - s_g)\hat{c}_t + s_g \hat{g}_t$$

- Log-linearizing Euler equation and plugging in

$$\hat{y}_t = -(1 - s_g)\sigma \left(\hat{i}_t - E_t\{\hat{\pi}_{t+1}\} \right) + E_t\{\hat{y}_{t+1}\} + s_g(\hat{g}_t - E_t\hat{g}_{t+1})$$

- Consequently in the flex price equilibrium

$$\hat{y}^n_t = -(1 - s_g)\sigma E_t\{\hat{r}^n_{t+1}\} + E_t\{\hat{y}_{t+1}\} + s_g(\hat{g}_t - E_t\hat{g}_{t+1})$$

- Difference gives modified IS curve:

$$\tilde{y}_t = -(1 - s_g)\sigma E_t \left(\hat{i}_t - \hat{\pi}_{t+1} - \hat{r}^n_{t+1} \right) + E_t\{\tilde{y}_{t+1}\}$$

where:

$$\hat{r}^n_{t+1} = \frac{1}{\sigma(1 - s_g)} \left(E_t\{\hat{y}^n_{t+1}\} - \hat{y}^n_t \right) + \frac{s_g}{(1 - s_g)\sigma}(\hat{g}_t - E_t\hat{g}_{t+1})$$

Flex Price Equilibrium

$$\hat{y}_t^n = \hat{a}_t + \hat{n}_t^n$$
$$\hat{y}_t^n - \hat{n}_t^n = \varphi \hat{n}_t^n + \gamma \hat{c}_t^n$$
$$\hat{y}_t = (1 - s_g)\hat{c}_t + s_g \hat{g}_t$$

- Solve for output:

$$\hat{y}_t^n = \left(\frac{1+\varphi}{\varphi + \frac{\gamma}{(1-s_g)}} \right) \hat{a}_t + \frac{\gamma s_g}{(1-s_g)\varphi + \gamma} \hat{g}_t$$

- Plug into natural rate of interest

$$\hat{r}_{t+1}^n = -\psi_a \left(E_t\{\hat{y}_{t+1}^n\} - \hat{y}_t^n \right) + \psi_g (\hat{g}_t - E_t \hat{g}_{t+1})$$

where $\psi_a = \frac{\gamma(1+\varphi)}{\varphi(1-s_g)+\gamma}$ and $\psi_g = \frac{\gamma s_g \varphi}{(1-s_g)\varphi+\gamma}$

Summary of Model With G

$$
\begin{aligned}
\tilde{y}_t &= -(1-s_g)\sigma E_t\left(\hat{i}_t - \hat{\pi}_{t+1} - \hat{r}^n_{t+1}\right) + E_t\{\tilde{y}_{t+1}\} \\
\hat{\pi}_t &= \kappa \tilde{y}_t + \beta E_t\{\hat{\pi}_{t+1}\} \\
\hat{y}^n_t &= \left(\frac{1+\varphi}{\varphi + \frac{\gamma}{(1-s_g)}}\right)\hat{a}_t + \frac{\gamma s_g}{(1-s_g)\varphi + \gamma}\hat{g}_t \\
\hat{r}^n_{t+1} &= -\psi_a\left(E_t\{\hat{y}^n_{t+1}\} - \hat{y}^n_t\right) + \psi_g(\hat{g}_t - E_t\hat{g}_{t+1}) \\
\hat{y}_t &= \tilde{y}_t + \hat{y}^n_t
\end{aligned}
$$

- Government spending affects $\hat{r}^n_{t+1}$ and $\hat{y}^n_t$
  - Due to negative wealth effect from taxation increasing labor supply $\uparrow \hat{g}_t \Rightarrow \uparrow \hat{y}^n_t, \hat{r}^n_{t+1}$.

Government Spending Multiplier

- If the central bank sets $\hat{i}_t = \hat{r}^n_{t+1} + E_t\{\pi_{t+1}\} + \phi_\pi \hat{\pi}_t$, $\tilde{y}_t = 0$ and $\hat{y}_t = \hat{y}^n_t$:

$$\frac{d\hat{y}_t}{d\hat{g}_t} = \frac{d\hat{y}^n_t}{d\hat{g}_t} = \frac{\gamma s_g}{(1-s_g)\varphi + \gamma}$$

- The multiplier is then:

$$\frac{dY_t}{dG_t} = \frac{Y}{G}\frac{d\hat{y}_t}{d\hat{g}_t} = \frac{\gamma}{(1-s_g)\varphi + \gamma} < 1$$

- Government spending crowds out consumption.
  - A \$1 of spending results in less than \$1 of output.
  - Why? Increase in the real interest rate reduces consumption today through intertemporal subsitution.
  - High real interest rate signals that resources are scarcer today, because the government takes them and throws them away.

Government Spending in a Liquidity Trap

- Return to $T-$period liquidity trap example with CB setting optimal discretionary policy:

$$\hat{y}_t = -\sigma(1-s_g)\sum_{s=0}^{T}(-\hat{\pi}_{t+s+1})$$

$$\tilde{y}_t = \hat{y}_t - \sigma(1-s_g)\sum_{s=0}^{T}(-\hat{r}^n_{t+1+s})$$

$$\hat{\pi}_t = \sum_{s=0}^{T}\beta^s\kappa\tilde{y}_{t+s}$$

- *Government spending has stimulative effect through inflation.*
    - Government spending raises MC of production ($\propto \tilde{y}_t$), which raises inflation through NKPC.
    - Higher expected inflation reduces real interest rate, which expands output today through intertemporal subsitution.
- Large multipliers at ZLB in calibrated models (well above 1).

Government in a Liquidity Trap

- Normal times $\Rightarrow$ use monetary policy (more nimble).
- ZLB $\Rightarrow$ use fiscal policy (monetary policy has hands tied and has to make non-credible commitments).
- However, very large multipliers *depend on inflationary effects of fiscal stimulus and intertemporal subsitution.*
  - Is the mechanism credible?

Productivity Shocks in a Liquidity Trap

- Return to $T-$period liquidity trap example with CB setting optimal discretionary policy:

$$\hat{y}_t = -\sigma(1-s_g)\sum_{s=0}^{T}(-\hat{\pi}_{t+s+1})$$

$$\tilde{y}_t = \hat{y}_t - \sigma(1-s_g)\sum_{s=0}^{T}(-\hat{r}^n_{t+1+s})$$

$$\hat{\pi}_t = \sum_{s=0}^{T}\beta^s\kappa\tilde{y}_{t+s}$$

- *Higher productivity has contractionary effect through inflation.*
  - Temporary higher productivity reduces natural rate of interest because the MC of production falls.
  - This lowers inflation through NKPC.
  - Lower expected inflation increases real interest rate, which contracts output today through intertemporal substitution.

Supply Shocks in a Liquidity Trap

- Argument applies to any shock to MC.
  - Productivity, willingness to work, minimum wage, unions, employment taxes, capital destruction, oil supply shocks...
- Can write a paper for each of them!
- But empirical evidence does not support these predictions (Wieland, 2019):
  - 2011 Earthquake in Japan contractionary.
  - Oil supply shocks more contractionary at ZLB than in normal times.
- Suggests inflation expectations mechanism not main driver in practice.
- Note: fiscal policy can still be powerful for other reasons.

Quo Vadis NK Model?

- New Keynesian model has problems in a liquidity trap, just like in normal times.
- But still the benchmark for analyzing policy.
  - Some sensible-looking predictions.
  - Can be used to understand central bank actions.
  - No clear alternative.
- Recent work has focussed on two key areas of improving the model:
  1. Menu costs models of pricing rather than Calvo.
     - Relatively well-settled: suggests Calvo is reasonable approximation.
  2. Incomplete markets rather than permanent-income representative-agent.
     - More recent literature suggests old-Keynesian MPCs more important than intertemporal substitution.
     - But policy lessons (so far) largely similar to NK model.

Retrospective: That's All!

- We have covered a lot of ground in the last ten weeks!
  1. Real Business Cycles
  2. The New Keynesian Model
     1. Empirical Motivation for Nominal Rigidity
     2. Money, Money Demand, and Output
     3. Monopolistic Competition and Markups
     4. Full New Keynesian Model
  3. Optimal Policy in a New Keynesian Framework
  4. The Liquidity Trap and Policy in a Liquidity Trap
- Hope you found class interesting and relevant for understanding business cycles and economic policy!
  - Will hopefully see you around building soon.
  - Good luck on exam and the rest of first year!