Fiscal Multipliers: Liquidity Traps and Currency Unions

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Lecture 3

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Overview

- Macroeconomic stabilization handled by monetary policy.
- Monetary policy has constraints $\Longrightarrow$ limited effectiveness.
- Examples: liquidity trap, ZLB, currency union etc.
- Fiscal policy can also stabilize the economy.
- Objectives:
  - clarifying theoretical mechanisms.
  - stimulate research around these subjects.

Some questions

- How the economy respond to government spending
  - during a liquidity trap.
  - within a currency union.
  - within incomplete markets.
  - with borrowing constrained consumers.

How ?

- NK closed and open-economy models.
- Fixed exchange rate (currency union).
- Focus on fiscal multipliers.
- Solve these multipliers.

Results (1)

- Fiscal policy can be potent during liquidity trap.
- More difficult to increase output through government spending within a currency union.
- Fixed exchange rate $\Longrightarrow$ Fixed nominal interest rate but fixed nominal interest rate $\not\Rightarrow$ Fixed exchange rate
- Low degree of openness can increase these multipliers.
- Persistency of government spending is important: the more temporary the government spending shock, the more the per-period transfer is saved.

Results (2)

- Ricardian effect: $G_t \nearrow \Longrightarrow Savings_t \nearrow$ (consequence of tax expectations) $\Longrightarrow C_t \searrow$.
- Two types of consumers $\Longrightarrow$ Non-Ricardian effects from fiscal policy
- Both in currency union and in liquidity trap, government spending has additional effects.
- Both incidence (redistribution from low to high propensity to consume increases output) and timing of taxes matter.
- Liquidity constraints magnify the difference between self and outside financed fiscal multipliers for temporary government spending shocks.

Literature

- Eggertsson (2011), Woodford (2011), and Christiano et al. (2011) show that fiscal multipliers can be large at the zero lower bound.
- Corsetti et al. (2011), Nakamura and Steinsson (2011), and Erceg and Linde (2012) show that fiscal multipliers are generally below one under fixed exchange rates yet higher than under flexible exchange rates (away from the zero bound).
- Gali et al. (2007) introduce hand-to-mouth consumers and study the effects of government spending under a Taylor rule in a closed economy.

Impulse response functions

Suppose government spending and output time series $\{\hat{g}_t, \hat{y}_t\}$ stationary after detrending and these time series can be written as a linear function of current and past shocks:

$$\hat{g}_t = \sum_{j=1}^{J} \sum_{k=0}^{\infty} \psi_k^{gj} \varepsilon_{t-k}^{j} \quad (1)$$

$$\hat{y}_t = \sum_{j=1}^{J} \sum_{k=0}^{\infty} \psi_k^{yj} \varepsilon_{t-k}^{j} \quad (2)$$

where the vector of shocks $\hat{\varepsilon}_t = \left(\varepsilon_t^1, \varepsilon_t^2, ..., \varepsilon_t^J\right)'$ follows $\mathbb{E}[\varepsilon_t] = 0$ and $\mathbb{E}\left[\hat{\varepsilon}_t \hat{\varepsilon}_s'\right] = 0$ for $t \neq s$.

- The coefficients $\left\{\psi_k^i\right\}$ are the IRFs of a specific shock.

Fiscal multipliers

- The sequences $\{\psi_k^g, \psi_k^y\}$ provide a full characterization of the joint behavior of $\{\hat{g}_t, \hat{y}_t\}$ with respect to the shock $\{\varepsilon_t\}$.
- Contemporaneous fiscal multiplier:

$$m_k = \frac{\psi_k^y}{\psi_k^g} \tag{3}$$

- Summary fiscal multiplier (unweighted the reaction over the first N periods):

$$M^y = \sum_{k=0}^{N} m_k \omega_k \tag{4}$$

  where $\omega_k = \psi_k^g / \sum_{k=0}^{N} \psi_k^g$.
- Also possible to obtain fiscal multipliers through regressions or models.

Closed economy: Households

- Households seek to maximize:

$$E_0 \left[\int_{t=0}^{+\infty} e^{-\rho t} \left(\frac{C_t^{1-\sigma}}{1-\sigma} + \chi \frac{G_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1-\phi} \right) dt \right] \qquad (5)$$

where C_t is consumption, G_t government spending and N_t labor.

- Consumption index is defined by $C_t = \left(\int_0^1 C_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$ where $j \in [0, 1]$ denotes an individual good variety, and ϵ the elasticity of substitution between differentiated goods (of the same origin).
- Price index is defined by $P_t = \left(\int_0^1 P_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}$ where $P_t(j)$ is the price of variety j.

Closed economy: Constraints

- Households seek to maximize their utility subject to the budget constraints

$$\dot{D}_t = i_t D_t - \int_0^1 P_t(j)\, C_t(j)\, dj + W_t N_t + \Pi_t + T_t \qquad (6)$$

for $t \geqslant 0$ together with a no-Ponzi condition. W_t is the nominal wage, Π_t nominal profits and T_t a nominal lump sum transfer. The bond holdings of home agents are denoted by D_t and the nominal interest rate for the currency union is denoted by i_t.

Closed economy: Government

- Government consumption G_t is an aggregate of varieties (as private consumption) defined by $G_t = \left(\int_0^1 G_t\left(j\right)^{\frac{\epsilon-1}{\epsilon}} \, dj \right)^{\frac{\epsilon}{\epsilon-1}}$.
- For any level of expenditure $\int_0^1 P_t\left(j\right) G_t\left(j\right) dj$, the government splits its expenditure across these varieties to maximize G_t.
- Spending is financed by lump-sum taxes.
- Ricardian equivalence (demand remains unchanged after debt-financed government spending) holds, so that the timing of these taxes is irrelevant.

Closed economy: Firms

- Simple production function $Y_t = A_t N_t(j)$ where A_t is productivity in the home country.
- Real marginal cost subject to constant employment tax $1 + \tau^L$ $\implies$ real marginal cost such as $\frac{1+\tau^L}{A_t}\frac{W_t}{P_t}$.
- Tax rate is set to offset the monopoly distortion: $\tau^L = -\frac{1}{\epsilon}$.
- Standard Calvo price-setting framework: in every moment a randomly flow ρ_δ of firms can reset their prices. Those firms that reset choose a reset price P_t^r to solve

$$\max_{P_t^r} \int_0^\infty e^{-\rho_\delta s - \int_0^s i_{t+z} dz} \left(P_t^r Y_{t+s|t} - (1+\tau^L) W_t \frac{Y_{t+s|t}}{A_t} \right)$$

where $Y_{t+k|t} = \left(\frac{P_t^r}{P_{t+k}}\right)^{-\epsilon} Y_{t+k}$, taking the sequences for W_t, Y_t and P_t as given.

Closed economy: Equilibrium

- Market clearing in the goods market: $Y_t = C_t + G_t$
- Market clearing in the labor market: $N_t = \frac{Y_t}{A_t}\Delta_t$ where Δ_t is an index of price dispersion.
- Euler equation: $\sigma \frac{\dot{C}_t}{C_t} = i_t - \pi_t - \rho$ where $\pi_t = \dot{P}_t / P_t$.
- The natural allocation is a reference allocation that prevails if prices are flexible and government consumption is held constant at its steady state value $\bar{G}$.

National multipliers: Liquidity trap

- Log-linearized equilibrium conditions around the natural allocation with constant government spending.
- The log linearized system up to a first-order approximation is

$$\begin{cases} y_t = c_t + g_t \\ \dot{c}_t = \hat{\sigma}^{-1}\left(i_t - \pi_t - \bar{r}_t\right) \\ \dot{\pi}_t = \rho\pi_t - \kappa\left(c_t + \left(1-\xi\right)g_t\right) \end{cases} \tag{7}$$

where $c_t \simeq \frac{C_t - \bar{C}_t}{Y}$, $y_t = \frac{Y_t - Y_t}{Y}$, $g_t = \frac{G_t - G_t}{Y}$, $\hat{\sigma} = \frac{\sigma}{1-\frac{G}{Y}}$, $\kappa = \rho_\delta\left(\rho + \rho_\delta\right)\left(\hat{\sigma} + \phi\right)$, and $\xi = \frac{\hat{\sigma}}{\hat{\sigma}+\phi}$.

- ρ_δ is the Calvo parameter.
- $\bar{r}_t$ is the natural rate of interest, defined as the (real) interest rate that prevail at the natural allocation (i.e. $\bar{r}_t = i_t - \pi_t$ for all $t \geq 0$).

Fiscal multipliers: Liquidity trap

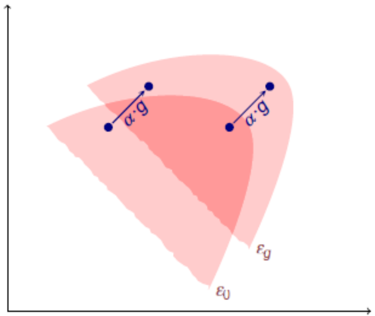
- System is linear $\Longrightarrow$ admits a closed form solution.
- We can express any solution with government spending as

$$y_t = \tilde{y}_t + g_t + \int_0^\infty \alpha_s^c g_{t+s} ds \tag{8}$$

$$c_t = \tilde{c}_t + \int_0^\infty \alpha_s^c g_{t+s} ds \tag{9}$$

$$\pi_t = \tilde{\pi}_t + \int_0^\infty \alpha_s^\pi g_{t+s} ds \tag{10}$$

- α_s^c represents total private consumption multipliers and does not depend on time t or interest rate paths.
- The impact on consumption or output depends only on the future path for spending summarized weighted by α_s^c.
- Conceptual and practical motivations to adopt $\int_0^\infty \alpha_s^c g_{t+s} ds$ as a measure of the impact of fiscal policy.



A schematic depiction of the set of equilibria without government spending and the set of equilibria for a given spending path $\{g_t\}$.

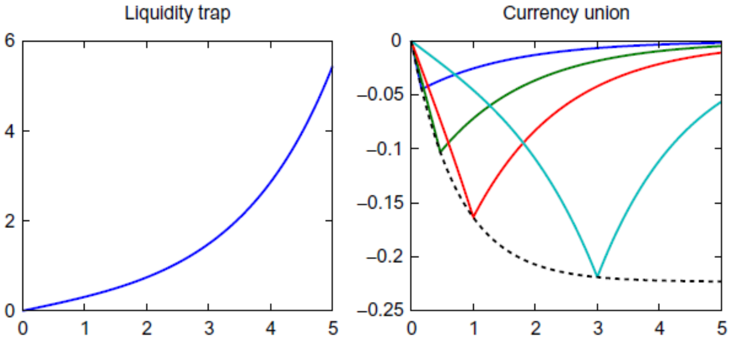
- $\mathcal{E}_0$ is the set of equilibria when $g_t = 0$ for all t, $\mathcal{E}_g$ the set of equilibria for a given path for spending $g = \{g_t\}$.
- $\alpha = \{\alpha_s^c, \alpha_s^\pi\}$ collects the fiscal multipliers. The product αg represents the integrals $\int_0^\infty \alpha_s^i g_{t+s} ds$ for $i = c, \pi$.
- The set $\mathcal{E}_g$ is a displaced version of $\mathcal{E}_0$ in the direction αg.

Closed economy multipliers

- The fiscal multipliers are given by

$$\alpha_s^c = \hat{\sigma}^{-1}\kappa\left(1-\xi\right)e^{-\bar{\nu}s}\left(\frac{e^{(\bar{\nu}-\nu)s}-1}{\bar{\nu}-\nu}\right) \tag{11}$$

  The instantaneous fiscal multiplier is $\alpha_0^c = 0$, but the fiscal multipliers are positive, increasing and convex for large s.
- $\nu = \frac{\rho-\sqrt{\rho^2+4\kappa\hat{\sigma}^{-1}}}{2} < 0$ and $\bar{\nu} = \frac{\rho+\sqrt{\rho^2+4\kappa\hat{\sigma}^{-1}}}{2} > 0$ are the eigenvalues of the system previously presented (Eqs. 7).



Liquidity trap and currency union consumption multipliers α_s^c and $\alpha_{s-t}^{c,t,CM}$ as a function of s. Each curve for $\alpha_{s-t}^{c,t,CM}$ is plotted for different values of $t \in \{0.25, 0.5, 1, 3\}$. The black dashed line shows the lower envelope. Parameters are $\sigma = 1$, $\eta = \gamma = 1$, $\epsilon = 6$, $\phi = 3$, $\lambda = 0.14$ and $\alpha = 0.4$.

Closed economy multipliers and price stickiness

- How fiscal multipliers are affected by the degree of price stickiness ?
- The fiscal multipliers α_s^c are zero when prices are rigid ($\kappa = 0$), are increasing in price flexibility κ, and converge to infinity in the limit as prices become fully flexible ($\kappa \longrightarrow \infty$).
- Spending acts on consumption through inflation.
- If prices were perfectly rigid, inflation would be fixed at zero and spending has no effect on consumption.
- If prices become more flexible, spending has a greater impact on inflation and, hence, on consumption.

Open economy model

- Consumption index becomes an aggregation of two consumption indexes

$$C_t = \left[(1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{12}$$

  where $C_{H,t}$ is the consumption index of domestic goods given by $C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$ where $j \in [0,1]$ and $C_{F,t}$ is the consumption index of foreign goods similarly defined, and α indexes the degree of home bias (measure of openness).
- $\alpha \longrightarrow 1$ captures a very open economy without home bias, $\alpha \longrightarrow 0$ a closed economy barely trading with the outside world.
- Budget constraints, government spending and production function are similar to the close economy.

Open economy model

- Households seek to maximize their utility subject to the budget constraints for $t \geq 0$

$$\begin{aligned} \dot{D}_t &= i_t D_t - \int_0^1 P_{H,t}(j) C_{H,t}(j) dj \\ &\quad - \int_0^1 \int_0^1 P_{i,t}(j) C_{i,t}(j) dj di + W_t N_t + \Pi_t + T_t \end{aligned} \tag{13}$$

  where $P_{H,t}(j)$ is the price of domestic variety j, $P_{i,t}$ is the price of variety j imported from country i, W_t is the nominal wage, Π_t represents nominal profits and T_t is a nominal lump-sum transfer.
- All these variables are expressed in the common currency.
- D_t represents bond holdings of home agents and i_t the (common) nominal interest rate within the union.

Open economy: Terms of trade and exchange rate

- The home Consumer Price Index (CPI) is

$$P_t = \left[(1-\alpha) P_{H,t}^{1-\eta} + \alpha P_t^{*1-\eta} \right]^{\frac{1}{1-\eta}} \tag{14}$$

where the home Producer Price Index (PPI) is $P_{H,t} = \left[\int_0^1 P_{H,t}(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}$ and P_t^* is the price index for imported goods.

- The terms of trade are defined by

$$S_t = \frac{P_t^*}{P_{H,t}} \tag{15}$$

- The real exchange rate is

$$Q_t = \frac{P_t^*}{P_t} \tag{16}$$

Open economy: Equilibrium conditions

- The goods market clearing condition is

$$Y_t = (1-\alpha)\, C_t \left(\frac{Q_t}{S_t}\right)^{-\eta} + \alpha S_t^{\gamma} C_t^{*} + G_t \tag{17}$$

- The labor market clearing condition and the Euler equation for the home country are similar to the closed economy.
- The country-wide budget constraint is

$$N\dot{F}A_t = (P_{H,t} Y_t - P_t C_t) + i_t NFA_t \tag{18}$$

where NFA_t is the country's net foreign assets at t measured in home numeraire (for convenience).

National and local fiscal multipliers

- The log linearized system is

$$\begin{aligned}
y_t &= c_t + g_t && (19)\\
\dot{c}_t &= \hat{\sigma}\left(i_t^* - \pi_{H,t} - \rho\right) - \alpha\left(\omega - 1\right)\dot{c}_t^* && (20)\\
\dot{\pi}_{H,t} &= \rho\pi_{H,t} - \kappa\left(c_t + \left(1 - \xi\right) g_t\right) && (21)\\
&\quad -\lambda\hat{\sigma}\alpha\left(\omega - 1\right) c_t^* - \lambda\hat{\sigma}\alpha\omega\theta\left(1 - \frac{G}{Y}\right)
\end{aligned}$$

where θ is the wedge in the log-linearized Backus-Smith equation which is equal to zero under complete markets, $\omega = \sigma\gamma + \left(1 - \alpha\right)\left(\sigma\eta - 1\right)$ and $\hat{\sigma} = \frac{\sigma}{1-\alpha+\alpha\omega}\frac{1}{1-\frac{G}{Y}}$.

Backus-Smith equation

- Correlations between consumption and real exchange rates are zero or negative.
- Under full risk sharing, relative consumption should be perfectly correlated with the real exchange rate.
- Countries with relative low prices should receive a transfer to take advantage of cheap consumption.

National and local fiscal multipliers: complete markets

- The log linearized system is

$$
\begin{aligned}
y_t &= c_t + g_t && (22)\\
\dot{c}_t &= -\hat{\sigma}^{-1}\pi_{H,t} && (23)\\
\dot{\pi}_{H,t} &= \rho\pi_{H,t} - \kappa\left(c_t + (1-\xi)\, g_t\right) && (24)
\end{aligned}
$$

- Solution with government spending are

$$
\begin{aligned}
c_t &= \tilde{c}_t + \int_{-t}^{\infty} \alpha_s^{c,t,CM} g_{t+s} ds && (25)\\
\pi_{H,t} &= \tilde{\pi}_t + \int_{-t}^{\infty} \alpha_s^{\pi,t,CM} g_{t+s} ds && (26)
\end{aligned}
$$

- Note that in this case:
  - forward- and backward-looking effects from government spending.
  - multipliers depend on calendar time t.

National and local fiscal multipliers: complete markets

- Suppose that markets are complete, then the fiscal multipliers are

$$\alpha_s^{c,t,CM} = \begin{cases} -\hat{\sigma}^{-1}\kappa(1-\xi)e^{-\nu s}\frac{1-e^{(\nu-\bar{\nu})(s+t)}}{\bar{\nu}-\nu} & s<0, \\ -\hat{\sigma}^{-1}\kappa(1-\xi)e^{-\bar{\nu} s}\frac{1-e^{-(\bar{\nu}-\nu)t}}{\bar{\nu}-\nu} & s\geq 0. \end{cases} \tag{27}$$

1. for $t=0$ we have $\alpha_s^{c,t,CM}=0$ for all s;
2. for $t>0$ we have $\alpha_s^{c,t,CM}<0$ for all s;
3. for $t\to\infty$ we have $\alpha_{s-t}^{c,t,CM}\to 0$ for all s;
4. spending at zero and infinity have no impact: $\alpha_{-t}^{c,t,CM}=\lim_{s\to\infty}\alpha_s^{c,t,CM}=0$.

National and local fiscal multipliers: complete markets

- Consumption response at any other date is actually negative (Point 2).
- Note that the Euler equation and the initial condition together imply that

$$c_t = -\hat{\sigma}^{-1} \log \frac{P_{H,t}}{P_H}. \tag{28}$$

- Government spending increases demand, leading to inflation, a rise in $P_{H,t}$.
- It leads to an appreciation in the terms of trade and this loss in competitiveness depresses private demand, from both domestic and foreign consumers.
- Consumption depends negatively on the terms of trade and government spending creates inflation.

National and local fiscal multipliers: complete markets

- The fiscal multipliers $\{\alpha_s^{c,t,CM}\}$ depend on price flexibility as follows:
  - Prices rigidity ($\kappa = 0$) leads to $\alpha_s^{c,t,CM} = 0$ for all s and t;
  - Flexible prices ($\kappa \rightarrow \infty$) leads to $\int_{-t}^{\infty} \alpha_s^{c,t,CM} g_{t+s} ds = -(1-\xi) g_t$ for all (continuous and bounded) paths of government spending $\{g_t\}$.
- Unlike in the liquidity trap, fiscal multipliers do not explode when prices become more flexible.

National and local fiscal multipliers: complete markets

- In a liquidity trap, government spending sets into motion a feedback loop between consumption and inflation:
$G_t \nearrow \Longrightarrow \pi_t \nearrow \Longrightarrow r_t \searrow \Longrightarrow C_t \nearrow \Longrightarrow \pi_t \nearrow \Longrightarrow ...$
- This feedback loop is non-existent in a currency union:
$G_t \nearrow \Longrightarrow \pi_t \nearrow \Longrightarrow S_t \nearrow \Longrightarrow C_t \searrow \Longrightarrow \pi_t \searrow$.
- Instead, the allocation converges to the flexible price allocation $c_t = -(1 - \xi)g_t$ when prices become very flexible.
- At the flexible price allocation, private consumption is entirely determined by contemporaneous government spending.

National and local fiscal multipliers: complete markets

- One can reinterpret the neoclassical outcome with flexible prices as applying to the case with rigid prices and a flexible exchange rate that is adjusted to replicate the flexible price allocation.
- The output multiplier is then less than one.
- The first result says that with rigid prices but fixed exchange rates, output multipliers are equal to one.
- In this sense, the comparison between fixed with flexible exchange rates confirms the conventional view from the Mundell-Flemming model that fiscal policy is more effective with fixed exchange rates.

National and local fiscal multipliers: incomplete markets

- Although the complete market assumption is often adopted for tractability, incomplete markets may be a better approximation to reality in most cases of interest.
- A shock to spending may create income effects that affect consumption and labor responses.
- The complete markets solution secures transfers from the rest of the world that effectively cancel these income effects.
- As a result, the incomplete markets solution is in general different from the complete market case (except in the Cole-Obstfeld case).

National and local fiscal multipliers: incomplete markets

- With incomplete markets, the system becomes

$$\dot{\pi}_{H,t} = \rho \pi_{H,t} - \kappa (c_t + (1-\xi) g_t) - (1-\mathcal{G}) \lambda \hat{\sigma} \alpha \omega \theta$$
$$\dot{c}_t = -\hat{\sigma}^{-1} \pi_{H,t}$$

with initial condition $c_0 = (1-\mathcal{G})(1-\alpha)\theta$, $\mathcal{G} = \frac{G}{Y}$, and $\theta = \Omega \rho \int_0^\infty e^{-\rho t} c_t dt$.

- We denote the consumption multipliers with a superscript IM, which stands for incomplete markets. We denote by $\hat{t}$ the time such that

$$\frac{e^{\nu \hat{t}}}{1 - e^{\nu \hat{t}}} = \omega \frac{\hat{\sigma}}{\hat{\sigma} + \phi} \frac{\alpha}{1-\alpha}$$

We also define

$$\bar{\Omega} = \frac{\Omega(1-\xi)}{1 - \Omega(1-\mathcal{G})(1-\alpha)\left[\frac{\rho}{\bar{\nu}} + \frac{\nu}{\bar{\nu}} \omega \frac{\hat{\sigma}}{\hat{\sigma}+\phi} \frac{\alpha}{1-\alpha}\right]}$$

National and local fiscal multipliers: incomplete markets

- Suppose that markets are incomplete, then fiscal multipliers are given by
$$\alpha_s^{c,t,IM} = \alpha_s^{c,t,CM} + \delta_s^{c,t,IM}$$
where $\alpha_s^{c,t,CM}$ is the complete markets consumption multiplier characterized previously and
$$\delta_s^{c,t,IM} = \frac{(1-\mathcal{G})\alpha\rho\bar{\Omega}}{e^{\rho(s+t)}\left(1-e^{\nu(s+t)}\right)^{-1}}\left[e^{\nu t}\frac{1-\alpha}{\alpha} - (1-e^{\nu t})\omega\frac{\hat{\sigma}}{\hat{\sigma}+\phi}\right] \quad (29)$$
- $\delta_s^{c,t,IM} = 0$ in the Cole-Obstfeld case $\sigma = \eta = \gamma = 1$.
- Away from the Cole-Obstfled case, the sign of $\delta_s^{c,t,IM}$ is the same as the sign of $(\frac{\omega}{\sigma} - 1)(t - \hat{t})$.
- $\delta_{-t}^{c,t,IM} = 0$ and $\lim_{s\to\infty} \delta_s^{c,t,IM} = 0$.

Liquidity constraints model

- A fraction $1-\chi$ of agents are optimizers, and a fraction χ are hand-to-mouth.
- Optimizers are exactly as before.
- Hand-to-mouth agents cannot save or borrow, and instead simply consume their labor income in every period, net of lump-sum taxes.
- These lump-sum taxes are allowed to differ between optimizers (T_t^o) and hand-to-mouth agents (T_t^r) such as

$$t_t^o = \frac{T_t^o - T^o}{Y} \qquad t_t^r = \frac{T_t^r - T^r}{Y} \tag{30}$$

where T^o and T^r are the per-capita steady state values of T_t^o and T_t^r.

Liquidity constraints log-linearized model

- Log-linearization is done around a steady state where optimizers and hand-to-mouth consumers have the same consumption and supply the same labor.
- The model can be summarized by

$$\dot{c}_t = \tilde{\sigma}^{-1}(i_t - \bar{r}_t - \pi_t) + \tilde{\Theta}_n \dot{g}_t - \tilde{\Theta}_\tau \dot{t}_t^r \tag{31}$$

$$\dot{\pi}_t = \rho\pi_t - \kappa[c_t + (1-\xi)g_t] \tag{32}$$

  where $\tilde{\sigma}$, $\tilde{\Theta}_n$ and $\tilde{\Theta}_\tau$ are positive constants defined in the appendix, which are increasing in χ and satisfy $\tilde{\Theta}_n = \tilde{\Theta}_\tau = 0$ and $\tilde{\sigma} = \hat{\sigma}$ when $\chi = 0$.
- The presence of hand-to-mouth consumers introduces two new terms in the Euler equation, one involving government spending and the other one involving taxes—both direct determinants of the consumption of hand-to-mouth agents.
- These terms drop out without hand-to-mouth consumers, since $\chi = 0$ implies $\tilde{\Theta}_n = \tilde{\Theta}_\tau = 0$ and $\tilde{\sigma} = \hat{\sigma}$.

Liquidity constraints multipliers

- As before we define

$$\tilde{\nu} = \frac{\rho - \sqrt{\rho^2 + 4\kappa\tilde{\sigma}^{-1}}}{2} \qquad \tilde{\bar{\nu}} = \frac{\rho + \sqrt{\rho^2 + 4\kappa\tilde{\sigma}^{-1}}}{2} \tag{33}$$

- With hand to mouth consumers, we have

$$c_t = \tilde{c}_t + \tilde{\Theta}_n g_t - \tilde{\Theta}_\tau t_t^r + \int_0^\infty \alpha_s^{c,HM} g_{t+s} ds - \int_0^\infty \gamma_s^{c,HM} t_{t+s}^r ds \tag{34}$$

where $\alpha_s^{c,HM} = \left(1 + \frac{\tilde{\Theta}_n}{1-\xi}\right)\tilde{\alpha}_s^{c,HM}$ and $\gamma_s^{c,HM} = \frac{\tilde{\Theta}_\tau}{1-\xi}\tilde{\alpha}_s^{c,HM}$.

- Then

$$\tilde{\alpha}_s^{c,HM} = \tilde{\sigma}^{-1}\kappa(1-\xi)e^{-\tilde{\bar{\nu}}s}\left(\frac{e^{(\tilde{\bar{\nu}}-\tilde{\nu})s} - 1}{\tilde{\bar{\nu}} - \tilde{\nu}}\right) \tag{35}$$

Liquidity constraints links

- g_t and t_t^r can be set independently of each other because the government can always raise the necessary taxes on optimizing agents by adjusting t_t^o, so that total taxes $t_t = \chi t_t^r + (1-\chi) t_t^o$ are sufficient to balance the government budget over time $(0 = \int_0^\infty (t_t - g_t) e^{-\rho t} dt)$.
- If there are additional constraints on the tax system, then g_t and t_t^r become linked.

Liquidity constraints and hand-to-mouth consumers

- Assuming the government must run a balanced budget, then $t_t^o = t_t^r = t_t = g_t$.
- In this case, taxes on hand-to-mouth agents satisfy

$$t_t^r = g_t \tag{36}$$

- The presence of hand-to-mouth consumers affects the closed-form solution by modifying the coefficients on spending and adding new terms.
- The terms fall under two categories:
  - $\tilde{\Theta}_n g_t - \tilde{\Theta}_\tau t_t^r$ capturing the concurrent effects of spending.
  - $\int_0^\infty \alpha_s^{c,HM} g_{t+s} ds - \int_0^\infty \gamma_s^{c,HM} t_{t+s}^r ds$ capturing the effects of future government spending and future taxes.

Liquidity constraints terms (1)

- The concurrent terms appear because, with hand-to-mouth consumers, current fiscal policy has a direct and contemporaneous impact on spending.
  - Traditional Keynesian effects, which are independent of the degree of price flexibility κ.
- The integral terms capture the effects of future fiscal policy through inflation.
  - New Keynesian terms, which scale with the degree of price flexibility κ, and disappear when prices are perfectly rigid $\kappa = 0$.

Liquidity constraints terms (2)

- $-\tilde{\Theta}_\tau t_t^r$ captures the fact that a reduction in current taxes on hand-to-mouth consumers increases their total consumption directly by redistributing income towards them, away from either unconstrained consumers, who have a lower marginal propensity to consume, or from future hand-to-mouth consumers.
- $\tilde{\Theta}_n g_t$ captures the fact that higher current government spending increases labor income and hence consumption of hand-to-mouth consumers, who have a higher marginal propensity to consume than optimizers.

Liquidity constraints consequences

- Lower taxes on hand-to-mouth consumers in the future, or higher government spending in the future, stimulates total future consumption.
- This increases inflation, reducing the real interest rate which increases the current consumption of optimizing agents.
- This, in turn, stimulates spending by hand-to-mouth consumers.
- These indirect effects all work through inflation.

Liquidity constraints and ZLB

- Fixed interest rates dependence ? Due, say, to a binding zero lower bound.
- Away from this bound, monetary policy could be chosen to replicate the flexible price allocation with zero inflation.
- The required nominal interest rate is impacted by the presence of hand-to-mouth consumer

$$i_t = \tilde{\sigma}\left[(1-\xi) + \tilde{\Theta}_n\right]\dot{g}_t + \tilde{\sigma}\tilde{\Theta}_\tau \dot{t}_t^r \qquad (37)$$

  but consumption is not $c_t = -(1-\xi)g_t$.
- Away from the ZLB, the neoclassical multiplier is determined completely statically and does not depend on the presence of hand-to-mouth consumers.
- In contrast, whenever monetary policy does not or cannot replicate the flexible price allocation, then hand-to-mouth consumers do make a difference for fiscal multipliers.

Conclusion (1)

Table 1 Summary output multipliers

	Liquidity trap						Currency union								
	Tax-financed			Deficit-financed			Tax-financed			Deficit-financed			Foreign-financed		
Rigid prices ($\lambda=0$)	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$
$\chi=0$	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.1160	1.1160	1.1160
$\chi=0.25$	4.5000	1.4804	1.0000	6.0000	1.8922	1.2386	1.6459	1.1956	1.0000	1.9474	1.3786	1.1314	2.0387	1.4823	1.2446
$\chi=0.5$	*	*	1.0000	*	*	1.7159	*	2.2835	1.0000	*	3.4861	1.3361	*	3.5041	1.4514
$\chi=0.75$	*	*	1.0000	*	*	3.1477	*	*	1.0000	*	*	1.7385	*	*	2.4971
Sticky prices ($\lambda=0.12$)	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$
$\chi=0$	1.0542	1.0542	1.0542	1.0542	1.0542	1.0542	0.8968	0.8968	0.8968	0.8968	0.8968	0.8968	0.9550	0.9550	0.9550
$\chi=0.25$	6.9420	1.6437	1.0542	−191.4702	−1.0069	0.5347	1.2856	1.0321	0.8984	1.5476	1.2020	1.0241	1.5819	1.2410	1.0611
$\chi=0.5$	*	*	1.0542	−*	−*	−0.5044	*	1.5451	0.9009	*	2.5252	1.2233	*	2.3385	1.2302
$\chi=0.75$	*	*	1.0542	−*	−*	−3.6218	*	*	0.9083	*	*	1.5770	*	*	1.6241
Sticky prices ($\lambda\simeq1.37$)	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$	$\rho=0$	$\rho=0.5$	$\rho=1$
$\chi=0$	1.8315	1.8315	1.8315	1.8315	1.8315	1.8315	0.6529	0.6529	0.6529	0.6529	0.6529	0.6529	0.6638	0.6638	0.6638
$\chi=0.25$	168.2368	4.5741	1.8315	−3.4965e8	−5153.3064	−242.9734	0.8142	0.7101	0.6542	0.9127	0.7795	0.7096	0.9266	0.7883	0.7141
$\chi=0.5$	*	*	1.8315	−*	−*	−732.5833	*	0.9238	0.6563	*	1.2767	0.7999	*	1.2515	0.7941
$\chi=0.75$	*	*	1.8315	−*	−*	−2201.4125	*	*	0.6612	*	*	0.9670	*	*	0.9559

Conclusion (2)

- Economic response to changes in government spending in some benchmark models is explored.
- Dynamics of these responses are characterized analytically
- Multipliers are defined as the partial derivative of private spending at any point in time, to public spending at any other date.
- Both closed and open economies are considered.
- Hand-to-mouth agents are incorporated in both these frameworks.

Conclusion (3)

- Fiscal policy can be potent during liquidity trap.
  Liquidity trap: $G_t \nearrow \Longrightarrow \pi_t \nearrow \Longrightarrow r_t \searrow \Longrightarrow C_t \nearrow \Longrightarrow \pi_t \nearrow$
- More difficult to increase output through government spending within a currency union.
  $G_t \nearrow \Longrightarrow \pi_t \nearrow \Longrightarrow$Competitiveness$\searrow \Longrightarrow C_t \searrow$
- Fixed exchange rate $\Longrightarrow$ Fixed nominal interest rate but fixed nominal interest rate $\not\Rightarrow$ Fixed exchange rate
- Low degree of openness can increase these multipliers.
- Persistency of government spending is important: the more temporary the government spending shock, the more the per-period transfer is saved.

Conclusion (4)

- Ricardian effect: $G_t \nearrow \Longrightarrow S_t \nearrow$ (tax expectations) $\Longrightarrow C_t \searrow$.
- Two types of consumers $\Longrightarrow$ Non-Ricardian effects from fiscal policy
- Both in currency union and in liquidity trap, government spending has additional effects.
- Both incidence (redistribution from low to high propensity to consume increases output) and timing of taxes matter.
- Liquidity constraints magnify the difference between self and outside financed fiscal multipliers for temporary government spending shocks.