Bonn Summer School
Advances in Empirical Macroeconomics

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Overview

From causal effects to policy recommendations is a big step.

It requires theory.

Theory needs to be consistent with reduced form evidence.

A Simple Theoretical Framework

Standard New Keynesian Model

1. Representative household consumes and supplies labor.
2. Monopolistically competitive firms produce and set prices.
3. Government sets interest rates, tax rates and transfers.

Setup close to Benigno and Woodford (2004), Correia, Farhi, Nicolini and Teles (2012)

Households

A representative household values $\{C_t, h_t\}_{t=1}^{\infty}$:

$$E_0 \sum_{t=1}^{\infty} \beta^t \omega_t \left(\ln\left(C_t\right) - \frac{\int_0^1 h_t(i)^{1+\nu} di}{1+\nu} \right) \text{ , } 0 < \beta < 1, \nu \geq 0$$

$$C_t = \left(\int_0^1 C_t(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}} \quad , \quad \theta > 1$$

Flow budget constraints for all $t > 0$

$$(1+\tau_t^c) \int_0^1 P_t(i) C_t(i) di + B_t \leq T_t \left(\int_0^1 W_t(i) h_t(i) di + \Pi_t \right) + (1+R_{t-1}) B_{t-1}$$

and some borrowing constraint.

$T_t(\cdot)$ determines disposable income (i.e. after taxes).
τ_t^c is a flat **sales tax rate**.

Utility maximization implies

$$\begin{aligned} C_t(i) &= (P_t(i)/P_t)^{-\theta} C_t \\ 1 &= \beta E_t \frac{\omega_{t+1}}{\omega_t} \frac{(1+\tau_t^c) C_t}{(1+\tau_{t+1}^c) C_{t+1}} \frac{P_t}{P_{t+1}} (1+R_t) \\ \frac{1-\tau_t}{1+\tau_t^c} W_t(i)/P_t &= h_t(i)^\nu C_t \end{aligned}$$

where $P_t = \left(\int_0^1 P_t(i)^{1-\theta} di \right)^{\frac{1}{1-\theta}}$ and

$\tau_t = 1 - \frac{\partial T_t(x_t)}{\partial x_t}$ is the **marginal tax rate on income**.

Firms

Monopolistically competitive firms indexed by $i \in [0,1]$

Produce $Y_t(i) = (P_t(i)/P_t)^{-\theta} Y_t$ with technology $Y_t(i) = X_t h_t(i)$.

Facing Calvo probability $0 \leq \lambda < 1$, a price changing firm chooses a new price $P_t^*(i)$ to maximize

$$E_t \sum_{j=0}^{\infty} \lambda^j Q_{t,t+j} \left[P_t^*(i) - \mu_t W_{t+j}(i)/X_{t+j}\right] Y_{t+j}(i)$$

where $Q_{t,t+j}$ is the relevant household discount factor.

μ_t is exogenous wage markup shock.

Profit maximization implies

$$\frac{P_t^*(i)}{P_t} = \frac{\theta}{\theta - 1} E_t \frac{\sum_{j=0}^{\infty} \lambda^j Q_{t,t+j} Y_{t+j} \left(\frac{P_{t+j}}{P_t}\right)^{1+\theta} \mu_{t+j} \frac{W_{t+j}(i)}{P_{t+j} X_{t+j}}}{\sum_{j=0}^{\infty} \lambda^j Q_{t,t+j} Y_{t+j} \left(\frac{P_{t+j}}{P_t}\right)^{\theta}}$$

Market Equilibrium Conditions

Impose goods market clearing: $Y_t = C_t$ and consider

$$\frac{W_{t+j}(i)}{P_{t+j}} = \frac{1+\tau^c_{t+j}}{1-\tau_{t+j}} \left(\frac{P^*_t(i)}{P_{t+j}}\right)^{-\theta\nu} Y^{1+\nu}_{t+j} X^{-\nu}_{t+1}$$

$$Q_{t,t+j} = \beta^j \frac{\omega_{t+j}}{\omega_t} \frac{P_t Y_t}{P_{t+j} Y_{t+j}} \frac{1-\tau_{t+j}}{1+\tau^c_{t+j}} \frac{1+\tau^c_t}{1-\tau_t}$$

Substituting into the price setting condition and imposing symmetry,

$$\left(\frac{P^*_t}{P_t}\right)^{1+\theta\nu} = \frac{\theta}{\theta-1} E_t \frac{\sum_{j=0}^{\infty} (\beta\lambda)^j \frac{\omega_{t+j}}{\omega_t} \left(\frac{P_{t+j}}{P_t}\right)^{\theta(1+\nu)} \left(\frac{Y_{t+j}}{X_{t+j}}\right)^{1+\nu} \mu_{t+j}}{\sum_{j=0}^{\infty} (\beta\lambda)^j \frac{\omega_{t+j}}{\omega_t} \frac{1-\tau_{t+j}}{1+\tau^c_{t+j}} \left(\frac{P_{t+j}}{P_t}\right)^{\theta-1}}$$

Inflation is linked to the reset price by

$$1 = \lambda(1+\pi_t)^{\theta-1} + (1-\lambda)(P^*_t/P_t)^{1-\theta}$$

Market Equilibrium Conditions

$$
\begin{aligned}
1 &= \beta(1+R_t)E_t \frac{\omega_{t+1}}{\omega_t}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{Y_t}{Y_{t+1}}\frac{1}{1+\pi_{t+1}} \\
\frac{\theta}{\theta-1}V_t/F_t &= \left(\frac{1-\lambda(1+\pi_t)^{\theta-1}}{1-\lambda}\right)^{\frac{1+\theta\nu}{1-\theta}}
\end{aligned}
$$

where

$$
\begin{aligned}
V_t &= \frac{\theta-1}{\theta}(Y_t/X_t)^{1+\nu}\frac{1+\tau_t^c}{1-\tau_t}\mu_t + \beta\lambda E_t(1+\pi_{t+1})^{\theta(1+\nu)}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{1-\tau_{t+1}}{1-\tau_t}\frac{\omega_{t+1}}{\omega_t}V_{t+1} \\
F_t &= 1+\beta\lambda E_t(1+\pi_{t+1})^{\theta-1}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{1-\tau_{t+1}}{1-\tau_t}\frac{\omega_{t+1}}{\omega_t}F_{t+1}
\end{aligned}
$$

Flexible Price and First Best Output Levels

When $\lambda = 0$,

$$Y_t^{flex}(i) = Y_t^{flex} \quad = \quad X_t \left(\frac{\theta - 1}{\theta \mu_t} \frac{1 - \tau_t}{1 + \tau_t^c} \right)^{\frac{1}{1+\nu}}$$

which is decreasing in τ_t and τ_t^c.

The efficient output level is

$$Y_t^{fb}(i) = Y_t^{fb} \quad = \quad X_t$$

An implementation of the efficient allocation must have $\pi_t = 0$.

Welfare Objective

$$\mathcal{W} = E_0 \sum_{t=1}^{\infty} \beta^t \omega_t \left(\ln(X_t) + \ln\left(\frac{Y_t}{X_t}\right) - \left(\frac{Y_t}{X_t}\right)^{1+\nu} \frac{v_t}{1+\nu} \right)$$

where v_t is defined recursively

$$v_t = (1-\lambda)^{1-\frac{\theta(1+\nu)}{\theta-1}} \left(1 - \lambda(1+\pi_t)^{\theta-1}\right)^{\frac{\theta(1+\nu)}{\theta-1}} + \lambda(1+\pi_t)^{\theta(1+\nu)} v_{t-1} \geq 1$$

Assume $v_0 = 1$.

The instruments are R_t , marginal rates τ_t^c and τ_t and the average tax rate (intercept of the net-of-tax function $T_t(\cdot)$).

Constraints are the two market equilibrium conditions, the GBC and the ZLB on R_t.

Optimal Policy

1. Without markup shocks ($\mu_t = \bar{\mu}$) and as long as the ZLB never binds $R_t > 0$, monetary policy can achieve first best with constant tax rates by setting R_t to the natural interest rate.

$$(1 + R_t)\beta E_t \frac{\omega_{t+1}}{\omega_t} \frac{X_t}{X_{t+1}} = 1 \quad , \quad \frac{1 - \tau_t}{1 + \tau_t^c} = \frac{\bar{\mu}\theta}{\theta - 1}$$

2. With markup shocks, as long as the ZLB never binds $R_t > 0$, monetary policy and one variable distortionary tax rate can achieve first best.

$$(1 + R_t)\beta E_t \frac{\omega_{t+1}}{\omega_t} \frac{X_t}{X_{t+1}} = 1 \quad , \quad \frac{1 - \tau_t}{1 + \tau^c} = \frac{\mu_t\theta}{\theta - 1}$$

or,

$$(1 + R_t)\beta E_t \frac{\omega_{t+1}}{\omega_t} \frac{X_t}{X_{t+1}} \frac{1 + \tau_t^c}{1 + \tau_{t+1}^c} = 1 \quad , \quad \frac{1 - \tau}{1 + \tau_t^c} = \frac{\mu_t\theta}{\theta - 1}$$

3. By varying both tax rates, tax policy can always achieve the first best when interest rates are constant or constrained.

$$(1+R)\beta E_t \frac{\omega_{t+1}}{\omega_t} \frac{X_t}{X_{t+1}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} = 1 \quad , \quad \frac{1-\tau_t}{1+\tau_t^c} = \frac{\mu_t \theta}{\theta - 1}$$

See Correia, Farhi, Nicolini and Teles (2012).

Note, endogenous component must be added to the policy rules to rule out alternative suboptimal outcomes (cfr. Taylor principle).

Systematic tax policies are valuable additions to monetary policy in case of markup shocks and/or the ZLB, and can even replace it entirely.

Similar conclusion without lump sum taxes, but only second best outcomes. See Benigno and Woodford (2004), Correia, Farhi, Nicolini and Teles (2012).

Fiscal Policy Interventions at the ZLB

How effective are ad-hoc fiscal policy interventions at the ZLB?

There exists a view that

- Government spending/ sales tax cuts increases have (much) larger output effects
- Income/Payroll tax stimulus is not effective and even contractionary at the ZLB.

Theoretical support in New Keynesian model under a liquidity trap (depressed output levels, deflation and zero nominal interest rates) after a shock that induces high private savings e.g. preference shocks ω_t.

Woodford and Eggertson (2003), Eggertson (2009), Woodford (2010), Christiano, Eichenbaum and Rebelo (2011)

Expectations Driven Liquidity Traps

Mertens and Ravn (2014)

Identical model New Keynesian environment, but a different shock: loss in “confidence”

1. Large drops in output and welfare can occur in an expectations driven liquidity trap
2. Spending and sales tax cuts become *less* effective than usual.
3. Cuts in marginal income tax become *more* effective.
4. Higher inflation targets can be a bad idea.

Consider

$$
\begin{aligned}
1 &= \beta(1+R_t)E_t \frac{\omega_{t+1}}{\omega_t}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{Y_t}{Y_{t+1}}\frac{1}{1+\pi_{t+1}} \\
\frac{\theta}{\theta-1}V_t/F_t &= \left(\frac{1-\lambda(1+\pi_t)^{\theta-1}}{1-\lambda}\right)^{\frac{1+\theta\nu}{1-\theta}} \\
1+R_t &= \max\left(\frac{1+\pi^*}{\beta}\left(\frac{1+\pi_t}{1+\pi^*}\right)^{\phi_\pi},1\right) \quad , \quad \phi_\pi > 1
\end{aligned}
$$

where

$$
\begin{aligned}
V_t &= \frac{\theta-1}{\theta}(Y_t/X_t)^{1+\nu}\frac{1+\tau_t^c}{1-\tau_t}\mu_t + \beta\lambda E_t(1+\pi_{t+1})^{\theta(1+\nu)}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{1-\tau_{t+1}}{1-\tau_t}\frac{\omega_{t+1}}{\omega_t}V_{t+1} \\
F_t &= 1+\beta\lambda E_t(1+\pi_{t+1})^{\theta-1}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{1-\tau_{t+1}}{1-\tau_t}\frac{\omega_{t+1}}{\omega_t}F_{t+1}
\end{aligned}
$$

Multiplicity of Equilibria

In monetary models, possible multiplicity of equilibria under interest rate rules is well known

Sargent and Wallace (JPE 1975),. . ., Atkeson, Chari and Kehoe (QJE 2010)

Even if local determinacy under Taylor Principle, global multiplicity due to zero lower bound:

- Perfect foresight: Benhabib, Schmitt-Grohé and Uribe (AER 2001, JET 2001, JPE 2002)
- Sunspot ZLB equilibria: Mertens and Ravn (2014), Aruoba, Cuba-Borda and Schorfheide (2014)

Steady States

Assume no shocks ($\omega_t = X_t = \mu_t = 1$, for all t), constant policies.

Intended Steady State (π_I, Y_I) where $\pi_I = \pi^*$ and the nominal interest rate is positive.

In case of $\pi^* = 0$ and a corrective tax rate the output level is efficient.

Unintended Steady State (π_U, Y_U) where $\pi_U = \beta < 1$, the nominal interest rate is zero and the allocation is inefficient because of price dispersion.

Sunspot Equilibria

Sunspot variable, ψ_t follows discrete Markov chain $\psi_t \in [\psi_1, ..., \psi_n]$ with transition matrix R.

A **Markov sunspot equilibrium** is an equilibrium where output and inflation are stochastic processes whose values depend on the realization of the state of confidence ψ_t.

Temporary liquidity traps:

- Low confidence triggers negative spiral of increased desire to save and soaring real interest rates.
- Monetary authority can locally defeat low confidence, but not globally because of the zero bound.
- Temporary nature is crucial: intertemporal substitution, forward looking price setting.

A Two State Sunspot Example

Suppose the sunspot variable ψ_t follows a two-state Markov chain

$$\psi_t \in [\psi_O, \psi_P] \quad , \quad TM = \begin{bmatrix} 1 & 0 \\ 1-q & q \end{bmatrix} \quad , \quad 0 < q < 1$$

Assume no other shocks ($\omega_t = X_t = \mu_t = 1$, for all t), constant policies.

π_i, Y_i: equilibrium values in state i$=O, P$

State O is the intended state (no ZLB), and π_P, y_P solves

$$1 = \beta \max \left(\frac{1+\pi^*}{\beta} \left(\frac{1+\pi_P}{1+\pi^*} \right)^{\phi_\pi}, 1 \right) \left[\frac{q}{1+\pi_P} + (1-q) \frac{Y_P}{Y_O} \frac{1}{1+\pi_O} \right] \quad \text{(EE)}$$

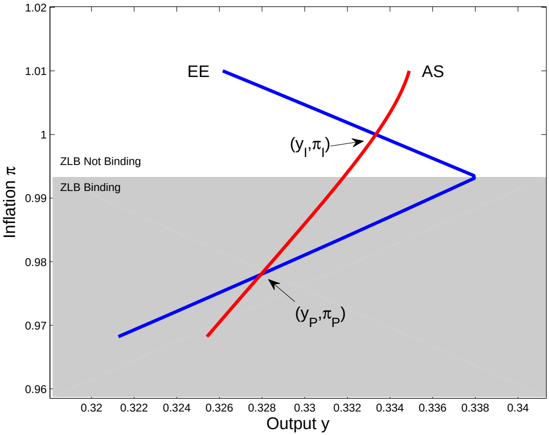
$$\frac{\theta}{\theta - 1} V_P / F_P = \left(\frac{1 - \lambda(1+\pi_P)^{\theta-1}}{1-\lambda} \right)^{\frac{1+\theta\nu}{1-\theta}} \quad \text{(AS)}$$

where

$$V_P = \frac{\theta-1}{\theta} (Y_P/X)^{1+\nu} \frac{1+\tau^c}{1-\tau} \mu + \beta\lambda \left[q(1+\pi_P)^{\theta(1+\nu)} V_P + (1-q)(1+\pi_O)^{\theta(1+\nu)} V_O \right]$$

$$F_P = 1 + \beta\lambda \left(q(1+\pi_P)^{\theta-1} F_P + (1-q)(1+\pi_O)^{\theta-1} F_O \right)$$

Existence of SS Liquidity Trap



A Two State Preference Shock Example

Suppose the preference ω_t follows a two-state Markov chain

$$\omega_t \in [\omega, 1] \;\; \omega < 1, \quad TM = \begin{bmatrix} 1 & 0 \\ 1 - q_\omega & q_\omega \end{bmatrix} \;, \quad 0 < q_\omega < 1$$

Assume no other shocks ($X_t = \mu_t = 1$, for all t), constant policies.

π_i, Y_i: equilibrium values in state i$=H, L$

State H is the state with $\omega = 1$, and π_L, y_L solves

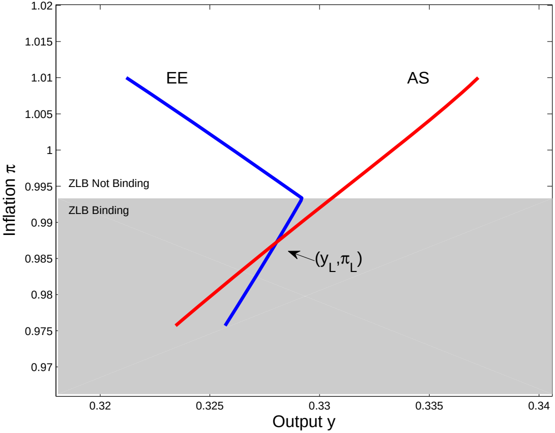
$$1 = \beta \max \left(\frac{1+\pi^*}{\beta} \left(\frac{1+\pi_L}{1+\pi^*} \right)^{\phi_\pi}, 1 \right) \left[\frac{q_\omega}{1+\pi_L} + (1-q_\omega) \frac{1}{\omega} \frac{Y_L}{Y_H} \frac{1}{1+\pi_H} \right] \tag{EE}$$

$$\frac{\theta}{\theta - 1} V_L / F_L = \left(\frac{1 - \lambda (1+\pi_L)^{\theta-1}}{1-\lambda} \right)^{\frac{1+\theta\nu}{1-\theta}} \tag{AS}$$

where

$$\begin{aligned} V_L &= \frac{\theta-1}{\theta} (Y_L/X)^{1+\nu} \frac{1+\tau^c}{1-\tau} \mu + \beta\lambda \left[q_\omega (1+\pi_L)^{\theta(1+\nu)} V_L + (1-q_\omega) \frac{1}{\omega} (1+\pi_H)^{\theta(1+\nu)} V_H \right] \\ F_K &= 1 + \beta\lambda \left(q_\omega (1+\pi_L)^{\theta-1} F_L + (1-q_\omega) \frac{1}{\omega} (1+\pi_H)^{\theta-1} F_H \right) \end{aligned}$$

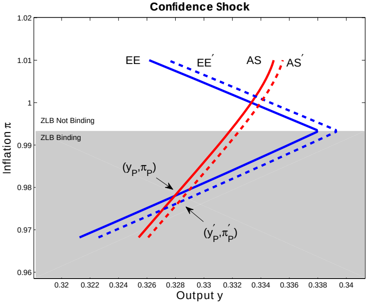
Existence of Preference Shock induced Liquidity Trap

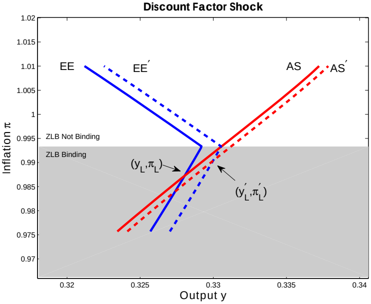


Insights

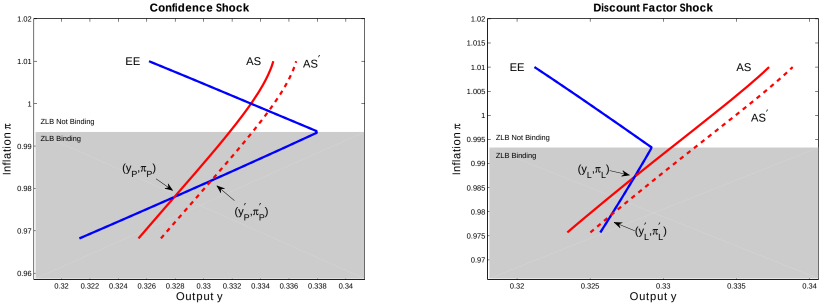
- Expectational liquidity trap exists for $q > q^{crit}$
- Preference shock liquidity trap exists for $q_\omega < q_\omega^{crit} \approx q^{crit}$.
- In both cases largest output and welfare losses are obtained when EE and AS have similar slopes (q's close to critical values).
- The difference in slopes of the EE and AS schedules is why policy interventions leads to different outcomes.

A Spending Increase in a Liquidity Trap





An Income Tax Cut in a Liquidity Trap



Summary

- Monetary policy alone is insufficient because of markup shocks and ZLB.
- Systematic tax policy can (dramatically) improve macroeconomic outcomes.
- Existing criticisms of discretionary tax interventions at the ZLB are precarious.

Very little evidence for ZLB multipliers:

Wieland (2014), Ramey and Zubairy (2014), Dupor and Li (2015)

Other interesting recent work on fiscal policy (at the ZLB):

- Werning, I. (2012). Managing a Liquidity Trap: Monetary and Fiscal Policy.
- Bianchi and Melosi (2015). Escaping the Great Recession.
- Drautzberg and Uhlig (2013). Fiscal Stimulus and Distortionary Taxation.
- Fernandez-Villaverde, Guerron-Quintana, and Rubio-Ramirez (2011). Supply-side policies and the zero lower bound.
- Gali, (2014). The Effects of a Money-financed Fiscal Stimulus.
- Johanssen (2013), When are the Effects of Fiscal Policy Uncertainty Large?