Liquidity Traps in a World Economy

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Euro Area Core inflation % p.a. (YoY)

Source: Eurostat (From Croitorov, Ratto, Pfeiffer, Roeger, 2020)

ECB deposit facility rate (% p.a.)

●This paper: analyzes low-rates environment in two-country sticky-prices model (NK) with ZLB

● Compare:

"fundamental" liquidity trap driven by adverse aggregate demand shocks (Krugman (1998); Eggertsson & Woodford (2003), Holden (2016))

vs.

"beliefs-driven" liquidity trap due to self-fulfilling deflationary expectations (Benhabib, Schmitt-Grohé & Uribe (2001))

vs.

Responses away from ZLB

Does the nature of the liquidity trap ("fundamental" vs "beliefs-driven") matter?
Show that this depends on shock persistence!

►Responses to <u>persistent</u> shocks in <u>"beliefs-driven"</u> liquidity trap *differ* greatly from responses in <u>"fundamental"</u> liquidity trap

►With <u>persistent</u> shocks: dynamics in <u>"beliefs-driven"</u> looks like standard dynamics <u>away from ZLB</u>:

⇒ "Irrelevance" of "beliefs-driven" liquidity trap (under persistent shocks)

What I mean by "persistent": persistence of standard business cycles shocks, e.g. autocorr. ρ=0.95

► **But with transitory shocks (less relevant empirically):**

Shock responses in “beliefs-driven” and “fundamental” liquidity traps are more similar, and

DIFFERENT from dynamics away from ZLB

SUMMARY (LT: liquidity trap)

- **Persistent shocks:**

"Fundamental LT" $\neq$ "Beliefs-driven LT" $\approx$ Away from ZLB

- **Transitory shocks:**

"Fundamental LT" $\approx$ "Beliefs-driven LT" $\neq$ Away from ZLB

BELIEFS-DRIVEN LIQUIDITY TRAPS:

■ **Benhabib et al. (2001): ZLB + active Taylor rule: induces multiple equilibria.**
Liquidity trap can be due to self-fulfilling pessimism about future inflation if monetary policy follows **'active' Taylor rule**

$$E_t\{\beta u'(C_{t+1})/u'(C_{t+1}))(1+i_{t+1})/\Pi_{t+1}=1$$

Under risk neutrality, certainty equivalent approximation:

$$E_t\Pi_{t+1}=\beta\cdot(1+i_{t+1})$$

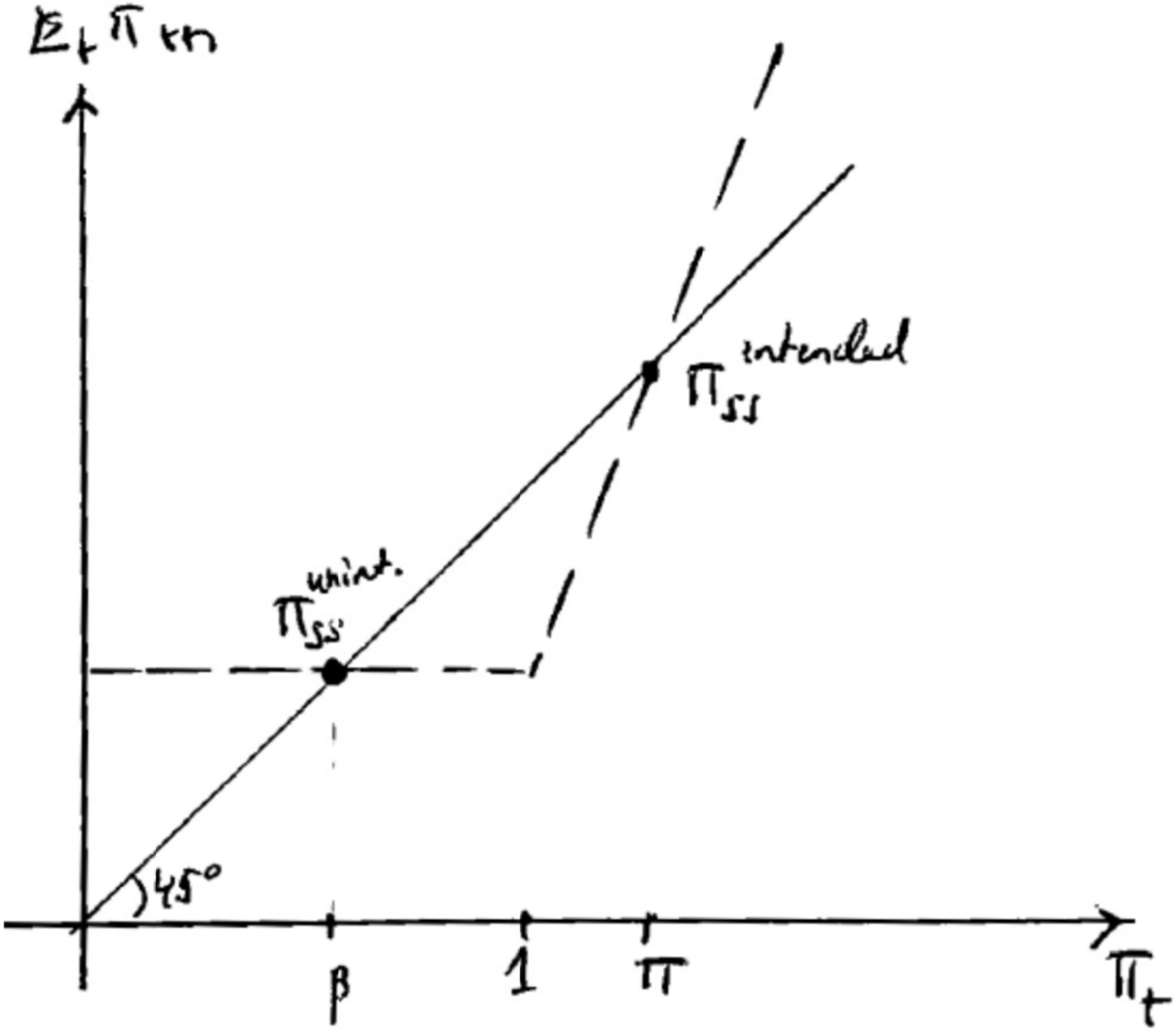
Taylor rule, with ZLB: $1+i_{t+1}=Max[1,\Pi/\beta+(\gamma_\pi/\beta)(\Pi_t-\Pi)]$

$\Pi>1$: **steady state (gross) inflation**

$\gamma_\pi>1$ **(Taylor rule)**

$$E_t\Pi_{t+1}=Max[\beta,\Pi+\gamma_\pi(\Pi_t-\Pi)]$$

Two steady states: $\Pi_{SS}^{\text{intended}}=\Pi>1$ **and** $\Pi_{SS}^{\text{unintended}}=\beta<1$



$$E_t \Pi_{t+1} = Max[\beta, \Pi + \gamma_\pi (\Pi_t - \Pi)]$$

●With random supply and demand (TFP,G) shocks: economy can fluctuate in the neighborhoods of the 'intended' and 'unintended' steady states

●There are sunspot equilibria in which inflation rate randomly switches between values in neighborhood of the 'intended' and 'unintended' steady states

$\Pi_t^B = \mu^B + \lambda^B r_t$ if ZLB constraint binds at t

$\Pi_t^S = \mu^S + \lambda^S r_t$ if ZLB constraint slack at t

r_t**: natural real interest rate**

● Construct equilibria with exogenous transition probabilities between ZLB regimes. Assume here: regime shifts solely driven by sunspot. Requires bounds on shock size.

- **Result: cross-country correlation of BELIEFS-DRIVEN liquidity traps is indeterminate**

● Large applied (policy) literature focuses on "fundamental" liquidity traps.

Can be analyzed with easy-to-use computer code (Guerrieri & Iacoviello (2015), Holden (2016))

Influential work that informs key policy debates

Andrade, Galí, Le Bihan & Matheron (2020)
Coenen, Montes-Galdon & Schmidt (2020)
Erceg, Jakab & Lindé (2020)

Thus: important to assess robustness of this class of models to source of liquidity trap & other model assumptions

● Few papers have considered business cycle models with "beliefs-driven" liquidity traps (closed economy models)

Mertens & Ravn (2014): compare beliefs-driven vs. fundamental liquidity trap. But focus on comparison of Gov't purchases vs. tax changes; special shock structure; no discussion of role of shock persistence

Arifovic, Schmitt-Grohé & Uribe (2018) and **Aruoba, Cuba-Borda & Schorfheide (2018):** beliefs-driven liquidity traps, no comparison vs. fundamental traps; no discussion of shock persistence

Benigno & Fornaro (2018)
no comparison vs. fundamental traps

- **Open econ macro literature with liquidity traps focuses entirely on “fundamental” liquidity traps driven by exogenous negative demand shock (e.g. rise in subjective discount factor)**

E.g.: Jeanne (2009), Erceg & Lindé (2010), Cook Devereux (2013), Fujiwara & Ueda (2013), Gomez et al. (2015), Farhi & Werning (2016), Blanchard, Erceg & Lindé (2016) [+ many others]

• **<u>In “fundamental” liquidity trap:</u>**

inflation responds more strongly to aggregate supply & demand shocks than when ZLB is slack

► positive TFP shock at ZLB: sharper fall in inflation

$\Rightarrow$ consumption & GDP <u>fall</u> (topsy-turvy world)

► positive Government purchases shock at ZLB: stronger rise in inflation $\Rightarrow$ larger fiscal multipliers

E.g. Eggertsson (2011), Erceg & Lindé (2011), Eggertsson, Ferrero & Raffo (2014)

This paper highlights further topsy-turvy features of “fundamental” liquidity traps, in open economies

► TFP $\uparrow$ $\Rightarrow$ RER appreciation

► G $\uparrow$ $\Rightarrow$ RER depreciation

• **“Beliefs-driven” liquidity trap with PERSISTENT SHOCKS (ρ=0.95)**

■’NORMAL’ RESPONSES OF REAL VARIABLES:

TFP $\uparrow \Rightarrow$ Y $\uparrow$ C $\uparrow$ RER $\downarrow$ (depreciation)

G $\uparrow \Rightarrow$ Y $\uparrow$ C $\downarrow$ RER $\uparrow$ (appreciation)

►“IRRELEVANCE OF ZLB”: SIMILARITY BETWEEN RESPONSES OF REAL VARIABLES (TO PERSISTEN SHOCKS) AT ZLB AND AWAY FROM ZLB

►Effect on Foreign Y & Trade Balance depends on trade elasticity, as in RBC model.

► Transmission to Foreign GDP switches sign, compared to “fundamental” liquidity trap

INTUITION: PERSISTENT SHOCKS ONLY HAVE MUTED EFFECT ON NATURAL INTEREST RATE & INFLATION $\Rightarrow$ ZLB CONSTRAINT DOES NOT MATTER MUCH

BUT RESPONSE OF INFLATION IS "TOPSY-TURVY" IN "BELIEFS-DRIVEN" LIQUIDITY TRAP:

TFP $\uparrow \quad \Rightarrow \quad \pi \uparrow$

G $\uparrow \quad \Rightarrow \quad \pi \downarrow$

I show: inflation (π) responses in beliefs-driven liquidity trap are weak if shocks are persistent

Why the difference?

- "Fundamental" liquidity trap baseline liquidity trap scenario: triggered by big one-time negative demand shock that induces negative value of unconstrained nominal interest rate (need big shock for long LiqTrap)
- Once shock has subsided, the liquidity trap ends, and agents believe that the economy will NEVER enter liquidity trap again
- Small shocks to baseline trajectory have big effects
- Inflation during liquidity trap determined using backward iteration, from trap exit date
- The backward iteration is explosive
- Small shocks around that baseline trajectory have big effects: e.g., TFP shock during liquidity trap lowers inflation after exit from liquidity trap $\Rightarrow$ massive front-loaded fall in inflation $\Rightarrow$ GDP $\downarrow$

By contrast: Beliefs-driven liquidity traps

Inflation as function of the <u>natural real interest rate</u> (rules depending on the ZLB state)

Equilibrium in which regime shifts are <u>purely</u> driven by changes in beliefs requires bounded shock

Persistent TFP, G shocks have little effect on natural real rate $\Rightarrow$ little effect on inflation

$\Rightarrow$ output response resembles response away from ZLB (under inflation targeting)!

"Beliefs-driven" liquidity trap with TRANSITORY SHOCKS

■ with transitory shocks, ZLB constraint bites more -- in unconstrained regime the interest rate would adjust strongly to adjust to sharp natural rate change

TFP ↑ ⇒ Y ↓ C ↓ RER ↑ (appreciation)
G ↑ ⇒ Y ↑ C ↓ RER ↓ (depreciation)

International spillovers change sign

Numerical illustration:

- Unit risk aversion, unit labor supply elast.
- Substitution elast. domestic vs. foreign goods: 1.5
- Price stickiness = 4 quarters (slope of Phillips curve: 0.08)
- Producer currency pricing
- Taylor rule inflation coefficient: 1.5
- No capital: purely forward looking model (inflation & other endogenous variables are all jump variables)

■ **Model variant with beliefs-driven liquidity trap:**

ZLB regime (slack or binding ZLB) is driven by sunspot
Probability of remaining in same ZLB regime next period: 0.95
ZLB regime uncorrelated across countries.

■ **Model variant with "fundamental" liquidity trap:**

Assume a baseline liquidity trap lasting 12 quarters, induced by big negative (autocorr. 0.95) shock to household subjective discount rate. Negative discount rate shock makes the unconstrained nominal interest rate (without ZLB) negative. Agents assume that once unconstrained rate becomes positive, the liquidity trap ends. Solve for inflation during liquidity trap by "backward" iteration of Euler & Phillips equations
E.g.: Blanchard, Erceg & Lindé (2016)

IMPACT RESPONSES TO HOME TFP SHOCK

	...............Home...............					.......Foreign......		
	i	π	GDP	TB/Y	RER	i	π	GDP
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
• 1% Home TFP shock, persistent (ρ=0.95)								
Beliefs-driven Liq.Trap	**0.00**	**0.26**	**1.11**	**0.10**	**-0.70**	**0.00**	**0.02**	**-0.05**
Fundamental Liquid.Trap	**0.00**	**-34.59**	**-17.63**	**-1.90**	**12.44**	**0.00**	**3.26**	**2.98**
Away from ZLB	**-0.37**	**-0.25**	**0.99**	**0.09**	**-0.79**	**-0.02**	**-0.01**	**-0.05**
RBC world	**--**	**--**	**1.05**	**0.10**	**-0.76**	**--**	**--**	**-0.05**
• 1% Home TFP shock, transitory (ρ=0.50)								
Beliefs-driven Liq.Trap	**0.00**	**-1.89**	**-0.47**	**-0.05**	**0.31**	**0.00**	**0.04**	**0.05**
Fundamental Liquid.Trap	**0.00**	**-2.03**	**-0.55**	**-0.06**	**0.37**	**0.00**	**0.05**	**0.07**
Away from ZLB	**-1.30**	**-0.86**	**0.42**	**0.04**	**-0.37**	**-0.03**	**-0.02**	**-0.03**
RBC world	**--**	**--**	**1.05**	**0.10**	**-0.76**	**--**	**--**	**-0.05**

Rise in RER: appreciation of Home real exchange rate

Fundamental liquidity trap: 12 quarters, triggered by shock to Home & Foreign household discount

Simulations assume that both countries are in the same ZLB regime.

i: nominal interest rate, % p.a.; π: PPI inflation, % p.a.

GDP, TB/Y & RER responses shown in %.

IMPACT RESPONSES TO HOME GOVERNMENT PURCHASES SHOCK

	Home					Foreign		
	i	π	GDP	TB/Y	RER	i	π	GDP
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
• 1% Home G shock, persistent (ρ=0.95)								
Beliefs-driven Liq.Trap	**0.00**	**-0.13**	**0.44**	**-0.05**	**0.35**	**0.00**	**-0.01**	**0.02**
Fundamental Liq.Trap	**0.00**	**9.93**	**5.85**	**0.51**	**-3.36**	**0.00**	**-0.71**	**-0.72**
Away from ZLB	**0.19**	**0.12**	**0.50**	**-0.05**	**0.31**	**0.01**	**0.01**	**0.02**
RBC world	**--**	**--**	**0.47**	**-0.05**	**0.33**	**--**	**--**	**0.02**
• 1% Home G shock, transitory (ρ=0.50)								
Fundamental Liq.Trap	**0.00**	**1.01**	**1.27**	**0.03**	**-0.18**	**0.00**	**-0.02**	**-0.03**
Beliefs-driven Liq.Trap	**0.00**	**0.94**	**1.23**	**0.02**	**-0.16**	**0.00**	**-0.02**	**-0.03**
Away from ZLB	**0.65**	**0.43**	**0.79**	**-0.02**	**0.14**	**0.01**	**0.01**	**0.02**
RBC world	**--**	**--**	**0.47**	**-0.05**	**0.33**	**--**	**--**	**0.02**

i: nominal interest rate, % p.a.; π: PPI inflation, % p.a.
GDP, TB/Y & RER responses shown in %. Rise in RER: appreciation of Home real exchange rate
Fundamental liquidity trap: 12 quarters, triggered by shock to Home & Foreign household discount
Liquidity trap regime: both countries; “Away from ZLB”: both countries.

Debortoli, Gali & Gambetti (2019) finding (VAR-based) of "Empirical (Ir)Relevance of the ZLB constraint"

Debortoli et al. (2019) argue that Empirical Irrelevance of ZLB reflects fact that unconventional monetary policy allowed to compensate for loss of interest rate tool at ZLB

This paper offers alternative interpretation of ZLB irrelevance: model with beliefs-driven liquidity trap and PERSISTENT shocks can rationalize ZLB irrelevance for GDP dynamics
(However, beliefs-driven model predicts that inflation response to shocks is qualitatively different at ZLB vs away from ZLB.)

This paper: beliefs-driven liquidity traps in open economies

Stylized model two-country NK model

- **Floating exchange rate**
- **Each country is specialized in production of a distinct tradable good, but consumes domestic & imported tradables (with home bias),**
- **Government purchases local output only**
- **Complete financial markets**
- **Sticky prices (price adjustment costs)**
- **Central bank targets inflation (Taylor principle)**

Study beliefs-driven sunspot equilibria with occasionally binding ZLB constraint

• Preferences [Home = H; Foreign = F]

$$E_0 \sum_{t=0}^{\infty} \beta^t \Psi_{H,t} U(C_{H,t}, L_{H,t}),$$ $\Psi_{H,t}$: preference shock

$$U(C_{H,t}, L_{H,t}) = \ln(C_{H,t}) - \tfrac{1}{1+1/\eta} (L_{H,t})^{1+1/\eta}$$

• Risk sharing

$$C_{H,t}/C_{F,t} = (\Psi_{H,t}/\Psi_{F,t})/RER_t$$

• Euler equation

$$(1+i_{H,t+1}) E_t \beta (\Psi_{H,t+1}/\Psi_{H,t})(C_{H,t}/C_{H,t+1})/\Pi^{CPI}_{H,t+1} = 1$$

• Price setting (Phillips equation)

$$\widehat{\Pi_{H,t}} = \kappa_w \cdot \widehat{mc_{H,t}} + \beta E_t \widehat{\Pi_{H,t+1}};$$ $\Pi_{H,t}$: PPI inflation; $mc_{H,t}$: real marg.cost

Producer currency pricing (PCP) assumed

• Monetary policy rule

$$1 + i_{H,t+1} = Max\{1, \Pi/\beta + (\gamma_\pi/\beta) \cdot (\Pi_{H,t} - \Pi)\},$$ Π: target inflation (gross)

Assume PPI inflation targeting

Linearize around target inflation rate "Euler-Phillips-MP" equation:

$$Max\{-(\Pi-\beta)/\Pi, \gamma_\pi \cdot \widehat{\Pi_{H,t}}\} + \tfrac{1}{\kappa}\widehat{\Pi_{H,t}} = (1+\tfrac{1+\beta}{\kappa})E_t\widehat{\Pi_{H,t+1}} - \tfrac{\beta}{\kappa}E_t\widehat{\Pi_{H,t+2}} + \widehat{r_{H,t}}$$

[This holds when substitution elasticity domestic vs. foreign goods = 1]

$r_{H,t}$: **natural real interest rate (flex-prices)**

$$\widehat{r_{H,t}} \equiv E_t\widehat{\theta_{H,t+1}} - \widehat{\theta_{H,t}} - \tfrac{1}{1+\eta}(E_t\widehat{g_{H,t+1}} - \widehat{g_{H,t}}) - [\xi + \tfrac{\eta}{1+\eta}(1-\xi)]E_t(\widehat{\Psi_{H,t+1}} - \widehat{\Psi_{H,t}}) - \tfrac{1}{1+\eta}(1-\xi)E_t(\widehat{\Psi_{F,t+1}} - \widehat{\Psi_{F,t}}),$$

$$\widehat{r_{H,t}} = (1-\rho)\{-\widehat{\theta_{H,t}} + \tfrac{1}{1+\eta}\widehat{g_{H,t}} + [\xi + \tfrac{\eta}{1+\eta}(1-\xi)]\widehat{\Psi_{H,t}} + \tfrac{1}{1+\eta}(1-\xi)\widehat{\Psi_{F,t}}\}$$

ρ: **autocorrelation of exogenous variables**

Aggregate TFP $\uparrow \;\Rightarrow\; r_t \downarrow$

Aggregate G $\uparrow \;\Rightarrow\; r_t \uparrow$

Sunspot equilibria:

Focus on equilibria in which inflation is a function of natural real interest rate:

$\widehat{\Pi_{H,t}^{B}} = \mu^{B} + \lambda^{B}\widehat{r_{H,t}}$ if country H ZLB constraint binds at t

$\widehat{\Pi_{H,t}^{S}} = \mu^{S} + \lambda^{S}\widehat{r_{H,t}}$ if country H ZLB constraint is slack at t

Assume constant transition probabilities between ZLB regimes (driven by sunspot)

In liquidity trap:
For persistent shock:

$$\theta_t \uparrow \;\Rightarrow\; r_t \downarrow \;\Rightarrow \widehat{\Pi_t} \uparrow, \quad E_t \widehat{\Pi_{t+1}} \uparrow$$

Intuition:

$$(1+i_{t+1}) E_t \beta \frac{C_t}{C_{t+1}} \frac{1}{\Pi_{t+1}} = 1$$

- With persistent shock ρ<1,

$$\theta_{H,t} \uparrow \;\Rightarrow\; \frac{C_t}{C_{t+1}} \uparrow$$

At ZLB: $i_{t+1}=0 \;\Rightarrow \Pi_{t+1} \uparrow \Rightarrow\; \Pi_t \uparrow$

But when ρ close to 1, then $\frac{C_t}{C_{t+1}}$ rises very little

$\Rightarrow$ **muted effect on inflation**

Conclusion

Shock transmission in presence of liquidity trap depends on the causes of the liquidity trap and on shock persistence

With persistent shocks: ZLB matters much less for response of real variables to business cycle shocks than what you think (based on popular "fundamental" liquidity trap models)

Global dimension of liquidity traps:
In "beliefs-driven" liquidity trap with persistent shocks, TFP & G shocks have similar effects on RER and foreign output as away from the ZLB
(By contrast, in "fundamental" liquidity trap the RER response is topsy-turvy)

International correlation of beliefs-driven liquidity traps is indeterminate

Avenues for future research:

►Analysis of beliefs-driven liquidity traps in richer models. Welfare effects of liquidity traps?

► Implications for monetary policy strategy ?