Revisiting the New Keynesian Paradoxes Under QE*

Dario Bonciani[1] Joonseok Oh[2]

[1]Bank of England

[2]Freie Universität Berlin

Yonsei University
September 9th, 2020

*The views expressed in this paper are those of the authors, and not necessarily those of the Bank of England or its committees.

Motivation

- Since Great Recession, nominal rates in the U.S. and the EU have approached zero.
- Japan's zero lower bound (ZLB) experience during the 1990's
- New Keynesian (NK) Policy Paradoxes at the zero lower bound
  - The Paradox of Flexibility:
    For a given demand shock, greater price flexibility is more contractionary.
    Eggertsson and Krugman (2012), Bhattarai, Eggertsson and Schoenle (2014)
  - Large Government Spending Multipliers:
    The classical government spending multiplier is greater than one.
    Christiano et al. (2011), Eggertsson (2011), Woodford (2011)
  - The Paradox of Toil:
    Distortionary labor tax cuts are contractionary.
    Eggertsson (2010)

Research Questions

- How can we understand these paradoxes?
  - A challenge to the conventional wisdom?
  - Some fundamental flaws of the NK model?
- How can we resolve these paradoxes?
- Any policy implication?

What We Do

- We revisit these policy paradoxes in the NK model with quantitative easing (QE).
- We consider the NK model (Sims et al., 2020) featuring
  1. short and long term bonds,
  2. short term nominal interest rate rule and ZLB (conventional monetary policy),
  3. central bank's long term bond portfolio (QE) rule (unconventional monetary policy).

Quantitative Easing

- QE is one of the key unconventional monetary policy.
- A central bank (CB) purchases longer-term securities from the open market.
- This increases the money supply and encourages lending and investment.
- This also expands the central bank's balance sheet.
- Against the COVID-19 pandemic, many CBs expanded balance sheet with QE.

What We Find

- QE aimed at stabilizing inflation eliminates these paradoxes.
  - For a given demand shock, greater price flexibility mitigates the output losses.
  - Government spending multipliers are significantly smaller than one.
  - Distortionary labor tax cuts become expansionary.
- The paradoxes are a failure of models to characterize monetary policy correctly.
- Monetary and fiscal policies should be executed very carefully in a liquidity trap.

Literature Review

- New Keynesian Policy Paradoxes
  Eggertsson (2010), Eggertsson (2011), Christiano et al. (2011), Woodford (2011), Eggertsson and Krugman (2012), Bhattarai, Eggertsson and Schoenle (2014)

- Possible Solutions
  - Sticky Information Model
    Kiley (2016), Eggertsson and Garga (2019)

  - Shadow Rate Smoothing (Forward Guidance)
    Hills and Nakata (2018), Bonciani and Oh (2020)

- Quantitative Easing
  Gertler and Karadi (2011), Gertler and Karadi (2013), Carlstrom et al. (2017), Cui and Sterk (2020), Sims and Wu (2020a), Sims and Wu (2020b), Sims et al. (2020)

Outline

1. **New Keynesian Model with QE**

2. **Analytical Results: Two-Period**

3. **Numerical Results: Infinite-Horizon**

4. **Conclusion**

Outline

1. **New Keynesian Model with QE**

2. Analytical Results: Two-Period

3. Numerical Results: Infinite-Horizon

4. Conclusion

New Keynesian Model with QE

- Two types of households
  - Parent (Patient): Short term bonds
  - Child (Impatient): Long term bonds
- Financial intermediary: Risk-weighted leverage constraint
- Production firms (Final, Retail, Wholesale): Retailers are subject to Calvo (1983)
- Monetary authority
  - Conventional monetary policy: Short term nominal interest rate & ZLB
  - Unconventional monetary policy: Central bank's long term bond portfolio (QE)
- Fiscal authority
  - Wasteful government spending
  - Distortionary labor income tax

Four Equation New Keynesian Model

- Dynamic IS Equation

$$x_t = E_t x_{t+1} - \frac{(1-s_g)(1-z)}{\sigma}\left(i_t - E_t\pi_{t+1} - r_t^n\right) + g_t - E_t g_{t+1} - (1-s_g)\, z\bar{b}^{cb}\left(E_t qe_{t+1} - qe_t\right)$$

- New Keynesian Phillips Curve

$$\pi_t = \beta E_t \pi_{t+1} + \left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)x_t - \frac{\gamma\sigma}{(1-s_g)(1-z)}g_t + \frac{\gamma}{1-\tau}\tau_t - \frac{\gamma\sigma z}{1-z}\bar{b}^{cb} qe_t$$

Four Equation New Keynesian Model

- Nominal Rate Policy with ZLB (Strict Inflation Targeting: SIT)

$$i_t > -\frac{i}{1+i} \quad s.t. \quad \pi_t = 0$$

- QE Rule

$$qe_t = -\vartheta \pi_t$$

Outline

1. New Keynesian Model with QE
2. **Analytical Results: Two-Period**
3. Numerical Results: Infinite-Horizon
4. Conclusion

Assumptions: The Paradox of Flexibility

1. (Shock): $r_1^n < 0$, $i_1 = -\frac{i}{1+i}$, $r_2^n = 0$
2. (Fiscal Policy): $(g_1, \tau_1) = (0, 0)$, $(g_2, \tau_2) = (0, 0)$
3. (Nominal Rate Policy: SIT): $\pi_2 = 0$
4. (QE): $qe_1 = -\vartheta\pi_1$
5. (Perfect Foresight): $E_t x_{t+1} = x_{t+1}$, $E_t\pi_{t+1} = \pi_{t+1}$

Aggregate Demand (AD)

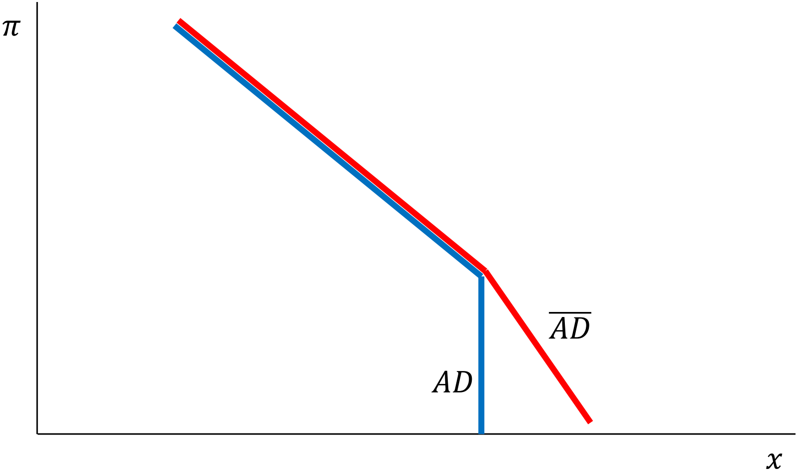
- Without QE: $\vartheta = 0$

$$x_1 = \frac{(1 - s_g)(1 - z)}{\sigma} \left(\frac{i}{1 + i} + r_1^n \right)$$

- With QE: $\vartheta > 0$

$$x_1 = \frac{(1 - s_g)(1 - z)}{\sigma} \left(\frac{i}{1 + i} + r_1^n \right) - (1 - s_g)\, z \bar{b}^{cb} \vartheta \pi_1$$

AD Curves



Aggregate Supply (AS)

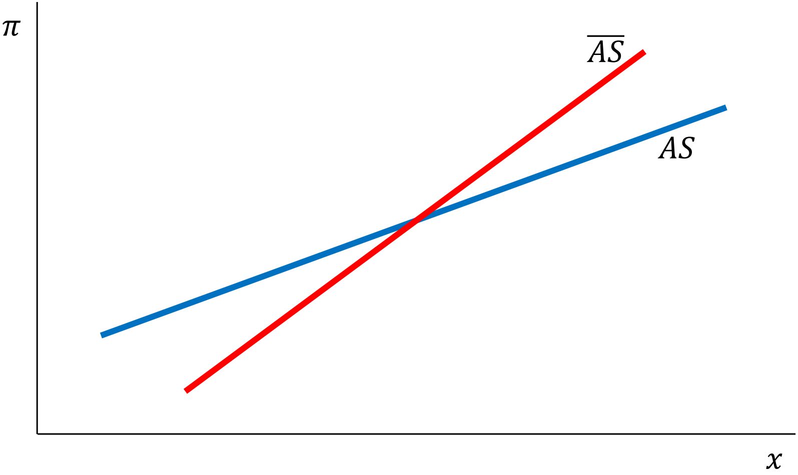
- Without QE: $\vartheta = 0$

$$\pi_1 = \left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)x_1$$

- With QE: $\vartheta > 0$

$$\pi_1 = \left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)x_1 \Big/ \left(1 - \frac{\gamma\sigma z \bar{b}^{cb}\vartheta}{1-z}\right)$$

AS Curves



Solutions

- Without QE: $\vartheta = 0$

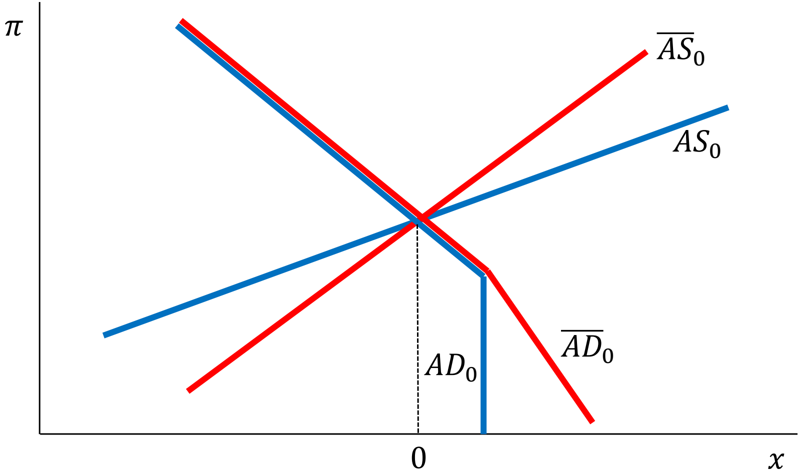
$$(x_1^\star)_{\vartheta=0} = \frac{(1-s_g)(1-z)}{\sigma}\left(\frac{i}{1+i} + r_1^n\right) < 0$$

- With QE: $\vartheta > 0$

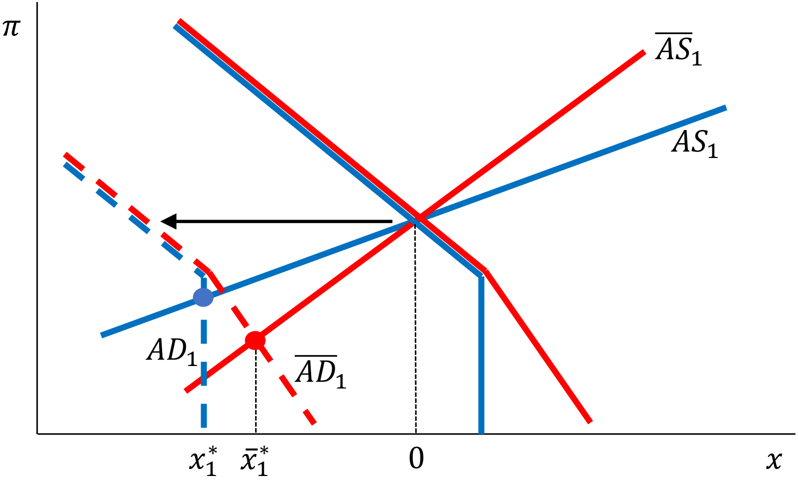
$$(x_1^\star)_{\vartheta>0} = \left[\frac{(1-s_g)(1-z)}{\sigma}\left(\frac{i}{1+i} + r_1^n\right)\right] \Bigg/ \left[1 + \left(\frac{(1-s_g)\, z\bar{b}^{cb}\vartheta}{1 - \frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)\right] < 0$$

- $$\left|(x_1^\star)_{\vartheta=0}\right| > \left|(x_1^\star)_{\vartheta>0}\right|$$

AD-AS Diagram



Negative Natural Rate Shock: $AD_0 \rightarrow AD_1$ & $\overline{AD}_0 \rightarrow \overline{AD}_1$



The Paradox of Flexibility

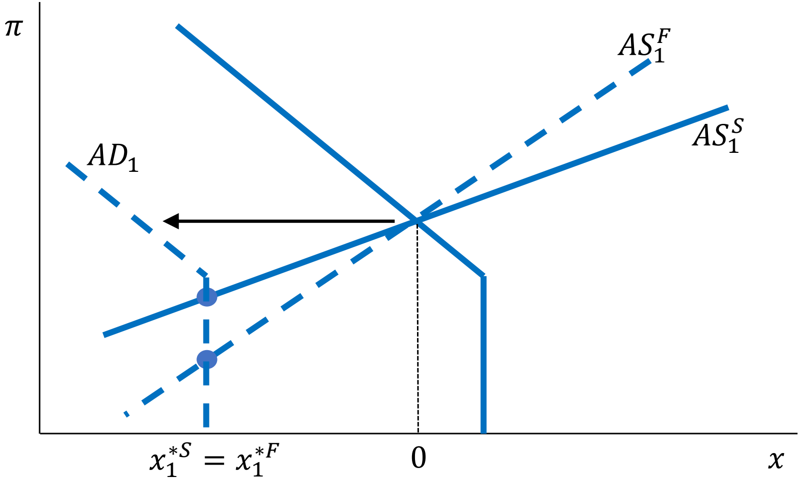
- Without QE: $\vartheta = 0$

$$\frac{d\left|(x_1^\star)_{\vartheta=0}\right|}{d\gamma} = 0 \quad \left(\frac{d\left|(x_1^\star)_{\vartheta=0}\right|}{d\phi} = 0\right)$$

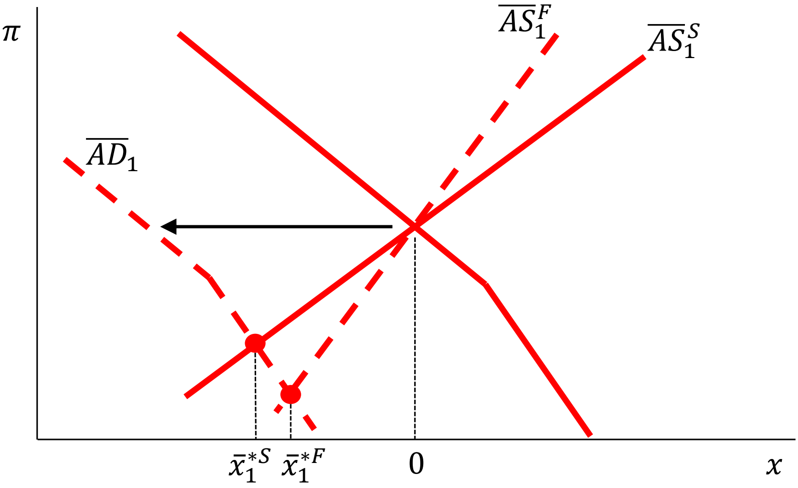
- With QE: $\vartheta > 0$

$$\frac{d\left|(x_1^\star)_{\vartheta>0}\right|}{d\gamma} < 0 \quad \left(\frac{d\left|(x_1^\star)_{\vartheta>0}\right|}{d\phi} > 0\right)$$

Greater Price Flexibility → No Impact on Output Gap



Greater Price Flexibility → Less Volatile Output Gap



Assumptions: Fiscal Paradoxes

1. (Shock): $r_1^n < 0$, $i_1 = -\frac{i}{1+i}$, $r_2^n = 0$
2. (Fiscal Policy): $(g_1, \tau_1) = (g_1, \tau_1)$, $(g_2, \tau_2) = (0, 0)$
3. (Nominal Rate Policy: SIT): $\pi_2 = 0$
4. (QE): $qe_1 = -\vartheta \pi_1$
5. (Perfect Foresight): $E_t x_{t+1} = x_{t+1}$, $E_t \pi_{t+1} = \pi_{t+1}$

Aggregate Demand (AD)

- Without QE: $\vartheta = 0$

$$x_1 = \frac{(1 - s_g)(1 - z)}{\sigma} \left(\frac{i}{1 + i} + r_1^n \right) + g_1$$

- With QE: $\vartheta > 0$

$$x_1 = \frac{(1 - s_g)(1 - z)}{\sigma} \left(\frac{i}{1 + i} + r_1^n \right) + g_1 - (1 - s_g) z \bar{b}^{cb} \vartheta \pi_1$$

Aggregate Supply (AS)

- Without QE: $\vartheta = 0$

$$\pi_1 = \left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)x_1 - \left(\frac{\gamma\sigma}{(1-s_g)(1-z)}\right)g_1 + \left(\frac{\gamma}{1-\tau}\right)\tau_1$$

- With QE: $\vartheta > 0$

$$\pi_1 = \left[\left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)x_1 - \left(\frac{\gamma\sigma}{(1-s_g)(1-z)}\right)g_1 + \left(\frac{\gamma}{1-\tau}\right)\tau_1\right] \Big/ \left[1 - \frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}\right]$$

Solutions

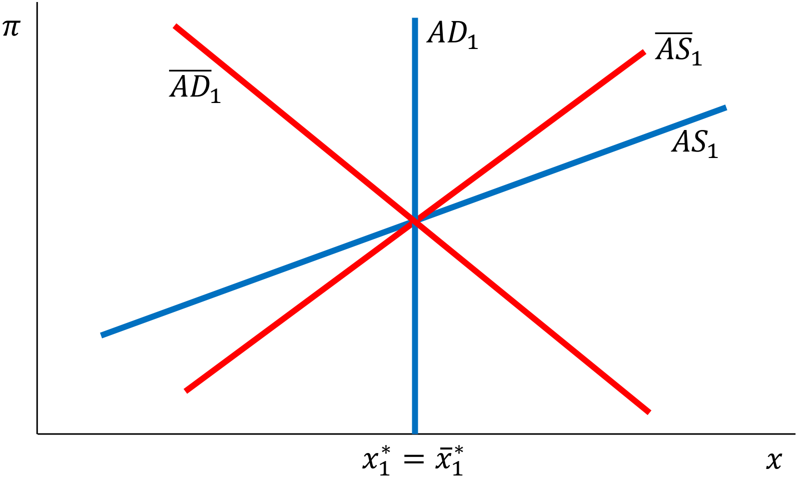
- Without QE: $\vartheta = 0$

$$(x_1^\star)_{\vartheta=0} = \frac{(1-s_g)(1-z)}{\sigma}\left(\frac{i}{1+i} + r_1^n\right) + g_1$$

- With QE: $\vartheta > 0$

$$(x_1^\star)_{\vartheta>0} = \left[\frac{(1-s_g)(1-z)}{\sigma}\left(\frac{i}{1+i} + r_1^n\right)\right.$$
$$+ \left\{1 + \left(\frac{(1-s_g)\,z\bar{b}^{cb}\vartheta}{1-\frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\frac{\gamma\sigma}{(1-s_g)(1-z)}\right)\right\} g_1$$
$$\left. - \left(\frac{(1-s_g)\,z\bar{b}^{cb}\vartheta}{1-\frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\frac{\gamma}{1-\tau}\right)\tau_1\right]$$
$$\Bigg/ \left[1 + \left(\frac{(1-s_g)\,z\bar{b}^{cb}\vartheta}{1-\frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)\right]$$

AD-AS Diagram: Adjusted Equilibrium at time 1



Large Government Spending Multipliers

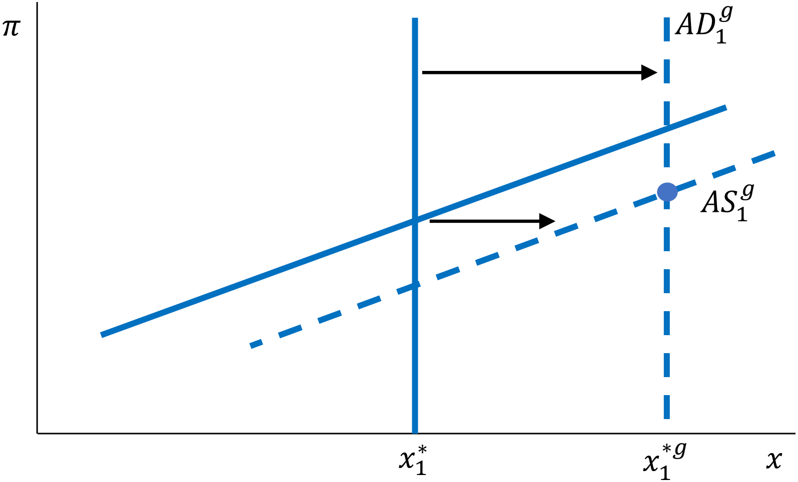
- Without QE: $\vartheta = 0$

$$\left(\frac{dx_1^\star}{dg_1}\right)_{\vartheta=0} = 1$$

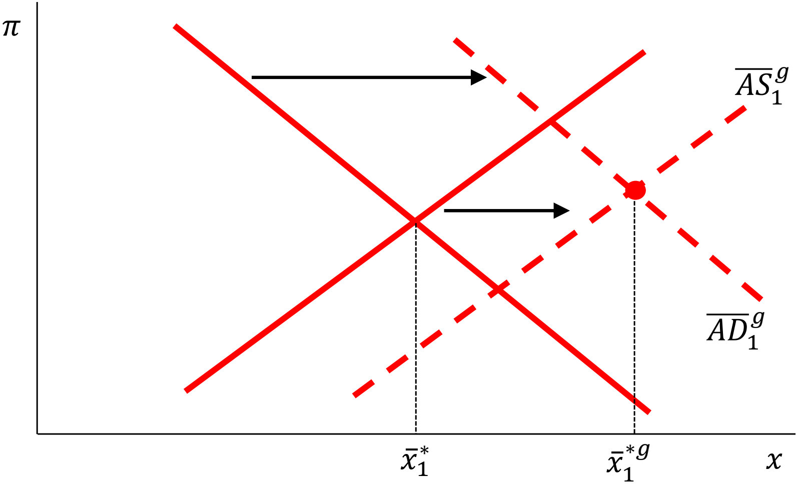
- With QE: $\vartheta > 0$

$$\left(\frac{dx_1^\star}{dg_1}\right)_{\vartheta>0} = \left[1 + \left(\frac{(1-s_g)\, z\bar{b}^{cb}\vartheta}{1 - \frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\frac{\gamma\sigma}{(1-s_g)(1-z)}\right)\right] \Big/ \left[1 + \left(\frac{(1-s_g)\, z\bar{b}^{cb}\vartheta}{1 - \frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\gamma\chi + \frac{\gamma\sigma}{(1-s_g)(1-z)}\right)\right] < 1$$

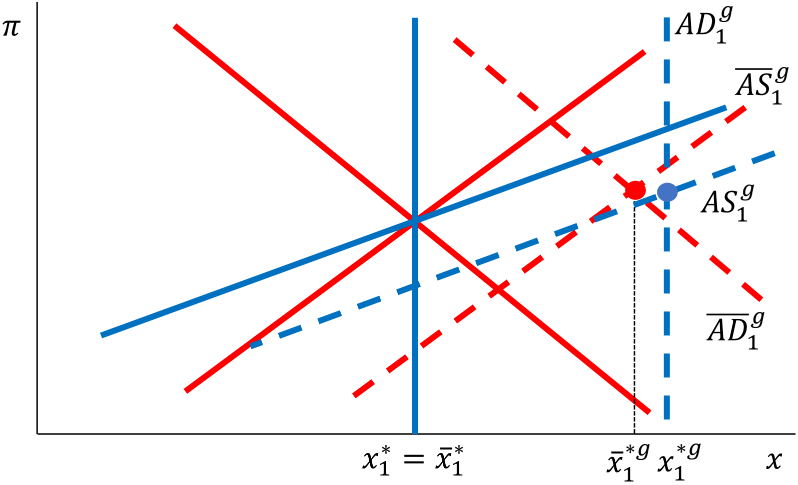
Increase in Govt. Spending: $AD_1 \rightarrow AD_1^g$ & $AS_1 \rightarrow AS_1^g$



Increase in Govt. Spending: $\overline{AD}_1 \rightarrow \overline{AD}_1^g$ & $\overline{AS}_1 \rightarrow \overline{AS}_1^g$



$\overline{x}_1^{*g}$ with QE $< x_1^{*g}$ without QE



The Paradox of Toil

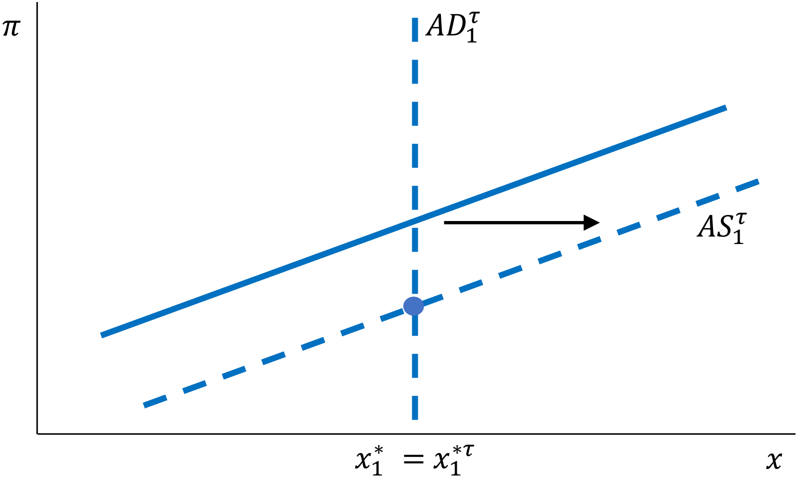
- Without QE: $\vartheta = 0$

$$\left(\frac{dx_1^\star}{d\tau_1}\right)_{\vartheta=0} = 0$$

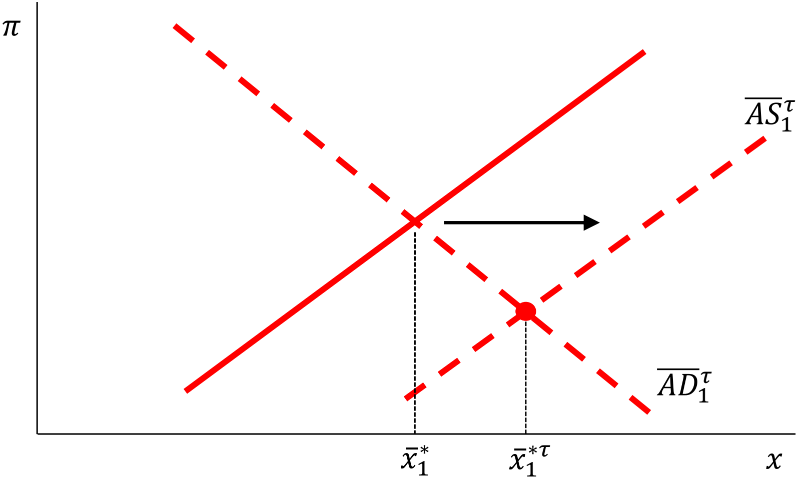
- With QE: $\vartheta > 0$

$$\left(\frac{dx_1^\star}{d\tau_1}\right)_{\vartheta>0} = -\left[\left(\frac{(1-s_g)\, z\bar{b}^{cb}\vartheta}{1-\frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\frac{\gamma}{1-\tau}\right)\right] \Big/ \left[1+\left(\frac{(1-s_g)\, z\bar{b}^{cb}\vartheta}{1-\frac{\gamma\sigma z\bar{b}^{cb}\vartheta}{1-z}}\right)\left(\gamma\chi+\frac{\gamma\sigma}{(1-s_g)\,(1-z)}\right)\right] < 0$$

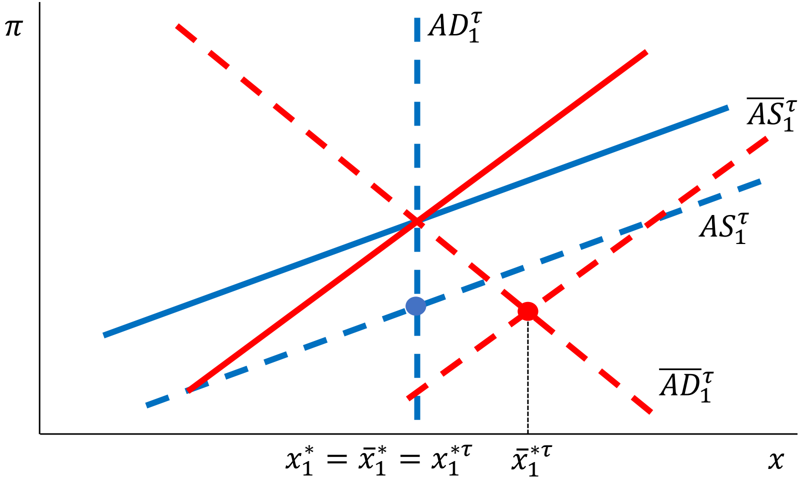
Labor Income Tax Cut: $AS_1 \rightarrow AS_1^{\tau}$



Labor Income Tax Cut: $\overline{AS}_1 \to \overline{AS}_1^{\tau}$



$\overline{x}_1^{*\tau}$ with QE $>$ $x_1^{*\tau}$ without QE



Outline

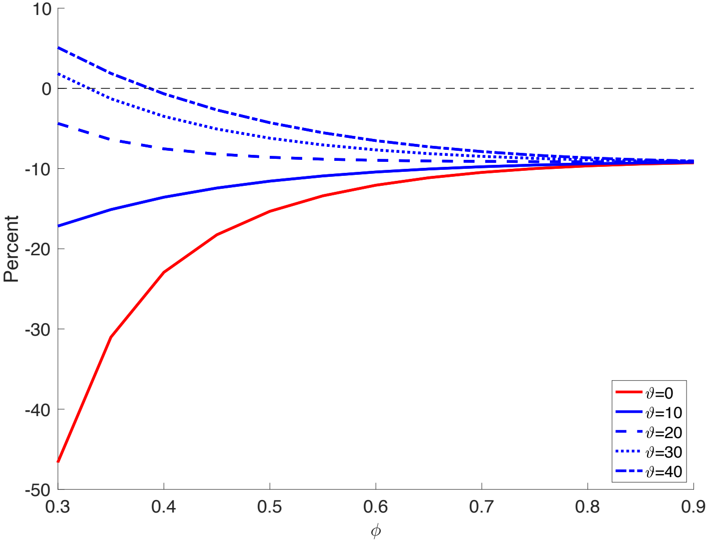
1. New Keynesian Model with QE
2. Analytical Results: Two-Period
3. **Numerical Results: Infinite-Horizon**
4. Conclusion

Numerical Results: Infinite-Horizon

Param.	Description	Value
β	Discount factor	0.997
z	Consumption share of child	0.33
σ	Risk aversion	1.032
χ	Inverse labor supply elasticity	1.7415
$\bar{b}^{cb}$	Weight on QE in IS/PC curves	0.3
ϵ	CES parameter	13.6012
ϕ	Probability of keeping price unchanged	0.75
s_g	SS government spending to output ratio	0.2
τ	SS labor income tax rate	0.1
	Without QE ($\vartheta = 0$)	
ρ_{rn}	ZLB bind for around 16 quarters	0.85
σ_{rnt}	10% output drop & 2.2% deflation	-0.0364

The Paradox of Flexibility

Impact Responses of Output Gap to Natural Rate Shocks (Shock Process Fixed)



Calculating Fiscal Multipliers

- Duration of ZLB = Duration of Fiscal Policy
- Government Spending

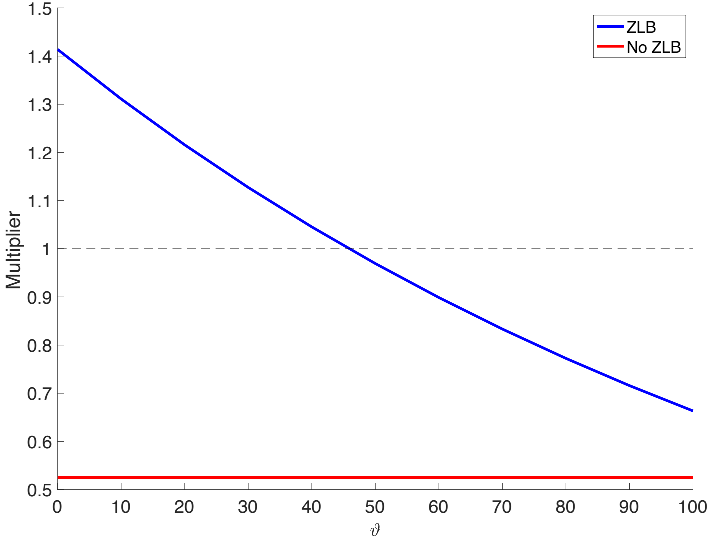
$$\frac{dx}{dg} = \frac{x(g > 0) - x(g = 0)}{g - 0}$$

- Labor Income Tax

$$\frac{dx}{d\tau} = \frac{x(\tau < 0) - x(\tau = 0)}{\tau - 0}$$

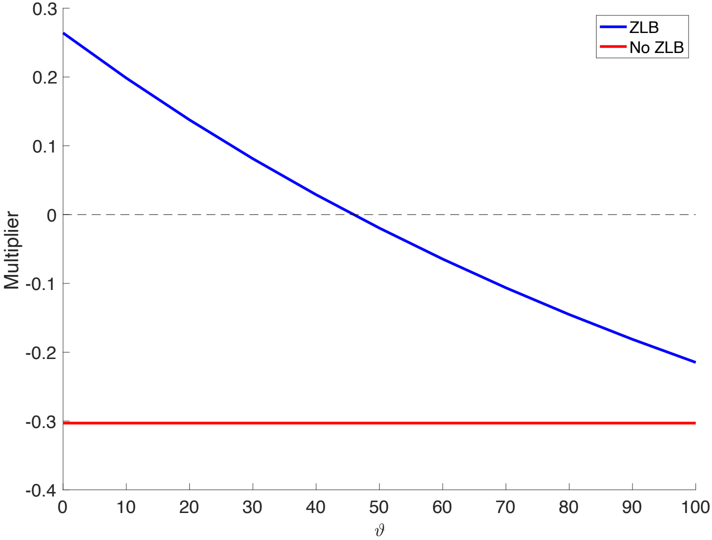
Large Government Spending Multipliers

Impact Government Spending Multipliers (Shock Process Adjusted: 2.2% Deflation)



The Paradox of Toil

Impact Labor Tax Multipliers (Shock Process Adjusted: 2.2% Deflation)



Outline

1. New Keynesian Model with QE
2. Analytical Results: Two-Period
3. Numerical Results: Infinite-Horizon
4. **Conclusion**

Conclusion

- QE aimed at stabilizing inflation resolves the NK policy paradoxes at the ZLB.
  - The paradox of flexibility
  - Large government spending multipliers
  - The paradox of toil
- The paradoxes are a failure of models to characterize monetary policy correctly.
- Monetary and fiscal policies should be executed very carefully in a liquidity trap.

Thank you very much for listening.