# Monetary Policy as a Financial Stabilizer

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Job Market Paper

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"One of the central and most widely shared ideas in the academic finance literature is the importance of time variation in the **risk premiums** (or expected returns) on a wide range of assets. At the same time, canonical macro models in the New Keynesian genre of the sort that are often used to inform monetary policy tend to exhibit little or no meaningful risk premium variation."

Jeremy Stein, Governor of the Federal Reserve System (2014)

"Monetary policy should not be **the first line of defense** - is not the first line of defense on **financial stability**. We look to more appropriate tools in the first instance, as a first line of defense. And those would be regulation, supervision, high-capital, high-liquidity stress testing, all of those things, macroprudential tools"

Jerome Powell, Chair of the Federal Reserve (2020)

**Big Question (Is it possible?)**

One monetary tool ($i_t$) $\Longrightarrow$ (i) inflation, (ii) output, and (iii) financial stability

1. To study a monetary policy's financial stability concern, turn our eyes to the first statement by Stein (2014) and reframe it into:

**Big Question (Is it possible?)**

One monetary tool ($i_t$) $\Longrightarrow$ (i) inflation, (ii) output, and (iii) risk-premium

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2. Open up a stock market where agents trade stocks in a standard New-Keynesian framework with questions:
   - Stock market fluctuations $\Longleftrightarrow$ business cycle: how?
   - $\exists$endogenous and time-varying risk-premium $\xrightarrow{\text{how?}}$ a change in monetary policy framework

1. Asset price level $\Longleftrightarrow$ aggregate output with nominal rigidity

2. Endogenous and time-varying financial volatility and risk-premium

   - Drive the stock market + business cycle fluctuations while determined by those fluctuations (hard problem)
   - Usually overlooked in a textbook macro model: why?
   - **Reason**: log-linearized $\Longrightarrow$ no price of risk ($\simeq$ risk-premium)

3. **Historic Example**: Great Crash and Great Depression Great Crash

**(Standard non-linear New-Keynesian model)**

1. **Show**: proper accounting of a price of risk $\Longrightarrow$ changes dynamics
   - **Conventional Taylor rules** $\Longrightarrow$ $\exists$new indeterminacy (aggregate volatility)
   - **Sunspot equilibria**: $\exists$sunspot arise in aggregate volatility: driving the business cycle

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**(Non-linear New-Keynesian model with a stock market + portfolio)**

2. **Build** a parsimonious New-Keynesian framework where:

Stock market volatility $\Longleftrightarrow$ risk-premium $\Longleftrightarrow$ wealth $\Longleftrightarrow$ aggregate demand (all endogenous and time-varying) Explain

   1. Asset price as endogenous shifter in aggregate demand (and vice-versa)
   2. **Stock market** + **portfolio decision** + **non-linearity** $\Longrightarrow$ time-varying risk-premium from the stock market volatility
      - **VAR analysis**: financial vs real volatility VAR analysis

3. **Conventional Taylor rules** $\Longrightarrow$ **Sunspot equilibria** (in stock market volatility): (endogenous) stock market volatility and risk-premium driven business cycle

4. **Risk-premium targeting** in a specific way $\Longrightarrow$ determinacy again

**Takeaway (Ultra-divine coincidence)**

One monetary tool ($i_t$) $\Longrightarrow$ (i) inflation, (ii) output, and (iii) risk-premium

- Generalization of the Taylor rule in a risk-centric environment with risk-premium
- Aggregate wealth management of the monetary policy

# What we do + findings

3. **Conventional Taylor rules** $\Longrightarrow$ **Sunspot equilibria** (in stock market volatility): (endogenous) stock market volatility and risk-premium driven business cycle

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5. **Zero lower bound (ZLB)** and **forward guidance** policy revisited
   - Bringing after-ZLB stability to ZLB episodes $\Longrightarrow$ mitigating recessionary pressures now (risk-premium$\downarrow$ and asset price$\uparrow$)
   - Two fiscal macroprudential policies during ZLB

**Remember**: no bubble $\Longrightarrow$ only fundamental asset pricing

- "leaning against the financial market" monetary policy

Bernanke and Gertler (2000), Galí (2021)

# Key previous works (only a few among many)

- Wealth (risk-intolerance), disruption (volatility), and macroeconomy

  Kiyotaki and Moore (1997), Gilchrist and Zakrajšek (2012), Brunnermeir and Sannikov (2014), Mian and Sufi (2014), Caballero and Farhi (2017), Guerrieri and Lacoviello (2017), Guerrieri and Lorenzoni (2017), Caballero and Simsek (2019, 2020), Di Tella and Hall (2020), Chodorow-Reich et al. (2021), Caballero et al. (2021)

**Our paper**: a monetary framework featuring financial wealth, aggregate financial volatility, and risk-premium (no financial friction)

- Monetary policy and financial (stock) market disruptions

  Bernanke and Gertler (2000), Nisticò (2012), Cúrdia and Woodford (2016), Cieslak and Vissing-Jorgensen (2020), Galí (2021)

**Our paper**: a monetary policy's financial targeting (level and volatility)

- Asset pricing and nominal rigidity

  Weber (2015), Gorodnichenko and Weber (2016), Campbell et al. (2020)

- Aggregate demand externality

  Farhi and Werning (2012, 2016, 2017), Korinek and Simsek (2016), Schmitt-Grohé and Uribe (2016)

- Time-varying risk-premium in the New-Keynesian model

  Laseen et al. (2015), Caramp and Silva (2021), Kekre and Lenel (2021)

- Indeterminacy with an idiosyncratic risk

  Acharya and Dogra (2020)

**Our paper**: New indeterminacy in aggregate volatility + new policy

# A non-linear textbook New-Keynesian model (demand block)

# A textbook New-Keynesian model with rigid price ($\pi_t = 0, \forall t$)

The representative household's problem (given $B_0$):

$$\max_{\{B_t, C_t, L_t\}_{t\geq 0}} \mathbb{E}_0 \int_0^\infty e^{-\rho t} \left[\log C_t - V(L_t)\right] dt \;\; \text{s.t.} \;\; \dot{B}_t = i_t B_t - \bar{p} C_t + w_t L_t + D_t$$

where

- $B_t$: nominal bond holding
- $D_t$ includes fiscal transfer + profits of the intermediate sector
- Rigid price: $p_t = \bar{p}$ for $\forall t$ (demand-determined)

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1. A non-linear Euler equation (in contrast to textbook log-linearized one)

Endogenous volatility

$$\mathbb{E}_t \left( \frac{dC_t}{C_t} \right) = (i_t - \rho) dt + \mathrm{Var}_t \left( \frac{dC_t}{C_t} \right)$$

Endogenous drift

2. (Aggregate) business cycle volatility↑ ⇒ precautionary saving↑ ⇒ recession now (thus the drift↑)

**Problem**: both **variance** and **drift** are endogenous, is monetary policy $i_t$ (Taylor rule) enough for stabilization?

With

$$\hat{Y}_t = \ln \frac{Y_t}{Y_t^n}, \quad \underbrace{\left( \sigma_t \right)^2 dt = \mathrm{Var}_t \left( \frac{dY_t^n}{Y_t^n} \right)}_{\text{Benchmark volatility}}, \quad \underbrace{\left( \sigma_t + \sigma_t^s \right)^2 dt = \mathrm{Var}_t \left( \frac{dY_t}{Y_t} \right)}_{\text{Actual volatility}}$$

Exogenous

Endogenous

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Exogenous

Endogenous

**A non-linear IS equation** (in contrast to textbook linearized one)

$$d\hat{Y}_t = \left[ i_t - \underbrace{\left( r_t^n \overbrace{- \frac{1}{2}(\sigma_t + \sigma_t^s)^2 + \frac{1}{2}(\sigma_t)^2}^{\text{New terms}} \right)}_{\equiv r_t^T} \right] dt + \sigma_t^s \, dZ_t \qquad (1)$$

- What is $r_t^T$?: a risk-adjusted natural rate of interest ($\sigma_t^s \uparrow \Longrightarrow r_t^T \downarrow$)

$$r_t^T \equiv r_t^n - \frac{1}{2}(\sigma_t + \sigma_t^s)^2 + \frac{1}{2}(\sigma_t)^2$$

# A textbook New-Keynesian model with rigid price ($\pi_t = 0, \forall t$)

**Big Question**: Taylor rule $\underline{i_t = r_t^n + \phi_y \hat{Y}_t \text{ for } \phi_y > 0}$ $\Rightarrow$ **full stabilization**?

- $\phi_y > 0$: Taylor principle (no sunspot in the first-order economy) $\Rightarrow \hat{Y}_t = 0$

- What about the global economy?

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- What about the global economy?

**Proposition (Fundamental Indeterminacy)**

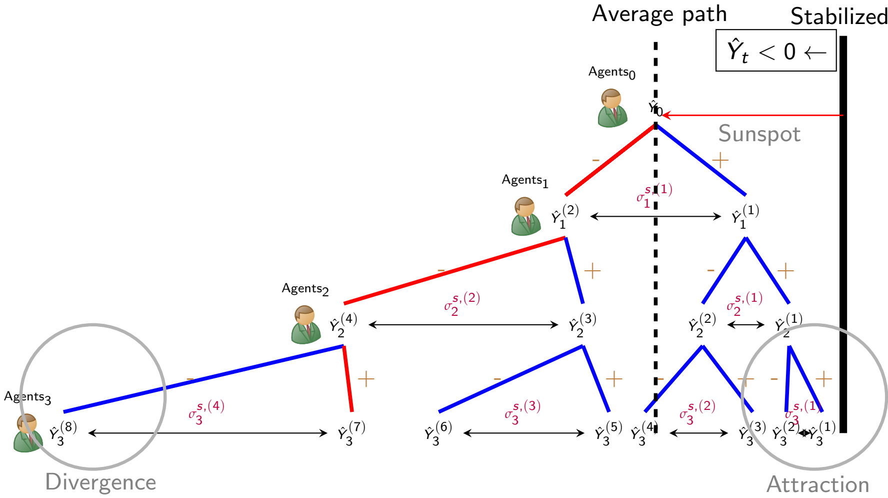
For any $\phi_y > 0$:

$\exists$a rational expectations equilibrium that supports a sunspot $\sigma_0^s > 0$ satisfying:

1. $\mathbb{E}_t\left(\hat{Y}_s\right) = \hat{Y}_t$ for $\forall s > t$ (martingale)
2. $\sigma_t^s \overset{a.s}{\to} \sigma_\infty^s = 0$ and $\hat{Y}_t \overset{a.s}{\to} 0$ (almost sure stabilization)
3. $\mathbb{E}_0(\max_{t\geq 0}(\sigma_t^s)^2) = \infty$ ($0^+$-possibility divergence)

Aggregate volatility$\uparrow$ possible through the intertemporal coordination of agents

**Key**: construct a path-dependent intertemporal consumption (demand) strategy




- Stabilized as **attractor**: $\sigma_t^s \xrightarrow{a.s} \sigma_\infty^s = 0$ and $\hat{Y}_t \xrightarrow{a.s} 0$ **but** $\mathbb{E}_0(\max_{t \geq 0}(\sigma_t^s)^2) = \infty$

# A textbook New-Keynesian model with rigid price ($\pi_t = 0, \forall t$)

1. An endogenous aggregate risk arises and drives the business cycle.

2. Sunspots in $\{\sigma_t^s\}$ act similarly to **animal spirit**?

3. New monetary policy

$$i_t = r_t^n + \phi_y \hat{Y}_t - \boxed{\frac{1}{2}\left((\sigma_t + \sigma_t^s)^2 - (\sigma_t)^2\right)}$$

Aggregate volatility targeting?
Animal spirit targeting?

- Restores a **determinacy** and **stabilization**, but what does it mean?

**Next**: open the stock market, and relate these terms to the **risk-premium**

# The model with a stock market + portfolio decision

**Standard demand-determined environment**

$\sigma_t^s \uparrow \implies$ precautionary saving$\uparrow \implies$ consumption (output)$\downarrow$

We can build a **theoretical framework with explicit stock markets** where

Financial volatility$\uparrow \implies$ risk-premium$\uparrow \implies$ wealth$\downarrow \implies$ output$\downarrow$

- Wealth-dependent aggregate demand
- Now, sticky price so $\underline{\pi_t \neq 0}$: Phillips curve à la Calvo (1983)

Skip the detail

Identical **capitalists** and **hand-to-mouth workers** (Two types of agents)

- **Capitalists**: consumption - portfolio decision (between stock and bond)
- **Workers**: supply labors to firms (hand-to-mouth)

Fundamental risk (Exogenous)

1. **Technology**

$$\frac{dA_t}{A_t} = \underbrace{g}_{\text{Growth}} \cdot dt + \sigma_t \cdot \underbrace{dZ_t}_{\text{Aggregate shock}}$$

2. **Hand-to-mouth workers**: supply labors + solves the following problem

$$\max_{C_t^w, N_t^w} \frac{\left(\frac{C_t^w}{A_t}\right)^{1-\varphi}}{1-\varphi} - \frac{(N_t^w)^{1+\chi_0}}{1+\chi_0} \quad \text{s.t.} \quad p_t C_t^w = w_t N_t^w$$

- Hand-to-mouth assumption can be relaxed, without changing implications

3. **Firms**: production using labors + pricing à la Calvo (1983)
4. **Financial market**: zero net-supplied risk-free bond + stock (index) market

**Capitalists**: standard portfolio and consumption decisions (very simple)

1. Total financial wealth $a_t = p_t A_t Q_t$, where (real) stock price $Q_t$ follows:

$$\frac{dQ_t}{Q_t} = \mu_t^q \cdot dt + \sigma_t^q \cdot dZ_t$$

Financial risk (Endogenous)

- $\mu_t^q$ and $\sigma_t^q$ are both endogenous (to be determined)

2. Each solves the following optimization (standard)

$$\max_{C_t, \theta_t} \mathbb{E}_0 \int_0^\infty e^{-\rho t} \log C_t dt \quad \text{s.t.}$$

$$da_t = (a_t(i_t + \theta_t(i_t^m - i_t)) - p_t C_t)dt + \theta_t a_t(\sigma_t + \sigma_t^q)dZ_t$$

- Aggregate consumption of capitalists $\propto$ aggregate financial wealth

$$C_t = \rho A_t Q_t$$

- Equilibrium **risk-premium** is determined by the total risk

$$i_t^m - i_t \equiv \text{rp}_t = \boxed{(\sigma_t + \sigma_t^q)^2}$$

# Other equilibrium conditions

**Dividend yield**: dividend yield$=\rho$, as in Caballero and Simsek (2020)

- A positive feedback loop between asset price $\Longleftrightarrow$ dividend (output)

**Determination of nominal stock return $d\mathbf{I}_t^m$**

$$d\mathbf{I}_t^m = \underbrace{[\underbrace{\rho}_{\text{Dividend yield}} + \underbrace{\underbrace{\pi_t}_{\text{Inflation}} + g + \mu_t^q + \overbrace{\sigma_t \sigma_t^q}^{\text{Covariance}}}_{\text{Capital gain}}]}_{= \underbrace{i_t^m}_{\text{Drift}} = \underbrace{i_t}_{\text{Monetary policy}} + \underbrace{(\sigma_t + \sigma_t^q)^2}_{\text{Risk-premium}}} dt + \underbrace{(\sigma_t + \sigma_t^q)}_{\text{Risk term}} dZ_t$$

- Close the model with supply-side (Phillips curve) and $\{i_t\}$ rule

**Flexible price economy** allocations (benchmark)

- $\sigma_t^{q,n} = 0$, $Q_t^n$, $N_t^{w,n}$, $C_t^n$, $r_t^n$ (natural rate), $\text{rp}_t^n$ (natural risk-premium)

**Gap economy** (log deviation from the flexible price economy)

- With asset price gap $\hat{Q}_t \equiv \ln \frac{Q_t}{Q_t^n} = \hat{C}_t$ and $\pi_t$

**Proposition (Dynamic IS)**

A dynamic gap economy can be described with the following equations.

1. $\mathbb{E}_t d\pi_t = (\rho\pi_t - \kappa\hat{Q}_t)dt$ with $\kappa > 0$
2. $d\hat{Q}_t = (i_t - \pi_t - \boxed{r_t^T})dt + \sigma_t^q\, dZ_t$ where $r_t^T = r_t^n - \frac{1}{2}(\text{rp}_t - \text{rp}_t^n)$

$$\equiv r_t^n - \frac{1}{2}\hat{\text{rp}}_t$$

where $\text{rp}_t = (\sigma_t + \sigma_t^q)^2$ and $\text{rp}_t^n = (\sigma_t)^2 \Longrightarrow \hat{\text{rp}}_t \equiv \text{rp}_t - \text{rp}_t^n$

Now, with asset (stock) price gap $\hat{Q}_t$:

Real volatility

$$d\hat{Q}_t = \left( i_t - \pi_t - \underbrace{\left( r_t^n - \frac{1}{2}\boxed{(\underbrace{\sigma_t + \sigma_t^q}_{\mathrm{rp}_t})^2} + \frac{1}{2}\boxed{(\underbrace{\sigma_t}_{\mathrm{rp}_t^n})^2} \right)}_{\equiv r_t^T} \right) dt + \sigma_t^q \, dZ_t \qquad (2)$$

**Here**

$$\sigma_t^q \uparrow \implies \mathrm{rp}_t \uparrow \implies \hat{Q}_t \downarrow \implies \hat{Y}_t \downarrow$$ More intuitions

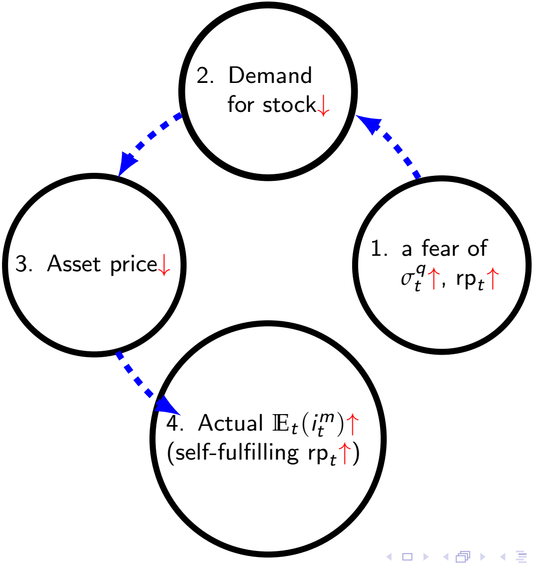
**Monetary policy**: Taylor rule to Bernanke and Gertler (2000) rule

$$i_t = r_t^n + \phi_\pi \pi_t + \phi_y \underbrace{\hat{y}_t}_{=\zeta \hat{Q}_t}$$

$$= r_t^n + \phi_\pi \pi_t + \phi_q \hat{Q}_t, \quad \text{where} \quad \underbrace{\phi \equiv \phi_q + \frac{\kappa(\phi_\pi - 1)}{\rho} > 0}_{\text{Taylor principle}}$$

**Multiple equilibria** (risk-premium sunspot)

- **How?**: countercyclical risk-premium with conventional Taylor rules



# Is a sunspot $\sigma_0^q \neq 0$ supported by a rational expectations equilibrium? : with Bernanke and Gertler (2000) rule

Assume $\underline{\sigma_0^q > 0}$ for some reason (initial disruption)

- The same **martingale equilibrium** ▶▶ Mathematical explanation ▶▶ Tree diagram

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Assume $\underline{\sigma_0^q > 0}$ for some reason (initial disruption)

- The same **martingale equilibrium** ▸▸ Mathematical explanation ▸▸ Tree diagram

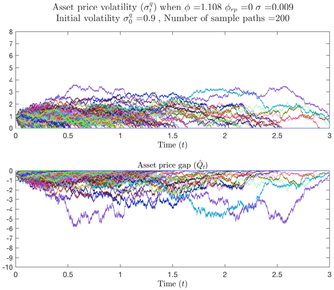
**Proposition (Fundamental Indeterminacy)**

For any $\phi > 0$:

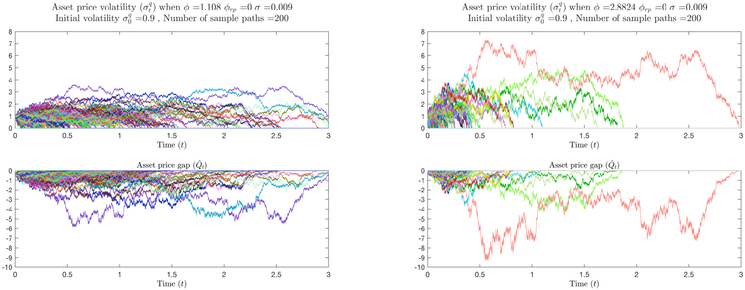
$\exists$a rational expectations equilibrium that supports a sunspot $\sigma_0^q > 0$ satisfying:

1. $\sigma_t^q \overset{a.s}{\to} \sigma_\infty^q = 0$, $\hat{Q}_t \overset{a.s}{\to} 0$, and $\pi_t \overset{a.s}{\to} 0$ (almost sure stabilization)
2. $\mathbb{E}_0(\max_{t \geq 0}(\sigma_t^q)^2) = \infty$ ($0^+$-possibility divergence)

1. (Almost surely) stabilized in the long run after sunspot $\sigma_0^q > 0$
   Meantime: **crisis** with financial volatility (risk-premium)$\uparrow$, asset price$\downarrow$, and business cycle$\downarrow$
2. $\mathbb{E}_0(\max_t(\sigma_t^q)^2) = \infty$: an $\epsilon \to 0$ possibility of $\infty$-severity crisis ($\sigma_t^q \to \infty$)
   - $\exists$big crisis that supports $\sigma_0^q > 0$ (Martin (2012) in pure asset pricing contexts)




(a) With $\phi_\pi = 1.5$

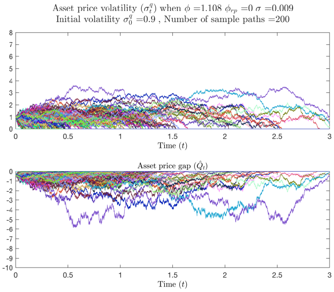



(a) With $\phi_\pi = 1.5$

(b) With $\phi_\pi = 2.5$.

Figure: $\{\sigma_t^q, \hat{Q}_t\}$ dynamics when $\sigma^{q,n} = 0$ and $\sigma_0^q = 0.9$, with reasonable calibration

- As monetary policy responsiveness $\phi\uparrow$
  Stabilization speed$\uparrow$, $\exists$more severe crisis sample path
- $\sigma_t^q\uparrow$ by $\sigma \implies 2 - 10\%\downarrow$ in $Q_t$ (depending on monetary responsiveness)

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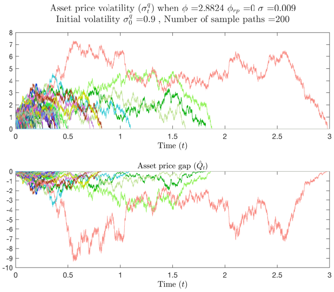


(b) With $\phi_\pi = 2.5$.

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**Opposite case**: with initial sunspot $\sigma_0^q < 0$

- Explains **boom** phase

  Financial volatility (risk-premium)$\downarrow$, asset price$\uparrow$ and business cycle$\uparrow$

**New monetary policy** $\Longrightarrow$ financial + macro stabilities $\hat{Q}_t = \pi_t = \hat{rp}_t = 0$

$$i_t = r_t^n + \phi_\pi \pi_t + \phi_q \hat{Q}_t - \overbrace{\frac{1}{2}\hat{rp}_t}^{\text{New targeting}}, \quad \text{where} \quad \underbrace{\phi \equiv \phi_q + \frac{\kappa(\phi_\pi - 1)}{\rho} > 0}_{\text{Taylor principle}}$$

Sharp

restores a determinacy with:

**Takeaway (Ultra-divine coincidence)**

One monetary tool ($i_t$) $\Longrightarrow$ (i) inflation, (ii) output, and (iii) risk-premium

Sharpness

**Leading to**:

$$\boxed{\underbrace{i_t + \mathrm{rp}_t}_{=i_t^m} - \overset{\text{Ito term}}{\frac{1}{2}\mathrm{rp}_t}} = \boxed{\underbrace{r_t^n + \mathrm{rp}_t^n}_{=i_t^{m,n}} - \overset{\text{Ito term}}{\frac{1}{2}\mathrm{rp}_t^n}} + \underbrace{\phi_\pi \pi_t + \phi_q \hat{Q}_t}_{\text{Business cycle targeting}}$$

$$\rho + \frac{\mathbb{E}_t(d\log a_t)}{dt} \qquad\qquad \rho + \frac{\mathbb{E}_t(d\log a_t^n)}{dt}$$

- $i_t^m$, not $i_t$, follows a Taylor rule?
- A rate of change of log-wealth follows a Taylor rule both in standard model (without risk-premium) and our framework (with risk-premium)

# Zero Lower Bound (ZLB) ▸▸ Setting

1. ZLB path (full stabilization after $T$)

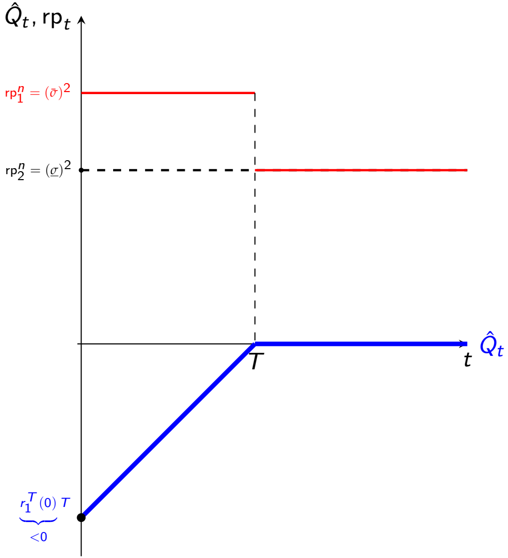



Figure: ZLB dynamics (Benchmark)

2. Traditional forward guidance (keep $\underline{i_t = 0}$ until $\hat{T} > T$)

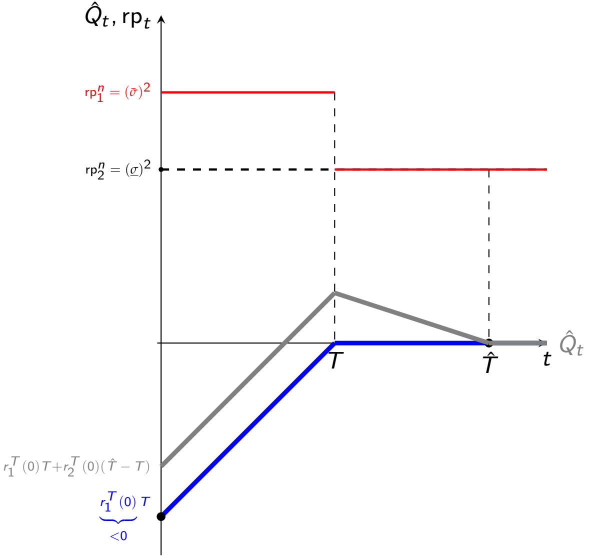



Figure: ZLB dynamics with forward guidance until $\hat{T} > T$

3. Central bank picks $\{\sigma_t^q\}$ and $\{\mathrm{rp}_t\}$ ⏩ Setting

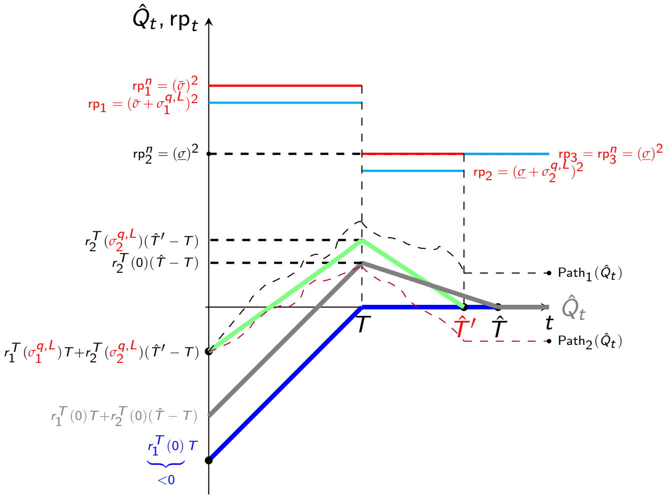



Figure: A commitment path of $\{\hat{Q}_t\}$ with $\sigma_1^{q,L} < \sigma_1^{q,n}$, $\sigma_2^{q,L} < \sigma_2^{q,n}$, and $\hat{T}' < \hat{T}$

⏩ Proposition

**Our framework**: Ricardian $\iff$ no quantity effect

Thus, the above commitment path $\neq$ quantity side of LSAPs (topic for Lee and Carreras (2021))

**Other macroprudential policies at the ZLB**:

1. Fiscal subsidy for the stock market investment ▶▶ Detail
2. Fiscal redistribution toward workers ▶▶ Detail

both of which: $\hat{Q}_t\uparrow$ and $\pi_t\uparrow$ during ZLB

# Conclusion

1. Stock (financial) market $\Longleftrightarrow$ monetary policy $\Longleftrightarrow$ business cycle

$$\begin{tikzcd}
 & \textbf{Monetary policy} \arrow[dl] \arrow[dr] & \\
\text{Stock market} \arrow[rr, leftrightarrow, "\text{time-varying } \mathrm{rp}_t", "\text{endogenous and time-varying } \sigma_t^q"'] & & \text{Business cycle}
\end{tikzcd}$$

2. New source of variation in the New-Keynesian framework: endogenous asset price volatility and risk-premium
    - Second-order **equilibrium indeterminacy** (endogenous arise of aggregate volatility)
    - **New monetary policy**

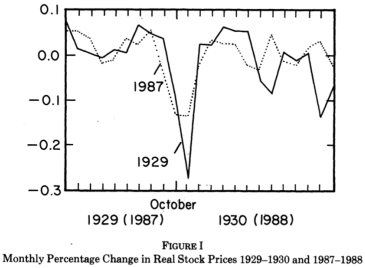
**Takeaway (Ultra-divine coincidence)**

One monetary tool ($i_t$) $\Longrightarrow$ (i) inflation, (ii) output, and (iii) risk-premium

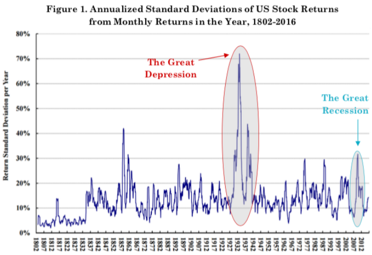
- Construction of the risk (or risk-premium) driven business cycle
- Generalization of the Taylor rule in a risky environment with risk-premium
- Many possible directions to go (will pursue after the job market)

Thank you very much!
(Appendix)

Go back




(a) Romer (1990)



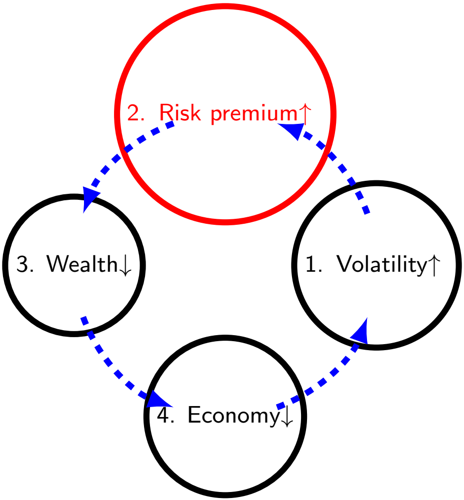

(b) Cortes and Weidenmier (2019)

Figure: Great Crash (1929)

Huge drop in the stock market level and spike in the sample stock return volatility during the Great Crash (1929)

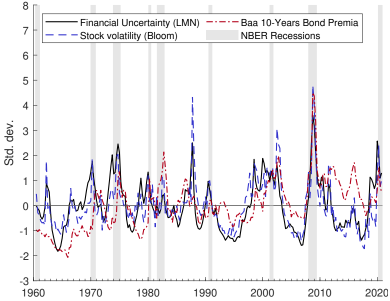
- Simultaneous drops in business cycle levels (e.g., real wage, employment), and the stock price

Go back




- **1** → **2** comes from "non-linearity (not linearizing)"
- **2** → **3** comes from "portfolio decision" of each investor and externality
- **3** → **4** comes from the fact wealth drives aggregate demand
- **4** → **1** where business cycle has its own volatility (self-sustaining)

▶▶ Go back




(a) Financial Uncertainty series    (b) Financial vs. Real Uncertainty

Figure: Common measures of the financial volatility (left) and real vs. financial uncertainty decomposed by Ludvigson et al. (2015) (right)

The correlation between series is remarkably high and they all display positive spikes at the beginning and/or initial months following NBER-dated recessions

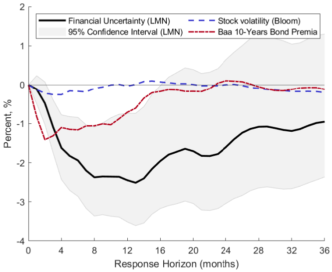
- Many of past recessions are, in nature, financial

In a similar manner to Bloom (2009), Ludvigson et al. (2015):

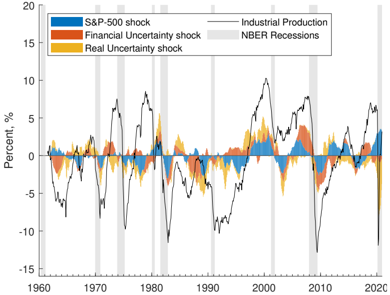
$$\text{VAR-11 order:} \quad \begin{bmatrix} \log(\text{Industrial Production}) \\ \log(\text{Employment}) \\ \log(\text{Real Consumption}) \\ \log(\text{CPI}) \\ \log(\text{Wages}) \\ \text{Hours} \\ \text{Real Uncertainty (LMN)} \\ \text{Fed Funds Rate} \\ \log(\text{M2}) \\ \log(\text{S\&P-500 Index}) \\ \text{Financial Uncertainty (LMN)} \end{bmatrix} \tag{3}$$

Financial uncertainty (LMN) is also replaced by the stock price volatility (following Bloom (2009)) and Baa 10-years bond premia

# Vector Autoregression (VAR) analysis




(a) Response: Industrial Production

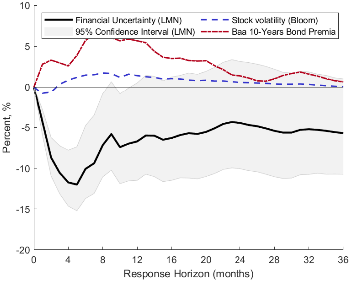



(b) Industrial Production

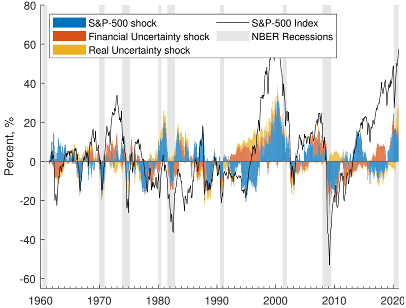
Figure: Impulse-response of IP to one std.dev shock in financial uncertainty measures (left) and the historical decomposition of IP to various attributes (right)

1. IP falls by 2.5% after one st.dev spike in the Ludvigson et al. (2015) financial uncertainty measure
   - Financial uncertainty has been important in driving IP boom-bust patterns
2. Other graphs: IRF and historical decomposition of S&P 500 S&P500, and FFR (monetary policy) FFR, FEVD FEVD

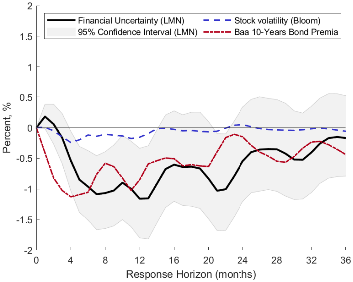
 Go back



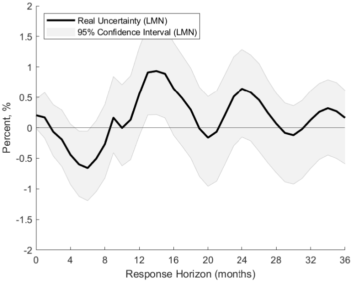

(a) Response: S&P-500 Index




(b) S&P-500 Index




(a) Shock: Financial Uncertainty




(b) Shock: Real Uncertainty

With 3 different financial uncertainty measures: Ludvigson et al. (2015), Bloom (2009), Baa 10-years bond premia (left)

(i) Industrial Production

| Horizon | Fin. Uncert. (LMN) | Real Uncert. (LMN) | Stock Vol. (Bloom) | Baa 10-Yr Premia |
|---|---|---|---|---|
| h=1 | 0 | 0.30 | 0.21 | 0.12 |
| h=6 | 1.27 | 3.37 | 2.98 | 1.36 |
| h=12 | 4.28 | 4.38 | 3.16 | 1.94 |
| h=36 | 3.24 | 1.67 | 1.98 | 0.64 |

(ii) S&P-500 Index

| Horizon | Fin. Uncert. (LMN) | Real Uncert. (LMN) | Stock Vol. (Bloom) | Baa 10-Yr Premia |
|---|---|---|---|---|
| h=1 | 0.11 | 0.08 | 0.39 | 0.06 |
| h=6 | 3.30 | 0.25 | 3.26 | 0.62 |
| h=12 | 4.77 | 0.54 | 10.03 | 2.16 |
| h=36 | 6.50 | 0.91 | 12.16 | 2.40 |

(iii) Fed Funds Rate

| Horizon | Fin. Uncert. (LMN) | Real Uncert. (LMN) | Stock Vol. (Bloom) | Baa 10-Yr Premia |
|---|---|---|---|---|
| h=1 | 0.01 | 0.98 | 0 | 0.08 |
| h=6 | 0.42 | 0.84 | 3.11 | 1.66 |
| h=12 | 1.47 | 0.91 | 4.69 | 2.30 |
| h=36 | 2.81 | 2.05 | 5.02 | 3.17 |

Financial uncertainty shocks explain close to 5% of the fluctuations in both IP and S&P-500 series, while real uncertainty explains an additional 2-4% of movements in industrial activity in the medium run

Go back

1. Capitalists bear $(\sigma_t + \sigma_t^q)$ amount of risks when investing in stock market
   - Risk-premium $\text{rp}_t = (\sigma_t + \sigma_t^q)^2$
   - Natural risk-premium (in the flexible price economy) $\text{rp}_t^n = (\sigma_t + \underbrace{\sigma_t^{q,n}}_{=0})^2$

2. If a real return on stock investment is different from its natural level (return of stock investment in the flexible price economy), then $\hat{Q}_t$ jumps

$r_t^T$: a real risk-free rate that makes:

**Stock market's real return (with risk-premium $\text{rp}_t$) = natural economy's**

$$\left(\underbrace{r_t^T}_{\substack{\text{Risk-free rate yielding}\\ \text{equal return on stock}}} + \text{rp}_t\right) - \frac{1}{2}\text{rp}_t = \left(\underbrace{r_t^n}_{\text{Natural rate}} + \text{rp}_t^n\right) - \frac{1}{2}\text{rp}_t^n$$

Ito term

Ito term

# Is a sunspot $\sigma_0^q \neq \sigma^{q,n}$ supported by a rational equilibrium? : with Bernanke-Gertler (2000) rule

Go back

Assume $\underline{\sigma_0^q > \sigma^{q,n} = 0}$ for some reason (initial disruption)

Blanchard and Kahn (1980) does not apply: we construct a rational expectations equilibrium (REE: not diverging on average) supporting an initial sunspot $\sigma_0^q$

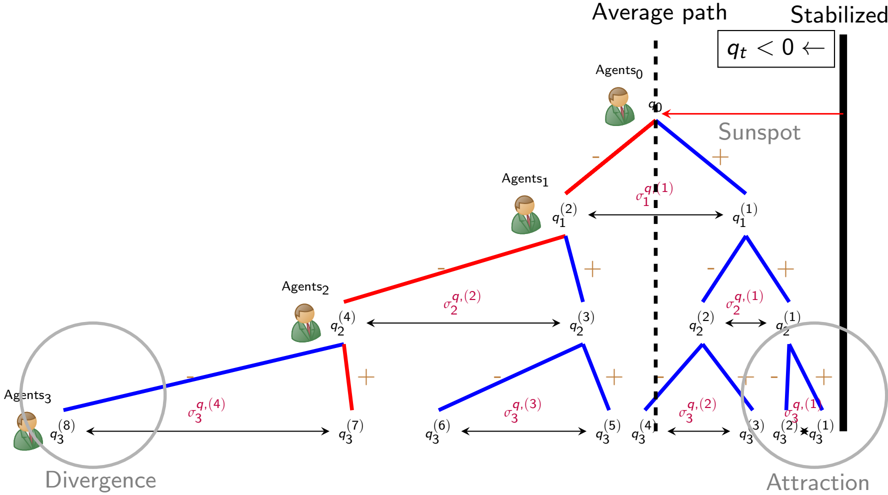
$$\begin{aligned} d\hat{Q}_t &= \left(i_t - \pi_t - \left(r_t^n - \frac{1}{2}(\mathrm{rp}_t - \mathrm{rp}_t^n)\right)\right)dt + \sigma_t^q dZ_t \\ &= \underbrace{\left((\phi_\pi - 1)\pi_t + \phi_q \hat{Q}_t + \frac{1}{2}(\mathrm{rp}_t - \mathrm{rp}_t^n)\right)}_{=0, \quad \forall t} dt + \sigma_t^q dZ_t \end{aligned}$$

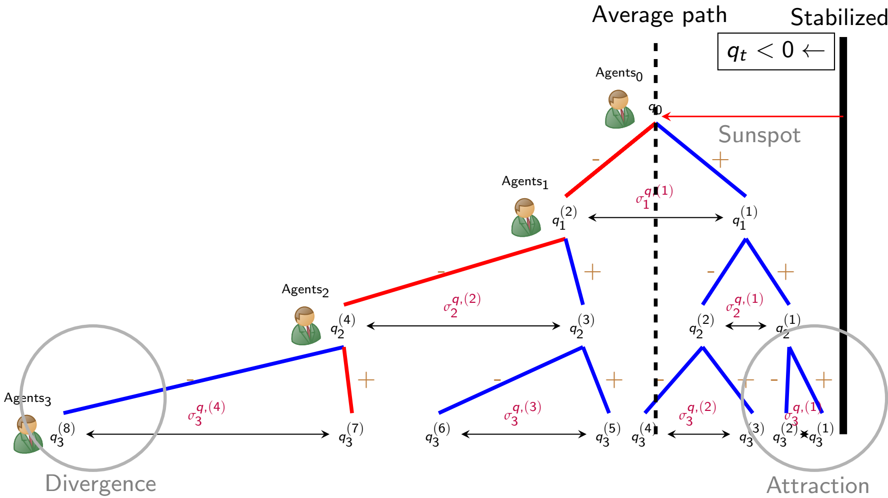
- Called the 'martingale equilibrium': supporting an initial sunspot in financial volatility $\sigma_0^q$
- $\{\sigma_t^q\}$ has its own (endogenous) stochastic process, given initial $\sigma_0^q \neq 0$

$$d\sigma_t^q = -\frac{\phi^2(\sigma_t^q)^2}{2(\sigma_t + \sigma_t^q)^3}dt - \phi\frac{\sigma_t^q}{\sigma_t + \sigma_t^q}dZ_t$$

Go back

Again, the same structure






Asset price $\{q_t\}$ and conditional stock price volatility $\{\sigma_t^q\}$ are stochastic

- Rational expectations equilibrium (REE): no divergence on expectation
- As $q_t$ approaches the stabilized path, then $\sigma_t^q \downarrow$, and more likely stays there: convergence ($\sigma_t^q \overset{a.s}{\to} \sigma_\infty^q = \sigma^{q.n}$)
- But in the worst scenario $\sigma_t^q$ diverges (with $0^+$-probability)

# Sharpness of policy rules

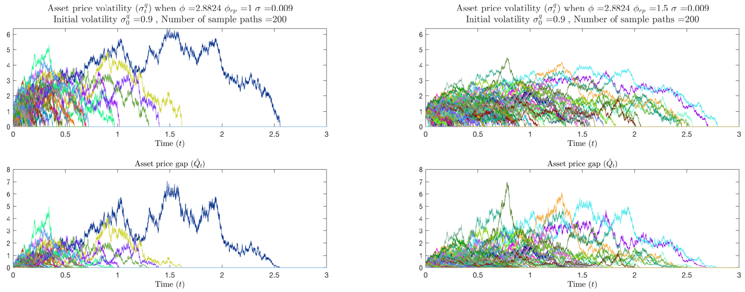
Go back

What if central bank uses the following alternative rule, where $\phi_{\text{rp}} \neq \frac{1}{2}$?

$$i_t = r_t^n + \phi_\pi \pi_t + \phi_q \hat{Q}_t - \boxed{\phi_{\text{rp}}} \hat{rp}_t, \quad \text{where} \quad \phi \equiv \phi_q + \frac{\kappa(\phi_\pi - 1)}{\rho} > 0$$

- Then still $\exists$martingale equilibrium supporting sunspot $\sigma_0^q \neq 0$
- As $|\phi_{\text{rp}} - \frac{1}{2}| \uparrow \implies$ (on average) longer time for $\sigma_t^q$ to vanish
- Especially, $\phi_{\text{rp}} < 0$ (**Real Bills Doctrine**) is a bad idea Summary Simulation

<table>
<tr><td>$\phi_{\mathbf{rp}} < 0$ (Real Bills Doctrine)</td><td>$0 < \phi_{\mathbf{rp}} < \frac{1}{2}$</td></tr>
<tr><td>(i) With $\phi_{rp} \downarrow$, convergence speed$\downarrow$ and less amplified paths<br><br>(ii) $\sigma_t^q > \sigma_t^{q,n} = 0$ means a crisis ($\hat{Q}_t < 0$ and $\pi_t < 0$)</td><td>(i) With $\phi_{rp} \uparrow$, convergence speed$\uparrow$ and more amplified paths<br><br>(ii) $\sigma_t^q > \sigma_t^{q,n} = 0$ means a crisis ($\hat{Q}_t < 0$ and $\pi_t < 0$)</td></tr>
<tr><td>$\phi_{\mathbf{rp}} = \frac{1}{2}$</td><td>$\phi_{\mathbf{rp}} > \frac{1}{2}$</td></tr>
<tr><td>No sunspot<br>(divine coincidence)</td><td>(i) With $\phi_{rp} \uparrow$, convergence speed$\downarrow$ and less amplified paths<br><br>(ii) $\sigma_t^q > \sigma_t^{q,n} = 0$ means a boom ($\hat{Q}_t > 0$ and $\pi_t > 0$)</td></tr>
<tr><td colspan="2">As $\phi \uparrow$, convergence speed$\uparrow$ and $\exists$ more amplified paths</td></tr>
</table>




(a) With $\phi_{\text{rp}} = 1$

(b) With $\phi_{\text{rp}} = 1.5$.

Figure: $\{\sigma_t^q, \hat{Q}_t\}$ dynamics when $\sigma^{q,n} = 0$ and $\sigma_0^q = 0.9$, with varying $\phi_{\text{rp}} > \frac{1}{2}$

Go back

TFP volatility $\sigma_t$ (exogenous) jumps from $t = 0$ to $t = T$

$$\sigma_t = \begin{cases} \bar{\sigma} & \text{for } 0 \leq t \leq T \\ \underline{\sigma} & \text{for } t > T \end{cases} \quad , \quad r_t^n \equiv r^n(\sigma_t) = \begin{cases} \underline{r} < 0 & \text{for } 0 \leq t \leq T \\ \bar{r} > 0 & \text{for } t > T \end{cases}$$

Monetary policy is constrained ($\underline{i_t = 0}$) until $T$ (ZLB)

1. $t \geq T$: central bank achieves perfect stabilization: $\hat{Q}_t = \pi_t = \hat{rp}_t = 0$
2. $t \leq T$: $i_t = 0$ but from $\mathrm{Var}_t(d\hat{Q}_t) = (\sigma_t^q)^2 dt$: $\sigma_t^q = \sigma_t^{q,n} = 0$
   - Future stabilization $\Longrightarrow$ current financial stabilization: $\sigma_t^q = 0$ and $r_t^T = r_t^n$
3. Same dynamics to Werning (2012) and Cochrane (2017) Diagram and welfare
   Insufficient demand for the risky stock at the ZLB $\Longrightarrow$ business cycle$\downarrow$

**Here**: focus on the **rigid price** case ($\pi_t \equiv 0$)

Go back

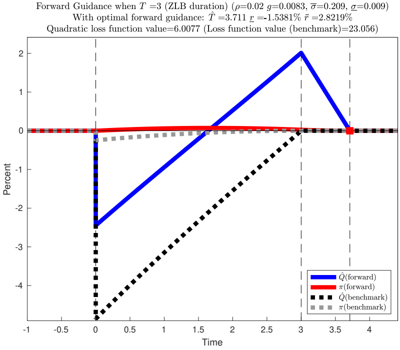



Figure: Zero lower bound (ZLB) crisis and forward guidance: $\{\hat{Q}_t, \pi_t\}$ dynamics

## Forward guidance is powerful

- Dividend and wealth↑ for $T \leq t \leq \hat{T}$ (Sharpe ratio↑) $\Longrightarrow$ dividend and wealth↑ for $t \leq T$

## Welfare

$$L(\{\hat{Q}_t, \pi_t\}_{t\geq 0}) = \mathbb{E}_0 \int_0^\infty \mathrm{e}^{-\rho t}(\hat{Q}_t^2 + \Gamma \pi_t^2)dt$$

Go back

**Recall** an economic mechanism in the ZLB and forward guidance

$$\boxed{\text{1. Central bank achieves perfect stabilization: } \hat{Q}_t = \hat{rp}_t = 0, \forall t \geq \hat{T}}$$

$$\downarrow$$

$$\boxed{\text{2. } \hat{Q}_{\hat{T}} = 0 \text{ guarantees } \sigma_t^q = \sigma_t^{q,n}, \text{rp}_t = \text{rp}_t^n \text{ for } t \leq \hat{T}}$$

Still if $\text{rp}_t^n$ is too high, might want to push $\{\sigma_t^q, \text{rp}_t\}$ down for $\hat{Q}_t \uparrow$?

- Thus achieve $\sigma_t^q < \sigma_t^{q,n}$, $\text{rp}_t < \text{rp}_t^n \implies \hat{Q}_t \uparrow$ at the ZLB

**Take contrapositive to the above**:

$$\boxed{\neg\text{2. } \sigma_t^q < \sigma_t^{q,n}, \text{rp}_t < \text{rp}_t^n \text{ for } t \leq \hat{T}}$$

$$\downarrow$$

$$\boxed{\neg\text{1. } \hat{Q}_{\hat{T}} \neq 0. \text{ Central bank commits not to perfectly stabilize the economy after } \hat{T}}$$

- Giving up future financial stability $\implies \text{rp}_t \downarrow$ and $\hat{Q}_t \uparrow$ now (at the ZLB)

Go back

**Proposition (Optimal commitment path)**

At optimum, $\sigma_1^{q,L} < \sigma_1^{q,n}$, $\sigma_2^{q,L} < \sigma_2^{q,n}$, and $\hat{T}' < \hat{T}$

## Subsidy policy

Go back

**ZLB**: insufficient demand for the risky stock (collectively pushes down $\hat{Q}_t$)

1. Instead of the original expected return $i_t^m$, capitalists receive $(1+\tau_t)i_t^m$ in expectation out of 1$ investment in the stock market.

2. Financed by $T_t$ amount of lump-sum (or wealth) tax on capitalists

3. Effectively raises the natural rate $\underline{r}$ as we have higher demand for the stock, which mitigates the recession (propping up $\hat{Q}_t$)

**Proposition (Subsidy and ZLB dynamics)**

For $\mathrm{rp}_t^n \equiv \overline{\mathrm{rp}}$ for $t \leq T$

$$d\hat{Q}_t = -\Big(\underbrace{\underbrace{\underline{r}}_{\equiv r^n(\bar{\sigma})<0} + \underbrace{\frac{\tau_t}{1+\tau_t}\overline{\mathrm{rp}}}_{>0}}_{\text{Effective natural rate}\uparrow} + \pi_t\Big)dt$$

$\simeq$ **Tax cuts on positive capital gains**

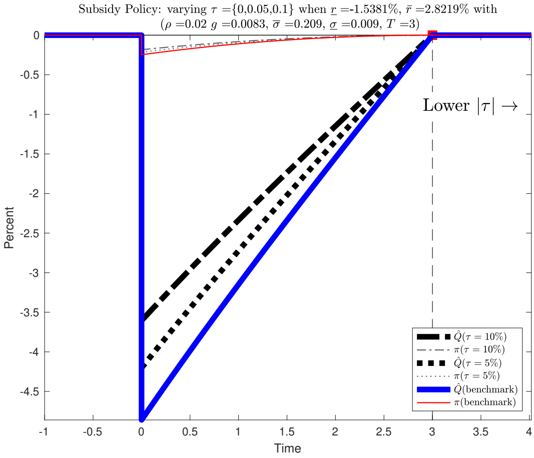



Figure: ZLB with varying $\tau_t$ rates: $\{\hat{Q}_t, \pi_t\}$ dynamics

What if we finance the policy through tax on hand-to-mouth workers?

- Bad idea: workers have a high MPC and reduce consumption (thus dividend$\downarrow$)
- Cancels with the above effect and no overall change in $\{\hat{Q}_t, \pi_t\}$ dynamics

Go back

1. Direct fiscal transfer from capitalists to workers: $D_t \uparrow$, $Q_t \uparrow$ (positive feedback)

2. Assume $T_t = \varphi_t p_t A_t Q_t$ ($\varphi_t$ portion of financial wealth transferred at $t$)
   - Dividend yield rises by $\varphi_t$ from $\rho$

$$i_t^m = \underbrace{\rho + \varphi_t}_{\text{Dividend yield}} + \mathbb{E}_t \left( \frac{d(p_t A_t Q_t)}{p_t A_t Q_t} \frac{1}{dt} \right)$$

**Proposition (Fiscal transfer and ZLB dynamics)**

The dynamic IS equation for $\hat{Q}_t$ in this case is written as:

$$d\hat{Q}_t = -(\underbrace{\underbrace{\underline{r}}_{\equiv r^n(\bar{\sigma})<0} + \underbrace{\varphi_t}_{>0}}_{\text{Effective natural rate}\uparrow} + \pi_t)dt$$