Optimal Policy for Behavioral Financial Crises

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Motivation

- Growing interest in behavioral credit cycles

- Predictable financial crises
  - Credit growth & Asset price booms — Jordá, Schularick & Taylor (2015)
  - 7% in normal times vs. 40% after — Greenwood et. al (2021)
  - Preceded by decreasing credit spreads — López-Salido et. al (2017)

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- Minsky (1977) & Kindleberger (1978) narratives
- Financial crises driven by systematic behavioral biases
  - Beliefs inconsistent with RE — Egan, MacKay & Yang (2021)
  - Key to match pre-crisis moments — Krishnamurthy & Li (2021)

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- Consensus shifting
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  - Stein (2021)
- Does the behavioral view warrant preemptive intervention?
  - Open question even if acknowledge that behavioral biases matter

Traditional view

Open Questions

1. When are behavioral biases a concern?
   - Greenspan (1996)

2. Does policy depend on the form of behavioral biases?
   - Krishnamurthy & Li (2021)

3. Is monetary policy needed for financial stability? Are macroprudential tools enough?
   - Bernanke (2002) ; Fischer (2014) ; Yaron (2019)

4. What if policymakers and the market hold the same beliefs?
   - Greenspan (2010)

5. What if regulators only have incomplete information about biases?
   - Yellen (2009)

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This paper: A model to address these questions

Results Preview

1. General decomposition identifying the sources of welfare losses
   - Irrational optimism in booms
   - Future irrational pessimism in financial crises: **key**
   - New externalities when biases depend on prices

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   - Prevents future endogenous pessimism if prices fall
   - Independent of whether high prices are due to fundamentals or a bubble
   - Complements macroprudential policy when biases depend on prices
     - Even with fully flexible macroprudential tools (Farhi & Werning 2020)
     - Even when planner and agents share the same beliefs
     - Even if monetary policy unconstrained during crises

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3. Uncertainty about biases increases incentives to tighten policy
   - Planner uncertain about booms driven by fundamentals or biases
   - Non-linear interaction between biases and frictions
   - Costs of false negative > costs of false positive

Model Preview

References

- Macroprudential Policy:
  - Incomplete Markets: Fisher (1932), Geanakoplos & Polemarchis (1985)
  - Aggregate Demand Externalities: Farhi & Werning (2016)
  - Pecuniary Externalities: Gromb & Vayanos (2002), Dávila & Korinek (2018)
  - Regulation: Diamond, Kashyap & Rajan (2017), Greenwood, Hanson, Stein & Sunderam (2017)
- Behavioral Credit Cycles :
  - Predictability of Financial Crises: Jorda, Schularick, & Taylor (2013), Greenwood & Hanson (2013), López-Salido, Stein, & Zakrajšek (2017)
  - Forecast Errors: Mian, Sufi, & Verner (2017), Bordalo, Gennaioli, Ma & Shleifer (2019), Egan, MacKay & Yang (2021)
  - Quantitative Models: Maxted (2020), Krishnamurthy & Li (2021)
  - Risk Perception: Pflueger, Siriwardane & Sunderam (2020)
- Welfare with Behavioral Agents :
  - General Theory: Farhi & Gabaix (2020)
  - Macro-Finance: Caballero & Simsek (2020), Farhi & Werning (2020), Dávila & Walther (2021)
- Leaning Against the Wind :
  - Financial Stability: Woodford (2012), Svensson (2017), Gourio, Kashyap & Sim (2018), Caballero & Simsek (2020)

▸ Closely Related Literature

Outline

1. Model

2. Welfare Analysis
   - The Sources of Welfare Losses
   - Optimal Policy

3. Sentiment Uncertainty

Setup & Preferences

- Three periods: $t \in \{1, 2, 3\}$
- Two agents:
  1. Financial Intermediaries: He & Krishnamurthy (2013)

$$U^b = \mathbb{E}_1 \left[\ln(c_1) + \beta \ln(c_2) + \beta^2 c_3 \right]$$

  2. Households (savers/lenders/...):

$$U^h = \mathbb{E}_1 \left[c_1^h + \beta c_2^h + \beta^2 c_3^h \right]$$

- Financial intermediaries issue deposits d_t to households
- Intermediaries can invest into the creation of H units of a risky asset
  - Paying a cost $c(H)$ at $t = 1$
  - Can only be held by financial intermediaries
  - Stochastic & i.i.d. dividends z_2 and z_3
  - Price q_t

Tiimeline

Financial Frictions

$$c_2 + d_1(1 + r_1) + q_2 h \leq \mathbf{d_2} + (z_2 + q_2)H$$

- Collateral Constraint:
  - Deposits at $t = 2$ backed by H-collateral: ▸ MBS Repo

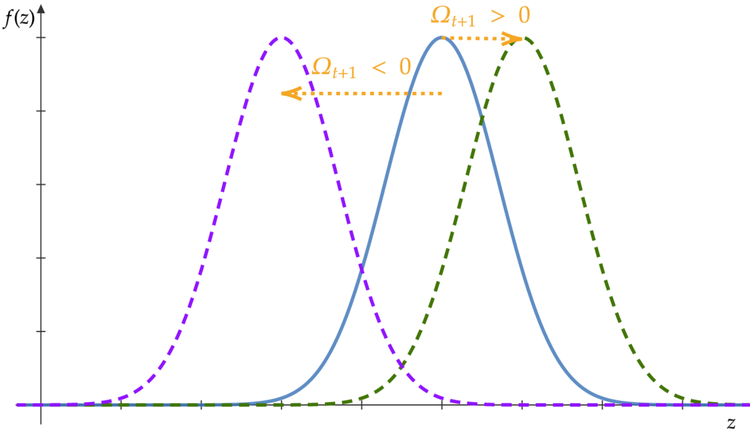
$$d_2 \leq \phi h \mathbb{E}_2[z_3] \qquad (\kappa)$$

  - Intermediaries' borrowing constraints can bind at $t = 2$ (crisis: $\kappa > 0$)
  - Future income borrowing constraint ▸ Micro-foundations
- **No** financial amplification ▸ Current Price
- **No** pecuniary externality ▸ REE Constrained Efficiency

▸ Real Production ▸ Households Beliefs ▸ Rational Equilibrium

Beliefs: Formulation

- General class of deviations from REE at $t = 1$ and $t = 2$
- Behavioral bias $\Omega_{t+1}(\mathcal{I}_t)$ shifting distribution of states of the world:



Perceived distributions of future dividends with behavioral biases

Beliefs: Examples

- **Inattention** (Exogenous)

$$\Omega_{t+1} = (\rho_s - \rho)(z_t - \bar{z})$$

  - Gabaix (2019)

- **Fundamental** Extrapolation (Exogenous)

$$\Omega_{t+1} = \alpha(z_t - z_{t-1})$$

  - Barberis, Shleifer & Vishny (1998), Rabin & Vayanos (2010), Fuster, Hebert & Laibson (2012), Bordalo, Gennaioli & Shleifer (2018), etc.

- **Price** Extrapolation (Endogenous)

$$\Omega_{t+1} = \alpha(q_t - q_{t-1})$$

  - De Long, Shleifer, Summers & Waldmann (1990), Hong & Stein (1999), Barberis, Greenwood, Jin & Shleifer (2018), Farhi & Werning (2020), Bastianello & Fontanier (2022a,b), etc.

▸ Forecast Errors ▸ Other Examples ▸ Learning From Prices ▸ Households Beliefs

Beliefs: Sophistication

- Agents can be biased at $t = 1$ and/or at $t = 2$
  - Biases during crises are key for most results
  - Are results robust to sophistication?
- ζ captures the level of sophistication:

$$\mathbb{E}_1\left[\ \mathbb{E}_2[z_3]\ \right] = \mathbb{E}_1[z_3 + \zeta\Omega_3].$$

- Pricing condition:

$$q_t = \beta\mathbb{E}_t\left[\frac{\lambda_{t+1}(z_{t+1} + \Omega_{t+1}, \zeta\Omega_{t+2})}{\lambda_t}\Big(z_{t+1} + \Omega_{t+1} + q_{t+1}\big(z_{t+1} + \Omega_{t+1}, \zeta\Omega_{t+2}\big)\Big)\right]$$

- Notation:

$$q_t = \beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(z_{t+1} + \Omega_{t+1} + q_{t+1}\right)\right]$$

Behavioral Equilibrium: Endogenous Ω_3

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3(q_2)] + \phi(1 - c_2)\mathbb{E}_2[z_3 + \Omega_3(q_2)]$$

$$c_2 = z_2 H - d_1(1 + r_1) + \phi H \mathbb{E}_2[z_3 + \Omega_3(q_2)] \quad (\kappa > 0)$$

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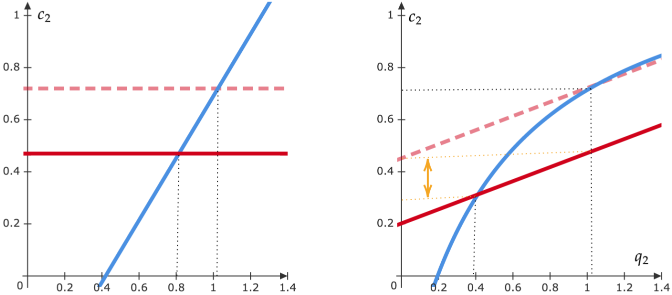

Effect of a shock to net worth n_2 when $\Omega_3(q_2)$ is endogenous

- Fall in net worth: Increase in marginal utility
  - Decrease in SDF $\rightarrow$ Fall in asset prices ...
    1. $\rightarrow$ Worsens pessimism $\rightarrow$ Fall in asset prices ...
    2. $\rightarrow$ Tightening of collateral constraint $\rightarrow$ Fall in consumption...
  - Belief Amplification

▸ Equilibrium with $\phi H q_2$ ▸ Equilibrium Unicity ▸ Bias on q_{t+1} ▸ Welfare: Collateral Externality

Outline

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1. Model

2. Welfare Analysis
   The Sources of Welfare Losses
   Optimal Policy

3. Sentiment Uncertainty

Welfare: Leverage

Uninternalized Welfare Effects of d_1

$$\mathcal{W}_d = \underbrace{\left(\mathbb{E}_1[u'(c_2)] - \mathbb{E}_1^{SP}[u'(c_2)]\right)}_{\text{Belief Wedge}} + \underbrace{\mathbb{E}_1^{SP}\left[\kappa \phi H \frac{d\Omega_3}{dq_2}\frac{dq_2}{dd_1}\right]}_{\text{Collateral Externality}}$$

▸ Initial Equilibrium ▸ $\mathcal{W}_d$ with $\phi H q_2$ ▸ Real Production

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- Two effects drive the Belief Wedge:
  1. Contemporaneous bias Ω_2
  2. Predictable future bias Ω_3

$$\mathcal{BW} \simeq \underbrace{-\Omega_2 H \mathbb{E}^{SP}\left[(-u''(c_2))\mathbb{1}_{\kappa>0}\right]}_{1.} + \underbrace{\phi H \mathbb{E}^{SP}\left[(1-\zeta)\Omega_3(-u''(c_2))\mathbb{1}_{\kappa>0}\right]}_{2.}$$

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- Financial frictions crucial
- Product of:
  - Mistake Ω_2
  - Cost of making a mistake $H\mathbb{E}^{SP}\left[(-u''(c_2))\mathbb{1}_{\kappa>0}\right]$

▸ Belief Wedge with $\phi H q_2$

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- Predictable losses
- Even if $\Omega_2 = 0$:
  - Future pessimism costly
  - Can even have $\mathbb{E}^{SP}[\Omega_3] = 0$
  - Comovement matters

▸ Belief Wedge with $\phi H q_2$

Welfare: Leverage

Uninternalized Welfare Effects of d_1

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- Belief Amplification $\implies$ Pecuniary Externality
- ζ **not** part of the expression
  - Agents can realize that increasing leverage impacts prices tomorrow...
  - And that low prices mean irrational distress tomorrow
  - But would need to **coordinate** to prevent this
  - Atomistic agents $\implies$ Pecuniary externality

– Even if regulator holds the same beliefs as sophisticated agents

▸ Behavioral Equilibrium ▸ Collateral Externality with $\phi H q_2$

Welfare: Investment

Uninternalized Welfare Effects of H

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[u'(c_2)(z_2+q_2)\right] - u'(c_1)q_1\right)}_{\text{Belief Wedge}} + \underbrace{\beta\mathbb{E}_1^{SP}\left[\kappa\phi H\frac{d\Omega_3}{dq_2}\left(\frac{dq_2}{dn_2}z_2 + \frac{dq_2}{dH}\right)\right]}_{\text{Collateral Externality}}$$

▸ $\mathcal{W}_H$ with $\phi H q_2$ ▸ Real Production

Welfare: Investment

Uninternalized Welfare Effects of H

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- Collateral externality > 0
- Countervailing effects:
  - Collateral assets ameliorate the net worth of the entire sector
  - It supports asset prices and thus sentiment
  - Exuberance alleviates this market failure
  - Martin & Ventura (2016)
- Unambiguously negative for large Ω_2
- ζ still **not** part of the expression

Collateral Externality $\phi H q_2$

Welfare: Prices

Uninternalized Welfare Effects of q_1

$$\mathcal{W}_q = \underbrace{\mathbb{E}_1^{SP}\left[\kappa\phi H\frac{d\Omega_3}{dq_1}\right]}_{\text{Reversal Externality}}$$

Welfare: Prices

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$$\mathcal{W}_q = \underbrace{\mathbb{E}_1^{SP}\left[\kappa\phi H \frac{d\Omega_3}{dq_1}\right]}_{\text{Reversal Externality}}$$

- Operative irrespective of contemporaneous exuberance
- Asset price at $t = 1$ enters equilibrium determination at $t = 2$
  - New state variable q_1
  - First-order welfare loss
- Anchoring
  - Price extrapolation $\implies d\Omega_3/q_1 = -\alpha$
- ζ **not** part of the expression
  - Again even if regulator holds the same beliefs as sophisticated agents
- See also Schmitt-Grohe & Uribe (2016) ; Farhi & Werning (2020)

▸ Reversal Externality with $\phi H q_2$ ▸ Optimal Policy

Outline

Optimal Policy: Leverage

- Restrictions to internalize $\mathcal{W}_d$
  - Macroprudential **tax** on borrowing $\tau_d = \mathcal{W}_d / u'(c_1)$
  - Equivalently borrowing **limit**
- Time-variation in τ_d
  - Tracks Ω_2
  - But also $\Omega_3 | \Omega_2$
- If pessimism during crisis is predictable:
  - Higher taxes because of neglected distress
  - Macroprudential policy achieves lower welfare than under Rational Expectations
- Leverage limit more **robust**
  - Protected against swings in Ω_2
  - Time-variation still needed for $\Omega_3 | \Omega_2$
  - **Counter-cyclical** buffers

Calibration Mistakes   Small Deviations   Heterogeneous Beliefs

Optimal Policy: Investment

- How to restrict creation of H?
- LTV/LTI ratios regulation
- But time-variation more subtle:
  - Belief wedge behaves as for leverage
  - Collateral externality moves in the other direction
- If the planner is suddenly more concerned about price-sensitivity of sentiment inside a future crisis, should *relax* LTV ratios
- Enough for second-best?

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- If the planner is suddenly more concerned about price-sensitivity of sentiment inside a future crisis, should *relax* LTV ratios
- Enough for second-best?
- Controlling for allocations is insufficient
  - Past price enters as a state-variable at $t = 2$
  - Need additional instrument Stein (2021)
  - $\implies$ Allows for looser regulation for $\boldsymbol{d_1}, \boldsymbol{H}$

▸ Buyer vs. Seller Regulations

Leaning Against the Wind

- Assume:
  - Demand-driven output
  - Fully unconstrained leverage requirements
  - Fully unconstrained LTV requirements
  - Macroprudential tools set at optimal levels

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- Assume:
  - Demand-driven output
  - Fully unconstrained leverage requirements
  - Fully unconstrained LTV requirements
  - Macroprudential tools set at optimal levels
- Monetary tightening has two first-order effects:
  1. Aggregate Demand
  2. Future Beliefs

Welfare Effects of Monetary Policy

$$\frac{d\mathcal{W}_1}{dr_1} = \underbrace{\frac{d\bar{Y}_1}{dr_1}\mu_1}_{(i)} + \underbrace{\mathbb{E}_1\left[\kappa\phi H \frac{d\Omega_3}{dq_1}\frac{d\bar{q}_1}{dr_1}\right]}_{(ii)}$$

Full effects of monetary policy $\phi H q_2$

Leaning Against the Wind: When?

Welfare Effects of Monetary Policy

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- Financial stability concerns when low unemployment — Stein (2021)
  - Not when $\mu_1 \gg 0$
- No need to distinguish fundamental-driven movements from bubbles
- Not a *substitute* for leverage restrictions
  - Monetary Policy as complement — Farhi & Werning (2020)
- Less pessimism in crises $\Longrightarrow$ Soften leverage restrictions
- Finding valid even if:
  - No irrational exuberance : $\Omega_2 = 0$
  - No belief amplification : $d\Omega_3/dq_2 = 0$
  - Sophisticated agents and regulator hold the same beliefs (ζ absent)

▸ Early vs. late tightening ▸ Dynamic spillovers ▸ Unintended crisis

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Incomplete Information: Setup (1)

- So far the planner:
  1. Perfectly knows Ω_2
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It was very difficult to definitively identify a bubble until after the fact – that is, when its bursting confirmed its existence.

- Alan Greenspan, August 2002

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  1. Perfectly knows Ω_2
  2. Perfectly knows $F(z_2)$

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- Alan Greenspan, August 2002

- Assume instead:
  - Uniform prior over sentiment:

$$w \sim \mathcal{U}\left[\bar{\Omega}_2 - \sigma_\Omega, \bar{\Omega}_2 + \sigma_\Omega\right]$$

  - Fundamentals backed out from equilibrium prices:

$$\bar{z}_2 = f_q^{-1}(q_1) - \bar{\Omega}_2$$

Incomplete Information: Setup (2)

- Optimal short-term debt condition:

$$u'(c_1) = \frac{1}{2\sigma_\Omega} \int_0^\infty \left[\int_{-\sigma_\Omega}^{\sigma_\Omega} \frac{\partial \mathcal{W}_2}{\partial n_2} \left(d_1, H; q_2, z_2 - \bar{\Omega}_2 - \omega_2 \right) d\omega_2 \right] f_2(z_2) dz_2$$

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- While agents use:

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- Gap between two solutions driven by:
  1. $\bar{\Omega}_2$
  2. σ_Ω

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- Gap between two solutions driven by:
  1. $\bar{\Omega}_2$
  2. σ_Ω
- $\bar{\Omega}_2 \quad \rightarrow \quad \mathcal{W}_d$
- $\sigma_\Omega \quad \rightarrow \quad$ **?**

Incomplete Information: Policy

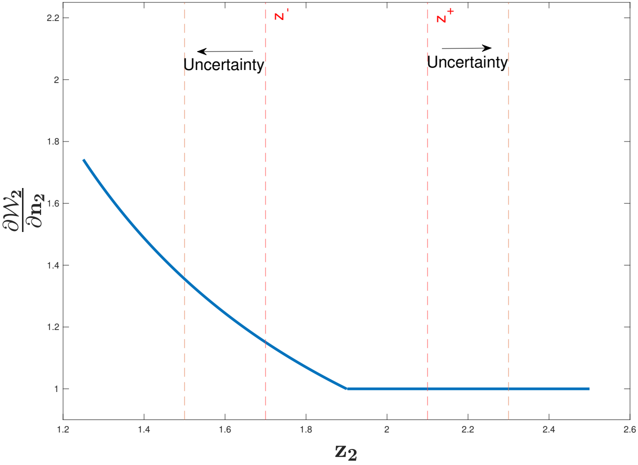
Ω_2-Uncertainty and Leverage Restrictions

The optimal leverage tax is increasing in σ_Ω . It is strictly increasing as long as there exist a ω in $[-\sigma_\Omega, \sigma_\Omega]$ for which, if sentiment is $\bar{\Omega}_2 + \omega$, there is a positive probability of a crisis in the next period.

- Sentiment noise increases expected marginal welfare
  - Jensen argument
  - Non-linear interaction between sentiment and financial crises
- Costs of false negative > costs of false positive
- Time-varying when $\bar{\Omega}_2$ or σ_Ω are time-varying
- Also true for Ω_3 -Uncertainty Show
- **Opposite for investment** !

Time-varying policy

Precautionary Restrictions



Reversal Uncertainty

- Assume:

$$\Omega_3 = \bar{\Omega}_3 - \boldsymbol{\alpha} q_1 \quad \text{with} \quad \alpha \sim \mathcal{U}[\bar{\alpha} - \sigma_\alpha, \bar{\alpha} + \sigma_\alpha]$$

Reversal-Uncertainty and Monetary Policy

The optimal interest rate at $t = 1$ is increasing in σ_α if the regulator has access to unconstrained leverage and investment regulations.

- Regulator fears that high prices could translate into over-pessimism
  - But unsure of the strength of the extrapolation
- More uncertainty around this extrapolation mechanism
  $\Longrightarrow$ more aggressive Leaning against the Wind

Extensions

- Extensions and Robustness:
  - Real production
  - Alternative collateral constraint
  - Heterogeneous beliefs
  - Sophisticated Agents
  - Bailouts
  - Investment micro-foundations and LTV Regulation
  - Early vs. late tightening
  - Infinite Horizon
  - Dynamic spillovers of anticipated LAW
- See Paper and Online Appendix

Conclusion

1. Biases during crises key for policy

2. Externalities robust to degree of sophistication of market's beliefs

3. Greater sentiment uncertainty $\implies$ stricter regulation

Appendix Slides

Traditional View

- Traditional view of financial crises
  - Unpredictable events Kaminsky & Reinhart (1999)
  - "Bolts from the sky" Diamond & Dybvig (1983), Cole & Kehoe (2000)
  - Asset price booms not a concern *per se*
- Leading to substantial policy consensus
  - Unconditional limits on leverage
  - No use of monetary policy
- Greenspan (1996), Bernanke (2002), Kohn (2004), Yellen (2009), Gorton (2012), Geithner (2014), ...

Motivation

Closely Related Literature

- Policy for Irrational Exuberance:
  - Farhi & Werning (2020), Dávila & Walther (2021)
  - This paper : **Behavioral biases during crises are central**
- Macroprudential Policy:
  - Gromb & Vayanos (2002), Dávila & Korinek (2018)
  - This paper : **New externalities with future-income**
- Drivers of Belief Fluctuations:
  - Krishnamurthy & Li (2021)
  - This paper : **Distinguishing drivers of sentiment matters**
- Leaning against the wind:
  - Caballero & Simsek (2020)
  - This paper : **Complement to flexible leverage restrictions**

Full related literature

References: Predictable Crises

- Borio & Lowe (2002)
  - Asset price growth and credit growth predict banking crises in small open economies
- Schularick & Taylor (2012)
  - Credit expansions forecast real activity slowdowns
- Greenwood & Hanson (2013)
  - Credit booms accompanied by a deterioration of quality of corporate issuers
  - High share of risky loans forecasts negative corporate bond returns
- López-Salido et al.(2017)
  - Predictable mean-reversion in credit spreads
  - Elevated credit-market sentiment predicts a decline in economic activity
- Baron & Xiong (2017)
  - Bank credit expansion predicts higher probability of crash in bank equity and negative subsequent return on bank equity
- Jorda, Schularick & Taylor (2015)
- Greenwood, Hanson, Shleifer & Sørensen (2020)
  - Combining credit growth measures with asset price growth substantially increases the out-of-sample predictive power

Introduction

This Paper

- Model of financial crises
- Financial Intermediaries
  - Channel savings into production of risky projects
  - Subject to a collateralized borrowing constraint
- Belief distortions
  - General deviation from rational expectations
  - Can depend on fundamental or prices
  - Allow for sophistication regarding future biases
- Normative analysis using planner's beliefs
  - Allows for incomplete information
  - Allows for identical beliefs with private agents
- Optimal policy with ex-ante instruments
  - Capital buffers
  - Loan-to-Value (LTV) limits
  - Price regulation

Results Preview

References: Belief Distortions

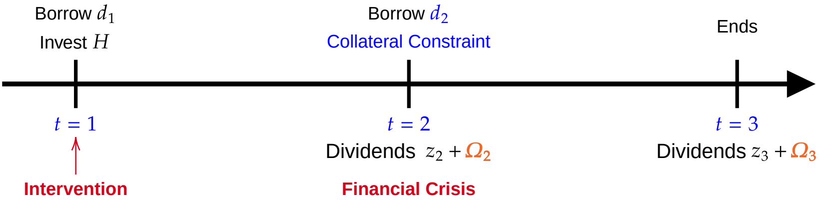
- Survey Data :
  - Bacchetta, Mertens & van Wincoop (2009)
  - Amromin & Sharpe (2014)
  - Greenwood & Shleifer (2014)
  - Adam, Beutel & Marcet (2017)
  - Bordalo, Gennaioli & Shleifer (2018)
  - Bordalo, Gennaioli, Ma & Shleifer (2018)
  - Cassella & Gulen (2018)
  - Bordalo, Gennaioli, La Porta & Shleifer (2019, 2020)
  - Bouchaud, Krueger, Landier & Thesmar (2019)
  - Bordalo, Gennaioli, La Porta & Shleifer (2019, 2020)
  - Chiappori, Salanié, Salanié, & Gandhi (2019)

- Calibrated Models :
  - Maxted (2020)
  - Krishnamurthy & Li (2021)

Introduction

Ingredients

- Lorenzoni (2008), Dávila & Korinek (2018)
- Three-period model
  1. Agents borrow and invest
  2. A financial crisis can happen
  3. The world ends
- Financial intermediaries face a collateral constraint at $t = 2$
- Agents subject to behavioral biases
- Social Planner can regulate equilibrium in the first period
  1. Knows behavioral biases
  2. Internalizes prices



Setup

Financial Frictions: Micro-foundations

$$c_2 + d_1(1 + r_1) + q_2 m \leq \mathbf{d_2} + (z_2 + q_2)H$$
$$d_2 \leq \phi H \mathbb{E}_2[z_3]$$

- Assume $\phi \mathbb{E}_2[z_3] < \min z_3$
- Microfoundations:
  1. Lack of commitment
  2. Default happens before the realization of z_3 is known
  3. Lenders seize fraction ϕ in default at $t = 3$
  4. Lenders only willing to offer risk-free contracts
- Alternative:
  - Default happens *after* the realization of z_3 is known
  - Collateral constraint now takes the form:

$$d_2 \leq \phi H \min z_3$$

  - Same results since Ω_{t+1} shifts whole distribution of payoffs

Return   Household Beliefs

H as Housing

- Continuum of construction entrepreneurs: $j \in [0, \infty]$ with
- Net worth A
- All projects yield the same payoffs in periods $t = 2$ and $t = 3$
- j must raise $I_j - A$ of outside funds from financial intermediaries
- Cost of investing into H projects for the financial intermediary is:

$$c(H) = \int_0^H (I_j - A)dj \tag{1}$$

- Loan-to-value ratio is thus simply:

$$LTV_H = \frac{I_H - A}{I_H} \tag{2}$$

- LTV regulation controls for the level of H in equilibrium

▸ Optimal Policy: Investment

H as MBS

- Default cost C, repayment of Z
- Default $\implies$ financial intermediary seizes the house
- House prices P distributed according to $F(P)$
- Optimal default $C < B - P$
- Expected payoff from the mortgage contract:

$$z = \int_0^{B-C} Pf(P)dP + \int_{B-C}^{+\infty} Bf(P)dP. \tag{3}$$

- Consider heterogenous unobserved default costs uniformly distributed in $[\underline{C}, \bar{C}]$.
- MBS payoff:

$$z(P) = \int_{\underline{C}}^{B-P} P\frac{dC}{\bar{C} - \underline{C}} + \int_{B-P}^{\bar{C}} B\frac{dC}{\bar{C} - \underline{C}} \tag{4}$$

- Tight link between Ω and house-price extrapolation on the downside

▸ Optimal Policy: Investment

Contemporaneous Price in Collateral Constraint

- Contemporaneous prices in constraint is essential for
  - Financial amplification and inefficiencies: $u'(c_2) \longleftrightarrow q_2$
  - Ottonello, Perez & Varraso (2019): inefficiencies disappear if depends on the future price
  - Challenge: quantitative predictions are the same

- Paper also provides the full analysis with:

$$d_2 \leq \phi H q_2$$

- Supplementary pecuniary externality :

$$\mathcal{C}_d = \mathbb{E}^{SP}\left[\kappa \phi H \frac{dq_2}{dd_1}\right]$$

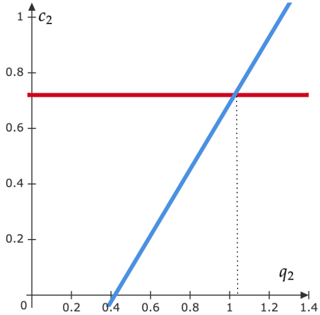
- Also operative in rational model

- Future-income collateral constraint to isolate new effects

Rational Equilibrium: Financial Crisis

$$q_2 = \beta c_2 \mathbb{E}_2[z_3] + \phi(1 - c_2)\mathbb{E}_2[z_3]$$

$$c_2 = \underbrace{z_2 H - d_1(1 + r_1)}_{\text{Net worth } n_2} + \phi H \mathbb{E}_2[z_3] \quad (\kappa > 0)$$



Effect of a shock to net worth n_2 on the rational equilibrium

▸ Financial Frictions ▸ REE with $\phi H q_2$

Beliefs and Collateral Constraints

- Assumed same beliefs for intermediaries and households
  - Important for results?

- Depends on the micro-foundations of the collateral constraint

- When $d_2 \leq \phi H \mathbb{E}_2[z_3]$:
  - Creditors' beliefs pin down the borrowing limit
  - Important for households to be over-pessimistic for externality results

- When $d_2 \leq \phi H q_2$:
  - Equilibrium price pins down the borrowing limit
  - Intermediaries' beliefs matter since they are the marginal pricers

- See Simsek (2013) ; Dávila & Walther (2021)

Financial Frictions   Beliefs: Formulation   Beliefs: Examples   Equilibrium at $t = 2$ $\phi H q_2$

Beliefs: Formulation for q_{t+1}

- General class of deviations from REE at $t = 1$ and $t = 2$
- Behavioral bias $\Omega_{t+1}(\mathcal{I}_t)$ shifting distribution of states of the world:

$$q_t = \beta \mathbb{E}_t \left[\frac{u'(c_{t+1}(z_{t+1} + \Omega_{t+1}))}{u'(c_t)} \left(z_{t+1} + \Omega_{t+1} + q_{t+1}(z_{t+1} + \Omega_{t+1}) \right) \right]$$

  – Notation:

$$q_t = \beta \mathbb{E}_t \left[\frac{u'(c_{t+1})}{u'(c_t)} (z_{t+1} + \Omega_{t+1} + q_{t+1}) \right]$$

Beliefs: Formulation for q_{t+1}

- General class of deviations from REE at $t = 1$ and $t = 2$
- Behavioral bias $\Omega_{t+1}(\mathcal{I}_t)$ shifting distribution of states of the world:

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  – Notation:

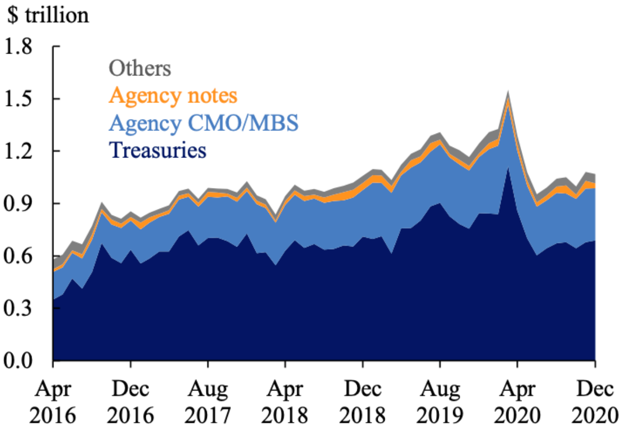
$$q_t = \beta \mathbb{E}_t \left[\frac{u'(c_{t+1})}{u'(c_t)} (z_{t+1} + \Omega_{t+1} + q_{t+1}) \right]$$

  – Expected price is what would prevail in a fully REE world with dividend $z_{t+1} + \Omega_{t+1}$

$$q_{t+1} \neq \beta \mathbb{E}_{t+1} \left[\frac{u'(c_{t+2})}{u'(c_{t+1})} (z_{t+2} + \Omega_{t+2} + q_{t+2}) \right]$$

- Neglect the presence of future biases
- Not necessary for results
  – Mostly for consistency

Repo Collateral

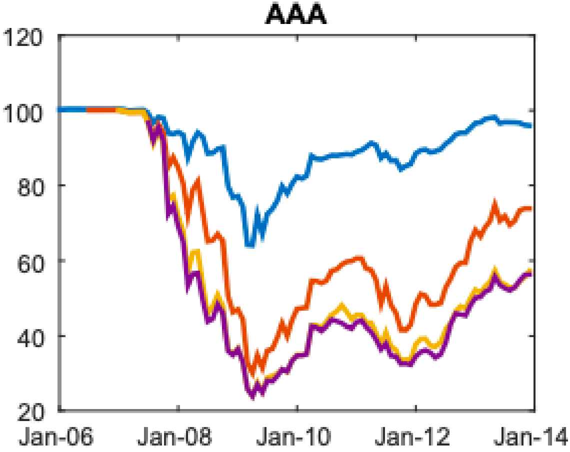


Note: CMO - collateralized mortgage obligations, MBS - mortgage-backed securities, "Others" include corporate debt, equities, private label MBS and asset-backed securities.
Source: Form N-MFP

Source: SEC, February 2021

Return

MBS Price Indexes



Subprime RMBS Price Indexes. Each line represents a different vintage of subprime RMBS. Source: Ospinal & Uhlig (2018)

Return

Extension: Real Production (1)

- Households supply labor at $t = 2$:

$$U^h = \mathbb{E}_1 \left[c_1^h + \beta \left(c_2^h - \nu \frac{l_2^{1+\eta}}{(1+\eta)} \right) + \beta^2 c_3^h \right]$$

- Competitive firms:

$$Y_2 = A l_2^{\alpha}$$

- Firms need to borrow to pay fraction of wages in advance
  - Funds $f_2 = \gamma w_2 l_2$
  - Interest rate required by intermediaries: $1 + r_f = \delta / f_2$
  - Stay away from corner solutions and preserve financial amplification
  - Linear relation between f_2 and c_2
- Budget constraint for intermediaries:

$$c_2 + d_1(1 + r_1) + \mathbf{f_2} + q_2 m \leq d_2 + (z_2 + q_2) H$$

▸ Financial Frictions ▸ Welfare: Leverage ▸ Conclusion

Extension: Real Production (2)

$$l_2 = \left(\frac{z_2 H - d_1(1+r_1) + \phi H q_2}{\gamma \nu \left(1 + \frac{1}{\beta\delta}\right)} \right)^{\frac{1}{1+\eta}}$$

$$Y_2 = A \left(\frac{z_2 H - d_1(1+r_1) + \phi H q_2}{\gamma \nu \left(1 + \frac{1}{\beta\delta}\right)} \right)^{\frac{\alpha}{1+\eta}}$$

- Price of the asset still "sufficient statistics"
    - Liquidity drought spills over the real sector
    - Propagates to employment and output
    - Cingano, Manaresi and & Sette (2016); Bentolila, Jansen & Jimenez (2018)

Extension: Real Production (3)

Planner's Optimality Condition for Leverage

$$0 = \Phi^h \mathbb{E}_1^{SP}\left[(\nu - \alpha A l_2^{\alpha-1})\left(\phi H \frac{dq_2}{dd_1} - (1+r_1)\right)\right] + \Phi^b \left\{\mathbb{E}_1\left[u'(c_2)\right] - \mathbb{E}_1^{SP}\left[u'(c_2)\right] - \mathbb{E}_1^{SP}\left[\phi H \kappa \frac{\partial q_2}{\partial n_2}\right]\right\}$$

- Pareto weights Φ_i
- Two distinct terms:
  1. Production term proportional to "capacity wedge" and price sensitivity
  2. Familiar $\mathcal{W}_d$

Extension: Real Production (4)

Planner's Optimality Condition for Investment

$$0 = \Phi^h \mathbb{E}_1^{SP}\left[(\nu - \alpha A l_2^{\alpha-1})\left(\phi H \frac{dq_2}{dH} + z_2 + \phi q_2\right)\right] +$$
$$\Phi^b \left\{ u'(c_1)q_1 - \mathbb{E}_1^{SP}\left[u'(c_2)(z_2+q_2)\right] - \beta \mathbb{E}_1^{SP}\left[\kappa\phi H\left(\frac{\partial q_2}{\partial n_2} z_2 + \frac{dq_2}{dH}\right)\right] - \right.$$
$$\left. \beta \mathbb{E}_1^{SP}\left[\kappa \phi H \frac{\partial q_2}{\partial \Omega_3}\frac{\partial \Omega_3}{\partial q_1} c''(H)\right]\right\}$$

- Pareto weights Φ_i
- Two distinct terms:
  1. Production term proportional to "capacity wedge" and price sensitivity
  2. Familiar $\mathcal{W}_H$

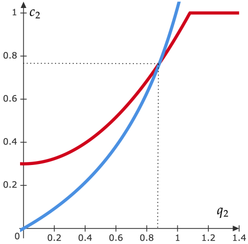
Extension: Pledgeable f

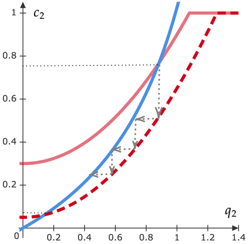
- Implicit assumption that f not pledgeable
- Extend collateral constraint formulation:
  - Collateral limit: $d_2 \leq \phi H q_2 + \psi f(1 + r_f)$
  - A fraction ψ of repayment can be recovered
  - More notation and loose linearity, but same insights
- New fixed-point problem:

$$c_2 + \frac{\delta c_2}{1 - \psi + \phi c_2} = n_2 + \phi H q_2$$

$$q_2 = \beta c_2 \mathbb{E}_1[z_3] + \phi q_2 (1 - c_2).$$

- Reinforces financial amplification further



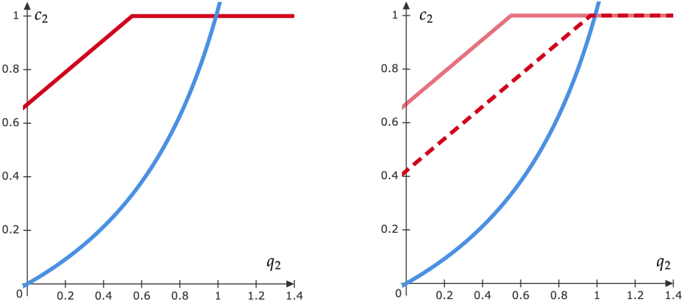


Return Conclusion

Rational Equilibrium: Normal Times

$$q_2 = c_2 \mathbb{E}_2[z_3] + \phi q_2 (1 - c_2)$$

$$c_2 = \frac{1}{\beta(1 + r_1)} \quad (\kappa = 0)$$



Effect of a shock to net worth n_2 in the REE without a crisis

▸ Crisis Equilibrium

Ω_{t+1} and Forecast Errors

- Ω_{t+1} models the inverse of forecast errors used in the literature
- Coibion & Gorodnichenko (2012)
- Bordalo, Gennaioli, La Porta & Shleifer (2019)
  - Agents are forecasting at t

$$z_{t+1} + \Omega_{t+1}$$

  - Forecast error:

$$z_{t+1} - (z_{t+1} + \Omega_{t+1}) = -\Omega_{t+1}$$

- For the planner, Ω_{t+1} corresponds to the predictable component of these forecast errors
- Conditioning on observables, construct:
  1. Point estimate of Ω_{t+1}
  2. Uncertainty range
- Both estimates factor in optimal policy

Beliefs: Formulation   Data: Forecast Errors

Beliefs: Examples

1. **Fundamental** Extrapolation (Exogenous)

$$\Omega_{t+1} = \alpha(z_t - z_{t-1})$$

   - Barberis, Shleifer & Vishny (1998), Rabin & Vayanos (2010), Fuster, Hebert & Laibson (2012), Bordalo, Gennaioli & Shleifer (2018), etc.

2. **Price** Extrapolation (Endogenous)

$$\Omega_{t+1} = \alpha(q_t - q_{t-1})$$

   - De Long, Shleifer, Summers & Waldmann (1990), Hong & Stein (1999), Barberis, Greenwood, Jin & Shleifer (2018), DeFusco, Nathanson & Zwick (2017), Farhi & Werning (2020), Liao, Peng & Zhu (2021), Bastianello & Fontanier (2022a,b), etc.

3. And many more...
   - Overconfidence
   - Sticky Beliefs
   - Inattention
   - Internal Rationality

Learning From Prices   Households Beliefs

Diagnostic Expectations

- Bordalo, Gennaioli & Shleifer (2018)
- State of the world follows an AR(1) process:

$$z_t = bz_{t-1} + \epsilon_t \tag{5}$$

with $\epsilon_t \sim \mathcal{N}(0, \sigma_\epsilon^2)$

- Diagnostic distribution is:

$$\mathbb{E}_t^\theta[z_{t+1}] = \mathbb{E}_t^{SP}[z_{t+1}] + \theta\left(bz_t - b^2 z_{t-1}\right) \tag{6}$$

- θ governs the representativeness bias
- Diagnostic expectations are thus nested as:

$$\Omega_{t+1} = \theta\left(bz_t - b^2 z_{t-1}\right) \tag{7}$$

Return

Internal Rationality (1)

- Adam & Marcet (2011), Adam, Marcet, & Beutel (2016)
- Agents are rational regarding the distribution of z_t
- But they perceive prices to evolve according to:

$$q_{t+1} = q_t + \beta_{t+1} + \epsilon_{t+1}$$

- ϵ_{t+1} is transitory and β_{t+1} is persistent:

$$\beta_{t+1} = \beta_t + \nu_{t+1}.$$

- Filtering yields:

$$\tilde{q}_{t+1} = \tilde{E}_t[q_{t+1}] = (1+g)(q_t - q_{t-1}) + (1-g)\tilde{E}_{t-1}[q_t]$$

with g the Kalman gain.

Return

Internal Rationality (2)

- Limiting case where this point estimate is believed to be certain
- Pricing equation becomes;

$$q_1 = \beta \mathbb{E}_1 \left[\frac{u'(c_2)}{u'(c_1)} (z_2 + q_2 + (\tilde{q}_2 - q_2)) \right].$$

- Implied bias is:

$$\Omega_2^q = \tilde{q}_2 - q_2$$

but only to the price of the asset, not on dividends

- Belief wedge can now be approximated as (see paper):

$$\mathcal{B}_d = -\mathbb{E}_1^{SP} \left[u'(c_2)^2 \phi H \Omega_2^q \mathbb{1}_{\kappa > 0} \right]$$

‣ Return to Examples ‣ Collateral Constraint Form

Internal Rationality (3)

- But externalities are present only if price in the collateral constraint
- However the sign of the key derivative for the reversal externality is clearly ambiguous:

$$\frac{d\Omega_3^q}{dq_1} = \frac{d\tilde{q}_3}{dq_1} = (1-g)\left(\frac{d\tilde{q}_2}{dq_1} - 1\right). \tag{8}$$

- This is because sentiment is "sticky" with learning
  - By reducing asset prices at $t = 1$, the planner makes future agents less optimistic in the boom
  - That makes then less optimistic in the bust
  - Hurts welfare.
- In general these models create under-reaction rather than over-reaction
- See Winkler (2020) for forecast error predictability with this model for example

‣ Return to Examples ‣ Collateral Constraint Form

Overconfidence

- Intermediaries have a prior over the distribution of dividends at $t = 2$:

$$z_2 \sim \mathcal{N}(\mu_0, \sigma_0^2)$$

- Receive a signal $s = z_2 + \epsilon$ with:

$$\epsilon \sim \mathcal{N}(0, \sigma_s^2).$$

- Overconfident financial intermediaries have a posterior of:

$$z_2 \sim \mathcal{N}\left(\mu_0 + \frac{\sigma_0^2}{\sigma_0^2 + \tilde{\sigma}_s^2}(s - \mu_0), \frac{\sigma_0^2}{1 + \frac{\sigma_0^2}{\tilde{\sigma}_s^2}}\right)$$

where $\tilde{\sigma}_s^2 < \sigma_s^2$

- The bias is given by:

$$\Omega_2 = \frac{\sigma_s^2 - \tilde{\sigma}_s^2}{(\sigma_0^2 + \tilde{\sigma}_s^2)(\sigma_0^2 + \sigma_s^2)}\sigma_0(s - \mu_0)$$

so that agents become exuberant after positive news $(s > \mu_0)$: $\Omega_2 > 0$.

Back

Sticky Beliefs

- Bouchaud, Krueger, Landier & Thesmar (2019)
- investors form expectations according to:

$$\tilde{\mathbb{E}}_1[z_2] = (1-\lambda)\mathbb{E}_1^r[z_2] + \lambda\tilde{\mathbb{E}}_0[z_2]$$

  where $\mathbb{E}_1^r$ is the rational time 1 expectations about the future dividend.

- Expectations of future dividends can be written:

$$\tilde{\mathbb{E}}_1[z_2] = \mathbb{E}_1^{SP}[z_2] + \lambda\left(\tilde{\mathbb{E}}_0[z_2] - \mathbb{E}_1^r[z_2]\right)$$

- The bias is:

$$\Omega_2 = \lambda\left(\tilde{\mathbb{E}}_0[z_2] - \mathbb{E}_1^r[z_2]\right).$$

- Expanding recursively:

$$\Omega_2 = \lambda\left(\mathbb{E}_0^r[z_2] - \mathbb{E}_1^r[z_2]\right) + \lambda\Omega_1.$$

Return

Inattention

- Gabaix (2019)
- Dividend process follows:

$$z_{t+1} = \rho z_t + (1 - \rho) z_0 + \epsilon_{t+1}$$

- Agents have to deal with too many autocorrelations, ρ_d on average
- May not fully perceive each autocorrelation, and instead use:

$$\rho_s = m\rho + (1 - m)\rho_d$$

- Bias becomes:

$$\Omega_{t+1} = (\rho_s - \rho)(z_t - z_0)$$

Return

Learning From Prices

- $\Omega_{t+1}(\mathcal{I}_t)$ defined as a bias on z_{t+1}, but can depend on q_t
- Can be modeled as a bias when learning from prices
- Bastianello & Fontanier (2022a,b)
  - Agents learn about fundamentals from prices
  - But fail to realize that other agents are learning in the same way
  - Micro-founds price extrapolation on fundamentals:

$$\mathbb{E}_t[z_{t+1}] = \mathbb{E}_{t-1}[z_{t+1}] + \left(1 + \frac{1}{\tilde{\zeta}}\right) \Delta q_t$$

  - where $\tilde{\zeta}$ reflects how strongly information is incorporated into prices
- Bias on $z_{t+1} \implies$ Results robust to alternative collateral constraints

▸ Beliefs: Formulation ▸ Beliefs: Examples

Collateral Constraint and Form of Biases

- The bias Ω_{t+1} is assumed to be on $\mathbb{E}[z_{t+1}]$
- Collateral constraint depends on $\mathbb{E}[z_{t+1}]$

  $\Longrightarrow$ Crucial interaction

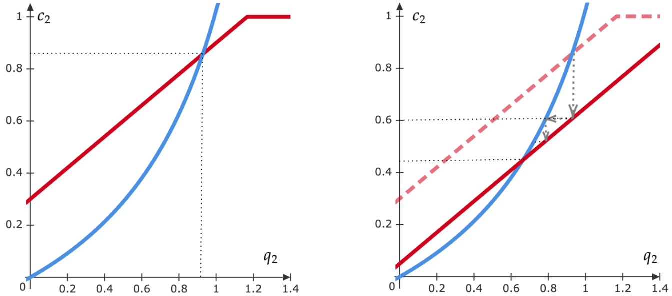
- What if Ω_{t+1} is on $\mathbb{E}_t[q_{t+1}]$?
  - Tightness of collateral constraint at $t = 2$ unaffected by Ω_{t+1}
  - No externality
  - Only belief wedge survives
- Externalities restored when collateral constraint is $\phi H q_2$
- Lian & Ma (2021): 80% of corporate debt is cash flow-based lending

Return to Equilibrium Internal Rationality Learning

Rational Equilibrium: $\phi H q_2$

$$q_2 = \beta c_2 \mathbb{E}_2[z_3] + \phi q_2 (1 - c_2)$$

$$c_2 = \underbrace{z_2 H - d_1(1 + r_1)}_{\text{Net worth } n_2} + \phi H q_2 \quad (\kappa > 0)$$



- Fall in net worth:
  - Decrease in SDF → Fall in asset prices ...
  - → Tightening of collateral constraint → Fall in consumption...
  - → Decrease in SDF → ...
- Pecuniary Externality

▸ REE with future price

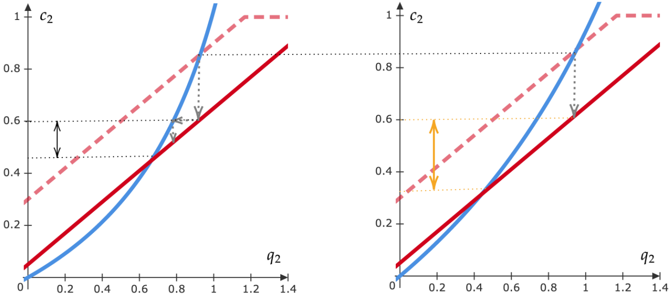
Behavioral Equilibrium: Endogenous Ω_3 with $\phi H q_2$

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3(\mathbf{q_2})] + \phi q_2(1 - c_2)$$

$$c_2 = z_2 H - d_1(1 + r_1) + \phi H q_2 \quad (\kappa > 0)$$

Behavioral Equilibrium: Endogenous Ω_3 with $\phi H q_2$

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3(\mathbf{q_2})] + \phi q_2(1 - c_2)$$
$$c_2 = z_2 H - d_1(1 + r_1) + \phi H q_2 \quad (\kappa > 0)$$



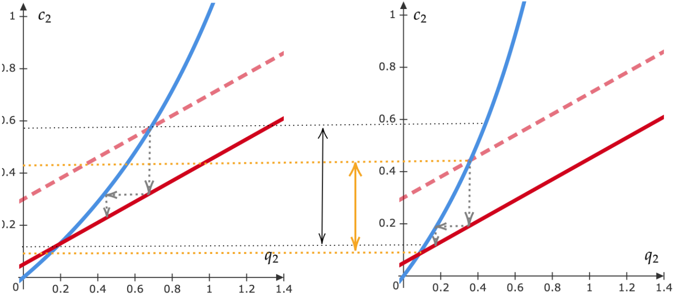
- Fall in net worth:
  - Decrease in SDF $\rightarrow$ Fall in asset prices ...
    1. $\rightarrow$ Tightening of collateral constraint $\rightarrow$ Fall in consumption...
    2. $\rightarrow$ Worsens pessimism $\rightarrow$ Fall in asset prices ...
  - Financial + Belief Amplification

▸ $\Omega_3(q_2)$ with Future price

Behavioral Equilibrium: Exogenous Ω_3 with $\phi H q_2$

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3] + \phi q_2(1 - c_2)$$

$$c_2 = z_2 H - d_1(1 + r_1) + \phi H q_2 \quad (\kappa > 0)$$



- **Constant pessimism**
  - Sentiment is entrenched
  - Financial crises more severe
  - But also less responsive to changes in net worth

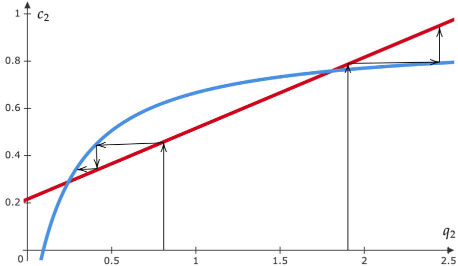
▸ $\Omega_3(z_2)$ with Future price

Multiple Equilibria

- Only when sentiment is endogenous
- The asset price determination is given by:

$$q_2 = \beta\left(n_2 + \phi H \mathbb{E}_2[z_3 + \Omega_3(q_2)]\right)\mathbb{E}_2[z_3 + \Omega_3(q_2)] \\ + \phi(1 - (n_2 + \phi H \mathbb{E}_2[z_3 + \Omega_3(q_2)]))\mathbb{E}_2[z_3 + \Omega_3(q_2)]$$

- Can have arbitrary number of equilibria depending on the shape of $\Omega_3(q_2)$
- For linear $\Omega_3(q_2)$
  - At most two equilibria
  - Only one stable

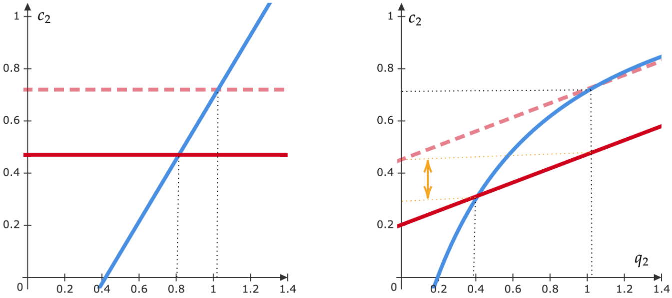


Return

Behavioral Equilibrium: Belief Amplification

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3(q_2)] + \phi(1 - c_2)\mathbb{E}_2[z_3 + \Omega_3(q_2)]$$

$$c_2 = z_2 H - d_1(1 + r_1) + \phi H \mathbb{E}_2[z_3 + \Omega_3(q_2)] \quad (\kappa > 0)$$

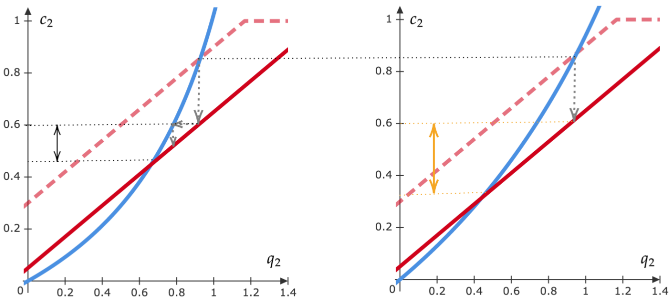


$$\frac{dq_2}{dn_2} = \frac{(\beta - \phi)\mathbb{E}_2[z_3 + \Omega_3]}{1 - (\phi + (\beta - \phi)(2c_2 - n_2))\frac{d\Omega_3}{dq_2}}$$

▸ Sensitivity with $\phi H q_2$ ▸ Behavioral Equilibrium ▸ Collateral Externality d_1

Behavioral Equilibrium: Belief Amplification with $\phi H q_2$

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3(\mathbf{q_2})] + \phi q_2(1 - c_2)$$
$$c_2 = z_2 H - d_1(1 + r_1) + \phi H q_2 \quad (\kappa > 0)$$



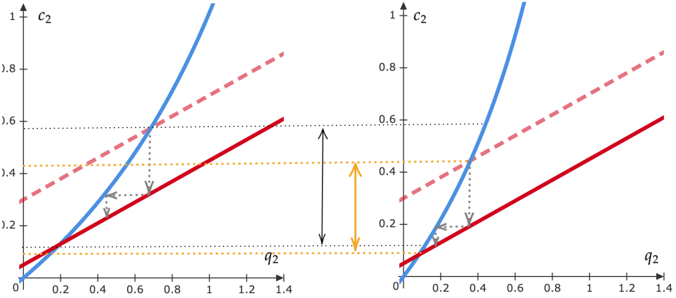
$$\frac{dq_2}{dn_2} = \frac{\beta \mathbb{E}_2\left[z_3 + \Omega_3\right] - \phi q_2}{1 - \beta \phi H\left(\mathbb{E}_2\left[z_3 + \Omega_3\right]\right) + 2\phi^2 H q_2 - c_2 \beta \frac{d\Omega_3}{dq_2}}$$

Exogenous Ω_3 Return

Behavioral Equilibrium: Exogenous Ω_3 and $\phi H q_2$

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3] + \phi q_2 (1 - c_2)$$

$$c_2 = z_2 H - d_1(1 + r_1) + \phi H q_2 \quad (\kappa > 0)$$



$$\frac{dq_2}{dn_2} = \frac{\beta \mathbb{E}_2\left[z_3 + \Omega_3\right] - \phi q_2}{1 - \beta \phi H \left(\mathbb{E}_2\left[z_3 + \Omega_3\right]\right) + 2\phi^2 H q_2}$$

Return

Initial Equilibrium

$$1 = \beta(1+r_1)\mathbb{E}_1\left[\frac{u'(c_2)}{u'(c_1)}\right]$$

$$q_1 = c'(H) = \beta\mathbb{E}_1\left[\frac{u'(c_2)}{u'(c_1)}(z_2 + \Omega_2 + q_2^r)\right]$$

- **Constrained efficiency**
  - Hart (1975); Stiglitz; (1982); Geanakoplos & Polemarchakis (1985)
  - Cannot complete markets
  - No intervention at $t = 2$
  - **REE**: constrained efficient

Externalities with $\phi H q_2$

- Social Planner evaluates welfare using $\mathbb{E}_1^{SP}$
  - Knows Ω_2
  - Internalizes $\Omega_3(z_2, z_1, q_2, q_1)$
- Boom-bust case:
  - $\Omega_2 \geq 0$
  - $\Omega_3 \leq 0$

$$\mathcal{W}_2 = \begin{cases} \beta\ln\left(n_2 + \phi H\mathbb{E}_2[z_3 + \Omega_3]\right) + \beta^2 c_3 & \text{if } z_2 \leq z^* \\ \beta\left(\beta\mathbb{E}^{SP}[z_3]H + n_2\right) & \text{otherwise} \end{cases}$$

Return

Crisis cutoff

- Limiting case: non-constrained Euler equation holds

$$z^* = \frac{1 + d_1(1 + r_1) - \phi H \mathbb{E}_2(z_3 + \Omega_3)}{H}$$

- Objective probability of crisis:

$$F_2\left(\frac{1 + d_1(1 + r_1) - \phi H \mathbb{E}_1(z_3 + \Omega_3)}{H}\right)$$

- Instead
  - Agents neglect their future bias Ω_3
  - Have a current bias Ω_2
- Subjective probability of a crisis:

$$F_2\left(\frac{1 + d_1(1 + r_1) - \phi H \mathbb{E}_1(z_3)}{H} - \Omega_2\right)$$

Initial Equilibrium

Constrained Efficiency of REE

- Private agents have FOC:

$$u'(c_1) = \mathbb{E}_1 \left[\frac{\partial \mathcal{W}_2}{\partial n_2} \right] \tag{9}$$

- Social Planner

$$u'(c_1) = \mathbb{E}_1^{SP} \left[\frac{\partial \mathcal{W}_2}{\partial n_2} + \frac{\partial \mathcal{W}_2}{\partial q_2} \frac{\partial q_2}{\partial n_2} \right] \tag{10}$$

  - Extra-term corresponding to the pecuniary impact of private borrowing decisions
  - But in REE, c_2 set independently of q_2
  - No impact on welfare whatsoever

$$\frac{\partial \mathcal{W}_2}{\partial q_2} = 0$$

- REE constrained efficient
  - Similarly for H

▸ Initial Equilibrium

Constrained Inefficiency of REE with q_2

- Private agents have FOC:

$$u'(c_1) = \mathbb{E}_1 \left[\frac{\partial \mathcal{W}_2}{\partial n_2} \right] \tag{11}$$

- Social Planner

$$u'(c_1) = \mathbb{E}_1^{SP} \left[\frac{\partial \mathcal{W}_2}{\partial n_2} + \frac{\partial \mathcal{W}_2}{\partial q_2} \frac{\partial q_2}{\partial n_2} \right] \tag{12}$$

  - Extra-term corresponding to the pecuniary impact of private borrowing decisions
  - With prices in collateral constraint, welfare impacted

- Collateral externality

$$\mathbb{E}_1 \left[\kappa \phi H \frac{dq_2}{dn_2} \right]$$

- REE constrained inefficient
  - Similarly for H

Initial Equilibrium

Welfare: Leverage

Uninternalized Welfare Effects of d_1

$$\mathcal{W}_d = \underbrace{\left(\mathbb{E}_1[\lambda_2] - \mathbb{E}_1^{SP}[\lambda_2]\right)}_{\text{Belief Wedge}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa\frac{dq_2}{dd_1}\right]}_{\text{Collateral Externality}}$$

Return to $\phi H \mathbb{E}_2[z_3]$

Welfare: Leverage

Uninternalized Welfare Effects of d_1

$$\mathcal{W}_d = \underbrace{\left(\mathbb{E}_1[\lambda_2] - \mathbb{E}_1^{SP}[\lambda_2]\right)}_{\text{Belief Wedge}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa\frac{dq_2}{dd_1}\right]}_{\text{Collateral Externality}}$$

- Two effects drive the Belief Wedge:
  1. Contemporaneous bias Ω_2
  2. Predictable future bias Ω_3

$$\mathcal{B}_d \simeq \underbrace{-\Omega_2 H \mathbb{E}_1^{SP}\left[\lambda_2^2\left(1+\phi\frac{dq_2}{dn_2}\right)\mathbb{1}_{\kappa>0}\right]}_{1.} + \underbrace{\phi H \mathbb{E}_1^{SP}[\Omega_3\lambda_2^2\frac{dq_2}{dz_3}\mathbb{1}_{\kappa>0}]}_{2.}$$

Welfare: Leverage

Uninternalized Welfare Effects of d_1

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- Financial frictions crucial
- Product of:
  - Mistake Ω_2
  - Cost of making a mistake $\mathbb{E}^{SP}\left[\lambda_2^2\left(1+\phi\frac{dq_2}{dn_2}\right)\mathbb{1}_{\kappa>0}\right]$

Return to $\phi H \mathbb{E}_2[z_3]$

Welfare: Leverage

Uninternalized Welfare Effects of d_1

$$\mathcal{W}_d = \underbrace{\left(\mathbb{E}_1[\lambda_2] - \mathbb{E}_1^{SP}[\lambda_2]\right)}_{\text{Belief Wedge}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa\frac{dq_2}{dd_1}\right]}_{\text{Collateral Externality}}$$

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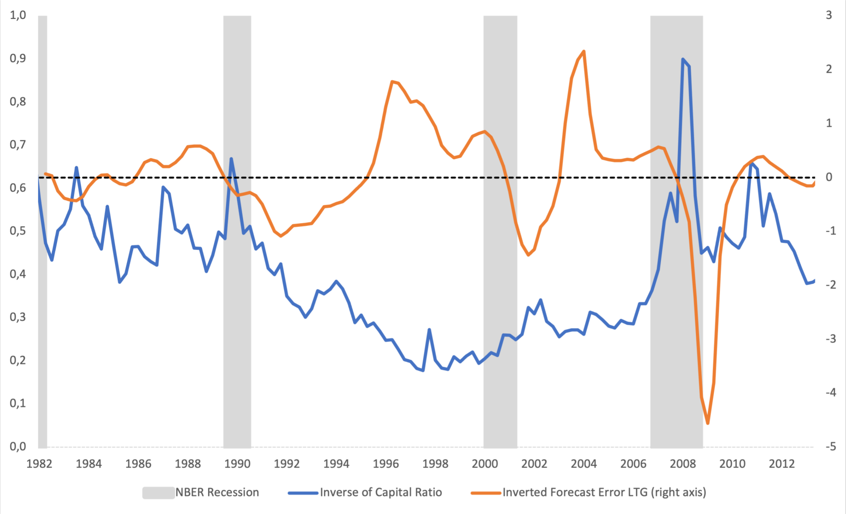
$$\mathcal{B}_d \simeq \underbrace{-\Omega_2 H\mathbb{E}^{SP}\left[\lambda_2^2\left(1+\phi\frac{dq_2}{dn_2}\right)\mathbb{1}_{\kappa>0}\right]}_{1.} + \underbrace{\phi H\mathbb{E}^{SP}\left[\Omega_3\lambda_2^2\frac{dq_2}{dz_3}\mathbb{1}_{\kappa>0}\right]}_{2.}$$

- Predictable losses
- Even if $\Omega_2 = 0$:
  - Future pessimism costly
  - Can even have $\mathbb{E}^{SP}[\Omega_3] = 0$
  - Comovement matters

Return to $\phi H\mathbb{E}_2[z_3]$

Welfare: $\mathbb{E}^{SP}[u'(c_2)\Omega_3 \mathbb{1}_{\kappa>0}]$



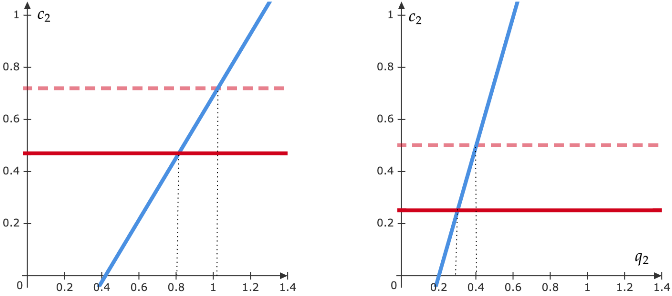
Source: He et al. (2017) ; Bordalo et al. (2020)

▸ High-Yield Share ▸ Credit Spreads ▸ Equity Indicators ▸ Ω_{t+1} and Forecast Errors ▸ Return

Behavioral Equilibrium: Exogenous Ω_3

$$q_2 = \beta c_2 \mathbb{E}_2[z_3 + \Omega_3] + \phi(1 - c_2)\mathbb{E}_2[z_3 + \Omega_3]$$

$$c_2 = z_2 H - d_1(1 + r_1) + \phi H \mathbb{E}_2[z_3 + \Omega_3] \quad (\kappa > 0)$$



Effect of a shock to net worth n_2 when $\Omega_3 < 0$ is exogenous

- Financial crises more severe
- **No** amplification

▸ Equilibrium with $\phi H q_2$ ▸ Household Beliefs ▸ Welfare: Collateral Externality

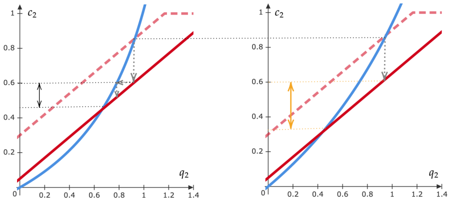
Welfare: Leverage

Uninternalized Welfare Effects of d_1

$$\mathcal{W}_d = \underbrace{\left(\mathbb{E}_1[\lambda_2] - \mathbb{E}_1^{SP}[\lambda_2]\right)}_{\text{Belief Wedge}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa\frac{d\bar{q}_2}{dd_1}\right]}_{\text{Collateral Externality}}$$

- Third effect: price sensitivity in crisis

$$\frac{dq_2}{dd_1} = -\frac{\beta\mathbb{E}_2\left[z_3 + \Omega_3\right] - \phi q_2}{1 - \beta\phi H(\mathbb{E}_2\left[z_3 + \boldsymbol{\Omega_3}\right]) + 2\phi^2 H q_2 - c_2\beta\frac{d\Omega_3}{dq_2}}\frac{1}{\beta}$$



Welfare: Investment

Uninternalized Welfare Effects of H

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[\lambda_2(z_2+q_2)\right]-\lambda_1 q_1\right)}_{\text{Belief Wedge}} + \underbrace{\beta\mathbb{E}_1^{SP}\left[\kappa\left(\phi\frac{dq_2}{dn_2}z_2+\frac{dq_2}{dH}\right)\right]}_{\text{Collateral Externality}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa\frac{dq_2}{d\Omega_3}\frac{d\Omega_3}{dq_1}c''(H)\right]}_{\text{Reversal Externality}}$$

Return to $\phi H\mathbb{E}_2[z_3]$

Welfare: Investment

Uninternalized Welfare Effects of H

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[\lambda_2(z_2+q_2)\right] - \lambda_1 q_1\right)}_{\text{Belief Wedge}} + \underbrace{\beta\mathbb{E}_1^{SP}\left[\kappa\left(\phi\overset{+}{\frac{dq_2}{dn_2}}z_2 + \overset{+}{\frac{dq_2}{dH}}\right)\right]}_{\text{Collateral Externality}}$$

- Collateral externality > 0
- Countervailing effects:
  - Collateral assets ameliorate the net worth of the entire sector
  - Exuberance alleviates this market failure
  - Martin & Ventura (2016)
- Unambiguously negative for large Ω_2

Return to $\phi H \mathbb{E}_2[z_3]$

Welfare: Prices

Uninternalized Welfare Effects of q_1

$$\mathcal{W}_q \quad = \quad \underbrace{\mathbb{E}_1^{SP}\left[\kappa\phi H \frac{dq_2}{d\Omega_3}\frac{d\Omega_3}{dq_1}\right]}_{\text{Reversal Externality}}$$

- Crucial interaction with financial frictions
- Financial + Belief amplification
  - $dq_2/d\Omega_3$ likely sizeable
  - Anchoring effect
  - Price extrapolation flavour:

$$\Omega_3 = \alpha(q_2 - q_1) \implies d\Omega_3/dq_1 = -\alpha$$

- Operative irrespective of contemporaneous exuberance
- Again even if holds the same beliefs as sophisticated agents

Return to $\phi H \mathbb{E}_2[z_3]$

He et. al (2017): Capital Ratio

- Aggregate wealth W_t
- Intermediary's capital ratio:

$$\eta_t = \frac{\text{Equity}_t}{\text{Asset}_t}$$

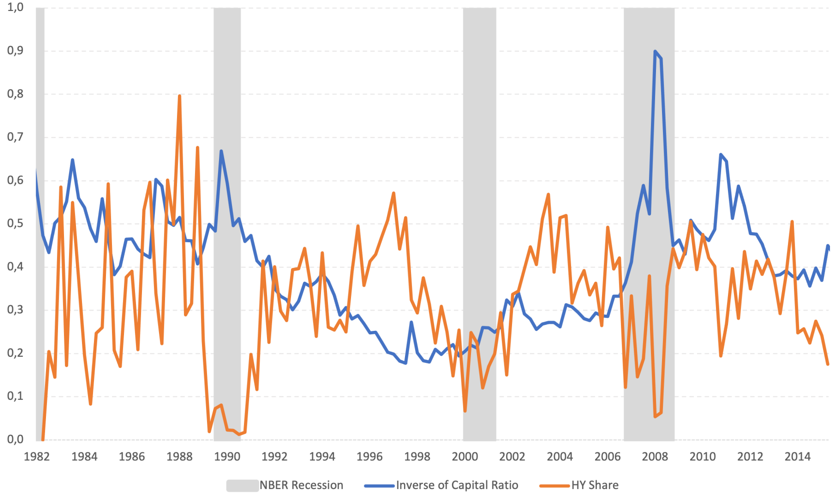
- Assume log utility as in this paper
- Intermediary's marginal value of wealth:

$$\lambda_t = \beta(\eta_t W_t)^{-1}$$

- Pricing kernel is proportional to inverse of capital ratio

▸ Return

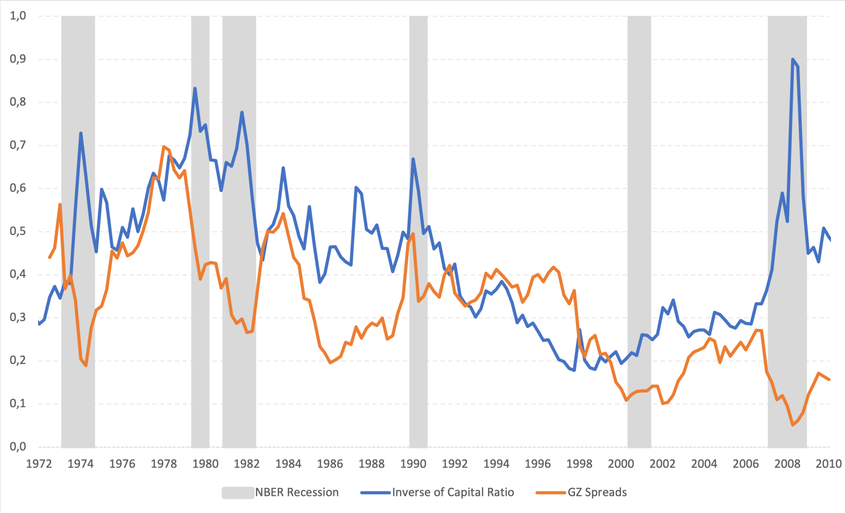
High-Yield Share



Source: Greenwood and Hanson (2013)

Return

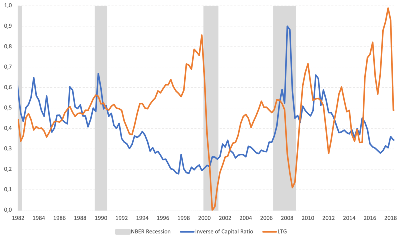
Inverted Credit Spreads

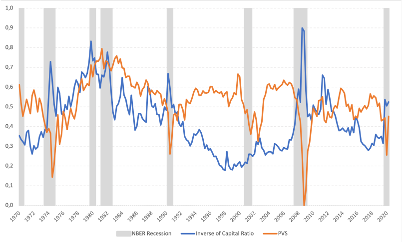


Source: Gilchrist and Zakrajsek (2012)

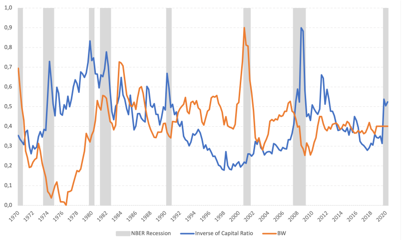
Return

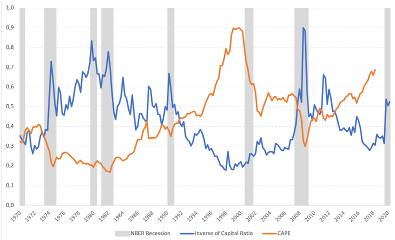
Equity Market Indicators





Source: Bordalo et al. (2020) & Pflueger et al. (2020)





Source: Baker and Wurgler (2007) & Case and Shiller (1996)

Return

Belief Wedge for Investment

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[u'(c_2)(z_2+q_2)\right] - u'(c_1)q_1\right)}_{\text{Belief Wedge}}$$

$$+ \underbrace{\beta\mathbb{E}_1^{SP}\left[\kappa\phi H \frac{d\Omega_3}{dq_2}\left(\frac{dq_2}{dn_2}z_2 + \frac{dq_2}{dH}\right)\right]}_{\text{Collateral Externality}}$$

$$+ \underbrace{\mathbb{E}_1^{SP}\left[\kappa\phi H \frac{d\Omega_3}{dq_1}c''(H)\right]}_{\text{Reversal Externality}}$$

- First-order approximation:

$$\mathcal{B}_H \approx \mathbb{E}_1^{SP}[\mathcal{B}_d(z_2)(z_2+q_2^r)\mathbb{1}_{\kappa>0}]$$
$$- \Omega_2\mathbb{E}_1^{SP}[u'(c_2)(1+(\beta-\phi)Hz_3)\mathbb{1}_{\kappa>0}] + \mathbb{E}_1^{SP}\left[\Omega_3 u'(c_2)\frac{dq_2}{dz_3}\mathbb{1}_{\kappa>0}\right]$$

where:

$$\mathcal{B}_d(z_2) = (\Omega_3 - \Omega_2)u'(c_2)^2$$

Return

Collateral Externality for Investment

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[u'(c_2)(z_2+q_2)\right] - u'(c_1)q_1\right)}_{\text{Belief Wedge}}$$

$$+ \underbrace{\beta\mathbb{E}_1^{SP}\left[\kappa\phi H \frac{d\Omega_3}{dq_2}\left(\frac{dq_2}{dn_2}z_2 + \frac{dq_2}{dH}\right)\right]}_{\text{Collateral Externality}}$$

$$+ \underbrace{\mathbb{E}_1^{SP}\left[\kappa\phi H \frac{d\Omega_3}{dq_1}c''(H)\right]}_{\text{Reversal Externality}}$$

$$\frac{dq_2}{dH} = \frac{(\beta-\phi))z_2 + \phi\mathbb{E}_2[z_3+\Omega_3])\mathbb{E}_2[z_3+\Omega_3]}{1-(\phi+(\beta-\phi)(c_2-\phi H\mathbb{E}_2[z_3+\Omega_3]))\frac{d\Omega_3}{dq_2}}$$

Return

Belief Wedge for Investment with $\phi H q_2$

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[u'(c_2)(z_2+q_2)\right] - u'(c_1)q_1\right)}_{\mathcal{B}_H} + \underbrace{\beta \mathbb{E}_1^{SP}\left[\kappa\left(\phi \frac{dq_2}{dn_2} z_2 + \frac{dq_2}{dH}\right)\right]}_{\text{Collateral Externality}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa \frac{dq_2}{d\Omega_3}\frac{d\Omega_3}{dq_1} c''(H)\right]}_{\text{Reversal Externality}}$$

- First-order approximation:

$$\mathcal{B}_H \approx \mathbb{E}_1^{SP}\left[\mathcal{B}_d(z_2)(z_2+q_2^r)\right] - \Omega_2 \mathbb{E}_1^{SP}\left[u'(c_2)^r\left(1+\frac{dq_2}{dz_2}\right)\mathbb{1}_{\kappa>0}\right] + \mathbb{E}_1^{SP}\left[u'(c_2)^r \Omega_3 \frac{dq_2}{dz_3}\mathbb{1}_{\kappa>0}\right]$$

where:

$$\mathcal{B}_d(z_2) = \Omega_2 u'(c_2)^2\left(H\Omega_2 + \phi\frac{dq_2}{dn_2}\right)\mathbb{1}_{\kappa>0} - \phi H \Omega_3 u'(c_2)^2 \frac{dq_2}{dz_3}\mathbb{1}_{\kappa>0}$$

Return

Collateral Externality for Investment with $\phi H q_2$

$$\mathcal{W}_H = \underbrace{\left(\mathbb{E}_1^{SP}\left[u'(c_2)(z_2+q_2)\right] - u'(c_1)q_1\right)}_{\mathcal{B}_H} + \underbrace{\beta\mathbb{E}_1^{SP}\left[\kappa\left(\phi\frac{dq_2}{dn_2}z_2 + \frac{dq_2}{dH}\right)\right]}_{\text{Collateral Externality}} + \underbrace{\mathbb{E}_1^{SP}\left[\phi\kappa\frac{dq_2}{d\Omega_3}\frac{d\Omega_3}{dq_1}c''(H)\right]}_{\text{Reversal Externality}}$$

$$\frac{dq_2}{dH} = \frac{\beta\phi q_2\mathbb{E}_2\left[z_3+\Omega_3\right] - \phi^2 q_2^2}{1-\beta\phi H\left(\mathbb{E}_2\left[z_3+\Omega_3\right]\right) + 2\phi^2 H q_2 - \beta c_2\frac{d\Omega_3}{dq_2}}$$

▸ Return

Small Deviation from Rationality

- Which features of $\mathcal{W}_d$ and $\mathcal{W}_H$ are first-order when behavioral biases Ω_t are small ?
- For infinitesimal levels of Ω_t, to the first-order:
  - $\mathcal{B}_d = \mathcal{O}(\Omega)$
  - $\mathcal{B}_H = \mathcal{O}(\Omega)$
- But:

$$\mathcal{R}_H = \mathbb{E}_1^{SP}\left[\kappa\phi H \frac{d\Omega_3}{dq_1} c''(H)\right]$$

- Reversal (and collateral) externality order of magnitude above
- Intuition?
  - Agents on their Euler equation at $t = 1$...
  - Negligible welfare effects of perturbation around it
  - Agents away from first-order conditions at $t = 2$...
  - Costly deviations since constrained

Optimal Policy

Heterogeneous Beliefs

- Widespread evidence
  - Giglio, Maggiori, Stroebel, & Utkus (2021); Mian & Sufi (2021); Meeuwis, Parker, Schoar & Simester (2021)
- Intermediaries indexed by $i \in [0, 1]$
  - Intermediary i holds a belief distortion of:

$$\Omega_{2,i} = \Omega_2 + \epsilon_2(2i - 1)$$

  - Assume H in fixed supply to focus on leverage decisions
- Utilitarian social planner maximizes welfare with uniform tax:

$$\tau_d = \frac{\mathbb{E}^{SP}[\bar{u}'(c_2)] - \int_0^i \mathbb{E}_{1,i}[\bar{u}'(c_2)] + \mathbb{E}_1^{SP}\left[\phi H \bar{\kappa} \frac{\partial \Omega_3}{\partial q_2} \frac{\partial q_2}{\partial \bar{n}_2}\right]}{\int_0^i \lambda_{1,i}}$$

- Binding leverage limit more robust and achieves higher welfare

Optimal Policy   Conclusion

Optimal Policy

- Restrictions to internalize $\mathcal{W}_d$ and $\mathcal{W}_H$
  - Capital buffers
  - LTV regulation
- Enough for second-best?

Optimal Policy

- Restrictions to internalize $\mathcal{W}_d$ and $\mathcal{W}_H$
  - Capital buffers
  - LTV regulation
- Enough for second-best?
- In a REE world, achieve financial stability by:

$$\mathcal{W}_2(\boldsymbol{d_1}, \boldsymbol{H}; z_2)$$

Optimal Policy

- Restrictions to internalize $\mathcal{W}_d$ and $\mathcal{W}_H$
  - Capital buffers
  - LTV regulation
- Enough for second-best?
- In a REE world, achieve financial stability by:

$$\mathcal{W}_2(\boldsymbol{d_1}, \boldsymbol{H}; z_2)$$

- With behavioral biases:
  - Similar for **exogenous** sentiment:

$$\mathcal{W}_2(\boldsymbol{d_1}, \boldsymbol{H}; z_2; \Omega_3)$$

Optimal Policy

- Restrictions to internalize $\mathcal{W}_d$ and $\mathcal{W}_H$
  - Capital buffers
  - LTV regulation
- Enough for second-best?
- In a REE world, achieve financial stability by:

$$\mathcal{W}_2(\boldsymbol{d_1}, \boldsymbol{H}; z_2)$$

- With behavioral biases:
  - Similar for **exogenous** sentiment:

$$\mathcal{W}_2(\boldsymbol{d_1}, \boldsymbol{H}; z_2; \Omega_3)$$

  - Breaks down for **endogenous** sentiment:

$$\mathcal{W}_2(\boldsymbol{d_1}, \boldsymbol{H}, \boldsymbol{q_1}; z_2; \Omega_3)$$

- Controlling for allocations is insufficient
  - Past price enters as a state-variable at $t = 2$
  - Need additional instrument
  - $\implies$ Allows for looser regulation for $\boldsymbol{d_1}, \boldsymbol{H}$

Incomplete Information: Role of Endogenous Sentiment

- When sentiment is exogenous:

$$\frac{\partial \mathcal{W}_2}{\partial d_1} = u'(c_2)$$

- If sentiment is endogenous, collateral externality enters:

$$\frac{\partial \mathcal{W}_2}{\partial d_1} = u'(c_2) + \underbrace{\mathbb{E}_1^{SP}\left[\kappa \phi H \frac{d\Omega_3}{dq_2} \frac{dq_2}{dn_2}\right]}_{\text{Collateral Externality}}$$

- Generally **accentuates** the need for preventive intervention

Ω_3-Uncertainty and Endogenous Sentiment

The uncertainty part of the optimal leverage tax is **higher** when $d\Omega_3/dq_2$ is constant, as in the price extrapolation example.

- Adds curvature in marginal welfare
- Increases costs of excessive pessimism and decreases relative benefits of relative optimism
- Result robust as long as $d\Omega_3/dq_2$ is not too concave in z_2 and z_3

Ω_2-Uncertainty

Incomplete Information: Ω_3-Uncertainty

- Assume that, state-by-state:

$$w_3 \sim \mathcal{U}\left[\bar{\Omega}_3 - \sigma_{\Omega,3}, \bar{\Omega}_3 + \sigma_{\Omega,3}\right]$$

Ω_3-Uncertainty and Leverage Restrictions

The optimal leverage tax is **increasing** in $\sigma_{\Omega,3}$. It is strictly increasing as long as there exist a state z_2, where average sentiment is $\bar{\Omega}_3$ and a ω_3 in $[-\sigma_{\Omega,3}, \sigma_{\Omega,3}]$ for which, if sentiment is $\bar{\Omega}_3 + \omega_3$, there is a positive probability of a crisis in the next period.

- Same curvature in marginal welfare
- Costs of excessive pessimism outweigh benefits of relative optimism

Ω_2-Uncertainty

REEE Calibration Mistakes

- Size of pecuniary externality is a structural object:

$$\mathbb{E}_1\left[\phi\kappa\frac{dq_2}{dn_1}\right]$$

- Rational models calibrate parameters (ϕ, $F(z)$, ...) combining:
  1. Severity/Probability of financial crisis
  2. Rational Expectations

- Calibrate a model such that in a crisis, prices drop by $X\%$

- Recover size of financial frictions:

$$X^{-1} = 1 + \frac{Hz_2}{2(1+\delta) - \phi Hz_2}$$

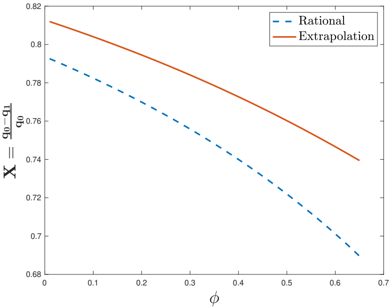
- Larger $X \implies$ Smaller $\phi \implies$ Smaller pecuniary externality:

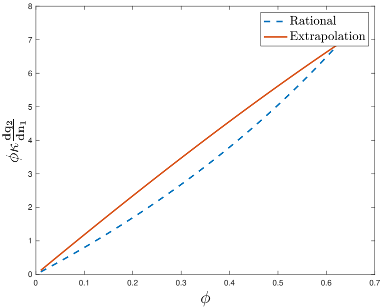
$$\frac{dq_2^r}{dn_1} = \frac{z_2}{1+\delta - \phi Hz_3}$$

Optimal Policy Conclusion

REE Calibration Mistakes (2)

$$\frac{dq_2}{dn_1} = -\frac{z_3 + \alpha(q_2 - q_1)}{1 + \delta - \phi H(z_3 + \theta(q_2 - q_1)) - \alpha c_2}$$





RMBS Optimal Policy Conclusion

Incomplete Information: Time-varying Policy

- The Social Planner:
  1. Holds gaussian priors over $\bar{z}_2$ and Ω_2:
  $$\bar{z}_2 \sim \mathcal{N}\left(\mu_z, \sigma_z^2\right) \quad ; \quad \Omega_2 \sim \mathcal{N}\left(\bar{\Omega}_2, \sigma_\Omega^2\right)$$
  2. Computes expectations over sentiment using a uniform distribution that minimizes the KL divergence with its posterior
- $\bar{\Omega}_2 \quad \rightarrow \quad \mathcal{W}_d \quad \rightarrow \quad \tau_d$
- Posterior:

$$\Omega_2 \sim \mathcal{U}\left[\bar{\Omega}(q_1) - \sqrt{\frac{3}{2}}\Sigma_\Omega \quad , \quad \bar{\Omega}(q_1) + \sqrt{\frac{3}{2}}\Sigma_\Omega\right]$$

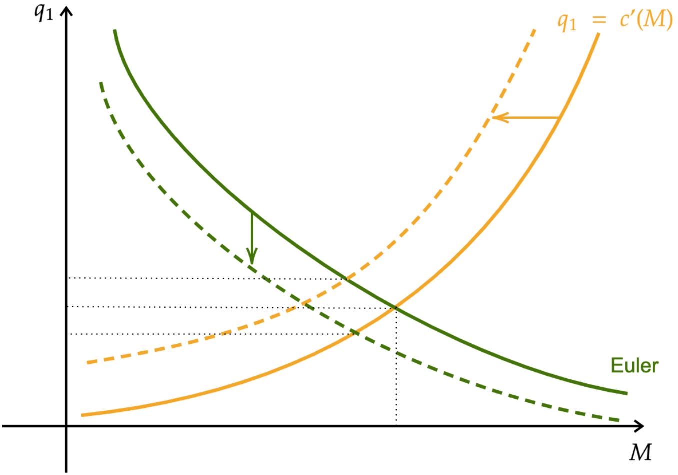
Ω-Uncertainty and Time Variation

The social planner's optimal leverage tax is increasing in both equilibrium prices q_1 and sentiment uncertainty σ_Ω.

- The more certain the planner is about z_2, the less uncertainty it has over Ω_2
- The less uncertainty there is about sentiment, the more the planner can adapt its leverage limits to observable conditions like asset prices

Buyer vs Seller Regulation

Equilibrium determination on the collateral asset market



▸ Return

Bailouts

- The planner can intervene during a crisis
  - Direct liquidity injection b to banks at $t = 2$
  - Paid back at market rate at $t = 3$
  - Cost $g(b)$

- Effect on welfare:

$$\mathcal{W}_2(d_1 - b, H; z_2) - g(b)$$

- Quadratic cost $g(b) = {}^{b^2}/_{2\xi}$

- Optimal bailout size:

$$b^* = \xi \frac{\partial \mathcal{W}_2}{dn_1} \equiv b^*(d_1, H, z_2, \Omega_3)$$

- Uninternalized welfare effects formulas hold

Conclusion

Moral Hazard & Exogenous Exuberance

$$u'(c_0) = \mathbb{E}\left[\frac{\partial \mathcal{W}_2}{dn_1}\left(d_1 - \underbrace{b^*(d_1, H, z_2 + \Omega_2, 0)}_{<b^*(d_1, H, z_2, \Omega_3)}, H, z_2 + \Omega_2\right)\right]$$

- Agents expect future bailouts
- Exuberance makes expected bailouts less than in reality:

$$\frac{\partial b^*}{\partial \Omega_2} < 0$$

- Similarly when agents neglect future pessimism
- **Reduces** the belief wedge

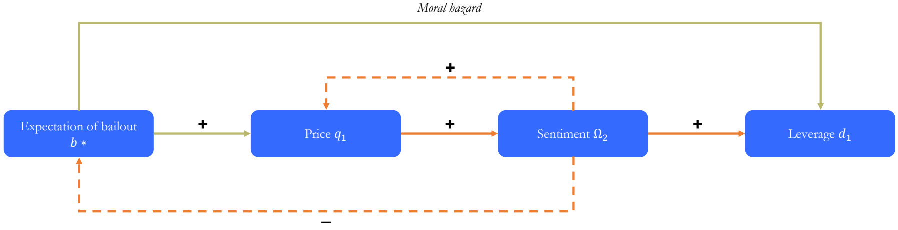
Conclusion

Moral Hazard & Endogenous Exuberance (1)

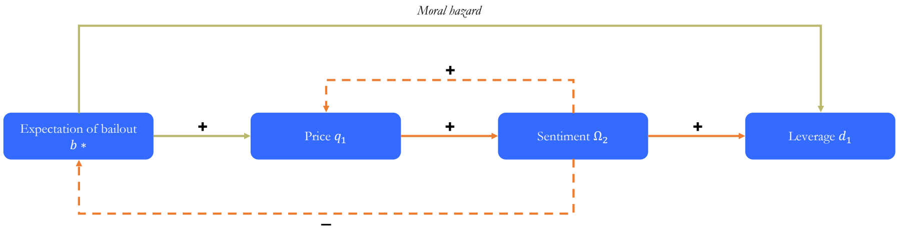
$$u'(c_1) = \mathbb{E}_1 \left[\frac{\partial \mathcal{W}_2}{dn_1} \left(d_1 - b^*(d_1, H, z_2 + \Omega_2(q_1 - q_0)), H, z_2 + \Omega_2(q_1 - q_0) \right) \right]$$

$$q_1 = \mathbb{E}_1 \left[\frac{\partial \mathcal{W}_2}{dH} \left(d_1 - b^*(d_1, H, z_2 + \Omega_2(q_1 - q_0)), H, z_2 + \Omega_2(q_1 - q_0) \right) \right]$$

Moral Hazard & Endogenous Exuberance (2)



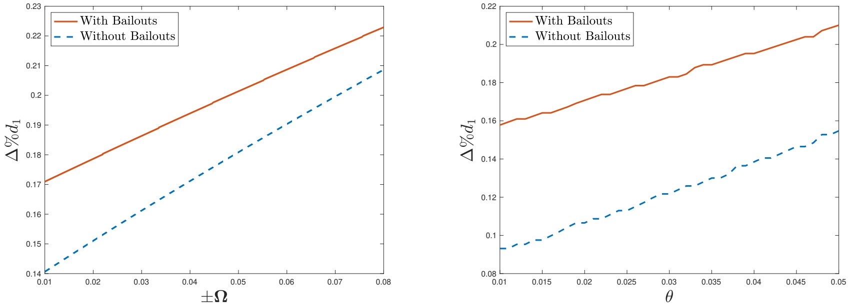
Moral Hazard & Endogenous Exuberance (2)



- Bailouts also exacerbate exuberance
  - Expected bailout $\Longrightarrow$ Higher asset prices
  - $\Longrightarrow$ Higher exuberance $\Longrightarrow$ Higher leverage
  - $\Longrightarrow$ ...
- Timing crucial
  - Jump $q_1 - q_0$ creates moral hazard problems
  - Bailouts to be announced as **early** as possible

▸ Conclusion

Moral Hazard & Exuberance



Excess Fragility for Exogenous Ω (left) and Price Extrapolation (right)

‣ Conclusion

Infinite Horizon Model

- Financial intermediaries:

$$U_t = \sum_{i \geq 0}^{+\infty} \beta^{t+i} \ln(c_{t+i})$$

- Households:

$$U_t^h = \sum_{i \geq 0}^{+\infty} \beta^{t+i} c_{t+i}^h$$

- Fixed stock of H
- Budget constraint of financial intermediaries:

$$c_t + d_{t-1}(1 + r_{t-1}) + q_t h \leq d_t + (z_t + q_t)H$$
$$d_t \leq \phi h \mathbb{E}_t[z_{t+1} + \Omega_{t+1}]$$

- First-order conditions:

$$\lambda_t = \frac{1}{c_t}$$
$$\lambda_t = \beta(1 + r_t)\mathbb{E}_t[\lambda_{t+1}] + \kappa_t$$
$$\lambda_t q_t = \beta \mathbb{E}_t[\lambda_{t+1}(z_{t+1} + \Omega_{t+1} + q_{t+1}^r)] + \phi \kappa_t \mathbb{E}_t[z_{t+1} + \Omega_{t+1}]$$

▸ Return to Extensions

Infinite Horizon: Policy

- Instruments: tax on borrowing, and tax on asset holdings
  - Tax on holdings to change equilibrium prices
  - In practice can use monetary policy
- Planner intervenes only once and commits to never intervene again
- Planner chooses directly d_t and q_t at t, and takes as given the future values of d_{t+j} and q_{t+j}

$$\mathcal{W}_t = \ln(c_t) + \beta \mathbb{E}_t[\mathcal{W}_{t+1}(d_t, q_t)]$$

- The first-order conditions of the social planner are given by:

$$0 = \lambda_t - \beta \mathbb{E}_t[\lambda_{t+1}] - \sum_{j \geq 1}^{+\infty} \beta^{t+j} \mathbb{E}_t \left[\kappa_{t+j} \phi H \frac{d\Omega_{t+j}}{dq_{t+1}} \frac{dq_{t+1}}{dn_{t+1}} \right]$$

$$0 = \sum_{j \geq 0}^{+\infty} \beta^{t+j} \mathbb{E}_t \left[\kappa_{t+j} \phi H \frac{d\Omega_{t+j}}{dq_t} \right]$$

▸ Return to Extensions

Infinite Horizon: Policy (2)

$$0 = \lambda_t - \beta \mathbb{E}_t[\lambda_{t+1}] - \sum_{j \geq 1}^{+\infty} \beta^{t+j} \mathbb{E}_t \left[\kappa_{t+j} \phi H \frac{d\Omega_{t+j}}{dq_{t+1}} \frac{dq_{t+1}}{dn_{t+1}} \right]$$

$$0 = \sum_{j \geq 0}^{+\infty} \beta^{t+j} \mathbb{E}_t \left[\kappa_{t+j} \phi H \frac{d\Omega_{t+j}}{dq_t} \right]$$

- Planner manipulates
  1. How future sentiment will be affected by future prices since a change in borrowing today impact prices tomorrow
  2. How future sentiment will be affected by current prices
- $d\Omega_{t+j}/dq_{t+1}$ are taking into account the full effects on Ω_{t+j}
  - Factors in how q_{t+1} directly impact Ω_{t+2}
  - And how Ω_{t+1} changes q_{t+2} and thus Ω_{t+2}

Return to Extensions

Monetary Policy: Setup

- Natural instrument to tame asset prices
- Enrich environment with:
  - Households supply labor at $t = 1$:

$$U^h = \mathbb{E}_1 \left[\left(\ln(c_1^h) - \nu \frac{v {l_1}^{1+\eta}}{(1+\eta)} \right) + \beta c_2^h + \beta^2 c_3^h \right]$$

  - **Nominal rigidities**: fully rigid wages $w = 1$
  - Linear production: $Y_1 = l_1$
  - Neutralize distributive effects with Pareto weights

Monetary Policy: Setup

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  - **Nominal rigidities**: fully rigid wages $w = 1$
  - Linear production: $Y_1 = l_1$
  - Neutralize distributive effects with Pareto weights

- Households can be off their labor supply curve at $t = 1$

- Labor wedge: Farhi & Werning (2020)

$$\mu_1 = 1 - \nu c_1^h l_1^\eta$$

- Positive when unemployment is high

Monetary Policy

Leaning Against the Wind: Full Effects

- Monetary tightening has five effects:
  1. Aggregate Demand
  2. Borrowing
  3. Investment
  4. Current Beliefs
  5. Future Beliefs

Welfare Effects of Monetary Policy

$$\frac{d\mathcal{W}_1}{dr_1} = \underbrace{\frac{dY_1}{dr_1}\mu_1}_{(i)} + \underbrace{\frac{dd_1}{dr_1}\mathcal{W}_d}_{(ii)} + \underbrace{\frac{dH}{dr_1}\mathcal{W}_H}_{(iii)}$$

$$+ \underbrace{\frac{d\Omega_2}{dq_1}\frac{dq_1}{dr_1}\left(\frac{dd_1}{d\Omega_2}\mathcal{W}_d + \frac{dH}{d\Omega_2}\mathcal{W}_H\right)}_{(iv)} + \underbrace{\mathbb{E}_1\left[\kappa\phi H\frac{d\Omega_3}{dq_1}\frac{dq_1}{dr_1}\right]}_{(v)}$$

▸ Monetary Policy

Leaning Against the Wind with $\phi H q_2$

Welfare Effects of Monetary Policy

$$\frac{d\mathcal{W}_1}{dr_1} = \underbrace{\frac{dY_1}{dr_1}\mu_1}_{(i)} + \underbrace{\frac{dd_1}{dr_1}\mathcal{W}_d}_{(ii)} + \underbrace{\frac{dH}{dr_1}\mathcal{W}_H}_{(iii)} + \underbrace{\frac{d\Omega_2}{dq_1}\frac{dq_1}{dr_1}\left(\frac{dd_1}{d\Omega_2}\mathcal{W}_d + \frac{dH}{d\Omega_2}\mathcal{W}_H\right)}_{(iv)} + \underbrace{\mathbb{E}_1\left[\kappa\phi H\frac{dq_2}{d\Omega_3}\frac{d\Omega_3}{dq_1}\frac{dq_1}{dr_1}\right]}_{(v)}$$

▸ Monetary Policy with future price

Early vs. Late Tightening

- Protracted periods of credit and asset price growth
  - Greenwood et al. (2021)
  - Tighten early or late?
- Specific case: $\Omega_{t+1} = \alpha q_t + \alpha_{-1} q_{t-1} + \alpha_{-2} q_{t-2}$
  - More general case in the paper
  - Assume dq_t/dr_t constant
- Consider **surprise** tightenings at $t = 0$ or at $t = 1$

Show

Comparison of Early and Late Leaning Against the Wind

It is optimal to lean against the wind in period 1 rather than in period 0 if and only if:

$$-\frac{dd_1}{d\Omega_2}\mathcal{W}_d\left(\alpha - \alpha_1\right) > \mathbb{E}_1\left[\frac{dq_2}{d\Omega_3}\kappa\phi H\right]\left(\alpha_{-1} - \alpha_{-2}\right)$$

- $\alpha_{-2} < 0$
  - Early tightening
- $\alpha_{-1} < 0$:
  - Late tightening to balance reversal externality
  - Early tightening backfires: kicking the can down the road
  - Galí & Gambetti (2015) ; Galí, Giusti & Noussair (2021)

Return
Conclusion

Dynamic Bias: Setup

- Policy **anticipated** once part of the toolbox
  - Consequences?

$$U^h = \mathbb{E}_0 \left[\left(\ln(c_0^h) - \nu \frac{l_0^{1+\eta}}{(1+\eta)} \right) + \left(\ln(c_1^h) - \nu \frac{l_1^{1+\eta}}{(1+\eta)} \right) + \beta c_2^h + \beta^2 c_3^h \right]$$

- Assume:
  1. Expectations of future rates:

$$r_1^e = r_1^* + \boldsymbol{\rho}(q_1 - \bar{q})$$

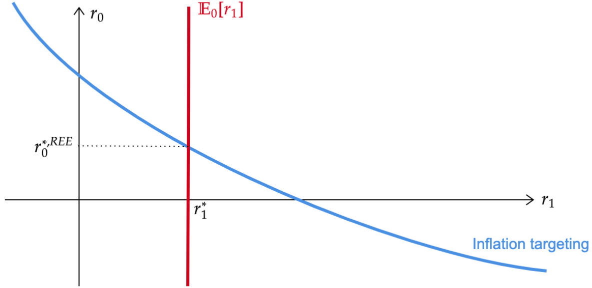
  2. Extrapolative expectations:

$$\mathbb{E}_0[q_1] = q_1^r + \alpha(q_0 - q_{-1})$$

- Inflation targeting at REE:

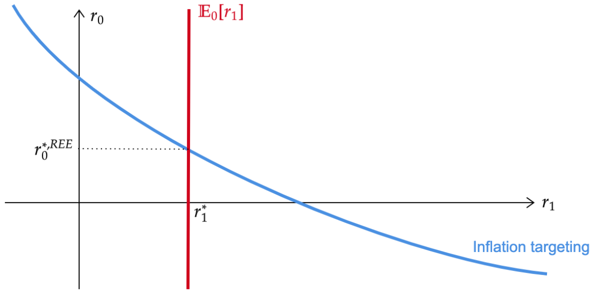
$$\beta^2(1 + r_0^*)(1 + r_1^*) = 1$$

Inflation Targeting: Rational Benchmark

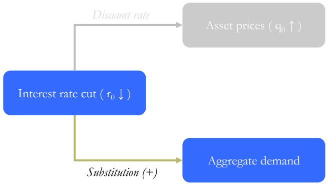


Interest rate determination at $t = 0$ in the REE case

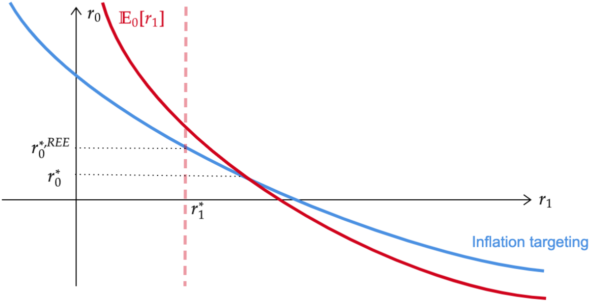
Inflation Targeting: Rational Benchmark



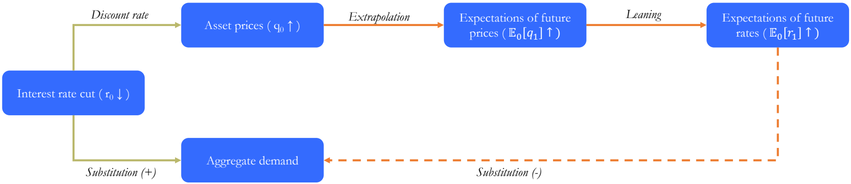
Interest rate determination at $t = 0$ in the REE case



Inflation Targeting: Extrapolation



Interest rate determination at $t = 0$ in the extrapolation case



Dynamic Bias of Leaning Against the Wind

Optimal Inflation Targeting at $t = 0$

The optimal interest rate at $t = 0$ can be expressed as, in a first-order approximation around the rational benchmark $\alpha \to 0$:

$$1 + r_0^* \approx \frac{\frac{1}{\beta^2} - \rho \alpha q_1^r}{1 + r_1^* - \rho \alpha q_{-1}}$$

- Numerator: r_0^* needs to be lower to account for the increase in $\mathbb{E}_0[r_1]$
- Denominator: feedback effect

Dynamic Bias of Leaning Against the Wind

Optimal Inflation Targeting at $t = 0$

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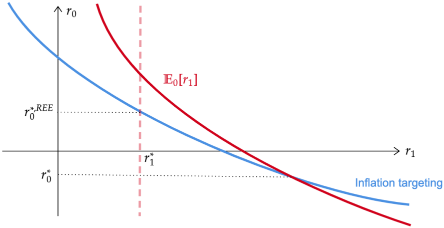
$$1 + r_0^* \approx \frac{\frac{1}{\beta^2} - \rho\alpha q_1^r}{1 + r_1^* - \rho\alpha q_{-1}}$$

- Numerator: r_0^* needs to be lower to account for the increase in $\mathbb{E}_0[r_1]$
- Denominator: feedback effect
- Trouble when $r_0^* < 0$



Early vs. Late Tightening: General Case

- More general case
  - Allows for sticky/mean-reversion in beliefs

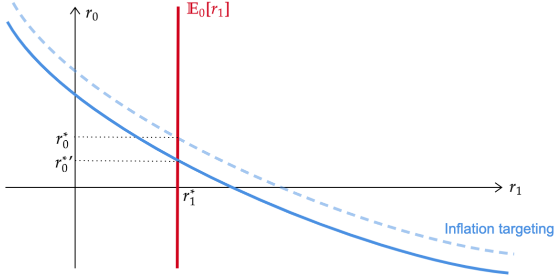
$$\Omega_{t+1} = \alpha_0 q_t + \alpha_1 q_{t-1} + \alpha_2 q_{t-2} + \gamma_0 \Omega_t + \gamma_1 \Omega_{t-1}$$

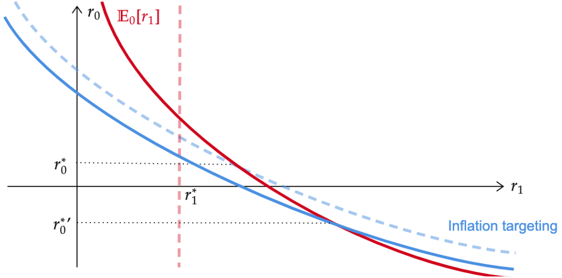
It is optimal to lean against the wind in period 1 rather than in period 0 if and only if:

$$-\frac{dd_1}{d\Omega_2}\mathcal{W}_d\left(\alpha_0(1-\gamma_0)-\alpha_1\right) > \mathbb{E}_1\left[\frac{dq_2}{d\Omega_3}\kappa\phi H\right]\left((\gamma_0\alpha_0+\alpha_1)(1-\gamma_0)-\gamma_1\alpha_0-\alpha_2\right)$$

- Same insights
- $\gamma_0 > 0$:
  - Exuberance today makes agents more optimistic tomorrow
  - Tightening later in the cycle has ambiguous effects
  - Trade-off between making the financial system less fragile, and creating irrational distress in the future which can itself trigger a financial crisis

Monetary Policy: Demand Shocks





Can a Monetary Tightening Trigger a Crisis?

- So far assumed collateral constraint binding only at $t = 2$
- Add the possibility at $t = 1$:

$$d_1 \leq \phi h \mathbb{E}_1[z_2 + \Omega_2]$$

- New costs if collateral constraint tight at $t = 1$
  - Monetary tightening leads to a reduction in leverage
  - Costly if banks would like to take more leverage

Welfare Effects of Monetary Policy

$$\frac{d\mathcal{W}_1}{dr_1} = \frac{dY_1}{dr_1}\mu_1 + \frac{dd_1}{dr_1}\kappa_1 + \mathbb{E}_1\left[\kappa_2 \phi H \frac{d\Omega_3}{dq_1}\frac{dq_1}{dr_1}\right]$$

- Welfare costs proportional to tightness of constraint at $t = 1$
- Costs are negligible to the first order if banks are not constrained
- Tradeoff unchanged with the employment channel

▸ LAW ▸ Conclusion

Can a Monetary Tightening Trigger a Crisis?

- Can monetary policy provoke a binding constraint at $t = 1$?
- A monetary tightening will change the upper limit as:

$$\phi H \frac{d\Omega_2}{dq_1} \frac{dq_1}{dr_1}$$

- Will provoke the crisis if reduction in debt limit is stronger than reduction in desired leverage:

$$-\frac{d \ln \Omega_2}{d \ln r_1} \geq \frac{1}{\phi(1+\beta)(1+r_1) - 1}$$

- Model argues for *less aggressive accomodation*
  - Not aggressive tightening

▸ LAW ▸ Conclusion