The Fed Put and Monetary Policy
An Imperfect Knowledge Approach

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European Economic Association
Annual Congress

August 23rd, 2022

Should Monetary Policy take into account stock prices?

Motivation

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2. Should central banks include stock prices in their monetary policy strategy?

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2. **Should central banks include stock prices in their monetary policy strategy?**

Current Paradigm:

- monetary policy should **NOT** take into account stock prices (**supply side**, Bernanke *et. al.* (1999,2001))
- result overturn by Winkler (2020, 2021)

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This paper aims at filling this gap

This Paper

Theoretical framework:

- Decoupling of stock prices from fundamentals due to imperfect information $\Longrightarrow$ consumption wealth effect $\Longrightarrow$ Aggregate Demand (absent under RE)

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Results

- quantitatively the model replicates the joint behavior of stock prices, business cycle and survey expectations
- monetary policy should take into account stock prices
  - Responding symmetrically is superior to reacting only in busts (FED Put) under non-transparency
  - Transparency is key in eliminating the inefficiencies arising from sentiment driven asset price cycles

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Policy Recommendation: announce 12 bp increase in policy rates for every 100% increase in stock prices $\longrightarrow$ 12% reduction in the cost of business cycles

Roadmap

1. Wealth Effects in endowment economies $\longrightarrow$ Intuition
2. Quantitative model and Estimation
3. Monetary Policy and Welfare

Facts

1. **Volatility Puzzle**

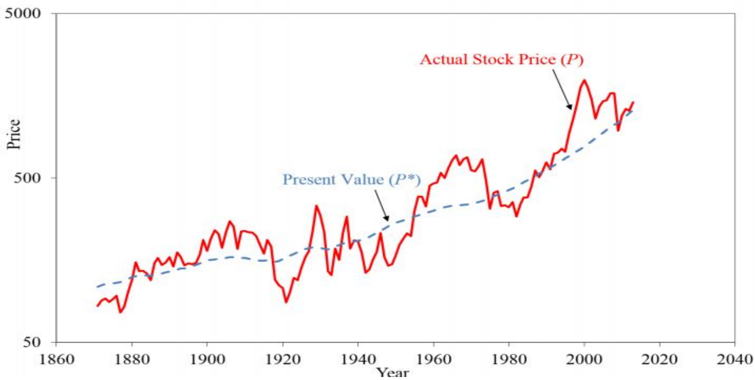

Figure 1. *Do Stock Prices Move Too Much to be Justifed by Subsequent Changes in Dividends?* (Shiller,1981) (Updated)

2. **Stock Price Wealth effects:** Case & Shiller (2001,2013), Chodorow-Reich *et al.* (2020), Di Maggio *et al.* (2020): estimates vary **2%-20%**

Wealth Effects in Endowment Economies
Households

- continuum of identical households
- agent i solves:

$$\max_{C_t^i, B_t^i, S_t^i} E_0^{\mathscr{P}_i} \sum_{t=0}^{\infty} \delta^t \frac{(C_t^i)^{1-\sigma}}{1-\sigma}$$
$$s.t. \quad P_t C_t^i + B_t^i + S_t^i Q_t \leq B_{t-1}^i (1 + i_{t-1}) + S_{t-1}^i (Q_t + D_t) \tag{1}$$

where $D_t \sim \mathscr{N}(\mu, \sigma^2)$ and $i_t = \phi_\pi \pi_t$

- FOCs are standard except the expectation operator
- Equilibrium: $\int_0^1 B_t^i \, di = 0, \; \int_0^1 C_t^i \, di = C_t = d_t, \; \int_0^1 S_t^i \, di = 1.$

Endowment Economy

Rational Expectations (RE)

- under RE agents know the mapping from dividends to prices
- the agent can apply the Law of Iterated Expectations (LIE) to the asset pricing FOC to obtain

$$q_t = E_t \sum_{j=1}^{\infty} \delta^j \left(\frac{C_{t+j}}{C_t} \right)^{-\sigma} d_{t+j}. \quad (2)$$

Optimal consumption decision under RE

$$\tilde{C}_t = (1-\delta) E_t \sum_{j=0}^{\infty} \delta^j \tilde{d}_{t+j} - \frac{1}{\sigma} \delta E_t \sum_{j=0}^{\infty} \delta^j (i_{t+j} - \pi_{t+j+1}). \quad (3)$$

RE equilibrium

$$\boldsymbol{\pi_t} = -\frac{\sigma}{\phi_\pi} \boldsymbol{\tilde{d}_t}. \quad (4)$$

Endowment Economy
Imperfect Knowledge

- agents
  - *internally rational* (IR)
  - identical but *they do not know this to be true*
- under imperfect knowledge we cannot apply the LIE to obtain equation (2)
- in this environment, the *optimality condition for stock prices is of the one-step ahead form*

$$q_t = \delta E_t^{\mathscr{P}} \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} (d_{t+1} + q_{t+1}) \right]. \tag{5}$$

Why?

Endowment Economy

Imperfect Knowledge

Optimal consumption decision under Imperfect Knowledge & IR

$$\tilde{C}_t \approx \overbrace{(1-\delta)E_t^{\mathscr{P}} \sum_{j=0}^{\infty} \delta^j \tilde{d}_{t+j} - \frac{\delta}{\sigma} E_t^{\mathscr{P}} \sum_{j=0}^{\infty} \delta^j (i_{t+j} - \pi_{t+j+1})}^{\text{RE Solution}}$$

- under Imperfect Knowledge, the *stock price wealth effect arises due to a wedge between actual stock prices and perceived fundamental value*

Endowment Economy

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Optimal consumption decision under Imperfect Knowledge & IR

$$\tilde{C}_t \approx \overbrace{(1-\delta)E_t^{\mathscr{P}}\sum_{j=0}^{\infty}\delta^j\tilde{d}_{t+j} - \frac{\delta}{\sigma}E_t^{\mathscr{P}}\sum_{j=0}^{\infty}\delta^j(i_{t+j}-\pi_{t+j+1})}^{\text{RE Solution}}$$

$$+ \underbrace{\underbrace{\delta\tilde{q}_t}_{\text{Stock Prices}} \underbrace{-(1-\delta)\left[E_t^{\mathscr{P}}\sum_{j=1}^{\infty}\delta^j\tilde{d}_{t+j} - \frac{\delta}{1-\delta}E_t^{\mathscr{P}}\sum_{j=0}^{\infty}\delta^j(i_{t+j}-\pi_{t+j+1})\right]}_{\text{Discounted sum of Dividends}}}_{\textbf{Wealth Effect = 0 under Rational Expectations}}$$

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Endowment Economy

Imperfect Knowledge: Beliefs

- Coibion & Gorodnichenko (2011, 2015) show that survey expectations depart from RE

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- similarly to RE, agents have perfect knowledge about $\tilde{d}_t, i_t$

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Assume:

- similarly to RE, agents have perfect knowledge about $\tilde{d}_t, i_t$
- agents think that inflation and stock prices follow an unobserved component model

$$\begin{aligned} x_t &= \beta_t^x + \epsilon_t \\ \beta_t^x &= \beta_{t-1}^x + \psi_t \end{aligned} \tag{6}$$

where $x = (\tilde{q}, \pi)'$.

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- optimal filter:

$$E_t^{\mathscr{P}}(\beta_t^x) = \hat{\beta}_t^x = \hat{\beta}_{t-1}^x + \lambda(x_t - \hat{\beta}_{t-1}^x) \tag{7}$$

- consistency of these beliefs with survey data will be checked in the quantitative version of the model

Endowment Economy

Imperfect Knowledge: Equilibrium

Learning Equilibrium

$$\boldsymbol{\pi_t} = \frac{\delta\sigma}{\phi_\pi}\boldsymbol{\hat{\beta}^{q}_{t-1}} - \Big[\frac{\sigma}{\phi_\pi} - \frac{(1-\sigma)(\delta\phi_\pi - 1)}{(1-\delta)\phi_\pi}\Big]\boldsymbol{\hat{\beta}^{\pi}_{t-1}} - \frac{\sigma}{\phi_\pi}\boldsymbol{\tilde{d}_t}. \quad (8)$$

- imperfect knowledge about stock prices influences the equilibrium relation of inflation
- parallel to Eusepi, Preston (2018)

The Model
Economic Environment

- Limited Asset Market Participation **NK** model with a stock market + **Imperfect Knowledge**

Agents

1. Households
   - Internally rational; heterogeneous regarding participation in the stock market
2. Other agents: Intermediary Firms, Final Good producers, Mutual Fund (owns firms & issue 1 share), Central Bank (Taylor Rule)

Beliefs: agents learn about $z_t = (\tilde{y}_t, \tilde{\pi}_t, \tilde{q}_t, \tilde{d}_t, \tilde{w}_t)'$.

Shocks: cost push, monetary policy, sentiment shock

Model Blocks Belief Shock

Quantitative Performance
Data vs Model

Business Cycle	Symbol	Data Moment	Learning Model Moment	Learning Model t-ratio	RE Model
Std. dev. of output	$\sigma(y)$	1.45	1.47	-0.39	0.87
Std. dev. of inflation	$\sigma(\pi)$	0.54	0.45	1	0.36
Correlation output/inflation	$\rho_{y,\pi}$	0.29	0.26	0.36	-1
Financial Moments					
Average PD ratio	E (Q/ D)	154	154	-0.38	132
Std. dev. of PD ratio	$\sigma(Q/D)$	63	65	-0.34	9
Auto-correlation of PD ratio	$\rho(Q/D)$	0.99	0.96	0.57	0.85
Std. dev. of equity return (%)	$\sigma(r^e)$	6.02	6.05	0.04	0.55
Std. dev. real risk free rate (%)	$\sigma(r^f)$	0.72	0.8	0.59	0.11
Non Targeted moments					
volatility ratio stock prices/output	$\sigma(Q)/\sigma(y)$	6.7	5.2	2	0.76
corr. Stock Prices/ output	$\rho(Q,y)$	0.5	0.45	0.53	1
Consumption Wealth Effect	dy/dQ	[0.02-0.2]	0.09		0
Std. dev. Expected Returns(%)	$\sigma(E_t(r^e_{t,t+4}))$	2.56	1.8		0.46
corr. Survey Expect./ PD ratio	$\rho(PD_t, E_t(r^e_{t,t+4}))$	0.74	0.45		-1

Table 1. Model implied moments Parameters Belief Dynamics

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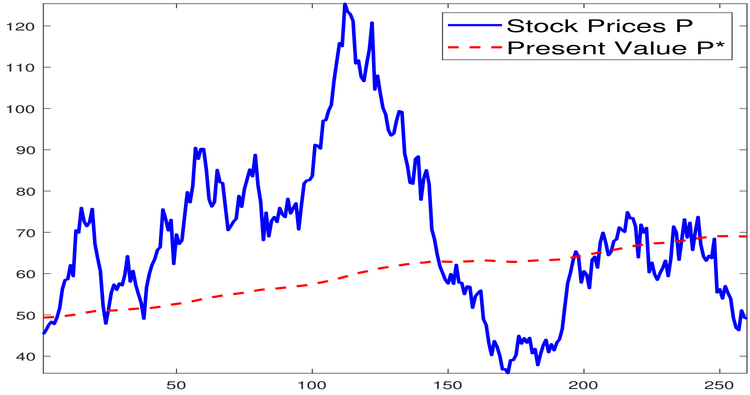

Figure 2. Simulation: Stock Prices vs rational prices

Monetary Policy and Stock Price Interaction

- The Taylor rule: $i_t = \phi_\pi \pi_t + \phi_y \tilde{y}_t + \phi_q \tilde{q}_{t-1}$

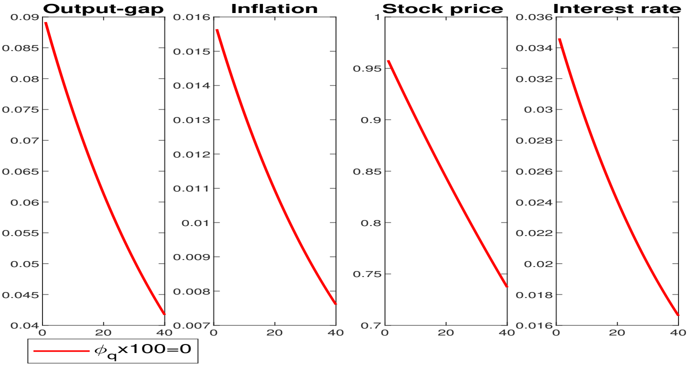

Figure 3. **IRFs to Sentiment Shocks:** the figure presents the IRF to a 1 % *i.i.d* sentiment shock for different reaction coefficients to stock prices. Policy and Wealth effects

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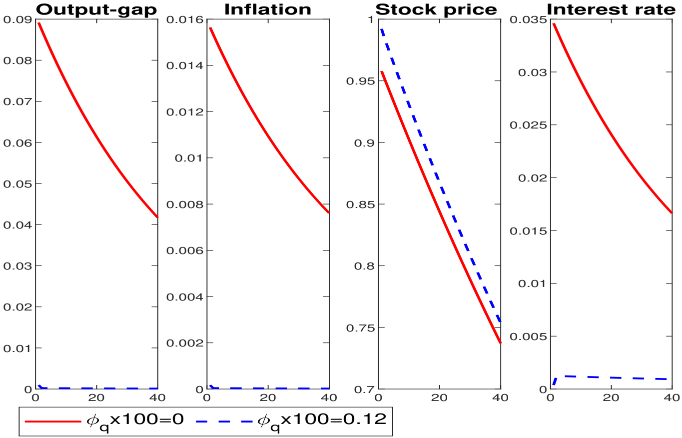

Figure 4. **IRFs to Sentiment Shocks:** the figure presents the IRF to a 1 % *i.i.d* sentiment shock for different reaction coefficients to stock prices. Policy and Wealth effects

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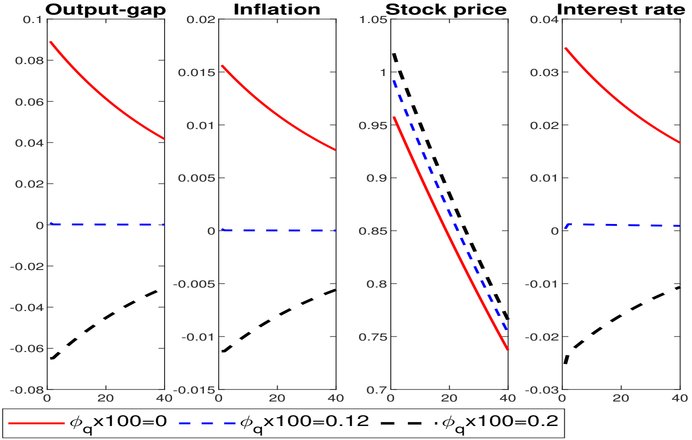

Figure 5. **IRFs to Sentiment Shocks:** the figure presents the IRF to a 1 % *i.i.d* sentiment shock for different reaction coefficients to stock prices. ▸ Policy and Wealth effects

Welfare Analysis: Non-Transparency

- **Central Bank**

$$i_t = 1.5\,\pi_t + 0.125\,\tilde{y}_t + \phi_q\,\tilde{q}_{t-1} 1_{\tilde{q}_{t-1} < Q^-} \quad \text{(Fed put)}$$

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- **agents do not internalize that MP is reacting to stock prices**

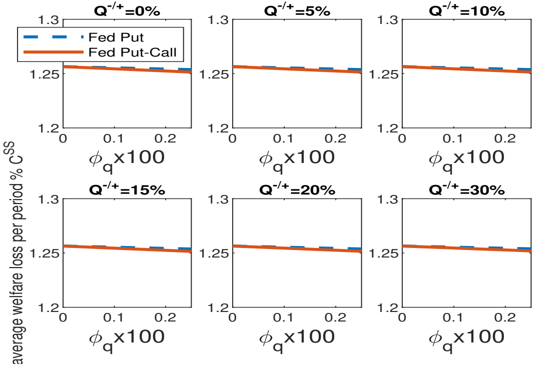
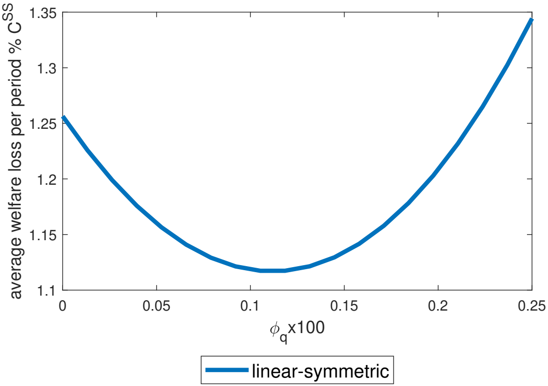


Figure 6. Welfare loss under Fed Put/Call policies

Welfare Analysis: Transparency



- Reacting symmetrically and transparently to stock prices brings substantial welfare gains: **12% reduction in business cycle costs**

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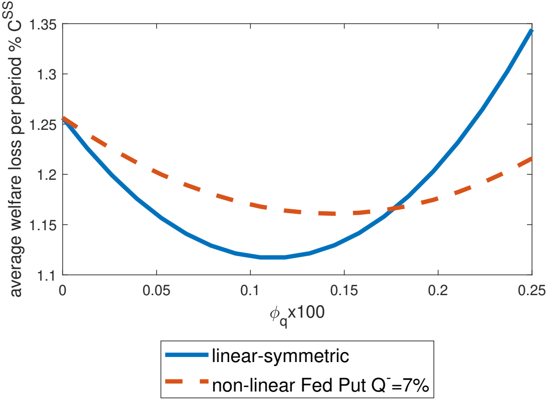

- Responding only to decreases in stock prices does not eliminate all the inefficiencies from expectation driven cycles

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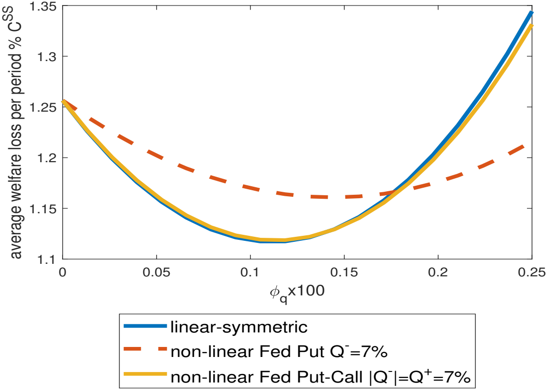

- The central bank can respond only to big deviations in stock prices ($> 7\%$)

Conclusions

- Theory of stock price wealth effects arising from imperfect knowledge
- The quantitative model can account for key business cycle, financial statistics and survey data stylized facts
- Different welfare implications of monetary policy rules in RE vs Imperfect Information:
  - **reacting to booms and busts driven by animal spirits reduces the cost of business cycles by 12%**
  - Transparency from the central bank is crucial in managing the non-fundamental effects of asset price cycles

Policy Recommendation: announce 12 bp increase in policy rates for every 100% increase in stock prices only when deviations exceeds 7%

Consistency of Expectations

The agent cannot apply LIE to obtain the infinite discounted sum since this will imply

- agent knows that he/she will be the marginal agent forever OR
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Consistency of Expectations

The agent cannot apply LIE to obtain the infinite discounted sum since this will imply

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$$q_t = \delta E_t^{\mathscr{P}_i}\Big\{\Big(\frac{C_{t+1}^i}{C_t^i}\Big)^{-\sigma}(d_{t+1} + q_{t+1})\Big\}$$

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&= \delta E_t^{\mathscr{P}_i}\Big\{\Big(\frac{C_{t+1}^i}{C_t^i}\Big)^{-\sigma}(d_{t+1}+\delta E_{t+1}^{\mathscr{P}_{mg}}\Big\{\Big(\frac{C_{t+2}^{mg}}{C_{t+1}^{mg}}\Big)^{-\sigma}(d_{t+2}+q_{t+2})\Big\}\Big\}
\end{aligned} \tag{9}
$$

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\end{aligned} \tag{9}
$$

- there is no reason for $E_t^{\mathscr{P}_i}E_{t+1}^{\mathscr{P}_{mg}} = E_t^{\mathscr{P}_i}$

Consistency of Expectations (cont.)

Intertemporal budget constraint

$$\frac{\mathscr{W}_t^i}{P_t} = E_t^{\mathscr{P}_i} \sum_{j=0}^{\infty} \delta^j \left(\frac{C_{t+j}^i}{C_t^i} \right)^{-\sigma} C_{t+j}^i + A_t^i. \tag{10}$$

where

$$A_t^i = \sum_{j=1}^{\infty} \delta^j E_t^{\mathscr{P}} E_{t+1}^{\mathscr{P}} \dots E_{t+j-1}^{\mathscr{P}} \left(\frac{C_{t+j}^i}{C_t^i} \right)^{-\sigma} \frac{\lambda_{t+j}^i}{\prod_{s=0}^{j} (1 + \pi_{t+s})} \tag{11}$$

Specifically, for $j = 1$

$$\lambda_{t+1}^i = \delta \left[E_t^{\mathscr{P}_{mg}} \left(\left(\frac{C_{t+2}^{mg}}{C_{t+1}^{mg}} \right)^{-\sigma} (P_{t+2} + D_{t+2}) \right) - E_t^{\mathscr{P}_i} \left(\left(\frac{C_{t+2}^i}{C_{t+1}^i} \right)^{-\sigma} (P_{t+2} + D_{t+2}) \right) \right] S_{t+1}^i$$

is the perceived error of agent i with respect to the marginal agent valuation.

Average Marginal Agent (AMA) Assumption: *up to a first order approximation* $A_t^i \approx 0$

Go Back

Demand

$$\tilde{c}_t^i = \Delta_i \tilde{\boldsymbol{w}}_{\boldsymbol{t}}^{\boldsymbol{i}} + \Delta_w \sum_{j=0}^{\infty} \delta^j E_t^{\mathscr{P}}(\tilde{w}_{t+j}) - \frac{\delta}{\sigma}\Delta_r \sum_{j=0}^{\infty} \delta^j E_t^{\mathscr{P}}(i_{t+j} - \pi_{t+j+1}). \tag{12}$$

Supply

$$p_t^* = (1-\delta\theta)\sum_{k=0}^{\infty}(\theta\delta)^k E_t^{\mathscr{P}}\left\{\frac{\alpha}{1-\alpha+\epsilon\alpha}\tilde{y}_{t+k} + \frac{1-\alpha}{1-\alpha+\epsilon\alpha}(\tilde{w}_{t+k}+\epsilon_{t+k}^u)+p_{t+k}\right\}. \tag{13}$$

Asset Prices

$$\tilde{q}_t = (1-\delta)E_t^{\mathscr{P}}(\tilde{d}_{t+1}) + \delta E_t^{\mathscr{P}}(\tilde{q}_{t+1}) - (i_t - E_t^{\mathscr{P}}(\tilde{\pi}_{t+1})) \tag{14}$$

Monetary Authority

$$i_t = \phi_\pi \pi_t + \phi_y \tilde{y}_t + \epsilon_t^i \tag{15}$$

The Model

Agents' model

- the probability space $(\Omega, \mathscr{S}, \mathscr{P})$ has typical element $\omega \in \Omega$, $\omega = \{Y_t, P_t, Q_t, D_t, W_t\}$ which is shared by all agents in the economy.

- **PLM**:

$$
\begin{aligned}
z_t &= \beta_t + \zeta_t \\
\beta_t &= \rho\beta_{t-1} + \vartheta_t
\end{aligned}
\tag{16}
$$

  where $z_t = (\tilde{y}_t, \tilde{\pi}_t, \tilde{q}_t, \tilde{d}_t, \tilde{w}_t)'$.

- optimal filter for $E^{\mathscr{P}}(\beta_t / g^t) = \hat{\beta}_t$ is the Kalman filter:

$$
\hat{\beta}_t = \rho\,\hat{\beta}_{t-1} + \lambda(z_{t-1} - \rho\,\hat{\beta}_{t-1}) + \epsilon_t^{\beta} \tag{17}
$$

- Adam, Marcet, Beutel (2017) show that equations of the form (17) replicate well actual survey data

- agents understand how monetary policy is conducted

The Model

Sentiment (Belief) Shocks

- agents observe the transitory price component, ζ_t, with a lag
- stock price beliefs updating

$$E_t^{\mathscr{P}}(\tilde{q}_{t+1}) = \rho\, E_{t-1}^{\mathscr{P}}(\tilde{q}_t) + \lambda(\ \tilde{q}_{t-1} - \rho\ E_{t-1}^{\mathscr{P}}(\tilde{q}_t)\ ) + \sigma_{\beta_q} \boldsymbol{\epsilon_t^{\beta_q}}$$

where

$\boldsymbol{\epsilon_t^{\beta_q}} \sim \mathcal{N}(0,1), i.i.d$ is a sentiment/belief/animal spirits shock

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Quantitative Performance
Parameters

Calibrated	Symbol	Value
Discount factor	δ	0.9928
Risk aversion coef.	σ	1
Frisch labor supply elasticity	$\frac{1}{\phi}$	0.75
Elasticity of substitution	ϵ	6
Prob. of not adjusting price	θ	2/3
Share of labor	$1-\alpha$	0.75
Taylor-rule coef. of inflation	ϕ_π	1.5
Taylor-rule coef. of output	ϕ_y	0.5/4
Equity Share Ownership	$1-\mathcal{O}$	0.47
Estimated		
Std. cost push shock	σ^u	0.0013
Std. equity belief shocks	σ^{β_q}	0.0623
Std. MP shocks	σ^{ϵ_i}	0.0007
Autoregressive coef. cost push shock	ρ_u	0.9539
Autoregressive coef. MP shocks	ρ_{β_q}	0.9685
Kalman gain	λ	0.0011
Autoregressive coef. beliefs	ρ	0.99

Table 2. Calibrated/Estimated (SMM) parameters: equity share ownership SCF 1989-2019 Back

Quantitative Performance

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Table 2. Calibrated/Estimated (SMM) parameters: equity share ownership SCF 1989-2019 Back

Belief Dynamics: $\rho(FR_{t,h},\ FE_{t,h})$

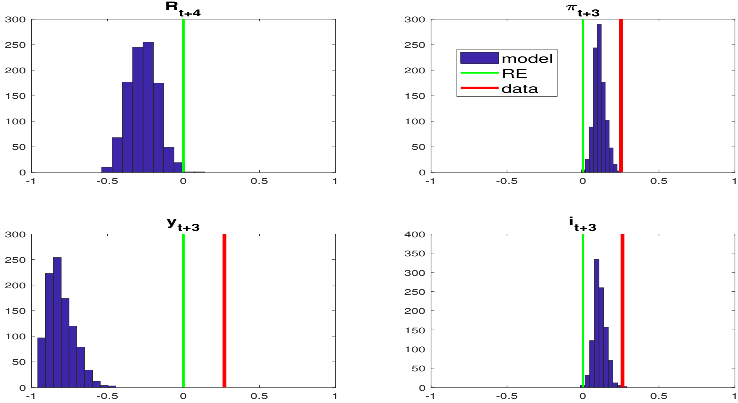

Figure 7. Correlation between FE and Revision in beliefs

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Monetary Policy influence on wealth effects

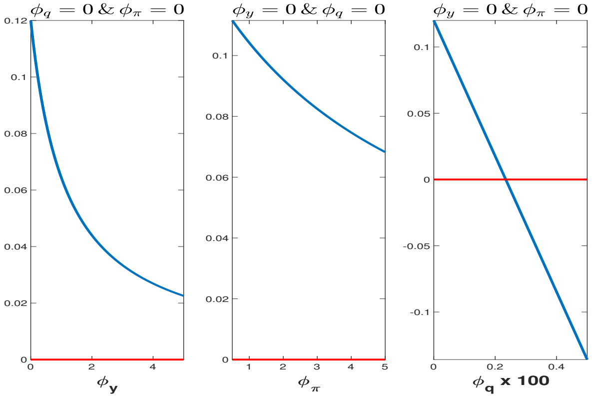

Figure 8. Stock Price Wealth Effects and Monetary Policy

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Welfare Maps

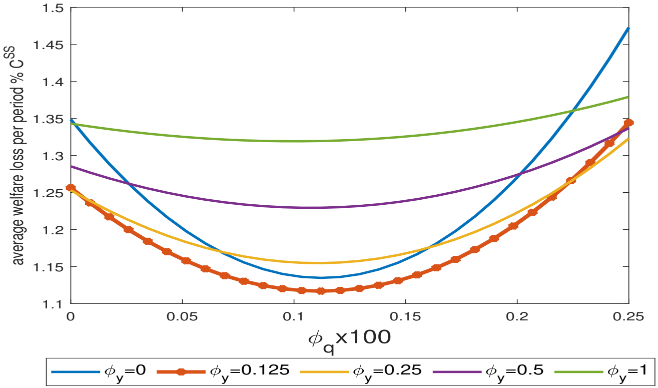

Figure 9. Welfare maps with respect to responses to output-gap and stock prices

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