Macro Uncertainty and Unemployment Risk

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Motivation

Question: 'How does uncertainty affect the macroeconomy?'

+ **Empirical evidence:** Identified macro uncertainty shock reduces
  - Output, Consumption, Investment, Employment, Inflation

    Bloom (2009), Fernandez-Villaverde et al. (2015), Leduc & Liu (2016), Basu & Bundick (2017), Oh (2020)

+ **Existing models:** Unable to match empirical evidence
  - RANK: Response of macro variables muted

    Born & Pfeifer (2014), de Groot et al. (2018)
  - Inflation increases

    Born & Pfeifer (2014), Fernandez-Villaverde et al. (2015), Mumtaz & Theodoridis (2015)

▸ Literature

Our Paper

Households' heterogeneity key for uncertainty propagation

+ **VAR evidence** using both aggregate and household-level data:
  - Macro uncertainty shock acts like aggregate demand shock
  - Households in bottom 60% of income distrib. most responsive to uncertainty

+ **HANK model** with SaM and Calvo:
  - Unemployment risk reinforces precautionary savings of uninsured HHs
  - Uncertainty generates drop in prices & amplifies responses to match data

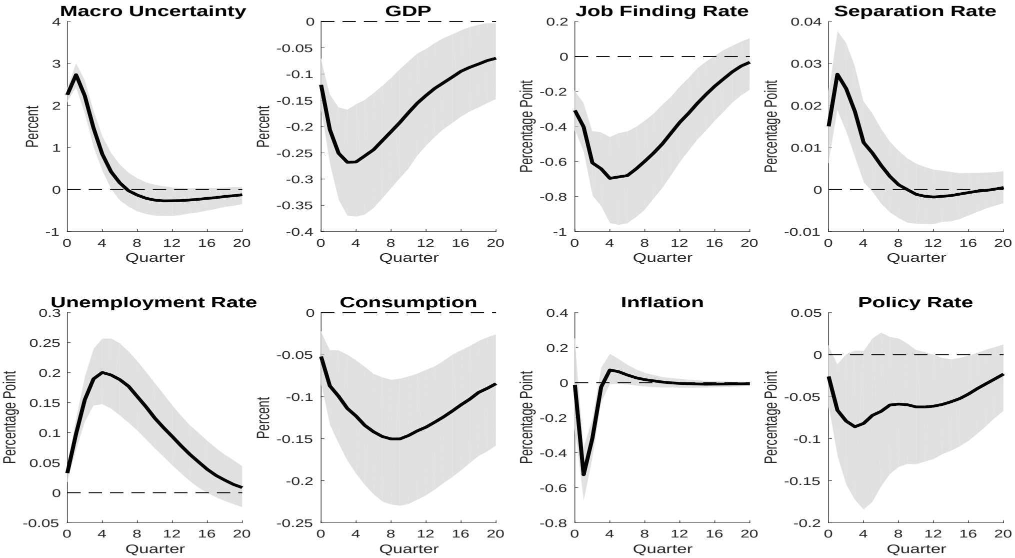
Empirical Evidence

VAR Evidence

- Data: US quarterly, 1982Q1-2015Q3
  - Macro uncertainty Jurado et al. (2015)
    Common variation in macro indicators' unforecastable factors
  - Macro data: National Income and Product Account
  - Household-level data: Consumer Expenditure Surveys ▸ More
- Identification: Cholesky ordering
  - Macro uncertainty ordered first:
    [Macro uncertainty, GDP, Job finding rate, Separation rate, Unemployment rate, Consumption, Inflation, Policy rate]
  - Constant and two lags

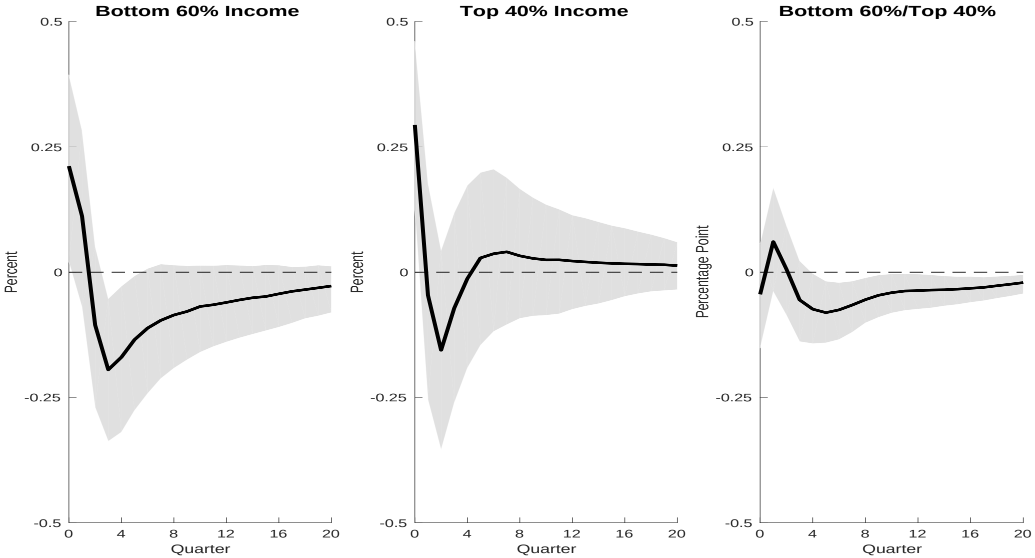
VAR Evidence: Macro Data

Robustness



VAR Evidence: Micro Data

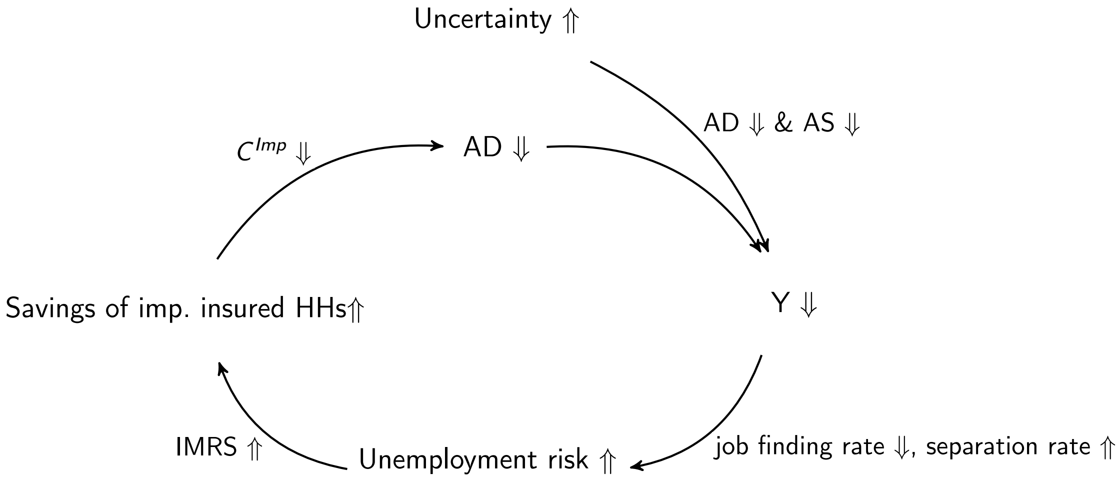
Robustness



Model

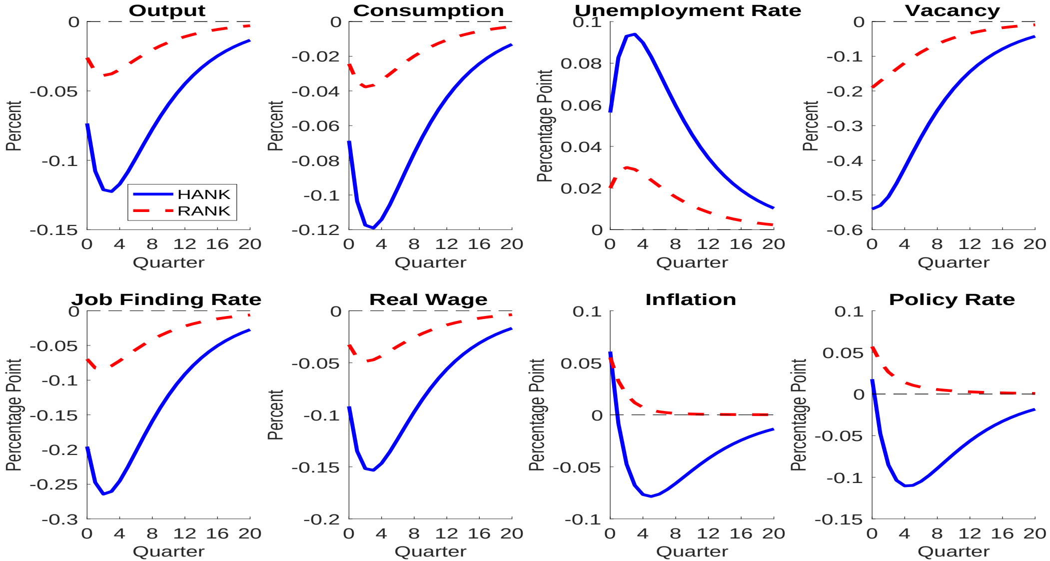
Feedback Loop

Model

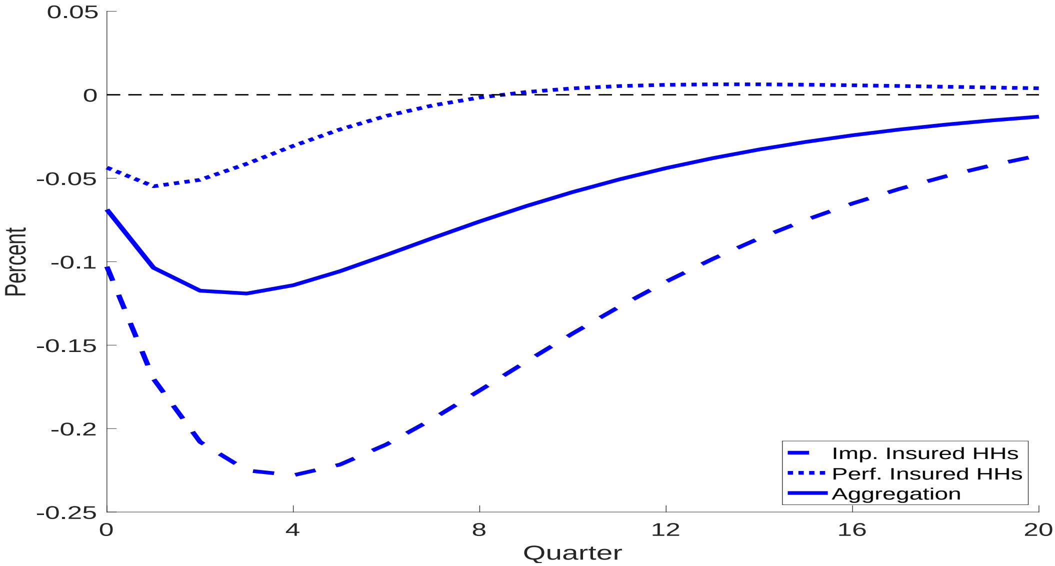


HANK: IRFs to 1SD Technology Uncertainty Shock

▸ Calibration ▸ Different Ω ▸ Robust



Consumption Heterogeneity



Conclusion

Households' heterogeneity important to uncertainty propagation

1. Macro uncertainty$\Uparrow$ $\rightarrow$ consumption, inflation, policy rate$\Downarrow$
2. Most responsive HHs: Bottom 60% of income distrib.
3. HA + Calvo + SaM
   - Uncertainty reduces AD and AS
   - Uninsured unemployment risk reinforces prec. savings (AD)
   - Responses in line with data

Calvo vs Rotem

Appendix

Consumer Expenditure Surveys

CEX: Rotating panel data

- Consumption: Non-durable

  Food and beverages, tobacco, apparel and services, personal care, gasoline, public transportation, household operation, medical care, entertainment, reading material, and education

- Income: before tax

  Wages, salaries, business and farm income, financial income, and transfers

- Real per capita: divide by number of family members, deflate by CPI-U series, and seasonally adjust by X-12-ARIMA

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Literature

- HANK
  McKay and Reis (2016), Kaplan et al. (2018)
- HANK and SaM
  Gronemann et al. (2016), McKay and Reis (2017), Ravn & Sterk (2017, 2018), Cho (2018), Challe et al. (2017), Challe (2019)
- Uncertainty
  Bloom (2009), Born & Pfeifer (2014), Jurado et al. (2015), Mumtaz & Theodoridis (2015), Leduc & Liu (2016), Basu & Bundick (2017), Fasani & Rossi (2018), Bayer et al. (2019), Ludvigson et al. (2019), Oh (2019)

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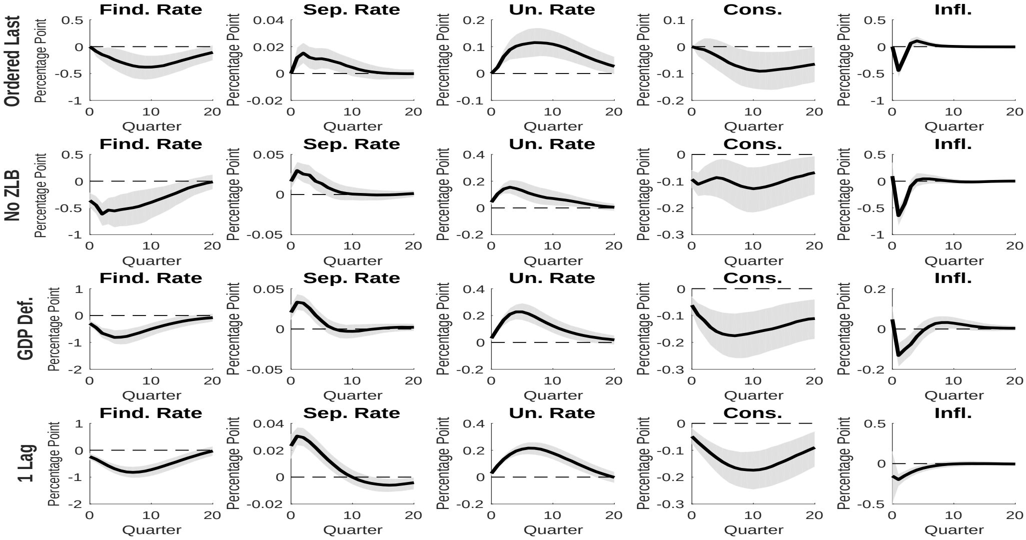
Robustness: Macro Data

Back



Robustness: Micro Data

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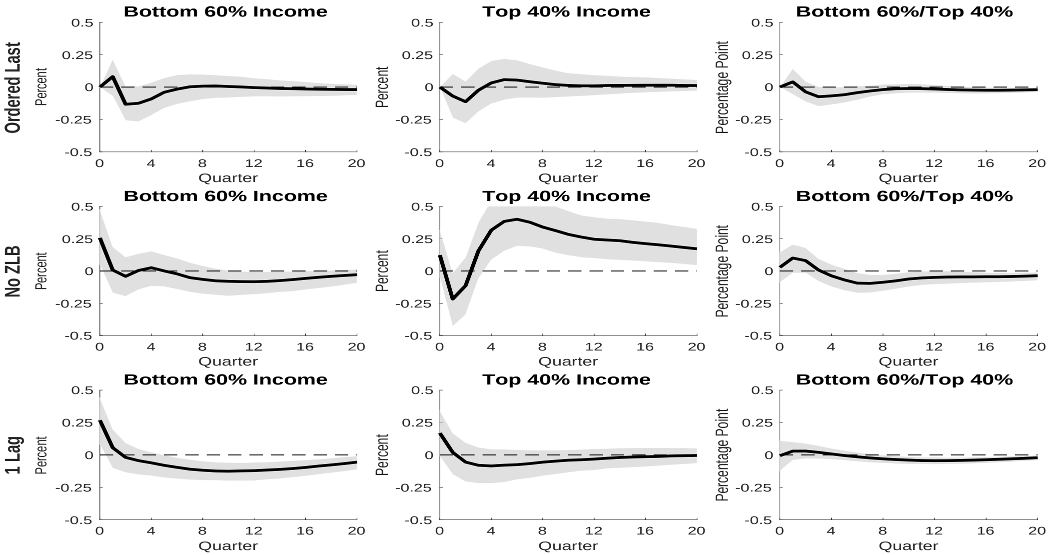


HANK with SaM and Uncertainty

+ Unit mass of **Households**
  - Share $1 - \Omega$ perfectly insured against unemployment risk

    $\Rightarrow$ Assets and C do **not** depend on employment status

  - Share Ω imperfectly insured against unemployment risk

    $\Rightarrow$ Subject to borrowing limit tighter than natural

    $\Rightarrow$ Assets and C **do** depend on employment status

Details

Imperfectly Insured Households

ASSUMPTION: Borrowing limit binding after 1 period unemp. (Challe et al. (2017))

- Three corresponding types of imperfectly insured households:
  1. Employed
  2. Unemployed for 1 period
  3. Unemployed for > 1 period

- Three consumption levels

- Two asset levels
  1. Assets for the employed impatient
  2. Borrowing limit

With 3 types of imperfectly insured, no need to keep track of whole distribution

HANK with SaM and Uncertainty

+ **Firms** ▸ More
  - Search and matching frictions
  - Calvo pricing

+ **Monetary authority**
  - Taylor rule

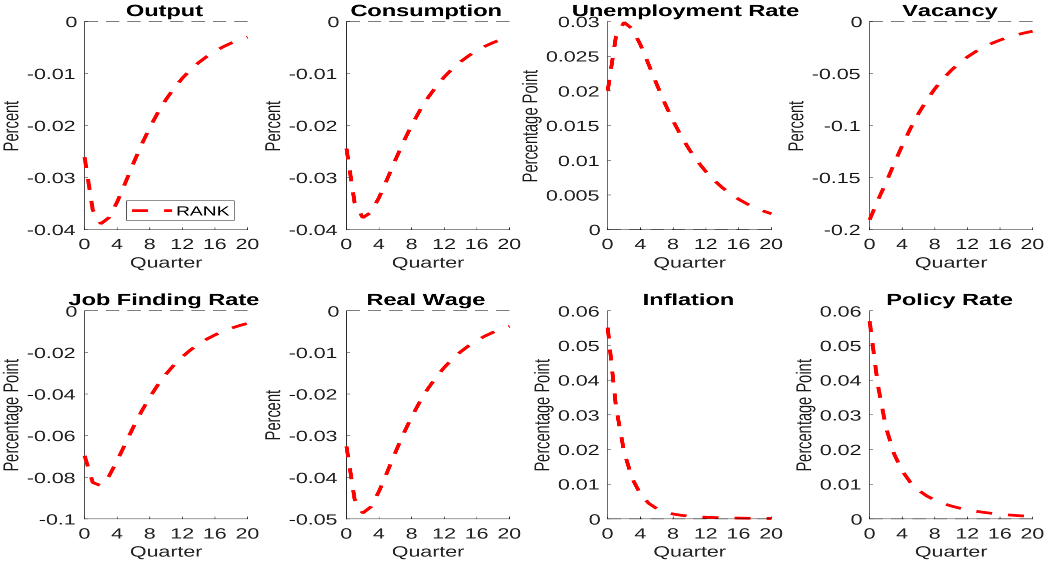
+ **Uncertainty** in technology process

$$\log z = \rho_z \log z_{-1} + \sigma^z \varepsilon^z$$

$$\log \sigma^z = (1 - \rho_{\sigma^z}) \log \bar{\sigma}^z + \rho_{\sigma^z} \log \sigma^z_{-1} + \sigma^{\sigma^z} \varepsilon^{\sigma^z}$$

+ Third-order perturbation method (Fernandez-Villaverde et al., 2011)

RANK: IRFs to 1SD Technology Uncertainty Shock



Direct Effect of Increased Uncertainty (RANK)

- Households: Precautionary savings ‣ Example

  U$\Uparrow$ $\rightarrow$ C$\Downarrow$ $\because$ Risk aversion

  $\rightarrow$ Nominal marginal cost$\Downarrow$ $\rightarrow$ Price $\downarrow$ $\rightarrow$ Markup$\Uparrow$ $\because$ Sticky prices

  $\Rightarrow$ Y$\Downarrow$, P$\Downarrow$ $\because$ AD$\Downarrow$

- Firms: Precautionary pricing ‣ Example

  U$\Uparrow$ $\rightarrow$ P$\Uparrow$ $\rightarrow$ Markup$\Uparrow$ $\because$ Risk aversion

  $\Rightarrow$ Y$\Downarrow$, P$\Uparrow$ $\because$ AS$\Downarrow$

- P$\Uparrow$ since AS$\Downarrow$ $>$ AD$\Downarrow$

‣ AS-AD

Indirect Effect: Uninsured Unemployment Risk (HANK)

- Uncertainty $\Uparrow$
  1. Precautionary savings: AD$\Downarrow$
  2. Precautionary pricing: AS$\Downarrow$
- Y$\Downarrow$ $\rightarrow$ Vacancy$\Downarrow$ $\rightarrow$ Job finding rate$\Downarrow$ $\rightarrow$ Separation rate$\Uparrow$
- Unemployment risk$\Uparrow$ $\rightarrow$ Imperfectly insured HHs' savings $\Uparrow$
- $C^I \Downarrow \rightarrow$ AD$\Downarrow$

IMRS AS-AD Back

Perfectly Insured Households

▸ State vector

$$V^p\left(a^p, n^p, X\right) = \max_{a^{p\prime}, c^p} \left\{u\left(c^p\right) + \beta^p \mathbb{E}\left[V^p\left(a^{p\prime}, n^{p\prime}, X^\prime\right)\right]\right\}$$

subject to:

$$c^p + a^{p\prime} = w^p n^p + (1+r)\, a^p + \Pi$$

Perfect insurance $\Rightarrow$ $a^{p\prime}$ & c^p do not depend on employment status

Imperfectly Insured Households

ASSUMPTIONS:

1. Partial risk sharing
2. Borrowing limit tighter than natural

- Cross-sectional distribution $\mu(a, N)$ over:
  - Assets $a \in \mathbb{R}$
  - Length of unemployment spell $N \in \mathbb{Z}_+$
- Becomes with countable and finite support
- Can be summarized by:
  - Assets: $\mathbf{a^i}(\mathbf{N})$
  - Associated number of HHs: $\mathbf{n^i}(\mathbf{N})$

▸ a^i and n^i

Imperfectly Insured Households

$$V^i\left(a^i(N), n^i(N), X\right) =$$

$$\max_{\left\{a^{i\prime}(N), c^i(N)\right\}_{N \in Z_+}} \left\{ \sum_{N \geq 0} n^i(N)\, u\left(c^i(N)\right) + \beta^i \mathbb{E}_{\mu,X}\left[V^i\left(a^{i\prime}(N), n^{i\prime}(N), X'\right)\right] \right\}$$

subject to:

- Borrowing constraint

$$a^{i\prime}(N) \geq \underline{a}$$

- Budget constraint if employed, $N = 0$

$$a^{i\prime}(0) + c^i(0) = (1-\tau)\, w + (1+r)\, A$$

- Budget constraint if unemployed for $N \geq 1$ periods

$$a^i(N) + c^i(N) = b^u + (1+r)\, a$$

State Vector

Tilde variables corresepond to beginning of labor transition stage.

$$X = \left\{ \mu\tilde{(.)}, a^p, a^i(0), R_{-1}, \Delta_{-1}, \tilde{\mathbf{n}}, z, \sigma^z \right\}$$

▸ Back

FOCs Impatient Households

- If $N = 0$

$$A' = \frac{1}{n^{i\prime}(0)} \left[\left(1 - s'\right) a^{i\prime}(0) + f' \sum_{N \geq 1} a^{i\prime}(N)\, n^{i}(N) \right]$$

$$n^{i\prime}(0) = \left(1 - s'\right) n^{i}(0) + f' \left(1 - n^{i}(0)\right)$$

- If $N \geq 1$

$$a^{i}(N) = a^{i\prime}(N-1)$$

$$n^{i\prime}(1) = s' n^{i}(0) \text{ and } n^{i\prime}(N) = \left(1 - f'\right) n^{i}(N-1) \text{ if } N \geq 2$$

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Monetary Policy and Unemployment Insurance Scheme

- Taylor rule

$$\frac{1+R}{1+\bar{R}} = \left(\frac{1+R_{-1}}{1+\bar{R}}\right)^{\rho_R} \left(\left(\frac{1+\pi}{1+\bar{\pi}}\right)^{\phi_\pi} \left(\frac{y}{y_{-1}}\right)^{\phi_y}\right)^{1-\rho_R}$$

- Balanced unemployment insurance scheme

$$\tau w \mathbf{n^i} = b^u \left(1 - \mathbf{n^i}\right)$$

$$\tau w^p \mathbf{n^p} = b^{up} (1 - \mathbf{n^p})$$

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Firms

1. Final goods firms: Perfectly competitive ▸ Final
2. Intermediate goods firms: Face Calvo pricing ▸ Intermediate
3. Wholesale goods firms: Perfectly competitive ▸ Wholesale
   - Use technology $y_m = z\check{n}$
4. Labor intermediaries: Hire both types of households ▸ Labor inter
   - Job finding rate
   $$f = \frac{m}{u} = \frac{\mu u^{\chi} v^{1-\chi}}{u}$$
   - Period-to-period job loss rate
   $$s = \rho(1 - f)$$
   - Wages set according to rule

▸ Back

Final Goods Firms

- Solve

$$\max_{y} y - \int_0^1 p_i y_i di$$

subject to

$$y = \left(\int_0^1 y_i^{\frac{\varepsilon - 1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon - 1}}$$

- Solution: final goods firms' demand of intermediate good

$$y_i \left(p_i \right) = p_i^{-\varepsilon} y$$

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Intermediate Goods Firms I

- Linear technology with fixed cost: $y_i = x_i - \Phi$
- Produce intermediate goods sold at price p_m
- Earn profit: $\Xi = (p_i - p_m)y_i - p_m\Phi$
- Value if reset prices:

$$V^R(X) = \max_{p_i} \left\{ \Xi + \theta \mathbb{E}_X \left[M^{P\prime} V^N(p_i, X') \right] + (1-\theta)\mathbb{E}_X \left[M^{P\prime} V^R(X') \right] \right\}$$

  - Set optimal price:

$$p^\star = \frac{\varepsilon}{\varepsilon - 1} \frac{p^A}{p^B}$$

$$p^A = p_m y + \theta \mathbb{E}_X \left[M^{P\prime} \left(\frac{1+\pi'}{1+\bar{\pi}} \right)^{\varepsilon} p^{A\prime} \right]$$

$$p^B = y + \theta \mathbb{E}_X \left[M^{P\prime} \left(\frac{1+\pi'}{1+\bar{\pi}} \right)^{\varepsilon - 1} p^{B\prime} \right]$$

Intermediate Goods Firms II

- Inflation law of motion:

$$\pi = \frac{\theta(1+\bar{\pi})}{\left(1-(1-\theta)p^{\star\,1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}} - 1$$

- Price dispersion:

$$\Delta = (1-\theta)\, p^{\star\,-\varepsilon} + \theta \left(\frac{1+\pi}{1+\bar{\pi}}\right)^{\varepsilon} \Delta_{-1}$$

- Value if do not reset prices:

$$V^N(p_{i,-1}, X) = \Xi + \theta \mathbb{E}_X \left[M^{P\prime} V^N(p_i, X')\right] + (1-\theta)\, \mathbb{E}_X \left[M^{P\prime} V^R(X')\right]$$

- Index price

$$p_i = \frac{1+\bar{\pi}}{1+\pi} p_{i,-1}$$

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Wholesale Firms

- Perfectly competitive, use linear technology: $y_m = z\check{n}$
- Solve:

$$\max_{n^d} \{p_m z\check{n} - Q\check{n}\}$$

- Q is real unit price of labor services n, given by FOC:

$$Q = p_m z$$

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Labor Intermediaries

- Beginning of period exogenous separation rate ρ
- Skill premium ψ for patient households
- Value of match with impatient and patient

$$J^i = Q - w + \mathbb{E}_X \left[\left(1 - \rho'\right) M^{i\prime} J^{i\prime} \right]$$
$$J^p = \psi Q - \psi w + \mathbb{E}_X \left[\left(1 - \rho'\right) M^{p\prime} J^{p\prime} \right]$$

- Free entry condition where λ is job filling rate

$$\underbrace{\lambda \left(\Omega J^i + \left(1 - \Omega\right) J^p \right)}_{\text{value}} = \underbrace{\kappa}_{\text{cost}}$$

- Wage rule

$$w = {w_{-1}}^{\gamma_w} \left(\bar{w} \left(\frac{\mathbf{n}}{\bar{n}} \right)^{\phi_w} \right)^{1-\gamma_w}$$

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Uncertainty

$$\log z = \rho_z \log z_{-1} + \sigma^z \varepsilon^z$$

$$\log \sigma^z = (1 - \rho_{\sigma^z}) \log \bar{\sigma}^z + \rho_{\sigma^z} \log \sigma^z_{-1} + \sigma^{\sigma^z} \varepsilon^{\sigma^z}$$

- Third-order perturbation method
  (Fernandez-Villaverde et al., 2011)

MP and b^u Clearing

Market Clearing

- Labor market

$$\text{Beginning of period} \qquad \tilde{n}^p = \tilde{n}^i = \tilde{\mathbf{n}}^{\mathbf{p}} = \tilde{\mathbf{n}}^{\mathbf{i}} = \tilde{\mathbf{n}}$$
$$\text{End of period} \qquad n^p = n^i = \mathbf{n}^{\mathbf{p}} = \mathbf{n}^{\mathbf{i}} = \mathbf{n}$$
$$\Omega \mathbf{n}^{\mathbf{i}} + (1-\Omega)\,\psi \mathbf{n}^{\mathbf{p}} = (\Omega + (1-\Omega)\,\psi)\,\mathbf{n} = \check{n}$$

- Asset market

$$\Omega\left(A + (1-\mathbf{n})\,\underline{a}\right) + (1-\Omega)\,a^p = 0$$

- Goods market
  - Final

$$c + \kappa v = y$$

  - Intermediate

$$\Delta y = y_m - \Phi$$

  - Wholesale

$$\int_0^1 x_i di = y_m = z\check{n}$$

Quarterly Calibration 1

Parameter	Description	Value	Target/Source
	Households		
Ω	Share of imperf. households	0.60	Challe et al. (2017)
$\underline{a}$	Borrowing limit	0	Challe et al. (2017)
σ	Risk aversion	2.00	Standard
β^I	Discount factor of imperf. households	0.917	21% consumption loss
β^P	Discount factor of pat. households	0.993	3% annual real interest rate
b^u	Unemployment benefits	0.27	33% replacement rate
	Firms		
ε	Elasticity of substitution btw goods	6.00	20% markup
Φ	Production fixed cost	0.22	Zero steady-state profit
θ	Price stickiness	0.75	4-quarter stickiness

Quarterly Calibration 2

Parameter	Description	Value	Target/Source
	Labor Market		
μ	Matching efficiency	0.72	71% job filling rate
χ	Matching function elasticity	0.50	Standard
ρ	Job separation rate	0.23	73% job find. & 6.1% job loss rates
κ	Vacancy posting cost	0.037	1% of output
ψ	Skill premium	2.04	Bottom 60% cons. share (42%)
γ_w	Wage stickiness	0.75	Challe et al. (2017)
ϕ_w	Wage elasticity wrt employment	1.50	Challe et al. (2017)
	Monetary Authority		
$\bar{\pi}$	Steady-state inflation	1.005	2% annual inflation rate
ρ_R	Interest rate inertia	0	Standard
ϕ_π	Taylor rule coefficient for inflation	1.50	Standard
ϕ_y	Taylor rule coefficient for output	0.20	Standard

Quarterly Calibration 3

Parameter	Description	Value	Target/Source
	Exogenous Processes		
ρ_z	Persistence of technology shock	0.95	Standard
$\bar{\sigma}^z$	Volatility of technology shock	0.007	Standard
ρ_{σ^z}	Persistence of uncertainty shock	0.85	Katayama & Kim (2018)
σ^{σ^z}	Volatility of uncertainty shock	0.37	Katayama & Kim (2018)

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Different Degrees of Heterogeneity

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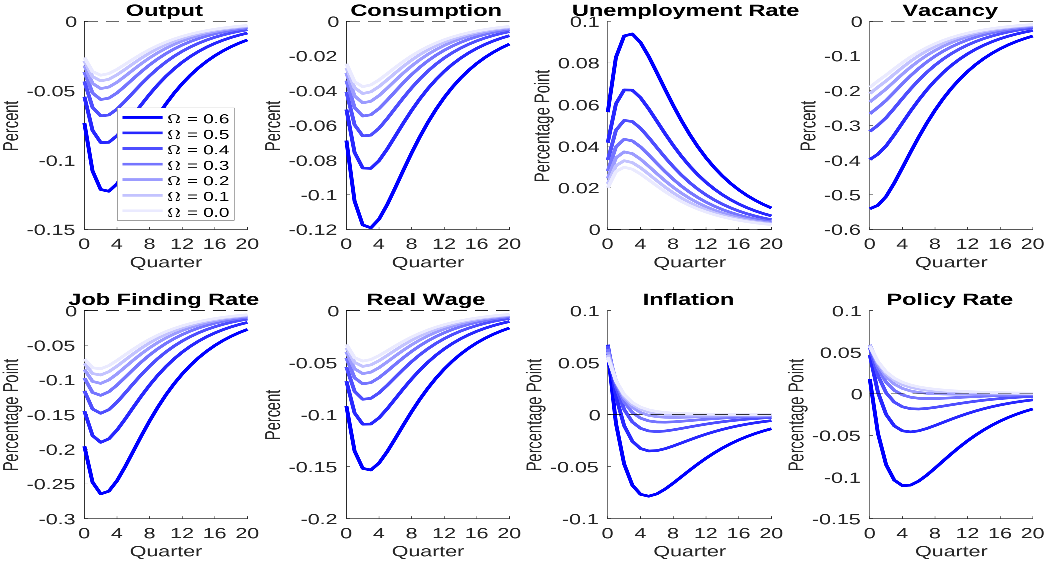
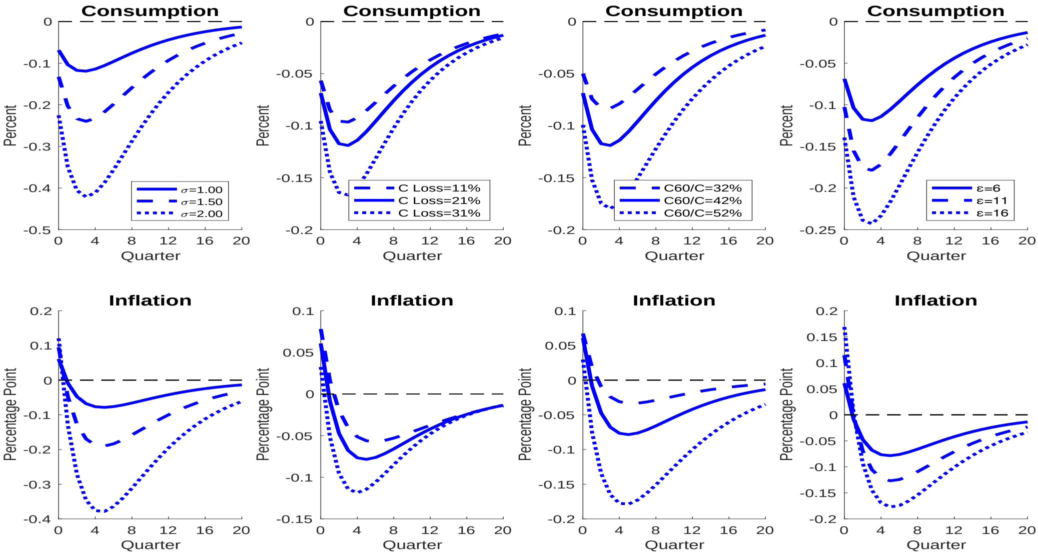


Robustness Check 1



Robustness Check 2

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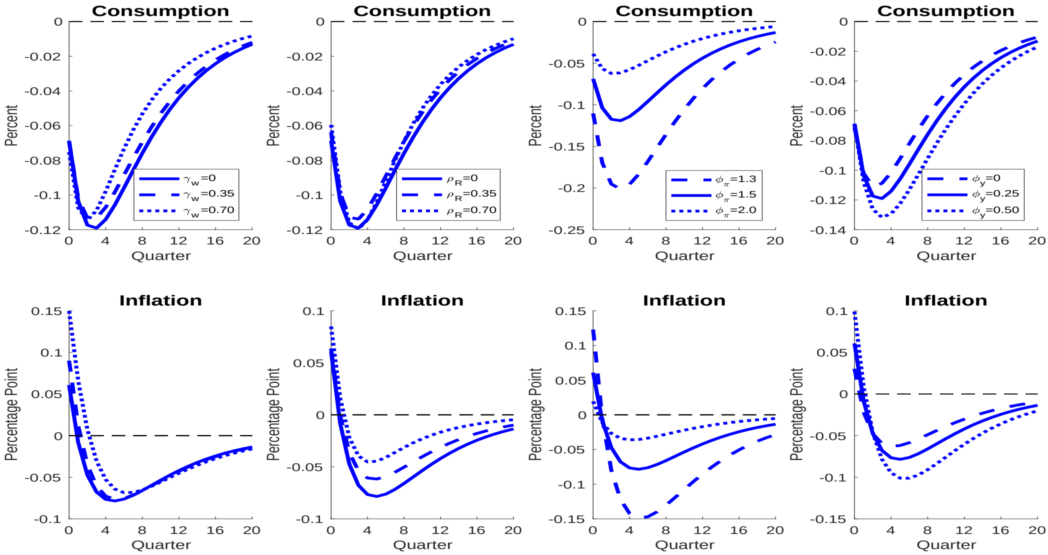

Calvo vs. Rotemberg

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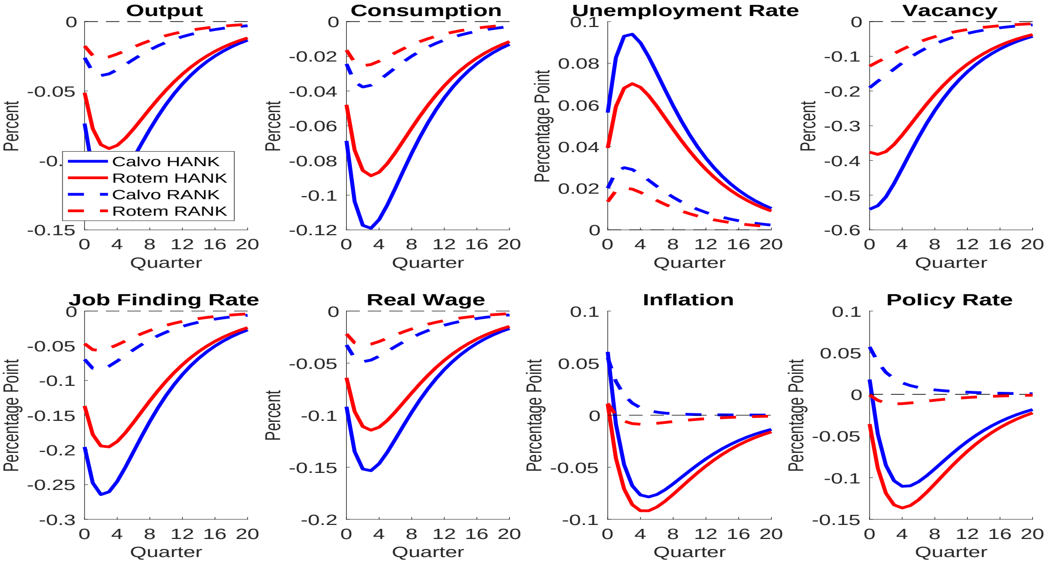

Precautionary Savings

- Risk averse households

$$\beta \left(\frac{c'}{c} \right)^{-\gamma} = IMRS'$$

- Jensen's inequality ($0 < q < 1$)

$$\begin{aligned} IMRS_{certainty} &= \beta \left(cc \right)^{-\gamma} \\ &\leq q\beta \left(cc^{l} \right)^{-\gamma} + (1-q)\beta \left(cc^{h} \right)^{-\gamma} = IMRS_{uncertainty} \end{aligned}$$

IMRS of Impatient Households

- $N = 0$
- IMRS increasing in separation rate

$$M^i(0) = \beta^i \frac{(1 - s') \, u_c^{i\,\prime}(0) + s' \, u_c^{i\,\prime}(1)}{u_c^i(0)}$$

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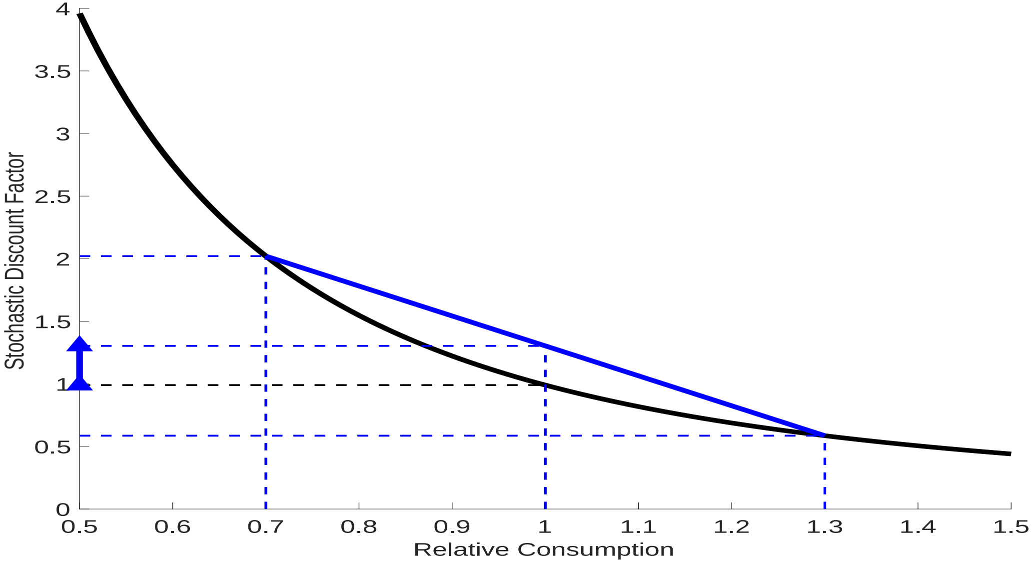
Precautionary Savings [Back]



Precautionary Pricing

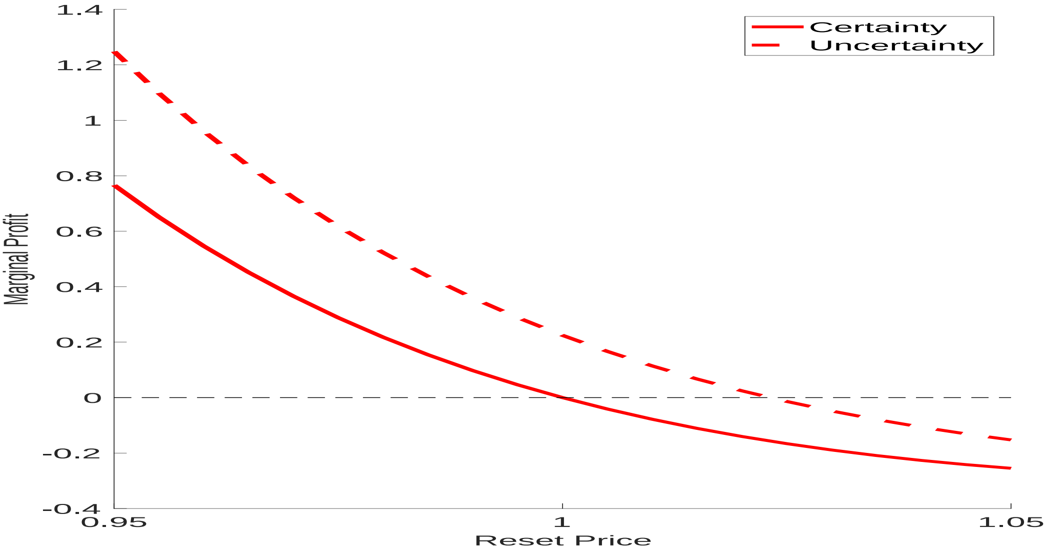
- Certainty

$$MP = \left((1-\varepsilon) \left(\frac{P^{\star}_{certainty}}{P} \right)^{1-\varepsilon} + \varepsilon mc \left(\frac{P^{\star}_{certainty}}{P} \right)^{-\varepsilon} \right) Y$$

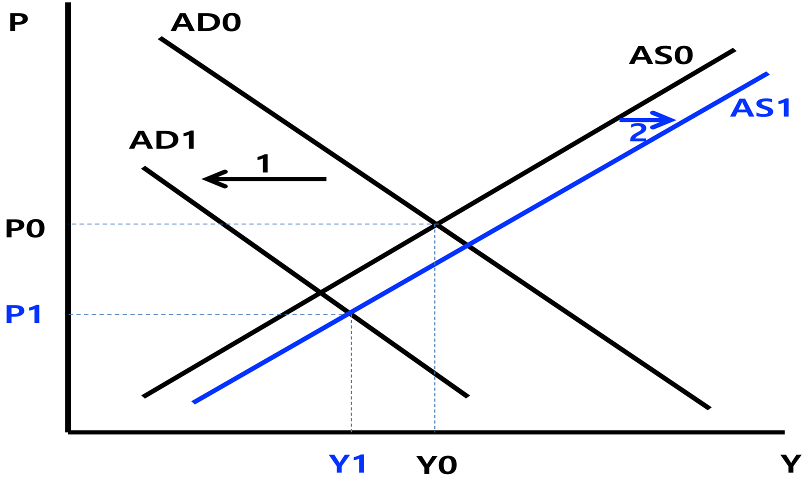
- Uncertainty: $EMP > MP \Rightarrow$ Risk averse

$$EMP = q \left((1-\varepsilon) \left(\frac{P^{\star}_{uncertainty}}{P^{l}} \right)^{1-\varepsilon} + \varepsilon mc \left(\frac{P^{\star}_{uncertainty}}{P^{l}} \right)^{-\varepsilon} \right) Y$$
$$+ (1-q) \left((1-\varepsilon) \left(\frac{P^{\star}_{uncertainty}}{P^{h}} \right)^{1-\varepsilon} + \varepsilon mc \left(\frac{P^{\star}_{uncertainty}}{P^{h}} \right)^{-\varepsilon} \right) Y$$

Precautionary Pricing ▸ Back

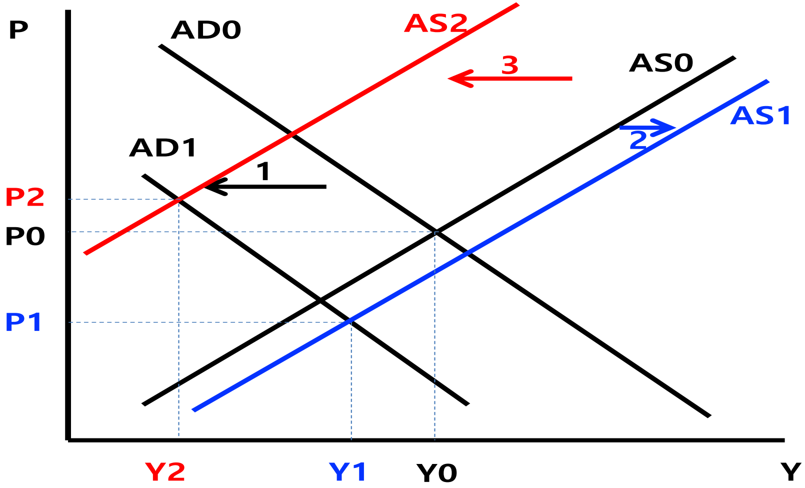


AS-AD: Households



AS-AD: Firms

▸ Back



AS-AD: HHs' Heterogeneity

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