The Risk-Premium Channel of Uncertainty: Implications for Unemployment and Inflation

Lukas B. Freund
University of Cambridge

Hanbaek Lee
University of Tokyo

Pontus Rendahl
Copenhagen Business School, CfM, and CEPR

16 September 2022

SITE 2022 - The Macroeconomics of Uncertainty and Volatility

How do we explain the labor market effects of uncertainty?

VAR evidence

- **Uncertainty**: important in GFC *[Bloom et al., 2018]* & Covid-19 induced recession *[Baker et al., 2020]*

- **Empirical evidence**: uncertainty $\uparrow \Rightarrow$ unemployment $\uparrow$

How do we explain the labor market effects of uncertainty?

- Uncertainty: important in GFC & Covid-19 induced recession
- Empirical evidence: uncertainty $\uparrow \Rightarrow$ unemployment $\uparrow$
- **Benchmark explanation**: negative demand effects *[Basu & Bundick, 2017]*
  - flex-price RBC model: precautionary savings $\uparrow \Rightarrow$ investment $\uparrow$
  - sticky-price NK model: precautionary savings $\uparrow \Rightarrow \downarrow$ agg. demand
  - NK+SaM: ... $\downarrow$ agg. demand $\Rightarrow \downarrow$ job creation $\Rightarrow \uparrow$ unemployment
  - $u \uparrow$, $\pi \downarrow$
  - uncertainty shocks $\approx$ aggregate demand shocks?
  - "divine coincidence"

How do we explain the labor market effects of uncertainty?

- Uncertainty: important in GFC & Covid-19 induced recession
- Empirical evidence: uncertainty $\uparrow \Rightarrow$ unemployment $\uparrow$
- Benchmark explanation: negative demand effects
- **Revisit this relationship** – for theoretical & empirical reasons
  1. theoretical link b/w financial discounts and job creation *[Hall, 2017; Liu, 2021]*
  2. mixed empirical evidence on inflation response *[Castelnuovo, 2019]*

$\Rightarrow$ How should we think about the labor market effects of uncertainty?

Paper highlights risk-premium channel of uncertainty

Revisit role of uncertainty using NK + Search-and-Matching framework

1. **Qualitative**: characterize transmission mechanisms of uncertainty

   $\Rightarrow$ recession even in flex-price economy: risk-premium channel

   $\Rightarrow$ risk-premium channel $\approx$ negative supply effect ($u\uparrow$, $\pi\uparrow$)

   $\Rightarrow$ NK+SaM: demand + risk-premium channels operate simultaneously

2. **Quantitative**: decompose effects using model calibrated to real + financial moments & reveal implications

   $\Rightarrow$ risk-premium channel accounts for $\approx \frac{1}{2}$ of *unemployment* $\uparrow$

   $\Rightarrow$ uncertainty shocks are less deflationary than demand shocks

   $\Rightarrow$ uncertainty shocks cannot be fully neutralized by monetary policy

Paper brings together 2 literatures

▸ Option Value

1. **Macroeconomic effects of uncertainty**
   - Bloom (2009); Fernandez-Villaverde et al. (2011); Bachmann and Bayer (2013); Born and Pfeifer (2014); Christiano et al. (2014); Fernandez-Villaverde et al. (2015); *Basu and Bundick (2017)*; Schaal (2017); Bloom et al. (2018); Cesa-Bianchi & Fernandez-Corugedo (2018); Ghironi & Ozhan (2019); Bachmann et al. (2019); Berger et al. (2019); Coibion et al. (2021); Den Haan et al. (2021) . . .

2. **Role of financial discounts in driving business cycle fluctuations**
   - *Hall (2017)*; Borovicka and Borovickova (2018); Petrosky-Nadeau et al. (2018); Basu et al. (2021); Kehoe et al. (2022); . . .

- **Leduc and Liu (2016, JME)**

Model

SaM Model with risk aversion & sticky prices

1. **Risk-averse** households
2. **Labor market** with DMP **search & matching frictions**
3. **Intermediates sector**: produce using labor
   - **time-varying volatility** in aggregate labor productivity
4. Retail sector: monopolistically competitive, aggregates intermediates
   - first consider flexible prices
   - later add Rotemberg price adjustment costs
5. Final goods sector: aggregates retail goods, sells to households

Representative household problem

- Choice over **consumption**, nominal **bonds** and (risky) **equity**
- Standard optimization problem:

$$\max_{\{c_t, a_t, B_t\}_{t=0}^{T}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t),$$

$$\text{s.t.} \quad c_t + a_t(J_t - d_t) + \frac{B_t}{P_t R_t} = w_t n_t + \tilde{d}_t + \frac{B_{t-1}}{P_t} + a_{t-1}(1-\delta)J_t, \ \forall t$$

- Asset position:
  - bond holdings B_{t-1}
  - equity a_{t-1} valued at cum-dividend price J_t
  - but exogenous fraction δ of firms goes out of business in each period
  - profits from other sources summarized in $\tilde{d}_t$
  - price level P_t, gross nominal interest rate R_t

Optimal consumption & portfolio choices

- Euler equation for bonds:

$$u'(c_t) = \beta E_t \left[\frac{R_t}{\Pi_{t+1}} u'(c_{t+1}) \right]$$

  - Π_t: gross inflation rate

- **Euler equation for equity**:

$$J_t = d_t + E_t \left[\underbrace{\beta \frac{u'(c_{t+1})}{u'(c_t)}}_{\equiv \Lambda_{t,t+1}} J_{t+1}(1-\delta) \right]$$

$\Rightarrow$ **Equity risk premium**:

$$\underbrace{\frac{E_t[J_{t+1}](1-\delta)}{J_t - d_t}}_{\text{return on equity}} - \underbrace{\frac{1}{E_t[\Lambda_{t,t+1}]}}_{R_t^{\text{rf}}}$$

Workers matched with firm(s) in frictional labor market

- **Employment** evolves according to:

$$n_t = \underbrace{(1-\delta)n_{t-1}}_{\text{surviving matches}} + \underbrace{m_t}_{\text{new matches}}$$

- **New matches**: $m_t = m(v_t, u_t^s)$
  - vacancies v_t : optimal firm choice
  - job seekers $u_t^s = 1 - (1-\delta)n_{t-1}$

- **Hiring rate**: $h_t = m_t / v_t$ & job finding rate $f_t = m_t / u_t^s$

Intermediate goods sector: forward-looking vacancy-posting

- **Equity market value:**

$$s_t \equiv \max_{\{v_{t+l}, n_{t+l}\}_{l=0}^{\infty}} E_t \left[\sum_{l=0}^{\infty} \Lambda_{t,t+l} \left(x_{t+l} z_{t+l} n_{t+l} - w_{t+l} n_{t+l} - \kappa v_{t+l} \right) \right],$$

s.t. $\quad n_t = (1-\delta) n_{t-1} + h_t v_t$

- **Match value** = cum-dividend price of equity:

$$J_t \equiv \frac{\partial s_t}{\partial n_t} = \underbrace{x_t z_t - w_t}_{=d_t} + (1-\delta) \left[\Lambda_{t,t+1} J_{t+1} \right]$$

  - x_t: *relative price* of intermediates in terms of the final good – inverse of markup charged by retailers; $x_t = \overline{x}$ under flexible prices

- **Optimal vacancy creation**: value of vacant position $J_t^v = 0$

$$J_t^v \equiv \frac{\partial s_t}{\partial v_t} = -\kappa + h_t J_t + (1-h_t) E_t \left[\Lambda_{t,t+1} J_{t+1}^v \right]$$

$$\Leftrightarrow \kappa = h_t J_t$$

...and bargain over wages using alternating offers

- **Wage-bargaining protocol**: alternating offers *[cf. Hall & Milgrom, 2008]*

$$w_t = \omega(x_t z_t) + (1-\omega)\chi$$

  - ω: worker bargaining power
  - χ: worker outside option during bargaining; key for employment volatility

- **Equity pricing equation** thus simplifies, sub'ing for dividends:

$$\mathbf{J_t = (1-\omega)(x_t z_t - \chi) + (1-\delta)E_t[\Lambda_{t,t+1} J_{t+1}]}$$

- Why not Nash bargaining? *[Den Haan - Freund - Rendahl, 2021]*

Flexible vs. sticky prices

▸ NKPC

- Thus far focused on real side of the model, elided nominal variables
- **Flex-price** (**RBC**) version: price of intermediate goods *relative* to final good constant at $x_t = x$ (inverse markup charged by retailers)
- **Sticky-price** (**NK**) version: augment model with 2 standard equations
  - Taylor rule (setting the nominal interest rate)
  - New Keynesian Phillips curve (relating inflation to real activity)
    – NB: linearized ($\rightarrow$ no precautionary pricing)

$\Rightarrow$ equity price J_t is affected by nominal variables via inverse markup x_t

Stochastic volatility in aggregate productivity

- **Stochastic** processes: AR(1) for productivity level *and* shock volatility

$$z_t = (1-\rho_z)z + \rho_z z_{t-1} + \sigma_{z,t-1}\epsilon_{z,t}$$
$$\sigma_{z,t} = (1-\rho_{\sigma_z})\sigma_z + \rho_{\sigma_z}\sigma_{z,t-1} + \sigma_{\sigma_z}\epsilon_{\sigma_z,t}$$

- **Uncertainty shock**: $\epsilon_{\sigma_z,t}\uparrow$
  - mean-preserving spread to distribution of future productivity shocks
  - **focus on *pure* uncertainty effects**, i.e., IRFs for some variable y: $y_{t+s} = g(y_{t+s-1}; \bar{\mathbf{z}}; \sigma_{z,t+s})$, for $s = 0, 1, \ldots$, where $g(\cdot)$ represents the policy function for y

- Solution method: *3rd*-order perturbation

Equilibrium definition

Definition

A competitive equilibrium in the search economy is a process of prices $\{J_t, R_t, \Pi_t, x_t, w_t\}_{t=0}^{\infty}$ and quantities $\{c_t, B_t, h_t, n_t, a_t\}_{t=0}^{\infty}$ such that:

1. consumption and portfolio choices $\{c_t, B_t, a_t\}_{t=0}^{\infty}$ solve the household's problem.
2. equity prices $\{J_t\}_{t=0}^{\infty}$ satisfy the asset pricing equation;
3. the hiring rate, $\{h_t\}_{t=0}^{\infty}$, satisfies the optimal posting condition;
4. employment, $\{n_t\}_{t=0}^{\infty}$, satisifies the law of motion;
5. wages $\{w_t\}_{t=0}^{\infty}$ are set according to alternating offers bargaining;
6. the gross nominal interest rate, $\{R_t\}_{t=0}^{\infty}$, satisfies the Taylor rule;
7. relative prices for intermediate goods and inflation, $\{x_t, \Pi_t\}_{t=0}^{\infty}$, satisfy the Phillips curve;
8. bond markets clear, $B_t = 0$;
9. equity market clear, $a_t = n_t$; and
10. intermediate goods markets clear.

Transmission channels

2-period model: purpose & structure

- Consider a stripped-down version of model, initially assuming that prices are flexible ("RBC")

- **2 objectives**:
  1. understand precisely how uncertainty shocks transmit to the labor market
  2. transparently illustrate method used later to numerically decompose contribution of different transmission channels

- **Environment**:
  - collapse all periods into *present* ($t = 0$) and *future* ($t = 1$)
  - $t = 0$: fixed productivity state z_0
  - $t = 1$: two possible outcomes for J, each occurring w/ probability $\frac{1}{2}$
    - good: $J_g = \bar{J} + \Delta$
    - bad: $J_b = \bar{J} - \Delta$
  - closed-form results: CRRA utility with risk-aversion parameter γ

How can $\uparrow\Delta$ affect period-0 outcomes?

- **Equity price** in $t = 0$...

$$J_0 = (1-\omega)(\bar{x}z_0 - \chi) + \frac{\beta(1-\delta)}{u'(c_0)}\left[\frac{1}{2}u'(c_g)J_g + \frac{1}{2}u'(c_b)J_b\right],$$

...will only be affected by $\uparrow\Delta$ if $\left[\frac{1}{2}u'(c_g)J_g + \frac{1}{2}u'(c_b)J_b\right]$ moves

- Rewriting

$$\left[\frac{1}{2}u'(c_g)J_g + \frac{1}{2}u'(c_b)J_b\right] = \underbrace{\frac{1}{2}(u'(c_g)+u'(c_b))\bar{J}}_{E[u'(c_1)]E[J_1]} + \underbrace{\frac{1}{2}\Delta(u'(c_g)-u'(c_b))}_{Cov(J,u'(c_1))}$$

- Two channels:
  1. **precautionary-motive:** changes in the *expected level of future marginal utility,* $E_0[u'(c_1)]$
  2. **risk-premium:** changes in the (conditional) *covariance* between future marginal utility and future asset price

Qualitative results (I)

Details

Proposition

Assume that utility is CRRA with coefficient of relative risk aversion γ. Then for any value of $\gamma > 0$, an incremental increase in Δ leads to a positive precautionary-motive effect and a negative risk-premium effect. Moreover, if $\gamma \leq 1$, the overall effect is negative.

Risk-premium channel of uncertainty

RP & Covariance

- **Risk-premium channel**: uncertainty $\uparrow$ amplifies the negative comovement between the marginal utility of consumption and the asset price $\Rightarrow \uparrow$ in the required risk premium for equity $\Rightarrow \downarrow$ equity price $J_0 \Rightarrow \downarrow$ vacancy posting $\Rightarrow \uparrow$ unemployment

- No covariance – no risk premium

Precautionary-motive channel: prudence & asymmetries

Asymmetry Proposition

- **Prudence**: prudent agents value all assets – including equity – more highly when faced with a $\uparrow$ uncertain future $\Rightarrow$ $\uparrow$ vacancy posting
- **Employment asymmetries**: greater expected future volatility lowers the expected level of future consumption due to nonlinearities in the employment process $\Rightarrow$ consumption-smoothing agents value asset more highly $\Rightarrow$ $\uparrow$ vacancy posting.

GE effects?

▸ GE expression

- Asset-pricing equation: thus far treated c_0 as fixed...

$$J_0 = (1-\omega)(\bar{x}z_0 - \chi) + \frac{\beta(1-\delta)}{u'(c_0)}\left[\frac{1}{2}u'(c_g)J_g + \frac{1}{2}u'(c_b)J_b\right],$$

- Given a J_0, optimal vacancy posting + CD matching fn. (with elasticity $\frac{1}{2}$) + market clearing imply **employment** & **consumption**:

$$n_0 = (1 - n_{-1} + \delta n_{-1})\psi^2 \frac{J_0}{\kappa} + (1-\delta)n_{-1}$$

$$c_0 = z_0 n_0$$

- **General equilibrium effects**, through $u'(c_0)$:
  1. amplification of RP channel: $\downarrow J_0 \Rightarrow \downarrow n_0 \Rightarrow \downarrow c_0 \Rightarrow \uparrow u'(c_0)$: desire to save relatively less in *any* asset $\Rightarrow \downarrow J_0 \Rightarrow$ ...
  2. amplification of precautionary-motive channel: $\uparrow J_0 \Rightarrow \uparrow n_0 \Rightarrow \uparrow c_0 \Rightarrow \downarrow u'(c_0)$: desire to save relatively more in *any* asset $\Rightarrow \uparrow J_0 \Rightarrow$ ...

Sticky prices

- With nominal rigidities, the relative price of intermediate goods is time-varying, so that J is affected by nominal variables

$$J_0 = (1-\omega)(x_0 z_0 - \chi) + \frac{\beta(1-\delta)}{u'(c_0)}\left[\frac{1}{2}u'(c_g)J_g + \frac{1}{2}u'(c_b)J_b\right]$$

- 2 more equations:
    - inflation determined by the Bond Euler equation + Taylor Rule

$$u'(c_0) = \beta\overline{R}\Pi_0^{\phi-1}\underbrace{\frac{1}{2}(u'(c_g)+u'(c_b))}_{E[u(c_1)]},$$

    - Phillips curve pins down x

$$x_0 = \frac{\eta-1}{\eta} + \frac{\Omega_p}{\eta}\Pi_0\left(\Pi_0 - 1\right).$$

Qualitative results (II): sticky prices & demand channel

Proposition

When prices are sticky, the effect of the precautionary motive is negative for sufficiently strong nominal rigidities (a sufficiently high value of Ω_p).

- Sticky prices fundamentally alter the implications of "precautionary-motive" $\rightarrow$ standard **Aggregate Demand** mechanism: $\uparrow$ expected SDF $\Rightarrow$ but Taylor Rule $\Rightarrow \downarrow$ demand $\Rightarrow$ insufficient $\downarrow$ price adjustment $\Rightarrow$ markups $\uparrow$ = relative price $\downarrow \Rightarrow \downarrow$ equity price $\Rightarrow \downarrow$ vacancy posting...

Decomposition approach in 2-period environment

- Let $\mathbf{1}_{\text{RP}}$ be an indicator function taking the value 1 if the risk-premium channel is present and 0 otherwise,

$$J_0 = (1-\omega)(x_0 z_0 - \chi) + \frac{\beta(1-\delta)}{u'(c_0)} \left\{ E[u'(c_1)]E[J_1] + \mathbf{1}_{\text{RP}} \text{Cov}[u'(c_1), J_1] \right\}$$

- Quantify RP-channel for some variable y_0:

$$\frac{\partial y_0}{\partial \Delta} = \underbrace{\left(\left\{ \frac{\partial y_0}{\partial \Delta} |_{\mathbf{1}_{\text{RP}}=1} \right\} - \left\{ \frac{\partial y_0}{\partial \Delta} |_{\mathbf{1}_{\text{RP}}=0} \right\} \right)}_{\text{Risk-premium channel}} + \underbrace{\left(\left\{ \frac{\partial y_0}{\partial \Delta} |_{\mathbf{1}_{\text{RP}}=0} \right\} \right)}_{\text{Precautionary-motive channel}}$$

- Propagating effect of **GE** is attributed to the relevant underlying channel

Quantitative analysis

Quantitative model: questions & approach

▸ Habit specification

- **Questions:**

  1. how important is the risk-premium channel in accounting for the unemployment effects of uncertainty shocks?
     - IRFs: flexible prices & sticky prices
     - decomposition
  2. are uncertainty shocks observationally equivalent to demand shocks?
     - compare distribution of observables under uncertainty vs. demand shocks

- **Approach**
  - CRRA utility + Campbell & Cochrane (1999) external habits *[Chen, 2017; Kehoe et al., 2022]*
  - calibrate model at monthly frequency to US data
  - 1 s.d. uncertainty shock $\uparrow \approx$ 40% relative to sample mean *[Leduc & Liu, 2016]*

Internally calibrated moments

Parameters

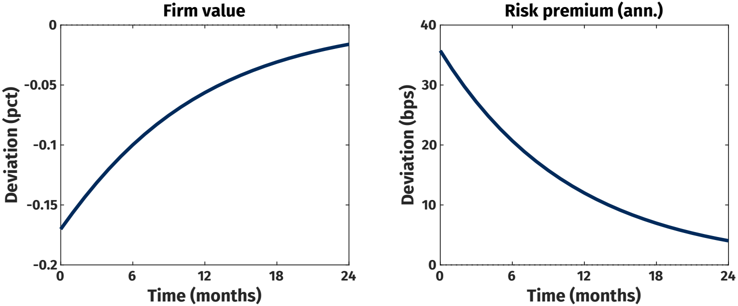
- Internally calibrate those parameters crucial for exogenous volatility and amplification
- 6 moments - 6 parameters: discount factor β, habit persistence ρ_s, relative risk aversion γ, average habit level $\overline{S}$, bargaining factor χ, and steady-state TFP volatility $\sigma_{\bar{z}}$

Moments	Data	Model	Data reference
Asset pricing moments			
Mean risk-free return (%p.q)*	0.24	0.2378	Chen (2017)
Volatility of risk-free return (%p.q)*	0.4	0.6915	Chen (2017)
Mean excess return (%p.q)*	1.47	1.0012	Chen (2017)
Volatility of excess return (%p.q)*	8.46	12.6435	Chen (2017)
AR(1) coef. of risk-free return (q)	0.88	0.9378	Chen (2017)
AR(1) coef. of of risk premium (q)	0.08	-0.0231	Chen (2017)
Real economy moments			
Unemployment volatility (%p.q)*	12.5	14.46	Hagedorn and Manovskii (2008)
Output volatility (%p.q)*	2.06	2.95	NIPA

Notes. The moments with * are the targeted moments. The volatilities of unemployment and output are obtained from applying the HP filter

IRFs: $1_{\text{RP}} = 1$ (flexible prices)

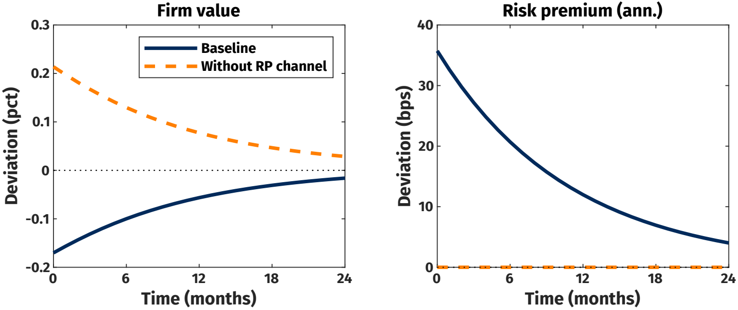
$\Rightarrow$ Even under flexible prices, an increase in perceived future volatility can lower the match value ($\rightarrow$ raise unemployment)



Notes. Pure uncertainty effect of a one sd shock to the volatility of productivity shocks. All parameters unchanged from calibration under sticky parameters, restricting price adjustment costs $\Omega_p = 0$. “Risk-premium” is the 12-months ahead equity risk premium.

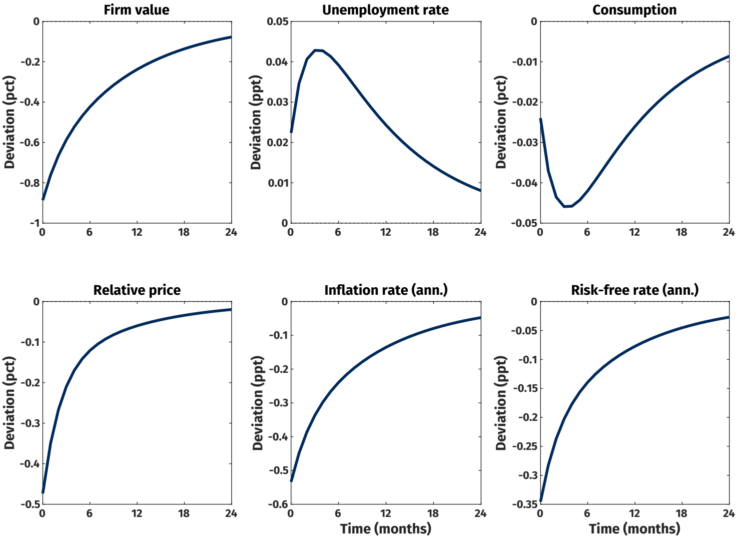
IRFs: $1_{\mathbf{RP}} = 0$ (flexible prices)

$\Rightarrow$ This result obtains due to the risk-premium channel; in its absence, uncertainty $\uparrow$ expansionary, due to the precautionary-motive channel



Notes. Pure uncertainty effect of a one sd shock to the volatility of productivity shocks.

IRFs: full model (sticky prices)

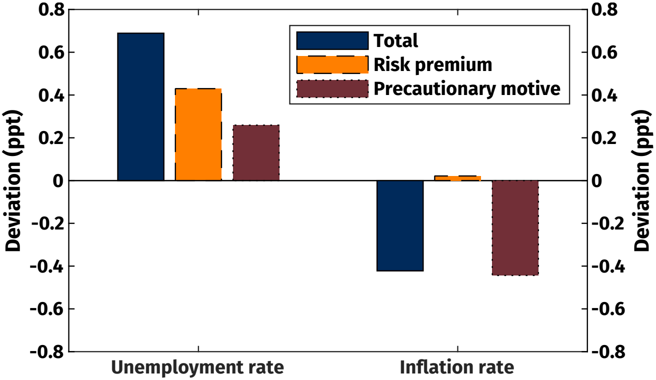


Notes. Pure uncertainty effect of a one sd shock to the volatility of productivity shocks.

Decomposition reveals important role of risk premium

IRF Comparison

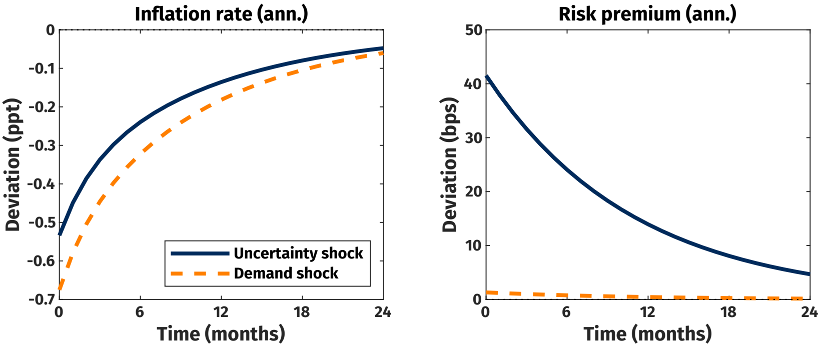
- Apply the decomposition method now in a quantitative setting & consider the cumulative impact on unemployment and inflation



Notes. "Risk premium" corresponds to difference between (cumulative) IRF from unrestricted model ("Total") and model restricting $\mathbf{1}_{\text{RP}} = 0$. "Precautionary-motive" channels account for the remainder (nb: linearized NKPC).

Implications

Uncertainty shocks are less deflationary than regular demand shocks



Notes. The sequence of interest rate shocks is such, in terms of magnitude and persistence, that the resulting effect on real economics activity is identical to that resulting from an uncertainty shock.

Conclusion

Summary: this paper...

▸ Monetary policy

1. **Explains transmission of uncertainty shocks to labor market**
    - under flexible & sticky prices
    - risk-premium channel & precautionary-motive channel(s)
    - importance of long-duration employment relationships/payoffs
    - GE interactions

2. **Quantifies contribution of risk-premium channel**
    - $\approx$ half of cumulative unemployment rise

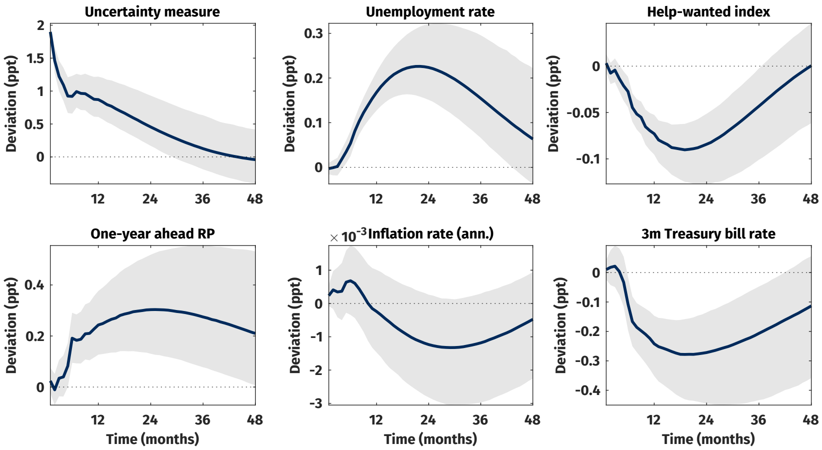
3. **Shows uncertainty shocks $\neq$ aggregate demand shocks**
    - reduced-form Phillips Curve is a mix of supply and demand factors

THANK YOU!

Extra slides: empirics

Illustrative results from simple, recursively identified SVAR (USA)

▶ Main



Notes. Empirical effects of a one standard-deviation uncertainty shock. Monthly US data spanning 1978:1-2016:12. Solid lines indicate the median posterior density of impulse responses, while the shaded area represents the 95 % highest posterior density (HPD) interval. The uncertainty measure is the fraction of respondents in the Michigan Consumer Survey pointing to an "uncertain future" as negatively affecting their their spending on durable goods over the coming year.

Details on VAR specification

- US data: measure of perceived consumer uncertainty based on the Michigan survey, unemployment rate, composite help-wanted index (Barnichon 2010; Barnichon's website), one-year ahead equity risk premium (Duarte et al., 2015, F. Duarte's website), year-on-year CPI inflation rate, 3-month Treasury bill rate
- 1978-2016, monthly frequency, 6 lags
- Standard recursive identification, with uncertainty proxy ordered first
- Bayesian estimation with normal-diffuse prior
- Results are very robust, e.g. using alternative uncertainty proxies such as Baker et al. Equity Market Volatility Tracker (1985-2016) yields very similar picture

Extra slides: model setup

Retail sector to model sticky prices

Main

- Final consumption good: $y_t = \left(\int_0^1 y_{j,t}^{\frac{\eta-1}{\eta}} \, dj \right)^{\frac{\eta}{\eta-1}}$
- Expenditure minimization + perfect competition in aggregation sector imply

$$y_{j,t}^d = \left(\frac{P_{j,t}}{P_t} \right)^{-\eta} y_t \tag{1}$$

$$P_t = \left(\int_0^1 P_{j,t}^{\frac{1}{1-\eta}} \, dj \right)^{1-\eta} \tag{2}$$

- Retail price-setting problem

$$\max_{P_{j,t+l}} \left\{ E_t \sum_{l=0}^{\infty} \Lambda_{t,t+l} \left(\frac{P_{j,t+l}}{P_{t+l}} y_{j,t+l} - x_{t+l} y_{j,t+l} - \underbrace{\frac{\Omega_p}{2} \left(\frac{P_{j,t}}{P_{j,t-1}\Pi} - \Pi \right)^2 y_t}_{\equiv ac_{j,t+l}} \right) \right\}$$

s.t. equation (1),

- Implied NKPC

$$x_t = \frac{\eta - 1}{\eta} + \frac{\Omega_p}{\eta} \left\{ \frac{\Pi_t}{\Pi} \left(\frac{\Pi_t}{\Pi} - 1 \right) - E_t \left[\Lambda_{t,t+1} \frac{y_{t+1}}{y_t} \frac{\Pi_{t+1}}{\Pi} \left(\frac{\Pi_{t+1}}{\Pi} - 1 \right) \right] \right\}.$$

Campbell & Cochrane (1999) type habits

Main

- Campbell & Cochrane (1999)

$$u'(c_t) = (S_t c_t)^{-\gamma}$$

- While CC specify exogenous consumption process, here consumption fluctuates endogenously
- Following Kehoe et al. (2022), $s_t = \log(S_t)$ is governed by

$$s_{t+1} = (1-\rho_s)\bar{s} + \rho_s s_t + \lambda_z(s_t)(\Delta \log(z_{t+1}) - E\Delta \log(z_{t+1}))$$

  where the sensitivity function $\lambda_z(s_t)$ is defined as

$$\lambda_z(s_t) = \frac{1}{\bar{s}}(1 - 2(s_t - \bar{s}))^{1/2} - 1 \geq 0$$

- Thus, in periods of low agg. productivity, risk aversion ↑
- Two parameters, $\bar{s}$ and ρ_s, that we discipline using asset price moments

Extra slides: calibration

Externally calibrated parameters

Main

- 1 s.d. uncertainty shock as in Leduc & Liu (2016): $\uparrow\approx$ 40% relative to sample mean

Parameter	Description	Value	Source
γ	Coefficient of risk aversion	1	Convention
ψ	Efficiency of matching	0.3101	Unemployment rate of 6.4%
δ	Separation rate	0.028	Krusell et al. (2017)
α	Elasticity of $f(\theta)$	0.5	Petrongolo and Pissarides (2001)
ω	Workers bargaining power	0.8043	Steady-state wage relation
Ω_p	Rotemberg adjustment cost	635	Avg. price resetting duration 9 months
ρ_z	Persistence of productivity	0.983	Leduc and Liu (2016)
ρ_σ	Persistence of uncertainty	0.913	Leduc and Liu (2016)
σ_σ	St. dev. of uncertainty shock	0.000853	Leduc and Liu (2016)
κ	Vacancy-posting cost	0.23643	2 percent of output
ϕ_π	Vacancy-posting cost	1.5	Standard

Notes. Parameters taken from Leduc & Liu (2016) have been adapted to monthly frequency.

Internally calibrated parameters: parameter values

Parameter	Description	Value
β	Discount factor	0.99780
ρ_s	Habit persistence	0.99700
$\overline{S}$	Average habit level	0.09
γ	Coefficient of relative risk aversion	0.50
χ	Income while delaying bargaining	0.79000
$\sigma_{\bar{z}}$	TFP volatility	0.00620

Notes. Global minimands to unweighted sum of squared distances between empirical and theoretical moments.

Extra slides: more results

Risk premium & covariance

▸ Main

- Euler equation for equity:

$$J_t = d_t + E_t\left[\underbrace{\beta\frac{u'(c_{t+1})}{u'(c_t)}}_{\equiv\Lambda_{t,t+1}} J_{t+1}(1-\delta)\right]$$

- Using the fact that

$$E_t[\Lambda_{t,t+1}J_{t+1}(1-\delta)] = E_t[\Lambda_{t,t+1}]E_t[J_{t+1}(1-\delta)] + \mathrm{Cov}(\Lambda_{t,t+1}, J_{t+1}(1-\delta))$$

- The risk premium can be written as

$$RP_t = -\frac{\mathrm{Cov}(\Lambda_{t,t+1}, J_{t+1}(1-\delta))}{J_t - d_t} \times \frac{1}{E_t[\Lambda_{t,t+1}]}$$

- Hence: **no covariance** $=$ **no risk premium**

Closed-form risk-premium channel

Main

- The uncertainty shock operates through the following terms:

$$\left[pu'(c_g)J_g + (1-p)u'(c_b)J_b\right] = \underbrace{\frac{1}{2}(u'(c_g)+u'(c_b))\bar{J}}_{E[u'(c)]E[J]} + \underbrace{\frac{1}{2}\Delta(u'(c_g)-u'(c_b))}_{Cov(u'(c),J)}.$$

- Differentiating the above expression with respect to Δ gives

$$\frac{\partial}{\partial \Delta}\left[(u'(c_g)+u'(c_b))\bar{J} + \Delta(u'(c_g)-u'(c_b))\right]$$

$$= \underbrace{\gamma\left(u'(c_b)\varepsilon_{c_b}\frac{\bar{J}}{J_b} - u'(c_g)\varepsilon_{c_g}\frac{\bar{J}}{J_g}\right)}_{\text{precautionary-motive channel}}$$

$$-\Delta\gamma\left(u'(c_g)\frac{\varepsilon_{c_g}}{J_g} + u'(c_b)\frac{\varepsilon_{c_b}}{J_b}\right) - (u'(c_b)-u'(c_g))$$

- The risk-premium effect is always negative for $\gamma > 0$ (given $c_g > c_b$)

The sign of the overall effect

- But is the RP effect strong enough to make the overall effect negative?
- The precautionary-motive effect is captured by

$$\begin{aligned}&\gamma\left(u'(c_b)\varepsilon_{c_b}\frac{\bar{J}}{J_b}-u'(c_g)\varepsilon_{c_g}\frac{\bar{J}}{J_g}\right)\\ =&\gamma(1-(1-\delta)n_{-1})\psi^2\frac{J}{\kappa}\left(\frac{u'(n_b)}{n_b}-\frac{u'(n_g)}{n_g}\right)>0.\end{aligned}$$

- For the total effect, the main equation above simplifies to

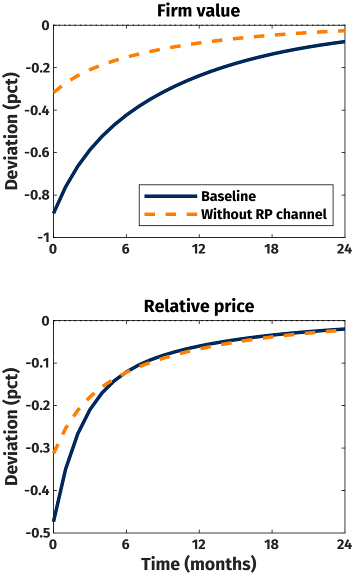
$$\gamma\left[c_g^{-\gamma}(1-\gamma\varepsilon_{c,g})-c_b^{-\gamma}(1-\gamma\varepsilon_{c,b})\right].$$

- Thus, if $\gamma \leq 1$ we have

$$\begin{aligned}\gamma\left[c_g^{-\gamma}(1-\gamma\varepsilon_{c,g})-c_b^{-\gamma}(1-\gamma\varepsilon_{c,b})\right]&<\gamma\left[c_b^{-\gamma}(1-\gamma\varepsilon_{c,g})-c_b^{-\gamma}(1-\gamma\varepsilon_{c,b})\right]\\ &=\gamma\left[c_b^{-\gamma}\gamma(\varepsilon_{c,b}-\varepsilon_{c,g})\right]<0.\end{aligned}$$

Full model: $1_{\text{RP}} = 1$ vs. $1_{\text{RP}} = 0$

Main



Employment asymmetry proposition

Main

Proposition

Consider employment as determined according to

$$n_t = (1-\delta)n_{t-1} + f_t\left(1-(1-\delta)n_{t-1}\right).$$

Suppose furthermore that all variables are covariance-stationary. Then the effect of the business cycle on the EMWS of employment is given by

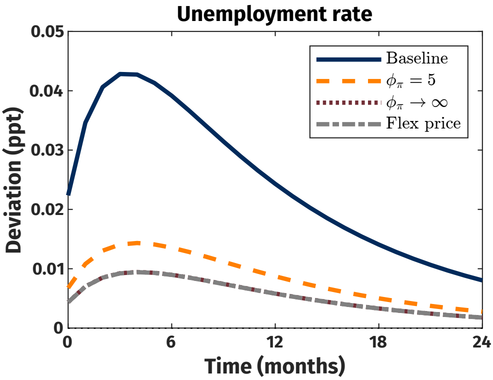
$$E\left[n_t\right] - n_t = \frac{1-\delta}{\delta+(1-\delta)f}\left\{-\mathrm{Cov}(f_t, n_{t-1}) + \left(\frac{\delta}{1-\delta} + (1-E[n_t])\right)(E[f_t] -\right.$$

Sufficient conditions for the EMWS of employment to lie below its DSS value are (i) $Cov(f_t, n_{t-1}) \geq 0$; (ii) $E[f_t] \leq f$; and (iii) at least one of the inequalities in (i) and (ii) holds strictly.

[Jung & Kuester, 2011]

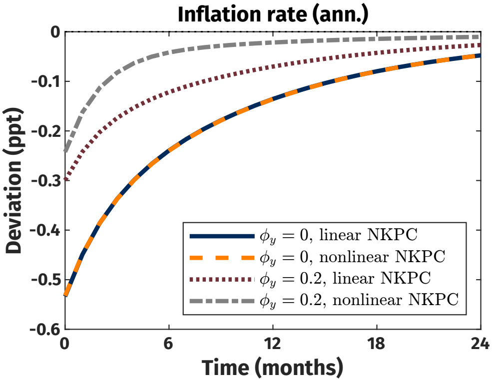
Monetary policy can (only) partially offset uncertainty shocks

▸ Main



Notes. The figure illustrates the response of unemployment to an uncertainty shock under sticky prices, varying the aggressiveness of the monetary authority's response to inflation.

Precautionary pricing



Notes. The figure illustrates the pure-uncertainty IRFs for a one standard-deviation shock to volatility. The different IRFs vary according to the coefficient on output in the Taylor rule, ϕ_y and differ in whether the structural New Keynesian Phillips curve equation is linearized or not when solving the model.