The Origins and Effects of Macroeconomic Uncertainty

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Motivation

- Growing literature studying the role of **uncertainty** using general equilibrium models
- Most of these papers tend to find modest effects of uncertainty
- These papers typically...
  1. only use **macroeconomic data**
  2. consider **only one source** of uncertainty
  3. rely on **a two-step procedure** in which uncertainty is **separately estimated**

This paper

We study the joint behavior of the macroeconomy and the term structure taking into account the **origins** and **effects** of uncertainty

- We construct a general-equilibrium model with an **endogenous term premium** and solve the model with a **risk-adjusted loglinearization**
- We introduce a novel **analytical decomposition** of the effects of uncertainty into **risk propagation channels**
- We conduct a **structural estimation** of the model in which we...
  1. employ **both macroeconomic** and **term structure data**
  2. distinguish between **demand-side** (preferences) and **supply-side** (TFP) uncertainty
  3. **jointly estimate** the process for **uncertainty** and its effects

Main results

- Both **supply-side** and **demand-side** uncertainty generate **sizable business cycle fluctuations** in consumption, investment, and term premia. But,...

  Supply-side uncertainty has larger effects on inflation and investment

- Analysis of the five risk propagation channels accounts for these differences

  1. The **investment risk premium channel** amplifies the response of investment to supply-side uncertainty: Investment in capital becomes relatively **riskier**
  2. The **nominal pricing bias channel** accounts for the different inflation responses: Demand-side uncertainty $\Rightarrow$ inflation uncertainty $\Rightarrow$ inflationary pressure
  3. The **precautionary savings channel** cannot account for these differences

- Good fit of the term structure, with realistic **nominal** and **real** term premia

The Model: Households

The representative household has recursive preferences:

$$V_t = \left[(1-\beta_t)\, u(C_t, L_t)^{1-1/\psi} + \beta_t \left(E_t \left[V_{t+1}^{1-\gamma} \right] \right)^{\frac{1-1/\psi}{1-\gamma}} \right]^{\frac{1}{1-1/\psi}}$$

$$u(C_t, L_t) = (C_t - h\overline{C}_{t-1}) exp(-\tau_0 \frac{L_t^{1+\tau}}{1+\tau})$$

where γ is the coefficient of risk aversion, ψ is the elasticity of intertemporal substitution, and $\beta_t = \left(1 + \hat{\beta} exp(\tilde{b}_t)\right)^{-1}$, where $\tilde{b}_t$ is a preference shock

$$\tilde{b}_t = \rho_\beta \tilde{b}_{t-1} + \sigma_{\beta,\xi_t^D} \varepsilon_{\beta,t}, \ \varepsilon_{\beta,t} \sim N(0,1)$$

The variable ξ_t^D follows a Markov-switching process with transition matrix H^D and determines the volatility regime of preference shocks at time t.

The Model: Firms

Final good representative firm uses a continuum of differentiated intermediate goods as input in a CES production technology

Representative intermediate firm faces:

- Monopolistic competition
- Sticky prices (Quadratic adjustment cost)
- Rental rate for capital (owned by households)
- Changes in the volatility of TFP shocks

$$Z_t = e^{n_t}, \; \Delta n_t = \mu + x_t$$
$$x_t = \rho_x x_{t-1} + \sigma_{x,\xi_t^S} \varepsilon_{x,t}, \; \varepsilon_{x,t} \sim N(0,1)$$

The variable ξ_t^S follows a Markov-switching process with transition matrix H^S and determines the volatility regime of TFP shocks at time t.

The Model: Policy makers

- The central bank follows a Taylor rule

$$\ln\left(\frac{R_t}{R^*}\right) = \rho_r \ln\left(\frac{R_{t-1}}{R^*}\right) + \\ +(1-\rho_r)\left[\rho_\pi \ln\left(\frac{\Pi_t}{\Pi^*}\right) + \rho_y \ln\left(\frac{\widehat{Y}_t}{\widehat{Y}^*_{ss}}\right)\right] + \sigma_m \varepsilon_{m,t}$$

- Fiscal authority keeps debt on a stable path

Propagation channels of uncertainty

- **Precautionary savings channel** - consumption Euler equation

$$\tilde{c}_t = E_t\left[\tilde{c}_{t+1}\right] - \widetilde{r}_{f,t} + (1-\overline{\beta}\rho_\beta)\tilde{b}_t + \rho_x \widetilde{x}_t \underbrace{-\frac{1}{2}Var_t\left[\widetilde{m}_{t+1}\right] + \frac{1}{2}(1-\gamma)^2 Var_t\left[\tilde{v}_{t+1} + \widetilde{x}_{t+1}\right]}_{\text{Precautionary savings motive}}$$

- **Investment risk premium channel** - asset pricing equation for investment return

$$E_t[\widetilde{r}_{i,t+1} - \widetilde{r}_{f,t}] = \underbrace{-Cov_t[\widetilde{m}_{t+1}; \widetilde{r}_{i,t+1}] - \frac{1}{2}Var_t[\widetilde{r}_{i,t+1}]}_{\text{Investment Risk Premium}}$$

- **Inflation risk premium channel** - asset pricing equation for nominal short term rate

$$\widetilde{r}_t = \widetilde{r}_{f,t} + E_t\left[\widetilde{\pi}_{t+1}\right] + \underbrace{Cov_t\left[\widetilde{m}_{t+1}; \widetilde{\pi}_{t+1}\right] - \frac{1}{2}Var_t\left[\widetilde{\pi}_{t+1}\right]}_{\text{Inflation Risk Premium}}$$

Propagation channels of uncertainty

- **Nominal pricing bias channel** - Phillips curve

$$\tilde{\pi}_t = \overline{\beta} E_t\left[\tilde{\pi}_{t+1}\right] + \kappa_R(\tilde{w}_t + \tilde{l}_t - \tilde{y}_t) + \underbrace{\frac{1}{2}\overline{\beta}^*\left(2Cov_t\left[\tilde{m}_{t+1} + \tilde{y}_{t+1} + \tilde{x}_{t+1}; \tilde{\pi}_{t+1}\right] + 3Var_t\left[\tilde{\pi}_{t+1}\right]\right)}_{\text{Nominal Pricing Bias}}$$

- **Investment adjustment channel** - firm's investment decision

$$\tilde{q}_t - \varphi_I e^{2\mu}\Delta i_t + \varphi_I e^{2\mu}\overline{\beta}\left(E_t\left[\Delta i_{t+1}\right] + \underbrace{Cov_t\left[\tilde{m}_{t+1} + \tilde{q}_{t+1}; \Delta i_{t+1}\right] + \frac{5}{2}Var_t\left[\Delta i_{t+1}\right]}_{\text{Investment adjustment}}\right) = 0$$

Capturing the effects of Uncertainty

Our approximation method is based on the following two key ideas

1. Expectational equations are approximated assuming log-normality. The approximate solution indeed satisfies this condition
2. Uncertainty is regime dependent: $V_t[x_{t+1}] = V_{\xi_t}[x_{t+1}]$

These two ideas allow us to write the risk-adjusted linearized system of equations as

$$\Gamma_0 S_t = \Gamma_1 S_{t-1} + \Gamma_\sigma Q_{\xi_t} \varepsilon_t + \Gamma_\eta \eta_t + \Gamma_{c,\xi_t} \tag{1}$$

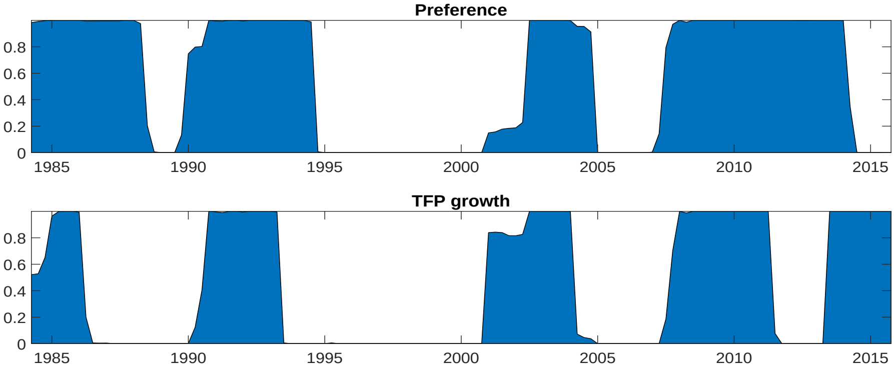
However, we need to know how the economy reacts to the exogenous shocks in order to compute the uncertainty terms in Γ_{c,ξ_t} $\Rightarrow$ iterative procedure.

The solution can be characterized as a MS-VAR:

$$S_t = \underbrace{C(\xi_t, \theta^v, \theta^p, H)}_{\text{Endogenous uncertainty}} + T(\theta^p) S_{t-1} + \underbrace{R(\theta^p) Q(\xi_t, \theta^v) \varepsilon_t}_{\text{Exogenous uncertainty}} \tag{2}$$

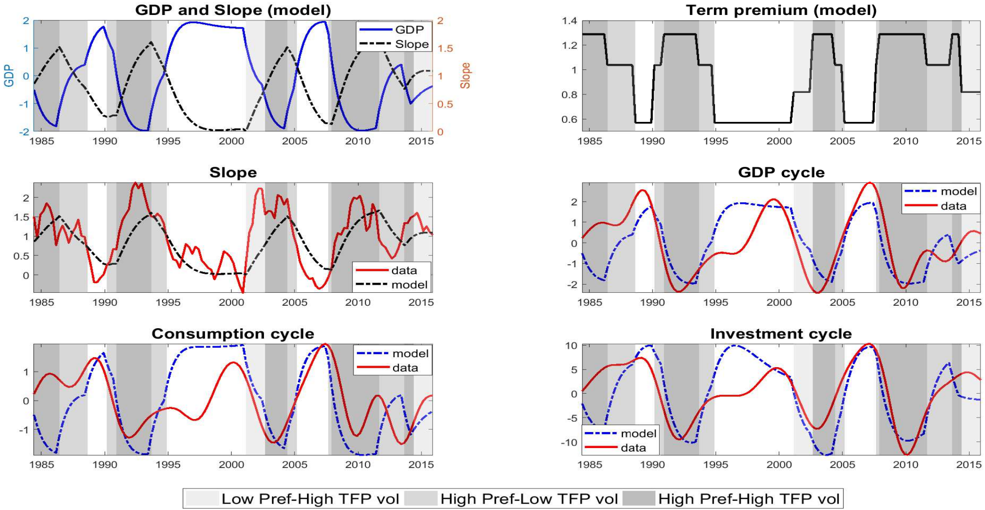
Parameter estimates

We estimate the model with Bayesian methods over the sample 1984:Q2-2015:Q4 using macro variables and yields with maturity from 1 year to 5 year.

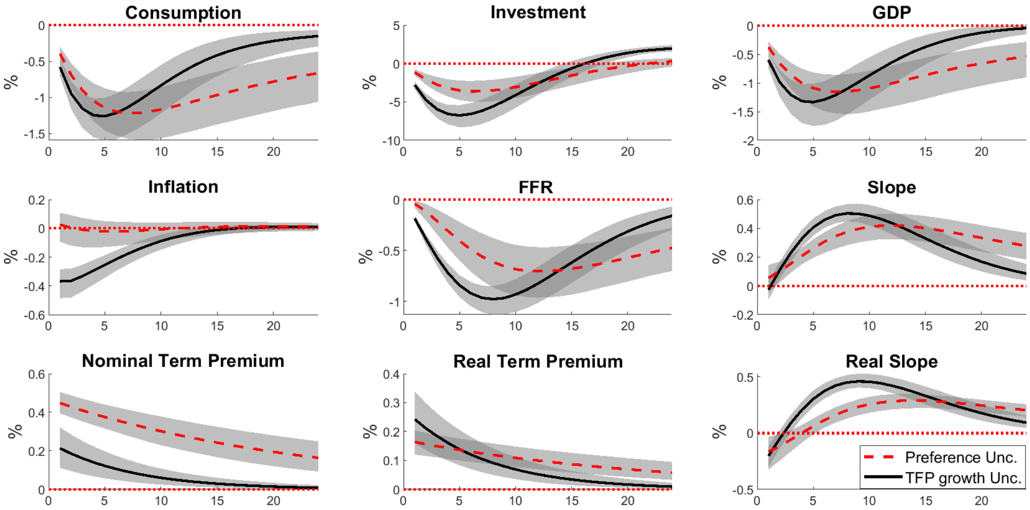


Probability of high uncertainty regimes

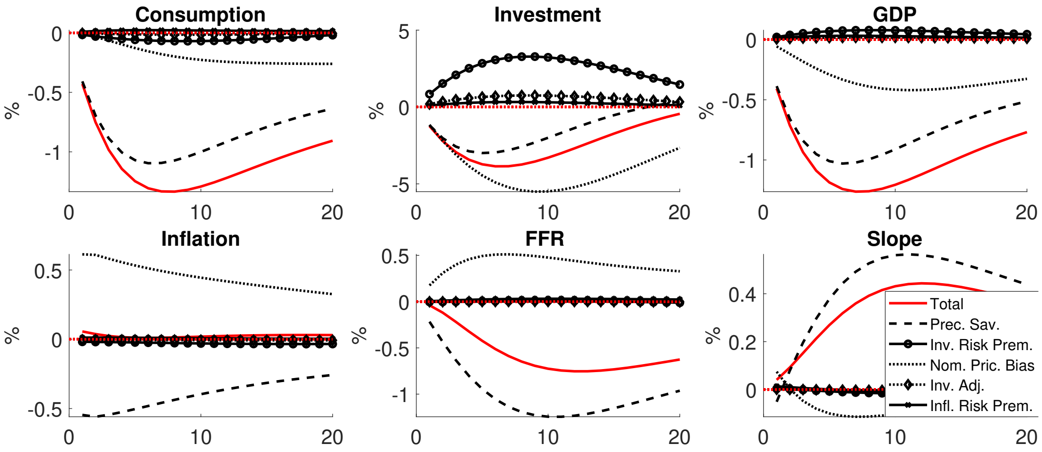
The Effects of Uncertainty



Effects of Uncertainty

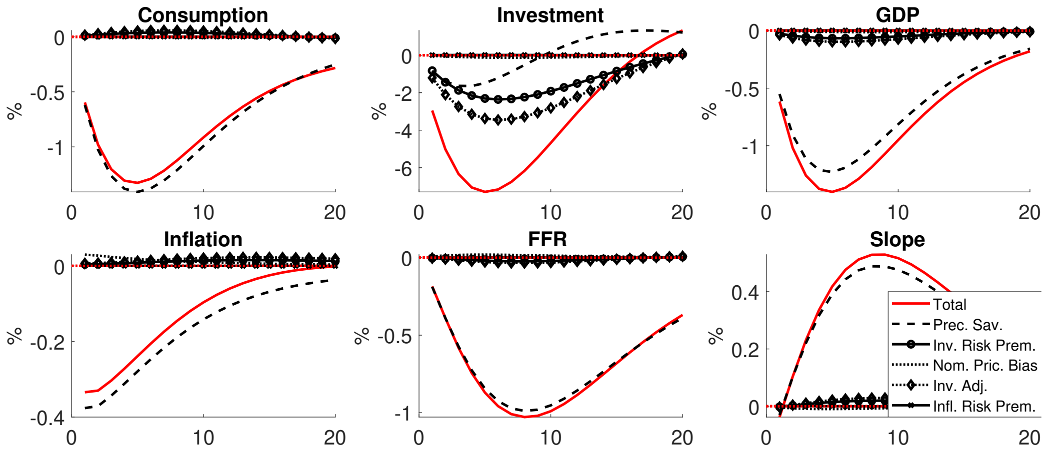


Channels of Uncertainty - Demand side



Response to an increase in demand uncertainty

Channels of Uncertainty - Supply side



Response to an increase in supply side uncertainty

Fit of term structure

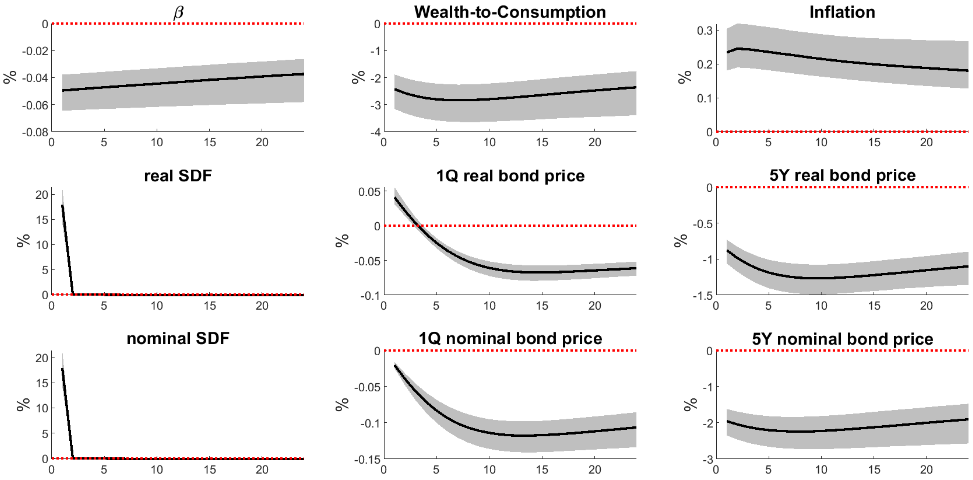
Upward slope of nominal and real term structure:

	Yields						Term Premium				
	1Q	1Y	2Y	3Y	4Y	5Y	Total	Risk	Liquidity	Only Pref.	Only TFP
Nominal	2.77	2.88	3.08	3.31	3.53	3.72	0.95	0.89	0.06	0.63	0.41
Real	0.57	0.58	0.71	0.89	1.06	1.21	0.63	0.63	-	0.22	0.43

Cochrane-Piazzesi regressions:

	Model				Data			
Maturity	2Y	3Y	4Y	5Y	2Y	3Y	4Y	5Y
$\beta^{(n)}$	0.41	0.83	1.21	1.56	0.45	0.81	1.24	1.50
	(2.91)	(3.35)	(3.49)	(3.49)	(3.65)	(3.56)	(3.99)	(4.03)
R^2	0.12	0.16	0.17	0.18	0.23	0.21	0.24	0.23
N obs	127	127	127	127	127	127	127	127

Term Premium



Conclusions

In this paper:

- An estimated general equilibrium model with **endogenous term premia** and **supply-side** and **demand-side** uncertainty
- Novel decomposition into **risk propagation channels** to study the effects of uncertainty in a **conditionally linear framework**
- **Uncertainty** emerges as an important driver of the business cycle and premia
- **Supply-side** uncertainty has larger effects on investment, inflation, and real premia
- **Risk channels** explain differences between demand-side and supply-side uncertainty