# Uncertainty Shocks In A Model Of Effective Demand


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Preliminary

# Can Higher Uncertainty Reduce Overall Economic Activity?

Many think it is an important driver of the current downturn

"I've been emphasizing uncertainties in the labor market. More generally, I believe that overall uncertainty is a large drag on the economic recovery."

– Narayana Kocherlakota, November 22, 2010

"What's critical right now is not the functioning of the labor market, but the limits on the demand for labor coming from the great caution on the side of both consumers and firms because of the great uncertainty of what's going to happen next."

– Peter Diamond, October 31, 2010

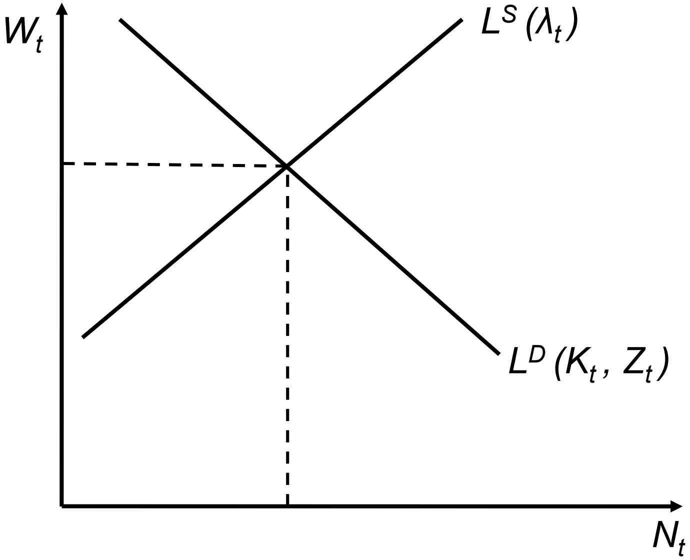
# Transmission of Uncertainty to Macroeconomy

| **Typical Partial Equilibrium Models** | | |
|---|---|---|
| Increased uncertainty | $\Rightarrow$ | Reduces consumption<br>(through precautionary saving) |
| Increased uncertainty | $\Rightarrow$ | Reduces investment<br>(through "real options" effect) |

| **Intuitive Economy-Wide Effects** | | |
|---|---|---|
| Increased uncertainty | $\Rightarrow$ | Reduces consumption & investment |
| Increased uncertainty | $\Rightarrow$ | Reduces total output, hours<br>$Y = C + I \quad (+\ldots)$ |

Do these intuitive partial-equilibrium results hold in general equilibrium?

# Flexible Price Model Intuition - Elastic Labor Supply



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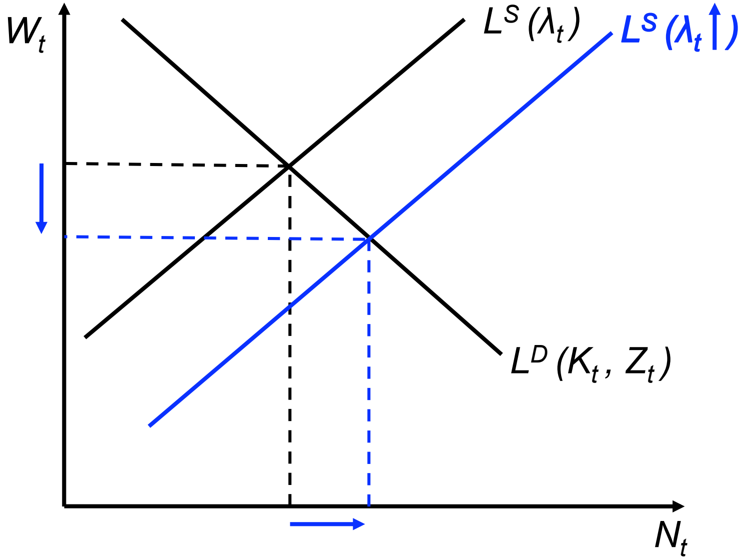


# Previous Literature

Most general-equilibrium models of uncertainty cannot produce simultaneous drops in output, consumption, investment, & hours worked

*Examples: Bloom, Floetotto, & Jaimovich (2009), Chugh (2010), Gourio (2010), Gilchrist, Sim, & Zakrajšek (2010) [for KPR utility]*

Several of these papers suggest that a simple representative-firm model cannot explain why uncertainty might be contractionary

# Effects of Uncertainty with Demand-Determined Output

How to restore primacy of reasoning from $Y_t = C_t + I_t$?

Our solution: Abandon short-run neoclassical assumption of full employment

Examine uncertainty shocks in model where output is demand-determined in the short run (the *Effective Demand* of the title)

Introduce endogenously-varying markups

We do so by assuming nominal price rigidity

Allows us to address the effects of uncertainty shocks at zero lower bound

# Sticky Price Model Intuition (I)

Labor demand for firm facing nominal rigidities:

$$\frac{W_t}{P_t} = \frac{1}{\mu_t} Z_t F_2(K_t, Z_t N_t)$$

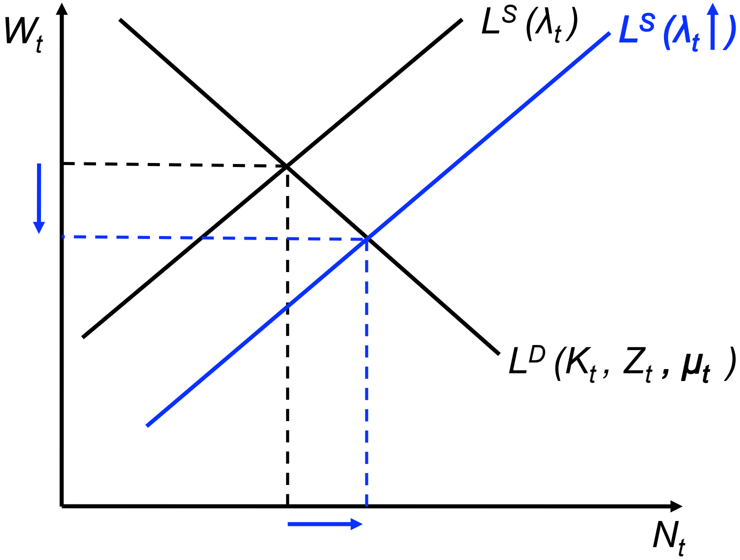
$\mu_t$: Markup of price over marginal cost

With sticky prices, precautionary working lowers wages & raises $\mu_t$

Reduces labor demand, so $Y_t$ and $N_t$ may fall

Specific example of general mechanism in Basu and Kimball (2003)

# Sticky Price Model Intuition (II)



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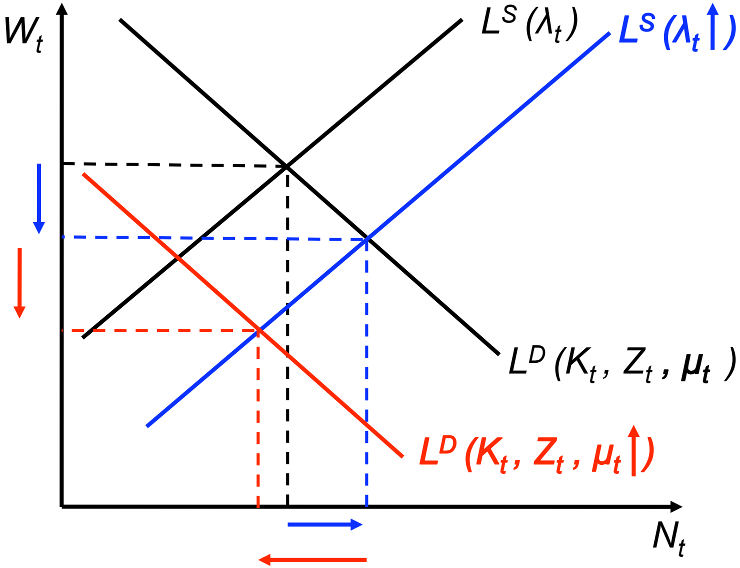


# A Mechanism with Broad Applicability

Example: How can bad news about the future lead to declines in current activity in simple DSGE models?

Bad news shifts labor supply outward: same analysis applies

We know ways to get this result in (complex) neoclassical models
*Examples: Beaudry-Portier (2007) & Jaimovich-Rebelo (2009)*

If we think nominal rigidity is necessary to explain the estimated effects of monetary shocks, then we should use the same model to examine effects of other shocks

# We Show

Increased uncertainty lowers $Y$, $C$, $I$, & $N$ when prices are slow to adjust

Same shock raises $Y$, $I$, and $N$ in the same model with flexible prices

Uncertainty can be associated with future technology or demand

We calibrate the model to reproduce the increase in uncertainty about future stock returns in the Great Recession

Model predicts demand uncertainty shocks are quantitatively significant

Effects are noticeably larger if monetary policy doesn't lower interest rates (for example, if constrained by the zero lower bound)

# Model Summary

New-Keynesian sticky price model with capital

Shares features with models of Ireland (2003, 2010) & Jermann (1998)

Household holds equity shares and one-period risk-free bonds

Firms owns capital stock, issue debt, & pay dividends

1st & 2nd moment shocks to technology & discount factors (demand)

All shocks are persistent, transitory, and independent

# Representative Household

Household maximizes lifetime utility from consumption and leisure

$$\max\ E_t \left\{ \sum_{s=0}^{\infty} \beta^s a_{t+s} \frac{C_{t+s}^{1-\sigma} (1 - N_{t+s})^{\eta(1-\sigma)}}{1-\sigma} \right\}$$

Subject to budget constraint

$$C_t + \frac{P_t^E}{P_t} S_{t+1} + \frac{1}{R_t^R} B_{t+1} = \frac{W_t}{P_t} N_t + \left( \frac{D_t^E}{P_t} + \frac{P_t^E}{P_t} \right) S_t + B_t$$

Stochastic process for preference (demand) shocks

$$\ln(a_t) = \rho_a \ln(a_t) + \sigma_t^a \varepsilon_t^a \qquad \varepsilon_t^a \sim N(0,1)$$

$$\ln(\sigma_t^a) = (1 - \rho_{\sigma^a}) \ln(\sigma^a) + \rho_{\sigma^a} \ln(\sigma_{t-1}^a) + \sigma^{\sigma^a} \varepsilon_t^{\sigma^a} \qquad \varepsilon_t^{\sigma^a} \sim N(0,1)$$

# Representative Goods-Producing Firm (I)

Firm owns capital stock $K_t(i)$ & employs labor $N_t(i)$

Quadratic cost of changing nominal price $P_t(i)$

$$\frac{\phi_P}{2}\left[\frac{P_t(i)}{\Pi P_{t-1}(i)} - 1\right]^2 Y_t$$

Cobb-Douglas production function subject to fixed costs

$$Y_t(i) = K_t(i)^\alpha \left[Z_t N_t(i)\right]^{1-\alpha} - \Phi$$

Adjustment costs to changing rate of investment

$$K_{t+1}(i) = (1-\delta)K_t(i) + I_t(i)\left(1 - \frac{\phi_I}{2}\left(\frac{I_t(i)}{I_{t-1}(i)} - 1\right)^2\right)$$

# Representative Goods-Producing Firm (II)

Firm $i$ chooses $N_t(i)$, $K_{t+1}(i)$, $I_t(i)$, and $P_t(i)$ to maximize cash flows

$$\max E_t \left\{ \sum_{s=0}^{\infty} \left( \frac{\beta^s \lambda_{t+s}}{\lambda_t} \right) \left( \frac{D_{t+s}(i)}{P_{t+s}} \right) \right\}$$

Definition of firm cash flows

$$\frac{D_t(i)}{P_t} = \left[ \frac{P_t(i)}{P_t} \right]^{1-\theta} Y_t - \frac{W_t}{P_t} N_t(i) - I_t(i) - \frac{\phi_P}{2} \left[ \frac{P_t(i)}{\Pi P_{t-1}(i)} - 1 \right]^2 Y_t$$

Firm issues 1-period bonds to finance fraction of capital stock each period

$$B_{t+1}(i) = \nu K_{t+1}(i)$$

Bonds earn 1-period real risk-free rate $R_t^R$

# Representative Goods-Producing Firm (III)

Total cash flows divided between payments to debt or equity

Payments to equity

$$\frac{D_t^E(i)}{P_t} = \frac{D_t(i)}{P_t} - \nu \left( K_t(i) - \frac{1}{R_t^R} K_{t+1} \right)$$

Leverage does not affect firm value or optimal firm decisions

(Modigliani & Miller (1963) theorem holds)

Equity becomes more volatile with leverage

# Aggregation

All users of final output assemble the final good $Y_t$ using the range of varieties $Y_t(i)$ in a CES aggregator

$$Y_t = \left[ \int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}$$

Aggregate production function

$$Y_t = K_t^{\alpha} \left( Z_t N_t \right)^{1-\alpha} - \Phi$$

Stochastic process for technology

$$\ln(Z_t) = \rho_z \ln(Z_t) + \sigma_t^z \varepsilon_t^z \qquad \varepsilon_t^z \sim N(0,1)$$

$$\ln(\sigma_t^z) = (1-\rho_{\sigma^z}) \ln(\sigma^z) + \rho_{\sigma^z} \ln(\sigma_{t-1}^z) + \sigma^{\sigma^z} \varepsilon_t^{\sigma^z} \qquad \varepsilon_t^{\sigma^z} \sim N(0,1)$$

# Monetary Policy & National Income Accounting

Nominal interest rate rule

$$\ln(R_t) = \rho_R \ln(R_{t-1}) + (1-\rho_R)\left(\ln(R) + \rho_\pi \ln(\Pi_t/\Pi) + \rho_y \ln(Y_t/Y_{t-1})\right)$$

National income accounting

$$Y_t = C_t + I_t + \frac{\phi_P}{2}\left(\frac{\Pi_t}{\Pi} - 1\right)^2 Y_t$$

# Model Calibration and Solution

Calibrate model parameters to estimates of Ireland (2003, 2010)

Set fixed cost of production $\Phi$ to eliminate steady-state pure profits

Calibrate leverage ratio = 0.45

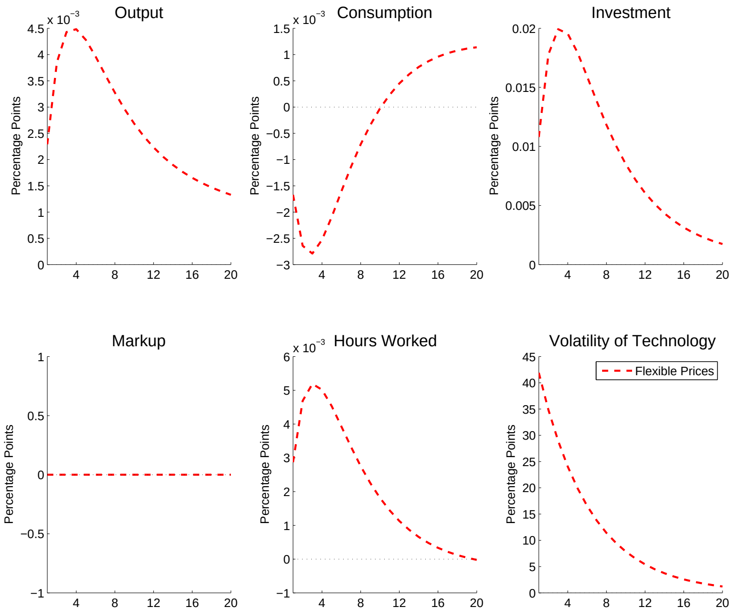
Interested in determining impact of uncertainty shocks under two cases:

1. Flexible Prices ($\phi_P = 0$)
2. Sticky Prices ($\phi_P = 160$)

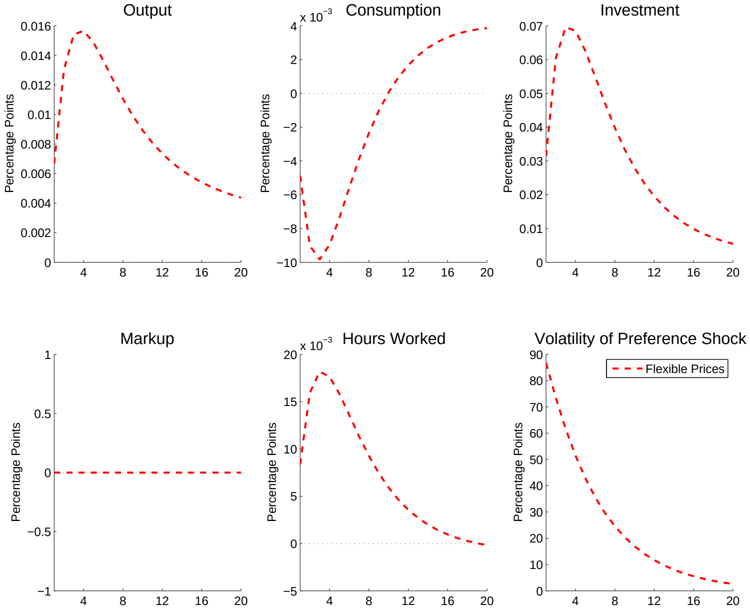
Solve model using 3rd-order approximation to policy functions of model

Need 3rd-order or higher approximation to study uncertainty shocks

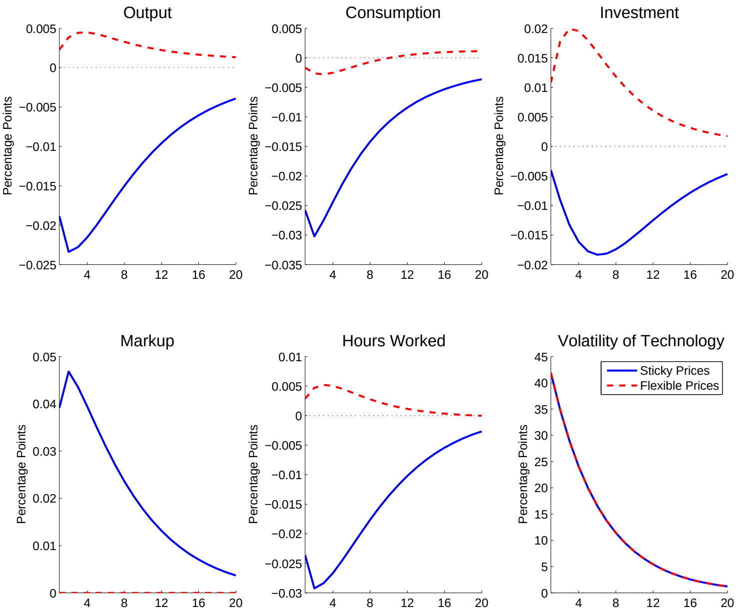
# Second Moment Technology Shock with Flexible Prices



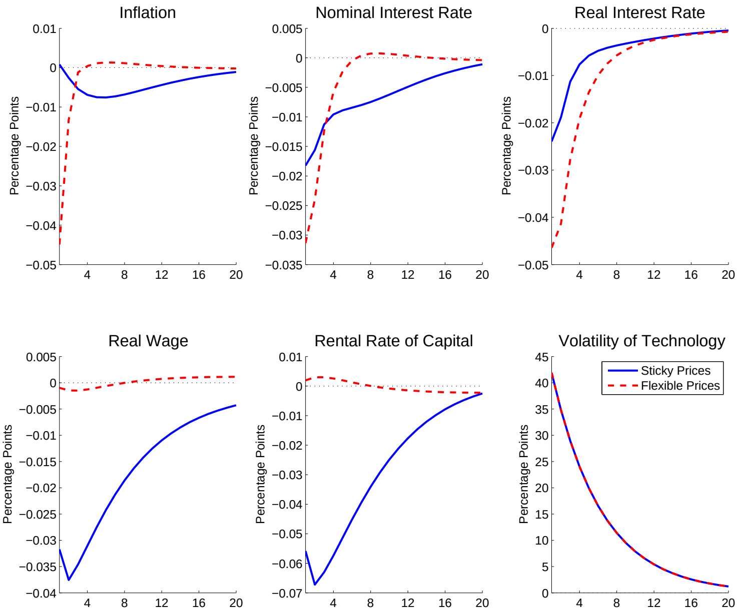
# Second Moment Preference Shock with Flexible Prices



# Second Moment Technology Shock with Sticky Prices (I)



# Second Moment Technology Shock with Sticky Prices (II)



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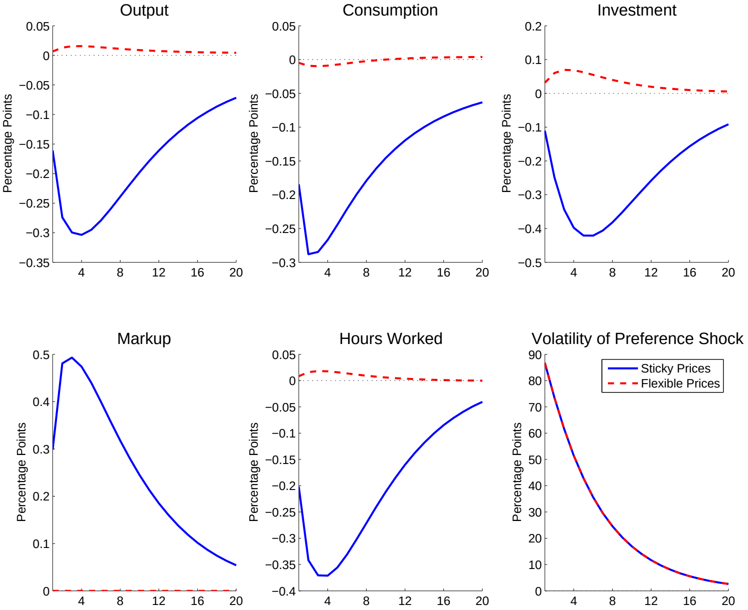

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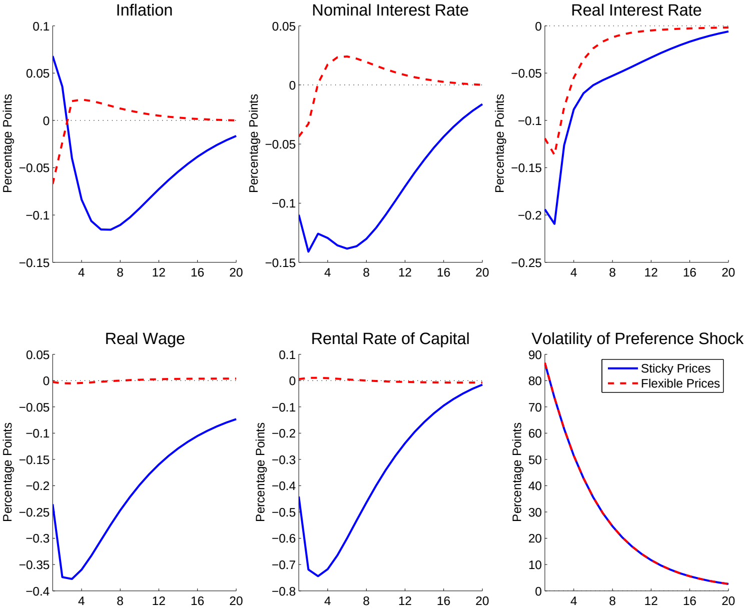


# Uncertainty Shock Calibration

Increased uncertainty can reduce $Y$, $C$, $I$, & $N$ under sticky prices

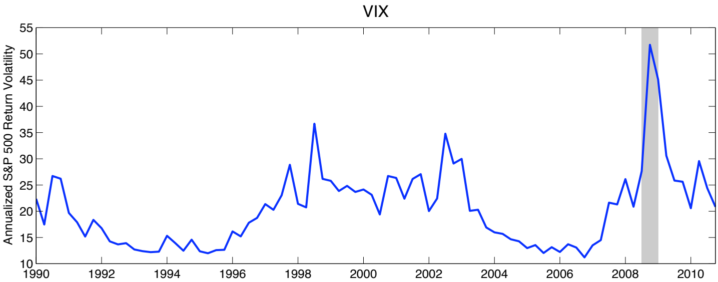
What is a reasonable-sized uncertainty shock in the data?

What does model predict for an uncertainty shock of this size?

Use VIX as measure of aggregate uncertainty

VIX is forward-looking measure of S&P 500 return volatility

# VIX & VIX-Implied Uncertainty Shocks



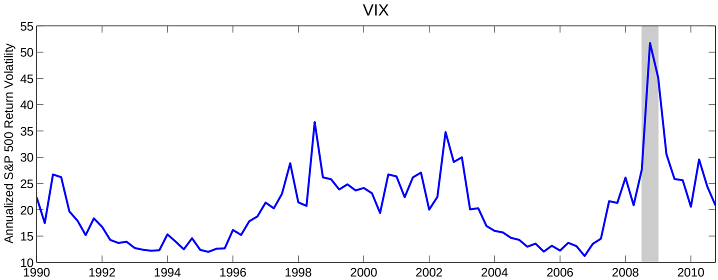

Estimate reduced-form AR(1) model for quarterly VIX $V_t^D$

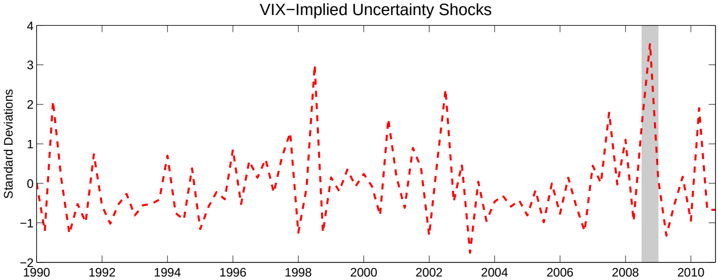
$$\ln(V_t^D) = (1-\rho_V)\ln(V^D) + \rho_V \ln(V_{t-1}^D) + \sigma^{V^D}\varepsilon_t^{V^D}, \quad \varepsilon_t^{V^D} \sim N(0,1)$$

Results: $V^D = 20.4\% \quad \rho_V = 0.83 \quad \sigma^{V^D} = 0.19$

$\varepsilon_t^{V^D}$: VIX-implied uncertainty shock

# VIX & VIX-Implied Uncertainty Shocks



# Uncertainty Shock Calibration

How do we calibrate the size and persistence of the 2nd moment shocks?

Use 3rd-order perturbation method to generate model-implied VIX

Household Euler equation for equity holdings:

$$1 = E_t \left\{ \left( \frac{\beta \lambda_{t+1}}{\lambda_t} \right) \left( \frac{D_{t+1}/P_{t+1} + P^E_{t+1}/P_{t+1}}{P^E_t/P_t} \right) \right\}$$

Return on equity

$$R^E_{t+1} \triangleq \frac{D_{t+1}/P_{t+1} + P^E_{t+1}/P_{t+1}}{P^E_t/P_t}$$

Model-implied VIX

$$V^M_t = 100 * \sqrt{4 * Var_t \left( R^E_{t+1} \right)}$$

# Uncertainty Shock Calibration

Model-implied VIX has AR(1) law of motion in volatility shocks

$$\hat{V}_t^M = \ldots + \eta^{\sigma^a} \hat{\sigma}_{t-1}^a + \eta^{\varepsilon^a} \varepsilon_t^{\sigma^a} + \eta^{\sigma^Z} \hat{\sigma}_{t-1}^Z + \eta^{\varepsilon^Z} \varepsilon_t^{\sigma^Z}$$

Reduced-form AR(1) model for quarterly VIX $V_t$

$$\hat{V}_t^D = 0.83\hat{V}_{t-1}^D + 0.19\varepsilon_t^{V^D}$$

Calibrate size of uncertainty shocks in model to match VIX-implied results

$$\varepsilon_t^{\sigma^a} = 1 \quad \Rightarrow \quad \text{Model-implied VIX} \uparrow 19\%$$

$$\varepsilon_t^{\sigma^Z} = 1 \quad \Rightarrow \quad \text{Model-implied VIX} \uparrow 19\%$$

Set persistence of uncertainty shocks such that $\eta^{\sigma^a} = \eta^{\sigma^Z} = 0.83$

# Quantitative Implications of Uncertainty Shocks

Did uncertainty play a role in the Great Recession?

3+ standard deviation VIX-implied uncertainty shock in Fall of 2008

Little evidence of change in the volatility of technology shocks
(Fernald (2010) using Basu, Fernald, & Kimball (2006) methodology)

3 standard deviation uncertainty shock to demand in model
$\Rightarrow$ Peak drop in output of 0.9 percentage points

Results suggest uncertainty contributed to severity of Great Recession

# Uncertainty or Financial Market Disruptions?

A false choice

A financial market disruption is an event, which can have multiple effects

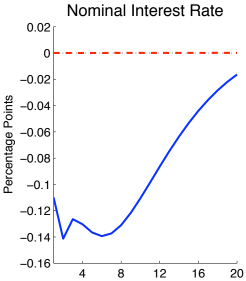
Most analysis has focused on first-moment effects
(higher cost of capital, tighter borrowing constraints, etc.)

We analyze likely effects of the concurrent rise in uncertainty

Increased uncertainty might also be due to financial disruptions

# Uncertainty Shocks, Monetary Policy, & ZLB

Monetary authority follows conventional active interest rate rule

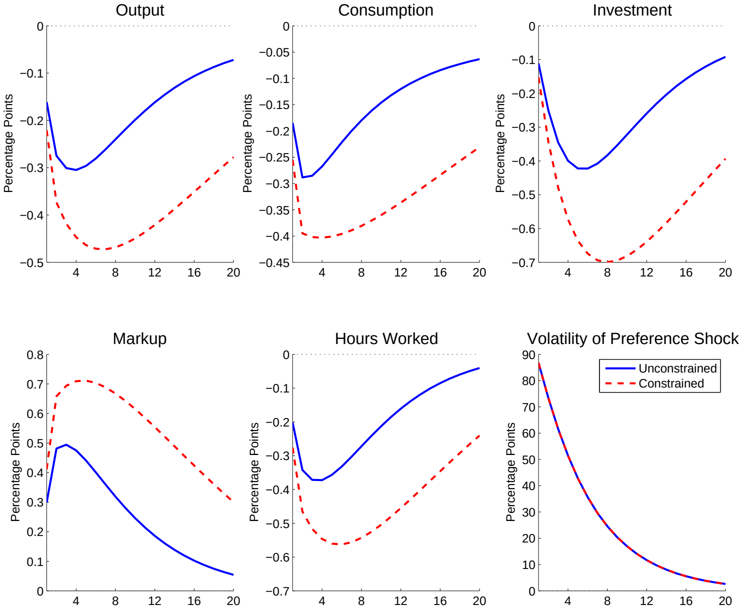



Helps stabilize economy by offsetting 2nd moment preference shock

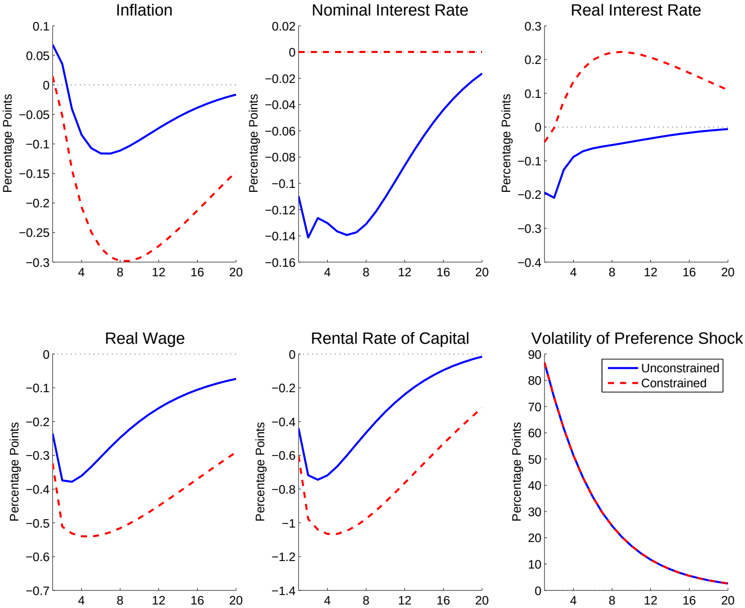
What if monetary authority is constrained by zero lower bound on nominal interest rates?

Preliminary results

# Second Moment Preference Shock at ZLB (I)



# Second Moment Preference Shock at ZLB (II)



# Conclusions

Under reasonable assumptions, uncertainty can decrease $Y$, $C$, $I$, & $N$

Effect is quantitatively significant, and is even larger if monetary policy is constrained from responding, as during the Great Recession

Idea that "good" shock to marginal cost can reduce labor demand is a mechanism with broad applicability

Modeling 2nd-moment shocks complements other work on crisis

Uncertainty may explain some observed changes in asset prices and risk premia during the crisis