

Really Uncertain Business Cycles

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This paper

- What is the contribution of second moment shocks to business cycles?
 - Time variation in the variance of innovations to productivity.

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- What is the contribution of second moment shocks to business cycles?
 - Time variation in the variance of innovations to productivity.
- Three distinct steps:
 - ① Empirical behavior of uncertainty proxies over the business cycle.
 - ② Dynamic stochastic GE model with first and second moment shocks.
 - ③ Evaluate the performance of the model using census micro data.

Measuring uncertainty

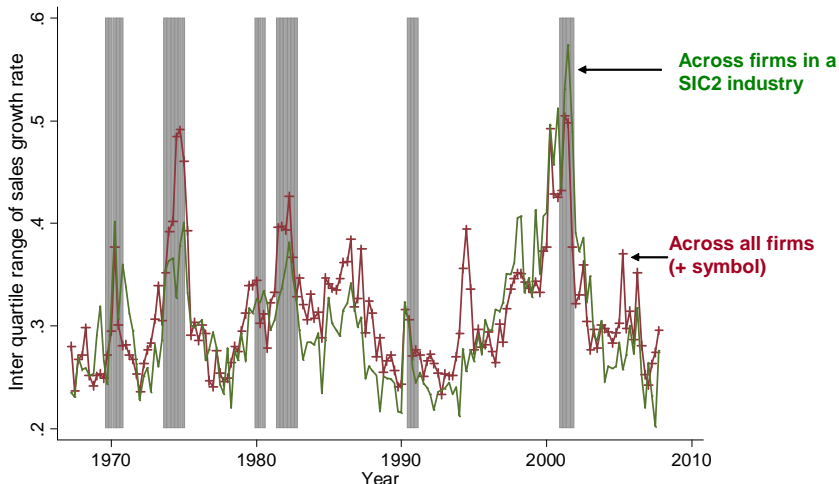
Model

Census Data

Uncertainty over the business cycle

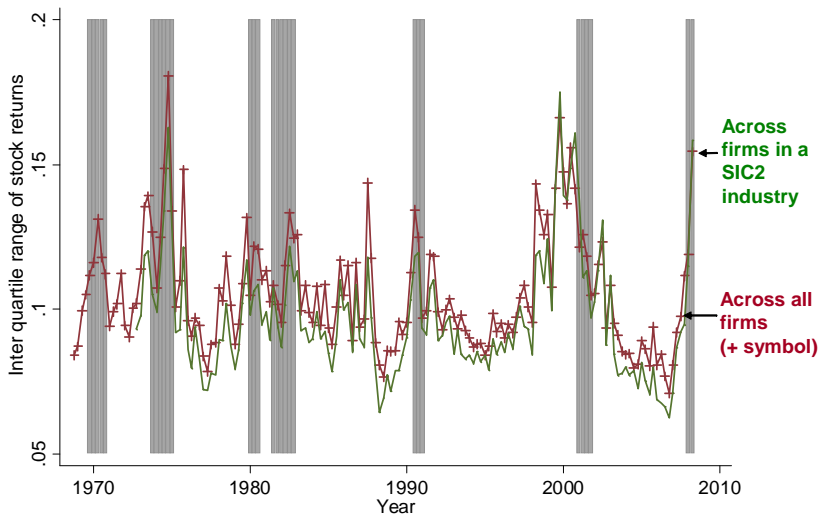
- Use different proxies for uncertainty.
 - ① Cross-firm and industry evidence (3 measures).
 - ② Time-series aggregate data (2 measures).
 - ③ Cross-forecaster evidence (2 measures).

Cross-firm sales growth spread



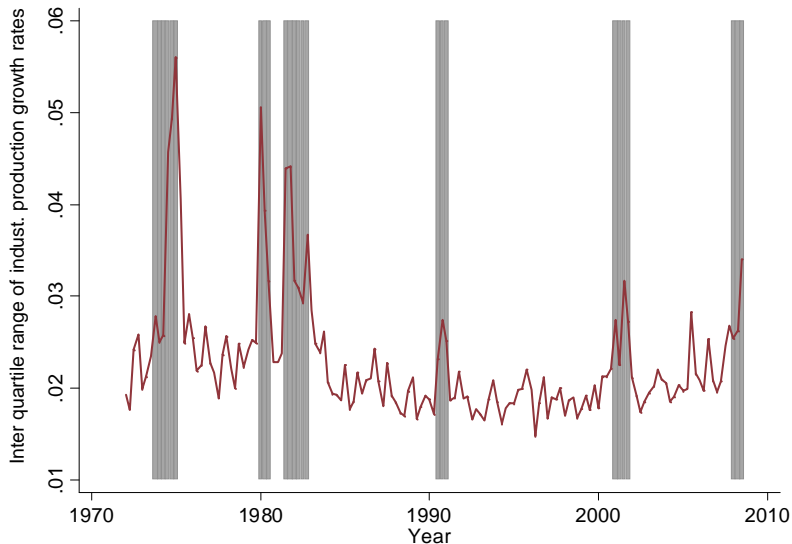
Notes: All Compustat firms with at least 25 years of quarterly accounts used (to reduce the impact of compositional changes). Only quarters with at least 500 firms kept to ensure sufficient sample size. Sales growth spread is defined as the inter-quartile range (IQR) across firms within each quarter. Sales growth is defined over a four quarter period to remove the effects of the quarterly accounting cycle, with this centered around the current quarter so that $(\text{Sales Growth})_t = (\text{Sales}_{t+2} - \text{Sales}_{t-2}) / (0.5 \cdot \text{Sales}_{t+2} + 0.5 \cdot \text{Sales}_{t-2})$. Spread within SIC2 industry uses only SIC2 year cells with at least 25 observations to calculate the IQR. Quarterly values are averages across the 24 SIC2 classes with 25 or more firms per quarter. The grey shaded columns are recessionary quarters defined according to the NBER.

Cross-firm stock-returns spread



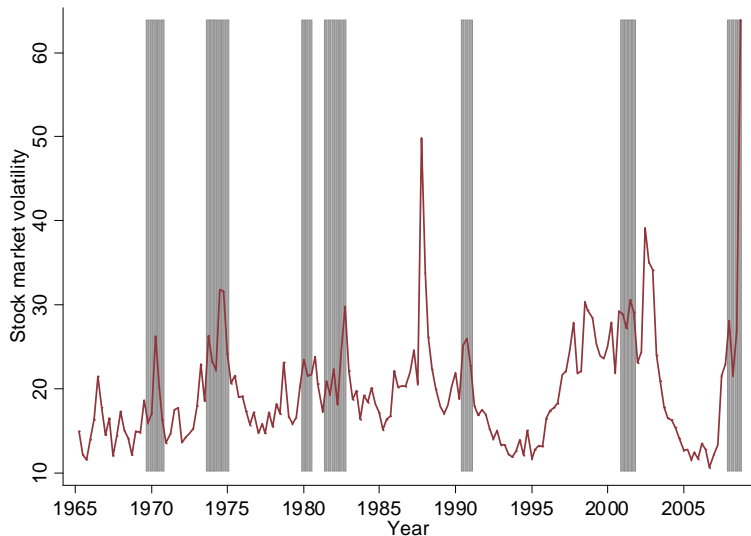
Notes: All firms with at least 25 years of quarterly returns used to reduce the impact of compositional changes. Only quarters with at least 1000 firms kept to ensure sufficient sample size. Stock returns spread calculation using the interquartile range (IQR) across firms within each quarter. Spread within SIC2 industry uses only SIC2 year cells with at least 25 observations to calculate the IQR. Quarterly values are averages across the 25 SIC2 classes with 25 or more firms per quarter. The grey shaded columns are recessionary quarters defined according to the NBER.

Cross-industry growth rate spread



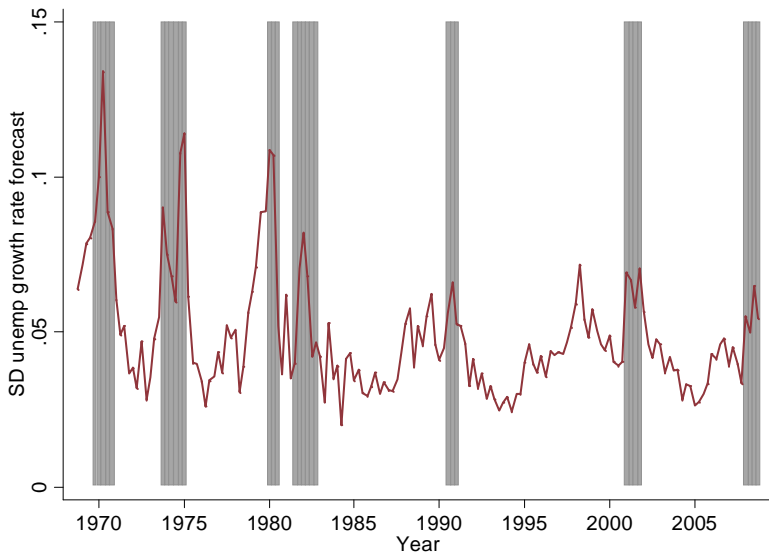
Note: Plots the inter-quartile range of the 3-month growth rates of industrial production, 1972 to 2008. Sample covers the manufacturing sector broken into 196 NAICS sectors, taken from the Federal Reserve Board. The grey shaded columns are recessionary quarters defined according to the NBER.

Stock-market volatility



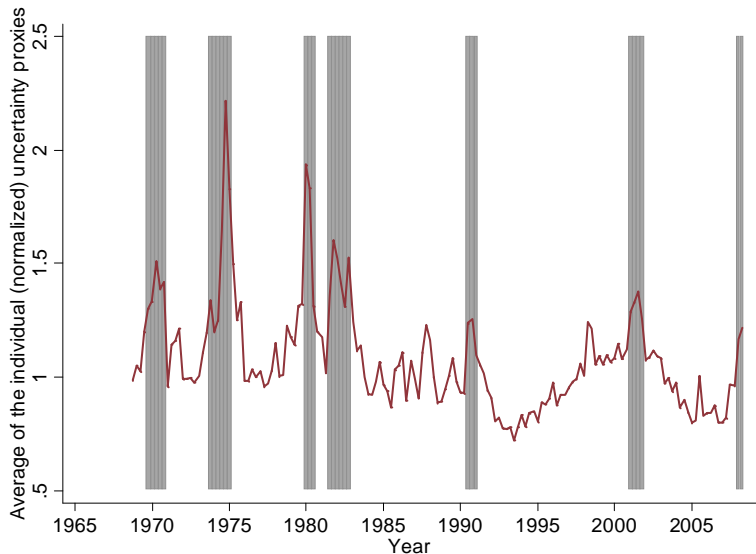
Notes: Stock market volatility used actual quarterly standard deviation of daily returns until 1987, and average quarterly implied volatility from 1987 onwards (see Bloom, 2007 for details). The grey shaded columns are recessionary quarters defined according to the NBER.

Forecaster unemployment dispersion



Notes: Standard deviation of cross-sectional forecasts divided by average of cross-sectional forecasts, 4 quarters ahead unemployment rates from the Survey of Professional Forecasters. Forecasts collected quarterly with an average of 41 forecasters per period. The grey shaded columns are recessionary quarters defined according to the NBER.

Uncertainty Index over the Business Cycle



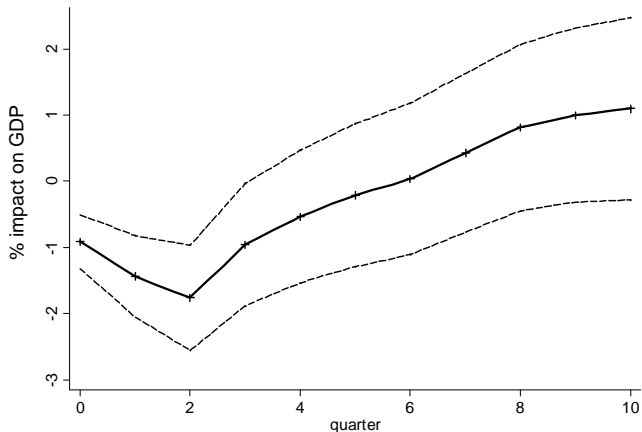
Notes: Uncertainty proxy defined as the average of the seven quarterly measures of uncertainty, after these have been normalized to have a value of unity on average during non-recessions. During 1968Q4-1971Q4 and 2008 only 6/7 indicators are available, so the average value is taken over those 6. Gray-shading denotes NBER defined recession quarters.

VAR analysis

- Are uncertainty increases **conditionally associated** with recessions?
- Following variables in the estimation order:
 - The uncertainty index.
 - Log(TFP) from Basu et al. (2006)
 - Federal Funds Rate
 - log(average hourly earnings)
 - log(consumer price index)
 - hours
 - log(employment)
 - log(GDP).

VAR analysis

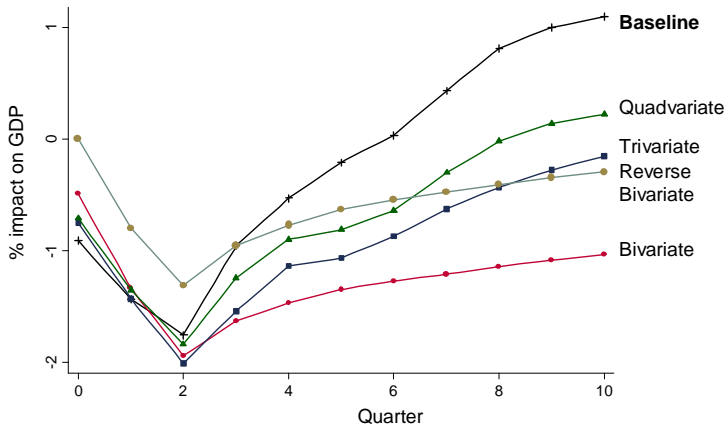
Effects of a 40% increase in uncertainty on GDP



Notes: VAR Cholesky orthogonalized impulse response to a 40% increase in the uncertainty index, calibrated to the average increase on the uncertainty index during a recession. Estimated on quarterly data from 1968:4 to 2006:5 using 4 lags. Dotted lines in top and bottom figures are the 95% confidence intervals. Variables (in order) are the uncertainty index, log TFP (from Basu et al. 2006), the federal funds rate, log wages, log CPI, hours, log employment and log real GDP.

VAR analysis

Effects of a 40% increase in uncertainty on GDP



Notes: VAR Cholesky orthogonalized impulse responses to a 40% increase in the uncertainty index, calibrated to the average increase on the uncertainty index during a recession. Estimated on quarterly data from 1968:4 to 2006:2 using 4 lags. Variables (in order) are: (i) "Bivariate": Variables (in order) are the uncertainty index and log real GDP; (ii) "Trivariate" uncertainty index, FFR and log real GDP; (iii) "Quadvariate" uncertainty index, FFR, log employment log GDP and (iv) "Reverse Bivariate" log real GDP and the uncertainty index. "Baseline" as in previous graphs.

Measuring uncertainty

Model

Census Data

Model

- Conforms as closely as possible to standard frictionless RBC.
- Main deviations:
 - Second moment shocks.
 - Heterogenous firms with capital & labor non-convex adjustment costs.
- Mechanism: Non-convexity & second-moment shocks generate time-varying option values.

Technology

- Continuum of heterogeneous firms
 - A_t : Aggregate productivity.
 - $z_{j,t}$: Idiosyncratic productivity.

$$y_{j,t} = A_t z_{j,t} k_{j,t}^\alpha n_{j,t}^\nu, \quad \alpha + \nu < 1$$

- Productivities follow an AR process:

$$\begin{aligned}\log(A_t) &= \rho_A \log(A_{t-1}) + \sigma_{t-1}^A \epsilon_t \\ \log(z_{j,t}) &= \rho \log(z_{j,t-1}) + \sigma_{t-1}^Z \epsilon_{j,t}\end{aligned}$$

- Variance of innovations to productivity (σ_t^A, σ_t^Z) changes over time.
 - Follows a two-state markov chain.

Capital and Labor adjustment costs

- Laws of motion:

$$k_{j,t+1} = (1 - \delta_k)k_{j,t} + i_{j,t}$$

$$n_{j,t} = (1 - \delta_n)n_{j,t-1} + s_{j,t}$$

$$\delta_n = \text{Exogenous attrition rate}$$

- Based on empirical results, allow for following adjustment costs:
 - Fixed cost in investment and hiring.
 - Partial irreversibility in capital.
 - Hiring/firing costs per worker.

Firm's value function

$$V(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) = \max_{i, n} \left\{ \begin{aligned} & Azk^\alpha n^\nu - w(A, \sigma^A, \sigma^Z, \mu)n - i - AC^k(k, k') - AC^n(n_{-1}, n) \\ & + E [m(A, \sigma^A, \sigma^Z, \mu, A', \sigma^{A'}, \sigma^{Z'}, \mu') V(k', n, z'; A', \sigma^{A'}, \sigma^{Z'}, \mu')] \end{aligned} \right\},$$

State variables:

- A firm's capital stock: k .
- A firm's hours stock from last period: n_{-1} .
- A firm's current idiosyncratic productivity: $z_{j,t}$.
- Aggregate productivity: A_t .
- Macro uncertainty: σ_t^A .
- Micro uncertainty: σ_t^Z .
- The joint distribution of firm-level z, k, n_{-1} : μ_t .

Households & solution

- Representative agent who works and owns shares in firms.
- Recursive competitive equilibrium.
- State vector includes:
 - The aggregate states.
 - A set of moments of the firm distribution over (z, k, n) .
- Solution method similar to:
 - Krusell and Smith (1998).
 - Kahn and Thomas (2003, 2008).
 - Bachman, Caballero, Engel (2008).

Calibration

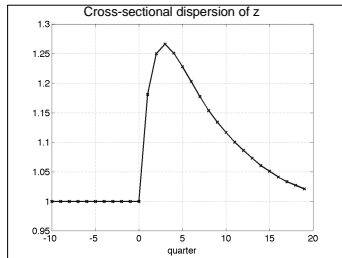
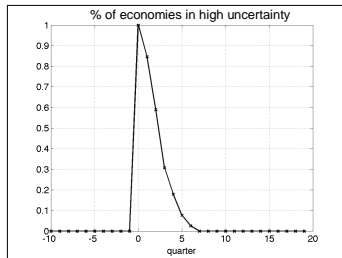
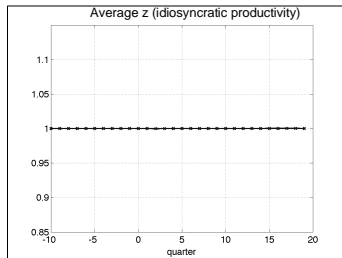
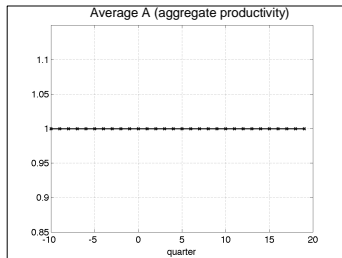
- δ_n : annual exogenous quit rate of 15%
 - Lowest annualized value of the monthly quit rate in JOLTS.
- Adjustment costs:
 - Fixed costs of capital adjustment: 1.5% of annual sales
 - Resale loss of capital: 40%
 - Fixed cost of adjusting hours: 2.1% of annual wages
 - Firing and hiring costs: 1.8% of annual wages
- Uncertainty: stochastic processes of $\sigma_{A,t}$ & $\sigma_{z,t}$
 - Size of uncertainty increase calibrated to generate an increase of 40% in cross-sectional dispersion of stock market returns and sales growth rates during recessions.
 - Transition matrix matches AC(1) of uncertainty index and implies 80% of time spent in normal state.

	Normal	Uncertain
Normal	0.95	0.05
Uncertain	0.2	0.8

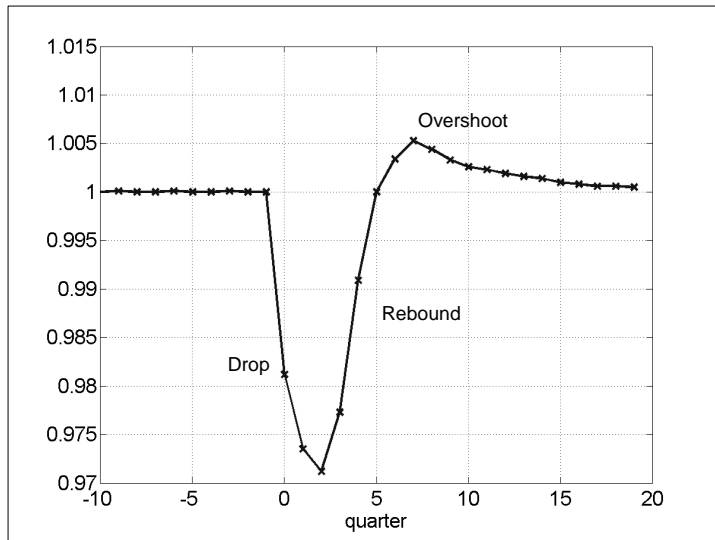
The effects of an increase in uncertainty

- Study the average response of variables to an increase in uncertainty:
 - The economy is in its ergodic distribution.
 - The macro and micro uncertainty are set to their low value.
 - At period 0: an increase in variance of **future** innovations, starting in period 1
 - Duration of uncertain state evolves according to markov chain.
 - Simulate over many economies and study the average response.

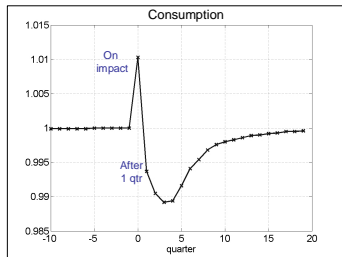
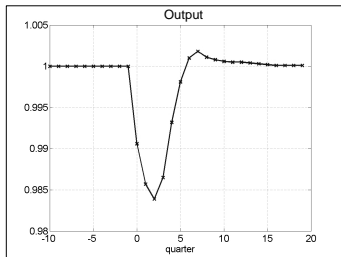
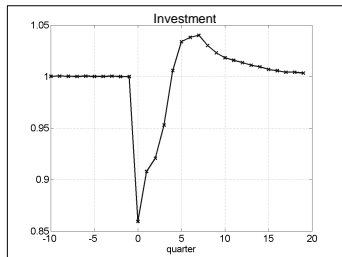
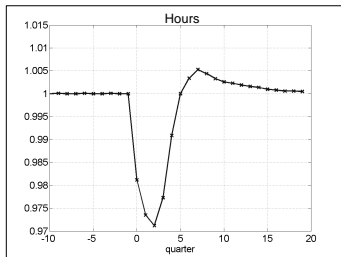
An increase in uncertainty, no first moment shock



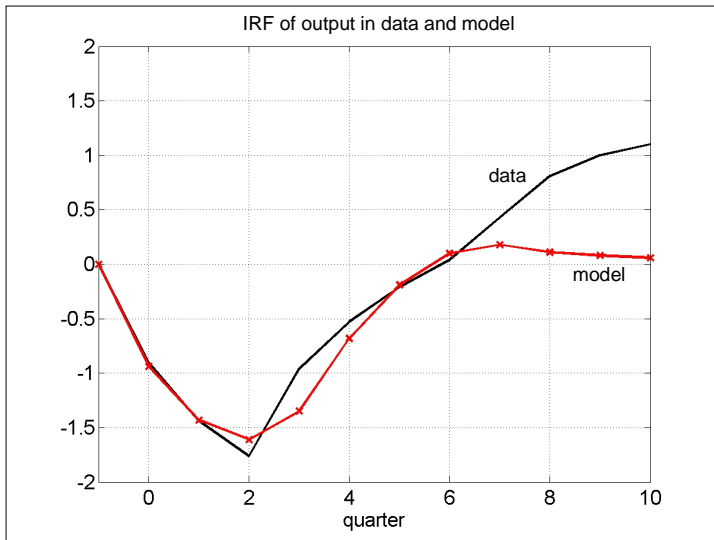
The effects of an increase in uncertainty on hours: 3 phases



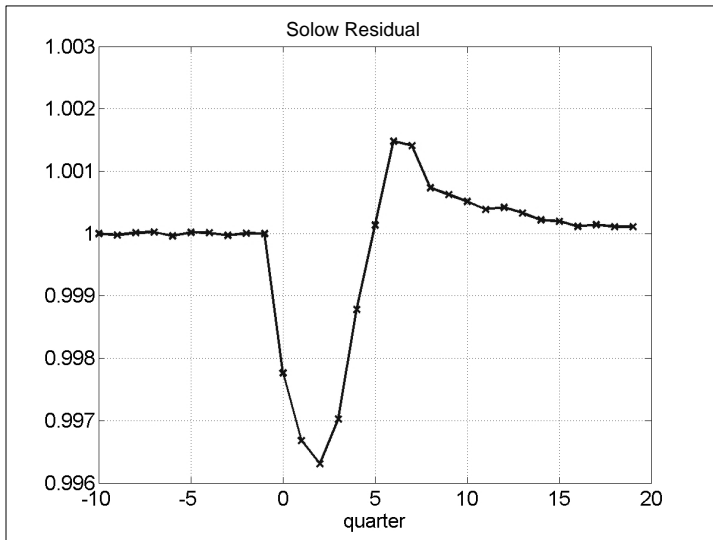
The effects of an increase in uncertainty



The effects of an increase in uncertainty on Output



The effects of an increase in uncertainty on the SR



Conclusions

- Next steps:
 - Extensions to induce a fall in C on impact.
 - Role of each of the AC.
 - Policy impact in the presence of uncertainty
 - Improvements on numerical solution.
- Census: Identification of 1st vs. 2nd moment shocks?