Take Bloom Seriously: Understanding Uncertainty in Business Cycles

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November 20, 2017

Introduction

Bloom, N., Floetotto, M., Jaimovich, N., Saporta-Eksten, I. and Terry, S.J. (2016).*Really Uncertain Business Cycles.* Working paper.[1]
Cited by: 755

[1]full access available at https://people.stanford.edu/nbloom/research

Introduction: Does uncertainty matter in business cycle?

Paul Krugman says it doesn't matter.

- Krugman, Paul. 2011. Phony Fear Factor. New York Times.
- Krugman, Paul. 2011. Varieties Of Uncertainty. NY Times.
- Krugman, Paul. 2012. The Uncertainty Scam. NY Times.
  "even if you accept the Bloom et al[2] paper as gospel (which you should not) ..."
- Krugman, Paul. 2012. Asymmetrical Uncertainty. NY Times.
  "...The paper never deserved this much weight..."
  "...They (Baker et al) declare that in our view the responsibility lies with both parties, and list some talking points; but that's not evidence..."

[2] Baker, Scott, Nicholas Bloom and Steven Davis (2012), "Measuring Economic Policy Uncertainty", Stanford mimeo.

Structure of the Presentation

- Intuitions on uncertainty in business cycles
- Empirical behaviour of uncertainty in business cycle
- Model set-up, calibration, and simulations
- Policy implications
- Suggested materials for further reading

Intuitions on Uncertainty in Business Cycles

Uncertainty can affect

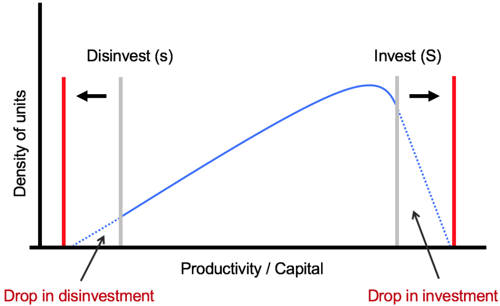
- Portfolio decisions: dramatic shift away from risky assets to risk-less assets;
- Consumption: delay endurable goods consumption;
- Investment: "Wait-and-See" business cycles[3];
- *"This is perfectly understandable behaviour on the part of consumers and firms – but behaviour which has led to a collapse of demand, a collapse of output and the deep recession we are in."*

[3] Bachmann, R. and Bayer, C., 2013. 'Wait-and-See' business cycles?. *Journal of Monetary Economics*, 60(6), pp.704-719.

Intuitions on Uncertainty: Delay Effects

Delay Effect: higher uncertainty leads firms to postpone decisions. So, net investment (and hiring) falls.

$\frac{dI}{d\sigma} < 0$, I=investment, $\sigma = uncertainty$



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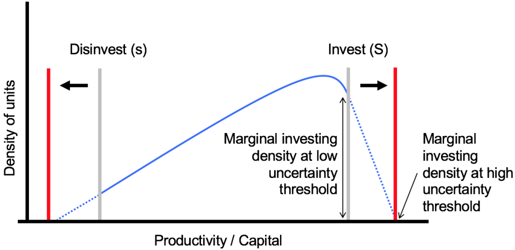
Intuitions on Uncertainty: Caution Effects

Caution Effect: higher uncertainty reduces firms response to other changes, like prices or TFP.

$\frac{d^2 I}{dA d\sigma} < 0$, A=price/TFP.



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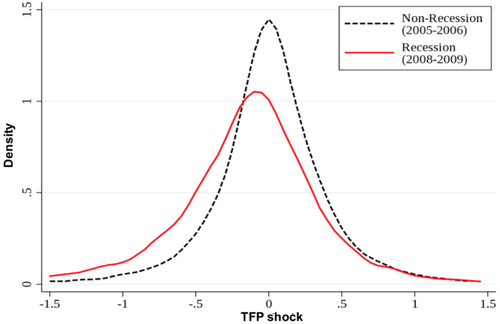
Empirical Behaviour of Uncertainty: Definition

$$y_{j,t} = A_t z_{j,t} f(k_{j,t}, n_{j,t})$$

- y:firm's output; k&n: idiosyncratic capital & labour;
- Productivity: A_t,aggregate component; $z_{j,t}$,idiosyncratic component.
- AR processes of two components:
  $log(A_t) = \rho^A log(A_{t-1}) + \sigma^A_{t-1}\epsilon_t$
  $log(z_{j,t}) = \rho^Z log(z_{j,t-1}) + \sigma^Z_{t-1}\epsilon_{j,t}$
- σs here can be regarded as the variance of innovations that move over time to two-state Markov Chain, which generate periods of low and high macro and micro uncertainty.

Empirical Behaviour: Firm-Level TFP Shocks

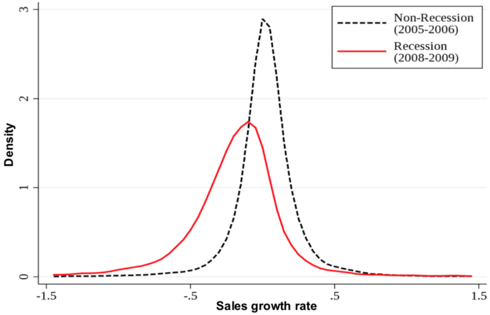
Figure 1: The variance of establishment-level TFP shocks increased by 76% in the Great Recession



Recession seems to have a negative first-moment (mean decreases) and positive second moment(variance increases) impact on firm-specific productivity.

Empirical Behaviour: Firm-Level Sales Growth

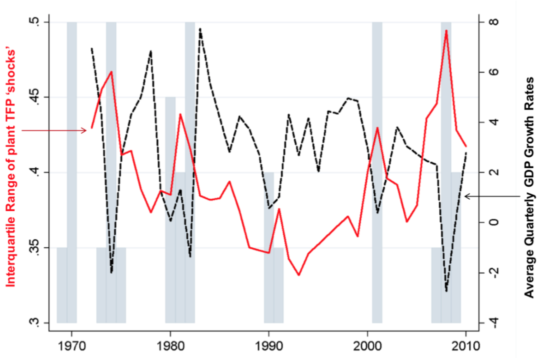
Figure 2: The variance of establishment-level sales growth rates increased by 152% in the Great Recession



Recession seems to have a negative first-moment (mean decreases) and positive second moment(variance increases) impact on firm-level sales growth rate.

Empirical Behaviour: Dispersion of TFP Shocks

Figure 3: TFP 'shocks' are more dispersed in recessions



The inter-quartile range of TFP shocks (red line) exhibits a very clear counter-cyclical behavior, which is particularly striking during the Great Recession (of 2007-2009).

Empirical Behaviour: Industry-Level Uncertainty

$$IQR_{i,t} = a_i + b_t + \gamma \Delta y_{i,t}.$$

- $IQR_{i,t}$:inter-quartile range of TFP shocks for all establishments in industry i at time t;
- a_i: a full set of industry fixed effects
- b_t: year fixed effects
- $\Delta y_{i,t}$: median growth rate of output between t and t+1 of industry i
- γ : ?
  if positive: pro-cyclical;
  if negative: counter-cyclical.

Empirical Behaviour: Industry-Level Uncertainty

Regression Result (column (1)): Counter-cyclical.

Table 2: Uncertainty is Also Robustly Higher at the Industry Level during Industry 'Recessions'

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent Variable:	IQR of establishment TFP shocks within each industry-year cell								
Specification:	Baseline	Median industry output growth	IQR of industry output growth	Median industry establishment size	IQR of industry establishment size	Median industry capital/labor ratio	IQR of industry capital/labor ratio	IQR of industry TFP spread	Industry geographic spread
Industry Output Growth	-0.132***	-0.142***	-0.176***	-0.119***	-0.116***	-0.111***	-0.111***	-0.191***	-0.133***
	(0.021)	(0.021)	(0.047)	(0.024)	(0.022)	(0.034)	(0.030)	(0.041)	(0.028)
Interaction of industry output growth with the variable in specification row		0.822	0.882	-0.032	-0.033	-0.197	-0.265	0.123	0.007
		(0.630)	(0.996)	(0.038)	(0.026)	(0.292)	(0.330)	(0.084)	(0.122)
Years	1972-2009	1972-2009	1972-2009	1972-2009	1972-2009	1972-2009	1972-2009	1972-2009	1972-2009
Observations	16,451	16,451	16,451	16,451	16,451	16,451	16,451	16,451	16,451
Underlying sample	446,051	446,051	446,051	446,051	446,051	446,051	446,051	446,051	446,051

Notes: Each column reports the results from an industry-by-year OLS panel regression, including a full set of industry and year fixed effects. The dependent variable in every column is the interquartile range (IQR) of establishment-level TFP 'shocks' within each SIC 4-digit industry-year cell. The regression sample is the 16,451 industry-year cells of the population of manufacturing establishments with 25 years or more of observations in the ASM or CM survey between 1972 and 2009 (which contains 446,051 underlying establishment years of data). These industry-year cells are weighted in the regression by the number of establishment observations within that cell, with the mean and median number of establishments per industry-year cell 27.1 and 17 respectively. The TFP 'shock' is calculated as the residual from the regression of log(TFP) at year t+1 on its lagged value (year t), a full set of year dummies and establishment fixed effects. In column (1) the explanatory variable is the median of the establishment-level output growth in that industry-year. In columns (2) to (9) a second variable is also included which is an interaction of that explanatory variable with an industry-level characteristic. In columns (2) and (3) this is the median and IQR of industry-level output growth, in columns (4) and (5) this is the median and IQR of industry-level establishment size in employees, in columns (6) and (7) this is the median and IQR of industry-level capital/labor ratios, in column (8) this is the IQR of industry-level TFP levels (note the mean is zero by construction), while finally in column in (9) this interaction is the dispersion of industry-level concentration measured using the Ellison-Glaeser dispersion index. Standard errors clustered by industry are reported in brackets below every point estimate. *** denotes 1% significance, ** 5% significance and * 10% significance.

Within-industry dispersion of TFP shocks (uncertainty) is significantly higher when industry is growing more slowly.

Empirical Behaviour: Industry-Level Robustness Test

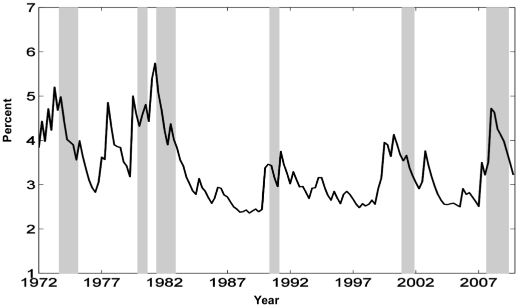
$IQR_{i,t} = a_i + b_t + \gamma \Delta y_{i,t} + \delta \Delta y_{i,t} * x_t$.
x_t denotes industry characteristics.

- $x_t =$ median growth rate: Whether faster growing industries are more volatile in economic recessions?
- $x_t =$ inter-quartile range of growth rate: Whether industries with larger variance in growth rates are more countercyclical in their dispersion?
- $x_t =$ ...
- All coefficients are estimated to be insignificant, which indicates that the counter-cyclical relations we get appear to be robust. (see column (2)-(9) in Table 2)

Empirical Behaviour: Macro-Level Uncertainty

Existing literature has documented counter-cyclical behaviour of macro-uncertainty. As an additional measure of aggregate uncertainty:

Figure A2: Macro volatility calculated from a GARCH(1,1) model estimated from aggregate TFP growth

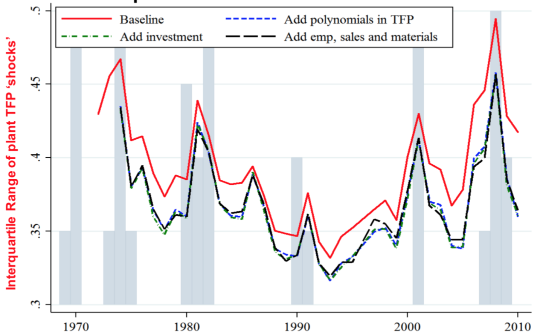


Notes: The conditional heteroskedasticity series above is estimated using a GARCH(1,1) model for the annualized percent change in the aggregate Solow residual in US quarterly data from 1972-2010, as available on John Fernald's website (series dTFP). The recession bars refer to standard dates from the NBER Business Cycle Dating Committee's website.

Empirical Behaviour of Uncertainty: Robustness Test

Are establishment-level TFP shocks a good proxy for uncertainty?

Figure 4: Robustness test: different measures of TFP 'shocks' are all more dispersed in recessions



Yes, they are.(see Table 3 for a rigorous regression.)

General Equilibrium Model: An Overview

The model departs from frictionless standard RBC models in three ways:

- Uncertainty is time-varying: inclusion of shocks to both the level of technology (first moment) and its variance (second moment), at both microeconomic and macroeconomic levels;
- Heterogeneous firms, subject to idiosyncratic shocks;
- Non-convex adjustment costs in both capital and labor.

General Equilibrium Model: Time-Varying Uncertainty and Heterogeneous Shocks

Recall the (diminishing returns to scale) production technology:
$y_{j,t} = A_t z_{j,t} k_{j,t}^{\alpha} n_{j,t}^{v}, \alpha + v < 1$

- y:firm's output; k&n: idiosyncratic capital & labour;
- Productivity: A_t,aggregate component; $z_{j,t}$,idiosyncratic component.
- AR processes of two components (first moment):
  $log(A_t) = \rho^A log(A_{t-1}) + \sigma_{t-1}^A \epsilon_t$ (macroeconomic shocks)
  $log(z_{j,t}) = \rho^Z log(z_{j,t-1}) + \sigma_{t-1}^Z \epsilon_{j,t}$ (microeconomic shocks)
- We allow σ_t^A and σ_t^Z to vary over time according to a two-state Markov chain.(second moment)

General Equilibrium Model: Non-convex Adjustment Cost

- **Capital Law of Motion:**
  $k_{j,t+1} = (1 - \delta_k) k_{j,t} + i_{j,t}$
  where δ_k denotes depreciation rate of capital and i_t denotes net investment.
- subject to capital adjustment cost:
  if $i > 0$, $AC^k = y(z, A, k, n) F^K$;
  if $i < 0$, $AC^k = y(z, A, k, n) F^K + S|i|$;
  where F^K is a fixed disruption cost, $S|i|$ is resale loss for disinvestment (when $i < 0$).

General Equilibrium Model: Non-convex Adjustment Cost

- **Hours Law of Motion:**
  $n_{j,t+1} = (1-\delta_n)n_{j,t} + s_{j,t}$
  where δ_n denotes exogenous destruction rate of hours worked (for example illness, retirement etc.)
  $s_{j,t}$ denotes net flows into hours worked.
- subject to labor adjustment cost:
  if $|s| > 0, AC^n = y(z, A, k, n)F^L + |s|Hw$;
  where F^L is a fixed disruption cost, $|s|Hw$ is a linear hiring/firing cost (Hw is aggregate wage).

General Equilibrium Model: Competitive Equilibrium

- **Firm** maximizes

$$V(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) = \qquad (10)$$

$$\max_{i,n} \left\{ \begin{array}{c} y - w(A, \sigma^A, \sigma^Z, \mu)n - i \\ -AC^k(k, n_{-1}, z, k'^A, \sigma^Z, \mu) - AC^n(k, n_{-1}, z, n; A, \sigma^A, \sigma^Z, \mu) \\ +\mathbb{E}\left[m\left(A, \sigma^A, \sigma^Z, \mu; A', \sigma^{A\prime}, \sigma^{Z\prime}, \mu'\right) V(k', n, z'; A', \sigma^{A\prime}, \sigma^{Z\prime}, \mu')\right] \end{array} \right\}$$

  subject to law of motion for productivity, capital and labour.

- **Household** maximizes

$$W(A, \sigma^A, \sigma^Z, \mu) = \max_{\{C,N,\psi'\}} \left\{U(C, N) + \beta\mathbb{E}\left[W(A', \sigma^{A\prime}, \sigma^{Z\prime}, \mu')\right]\right\}, \qquad (12)$$

  subject to a sequential budget constraint(equation 13).

- **Market Clearing Conditions**: asset markets, good markets and labour markets.

General Equilibrium Model: Parameter Calibration

Most parameters are calibrated as in the RBC literature:

Table 4: Calibrated Model Parameters

Preferences and Technology		
β	$.95^{1/4}$	Annual discount factor of 95%
η	1	Unit elasticity of intertemporal substitution (Khan and Thomas 2008)
θ	2	Leisure preference, households spend 1/3 of time working
χ	1	Infinite Frisch elasticity of labor supply (Khan and Thomas 2008)
α	0.25	CRS production, isoelastic demand with 33% markup
ν	0.5	CRS labor share of 2/3, capital share of 1/3
ρ^A	0.95	Quarterly persistence of aggregate productivity (Khan and Thomas 2008)
ρ^Z	0.95	Quarterly persistence of idiosyncratic productivity (Khan and Thomas 2008)
Adjustment Costs		
δ_k	2.6%	Annual depreciation of capital stock of 10%
δ_n	8.8%	Annual labor destruction rate of 35% (Shimer 2005)
F^K	0	Fixed cost of changing capital stock (Bloom 2009)
S	33.9%	Resale loss of capital in % (Bloom 2009)
F^L	2.1%	Fixed cost of changing hours in % of annual sales (Bloom 2009)
H	1.8%	Per worker hiring/firing cost in % of annual wage bill (Bloom 2009)

Notes: The model parameters relating to preferences, technology, and adjustment costs are calibrated as referenced above.

General Equilibrium Model: Parameter Estimation

- A simulated method of moments (SMM) is adopted to estimate parameters that govern the uncertainty process.
- Recall the two-state Markov chain process of uncertainty[4]:
  $\sigma_t^A \in [\sigma_L^A, \sigma_H^A]$, where $Pr(\sigma_{t+1}^A = \sigma_j^A | \sigma_t^A = \sigma_k^A) = \pi_{k,j}^{\sigma}$
  $\sigma_t^Z \in [\sigma_L^Z, \sigma_H^Z]$, where $Pr(\sigma_{t+1}^Z = \sigma_j^Z | \sigma_t^Z = \sigma_k^Z) = \pi_{k,j}^{\sigma}$
- There are six uncertainty parameters: $\sigma_L^A, \sigma_H^A, \sigma_L^Z, \sigma_H^Z, \pi_{L,H}^{\sigma}, \pi_{H,L}^{\sigma}$

Table 5: Estimated Uncertainty Parameters

Quantity	Estimate	Standard Error	
$\sigma^A{}_L$	0.67	(0.098)	Quarterly standard deviation of macro productivity shocks, %
$\sigma^A{}_H / \sigma^A{}_L$	1.6	(0.015)	Macro volatility increase in high uncertainty state
$\sigma^Z{}_L$	5.1	(0.807)	Quarterly standard deviation of micro productivity shocks, %
$\sigma^Z{}_H / \sigma^Z{}_L$	4.1	(0.043)	Micro volatility increase in high uncertainty state
$\pi^\sigma{}_{L,H}$	2.6	(0.485)	Quarterly transition probability from low to high uncertainty,%
$\pi^\sigma{}_{H,H}$	94.3	(16.38)	Quarterly probability of remaining in high uncertainty, %

[4] We assume micro- and macro- uncertainty follow the same process.

Quantitative Analysis: Business Cycle Statistics

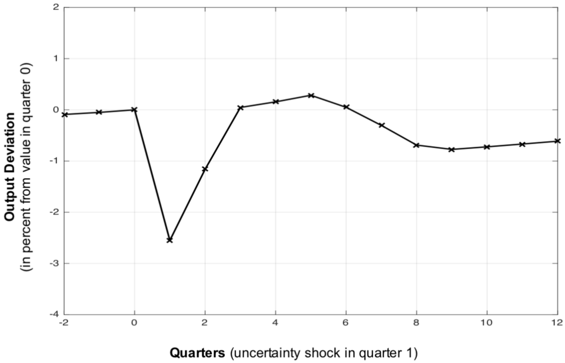
Real data vs. Model-generated statistics:

	Data			Model		
	$\sigma(x)$	$\frac{\sigma(x)}{\sigma(y)}$	$\varrho(x,y)$	$\sigma(x)$	$\frac{\sigma(x)}{\sigma(y)}$	$\varrho(x,y)$
Output	1.6	1.0	1.0	2.0	1.0	1.0
Investment	7.0	4.5	0.9	11.9	6.0	0.9
Consumption	1.3	0.8	0.9	0.9	0.4	0.5
Hours	2.0	1.3	0.9	2.4	1.2	0.8

- Investment, hours and consumption co-move with output;
- Investment is more volatile than output;
- Consumption is less volatile than output;

Quantitative Analysis: Pure Uncertainty Shock

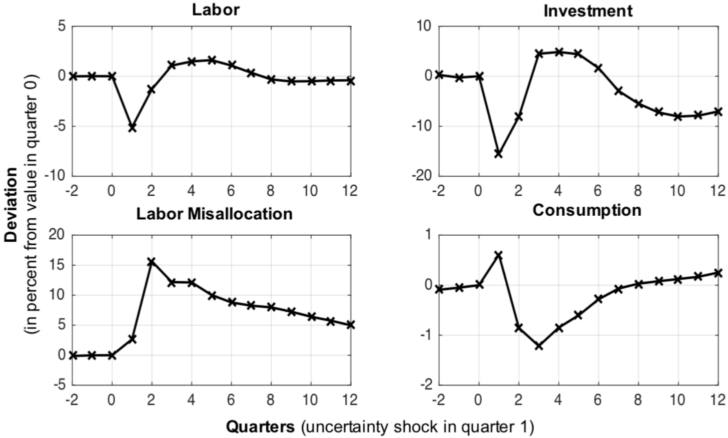
Impact On Output:



- A drop in output shortly after the uncertainty shock;
- A “double dip” recession;

Quantitative Analysis: Pure Uncertainty Shock

Impact On Labor, Capital, Misallocation of factors and Consumption[5]:



[5]An unattractive feature of a pure uncertainty shock model of business cycle

Quantitative Analysis: Pure Uncertainty Shock

Options to address the rise in consumption:

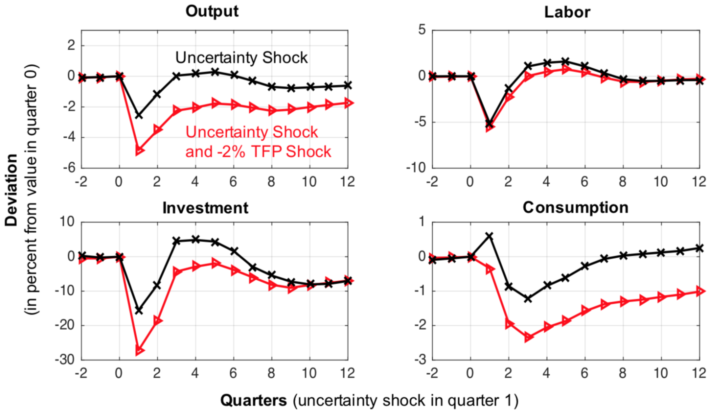
- An open economy approach[6]: to allow consumers to save in other technologies besides capital, for example, in foreign assets.
- A complementary preference approach[7]:to use a utility function with complementarity b/w consumption and hours in preference structures.
- A compound shock approach: to use a first moment shock *AND* a second moment shock.

[6] Fernandez-Villaverde, J., Guerron-Quintana, P., Rubio-Ramirez, J. and Uribe, M. (2011), Risk matters: the real effects of volatility shocks. *The American Economic Review* 101(6), 2530 2561.

[7] Greenwood, Jeremy, Hercowitz, Zvi, and Huffman, Gregory W. (1988), Investment, Capacity Utilization, and the Real Business Cycle, *American Economic Review*, 78(3), 402-417

Quantitative Analysis: First and Second Moment Shocks

Impulse response to an uncertainty shock *AND* a -2% exogenous first moment shock:



Quantitative Analysis: “Double Dip”

“Double dip” behaviour of output:

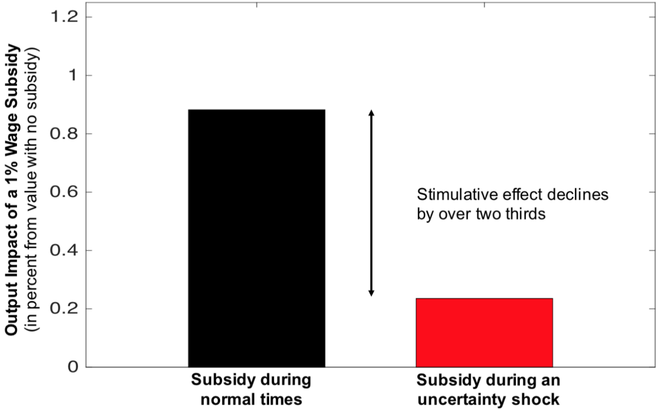
- First drop: real option effect;
- Quick rebound: realization of high micro volatility;
- Double dip recession:
  High level of misallocation of production factors;
  Declining path for investment.

Policy Implication: An Policy Experiment

Recall the caution effect: higher uncertainty reduces firms' response to other changes.

- Policy: 1 % wage bill subsidy paid for one quarter (financed througha lump-sum tax on households);
- Two economies:
  Economy A without uncertainty shock;
  Economy B with uncertainty shock;
- Net impact of policy:
  Economy A: No shock with policy - No shock without policy;
  Economy B: With shock and policy - No shock without policy.

Policy Implication: Uncertainty on Policy Effectiveness



The presence of uncertainty reduces the effects of wage policy by over two thirds on impact.

Did Paul Krugman Get It All Wrong?

- **Take uncertainty seriously, but as a valuable constraint on the economy.**

  "Look at the role that certainty played in fueling the bubble. The assurance that an AAA rating offered, the unquestioning belief in the rise of national house prices in America and the faith in risk dispersion through securitization all had pernicious effects."

- **Take uncertainty seriously, but as an awareness of our ignorance: "known unknown".**

  "Uncertainty gives rise to business fluctuations and offsets stimulation effects, but without certainty things might have been even worse, i.e., giving bank 'too big to fall' status, or reinforcing animal spirits and thus creating bigger bubbles."

Reference

- **Further Reading on Uncertainty**

Bloom, N. (2014), Fluctuations in Uncertainty, JEP.
Bloom, N. (2009), The Impact of Uncertainty Shocks, Econometrica.
Baker, S. R. et al. (2016). Measuring economic policy uncertainty. QJE.
Bloom, N., et al. (2016).Really Uncertain Business Cycles.Working paper.
Bachmann, R. et al (2013), Wait-and-See Business Cycles?, JME.

- **Further Reading on Techniques**

Bachmann, R.et al. (2013), Aggregate Implications of Lumpy Investment: New Evidence and a DSGE Model, AEJ:Macro.
Khan, A. et al. (2008), Idiosyncratic Shocks and the Role of Nonconvexities in Plant and Aggregate Investment Dynamics, ETCA.
Young, Eric R. (2010),Solving the incomplete markets model with aggregate uncertainty using the Krusell-Smith algorithm and non-stochastic simulations, JEDC.

- **Further Reading on the Great Recession**

Bernanke. The courage to act: A memoir of a crisis and its aftermath.
Geithner. Stress test: Reflection on financial crises.