# Time-varying uncertainty in macro

**Nick Bloom (Stanford & NBER)**

**SED, June 26th 2014**

# Resurgence of uncertainty research since 2008

1. Great Recession: accompanied by a spike in uncertainty, which many people argue is one factor driving the downturn

   *"increased uncertainty is depressing investment by fostering an increasingly widespread wait-and-see attitude"*
   FOMC minutes, April 2008

2. At the same time the Great Moderation (1984-2007) 'ended' which had previously dampened business cycle research

3. Faster computers: can run models with higher moments

4. More data: high-frequency trading, surveys, text-search etc

# Uncertainty has also been in the media a lot

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## How to make Europe's incipient recovery durable: End policy uncertainty

**Marco Buti, Pier Carlo Padoan,** 12 September 2013

*The Eurozone is recovering but the revival is fragile – ringed by downside risks. This column argues that three steps – reducing policy uncertainty, repairing the financial system, and creating new investment opportunities – are essential. They could switch the negative confidence-growth feedback loop into a positive one, thus paving the way to robust medium-term growth. There is no room for complacency or procrastination.*

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When leaders met for the G20 Summit in Saint Petersburg last weekend, they welcomed the incipient recovery in the Eurozone. However, they also recognised that "despite our actions the [global] recovery is too weak" and fraught with risks. This is particularly relevant for the Eurozone, firstly because GDP growth in the area itself is still very weak and uneven, and secondly because, in the current external macroeconomic environment, the Eurozone economy

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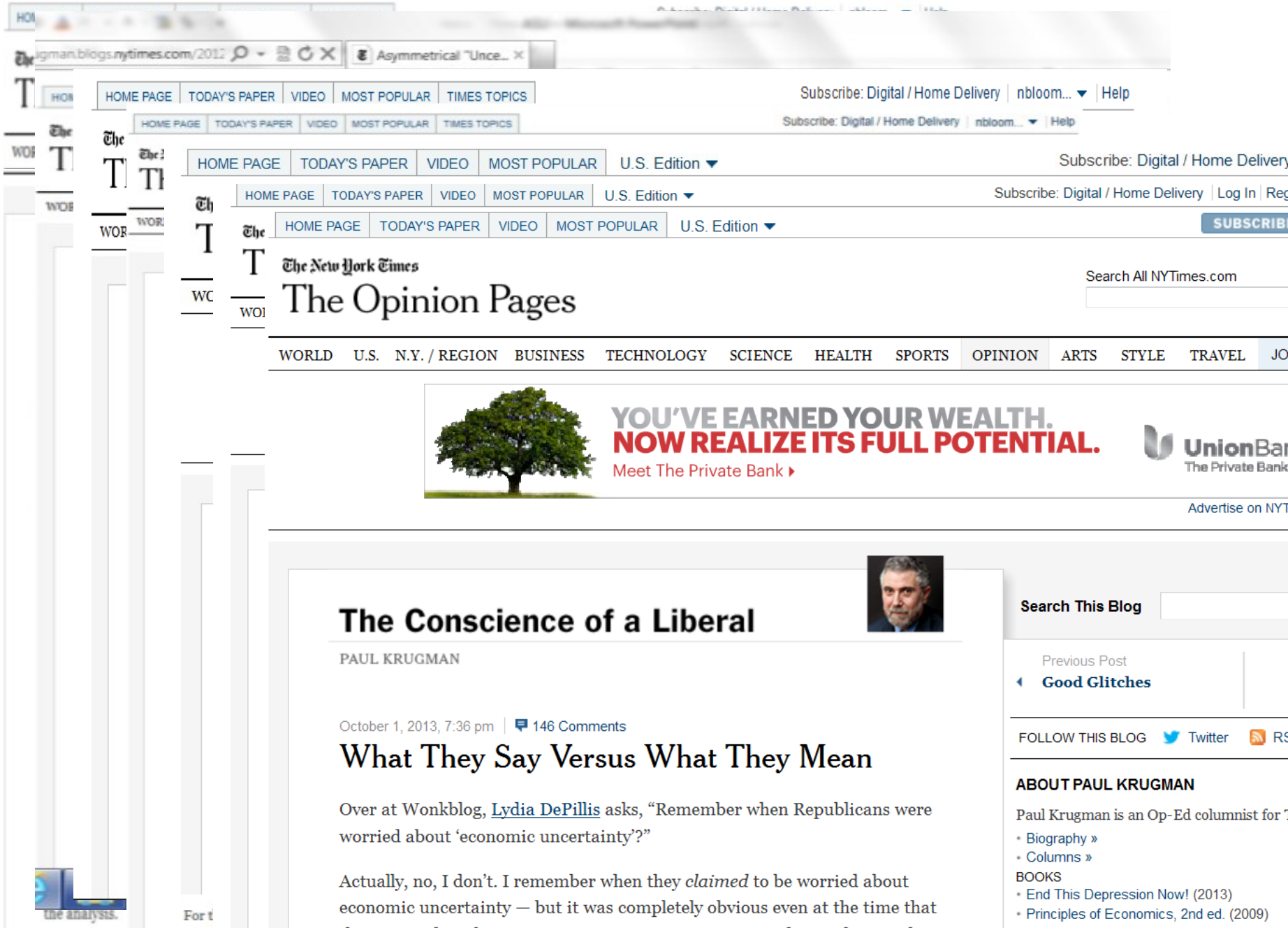
**But for some people the best evidence that uncertainty matters is that….**

# ….Paul Krugman thinks it does not



# Today I will discuss four areas briefly

1. Theory: Generally in good shape, with a rich set of models identifying many channels of uncertainty impact

2. Measurement: No one killer measure of uncertainty, but some stylized facts seem to be emerging

3. Identification (causality): Less conclusive - my view is this goes in both directions: uncertainty ↔ growth

4. Future work: Measurement, identification and computation

- **Theory**
- Measurement
- Identification
- Current work

# Uncertainty needs curvature to matter

In completely linear systems no role for uncertainty,
e.g. for U(C)=a+bC can simply use expected value of C

Likewise in log-linearized models can again just use certainty equivalence (e.g. Kydland & Prescott, 1982)
Hence, in much of the early (pre-2000s) business-cycle literature uncertainty played little role

# Wide range of potential sources of curvature, which are also theoretically ambiguous in sign

<u>Negative Uncertainty Effects</u>

- Adjustment costs (real options)
- Utility functions (risk-aversion)
- Financial frictions (lump-sum costs)
- Ambiguity (pessimism)

<u>Positive Uncertainty Effects</u>

- Production functions (Oi-Hartman-Abel effects)
- Bankruptcy (Growth options)

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- Bankruptcy (Growth options)

# Real options literature emphasizes that many investment and hiring decisions are irreversible

Key early papers Bernanke (1983), McDonald & Siegel (1986), Bertola & Bentolila (1990), Dixit & Pindyck (1994)

Also idea behind my paper Bloom (2009) “Impact of uncertainty shocks” doing micro-macro in partial-equilibrium

# Summarize “Really uncertain business cycles” (Bloom, Floetotto, Jaimovich, Saporta & Terry, 2014)

Large number of heterogeneous firms

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

Macro productivity with time variation in the variance of innovations

Uncertainty (σA ar

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

# Capital and labor adjustment costs

- Capital and labor follow the laws of motion:

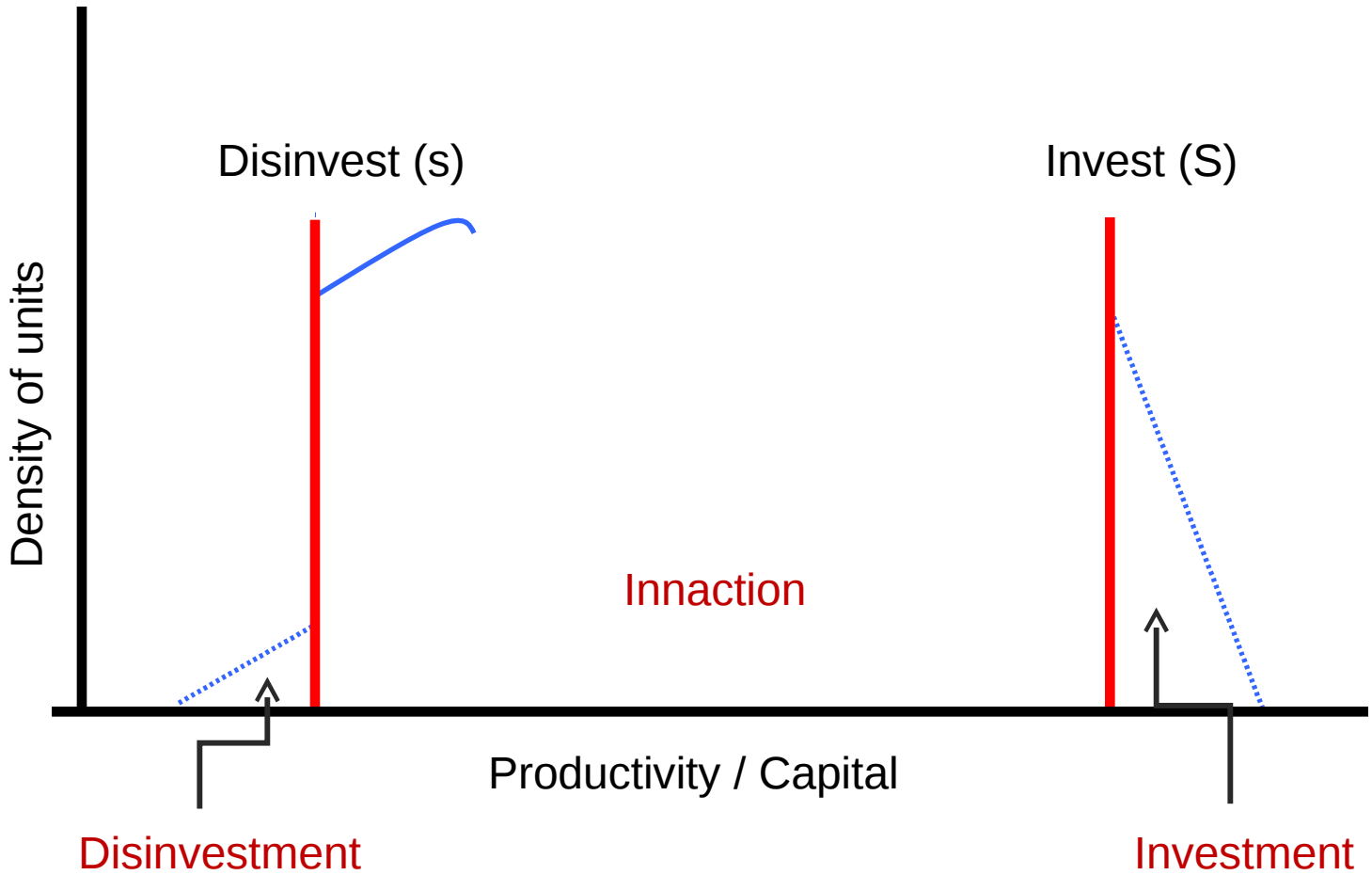
$$
\begin{aligned}
k_{j,t+1} &= (1-\delta_k)k_{j,t} + i_{j,t} \\
n_{j,t} &= (1-\delta_n)n_{j,t-1} + s_{j,t}
\end{aligned}
$$

where i: investment δk: depreciation

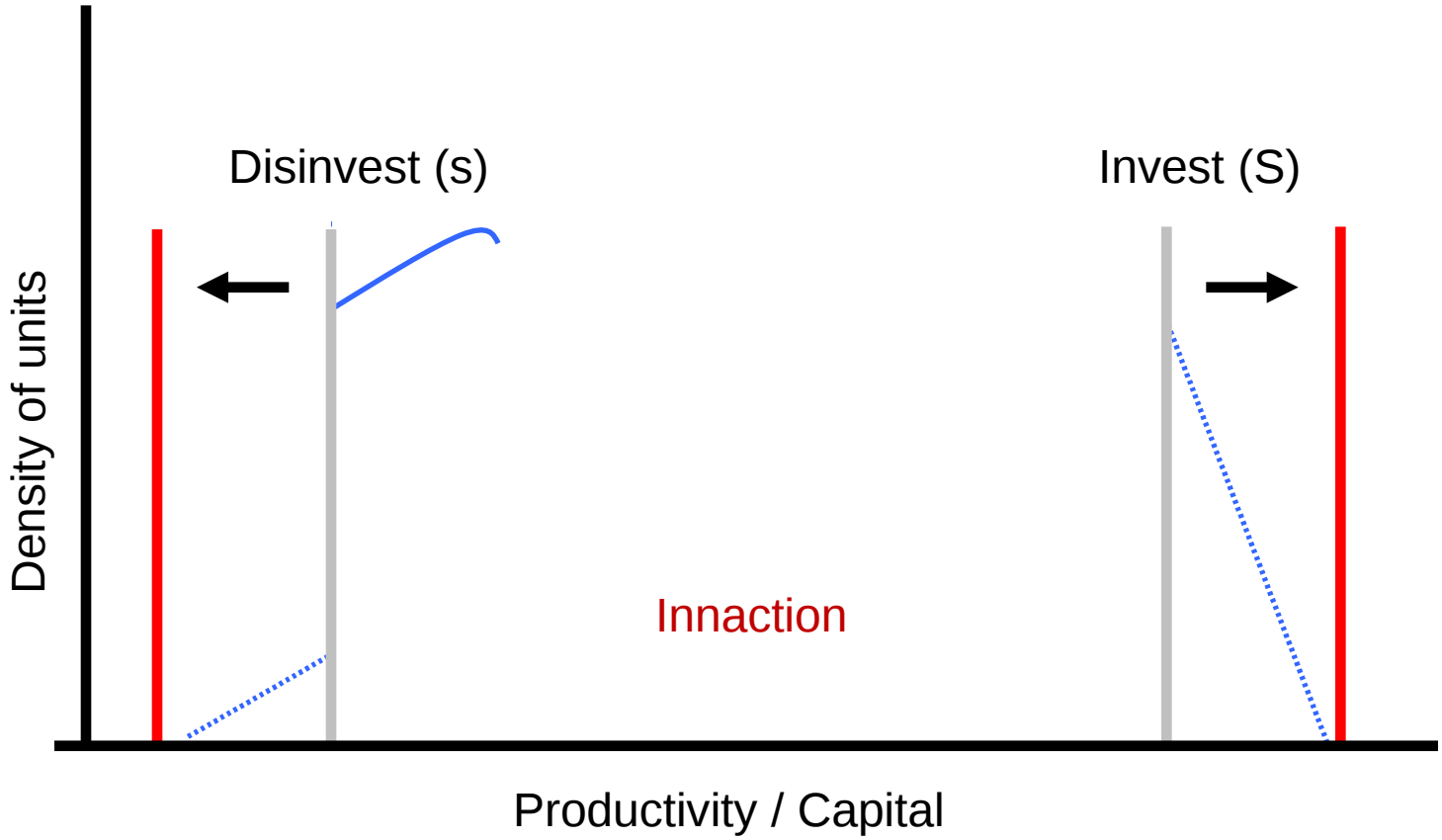
s: hiring δn: attrition

- Allow for the full range of adjustment costs found in micro data
  - Fixed – lump sum cost for investment and/or hiring
  - Partial – per $ disinvestment and/or per worker hired/fired

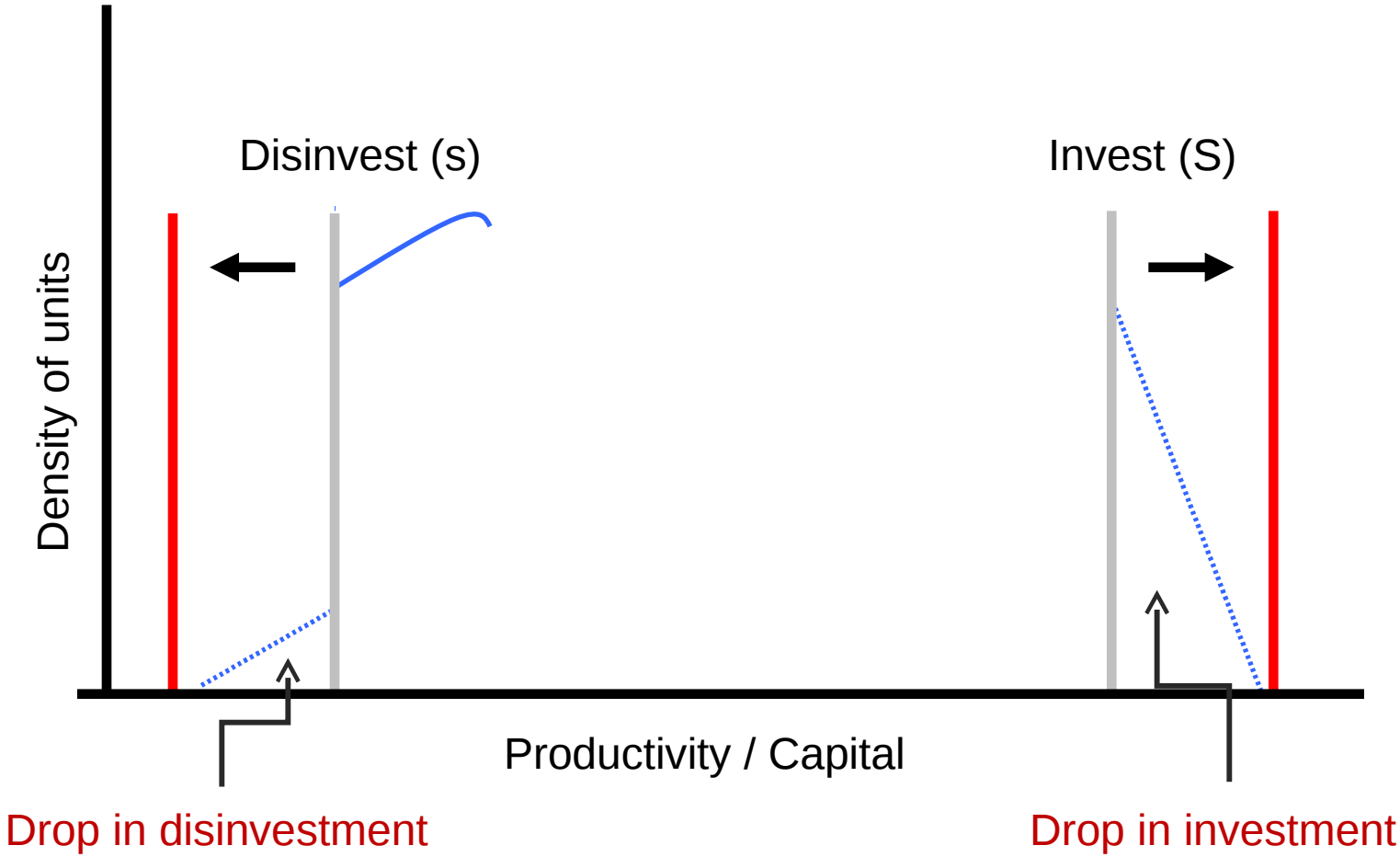
# For both investment and hiring this leads to Ss models with investment/disinvestment thresholds



# Increased uncertainty makes the SS thresholds move outwards



# This leads net investment to fall, because investment drops more than disinvestment

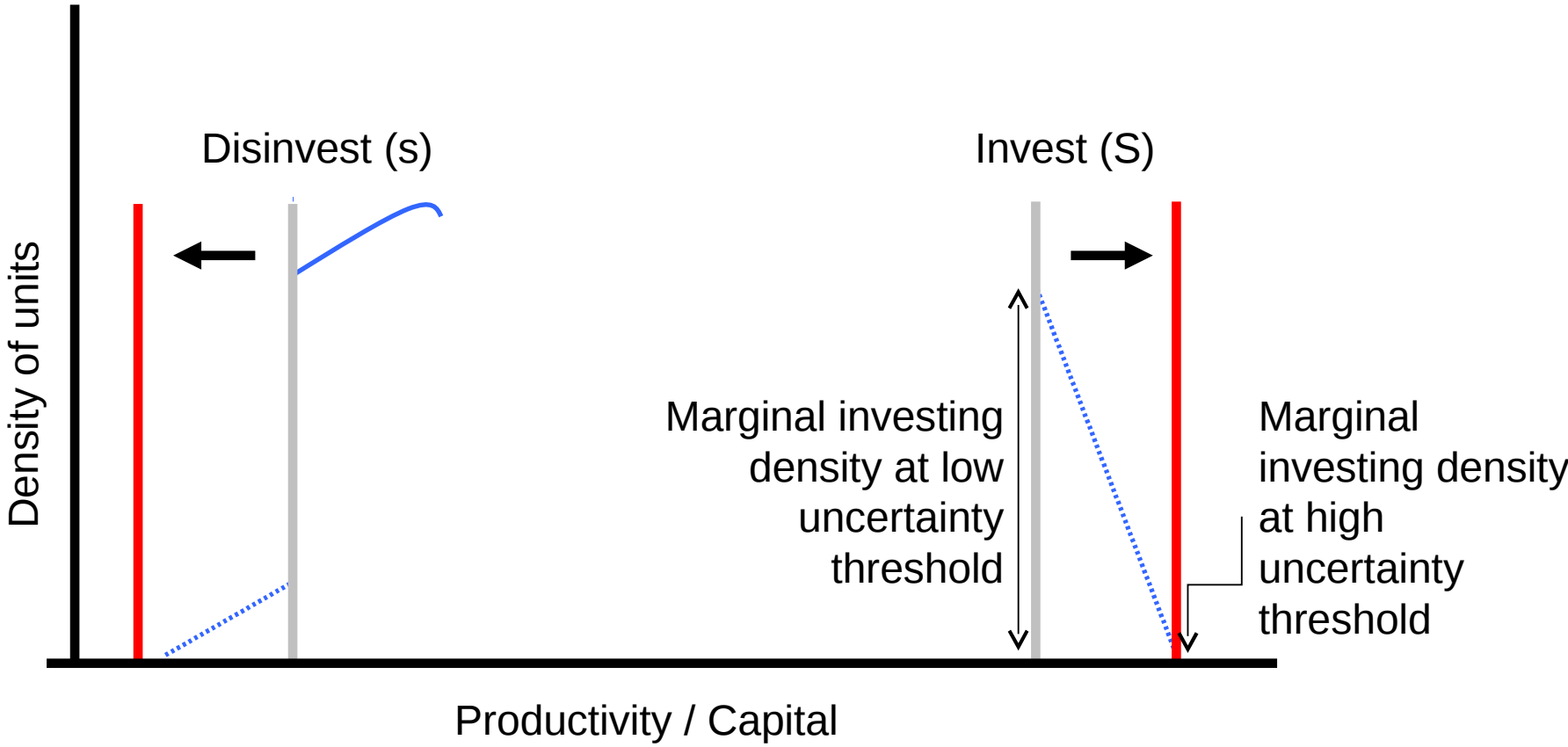


# This leads to the:

"***Delay effect***": higher uncertainty leads firms to postpone decisions. So net investment (and hiring) falls

$\partial I/\partial \sigma < 0$ where I=investment or hiring, σ=uncertainty

# Higher uncertainty also reduces responsiveness to stimulus (like prices, taxes and interest rates)



# This leads to the :

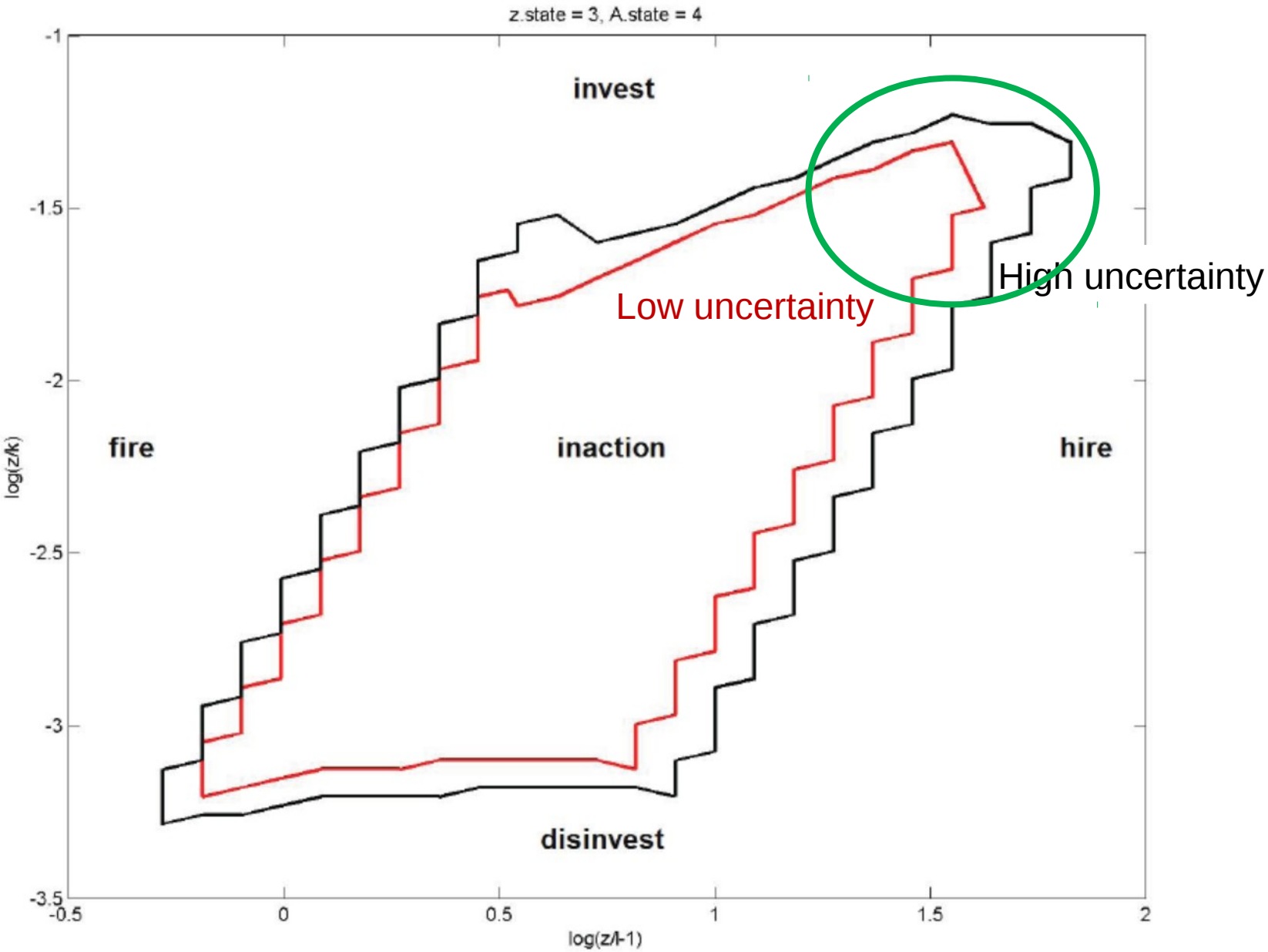
"***Delay effect***": higher uncertainty leads firms to postpone decisions. So net investment and hiring falls

$\partial I/\partial\sigma<0$ where I=investment or hiring, σ=uncertainty

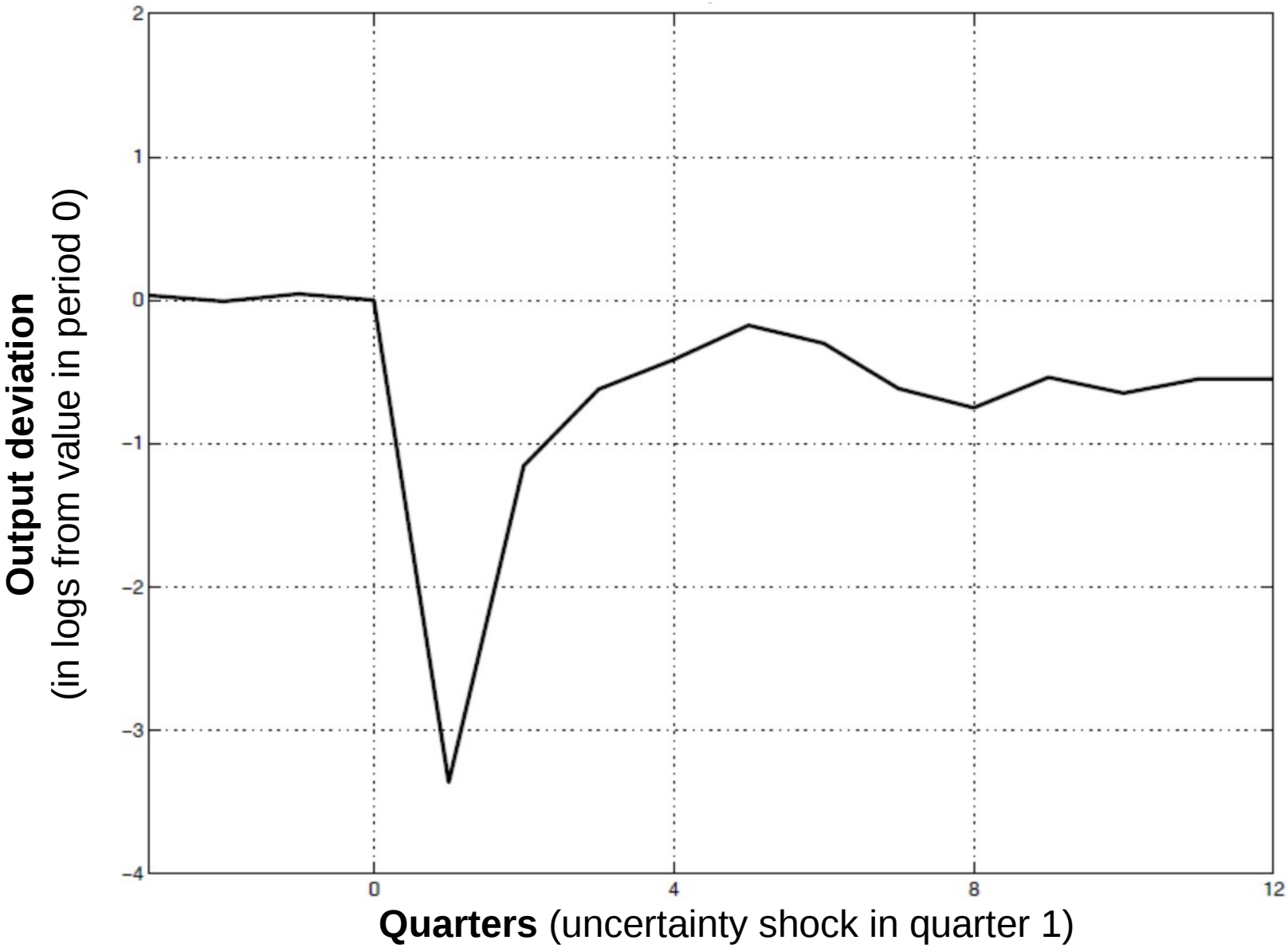
"***Caution effect***": higher uncertainty reduces firms response to other changes, like prices or TFP

$\partial 2I/\partial A\partial\sigma<0$ where I and σ as above, A=prices or TFP

# Since this model has 2-factors with adjustment costs it has a 2-dimensional response box



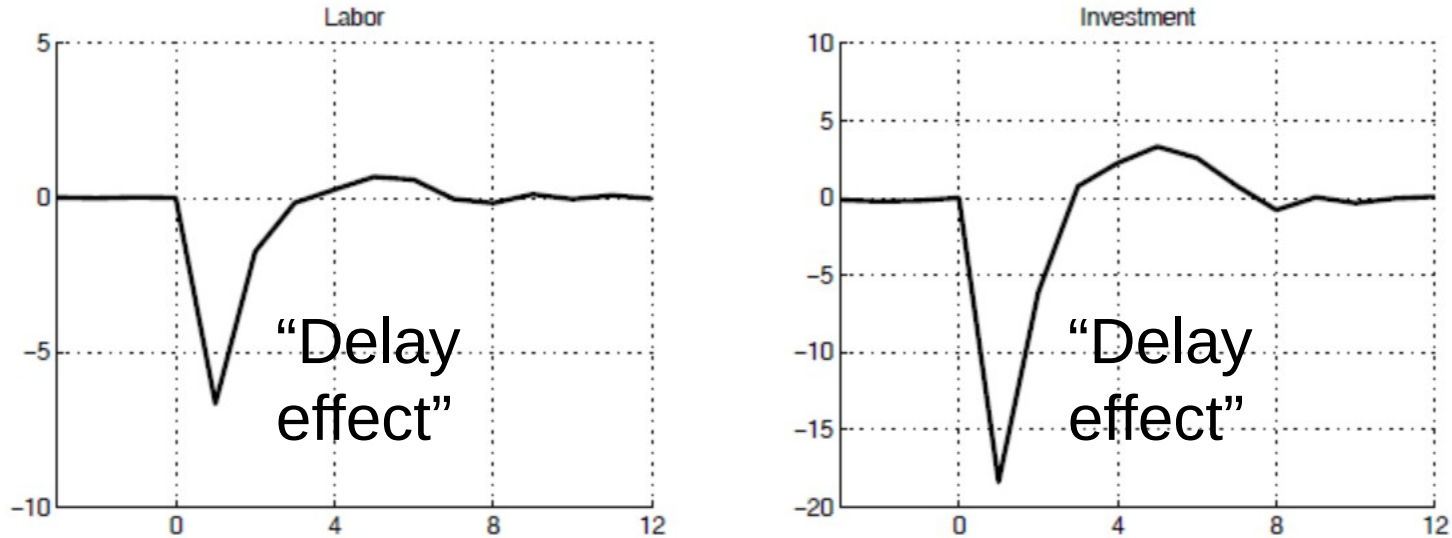
# An uncertainty shock causes an output drop of about 3.5%, and a recovery to almost level within 1 year



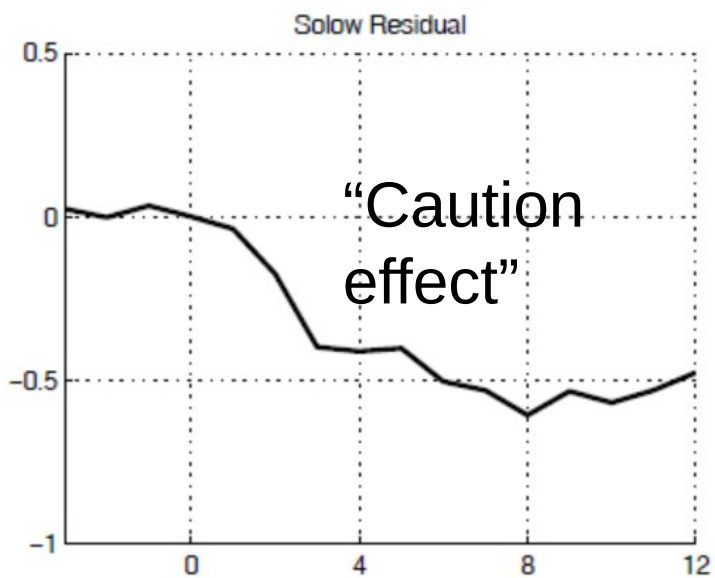

**Source: "Really Uncertain Business Cycles" by Bloom, Floetotto, Jaimovich, Saporta and Terry**

# Labor and investment drop and rebound, while TFP slowly drops and rebounds

**Deviation**
(in logs from value in period 0)




**Quarters** (uncertainty shock in quarter 1)




**Quarters** (uncertainty shock in quarter 1)

# How general are these results? Real option effects only arise under certain conditions

1. You can wait – rules out now or never situations (e.g. patent races, first-mover games, auctions etc)

2. Investing now reduces returns from investing later – rules out perfect competition and constant returns to scale

3. You can act ‘rapidly’ – rules out big delays, which Bar-Ilan & Strange (1996) show generate offsetting growth options

4. Requires non-convex adjustment costs – fixed or partial irreversibility (rather than only quadratic) adjustment costs

- Theory
- **Measurement**
- Identification
- Current work

# “Uncertainty” literature often rolls <u>uncertainty</u> & <u>risk</u> together, but theoretically they are distinct

Frank Knight (1921) defined:

<u>Risk</u>: A known probability distribution over events.
Example: A coin-toss


<u>Uncertainty (Knightian)</u>: Unknown probability distribution
Example: Number of coins produced since 2000BC

In practice these are linked, so for simplicity I’ll refer to both as “uncertainty” (as has in fact most of the literature)

# There are a number of proxies for uncertainty, that yield four stylized facts

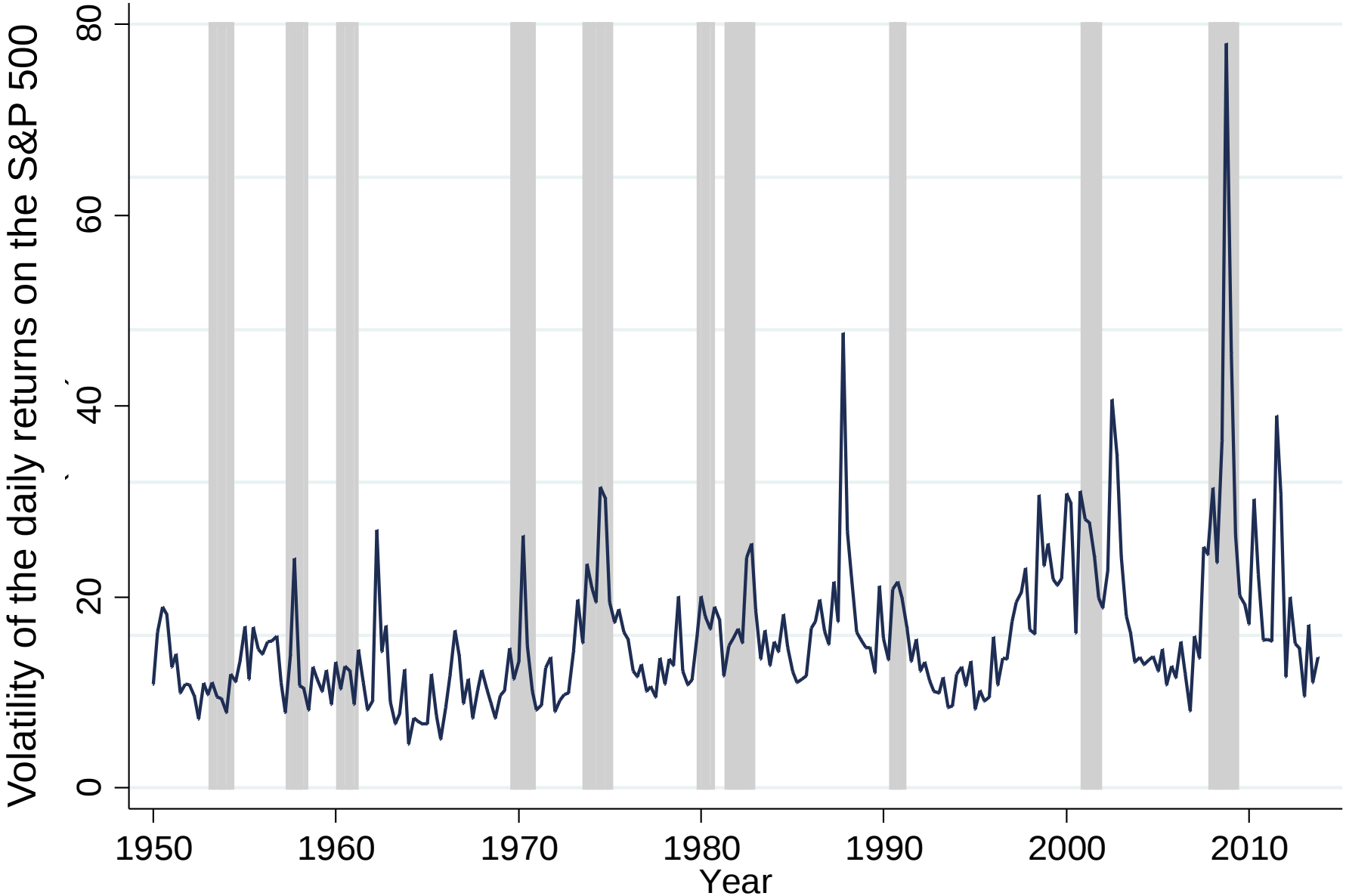
1) **Macro uncertainty appears countercyclical**

2) Micro firm uncertainty appears countercyclical

3) Higher micro moments appear *not* to be cyclical?

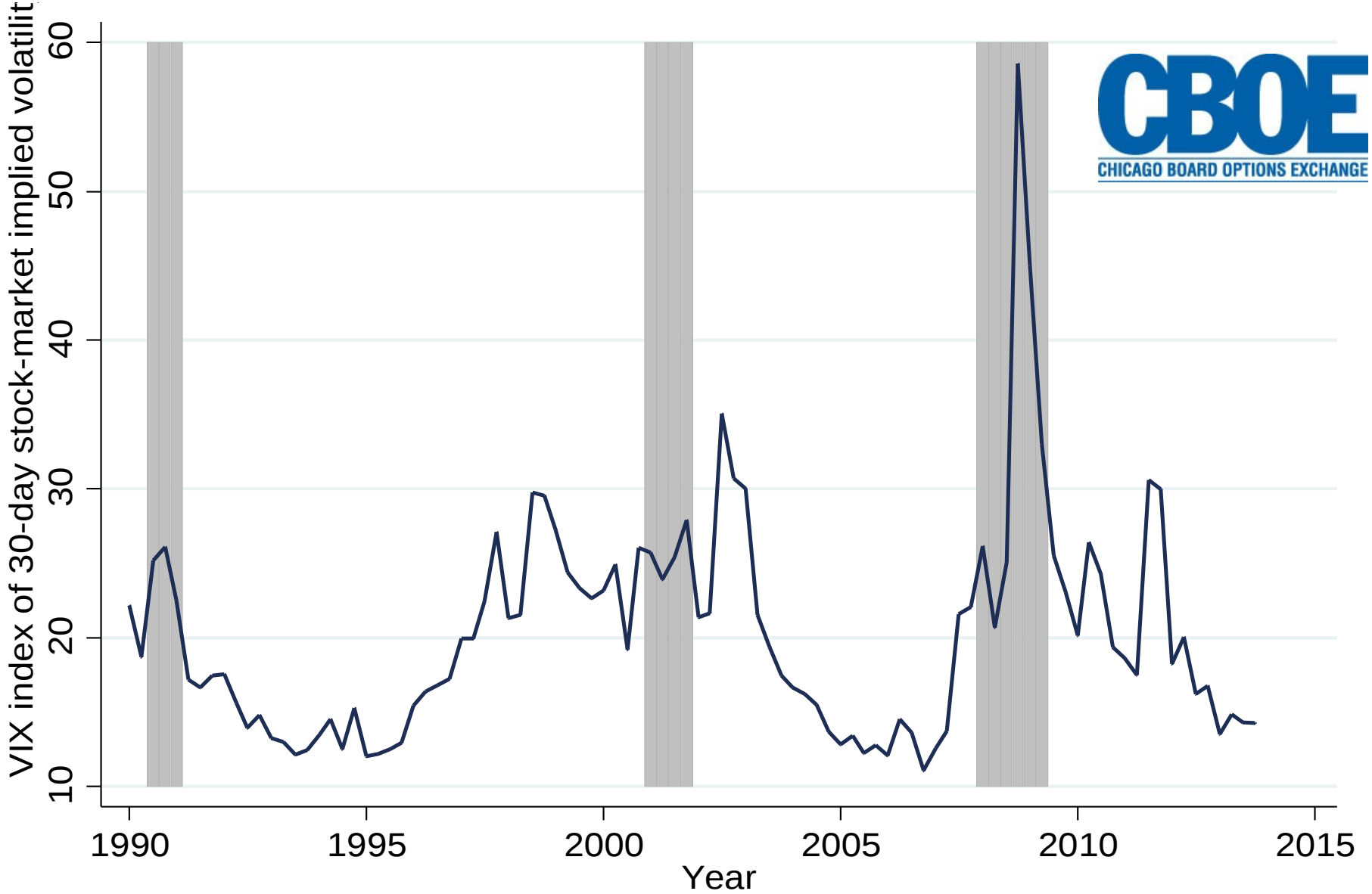
4) Uncertainty is higher in developing countries

# Stock returns realized volatility (back to 1950)



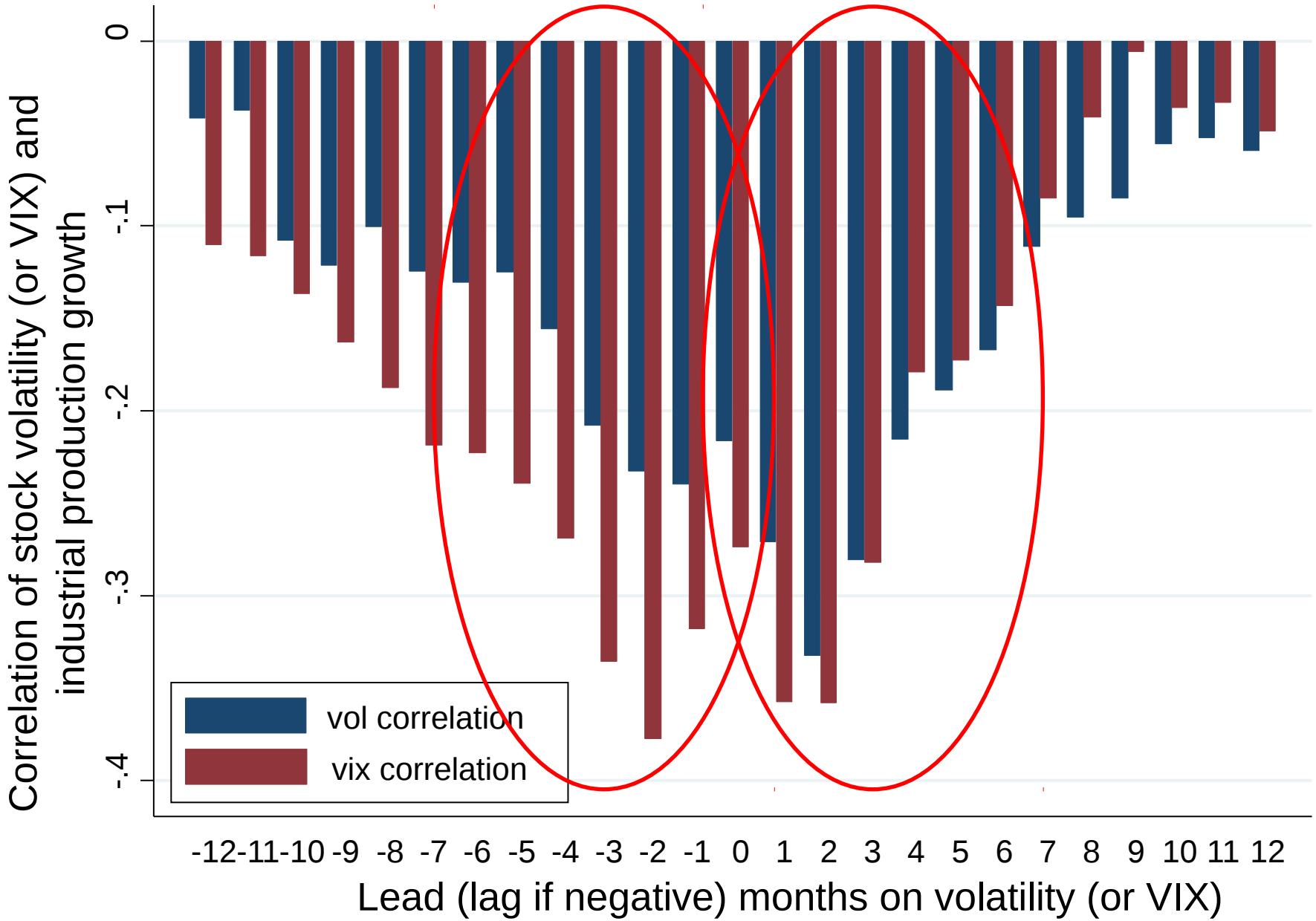

**Source:** Monthly volatility of the daily returns on the S&P500 at an annualized level. Grey bars are NBER recessions. Data spans 1950Q1-2013Q4.

# VIX, the 1-month ahead implied S&P500 volatility




**Source:** VIX is the implied volatility on the S&P500, averaged to the quarterly level, provided by the Chicago Board of Options and Exchange. The VIX is the markets implied level of stock-market volatility over the next 30-days, where values are in standard-deviations on the S&P 500 at an annualized level. Grey bars are NBER recessions. Data spans 1990Q1-2013Q4.

# Stock-volatility and VIX lead <u>and</u> lag the cycle




**Source:** Industrial production monthly data from Federal Reserve Board data from 1970 onwards (VIX from 1990 onwards)

# Interestingly, volatility now at very low levels

Global Macro Research

Goldman Sachs

## Top of Mind

June 25, 2014

Issue 24

### Volatility: Lower for longer?

**From the editor**: The decline in economic and asset market volatility this year from already low levels in 2013 has been striking. Questions about how long this low volatility can last – and the impact it will have – are Top of Mind. We interview three experts to assess if low vol is breeding the same complacency and excessive risk-taking that led to crises past. Our own Charlie Himmelberg is relatively sanguine that the credit cycle will play out, but likely not for a long time; Markus Brunnermeier and Nicholas Bloom are somewhat more concerned, but not for the same reasons. We assert that low asset vol is consistent with the current phase of the business cycle and discuss investment implications should low vol persist (cheap options, but scarcer trading opportunities, and a need for active managers to focus more on stock-picking). We also ask what could push vol higher (interest rate and geopolitical risk – the latter (kind of) playing out in oil).

Inside

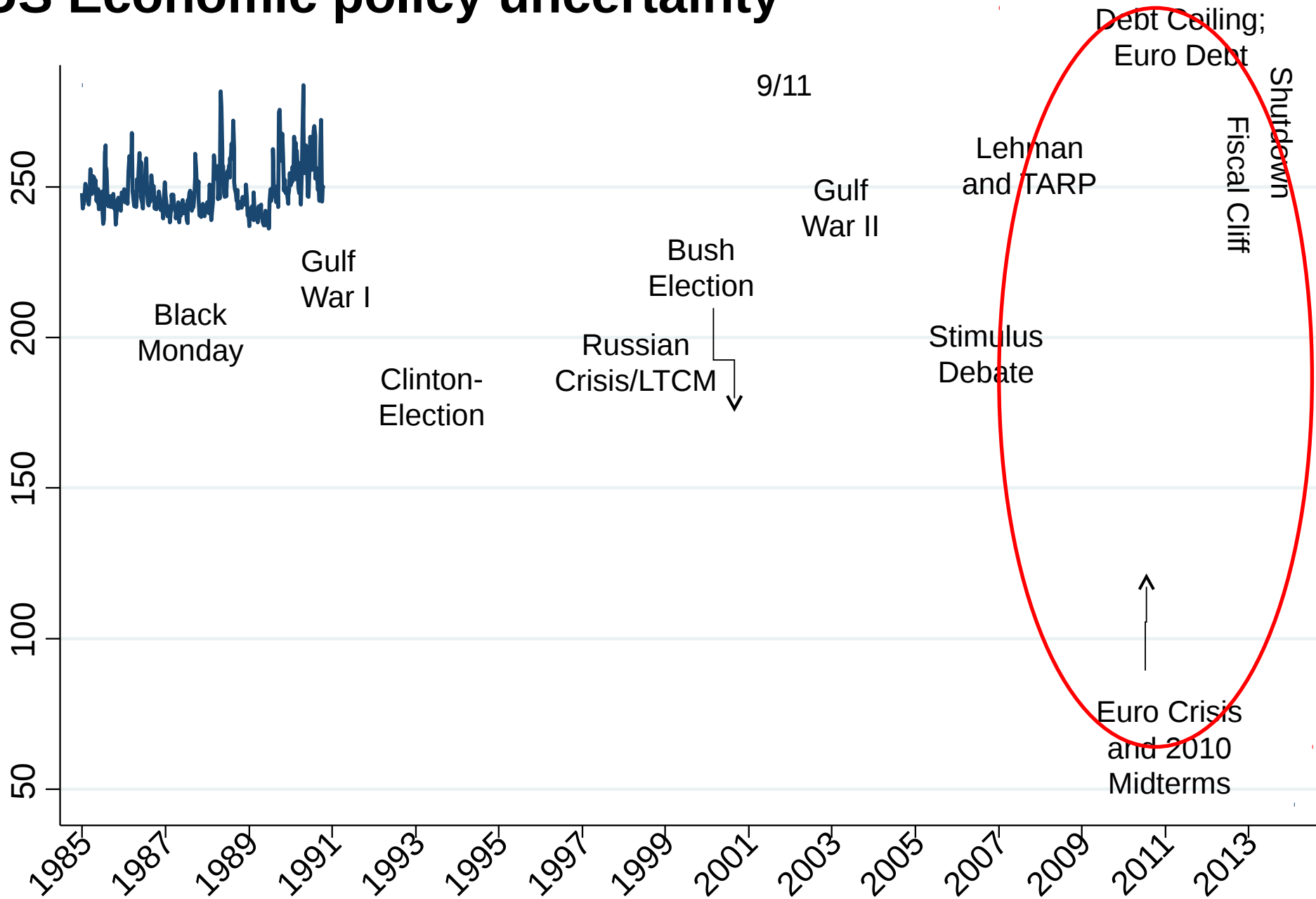
# News-Based uncertainty indicators

US Newspapers:

- Boston Globe
- Chicago Tribune
- Dallas Morning News
- Los Angeles Times
- Miami Herald
- New York Times
- SF Chronicle
- USA Today
- Wall Street Journal
- Washington Post

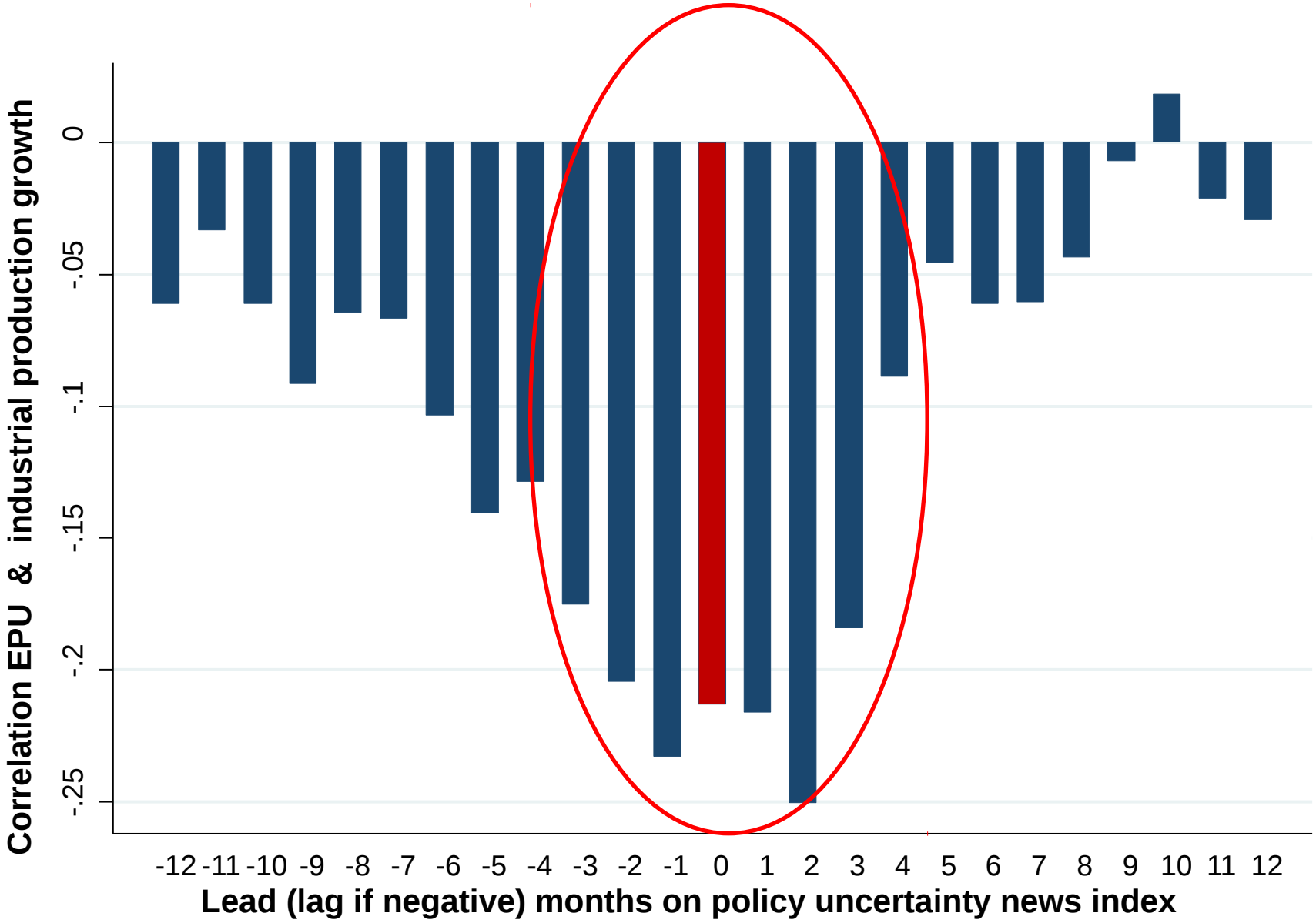
Basic idea is to search for frequency of words like econom* and in newspapers

# US Economic policy uncertainty



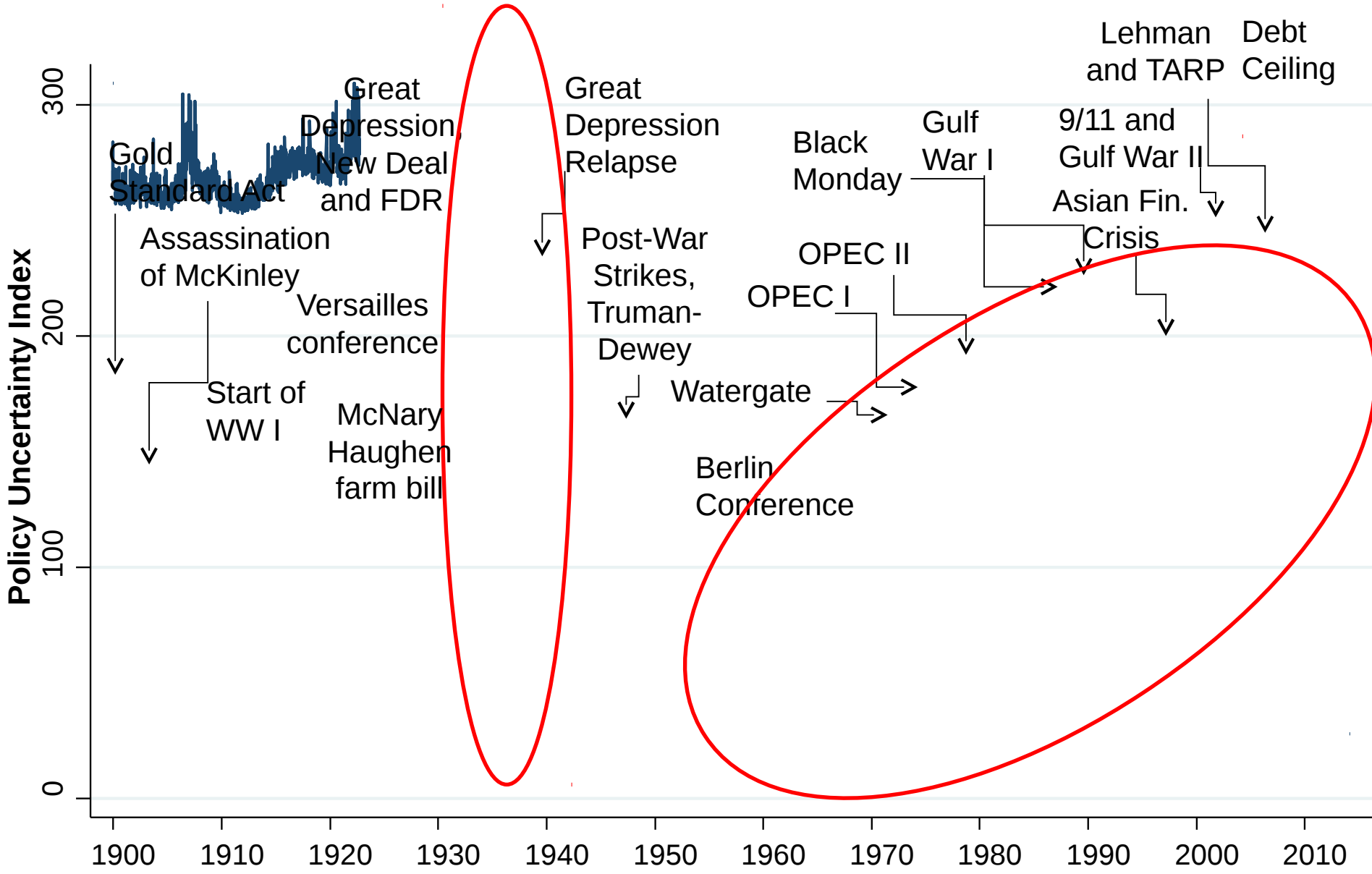

Source: "Measuring Economic Policy Uncertainty" by Scott R. Baker, Nicholas Bloom and Steven J. Davis, all data at www.policyuncertainty.com. Data normalized to 100 prior to 2010.

# Policy Uncertainty also leads and lags the cycle



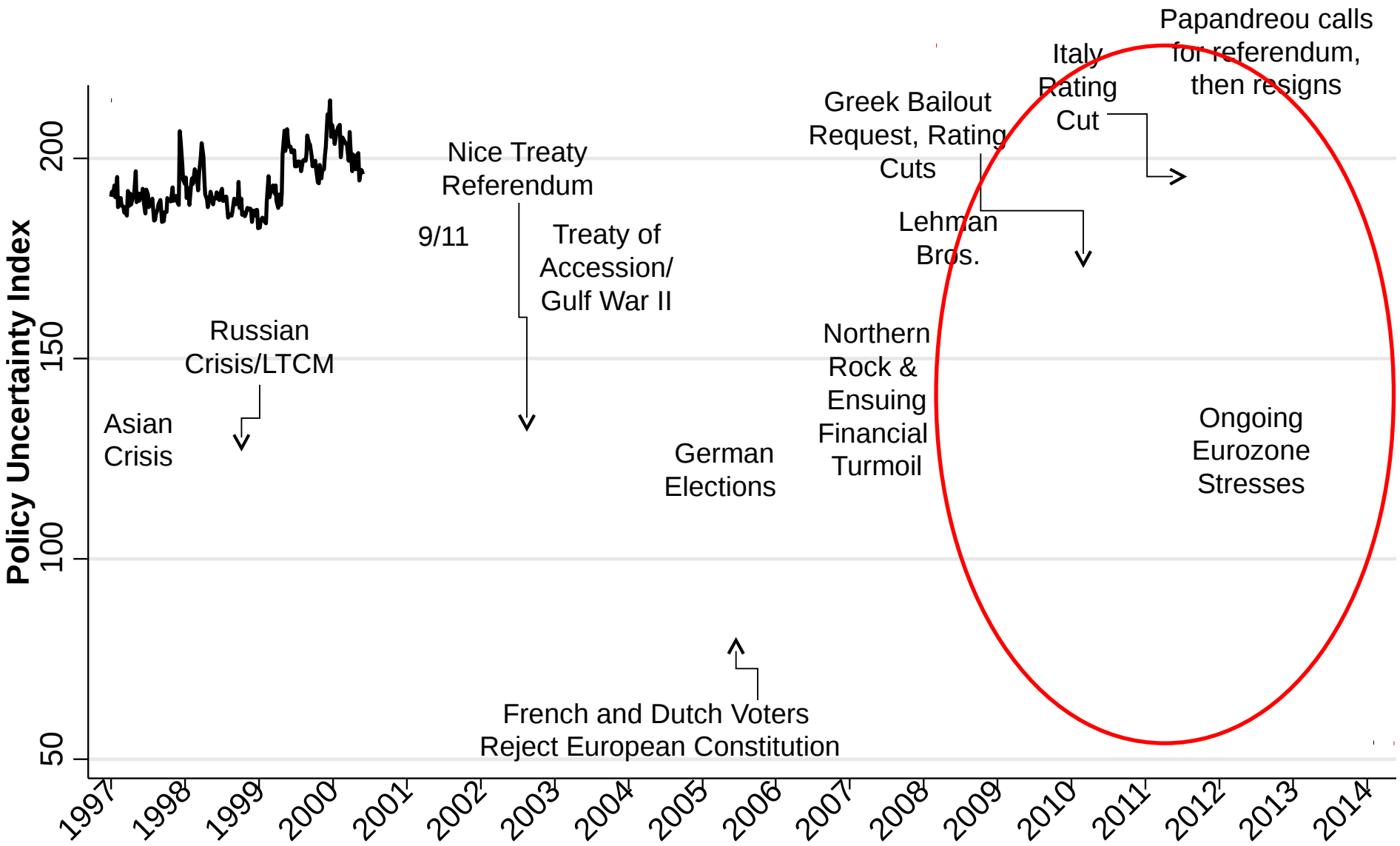

**Source:** Economic Policy Uncertainty Index from www.policyuncertainty.com. Industrial production monthly data from Federal Reserve Board. Data from 1985 onwards.

# News based measures are useful back in time



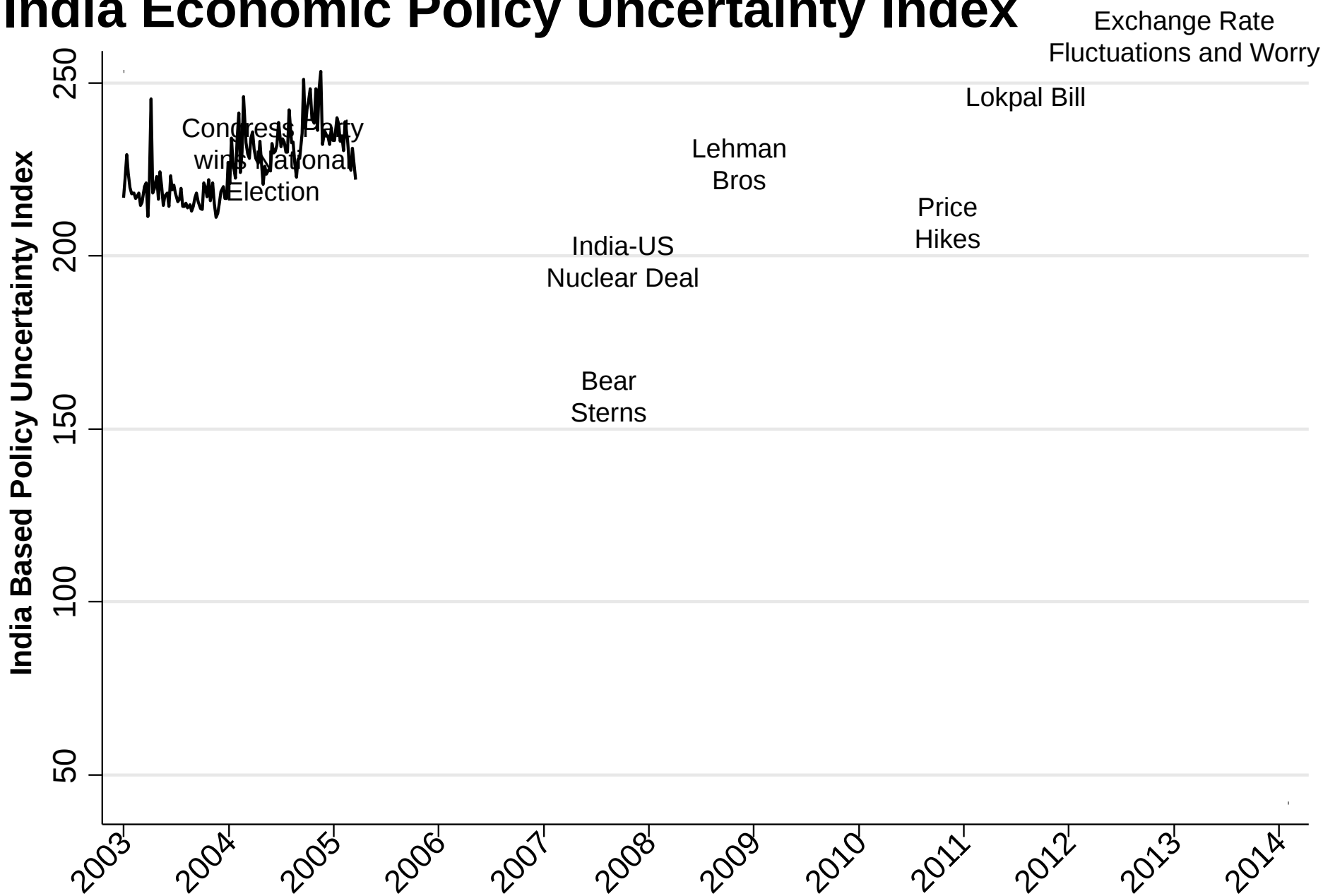

**Notes:** Index of Policy-Related Economic Uncertainty composed of quarterly news articles containing uncertain or uncertainty, economic or economy, and policy relevant terms (scaled by the smoothed total number of articles) in 5 newspapers (WP, BG, LAT, WSJ and CHT). Data normalized to 100 from 1900-2011.

# European Economic Policy Uncertainty Index



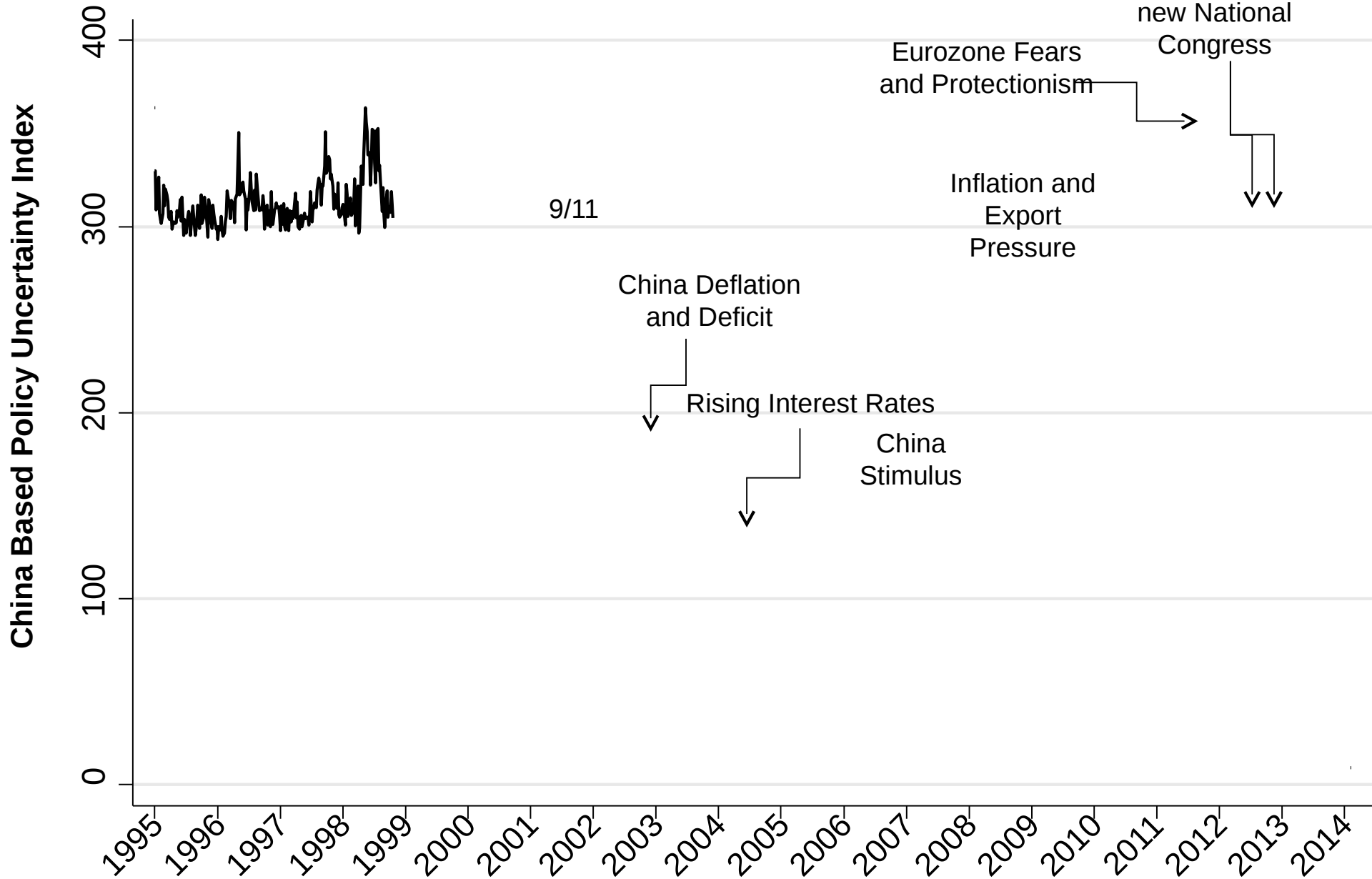

Source: www.policyuncertainty.com. Based on 10 paper (El Pais, El Mundo, Corriere della Sera, La Repubblica, Le Monde, Le Figaro, the Financial Times, Times, Handelsblatt, FAZ.)

# India Economic Policy Uncertainty Index



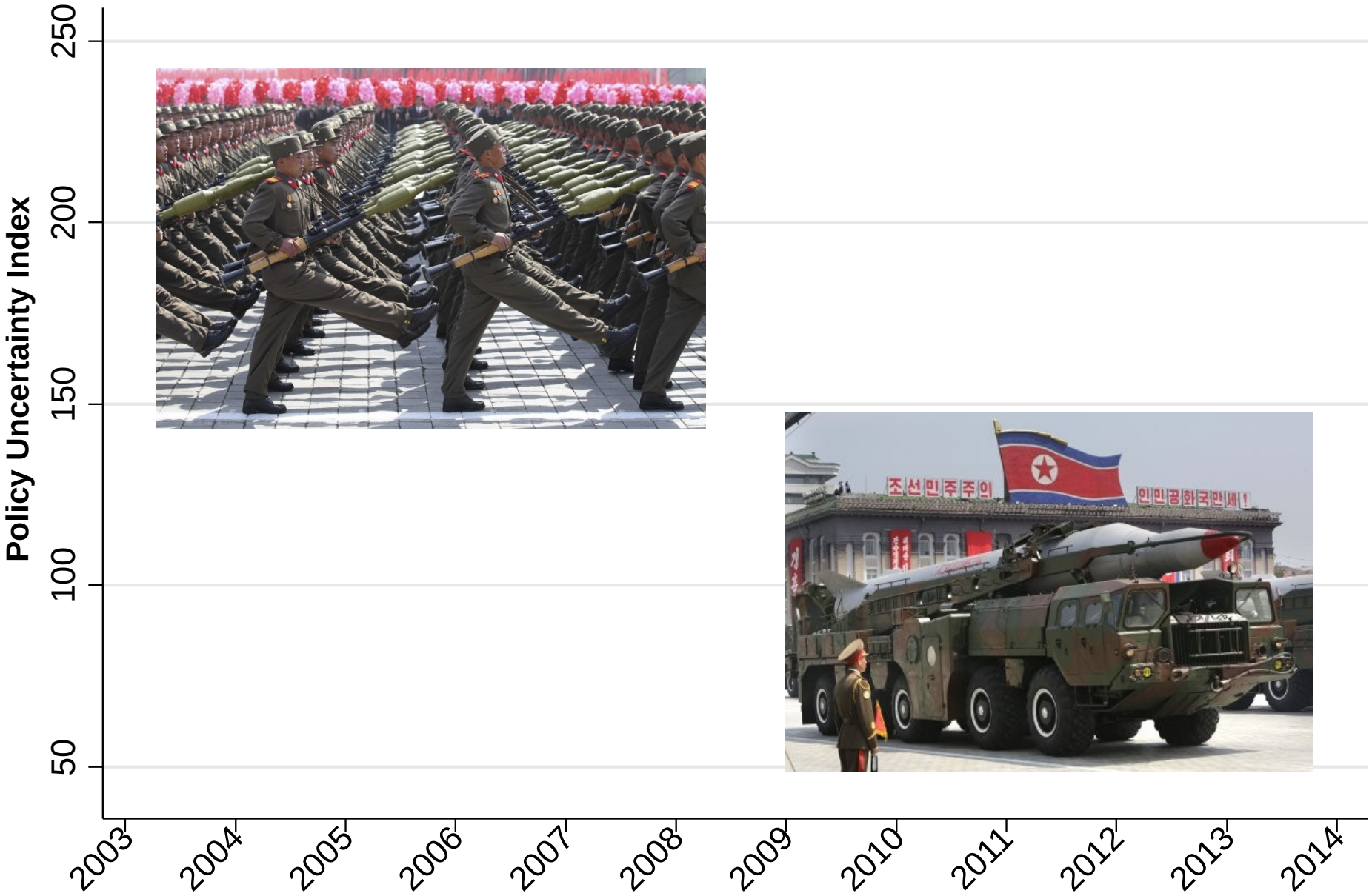

Source: www.policyuncertainty.com. Data from 7 Indian newspapers (Economic Times, Times of India, Hindustan Times, Hindu, Statesman, Indian Express, and Financial Express)

# China Economic Policy Uncertainty Index



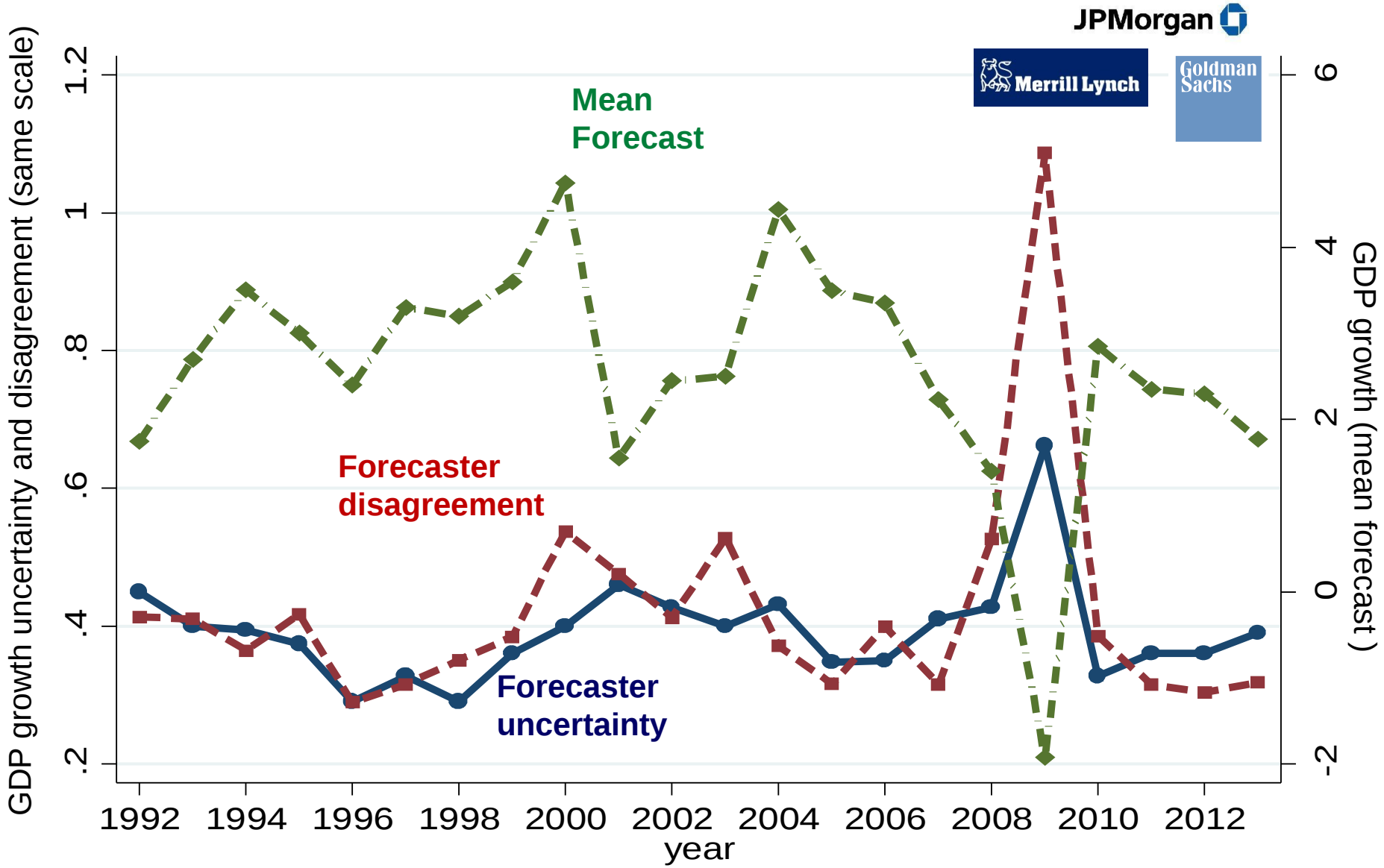

Source: www.policyuncertainty.com. Data until February 2014. Based on newspaper articles from the South China Morning Post.

# North Korean Economic Policy Uncertainty Index



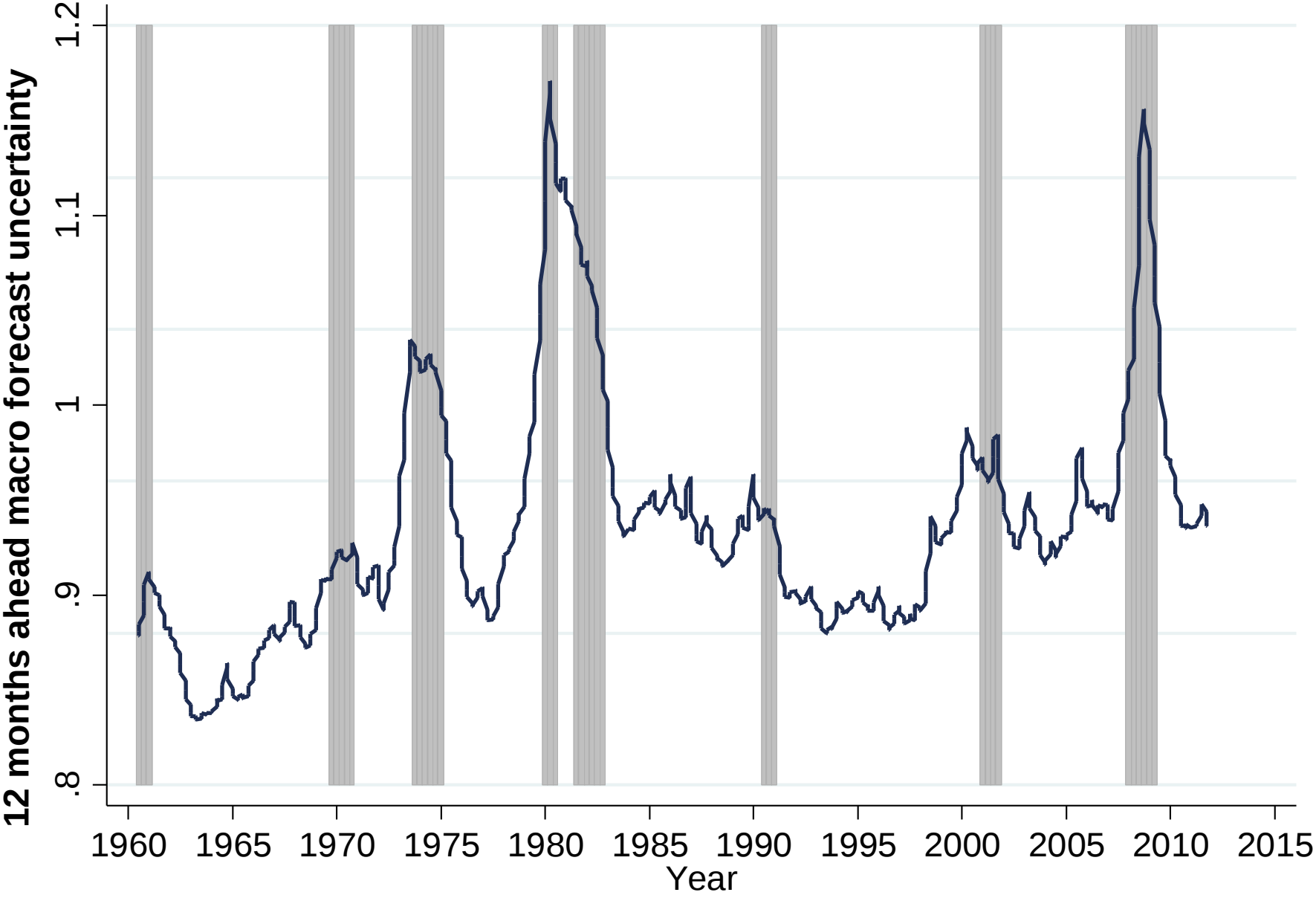

Source: www.policyuncertainty.com. Data from 0 North Korean newspapers

# Forecaster disagreement and uncertainty: GDP




**Notes:** Data from the probability changes of GDP annual growth rates from the Philadelphia Survey of Professional Forecasters. **Mean forecast** is the average forecasters expected GDP growth rate, **forecaster disagreement** is the cross-sectional standard-deviation of forecasts, and **forecaster uncertainty** is the median within forecaster subjective variance. Data only available on a consistent basis since 1992 Q1, with an average of 48 forecasters per quarter. Data spans 1992-20013.

# Econometric forecast uncertainty




**Source**: Jurado, Ludvigson and Ng (2013). Forecasts from a bundle of 132 mostly macro series

1) Macro uncertainty appears countercyclical

**2) Micro firm uncertainty appears countercyclical**

3) Higher micro moments appear *not* to be cyclical?

4) Uncertainty is higher in developing countries

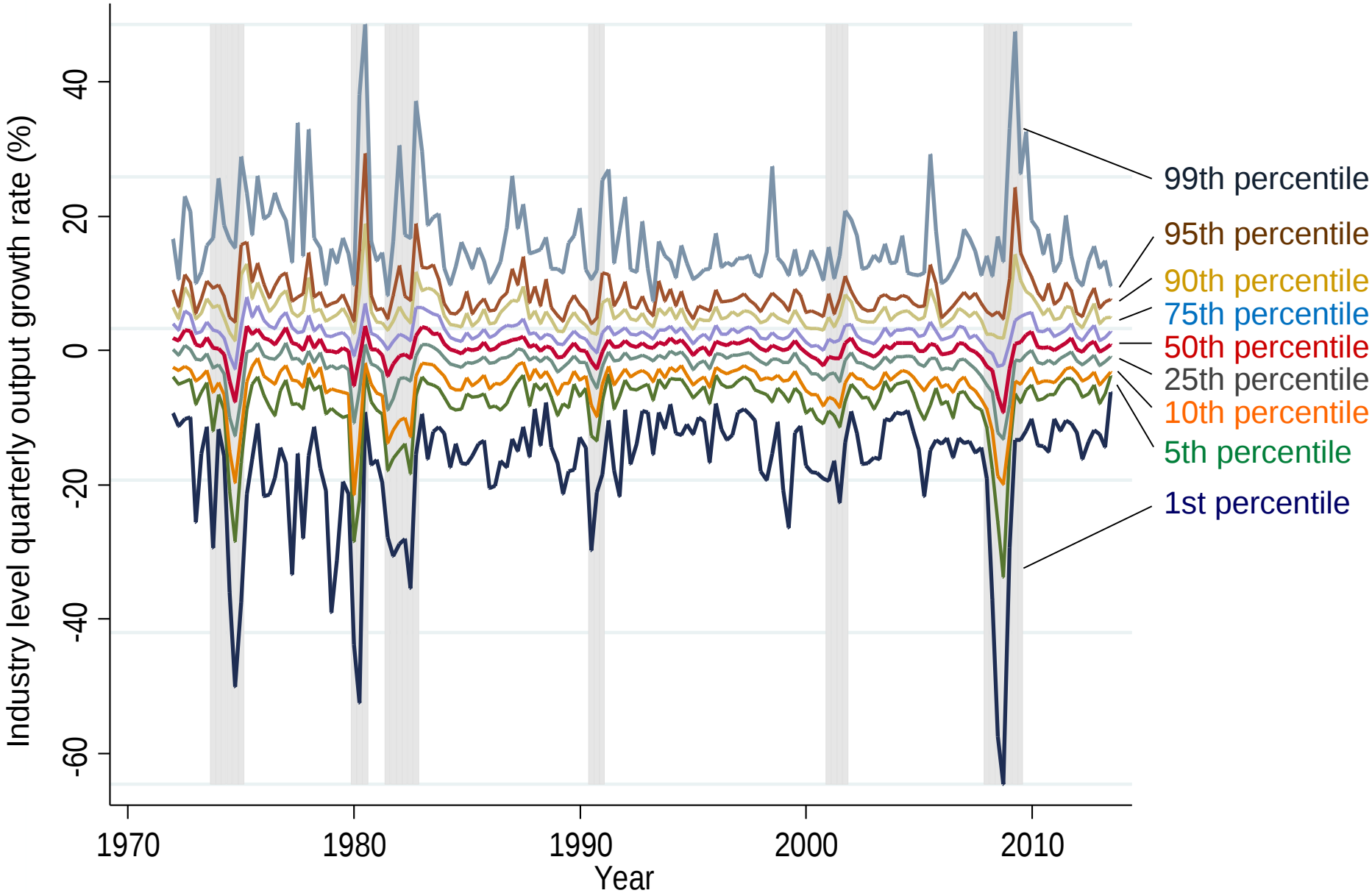
# The economy is 'fractal' - micro uncertainty seems to rise at every level in recessions

$$\underbrace{y_{j,t}}_{\text{Output}} = \underbrace{A_{,t}}_{\text{Aggregate Productivity}} * \underbrace{z_{j,t}}_{\text{Idiosyncratic Productivty}} * \underbrace{k_{j,t}^{\alpha} n_{j,t}^{\nu}}_{\text{Production Function}}$$

Idiosyncratic shocks appear more volatile in recessions at all levels:

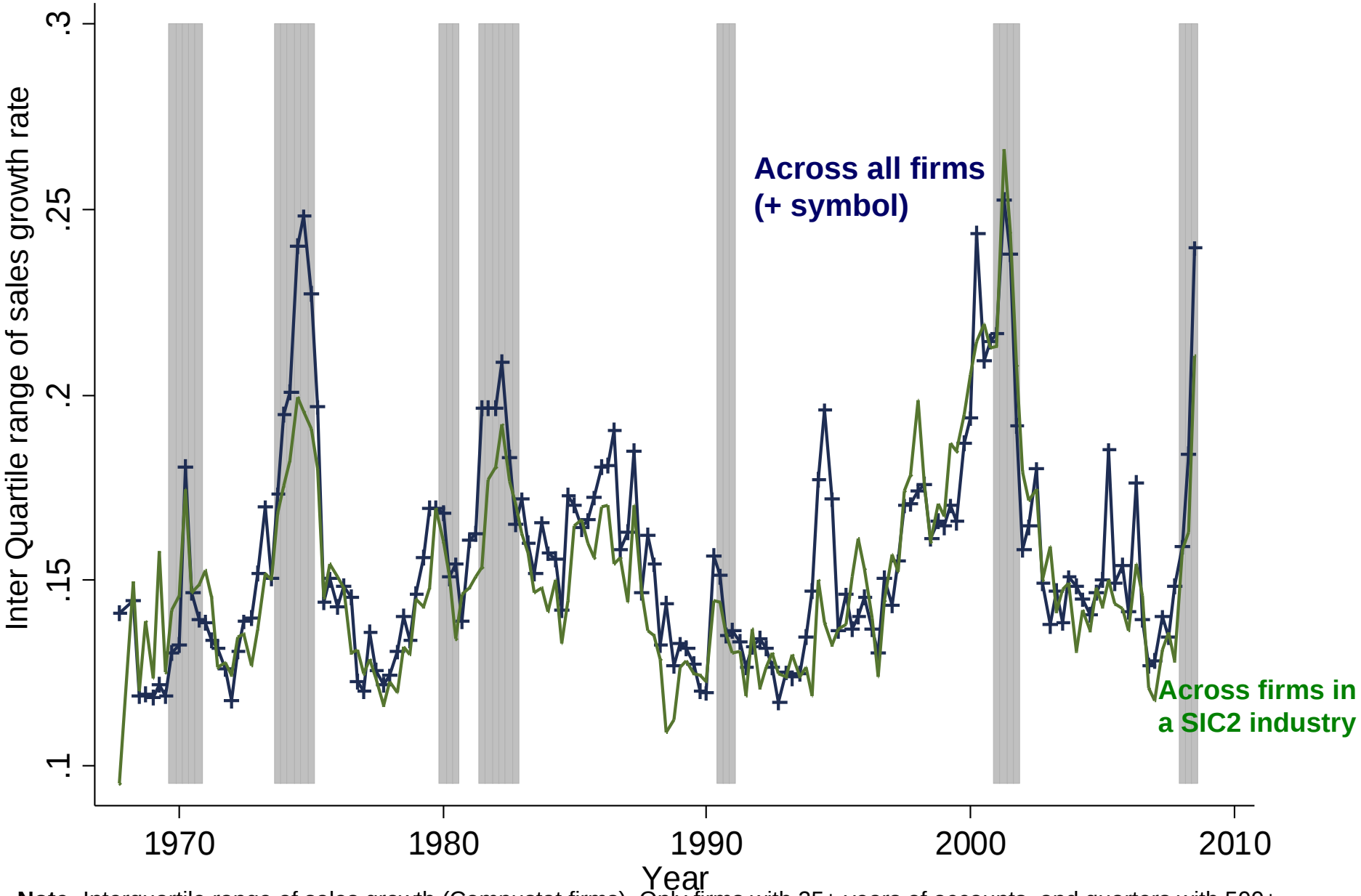
- industry
- firm
- plant
- product

# Industry growth dispersion (by month)



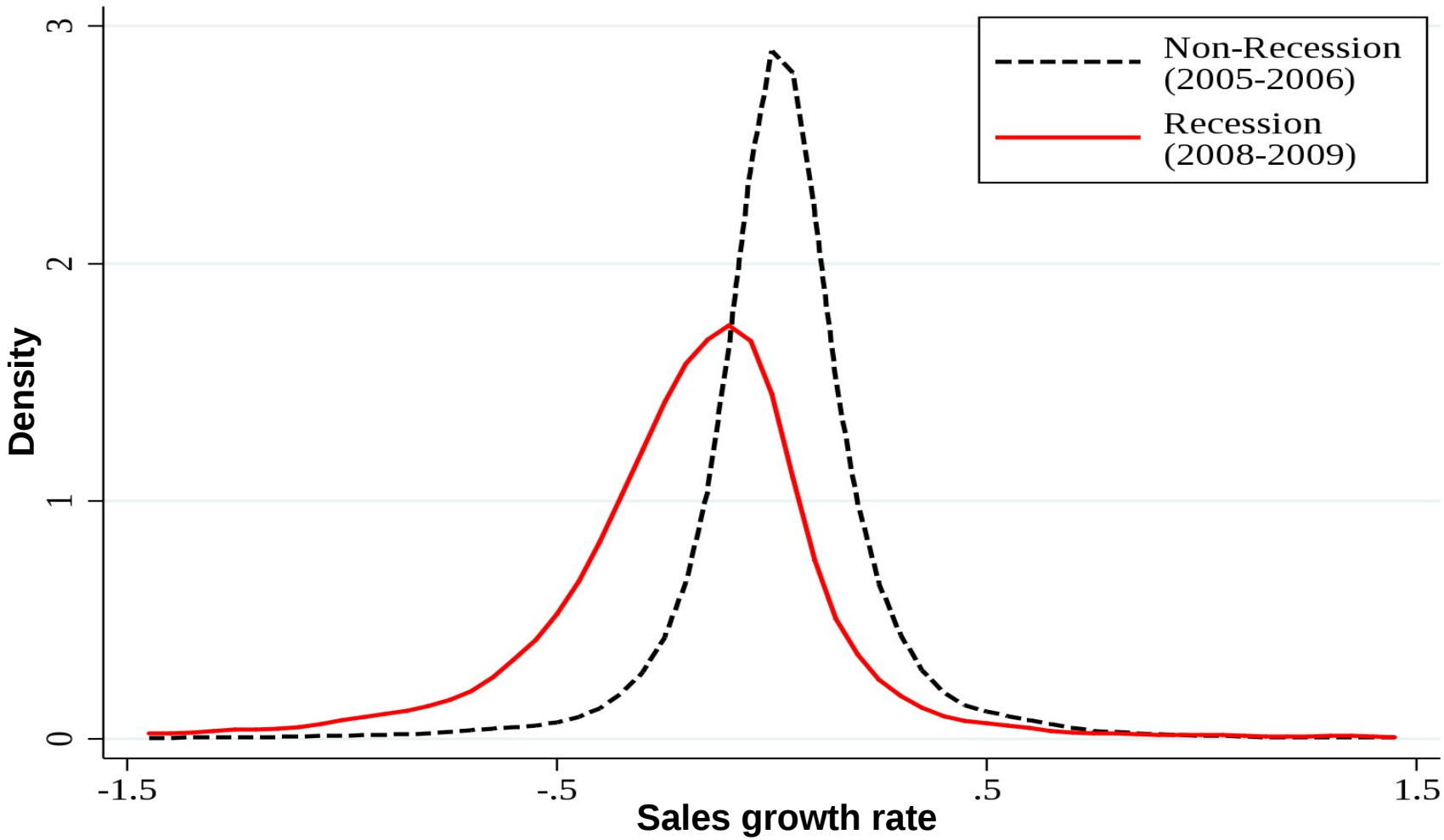

**Note:** 1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 99th percentiles of 3-month growth rates of industrial production within each quarter. All 196 manufacturing NAICS sectors in the Federal Reserve Board database. Source: Bloom, Floetotto and Jaimovich (2009)

# Firm growth dispersion (by quarter)




**Note:** Interquartile range of sales growth (Compustat firms). Only firms with 25+ years of accounts, and quarters with 500+ observations. SIC2 only cells with 25+ obs. SIC2 is used as the level of industry definition to maintain sample size. The grey shaded columns are recessions according to the NBER. Source: Bloom, Floetotto, Jaimovich, Saporta and Terry (2011)

# Plant growth dispersion pre & during great recession

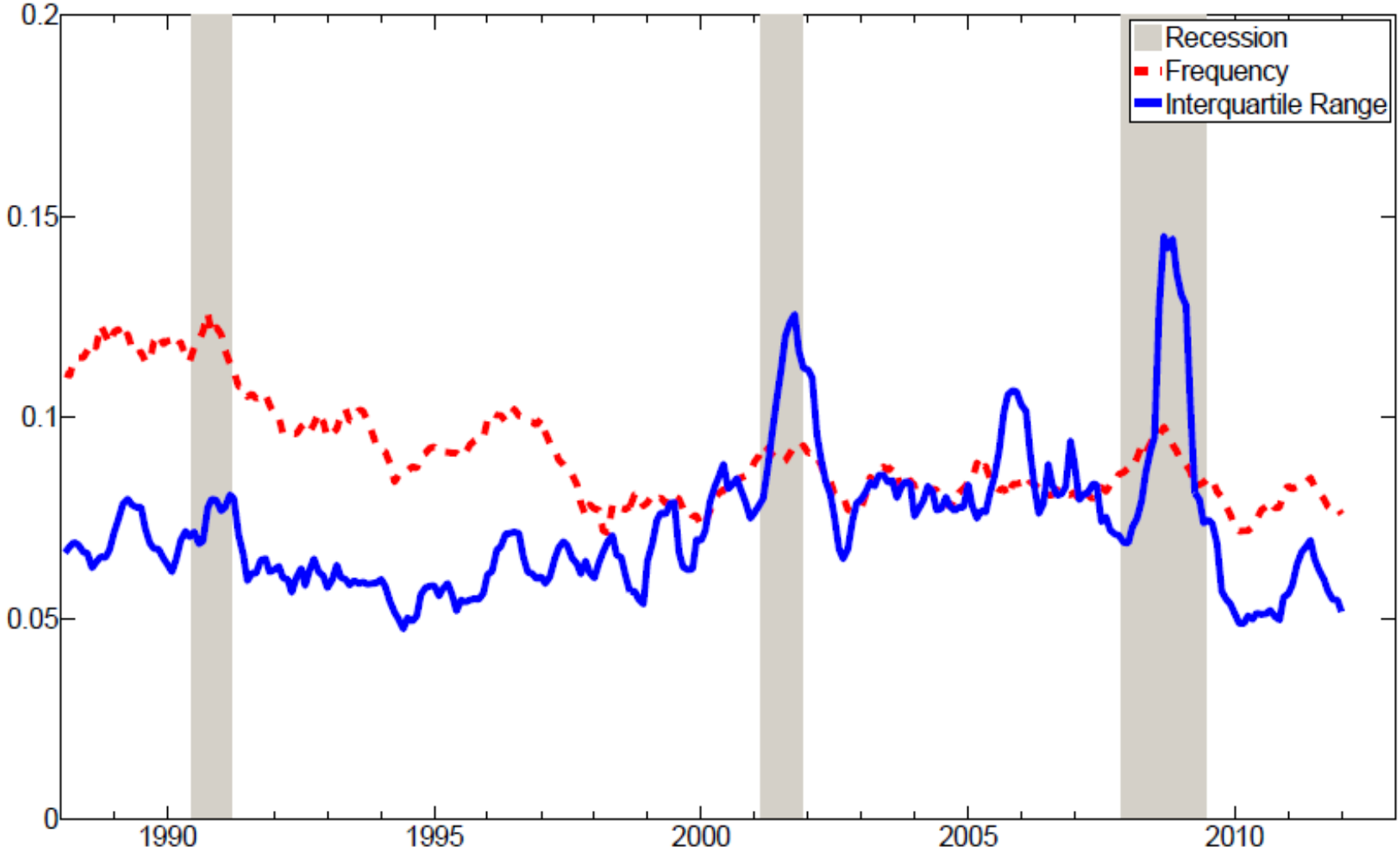



**Source: "Really Uncertain Business Cycles" by Bloom, Floetotto, Jaimovich, Saporta and Terry (2012)**

**Notes:** Constructed from the Census of Manufactures and the Annual Survey of Manufactures using a balanced panel of 15,752 establishments active in 2005-06 and 2008-09. Moments of the distribution for non-recession (recession) years are: mean 0.026 (-0.191), variance 0.052 (0.131), coefficient of skewness 0.164 (-0.330) and kurtosis 13.07 (7.66). The year 2007 is omitted because according to the NBER the recession began in December 2007, so 2007 is not a clean "before" or "during" recession year.

# Product level price dispersion (by quarter)

Figure 1: Price Changes Across Time




Data is seasonally adjusted using 12 monthly dummies and smoothed with a 6 month moving average.
Frequency is the Median Frequency of Adjustment.

**Source**: Joe Vavra (2014, QJE) “Inflation dynamics and time varying volatility”

1) Macro uncertainty appears countercyclical

2) Micro firm uncertainty appears countercyclical

**3) Higher micro moments appear *not* to be cyclical?**

4) Uncertainty is higher in developing countries

# Higher moments harder to measure - need yet larger samples - but these suggest little cyclical behavior

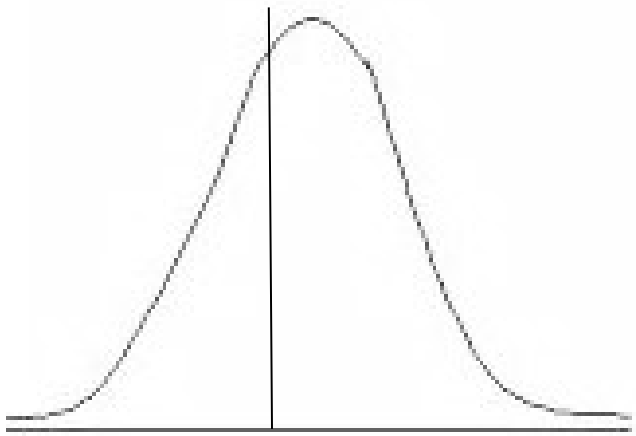
**Table 1: Uncertainty is Higher During Recessions**

| Dependent Variable: | (1) S.D. of log(TFP) shock | (2) Skewness of log(TFP) shock | (3) Kurtosis of log(TFP) shock |
|---|---|---|---|
| Sample: | Establishments (manufacturing) | Establishments (manufacturing) | Establishments (manufacturing) |
| Recession | 0.063*** | -0.244 | -1.432 |
| | (0.010) | (0.179) | (2.088) |
| Mean of Dep. Variable: | 0.499 | -1.527 | 20.514 |
| Corr. with GDP growth | -0.440*** | 0.131 | 0.038 |
| Frequency | Annual | Annual | Annual |
| Years | 1972-2009 | 1972-2009 | 1972-2009 |
| Observations | 37 | 37 | 37 |
| Underlying sample | 446,051 | 446,051 | 446,051 |

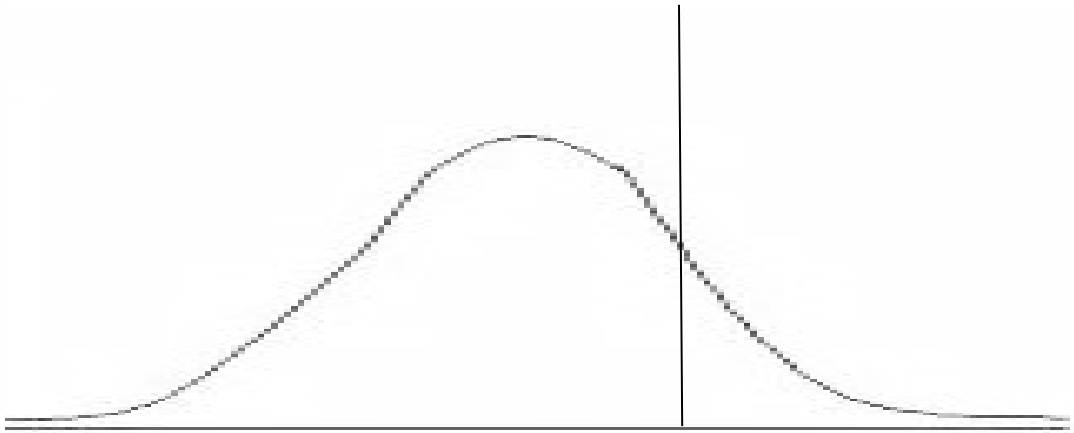
**Source: "Really Uncertain Business Cycles" by Bloom, Floetotto, Jaimovich, Saporta and Terry (2012)**

**Note**: Annual Survey of Manufacturing establishments with 25+ years (to reduce sample selection). Shaded columns are share of quarters in recession. Source Bloom, Floetotto, Jaimovich, Saporta and Terry (2011)

# So in summary, in <u>firms and plants</u> we see



Normal distribution of TFP shocks



Recessionary distribution of TFP shocks

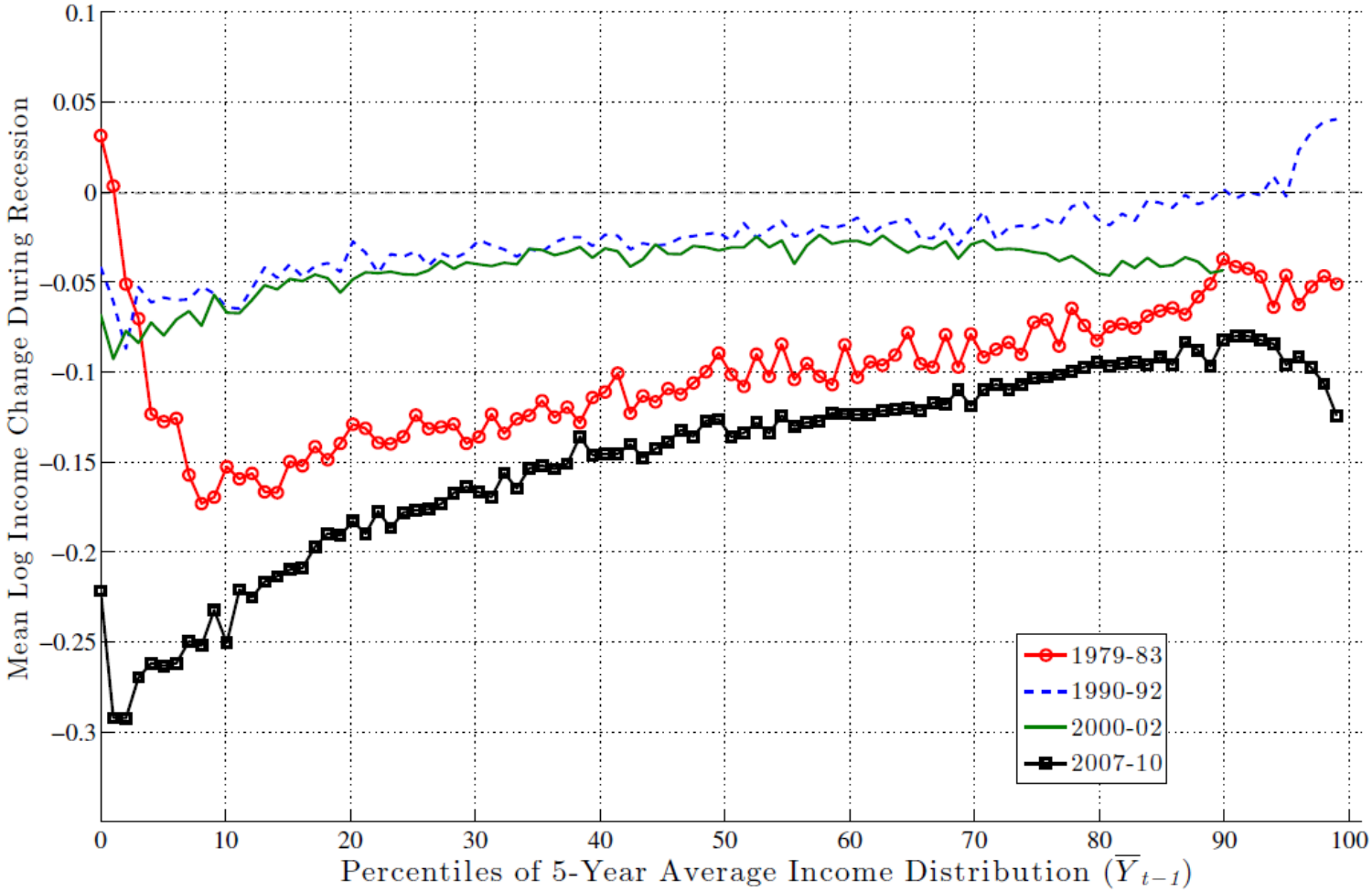
# Earlier literature suggested income growth had a similar counter-cyclical second moment

Storesletten, Telmer & Yaron (2004) show US cohorts that lived through more recessions have more dispersed incomes

Meghir & Pistaferri (2004) show that labor market residuals have a higher standard deviation in recessions

Both used PSID which has about 20k individuals per year

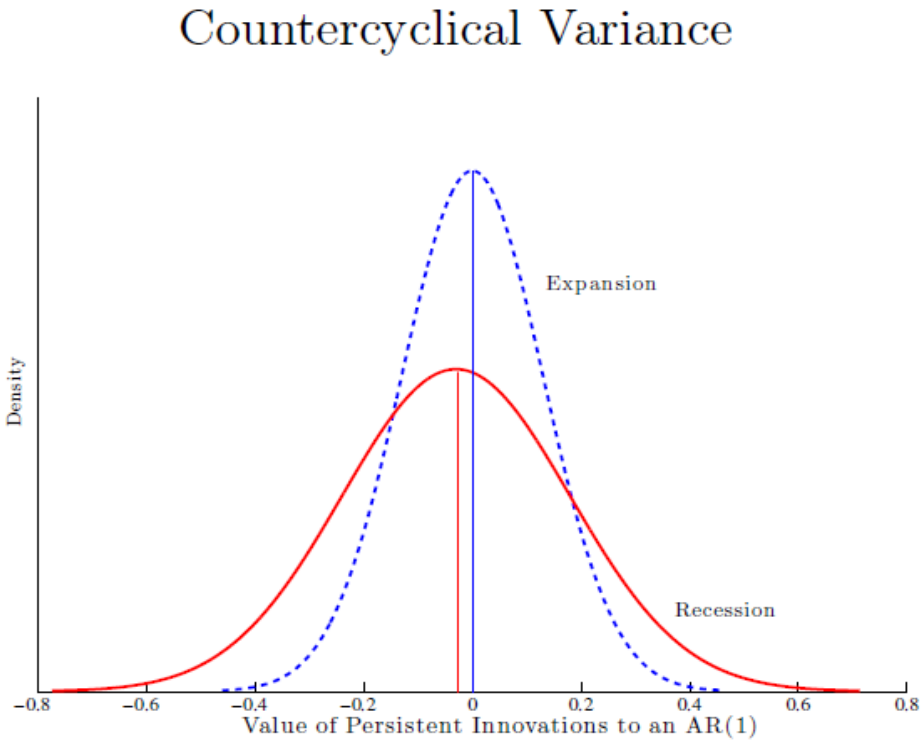
# But SSA data on several million individuals shows rising 3rd moment but flat 2nd moment in re

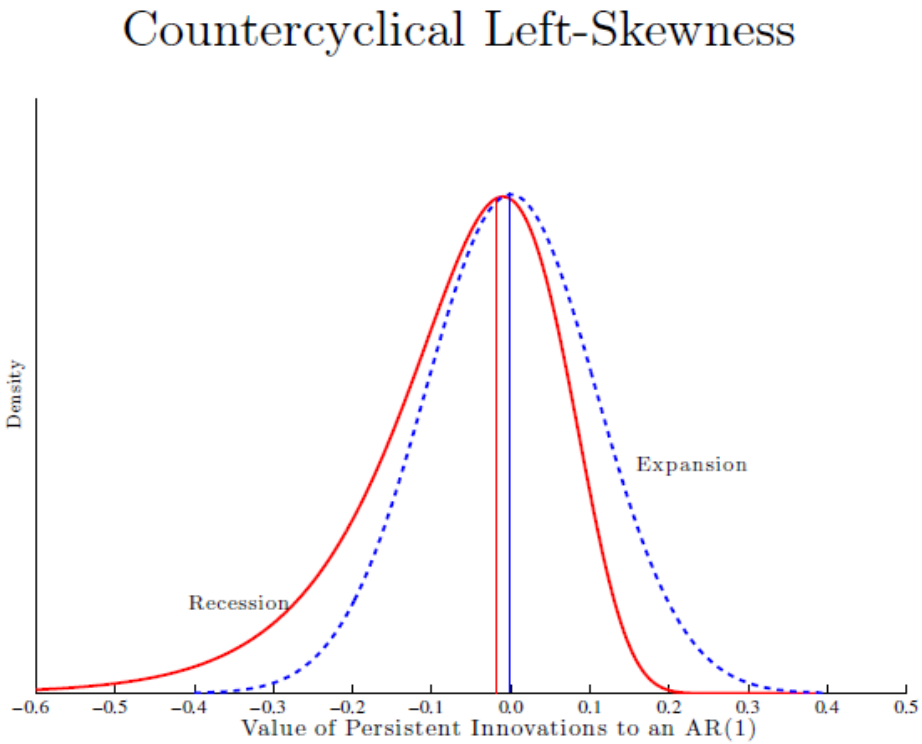



Guvenen, Ozkan & Song, “The nature of countercyclical income risk” (2014, JPE)

**Notes**: Uses about 5m obs per year from the US Social Security Administration earnings data

# So firms and workers seem to differ in higher moments across recessions – not clear why?




Macro, industry, firms, plants and prices

Wages

Working with Jae Song, David Price and Fatih Guvenen to investigate (David is presenting this on Saturday at 11:30)

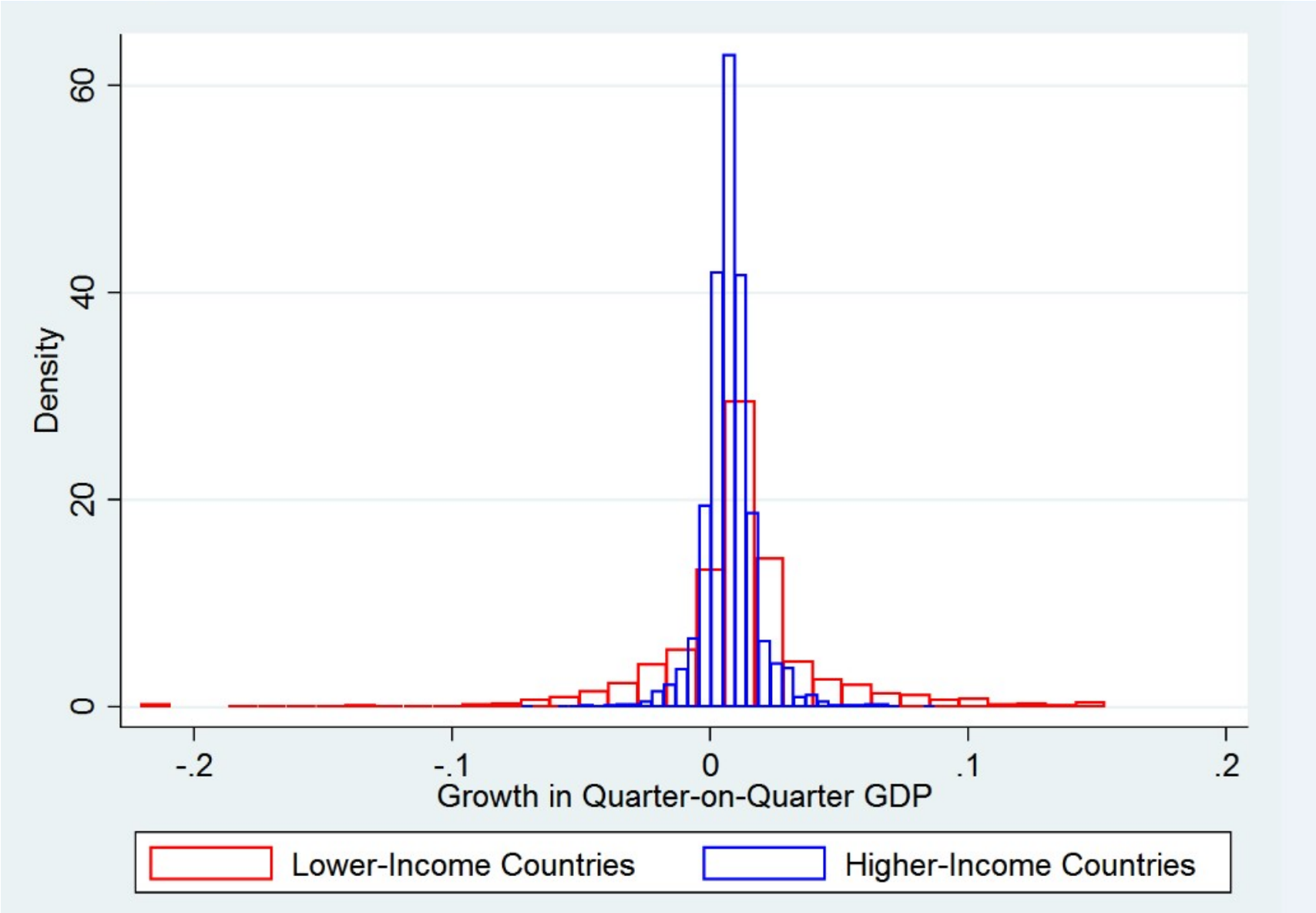
1) Macro uncertainty appears countercyclical

2) Micro firm uncertainty appears countercyclical

3) Firm skewness and kurtosis appear to be acyclical

**4) Uncertainty is higher in developing countries**

# Developing countries about 50% more volatile GDP




**Source**: Baker & Bloom (2012) "Does uncertainty reduce growth? Evidence from disaster shocks".
**Notes:** Rich=(GDP Per Capita>$20,000 in 2010 PPP)

- Theory
- Measurement
- **Identification (causality)**
- Current work

# Question is what causes what?

**Uncertainty**

?

Focus of the theory discussed earlier and also my work (e.g. Bloom et al. 2014)

**Recessions**

# Good reasons to worry about reverse causality, e.g.

“Krugman story”: recessions a good time for Governments to try new policies, as in Pastor and Veronesi (2012)

Learning: Fajgelbaum, Schaal & Taschereau-Dumouchel (2014) activity generating information, so recessions increase uncertainty and visa-versa (the “uncertainty trap”)
builds on Van Nieuwerburgh and Veldkamp (2006)

Experiments: Bachmann and Moscarini (2011) recessions are good times to experiment

Forecasting: Orlik and Veldkamp (2014) argue recessions impede forecasting future outcomes

**So what does the data say on causality?**

**It’s not conclusive - it suggests some causal impact of uncertainty, but the results are not “robust”**

# <u>Micro</u> papers on firms typically find negative association but struggle with causality, e.g.

Leahy & Whited (1996) regresses firm I/K on stock-return volatility, lags as instruments, find negative <u>“delay effect</u>”
(uncertainly lowers level of investment)

Bloom, Bond and Van Reenen (2007) use GMM on similar firm data, finding a negative <u>“caution effect”</u> (uncertainty makes firms less responsive)

But causality assumed via lags - not ideal as many variables are forward looking

# <u>Macro</u> papers mostly pretty similar, e.g.

Ramey and Ramey (1995, AER) cross-country regression volatility on growth, using Government expenditure as an instrument for volatility, and find negative <u>“delay effect”</u>

Engel and Rangel (2008, RFS) update this using a larger cross-country panel and rich dynamics, again find a <u>negative “delay effect”</u> using lags for identification

But again not a particularly convincing causality story

# One approach is to use exogenous shocks (Bloom, 2009) and try to control for 1st moment effects

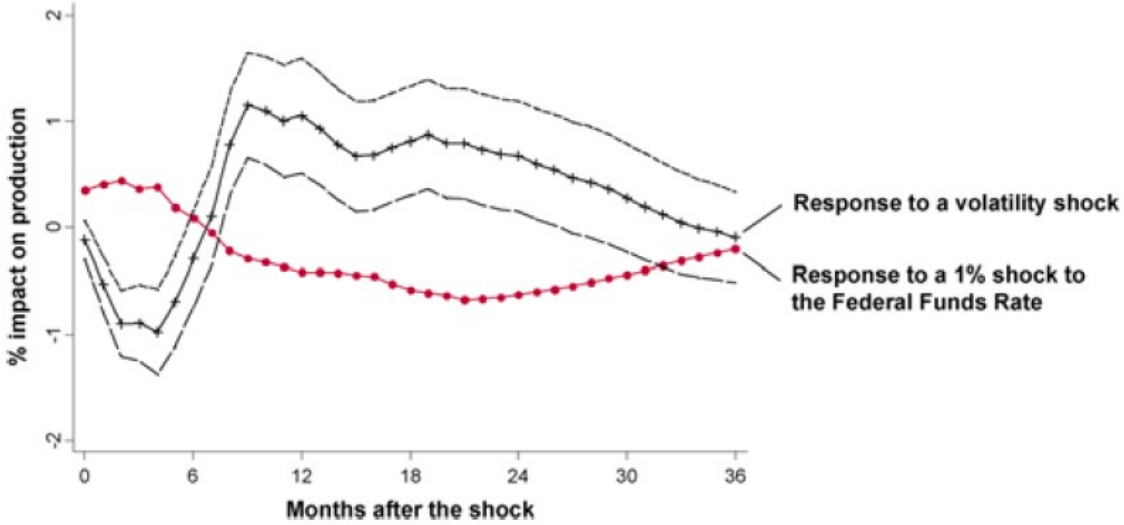



FIGURE 2.—VAR estimation of the impact of a volatility shock on industrial production. *Notes*: Dashed lines are 1 standard-error bands around the response to a volatility shock.

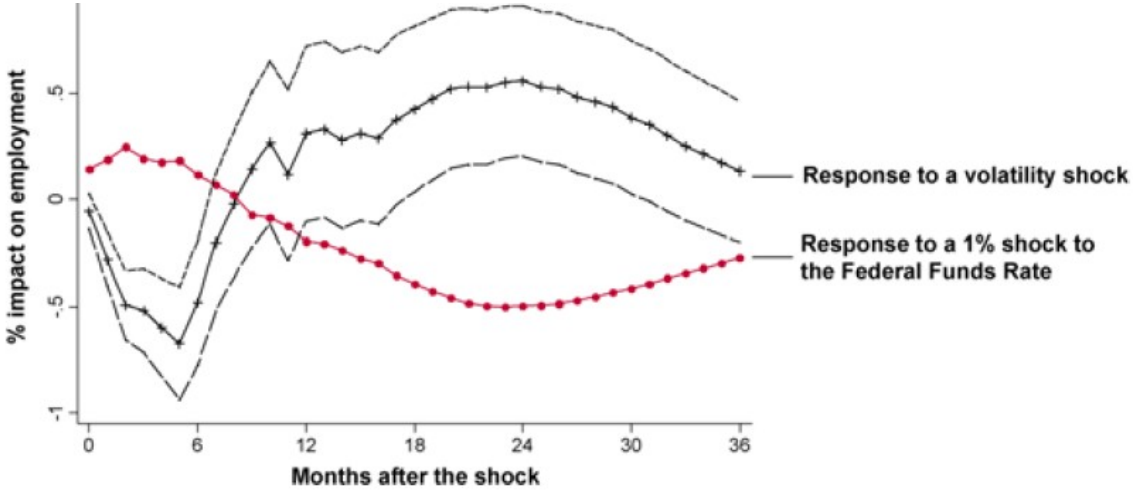



FIGURE 3.—VAR estimation of the impact of a volatility shock on employment. *Notes*: Dashed lines are 1 standard-error bands around the response to a volatility shock.

**Source**: Cholesky VAR estimates using monthly data from June 1962 to June 2008, variables in order include stock-market levels, VIX, FFR, log(ave earnings), log (CPI), hours, log(employment) and log (IP). All variables HP detrended (lambda=129,600). Reults very robust to varying VAR specifications (i.e. ordering, variable inclusion detrending etc).
Source: Bloom (2009)

# Another is to use micro-variation in terms of exposure to drivers of uncertainty

Stein and Stone (2012) use energy and currency instruments in firm data finding a large negative impact of uncertainty on investment and hiring (and positive on R&D - growth options)

Baker, Bloom and Davis (2014) look at policy uncertainty and use sector-level in exposure to government (from contracts) and also find a negative impact on investment and hiring

Helpful for causality, but micro data will miss GE macro effects

# In summary the literature is suggestive of a negative impact of uncertainty, but is not definitive

# My view is uncertainty is both a cause and effect

1. Some big shock occurs: oil-shock, 9/11, housing crash etc

2. This combines a negative first moment shock (bad news) and positive second moment shock (increased uncertainty)

3. As the recession progresses uncertainty rises further, deepening and lengthening the slowdown

Hence, I see uncertainty as both an:

-. Impulse
-. Amplification and propagation mechanism

- Theory
- Measurement
- Identification (causality)
- **Future work**

# Wide range of open questions

- Measurement: of macro and micro uncertainty over time and space (countries, regions, industries and firms).

- Impact: identifying cause vs effect

- Mechanisms: many theory channels but which matter most?

- Computation: include higher-moments in micro-macro models (e.g. Kahn and Thomas; Fernandez-Villaverde, Guerron, Kuester, Rubio-Ramirez and Uribe)

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# One thing I am working on is firm-level surveys

**Projecting ahead over the next twelve months, please provide the approximate percentage change in your firm's SALES LEVELS for:**

The LOWEST CASE change in my firm's sales levels would be: -9 %
The LOW CASE change in my firm's sales levels would be: -3 %
The MEDIUM CASE change in my firm's sales levels would be: 3 %
The HIGH CASE change in my firm's sales levels would be: 9 %
The HIGHEST CASE change in my firm's sales levels would be: 15 %

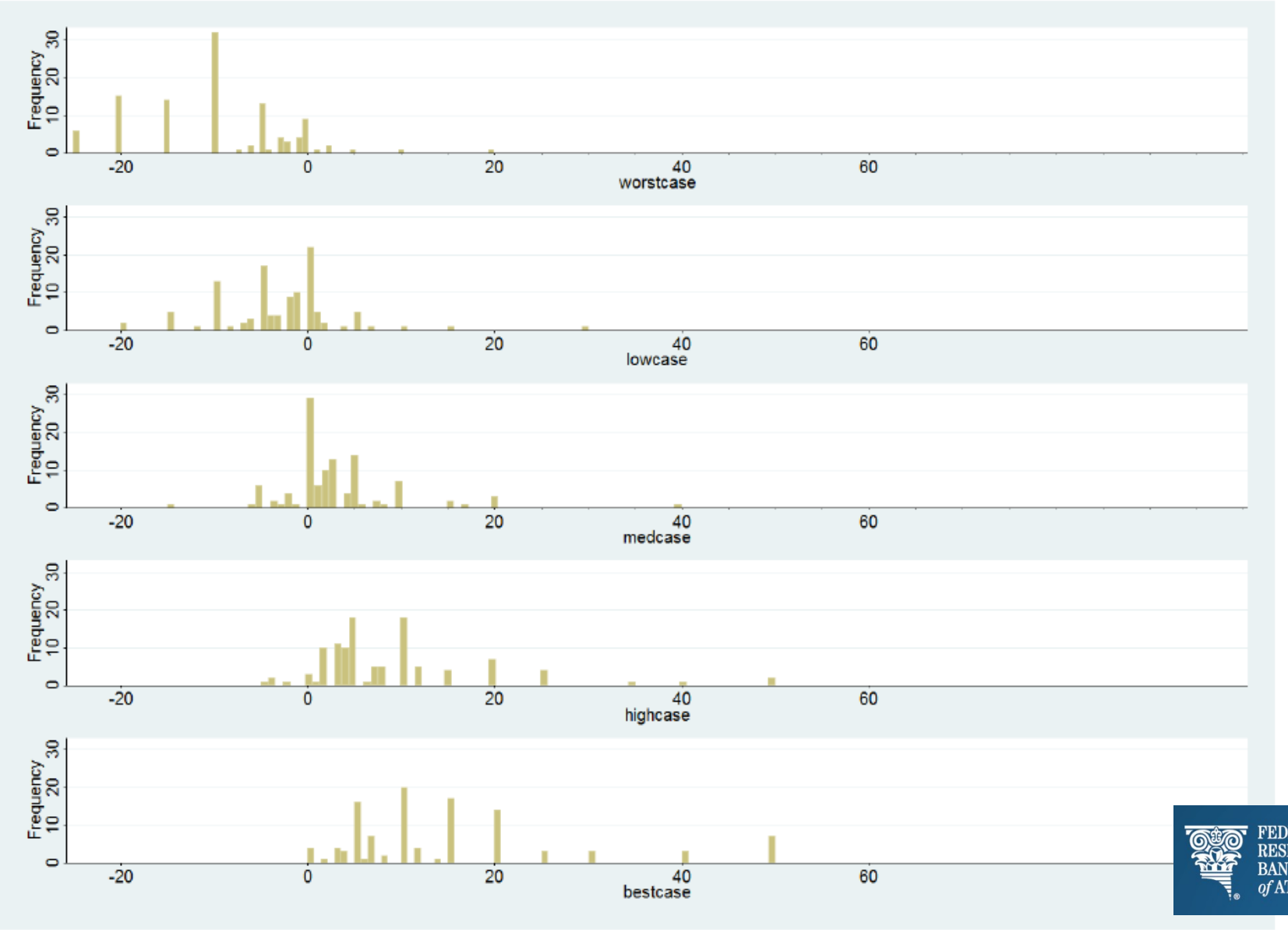
Numbers in red are the average response from the pilot on 300 firms

FEDERAL RESERVE BANK of ATLANTA

United States Census Bureau

U.S. Department of Commerce
Economics and Statistics Administration
U.S. CENSUS BUREAU

# Piloting results look good from testing on a monthly survey on 300 firms: <u>change in sales</u>

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# One thing I am working on is firm-level surveys

**Please assign a percentage likelihood to these SALES LEVEL changes you selected above (values should sum to 100%)**

10 % : The approximate likelihood of realizing the LOWEST CASE change
18 % : The approximate likelihood of realizing the LOW CASE change
40 % : The approximate likelihood of realizing the MEDIUM CASE change
23 % : The approximate likelihood of realizing the HIGH CASE change
9 % : The approximate likelihood of realizing the HIGHEST CASE change

Numbers in red are the average response from the pilot on 300 firms

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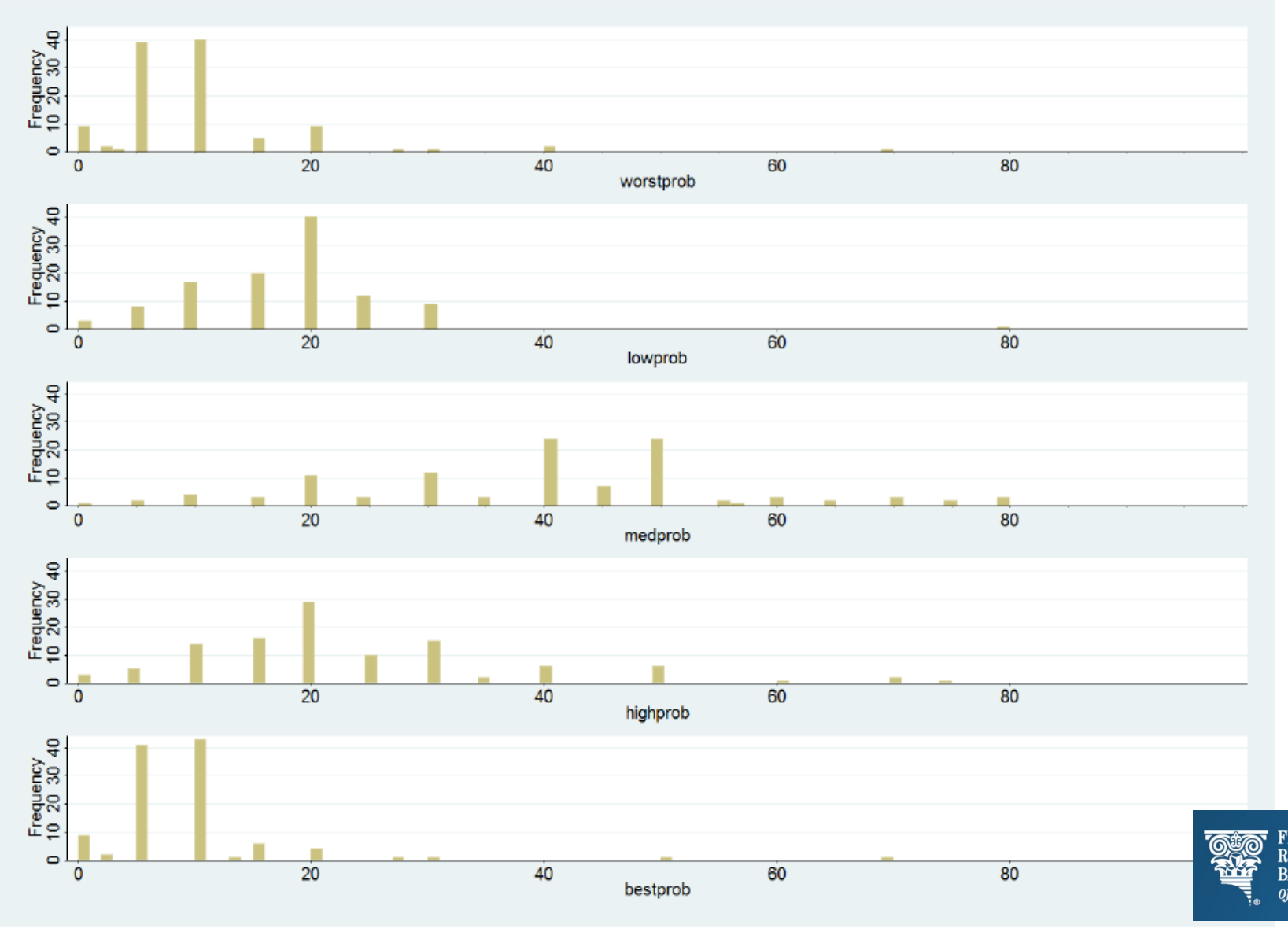
# Piloting results look good from testing on a monthly survey on 300 firms: <u>probabilities</u>

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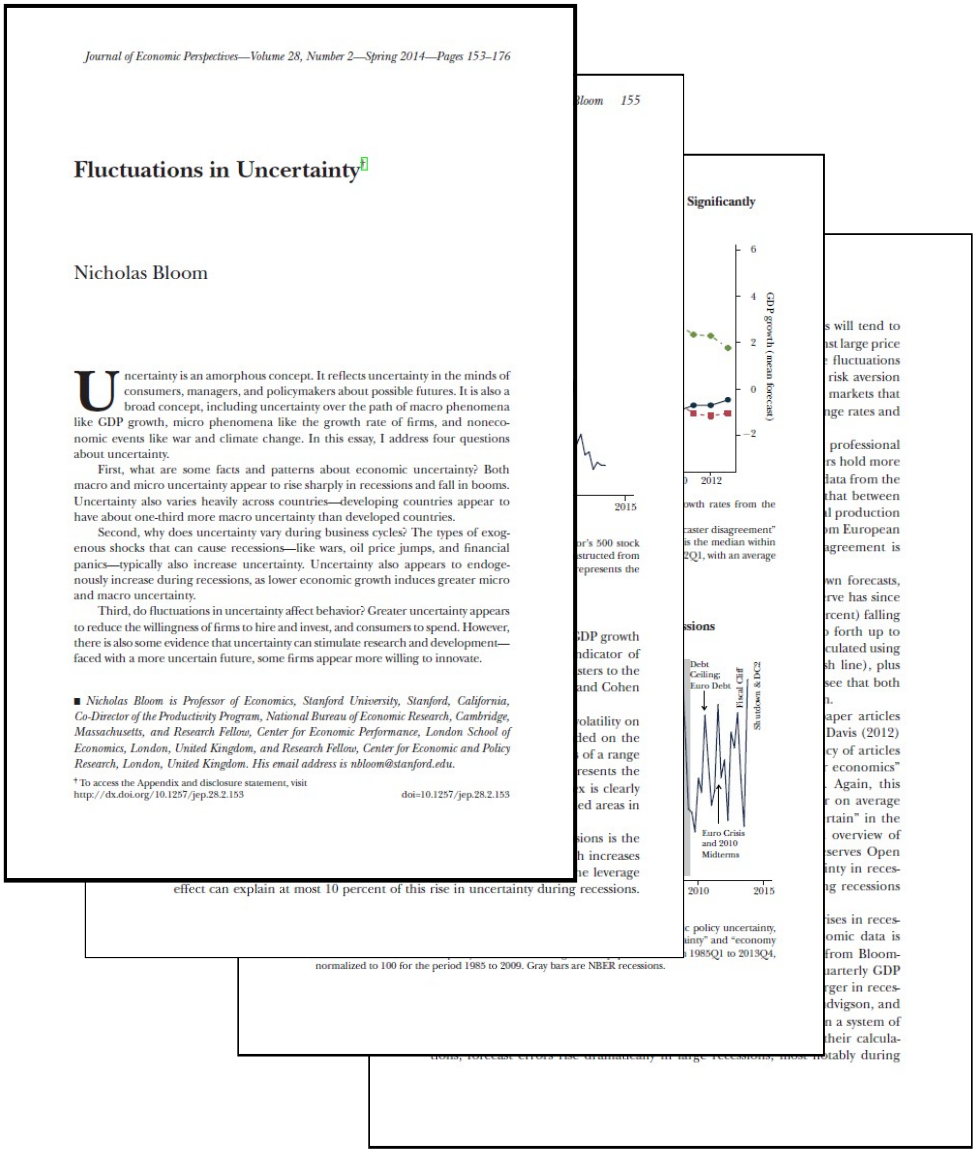
# Further reading JEP survey and draft JEL survey (with Fernandez-Villaverde and Schneider)



*Journal of Economic Perspectives—Volume 28, Number 2—Spring 2014—Pages 153–176*

## Fluctuations in Uncertainty[†]

Nicholas Bloom

Uncertainty is an amorphous concept. It reflects uncertainty in the minds of consumers, managers, and policymakers about possible futures. It is also a broad concept, including uncertainty over the path of macro phenomena like GDP growth, micro phenomena like the growth rate of firms, and noneconomic events like war and climate change. In this essay, I address four questions about uncertainty.

First, what are some facts and patterns about economic uncertainty? Both macro and micro uncertainty appear to rise sharply in recessions and fall in booms. Uncertainty also varies heavily across countries—developing countries appear to have about one-third more macro uncertainty than developed countries.

Second, why does uncertainty vary during business cycles? The types of exogenous shocks that can cause recessions—like wars, oil price jumps, and financial panics—typically also increase uncertainty. Uncertainty also appears to endogenously increase during recessions, as lower economic growth induces greater micro and macro uncertainty.

Third, do fluctuations in uncertainty affect behavior? Greater uncertainty appears to reduce the willingness of firms to hire and invest, and consumers to spend. However, there is also some evidence that uncertainty can stimulate research and development—faced with a more uncertain future, some firms appear more willing to innovate.

■ *Nicholas Bloom is Professor of Economics, Stanford University, Stanford, California, Co-Director of the Productivity Program, National Bureau of Economic Research, Cambridge, Massachusetts, and Research Fellow, Center for Economic Performance, London School of Economics, London, United Kingdom, and Research Fellow, Center for Economic and Policy Research, London, United Kingdom. His email address is nbloom@stanford.edu.*

† To access the Appendix and disclosure statement, visit http://dx.doi.org/10.1257/jep.28.2.153

doi=10.1257/jep.28.2.153



## The Macroeconomics of Time-Varying Volatility and Uncertainty

Nick Bloom[*], Jesus Fernandez-Villaverde[†] and Martin Schneider[‡]

December 2012

**Abstract**

A growing body of evidence suggests that uncertainty is counter cyclical, rising sharply in recessions and falling in booms. We start by defining the concept of uncertainty, and how this links to risk, volatility and ambiguity. We then describe eight stylized facts about uncertainty - noting macro and micro uncertainty are counter-cyclical, that higher-moments tend not to be countercyclical, and then uncertainty is higher in developing countries. We then examine the impact of uncertainty in terms of reducing the level and responsiveness of firms and consumers investment decisions to productivity and income shocks, XXX for asset prices. Following this we discuss the potential causes of movements in uncertainty over time, focusing on a number of models that suggest that recessions lead to higher uncertainty, thereby endogenizing uncertainty over the business cycle. Finally, we conclude by highlight four key areas for future research: the improved measurement of uncertainty, the identification of cause-and-effect for movements in uncertainty over the business cycle, the main channels of impact for uncertianty on the economy, and the design of opitmal policy to deal with higher uncertainty.

**Keywords:** Uncertainty, volatility and risk.

**JEL Classification:** D92, E22, D8, C23.

**Acknowledgement:** We would like to thank the National Science Foundation for financial support.

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# Time-varying uncertainty in macro

**Nick Bloom (Stanford & NBER)**

**SED, June 26th 2014**