The macroeconomics of uncertainty

Nick Bloom (Stanford & NBER)

Chicago Macro Lecture, December 4th 2012

(1) Lecture summarizes a JEL draft with Fernandez-Villaverde and Schneider

Uncertainty in Macroeconomics

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 countercyclical, 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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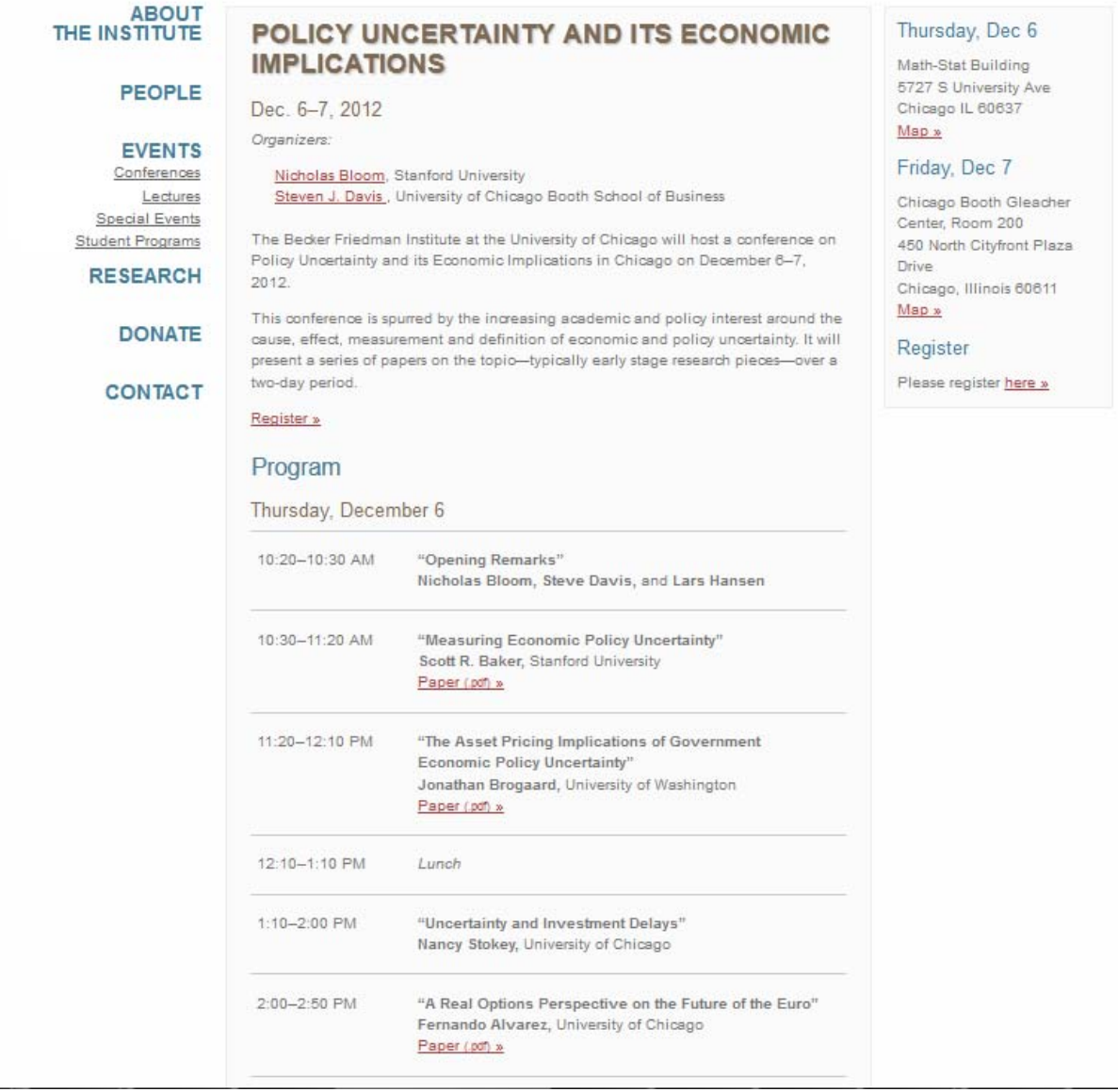
I can circulate the current scrappy version and will post on-line a better version in the next few months

(2) Thursday and Friday the BF Center has a Policy Uncertainty conference



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POLICY UNCERTAINTY AND ITS ECONOMIC IMPLICATIONS

Dec. 6–7, 2012

Organizers:

Nicholas Bloom, Stanford University
Steven J. Davis, University of Chicago Booth School of Business

The Becker Friedman Institute at the University of Chicago will host a conference on Policy Uncertainty and its Economic Implications in Chicago on December 6–7, 2012.

This conference is spurred by the increasing academic and policy interest around the cause, effect, measurement and definition of economic and policy uncertainty. It will present a series of papers on the topic—typically early stage research pieces—over a two-day period.

Register »

Program

Thursday, December 6

10:20–10:30 AM	"Opening Remarks" **Nicholas Bloom, Steve Davis,** and **Lars Hansen**
10:30–11:20 AM	"Measuring Economic Policy Uncertainty" **Scott R. Baker,** Stanford University Paper (pdf) »
11:20–12:10 PM	"The Asset Pricing Implications of Government Economic Policy Uncertainty" **Jonathan Brogaard,** University of Washington Paper (pdf) »
12:10–1:10 PM	*Lunch*
1:10–2:00 PM	"Uncertainty and Investment Delays" **Nancy Stokey,** University of Chicago
2:00–2:50 PM	"A Real Options Perspective on the Future of the Euro" **Fernando Alvarez,** University of Chicago Paper (pdf) »

Thursday, Dec 6

Math-Stat Building
5727 S University Ave
Chicago IL 60637
Map »

Friday, Dec 7

Chicago Booth Gleacher Center, Room 200
450 North Cityfront Plaza Drive
Chicago, Illinois 60611
Map »

Register

Please register here »

- **Definition: What is uncertainty?**
- Stylized facts: Uncertainty over time and countries
- Theory: Why might uncertainty matter?
- Empirics: Evidence on the impact of uncertainty

Defining uncertainty and volatility

Uncertainty is forward looking and volatility is realized

For example in the simple Brownian motion process:

$$dX_t = \mu dt + \sigma_{t-1} dw_t \quad \text{where } dw_t \sim N(0,1)$$

uncertainty about $dX_{t+1}=\sigma_t$
volatility over period t-s to t=variance($dX_{t-s}, dX_{t-s+1} \ldots dX_t$)

These are linked because E[variance of dX_{t+1}]=σ_t

An example for the S&P5000 from 2007 to 2012

A volatile period

So uncertainty about the future was high here (implied volatility on the VIX was >40)

Difference concepts of uncertainty

The last slide used a stochastic volatility definition (a process that evolves over time with a changing variance)

There is another broad concept of uncertainty:

Bayesian uncertainty, which is how diffuse your prior is.

- *Knightian uncertainty* is the situation when the prior is infinitely diffuse (you have no idea)

Ambiguity is similar to Bayesian uncertainty.

Risk, is very similar to uncertainty, except it is more often used when some outcomes involve loses

- Definition: What is uncertainty?
- **Stylized facts: Uncertainty over time and countries**
- Theory: Why might uncertainty matter?
- Empirics: Evidence on the impact of uncertainty

Uncertainty is hard to measure because it is not directly observed

Unfortunately no working uncertainty barometer exists…

But there are a number of indirect proxies, yielding four stylized facts I'll cover in some detail

1) Macro uncertainty appears countercyclical

2) Micro uncertainty appears countercyclical

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

4) Uncertainty is higher in developing countries

Hence, it looks like the following is a reasonable model for macro and micro shocks

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

$$\text{Macro TFP} \quad : \quad \log(A_t) = \rho^A \log(A_{t-1}) + \sigma_{t-1}^A \epsilon_t$$

$$\text{Micro TFP + demand} \quad : \quad \log(z_{j,t}) = \rho^Z \log(z_{j,t-1}) + \sigma_{t-1}^Z \epsilon_{j,t}$$

Would naturally generalize A_t to include demand (and other) shocks (e.g. Hopenhayn and Rogerson, 1993)

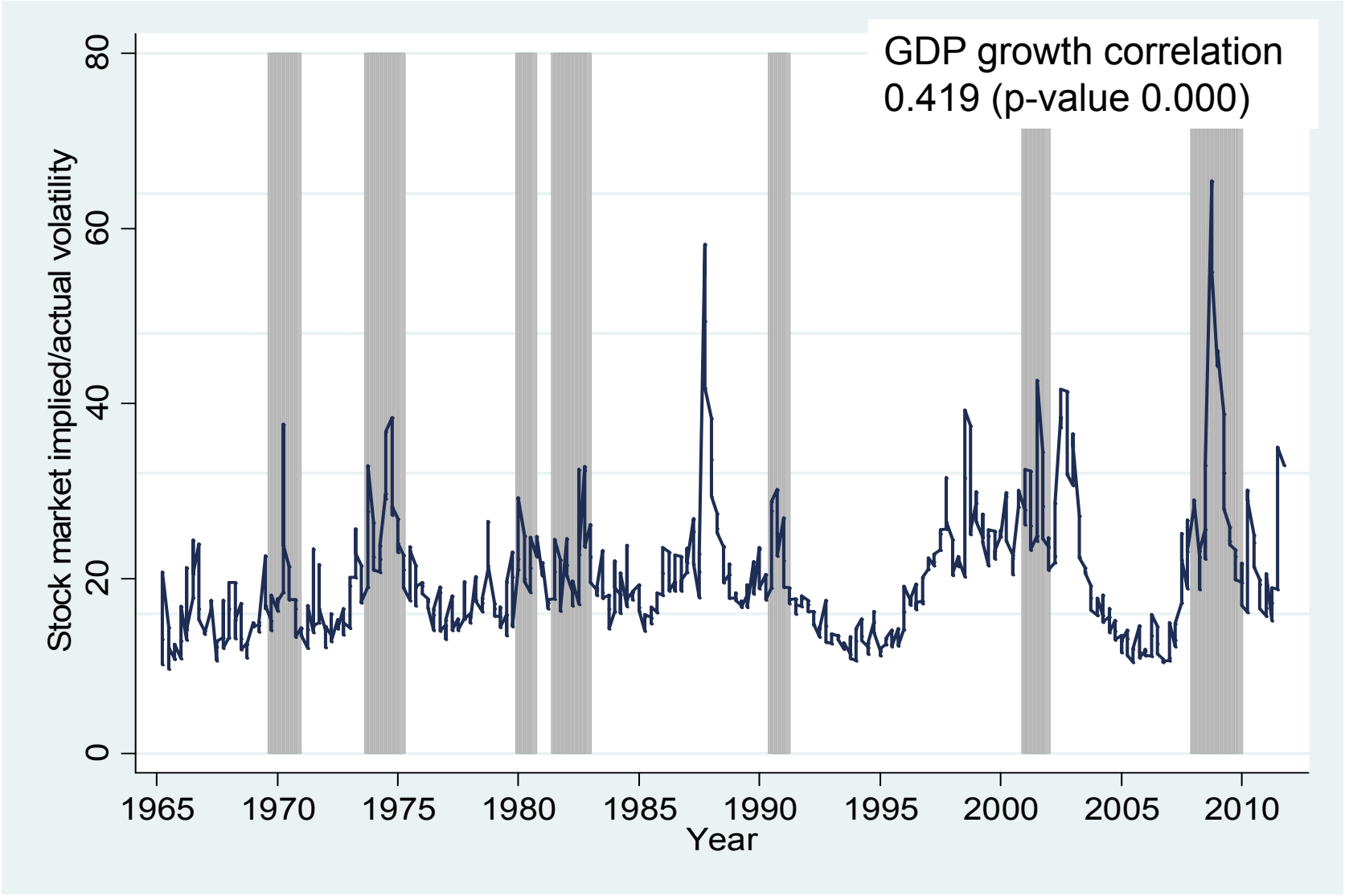
1) **Macro uncertainty appears countercyclical**

2) Micro firm uncertainty appears countercyclical

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

4) Uncertainty is higher in developing countries

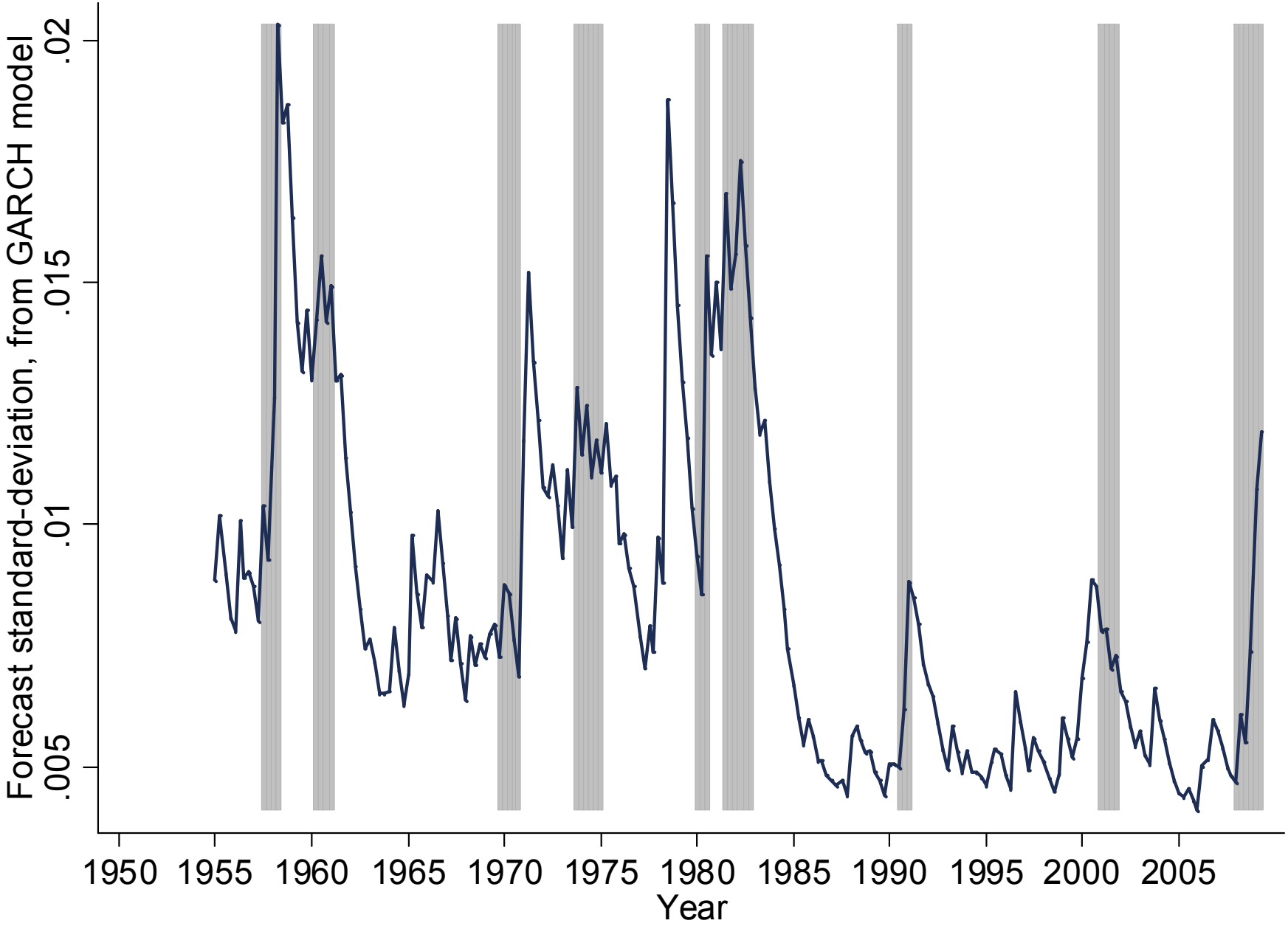
Macro uncertainty: Stock returns (implied from 1990 onwards)



Source: Bloom (2009).

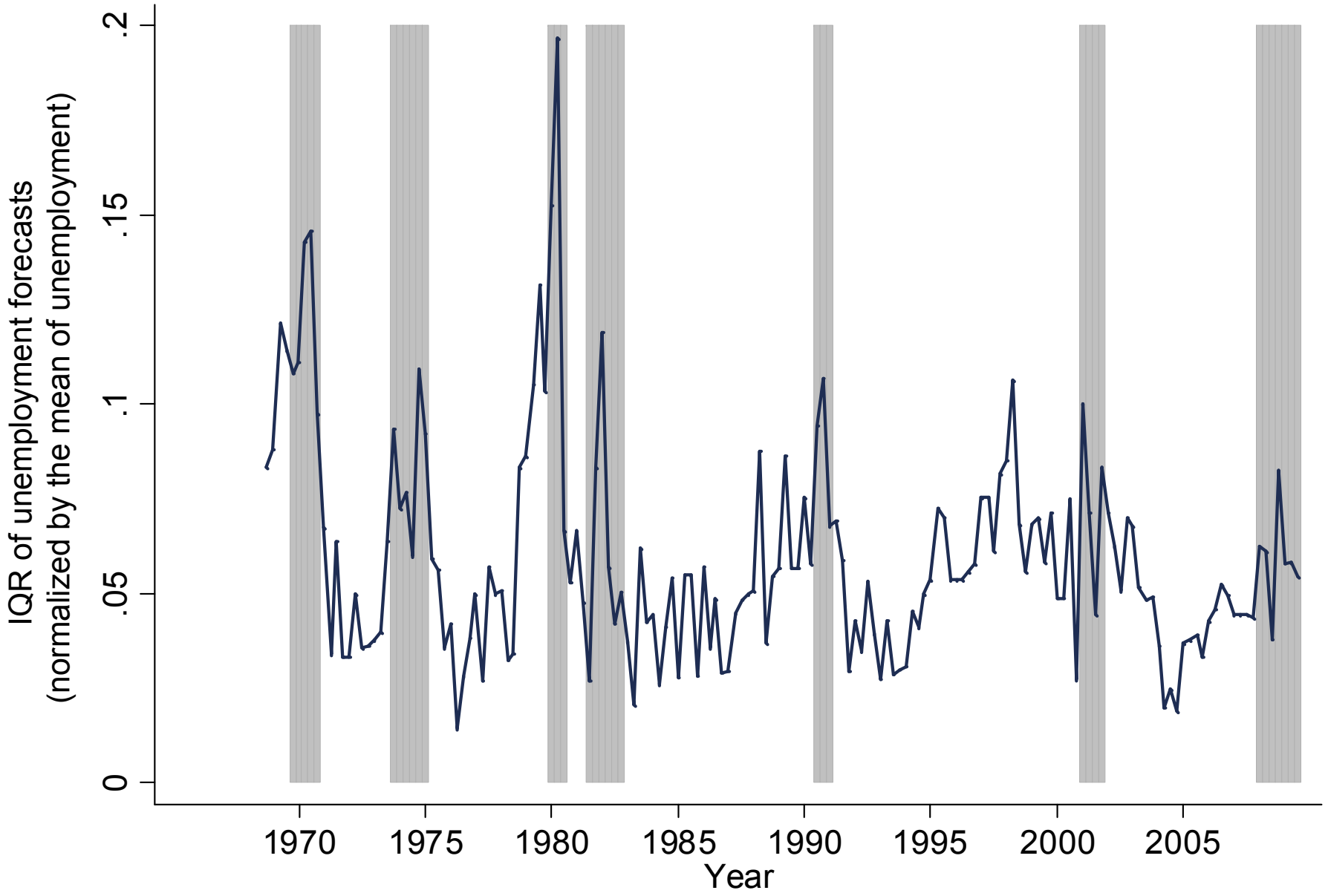
Notes: Realized volatility from 1962 to 1990 on S&P100, and implied volatility from 1990 onwards (Source Bloom 2009). Grey bars are NBER recessions.

Macro uncertainty: GARCH for TFP



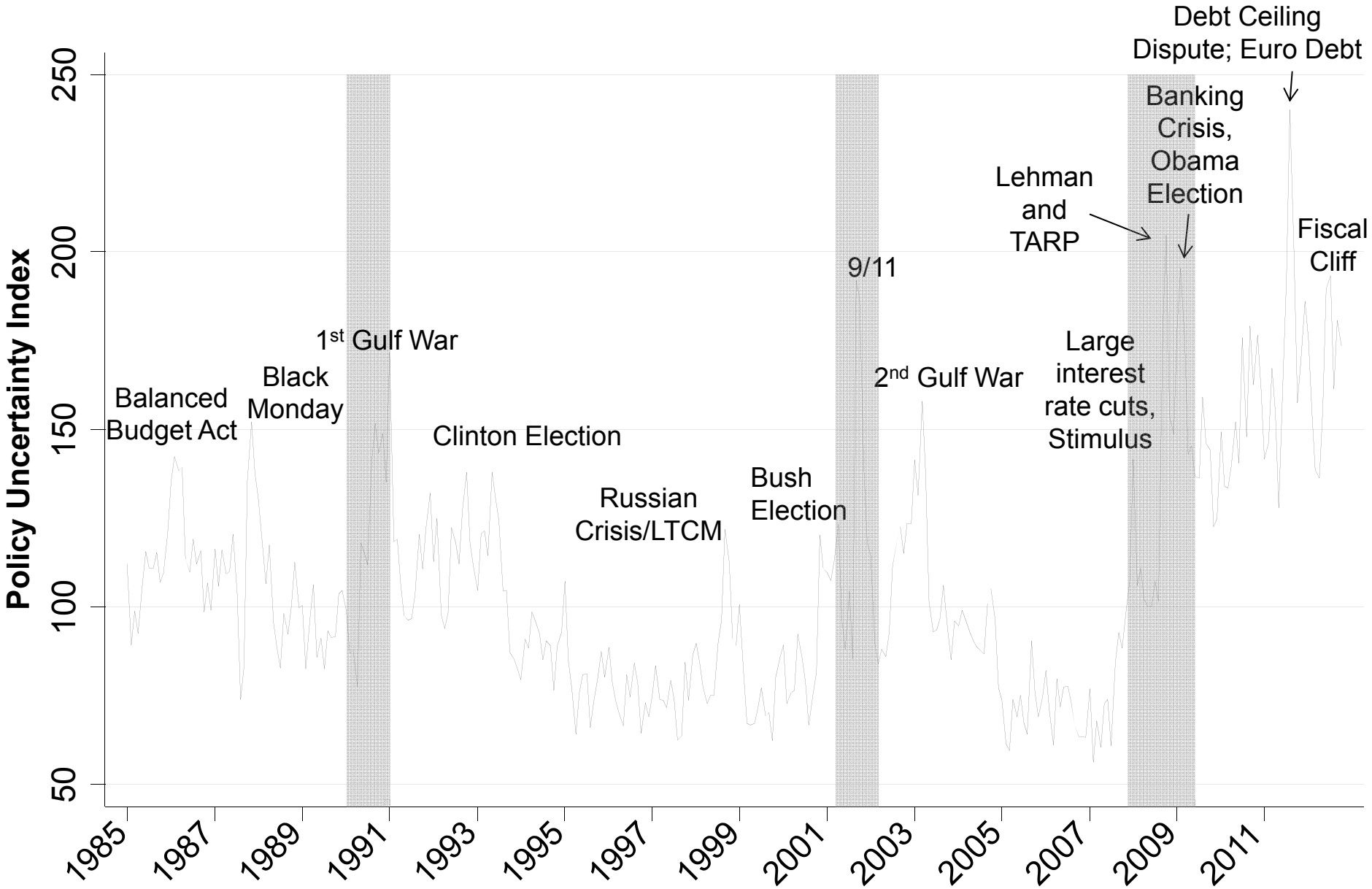
Note: Predicted volatility from a GARCH(1,1) estimation of current quarterly log(GDP) on its four lagged values. Source Bloom, Floetotto, Jaimovich, Saporta and Terry 2011 using TFP data provided by John Fernald.

Macro uncertainty: Disagreement (unemployment)



Note: Interquartile range 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.

Macro uncertainty: Economic policy uncertainty



Source: Baker, Bloom and Davis (2012). Data at www.policyuncertainty.com. Data normalized to 100 prior to 2010. Plotted up until October 2012

1) Macro uncertainty appears countercyclical

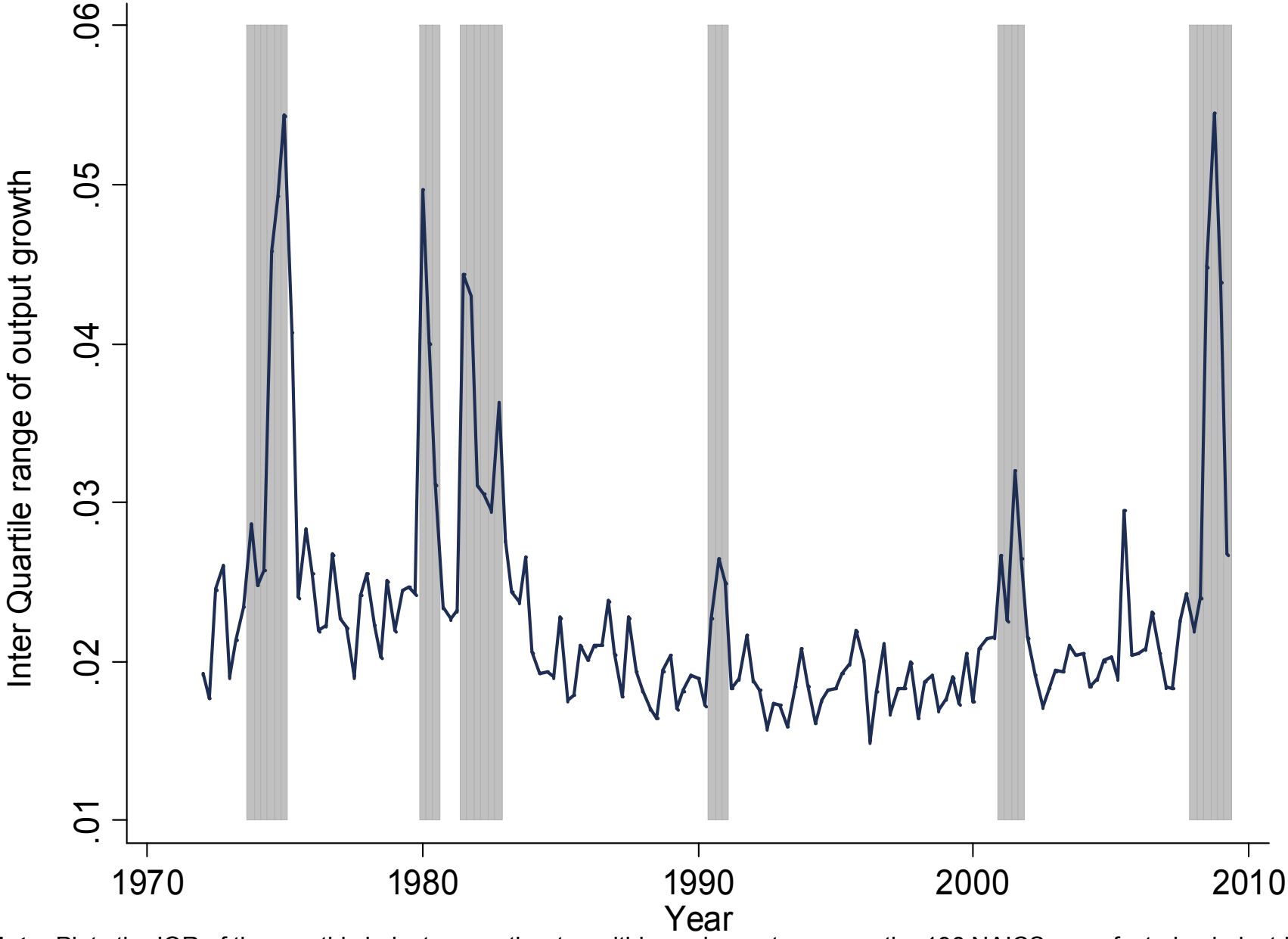
2) Micro firm uncertainty appears countercyclical

3) Firm skewness and kurtosis appear to be acyclical

4) Uncertainty is higher in developing countries

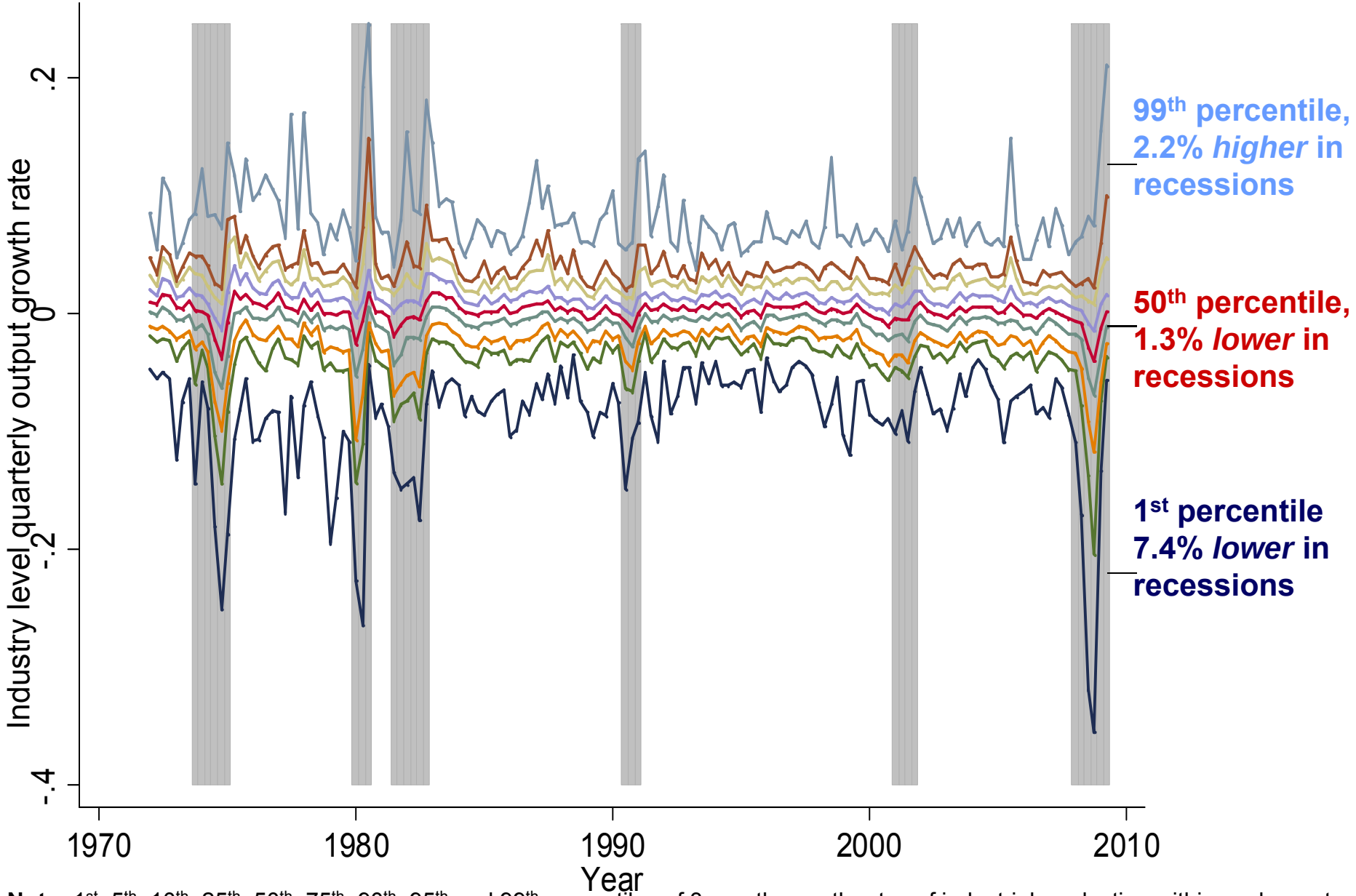
5) Income uncertainty and skewness appear countercyclical

Micro uncertainty: Industry growth dispersion (1/2)



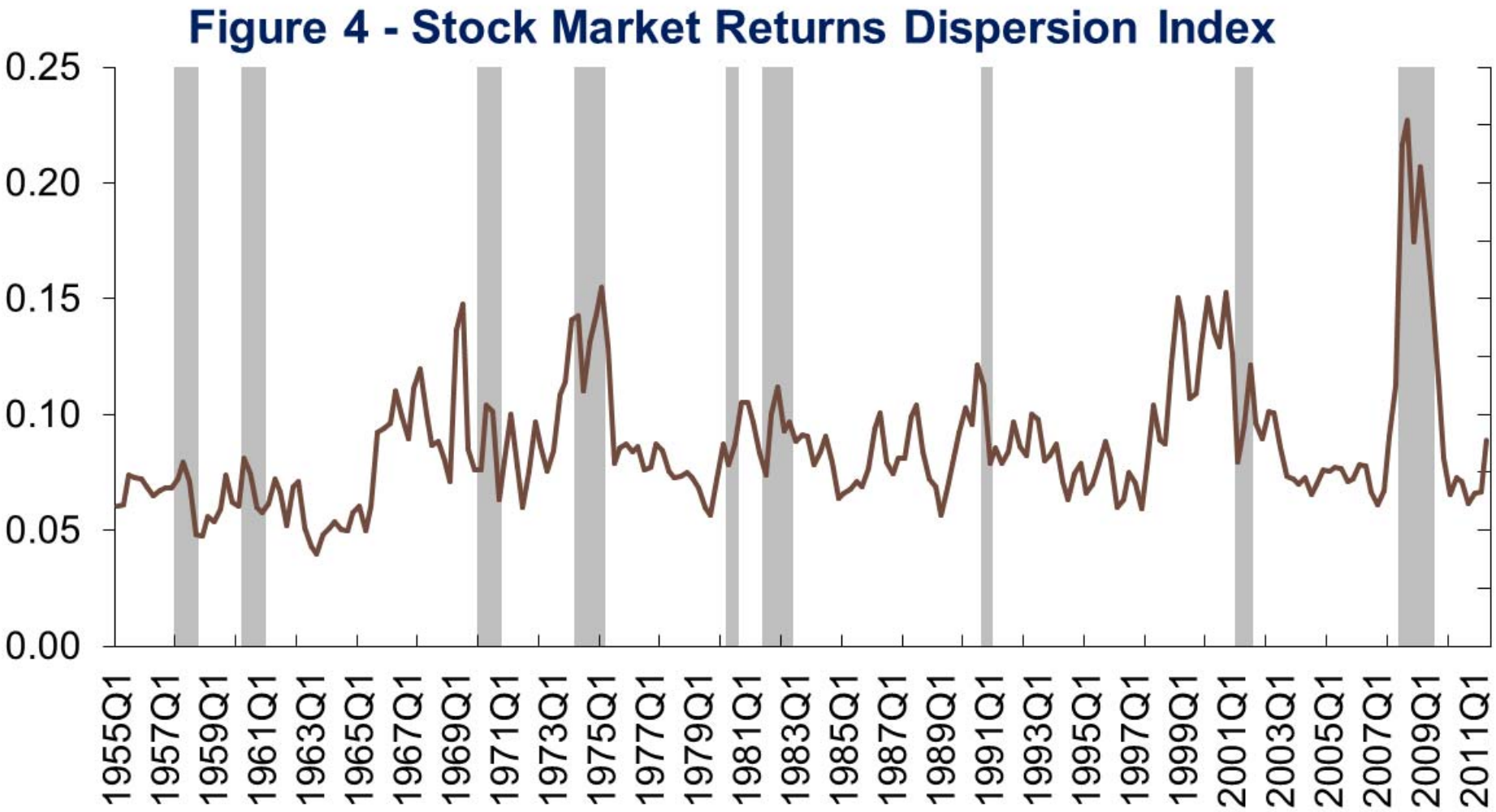
Note: Plots the IQR of the monthly industry growth rates within each quarter across the 196 NAICS manufacturing industries.
Source: Bloom, Floetotto and Jaimovich (2009)

Micro uncertainty: Industry growth dispersion (2/2)



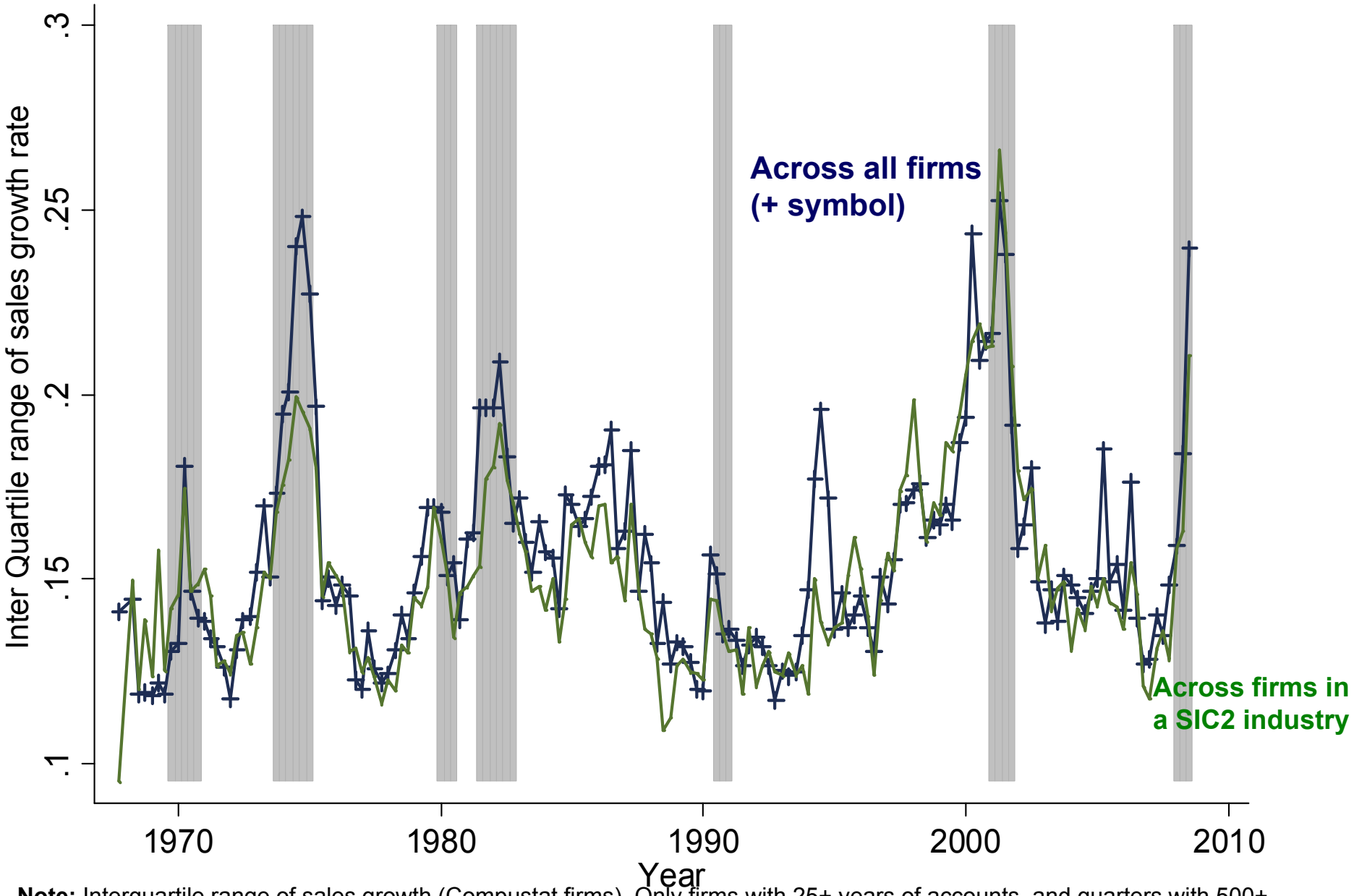
Note: 1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 99th percentiles of 3-month growth rates of industrial production within each quarter. All 196 manufacturing NAICS sectors in the Federal Reserve Board database. Source: Bloom, Floetotto and Jaimovich (2009)

Micro uncertainty: Industry stock-returns spread



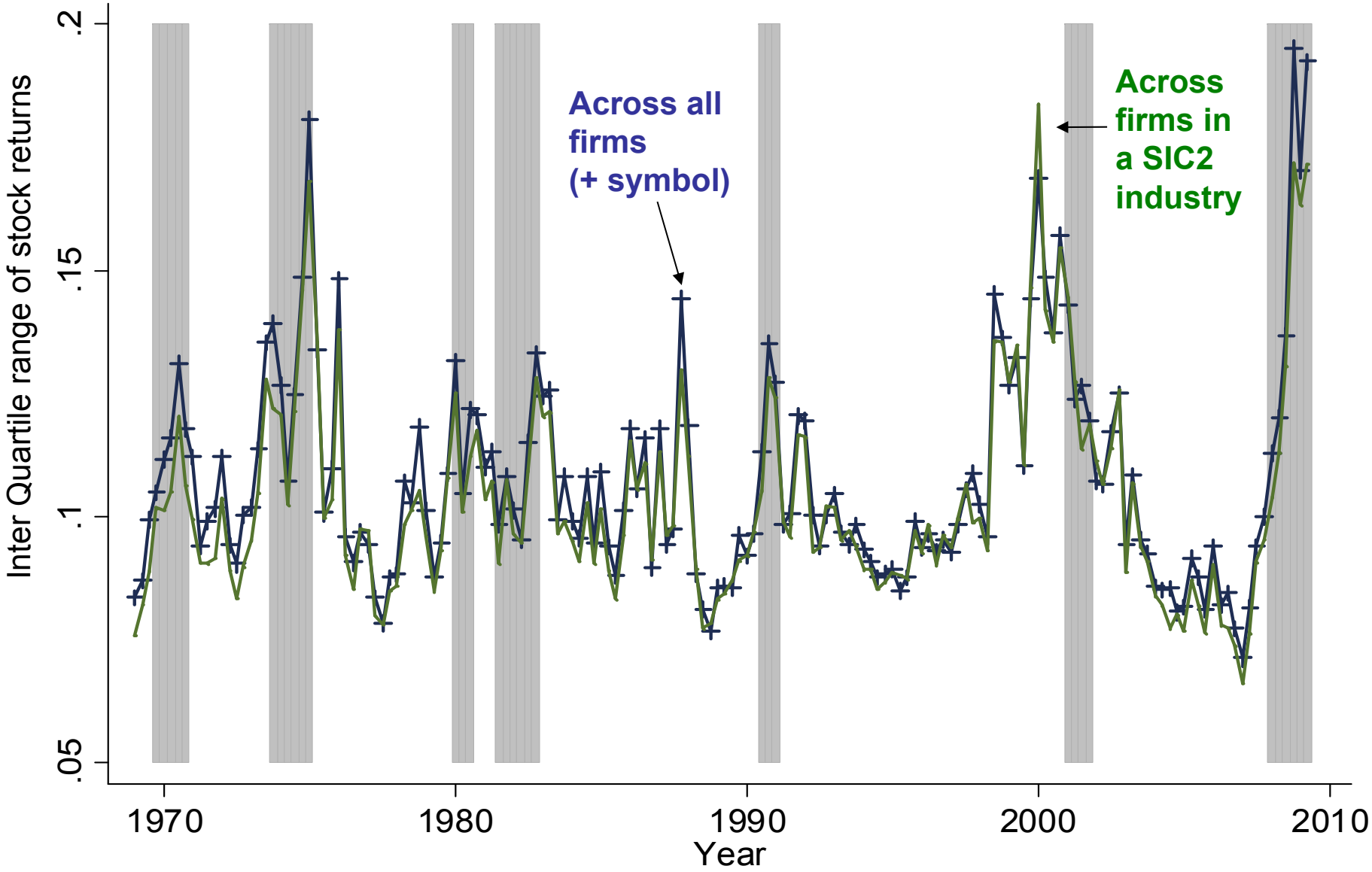
Source: Chen, Kannan, Loungani and Trehan (2012)

Micro uncertainty: Firm growth dispersion



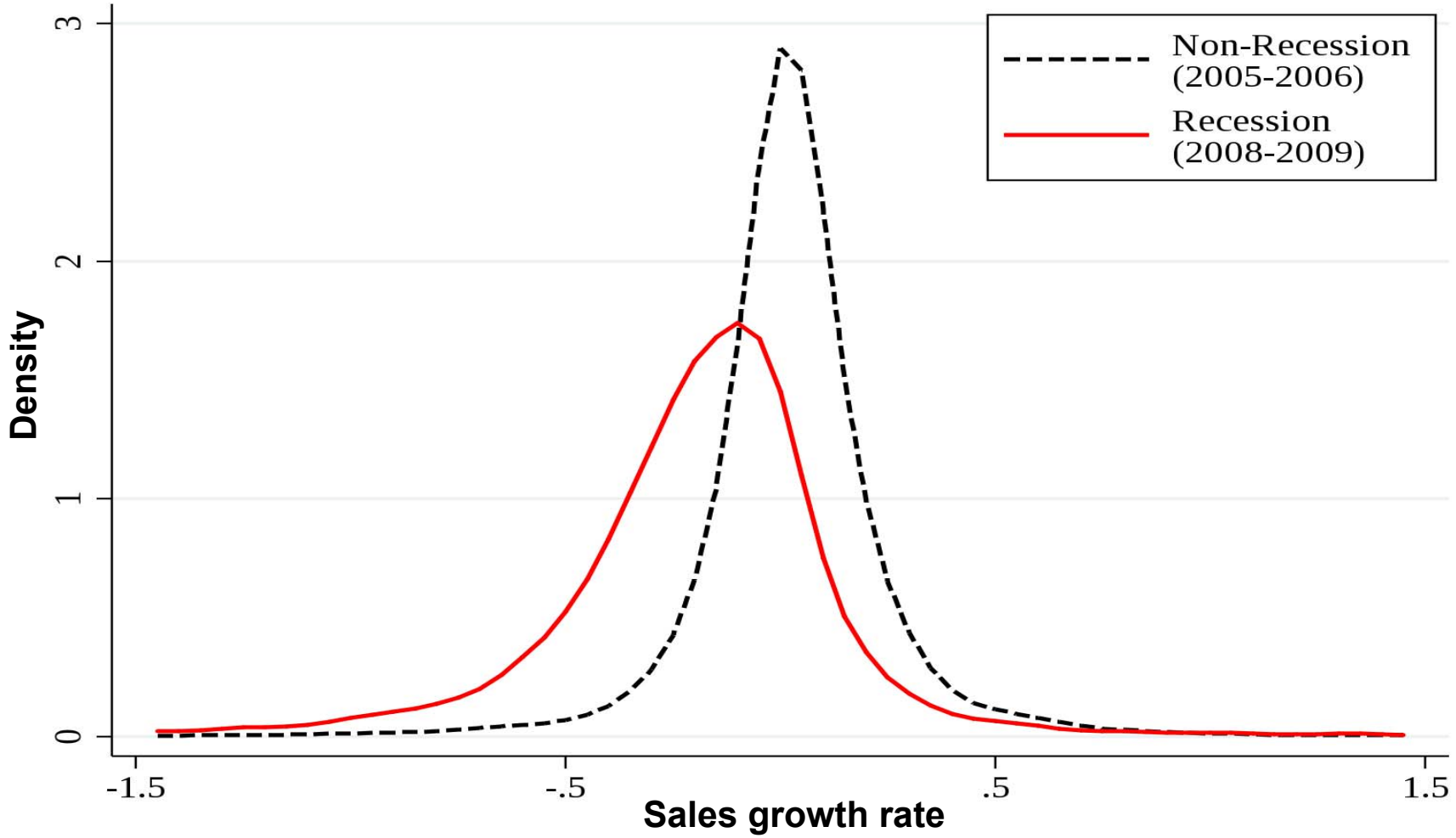
Note: Interquartile range of sales growth (Compustat firms). Only firms with 25+ years of accounts, and quarters with 500+ observations. SIC2 only cells with 25+ obs. SIC2 is used as the level of industry definition to maintain sample size. The grey shaded columns are recessions according to the NBER.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

Micro uncertainty: Firm stock-returns dispersion



Note: Interquartile range of stock returns (CRSP firms). Only firms with 25+ years of accounts, and quarters with 1000+ observations. SIC2 only cells with 25+ obs. SIC2 is used as the level of industry definition to maintain sample size. Source: Bloom, Floetotto, Jaimovich, Saporta and Terry (2011)

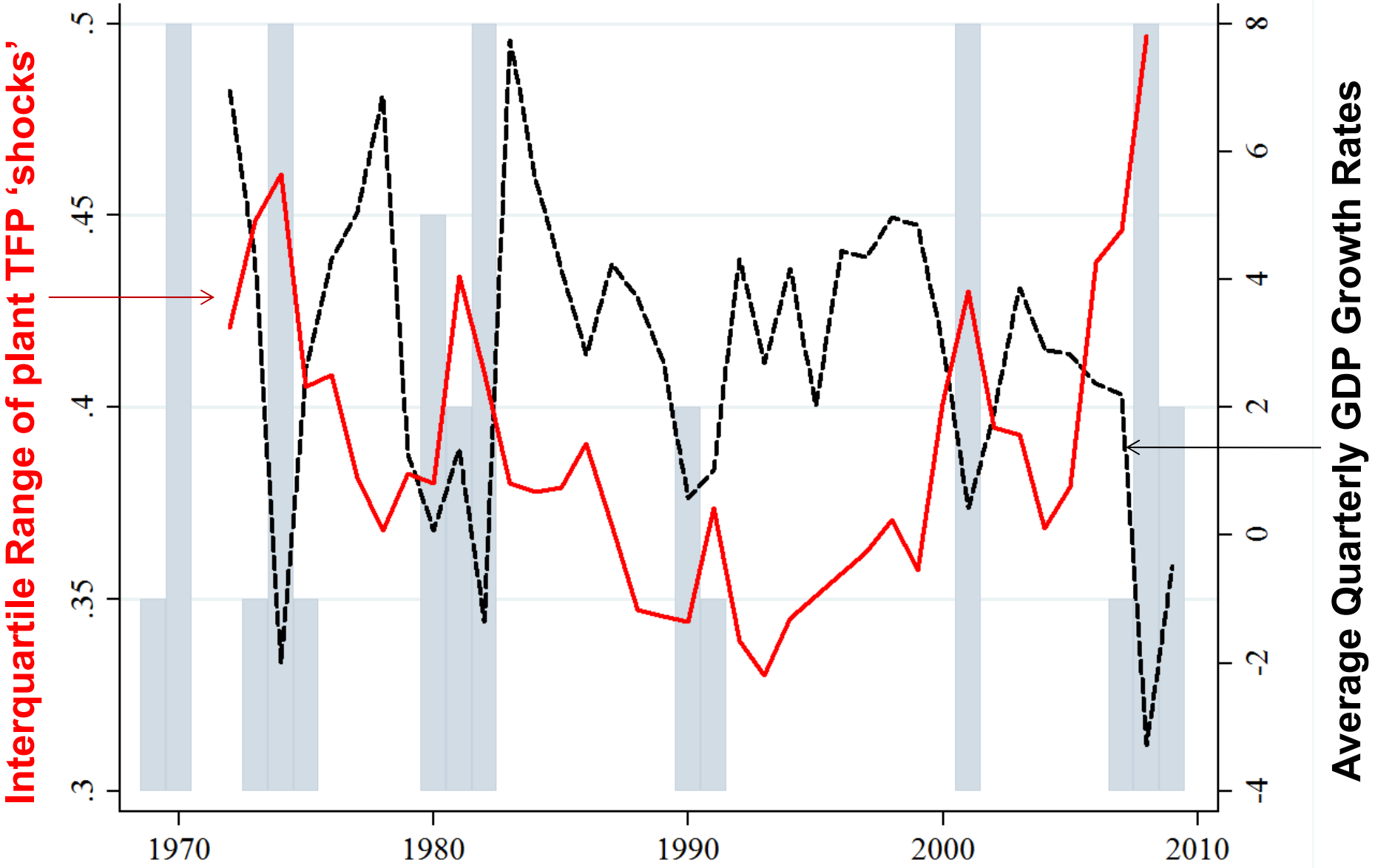
Micro uncertainty: Plant sales growth



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.

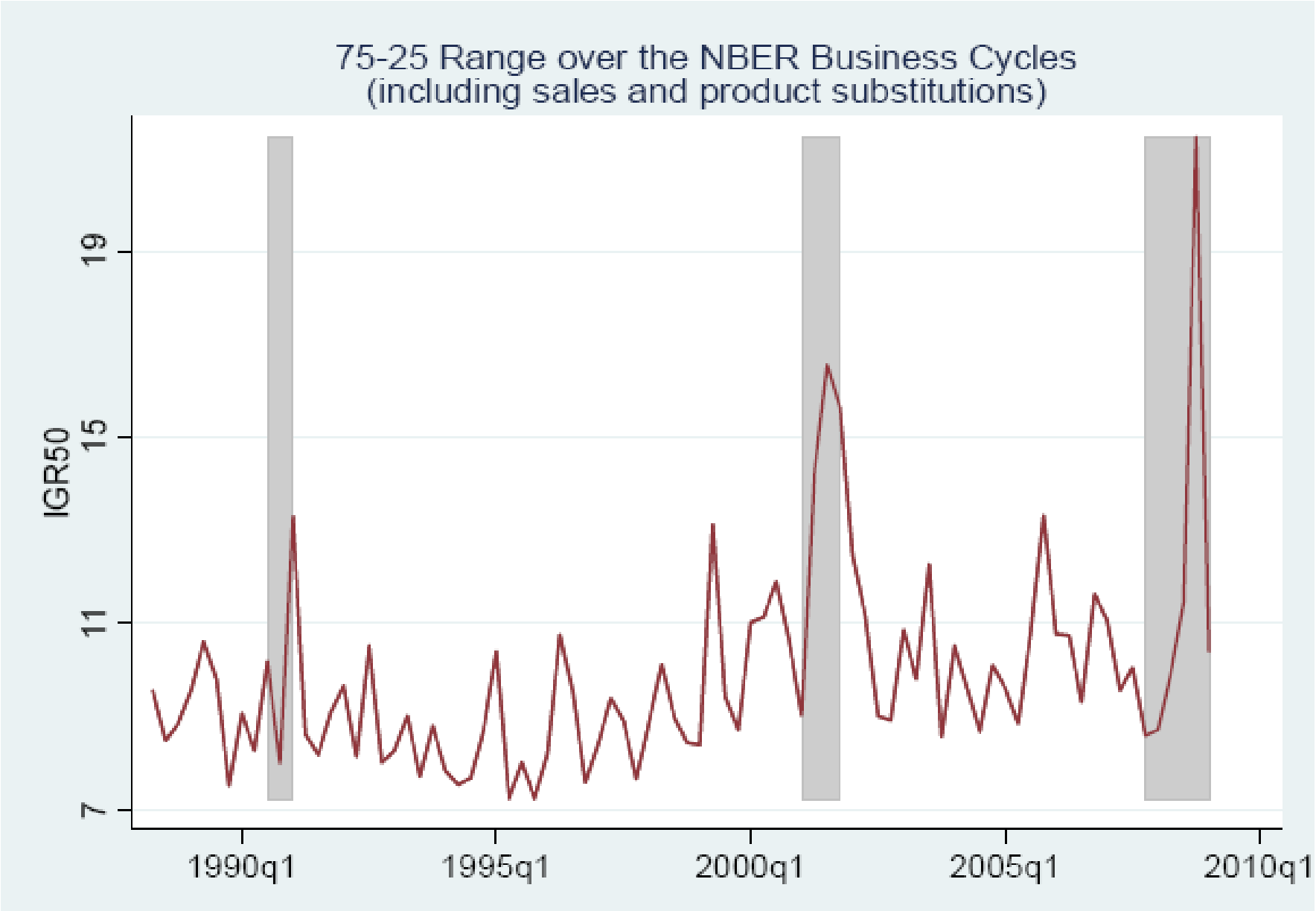
Micro uncertainty: Plant TFP 'shock' dispersion



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).

Micro uncertainty: Item level price changes



Source: David Berger and Joe Vavra (2009, Yale Mimeo)

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).

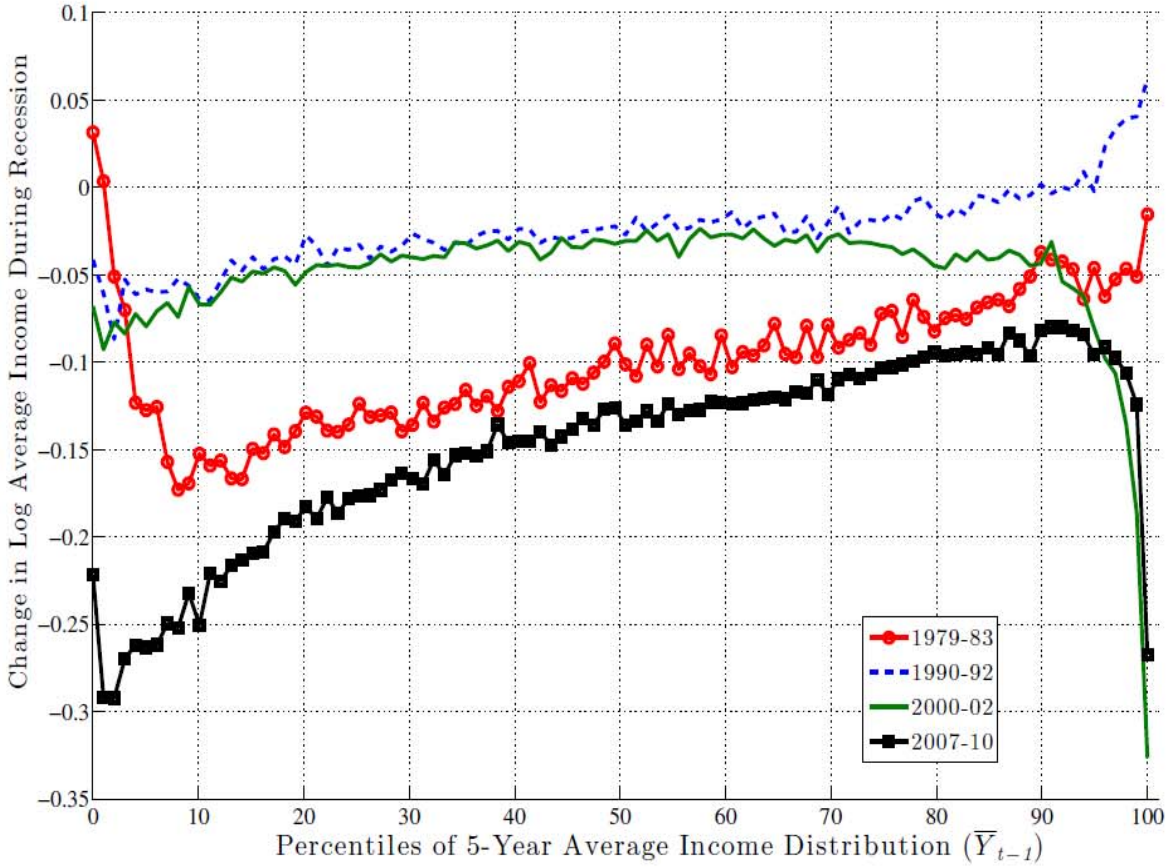
Income seems to display a similar increasing spread as plant data, at least in earlier analysis

Storesletten, Telmer and Yaron (2004) show that US cohorts in the PSID that have lived through more recessions have more dispersed incomes

Meghir and Pistaferri (2004) (also on the PSID) show that labor market residuals have a higher standard deviation in recessions

Recent data suggests a rising third moment (skewness) in recessions, particularly 2007-10

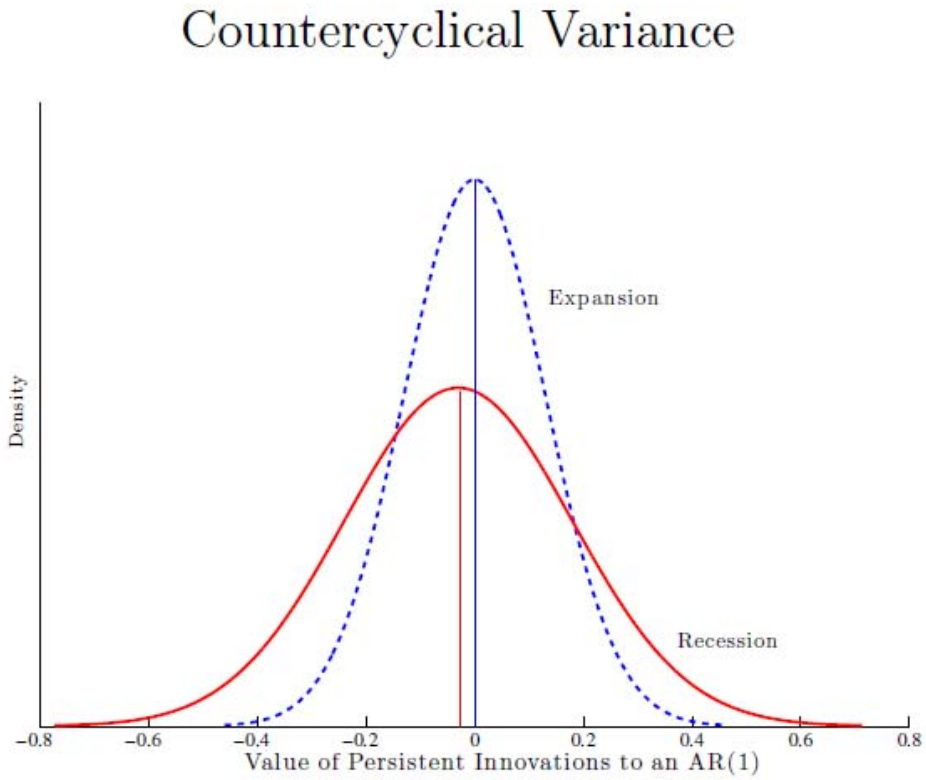
Figure 13: Growth in Log Average Earnings during Recessions, Prime-Age (35–54) Males

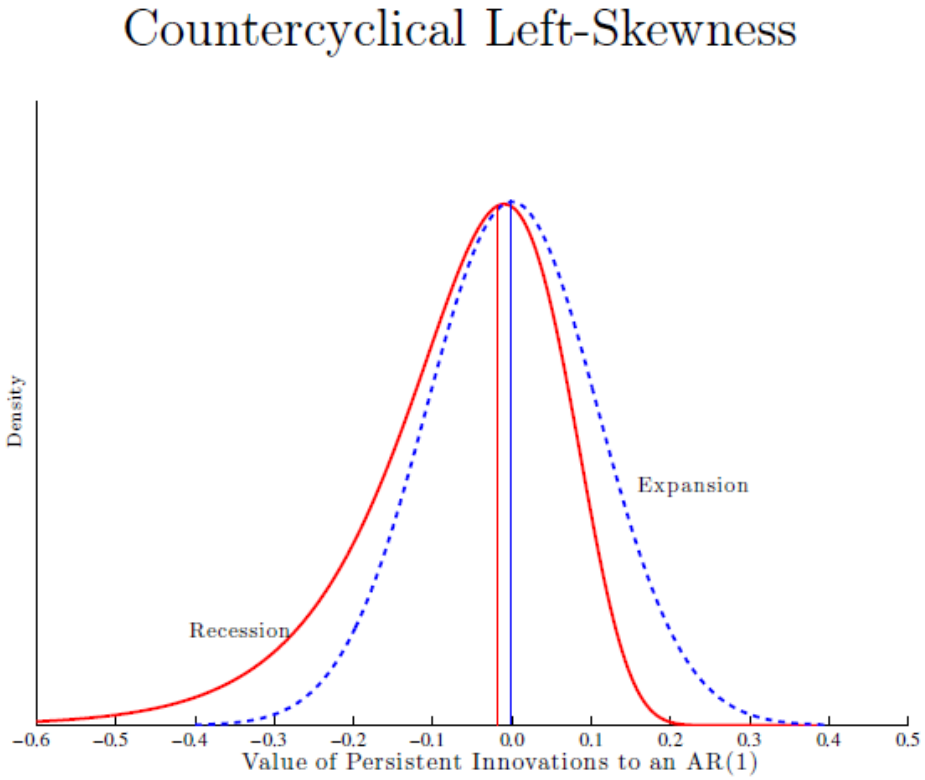


Source: Guvenen, Ozkan and Song, "The nature of countercyclical income risk" (2012), Minneapolis Fed mimeo

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

So in summary





Macro, industry, firms, plants and product prices

Incomes?

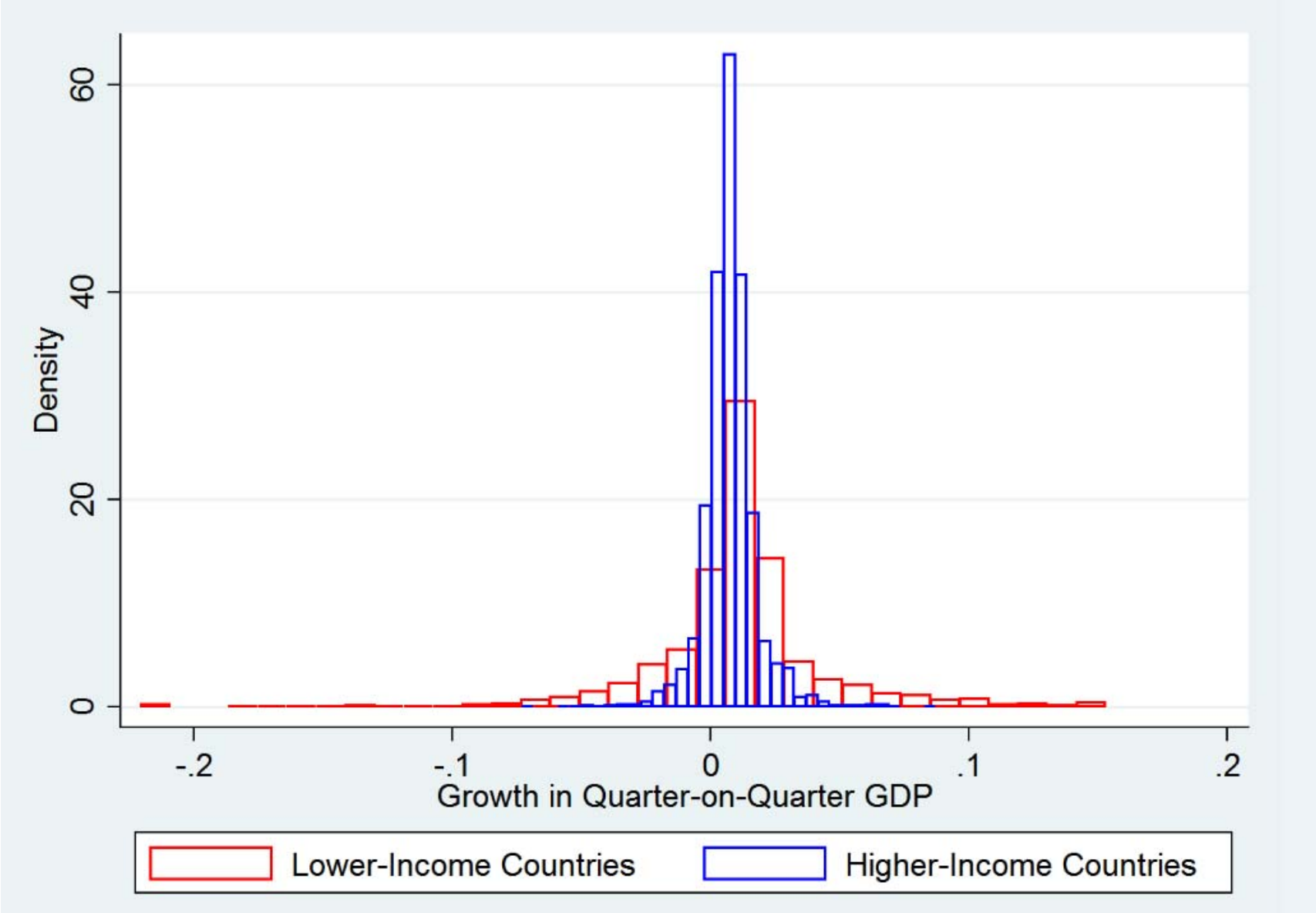
1) Macro uncertainty appears countercyclical

2) Micro firm uncertainty appears countercyclical

3) Firm skewness and kurtosis appear to be acyclical

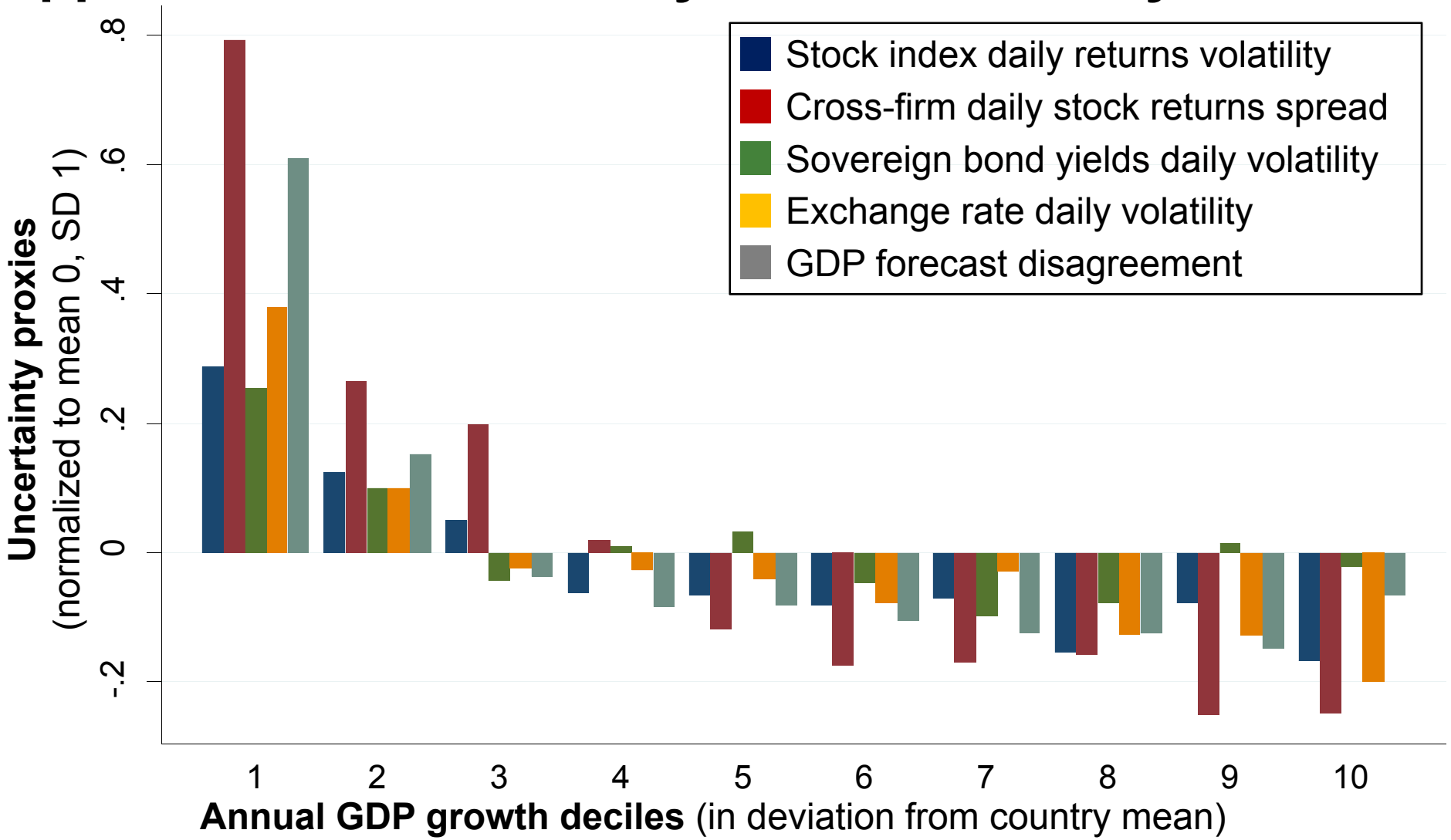
4) Uncertainty is higher in developing countries

Developing countries have 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)

Developing (and in fact all) countries also appear to have countercyclical uncertainty

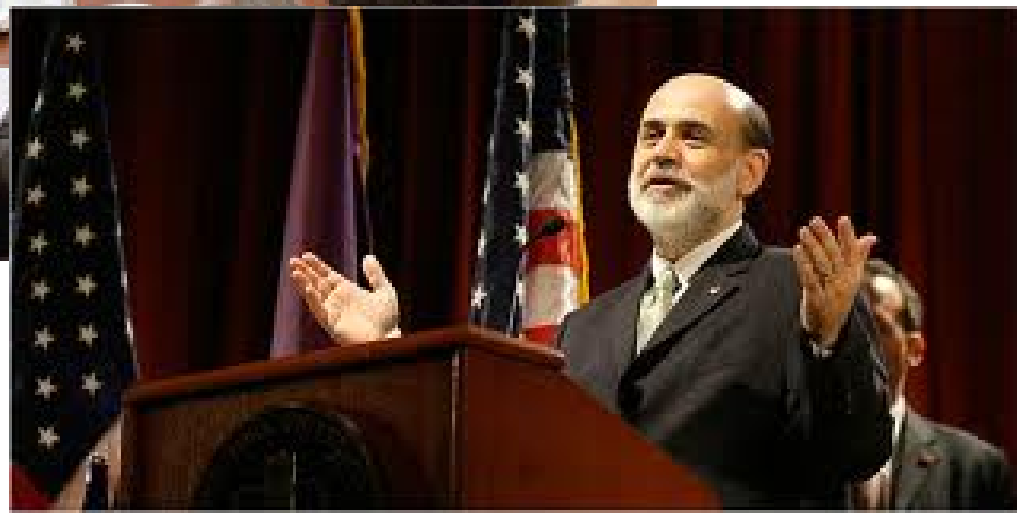


Source: Baker and Bloom (2012), "Does uncertainty reduce growth? Evidence from disaster shocks"

Notes: Volatility indicators constructed from the unbalanced panel of daily data from 1970 to 2012 from 60 countries. The GDP growth quintiles are calculated using annual values in deviations from the country mean across the sample.

- Definition: What is uncertainty?
- Stylized facts: Uncertainty over time and countries
- **Theory: Why might uncertainty matter?**
- Empirics: Evidence on the impact of uncertainty

Policymakers think that uncertainty matters



Policymakers think that uncertainty matters

FOMC (October 2001) “increased uncertainty is depressing investment by fostering an increasingly widespread wait-and-see attitude about undertaking new investment expenditures

FOMC (April 2008)
“participants reported that uncertainty about the economic outlook was leading firms to defer spending projects until prospects for economic activity became clearer.”

FOMC (June 2009)
“participants noted elevated uncertainty was said to be inhibiting spending in many cases.”

FOMC (September 2010)
“A number of business contacts indicated that they were holding back on hiring and spending plans because of uncertainty about future fiscal and regulatory policies”

Famous economists also worry about uncertainty

Olivier Blanchard (January 2009)
"Uncertainty is largely behind the dramatic collapse in demand. Given the uncertainty, why build a new plant, or introduce a new product now? Better to pause until the smoke clears."

Christina Romer (April 2009)
"Volatility has been over five times as high over the past six months as it was in the first half of 2007. The resulting uncertainty has almost surely contributed to a decline in spending."

Larry Summers (March 2009)
"…unresolved uncertainty can be a major inhibitor of investment. If energy prices will trend higher, you invest one way; if energy prices will be lower, you invest a different way. But if you don't know what prices will do, often you do not invest at all."

Although not everyone agrees….

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October 13, 2011, 8:52 AM | 60 Comments

Varieties Of Uncertainty

Some of the usual suspects have lately been touting a research paper by Baker et al that supposedly shows that policy uncertainty is an important factor in restraining the ecc
view. Larry Mishel

As Mishel points c
uncertainty is base
Murdoch empire c
uncertainty, the au
as the propaganda

But even setting th
all what the right v
visibly move their
dispute. So you co
that socialist Islan
hostage-taking. Th
the analysis.

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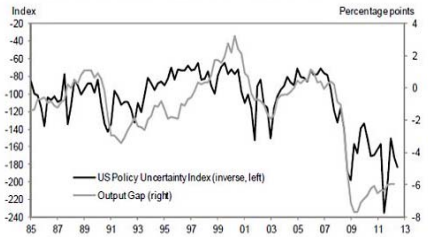
The "Uncertainty" Scam

One of the central talking points of right-wing economists is that "uncertainty" caused by Obama is holding the economy back; they cite, again and again, a paper by Bloom et al purporting to find a relationship between uncertainty and jobs, with uncertainty measured via such things as article counts.

But what's driving that uncertainty index? Jan Hatzius and his team at Goldman have an analysis, cited by FT Alphaville, pointing out something that I thought I knew, but with much more clarity: it's not at all about Obama.

Here's my key graph from the Hatzius paper:

Exhibit 2: Is Policy Uncertainty Cause or Effect of the Weak Economy?



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October 31, 2012, 3:15 PM | 157 Comments

Asymmetrical "Uncertainty"

Ever since it came out, Obama-bashers have loved to cite a paper by Baker, Bloom, and Davis claiming that policy uncertainty is holding back the recovery. See, they say, it's Obama and his socialist plans! The paper never deserved this much weight — like the Alesina/Ardagna work on expansionary austerity, or, yes, the unfortunate and uncharacteristically sloppy Reinhart/Rogoff

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August 10, 2012, 5:10 PM | 294 Comments

Culture Of Fraud

Still on vacation, but I have internet access for a bit, and have checked in on a few matters. The big story of the week among the dismal science set is the Romney campaign's white paper on economic policy, which represents a concerted effort by three economists — Glenn Hubbard, Greg Mankiw, and John Taylor — to destroy their own reputations. (Yes, there was a fourth author, Kevin Hassett. But the co-author of "Dow 36,000" doesn't exactly have a reputation to destroy).

And when I talk about destroying reputations, I don't just mean saying things I disagree with. I mean flat-out, undeniable professional malpractice. It's one thing to make shaky or even demonstrably wrong arguments. It's something else to cite the work of other economists, claiming that it supports your position, when it does no such thing — and don't take my word for it, listen to the protests of the cited economists.

Previous Post: Poor Spokesmen

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Uncertainty and volatility matter when you have curvature so that distributions matter

- Imagine everything was linear – for example utility is a linear function $U(c) = A+Bc$

- Then you only care about is the mean of c, the first moment which is $E(c)$ (certainly equivalence)

- As soon as you have curvature the distribution of c also matters, for example $U(c) = A + Bc – Dc^2$

The main sources of curvature by firms and consumers

Firms

- **Adjustment costs (real options)**
- Revenue functions (Oi-Hartman-Abel effects)
- Financial frictions
- Managerial risk-aversion

Consumers

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

- Idea is that investment and hiring are (partially) sunk-costs
- As a result when uncertainty is high about the future you want to wait to find out before investing or hiring
- Literature most strongly associated with Dixit and Pindyck's (1994) book
- Other key early papers include Bernanke (1983), McDonald, Siegel (1986) and Bertola and Bentolila (1990)

A micro to macro model (from "Really uncertain business cycles", Bloom et al. 2012)

- 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 and micro productivity follow an AR process with time variation in the variance of innovations

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

- Uncertainty (σ^A and σ^Z) also persistent - e.g. follows a 2-point markov chain

Capital and labor adjustment costs

- Capital and labor follow the laws of motion:

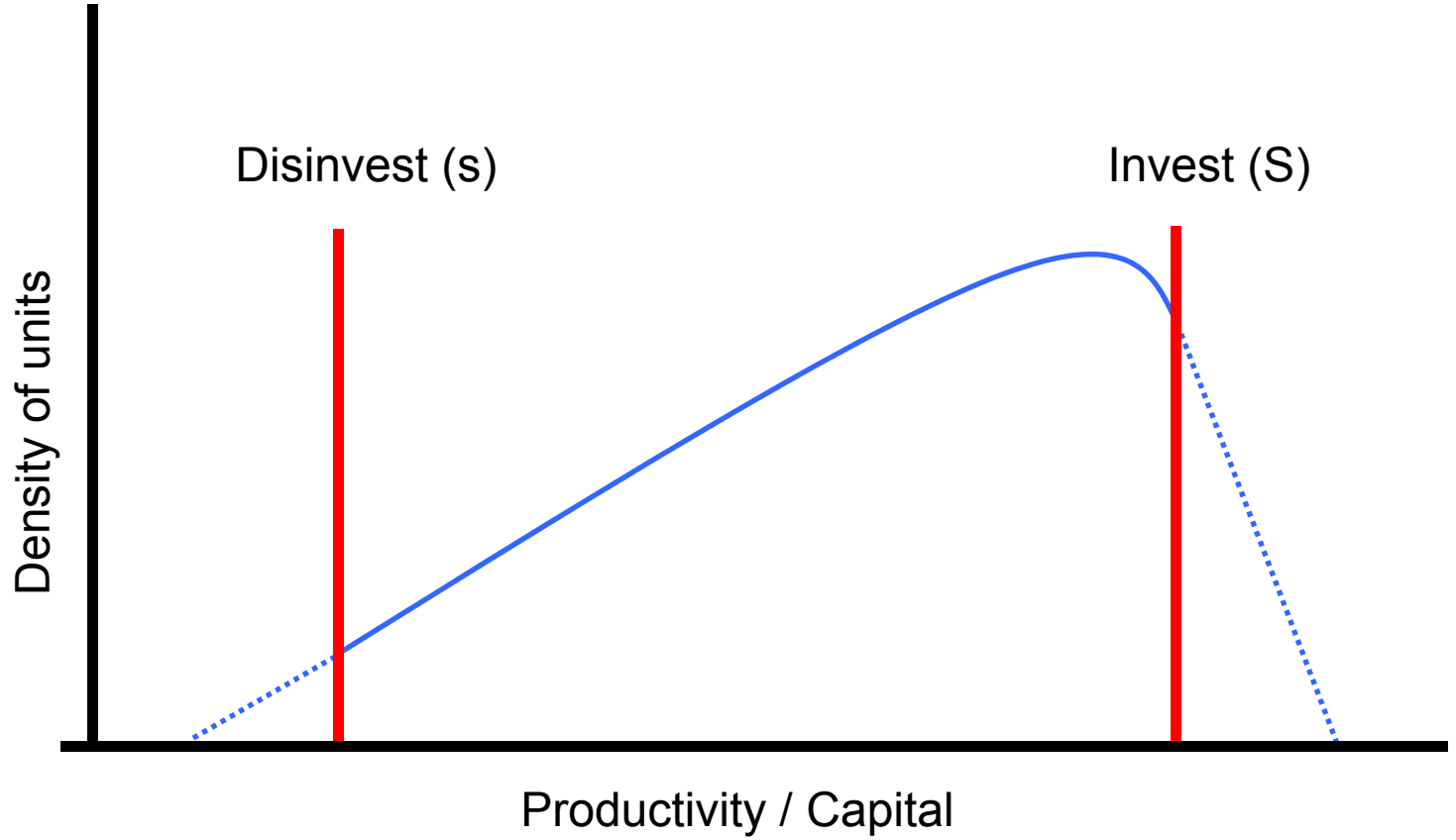
$$\begin{aligned} k_{j,t+1} &= (1-\delta_k)k_{j,t} + i_{j,t} \\ n_{j,t} &= (1-\delta_n)n_{j,t-1} + s_{j,t} \end{aligned}$$

where i: investment δ_k: depreciation

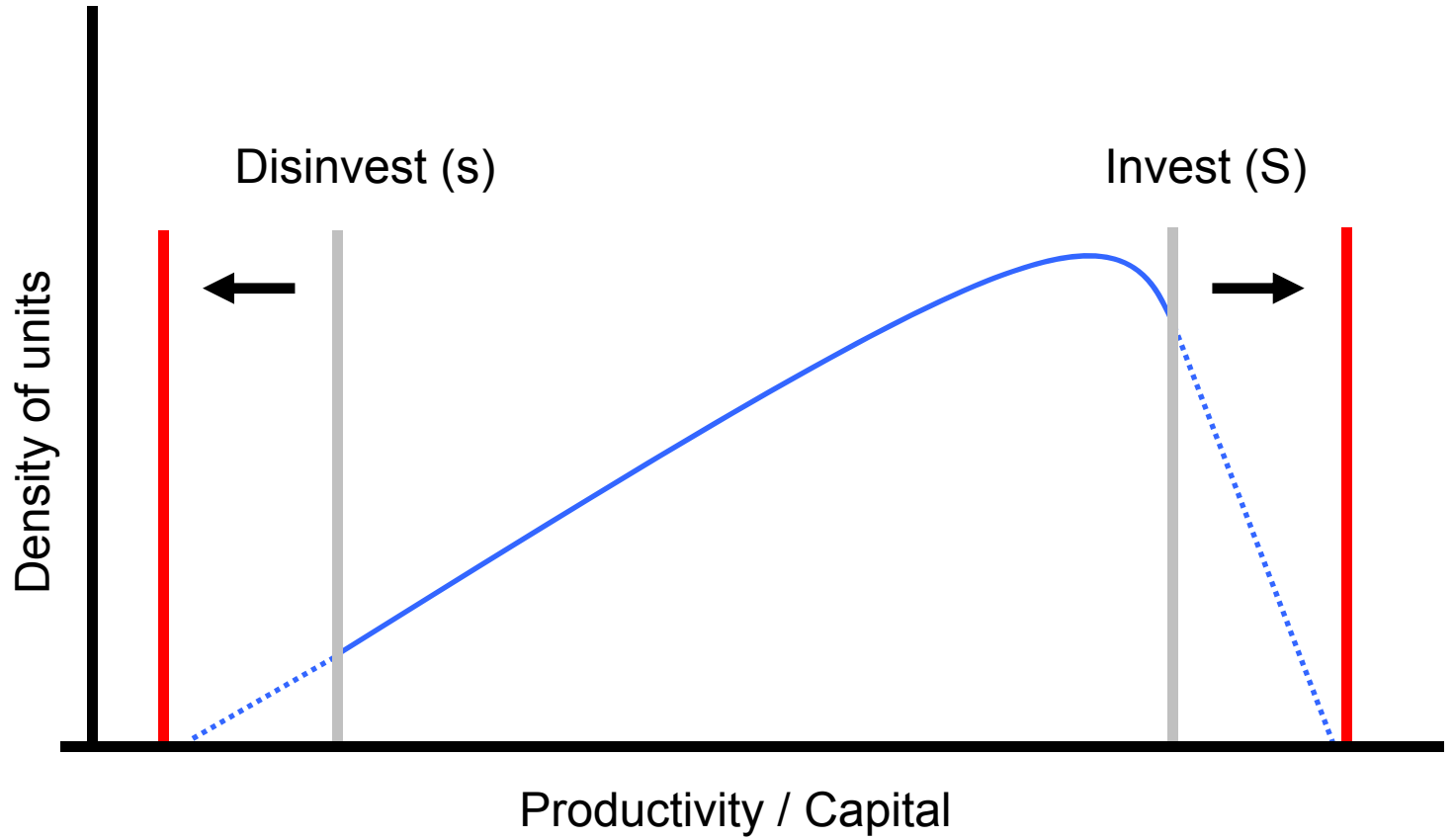
s: hiring δ_n: attrition

- 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

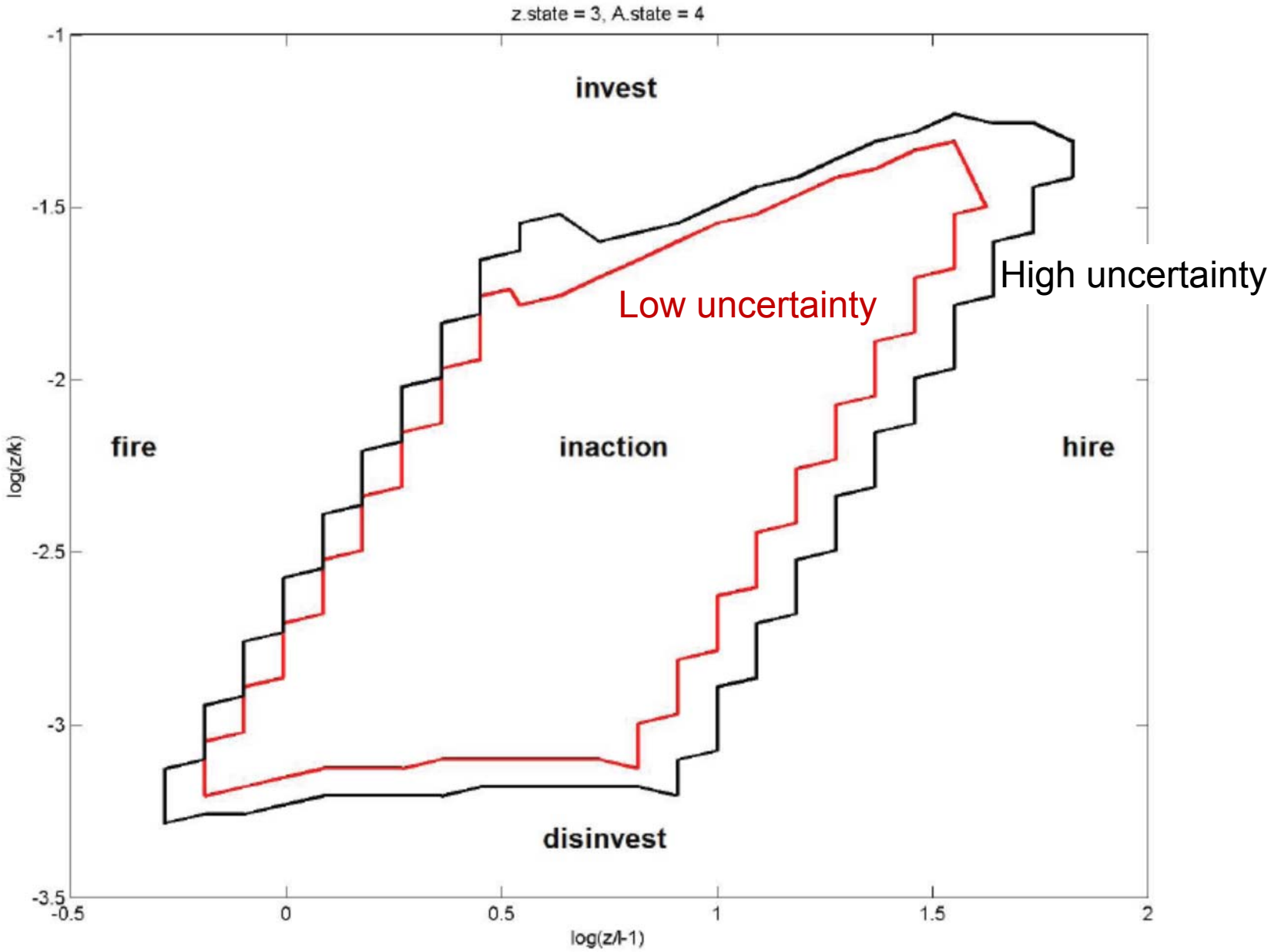
For both investment and hiring get these Ss type models with investment/disinvestment thresholds



When uncertainty increases the thresholds move out and investment temporarily falls



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



The real options effects work through two channels

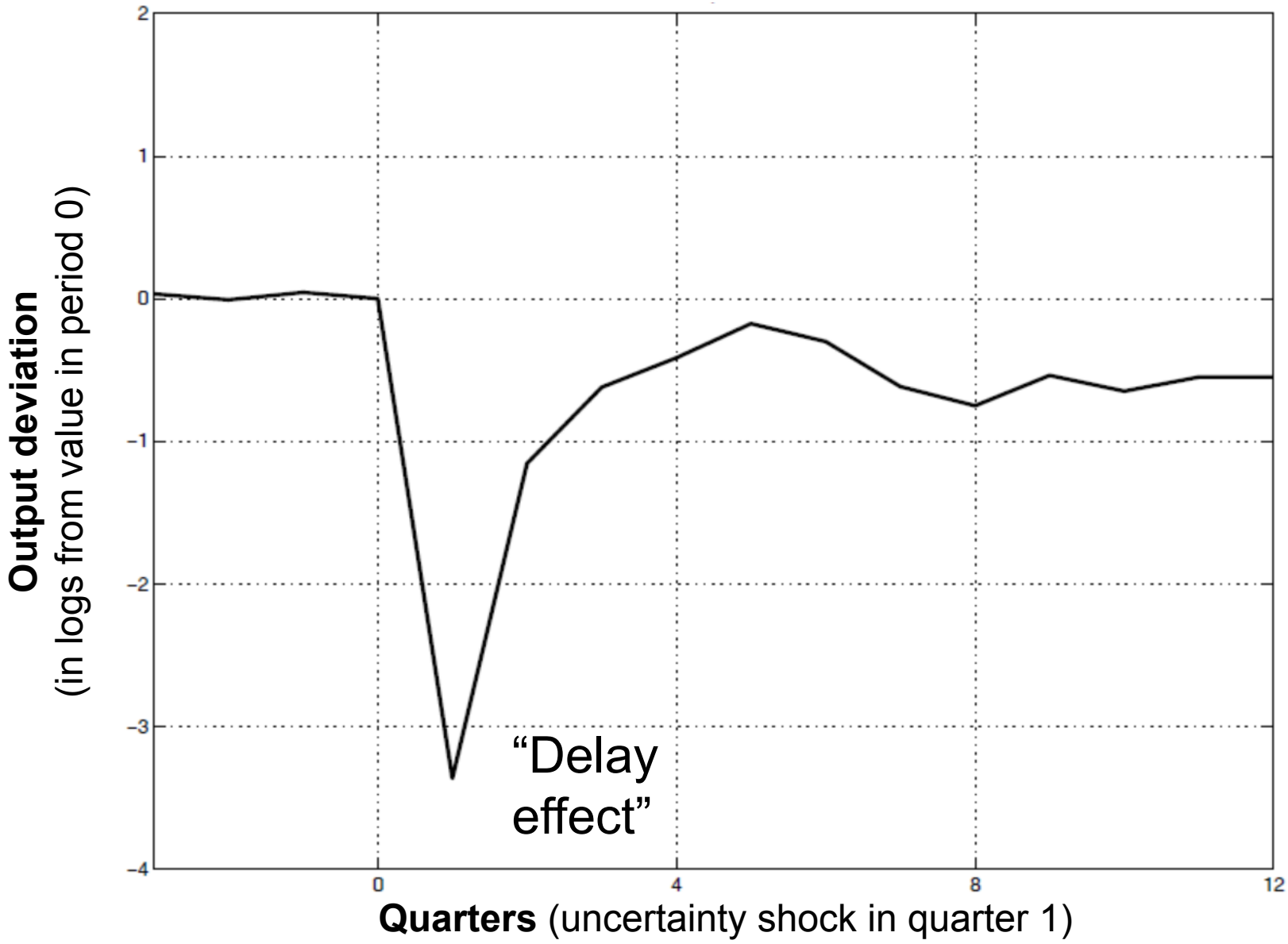
"***Delay effect***": when uncertainty increases firms put off making decisions. So investment and hiring tends to fall.

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

"***Caution effect***": when uncertainty increases firms are less sensitive to other changes, like prices and demand

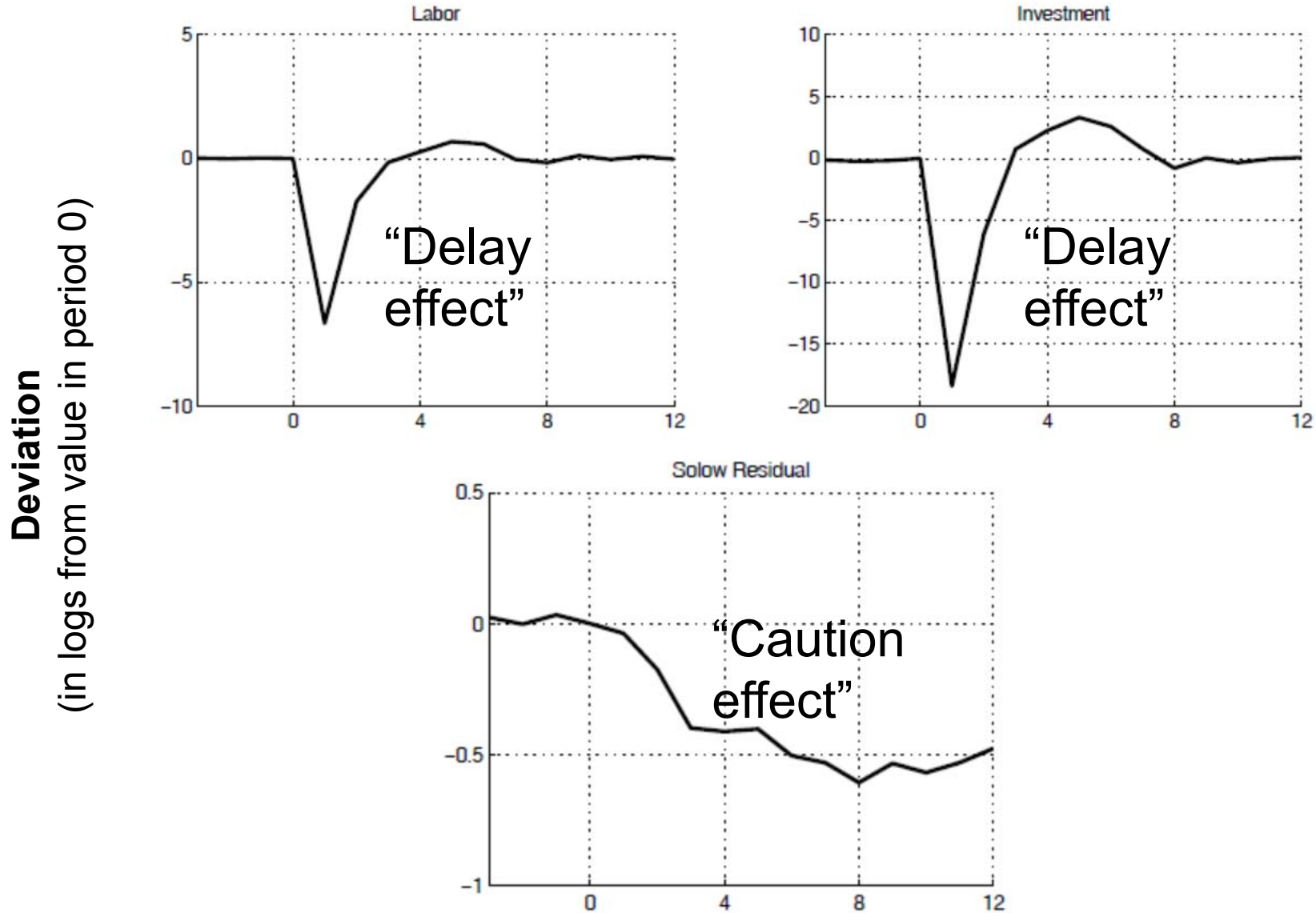
$\partial^2 I/\partial A \partial \sigma < 0$ where I and σ as above, A=TFP or demand

Figure 1: An uncertainty shock causes an output drop of just over 3%, and a recovery to almost level within 1 year



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

Figure 2: Labor and investment drop and rebound, and TFP slowly falls and rebounds



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

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 large delays, which Bar-Ilan & Strange (1996) show generate offsetting put options

4. Some 'non-convex' adjustment costs – this means some fixed (lump-sum) or partial irreversibility (i.e. a resale loss), rather than only quadratic (smoothly increasing) costs

Also uncertainty has to be rising (rather than permanently high)

- The early literature (e.g. Dixit and Pindyck, 1996) focused on constant uncertainty and did comparative statics on $\boldsymbol{\sigma}$

- Reason is the maths of dealing with stochastic volatility (so a time varying $\boldsymbol{\sigma_t}$) is very hard

- But steady-state impact of high uncertainty is actually very small (e.g. Abel and Eberly, 1999).
  - Intuition is all investment is delayed, so do last period's now and do this period's next period

Other macro models have exploited price (rather than factor input) adjustment costs

In a New Keynesian model in which prices are sticky in the short-run, Basu and Bundick (2011) obtain negative uncertainty effects from a lack of demand

Benigno and Ricci (2011) show that with downward nominal wage rigidity higher uncertainty increases probability of binding, reducing hiring

The main sources of curvature in economics from firms and consumers

Firms

- Adjustment costs (real options)
- **Revenue functions**
- Financial frictions
- Managerial risk-aversion

Consumers

Non-linear revenue functions can also induce uncertainty effects (1/2)

- The Oi-Hartman-Abel effect (sometimes Hartman-Abel effect) based on the impact of uncertainty on revenue. Based on Oi (1961), Hartman (1972) and Abel (1983)

- The basic idea is that if capital and labor are costlessly adjustable variability is good for average revenue
  - When demand is high expand
  - When demand is low contract

Non-linear revenue functions can also induce uncertainty effects (2/2)

For example, for Cobb-Douglas if profits are:

$$\Pi = AK^{\alpha}L^{\beta} - rK - wL$$

Then you obtain for optimal (flexible) capital and labor

$K^* = \lambda_K A^{1/(1-\alpha-\beta)}$ $\quad$ $L^* = \lambda_L A^{1/(1-\alpha-\beta)}$

where λ_K and λ_L are constants

As a result K* and L* are convex in A, so a higher variance in A leads to higher average K and L

But the Oi-Hartman-Abel effect is not robust

This result requires no capital or labor adjustment costs, which in reality is very unlikely to happen

Hence, while theoretically this can reverse the impact of uncertainty, in practice I don't think it's an important channel in the short-run (when factors are fixed).

Bloom et al. (2012) find real-option effects dominate in the short-run (≤6 quarters) and OHA in medium-run (6+ quarters)

The main sources of curvature in economics from firms and consumers

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Consumers

Recent financial crisis have emphasized the role of uncertainty and finance

The 2007-2009 crisis clearly highlighted the issues of both finance and uncertainty, and natural to ask do they interact?

Many recent papers (e.g. Arrellano, Bai & Kehoe 2011, Gilchrist, Sim & Zakrajsek 2011, and Christiano, Motto & Rostango, 2011) emphasize uncertainty-finance interaction

They have an empirical and theory component – both suggest financial frictions and uncertainty amply each other

The main sources of curvature in economics from firms and consumers

Firms

- Adjustment costs (real options)
- Revenue functions
- Financial frictions
- **Managerial risk-aversion**

Consumers

Another channel is that managers are typically not well diversified, so firm risk=personal risk

While investors may be diversified (at least for publicly quoted firms) managers typically are not.

Managers hold human-capital in the firm (firm-specific training etc) and often financial capital (shares)

As a result they have a risk-return trade-off for the firm. So higher uncertainty should induce more cautious behavior, typically meaning less investment and hiring

The main sources of curvature in economics from firms and consumers

Firms

Consumers

- **Risk aversion**
- Durable adjustment costs (real options)

Risk aversion has seen an increase in interest recently

Classic idea is higher risk requires higher returns, reducing investment and hiring

Fernandez-Villaverde, Guerron, Rubio-Ramirez and Uribe (2011) use numerical methods to solve complex realistic models and find significant negative impacts

Ilut and Schneider (2012) use ambiguity aversion to demonstrate large negative effects (fear of the worst case)

Gourio (2011) has higher-moment (left-tail) concerns that again generate drops in uncertainty

The main sources of curvature in economics from firms and consumers

Firms

Consumers

- Risk aversion
- **Durable adjustment costs (real options)**

For consumption there is also a real-options effect on durable expenditure

For consumers (like firms) sunk investments have option values if they can delay

The classic example is buying a car – you can always delay. If uncertainty is high the option value of waiting may be so high you do not purchase this period

Note: Non-durables do not satisfy the "Investing now reduces returns from investing later" criteria, so no option value of delay. e.g. Eating next year no substitute for eating this year

For consumption there is also a real-options effect on durable expenditure

Classic papers include:

Romer (1990) who showed a big drop of durable/non-durable expenditure during the Great Depression arguing this is due to Uncertainty

Eberly (1994) looked at US car purchases, showing higher uncertainty led to a *caution effect* (Ss bands moved out).

- Definition: What is uncertainty?
- Stylized facts: Uncertainty over time and countries
- Theory: Why might uncertainty matter?
- **Empirics: Evidence on the impact of uncertainty**

Impact of uncertainty on growth

Micro evidence

Macro evidence

Identification and reverse causality

Micro papers on firms typically find negative effects of uncertainty on investment, e.g.

- Leahy and Whited (1996) is the classic in the literature. Build a firm-level panel (Compustat) and regresses investment on Tobin's Q and stock-return volatility (using daily data within each year)

- Used lagged values as instruments for identification

- Find a significant negative effect of uncertainty on investment, but nothing for covariance

Other papers have also found good micro-data evidence of negative uncertainty impacts

- Guiso and Parigi (1999) used Italian survey data on firms expectations of demand, and again found a negative impact on levels ("delay effect")

- Bloom, Bond and Van Reenen (2007) build a model and estimated on UK data using GMM, finding a negative "caution effect" (makes firms less responsive)

- Panousi and Papanikolaou (2011) undertook a novel twist demonstrating part of negative uncertainty effect appears to be management risk aversion.

Impact of uncertainty on growth

Micro evidence

Macro evidence

Identification and reverse causality

Basic results suggest a drop and recovery from VAR types estimates, e.g. Bloom (2009)

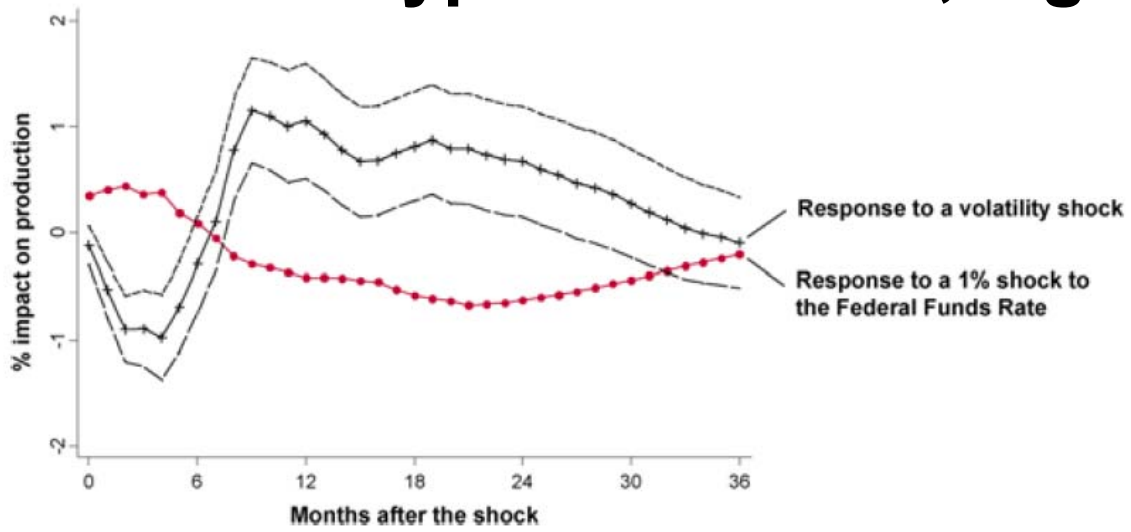

FIGURE 2.—VAR estimation of the impact of a volatility shock on industrial production. *Notes*: Dashed lines are 1 standard-error bands around the response to a volatility shock.

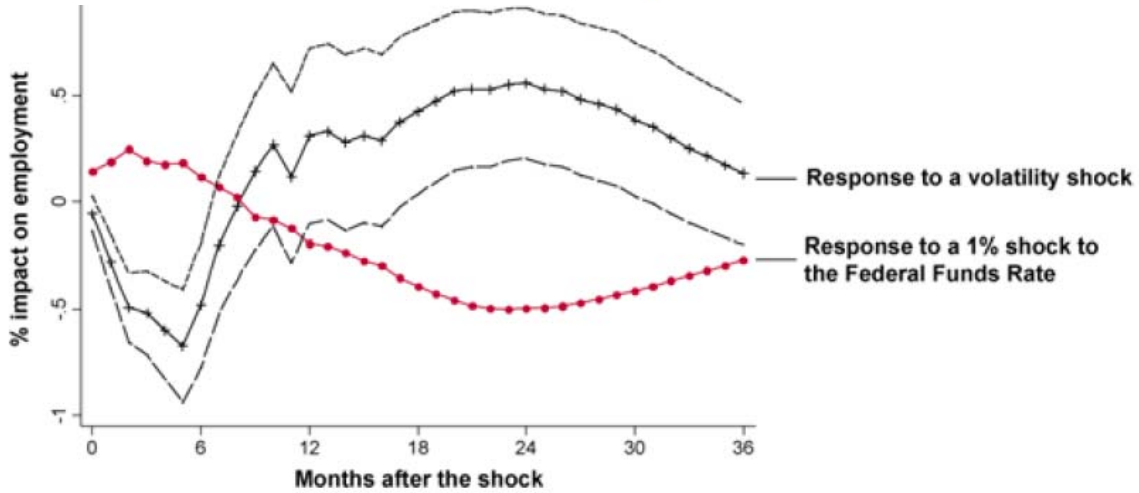

FIGURE 3.—VAR estimation of the impact of a volatility shock on employment. *Notes*: Dashed lines are 1 standard-error bands around the response to a volatility shock.

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)

Some papers use a cross-country approach

- Ramey and Ramey (1995) provided evidence on volatility and growth, using Government expenditure as an instrument for volatility, and find a strong negative relationship

- Engel and Rangel (2008) update this using a larger and more details cross-country panel and a better volatility measure, and again find a large negative correlation between volatility on growth

Impact of uncertainty on growth

Micro evidence

Macro evidence

Identification and reverse causality

An obvious concern is over reverse causality, which seems very plausible from the theory

- One model is Van Nieuwerburgh and Veldkamp (2006) which assumes learning is generated by activity, so recessions slow learning

- Bachmann and Moscarini (2011) assume instead that recessions are good times to experiment

- Kehrig (2011) has some very nice data showing counter-cyclical productivity dispersion and a model endogenizing volatility due to fixed costs of production

- Or maybe recessions are a good time for Governments to try new policies, as in Lubos and Veronesi (2012)

The evidence on causality between uncertainty and recessions is weak, and an active research area

- In Baker and Bloom (2012) use disasters as instruments and find a negative causal impact of uncertainty on growth

- Stein and Stone (2012) use energy and currency instruments in firm data finding a large causal impact of uncertainty on investment, hiring and advertising but positive on R&D

But still an open and very interesting research question

- Definition: What is uncertainty?
- Stylized facts: Uncertainty over time and countries
- Theory: Why might uncertainty matter?
- Empirics: Evidence on the impact of uncertainty
- **Conclusions**

Wrap-up summary

1. Micro and macro uncertainty are countercyclical

2. Theory suggests this is likely to reduce hiring, investment and consumer durable expenditures due to:
   a) Postponing action due to real-options "*delay effects*"
   b) Risk aversion (from consumers and managers)

3. Empirical evidence suggests negative impacts of uncertainty, maybe explains ≈ 1/3 of business cycles

4. Uncertainty also reduces policy impact due to real options "*caution effects"* – makes firms & consumers less responsive

Goodbye from
General Equilibrium