Uncertainty and Inaction

Investment, Finance, Asset Prices ECON5068

Thomas Walsh

Adam Smith Business School

Lecture Overview

- Uncertainty - Definition and Measures
- Uncertainty, Investment, Inaction.
- Reading:
  1. Bernanke (1983) Irreversibility, Uncertainty, and Cyclical Investment, Quarterly Journal of Economics
  2. Bloom, Bond and Van Reenen (2007), *Uncertainty and Investment Dynamics*, Review of Economic Studies.
  3. Bloom (2009), The Impact of Uncertainty Shocks, Econometrica
  4. Bloom, Nicolas (2014), *Fluctuations in Uncertainty*, Journal of Economic Perspectives.

Uncertainty

Policymakers think that uncertainty matters

Policymakers (Fed FOMC) care about Uncertainty

Trade Policy (2025, 2010s) and Pandemic Policy (2020-21)

(07/2025) "ongoing **policy uncertainty** had continued to **slow business investment**"

(06/2025) "firms were proceeding with existing investment projects but that **heightened uncertainty** was making them **cautious** about beginning **new projects**, especially larger ones"

(09/2019) "downside risks to the outlook for economic activity had increased somewhat (...), particularly those stemming from **trade policy uncertainty**"

(11/2020) "many businesses (..) were deferring longer-term commitments because of heightened uncertainty about the economic outlook"

(04/2021) "investment (...) declined further in the first quarter, likely reflecting ongoing uncertainty about the longer-term effects of the pandemic on businesses"

Uncertainty in the Global Financial Crisis (GFC) years

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."

What is Uncertainty?

- Frank Knight (1921) defines uncertainty as **the agents' inability to forecast the likelihood of events happening**.
- In other words, the distribution of outcomes is immeasurable (unknown).
- Different from **Risk**.
- Risk describes a known probability distribution over all possible events.
- Example: **Tossing a coin is risky** while the total **number of coins produced** by mankind is uncertain.
- Need to be careful to handle **Risk/Dispersion** versus **Uncertainty** ... sometimes the two terms (wrongly!) used interchangeably

How do we measure uncertainty

- Uncertainty is not directly observable, which makes it **hard to measure**.
- There is no perfect measurement, but a **broad range of proxies** have been suggested.
- The **volatility of stock market or GDP** is often used as a measure of uncertainty (VIX or GDP-at-Risk)
- when a data series becomes **more volatile it is harder to forecast**.

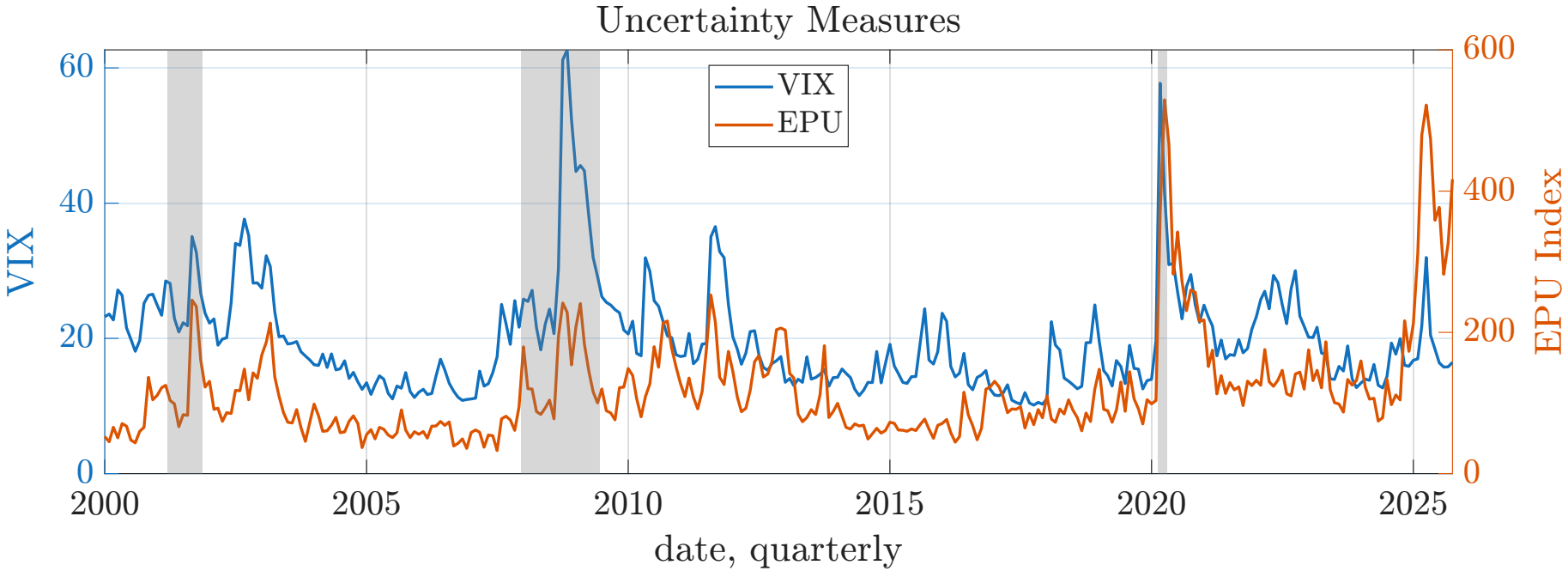


Figure 1: Common Measures of Uncertainty (stock-market and news mentions based)

EPU= captures what are people talking about in the news? Count measure of economic policy and uncertainty keywords

How do we measure uncertainty continued

- **Analysts / SPF**: Another measure is forecaster disagreement which is the differences in opinion or expectations about how economic variables are going to evolve. High disagreement indicates high uncertainty. Data is usually SPF (survey of professional forecasters at large finance houses).

- **Text Analysis of News**: Other measures include mentions of "uncertainty" in the news. Bloom's economic uncertainty index works this way

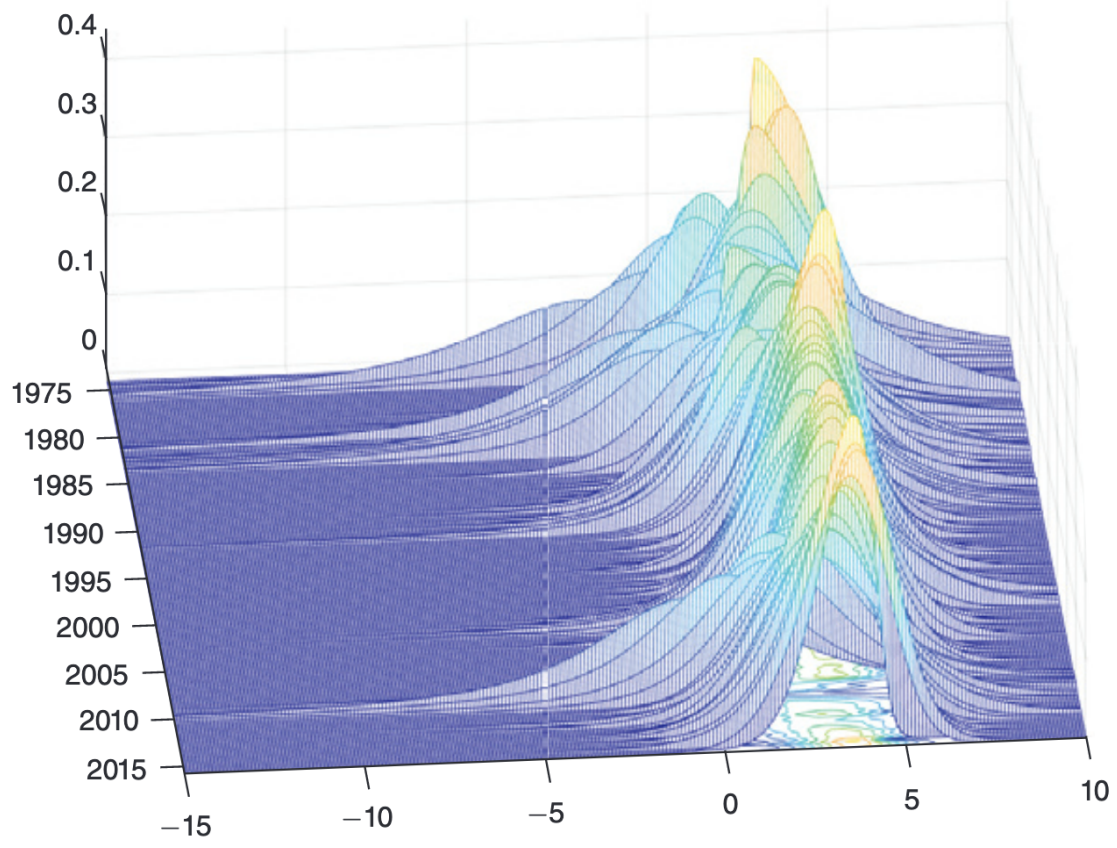
- **Text Analysis of Government Documents**: what are policymakers talking about? Are they planning changes?

- **Dispersion**: the variance/spread of shocks to firms (productivity, demand). My own work!

Kelvingrove Asset Management: Forecaster panel

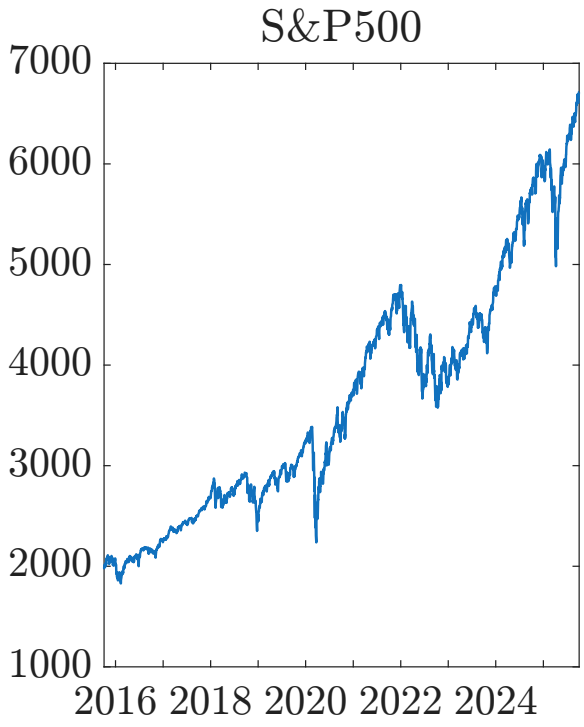
You are all forecasting analysts at Kelvingrove Asset management

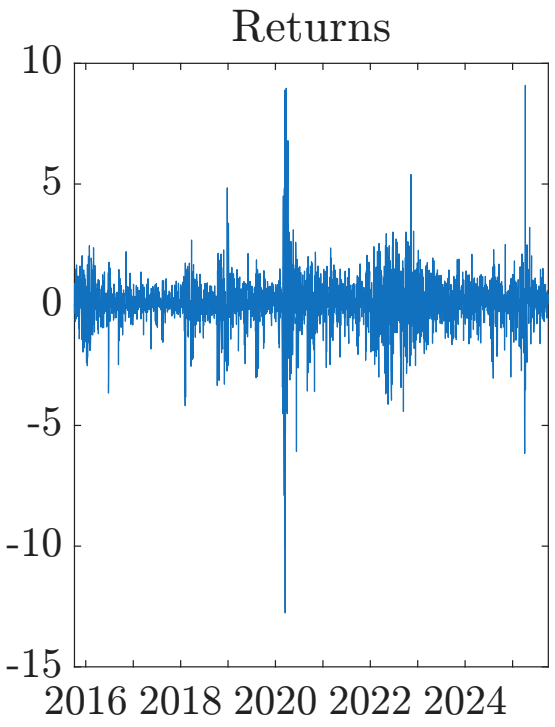
The Tail of GDP-Forecast Distribution

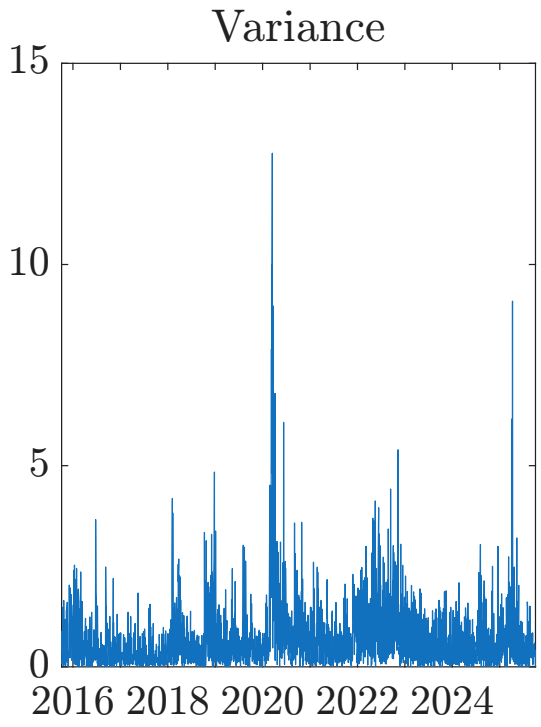


- **Forecasting distribution** of GDP shows very **long left tail** in '80s, '90, '09
- **Worst-case-scenario** ($Pr = 1\%$) events are **very bad in recessions** (-10% GDP growth in crisis vs. around 0% GDP growth in good years)

Uncertainty Measures: Stock Volatility



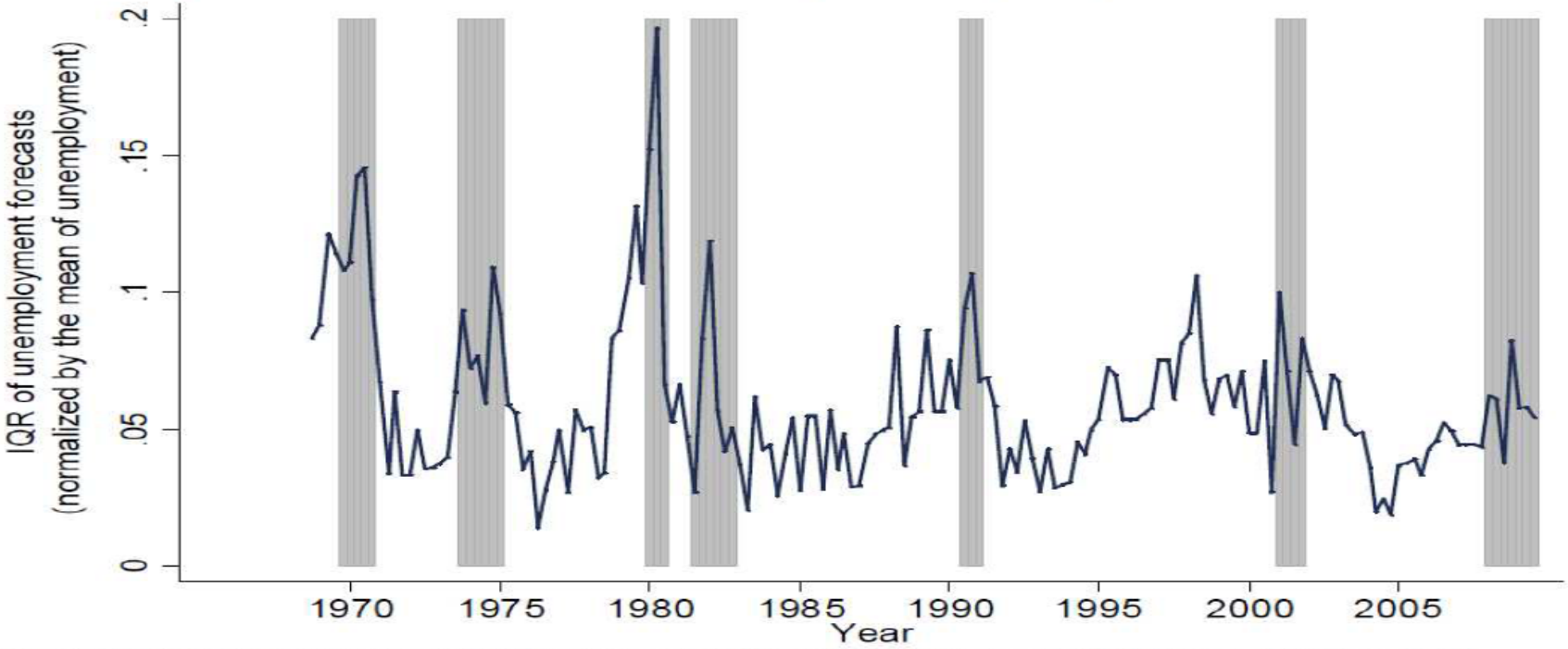




- Stock prices show strong **volatility clustering**
- **small changes** typically follow days with **small changes**
- **large changes** typically follow days with **large changes**
- time-varying dispersion: **periods of calm vs turbulence**
- high variance: markets cannot reliably price assets, future is hard to predict

Uncertainty Measures: Forecasters' Disagreement

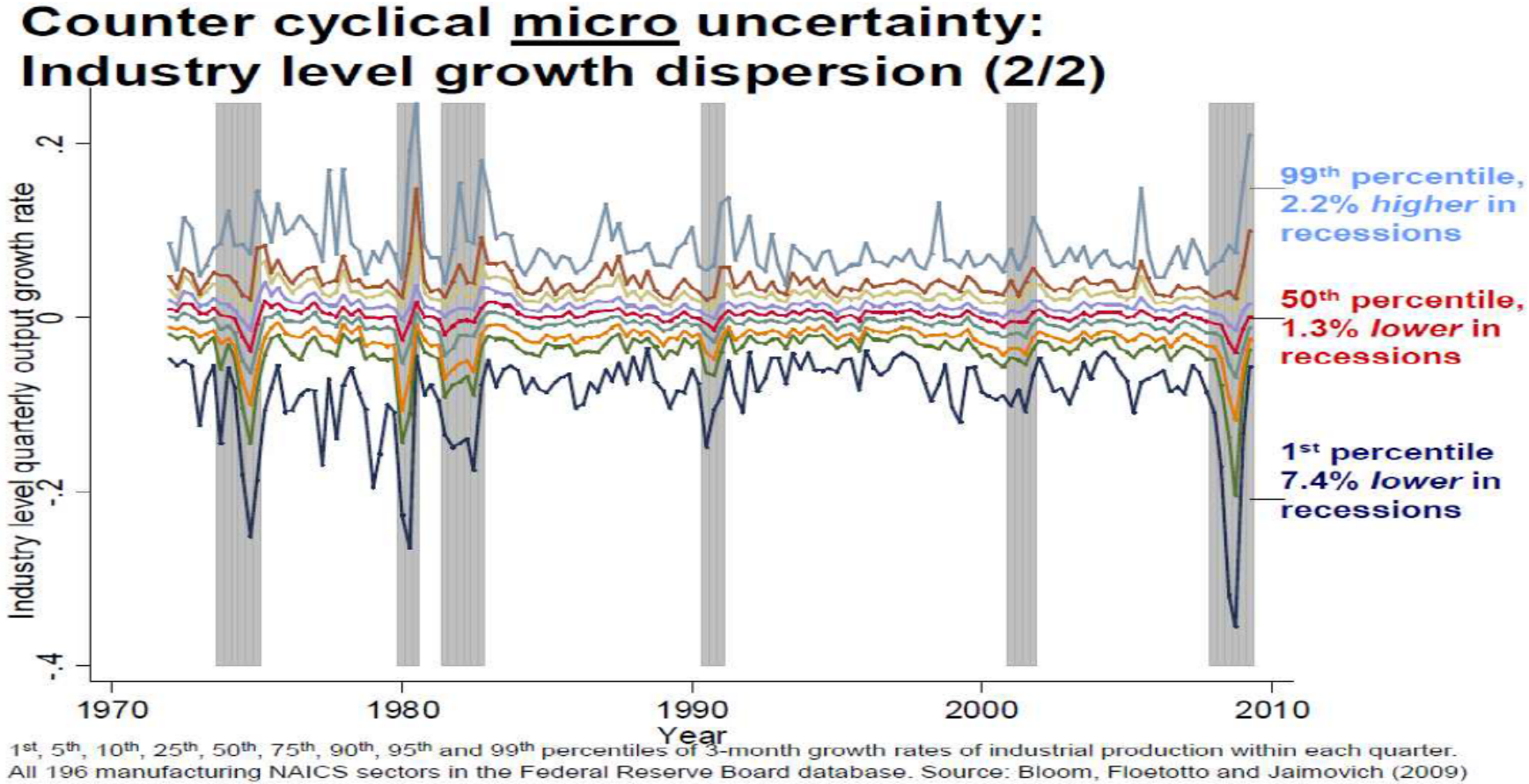
Counter cyclical macro uncertainty:
Disagreement measures (unemployment)



Notes: 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.

- Even when money is on the table: forecasters in (e.g. big banks) disagree more in recessions

Industry dispersion: "Floor falls out in recessions"

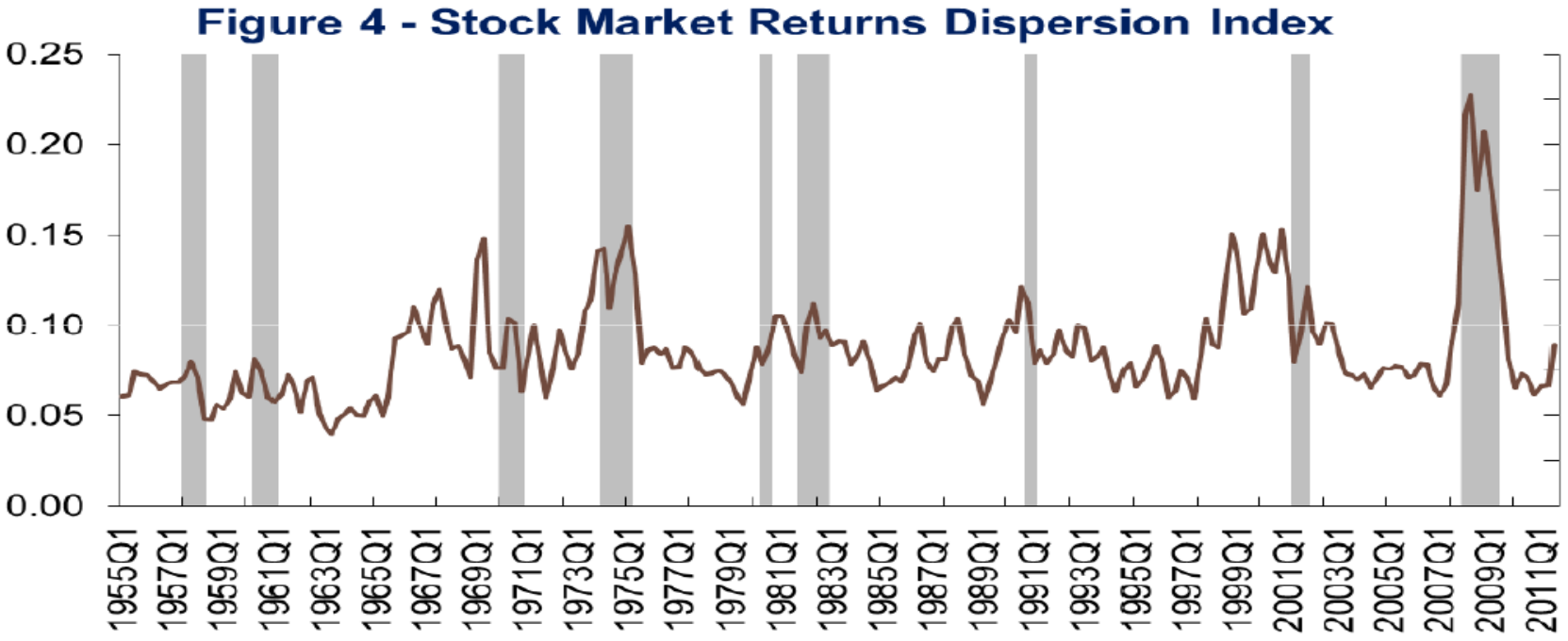


1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 99th percentiles of 3-month growth rates of industrial production within each quarter. All 196 manufacturing NAICS sectors in the Federal Reserve Board database. Source: Bloom, Floetotto and Jaimovich (2009)

- The median industry not hit too hard (<5 percent)
- The **worst performers do much worse** in recessions
- Households: only a fraction of workers lose their jobs in recessions

Uncertainty Measures - dispersion of stock price returns

Counter cyclical micro uncertainty:
Industry level stock-returns dispersion



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

- Market implications of the last slide: recessions are periods of very asymmetric shocks

Uncertainty and the Business Cycle - Facts

- **Recessions** seem to be not just a **negative shock to everyone** (1st moment) but also to **the variance** of firm/household-level processes (2nd moment)
- **Economywide**: Macro Uncertainty Rises in Recessions.
- **Firms and Sectors**: Micro Uncertainty Rises in Recessions.
- **Households**: Wages and Income Volatility are Counter-Cyclical (variance/inequality is higher in recessions)

Uncertainty and Aggregate Investment

- During periods of high uncertainty, we observe low investment spending.
- This was the case during the short-lived 2001 recession in U.S. when investment dropped below historical average and stayed at these low levels for several years.

Uncertainty and Investment

- Early contributions by Bernanke or Dixit and Pindyck.
- They argue that uncertainty creates **real options** for investment.
- Firm has (call) **option to invest** (the right but not obligation to invest) - **can wait for more information**.
- Options are many:
  1. delay start of project
  2. stop before completion
  3. abandon after completion
  4. temporarily stop producing, restart later
  5. slow speed
  6. speed up
- Under **uncertainty**, NPV of **inaction (=waiting or delaying)** might be higher than NPV of investing now.

Uncertainty and Investment

- **Real options** arises only when investment **decisions cannot be reversed**,
- If investment is irreversible (sunk cost), there is **an opportunity cost** of investing now rather than waiting.
- **Opportunity cost** (the value of option, flexibility) can be very **large**.
- Higher the uncertainty, higher is the value of option.

Uncertainty and Investment

- Let's look at 3 papers:
  1. Bernanke: Real Options and the Bad News Principle
  2. Bond, Bloom, Van Reenen: Uncertainty kills responsiveness (firm-level)
  3. Bloom: The Macro impact of uncertainty (aggregates to economy-level)

Uncertainty with Irreversible Investments from a Menu of Projects

Bernanke (1983): Irreversibility, Uncertainty, and Cyclical Investment
Quarterly Journal of Economics

Bernanke (1983): Wait-and-See and the Bad News Principle

Ben Bernanke:

- **Professor** at Princeton, many "classic" papers!
- Chair of the **Federal Reserve** 2006 - 2014 Crisis years
- **Nobel Prize** winner in 2022 for financial economics (financial crises, banking and money, firm investment)
- Today we look at a **underrated gem** in his early work (a PhD chapter!)
  - Has the flavour of a more complicated "High Rollers" game
  - Features Optimal Stopping / Committment behaviour

The Investment "Lock-In" Timing Problem

Standard Investment Theory (User Cost model, for example):

- Invest when expected return $>$ cost of capital
- Capital is malleable (can be changed)
- Timing doesn't matter much, we can always pivot if we make a mistake

Bernanke's Insight: When Investment cannot be undone

- Different projects are **alternatives** (mutually exclusive)
- Cannot "undo" - committed forever once chosen
- **Timing matters**: trade off current returns vs. waiting for information
- On menu of N alternatives, there is choice $N + 1$: wait and see
- **Flexibility is a valuable asset!**

The Investor's Problem

The Key Question

Should you **invest** in the best project today, or **wait** to learn more?

Example: Build oil refinery (Project A) vs. natural gas plant (B)

- Once built, can't **convert between them** (100% committed)
- Energy prices **uncertain** - which will be more profitable?
- Even if **oil looks better today**, **waiting** might reveal gas is superior
- Bernanke emphasises there is a hidden Project C: **wait** and **chose again (A, B or C) tomorrow**.

Defining Value

Value of the project: pays an **uncertain stream of returns**:

$$R_{i,t} = r_{i,t} + \mathbb{E}[\beta r_{i,t+1} + \beta^2 r_{i,t+2} + ... + \beta^{T-t} r_{i,T}]$$

Shocks enter the future returns. Recursively:

$$R_{i,t} = r_{i,t} + \beta \mathbb{E}_t[R_{i,t+1}]$$

Value of Waiting: can always decide tomorrow!

$$W_t = \beta \mathbb{E}_t \max\{R_{1,t+1}, ..., R_{N,t+1}, W_{t+1}\}$$

Choice today: invest in the best project, or wait:

$$Payoff = \max\left\{ \max_j\{R_{j,t}\}, W_t \right\}$$

Take the best of W or R^*; R^* is the best project.

Deriving the Option Value

The Investment Decision:

Invest in project (i) **iff its value exceeds all others, AND waiting**:

$$R_{i,t} \geq \max_{j \neq i}(R_{j,t}, W_t)$$

Substitute the decomposition of $R_{i,t}$ (assuming project(i) beats all other projects):

$$r_{i,t} + \beta E_t[R_{i,t+1}] \geq W_t$$

Rearrange:

$$r_{i,t} \geq W_t - \beta E_t[R_{i,t+1}]$$

This is the **option value** $Z_{i,t}$:

$$Z_{i,t} = W_t - \beta E_t[R_{i,t+1}]$$

Interpreting the Wait-and-See Option Value

$$Z_{i,t} = \underbrace{W_t}_{\text{Value of flexibility}} - \underbrace{\beta E_t[R_{i,t+1}]}_{\text{Continuation value if commit to } i}$$

Option Value: "what I give up in **terms of future flexibility** by **committing** to project i today."

Expanding W_t:

Since $W_t = \beta E_t[\max(R_{1,t+1}, ..., R_{k,t+1}, W_{t+1})]$, we can write:

$$\begin{aligned} Z_{i,t} &= \beta E_t[\max(R_{1,t+1}, ..., R_{k,t+1}, W_{t+1}) - R_{i,t+1}] \\ &= \beta E_t[\max(R_{1,t+1} - R_{i,t+1}, 0, W_{t+1} - R_{i,t+1})] \end{aligned}$$

Notice: Inside there is always $R_{i,t+1} - R_{i,t+1} = 0$, so always ≥ 0 because the max over all options can't be less than any particular option.

Regret matters for Option Value

What would I be willing to pay to undo my decision?

$$Z_{it} = E_t(x_{i,t+1} |\ x_{i,t+1} \geq 0)$$

where we can measure regrets as future returns beating project(i):

$$x_{i,t+1} = \max_j(R_{jt+1} - R_{it+1}, 0,\ W_{t+1} - R_{it+1})$$

Uncertainty and Rank Risks

Increases in Uncertainty: R_{jt+1} more dispersed.

- Reshuffling risk: High probability that some other project j will dominate i tomorrow
- Harder to predict future ranking of returns to projects
- Lots of rearranging the ranking of projects
- High chance you'd regret committing to i today

$\Rightarrow$ **Downside uncertainty matters** for **irreversible** decisions, upside does not!

- Higher variance of shocks to returns: $r_{jt+1}, ..., r_{jT}$
- Harder to Predict Value tomorrow

Main Takeaways from Bernanke Model:

The Decision Rule:

Invest in project i today if and only if:

$$r_i^{today} \geq Z_i = \text{Option Value}$$

where the **option value** is:

$$Z_i = \beta \times E[\text{Regret from choosing } i \mid \text{Bad news arrives}]$$

The "Bad News Principle"

Only downside risk matters for the investment decision!

- **Good news** (project i turns out great): Irrelevant - you're already locked in
- **Bad news** (project i worse than alternatives): Costly - stuck with wrong choice

Key Result: $\uparrow$ Uncertainty about bad outcomes $= \uparrow$ Option value $= \downarrow \mathcal{I}$

Even with risk-neutral investors, high expected returns, and no market failures!

Flexibility, Ranking Projects, and Policy

Bernanke's Paradox: A rise in all returns today (and expected tomorrow) can lower investment!

How? The value of waiting also rises. The net effect depends on which project's expected returns rise **most**

Bernanke's Key Insight: Uncommitted resources can dominate *all* positive-return investments when option values are high - **flexibility itself has value**!

Policy Implications:

- Policy stability and predictability $>$ policy optimality for investment
- favorable policy announcements can freeze investment if uncertainty rises
- News that changes project rankings depress investment, even if all returns increase

Example: Fiscal Uncertainty in the UK

Fiscal = Goverment tax, spending, debt management; local and national.

Gita Gopinath, former Director of IMF says:

"The UK has a fiscal problem (...) excessive fiscal policy uncertainty".

- **x2 per year** Budget Annoucements introduce **too much policy uncertainty**
- Firms, Markets **cannot plan long-term** if fiscal policy is adjusted every 6 months to changing forecasts (inherently noisy)
- **No hard evidence** in the data that doing fiscal policy this way induces a real options effect in firms, and spillovers to financial markets.

The Micro Impact of Uncertainty

Bloom, Bond, Van Reenan (2007): Uncertainty and Investment Dynamics

Uncertainty and Investment - BBV (2007)

- Under **option theory** of Bernanke or Dixit and Pindyck, investment behaviour becomes **cautious**.
- We now turn to a study by Bloom, Bond and Van Reenen (2007).
- They **theoretically model** and **empirically examine** the effects of **demand uncertainty on investment** allowing for plant and firm-level disaggregation.

Uncertainty and Investment - BBV (2007)

- **Question**: *Can the effects of uncertainty and irreversibility be detected in an econometric study using firm-level data?*
- They build a model incorporating both uncertainty about demand + irreversibility.
- **Irreversibility** is modelled as difference in the purchase and **resell price of capital**.
- Uncertainty about demand is modelled as a **time-varying variance** in the process that determines the product price.

Uncertainty and Investment - BBV (2007)

- Different specifications of adjustment costs

- Allow for aggregation across:
  1. different types of complementary capital like structures, equipment and vehicles, and

  2. production units or plants, each firm on average has around 220 plants (based on U.K. data)

Main Result of BBV: Uncertainty kills Responsiveness

- With irreversibility of installations
- **investment-responses** to firm-specific **demand shocks tends to be weaker** for firms that are subject to a **higher uncertainty**.

Uncertainty and Investment - Bloom, Bond and Van Reenen

- Compare model results with real data sample containing 672 publicly traded U.K. manufacturing companies over the period 1972-1991.

- Find evidence:
  1. of more cautious investment behaviour for firms subject to greater uncertainty and
  2. of a convex response of investment to real sales growth.

- They conclude that investment behaviour of large firms is consistent with a partial irreversibility model in which uncertainty dampens the short run adjustment of investment to demand shocks.

Uncertainty and Investment - Bloom, Bond and Van Reenen

- Finally, simulations of their model suggest that observed fluctuations in uncertainty can play an important role shaping firm level investment decisions.

- For example, a one standard deviation increase in the uncertainty measure, like that which occurred after September 11, 2001 and the 1973 oil crisis can **halve** the impact effect of demand shocks on company investment.

Uncertainty and Investment - Bloom, Bond and Van Reenen

- In an attempt to capture all relevant factors in one scalar measure, authors follow the approach suggested by Leahy and Whited (1996).
- **They use the standard deviation of stock returns for each firm in every accounting year.**
- Intuitively the variance in a firm's stock return captures uncertainty about its future demand, productivity, business conditions.
- This measure has its flaws...other measures prefered!

Model Responses: Qualitatively matches Facts in Data

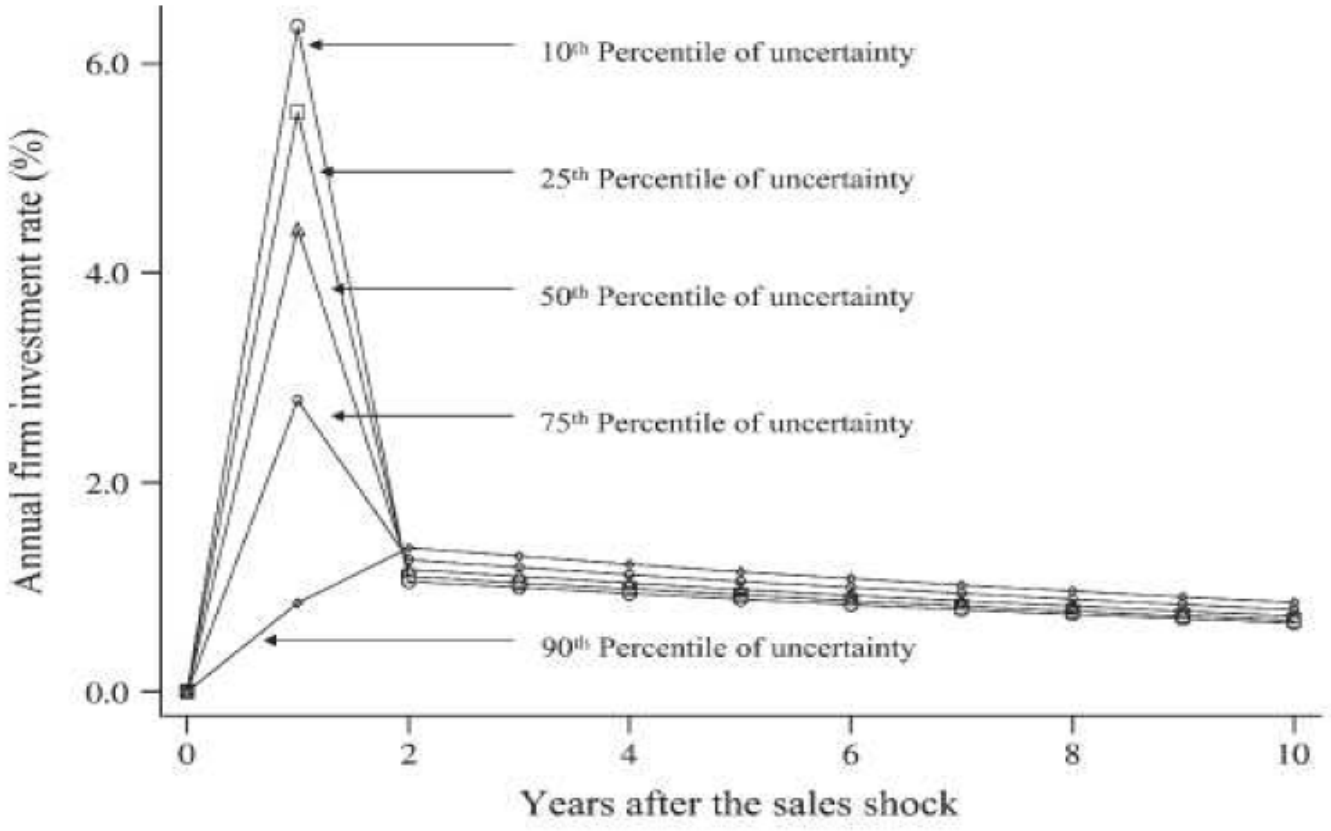


FIGURE 2

Investment response to a sales shock at different levels of uncertainty, U.K. firm-level data

The Macro Impact of Uncertainty

Bloom (2009): The Impact of Uncertainty Shocks

Bloom (2009) – Overview

- **BBV** show the **micro-effects of uncertainty** on firm-level responses
- **Bloom asks, do these effects aggregate up to affect the macroeconomy?**
- Studies the effect of uncertainty on firm investment and hiring decisions.
- Uses a real options approach with irreversiblity and fixed costs.

Key Mechanism

- Investment/hiring decisions are irreversible.
- Firms face uncertainty in productivity and future payoffs.
- Uncertainty increases the value of waiting.

Firms produce with inputs: capital, labour, hours

$$S(A, K, L, H) = A^{(1-a-b)} K^a (LH)^b$$

Productivity at the unit (plant) level has **unit-firm-macro components** :

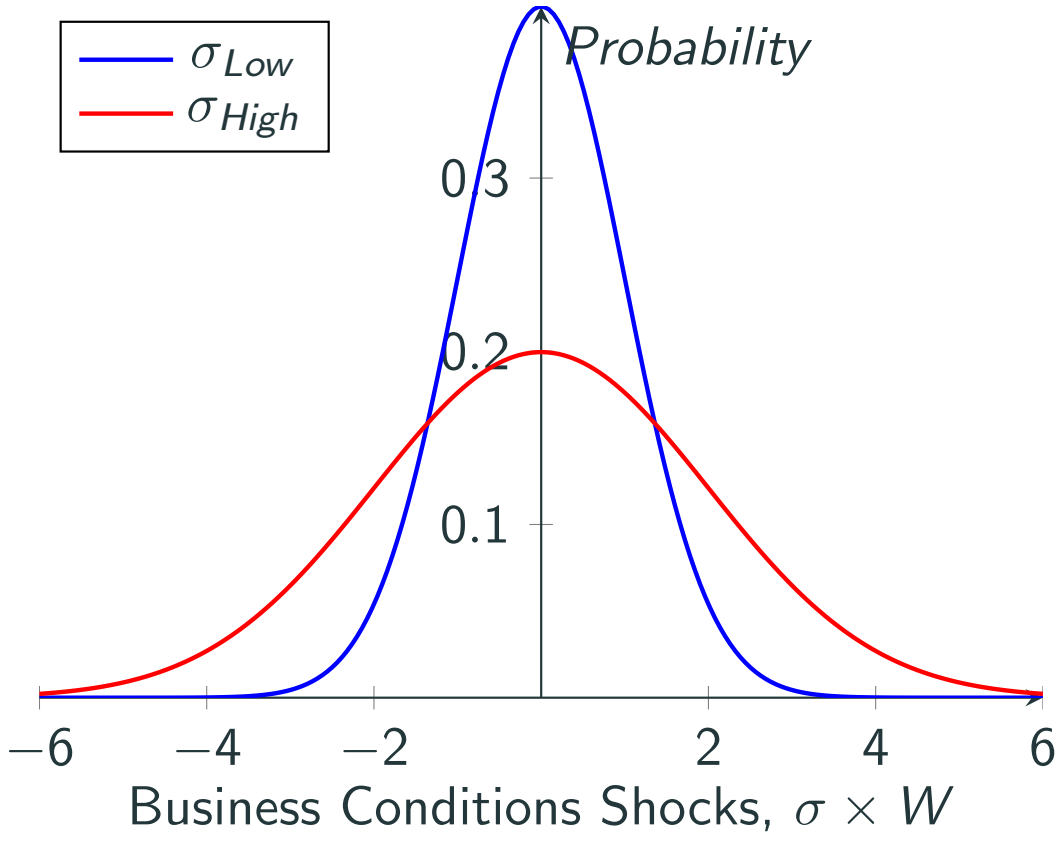
$$A_{i,j,t} = A_{ijt}^{Unit} \cdot A_{ijt}^{Firm} \cdot A_{ijt}^{Macro}$$

each part $X = (unit, firm, macro)$ follows a process:

$$A_t^X = A_{t-1}^X (1 + \sigma_{t-1} W_t^X); \quad W^X \sim N(0, 1)$$

Uncertainty enters as $\sigma_t \in \{\sigma_L, \sigma_H\}$ with transition probabilities $\pi_{t+1|t}^{\sigma}$

Business Conditions with Different σ



Effects of dispersion: (1) Reallocation versus (2) Real Options

Two effects in the model from higher dispersion:

- Some units of the firm will draw larger +ive shocks, and firm can send more resources there (Volatility / Abel-Hartman effect)
- **1. Reallocation Channel: Equalise MPK across plants:** If one has higher A, the firm will allocate it a larger share of total capital, until MPK falls. $F(A,k) = Ak^{0.33}$ in both.

- $[A_{Kelvindale}, A_{Partick}].(1,1) \rightarrow (1, 1.2), K^*_{Part} = (\frac{A_P}{A_K})^{\frac{1}{1-\alpha}} K^*_{Kelvin} \approx 1.83 K^*_{Kelvin}$
- Even if capital is fixed ($K_1 + K_2 = K$), output can rise +26 percent due to reallocation across plants
- **2. Wait-and-See/Real Options Channel**: higher likelihood of large negative shock (Bernanke BAD NEWS mechanism)

$\Rightarrow$ With adjustment costs, reallocation channel can be dampened

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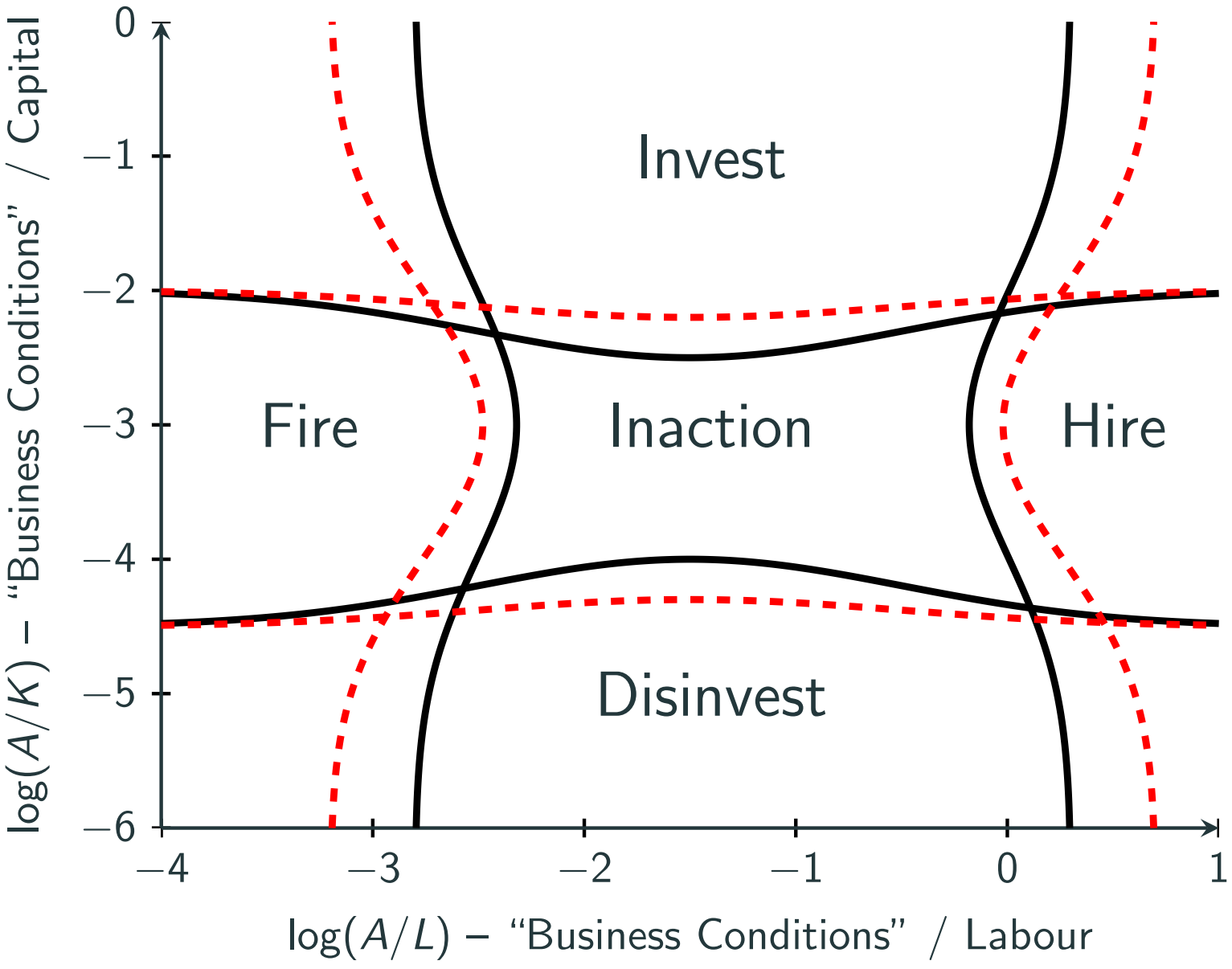
Expanded Inaction Region

- Range where firms optimally **delay action**.
- Wider under higher uncertainty.
- Only sufficiently large shocks trigger investment or hiring.
- NB: Bloom plots the state variable such that the meaning of the axes is reversed, the left is abundance, right is scarcity (relative to conditions).

Uncertainty expands the Inaction Region in State-space



Implications

- Micro: Firms are more cautious in uncertain environments.
- Macro: Aggregate investment and employment growth slow during high uncertainty.
- Policy: Reducing uncertainty can stimulate investment. Clarity and consistency are more valuable than exactly the right policies