The Great Diversification and Its Undoing

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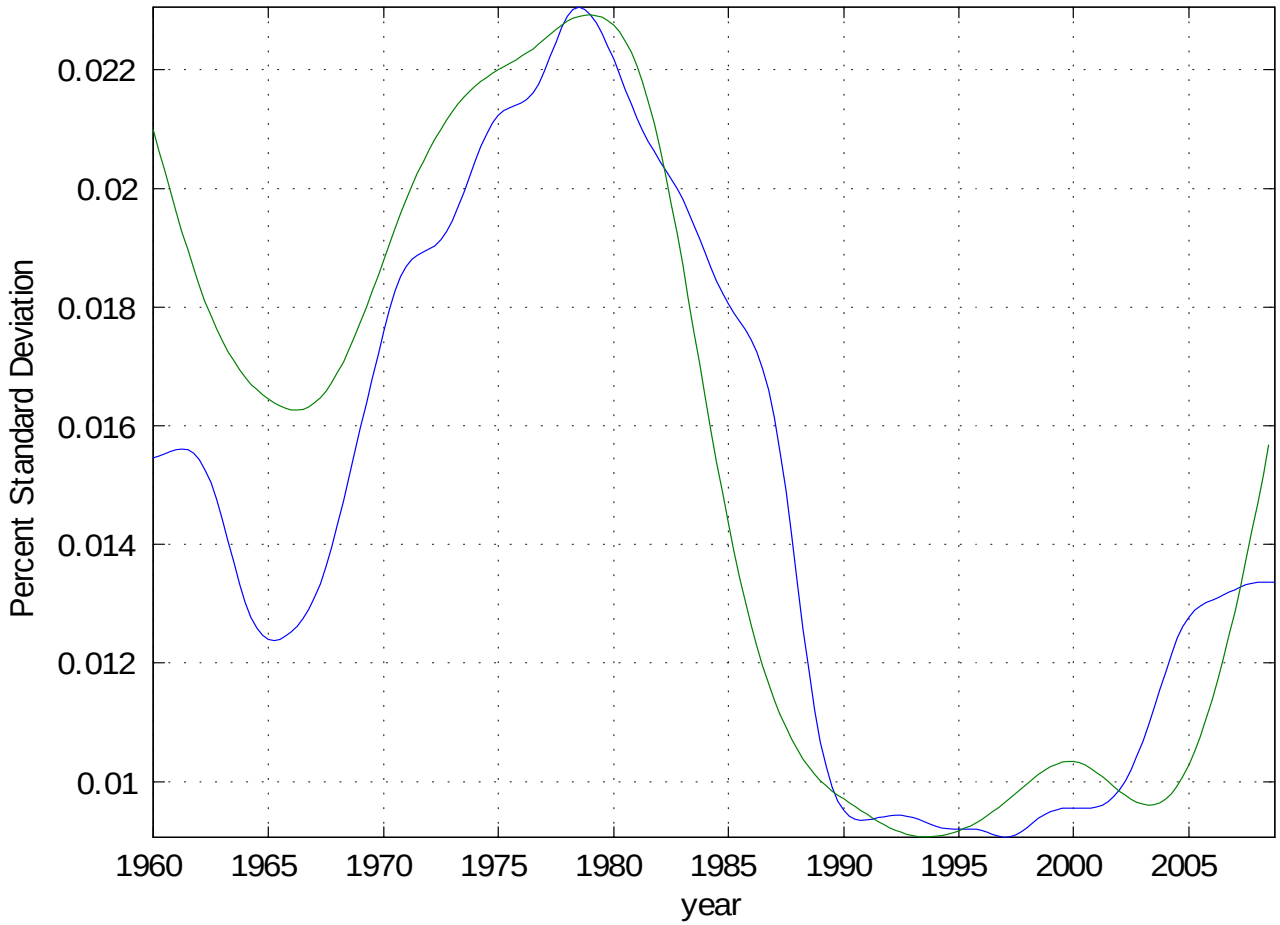
Intro

Whence Macro Volatility?



Two measures of GDP Volatility (US 1960:2008)

Intro

The Micro Origins of Macro Volatility

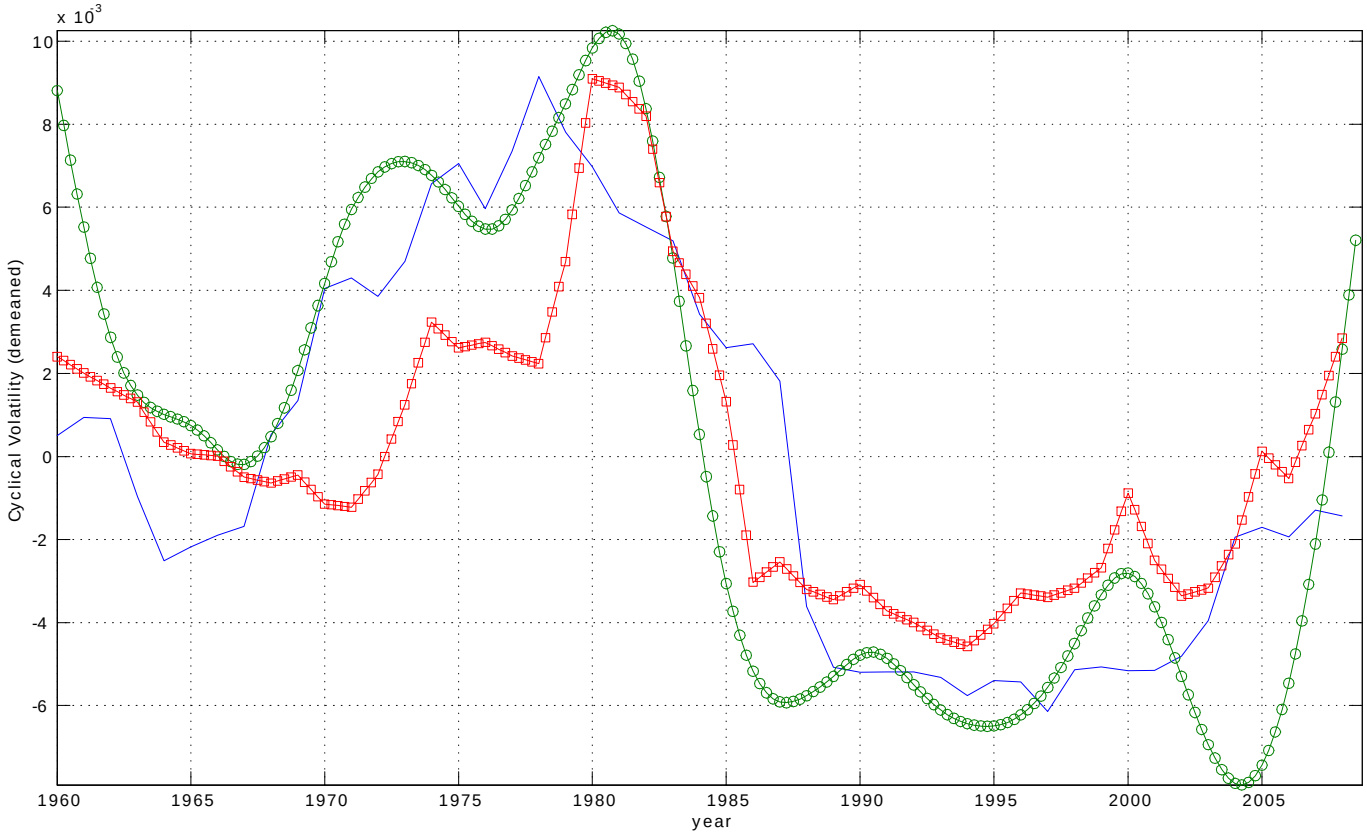
- What drives GDP volatility over the past half century?
- We propose that:
  - Macroeconomic volatility behaves as if all volatility was due to idiosyncratic microeconomic shocks.
  - Operationalize this by defining "fundamental" volatility:

$$\sigma_{Ft} = \sqrt{\sum_{i=1}^{n} \left(\frac{S_{it}}{Y_t}\right)^2 \sigma_i^2}$$

  - Evolution of macro volatility reflects only changing composition of micro units up to a constant multiplier (micro volatility is assumed constant)

Intro

The Micro Origins of Macro Volatility



In red: $\sigma_{Yt} = 4.6\sigma_{Ft}$; all volatility measures demeaned

Intro

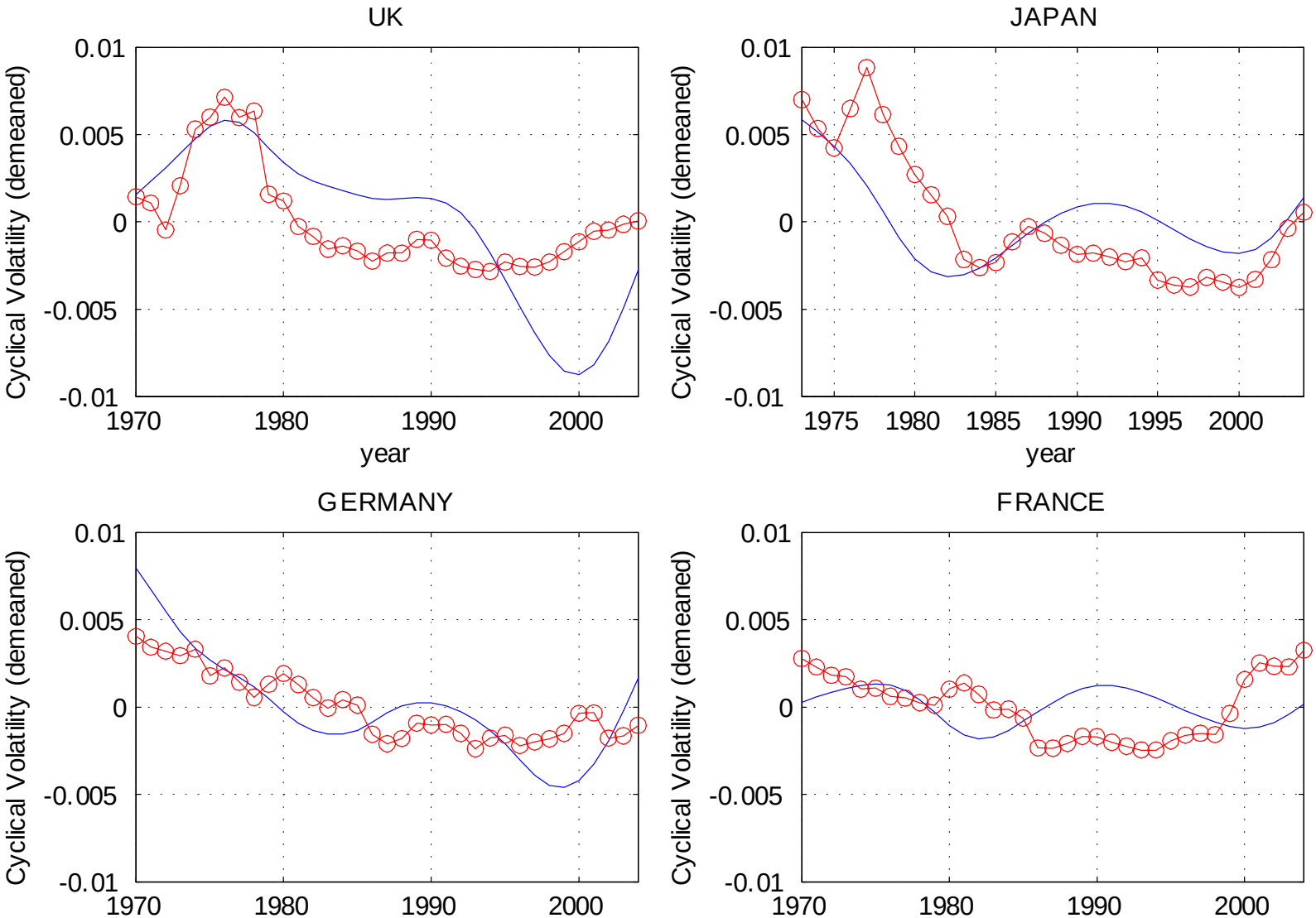
The Micro Origins of Macro Volatility Swings

- Changing importance of key sectors can explain the evolution of GDP volatility in the US & offers a narrative for the past 50 years of US macro volatility:
  - low frequency decline from 60s to mid-90s is due to the decline of a handful of manufacturing technologies, that accelerates circa 1980.
  - late 70s temporary peak reflects only movements in energy-related technologies
  - mid/late 90s reversal and recent increase reflects (mostly) the rise of finance activities

- What about other countries?

Intro

The Micro Origins of Macro Volatility Swings: International Evidence



blue σ_{Yct}; red: $4.5\overline{\sigma}_{Fct}$

Intro

Related Literature

- Origins of macroeconomic shocks
  - vindicate the hypothesis that macro fluctuations can be traced back to micro shocks (Long and Plosser 83; Horvath 00; Gabaix 09; Carvalho 09)
- Origins of the Great Moderation
  - provide an alternative, micro-based, explanation for the origins of the great moderation (Blanchard and Simon 01; Stock and Watson 03&05; Arias, Hansen and Ohanian 07; Justiniano and Primicieri 08; Gali and Gambetti 09)
- Technological Diversification & Structural Change
  - we emphasize movements over time rather than levels of volatility across countries (Imbs and Wacziarg 03; Koren and Tenreyro 07&09; Moro 09)
  - based on micro-TFP accounting rather than evolution of value added shares

Intro

Roadmap

- Fundamental Volatility
  - Measurement
  - The US case
  - Some international evidence
- How to model it
- A brief narrative of the evolution of fundamental volatiliy
- Time-varying tail risks in the aggregate economy

Fundamental Volatility

Key Statistic

- Starting point: Hulten's (1978) TFP growth formula

$$\Delta TFP_t = \sum_{i=1}^{N} \frac{S_{it}}{Y_t} \Delta TFP_{i,t}$$

- Fundamental volatility: Hulten + independent draws of $\Delta TFP_{i,t}$

$$\Rightarrow \sigma_{Ft} = \sqrt{\sum_{i=1}^{n} \left(\frac{S_{it}}{Y_t}\right)^2 \sigma_i^2}$$

- Multi-sector model (developed later)

$$\begin{aligned} \sigma_{Yt} &= \mu \sigma_{Ft} \\ \mu &\equiv \frac{1+\varphi}{\alpha} \end{aligned}$$

where φ is Frisch elasticity, α is labor share

Sectoral Data

Overview

- Extension of traditional Jorgenson KLEM data
  - $\simeq$ 80 sectors, 2 digit SIC, annual panel 1960-05
  - Covers entire economy: added detail in service sectors
  - Prices reflect quality adjustments
  - Can do sectoral TFP accounting
  - Aggregate up to get consistent aggregate GDP series
- Splice with BLS input-output data till 2008

Fundamental Volatility

Ingredient 1: Domar Weights

- Look into the Herfindahl-like index for Domar weights

$$h_t^D = \sum_{i=1}^{N} \left(\frac{S_{it}}{Y_t} \right)^2$$

where S_{it} is sector i nominal *gross* output in year t

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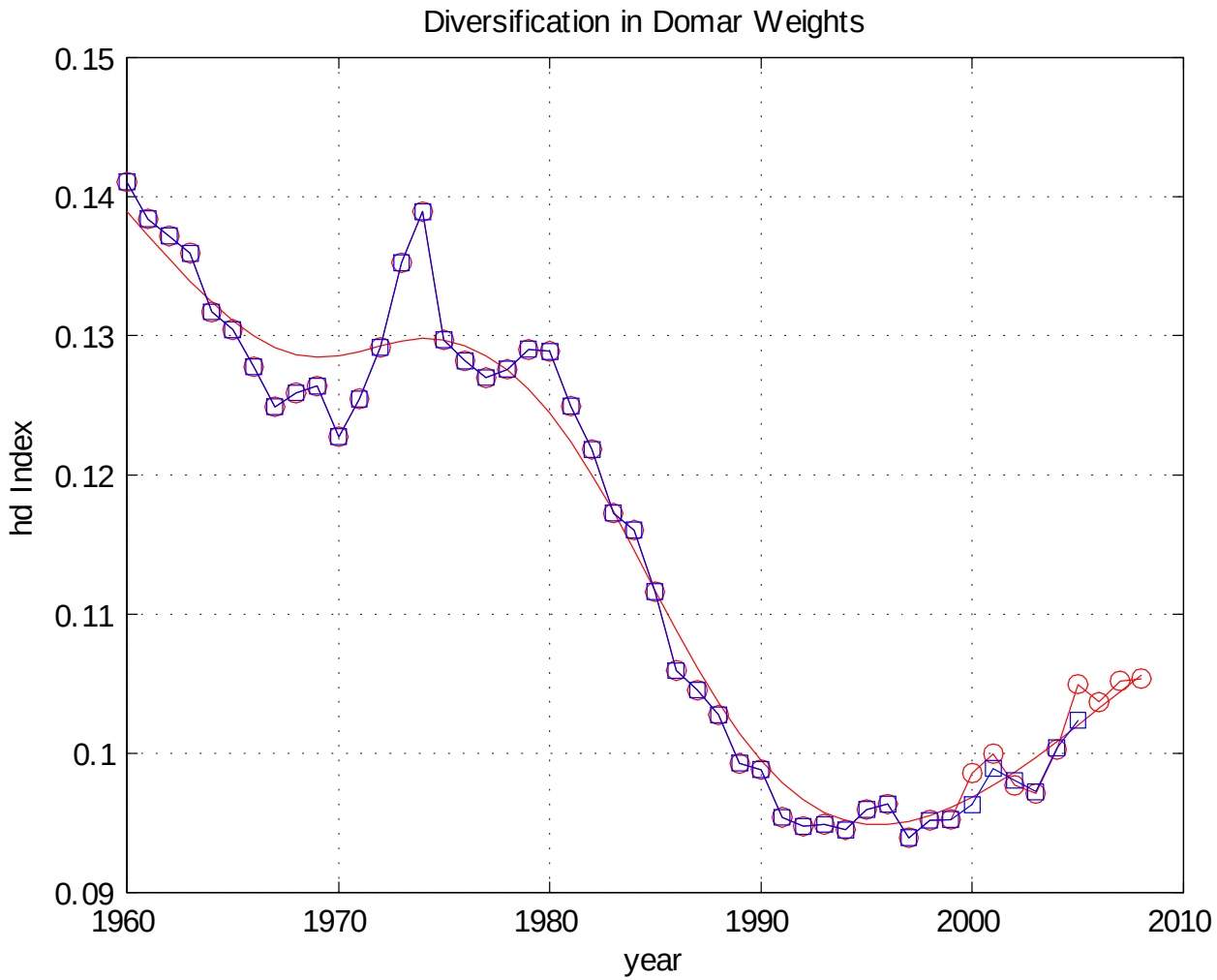
  - Note: Domar weights do not sum to one
  - But still valid to look at cross-sectional second moments

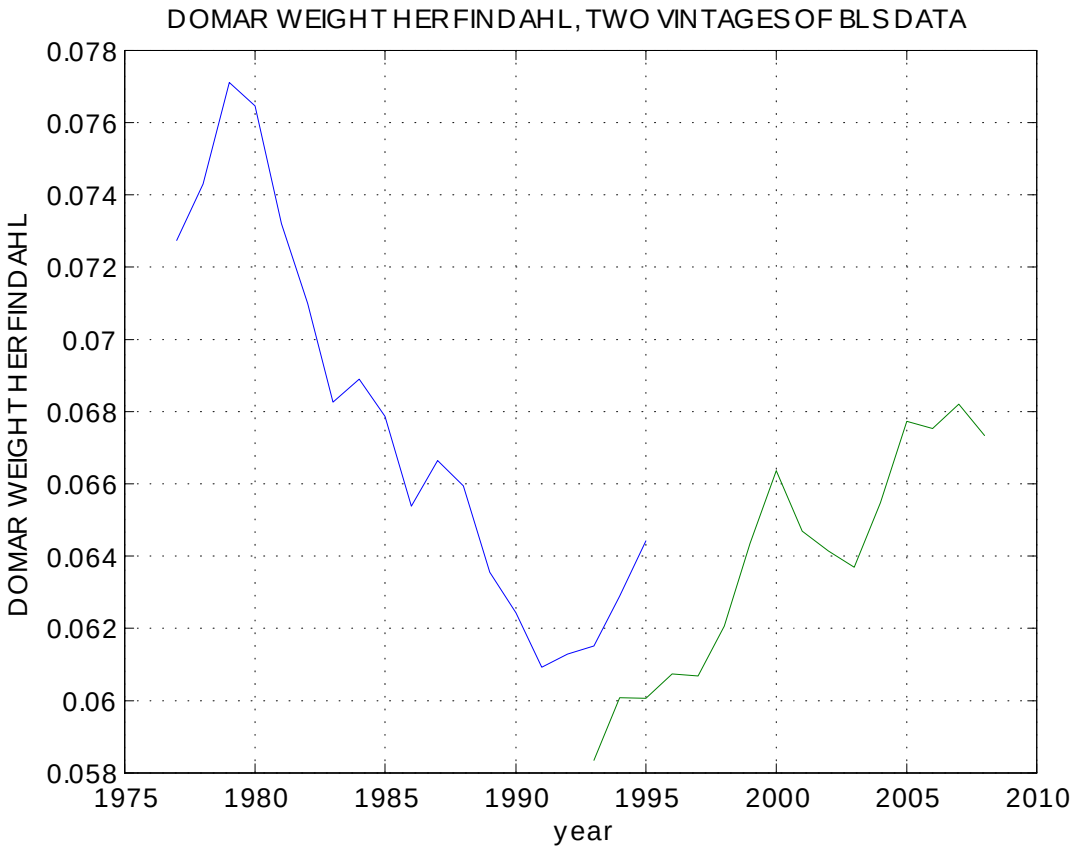
Trends and Swings in Diversification

Ingredient 1: Domar Weights



Trends and Swings in Diversification

Ingredient 1: Domar Weights (cross-checks)



- Also holds in BLS source data:
  - ($\simeq$ 200 sectors)
  - SIC vintage (77-95)
  - NAICS vintage (93-08)
- Holds with other measures of dispersion/concentration
- Holds with value added or employment data

Fundamental Volatility

Ingredient 2: Sectoral TFP volatility

- Sectoral TFP growth

$$\Delta TFP_{i,t} = \Delta \log(Q_{i,t}) - \overline{v}_{K_{i,t}} \Delta \log(K_{i,t}) - \overline{v}_{L_{i,t}} \Delta \log(L_{i,t}) - \overline{v}_{X_{i,t}} \Delta \log(X_{i,t}$$

- Sectoral TFP volatility:

$$\sigma_i^2 = Var(\Delta TFP_{i,t})$$

- No time-varying sectoral volatility (borne out by data)
- Assemble to get fundamental volatility:

$$\sigma_{Ft} = \sqrt{\sum_{i=1}^{n} \left(\frac{S_{it}}{Y_t}\right)^2 \sigma_i^2}$$

Aggregate and Fundamental Volatility

- Now consider a regression:

$$\sigma_{Yt} = a + b\sigma_{Ft} + \varepsilon_t$$

- where σ_{Yt} is a measure of cyclical volatility:
  - σ_{Yt}^{Roll} : Rolling window standard deviation at quarter t
  - σ_{Yt}^{Inst} : Instantaneous quarterly standard deviation computed as

$$\begin{aligned} \Delta y_t &= \psi + \phi \Delta y_{t-1} + \epsilon_t \\ \sigma_{Yt}^{Inst} &\equiv 2\sqrt{\frac{\pi}{2}}|\widehat{\epsilon}_t| \end{aligned}$$

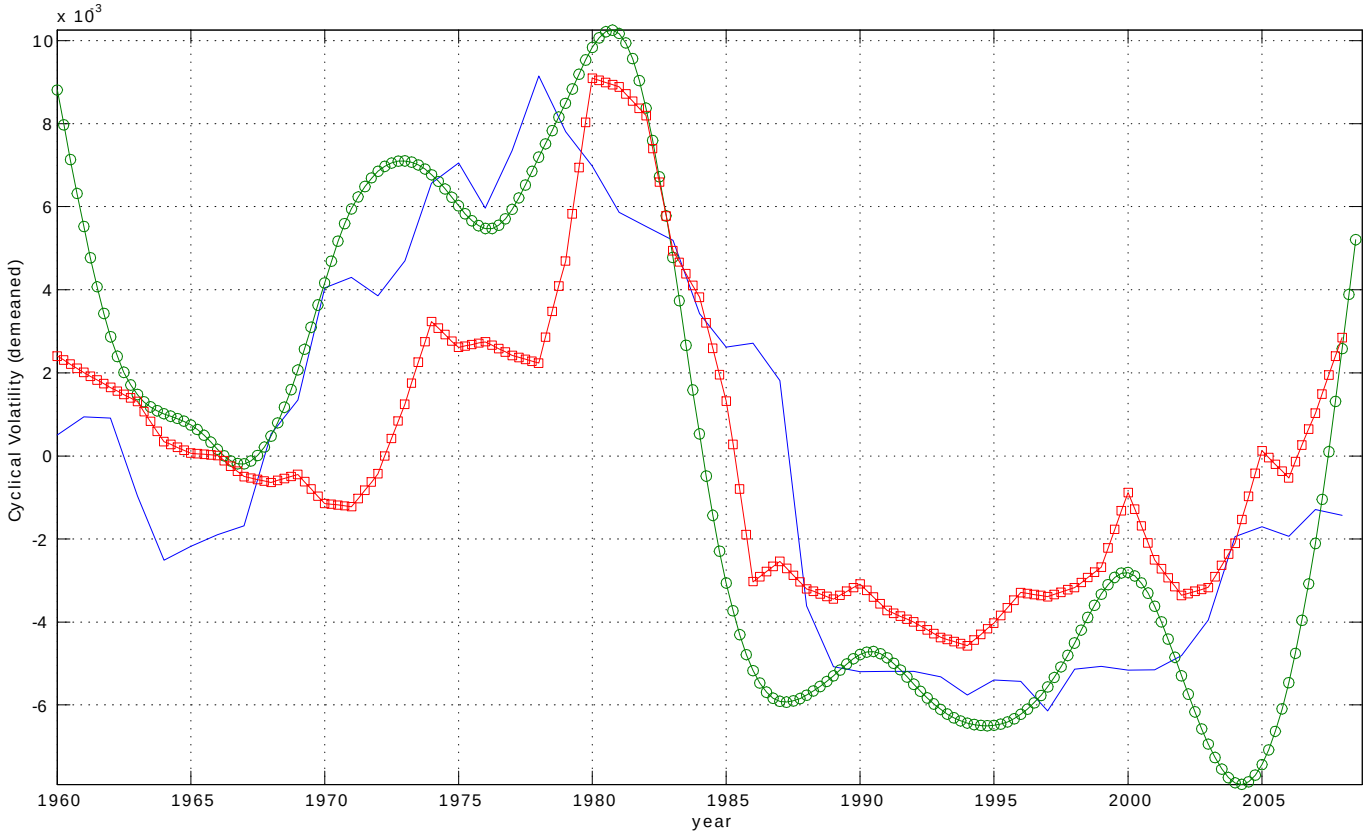
  - Annualize by taking 4-quarter average

Aggregate and Fundamental Volatility

	Annual Data- σ_{Yt}^{Roll}	Annual Data- σ_{Yt}^{Inst}
$\widehat{a}$	-0.011 (0.005)	-0.019 (0.013)
$\widehat{b}$	4.614 (0.574)	6.741 (1.434)
R^2	0.60	0.33

- $\sigma_{Yt} = a + b\sigma_{Ft} + \varepsilon_t$
- s.e. in parenthesis
- Same results for quarterly frequency

Aggregate and Fundamental Volatility



In red: $\sigma_{Yt} = 4.6\sigma_{Ft}$; all volatility measures demeaned

Fundamental Volatility

Accounting for Breaks

- A common way of encoding the Great Moderation is to test null of a constant level in volatility:

$$\sigma_{Yt}^{Inst} = a + \eta_t$$

against the alternative featuring a break:

$$\sigma_{Yt} = a + cD_t + \eta_t$$

where D_t is a dummy (1 for $t \geq T$) for an estimated break date T.

- Strong support for a level break in 1984:Q1 (as in McConnell and Quiros, 00)
- Estimate $\widehat{c}$ implies a permanent percentage point decrease in aggregate volatility after this date.

Fundamental Volatility

Accounting for Breaks

- Now consider testing the following hypothesis
  - Controlling for our fundamental volatility measure there is no level break in aggregate volatility.
  - That is we test for the null of no break in the intercept in the following equation:

$$\sigma_{Yt}^{\text{Inst}} = a + b\sigma_{Ft} + \eta_t$$

	Without σ_{Ft}	With σ_{Ft}	
H_0	No break in a	No Break in a	No Break in b
$SupF$ test	32.33	8.60	8.96
Null of no break	Reject	Accept	Accept
Est. break date	1984:1	None	None

International Evidence

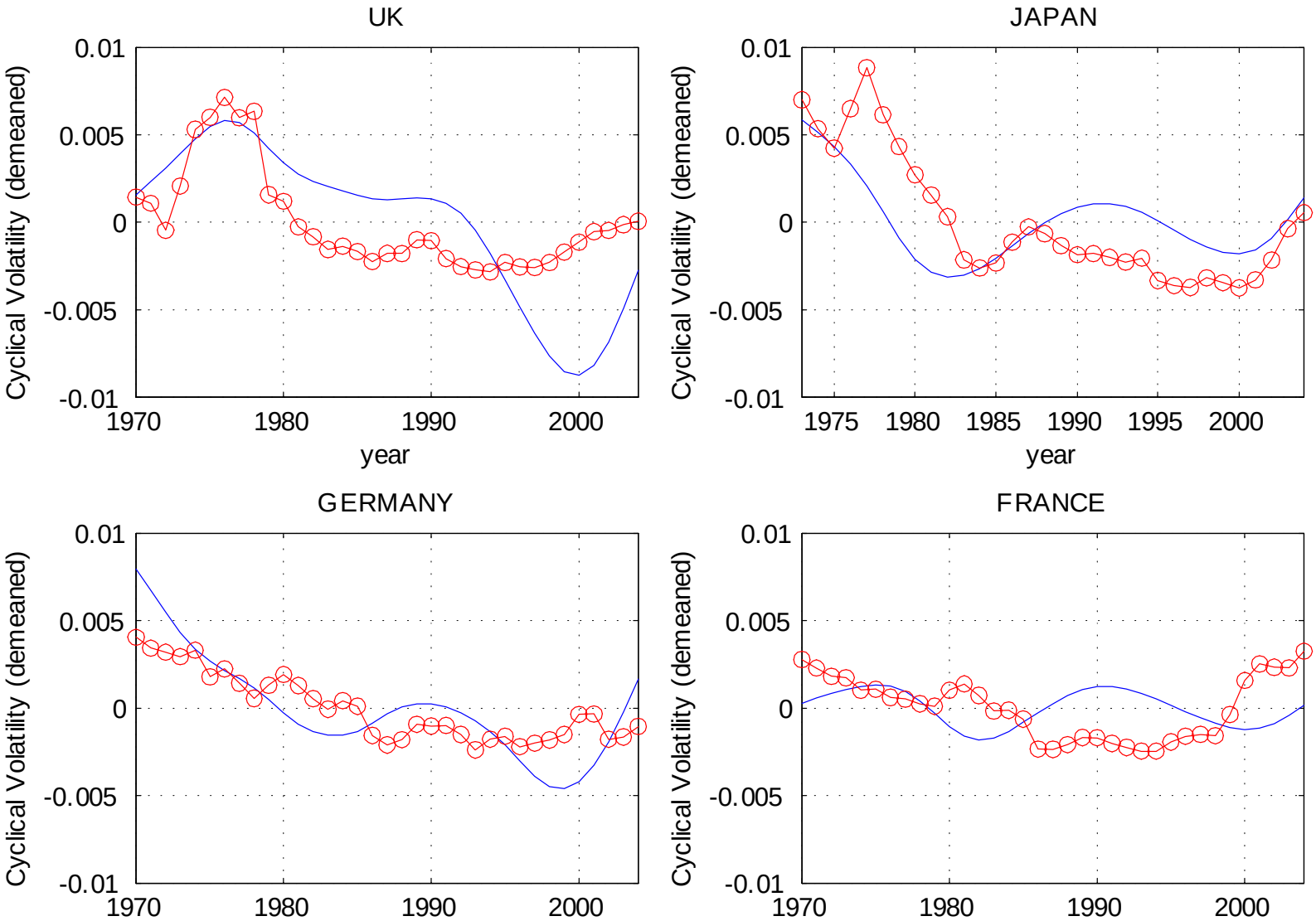
- Different countries exhibit different time patterns in macro-volatility.
  - Does this reflect different evolution of fundamental volatility?

- Look into largest economies: France, Germany, Japan and UK
  - Use EUKLEMS database (1970-2005 only)
  - Sufficiently detailed nominal breakdown
  - Limitation: uneven availability of sectoral price indexes⇒can't do σ_i^2 for $\forall i$
    - Instead define country-specific fundamental volatility:

$$\overline{\sigma}_{Fct} = \overline{\sigma}_c \sqrt{\sum_{i=1}^{N} \left(\frac{S_{ict}}{Y_{ct}} \right)^2}$$

    - where $\overline{\sigma}_c$ is the average for the sectors we do observe prices

International Evidence



- Red: Fundamental volatility measure, $\sigma_{Yt} = 4.5\overline{\sigma}_{Ft}$.

International Evidence

- As a complement, consider running panel:

$$\sigma_{Yct} = \alpha_c + \chi t + \beta \overline{\sigma}_{Fct} + \varepsilon_{ct}$$

- σ_{Yct}: cyclical volatility for country c in year t (rolling window measure)
- Include the US along with the four other economies mentioned above.
-

	$\sigma_{ct}(OLS)$	$\sigma_{ct}(OLS)$
$\widehat{\beta}$	3.193 (0.478)	1.971 (0.578)
χt	No	Yes
Observations	172	172

- Still significant when instrumenting by lagged fundamental volatility.

Fundamental Volatility

A simple, static, multi-sector model

Technology

- 1 final good: used either for consumption C or for use as an input in each of the N sectors, X_i.
- Final good technology: CES aggregate of the intermediates Q_i

$$\left(\sum_{i=1}^{N} Q_i^{\frac{1}{\psi}}\right)^{\psi} = Y + \sum_{i=1}^{N} X_i, \qquad \psi > 1$$

- Each intermediate sector combines labor L_i, capital, K_i and the final good X_i
- Cobb-Douglas, constant returns to scale

$$Q_i = \frac{1}{\kappa} A_i (L_i^{\alpha} K_i^{1-\alpha})^b X_i^{1-b}$$

where κ normalization constant: $\kappa = b^b (1-b)^{1-b}$

Fundamental Volatility

A simple, static, multi-sector model

Preferences and Endowments:

- Representative Household

$$U(C, L) = C - L^{1+\frac{1}{\varphi}}$$

- The household owns stock of labor L and capital K. Capital rented out to the N sectors at rate r.

Resource Constraints:

- There is no investment, so $C = Y$.
- $\sum K_i = K$, $\sum L_i = K$

Fundamental Volatility

A simple, static, multi-sector model

- Social Planner's solution gives:

$$\text{GDP} : Y = \Lambda L^{\alpha} K^{1-\alpha}$$

$$\text{TFP} : \Lambda = \left(\sum_i A_i^{1/(\psi-1)} \right)^{(\psi-1)/b}$$

- $1/b$ is a "productivity multiplier". If all sectors increase their productivity A_i by 1%, TFP increases by $1/b$ %.

Fundamental Volatility

A simple, static, multi-sector model

- Suppose each sector i is hit by productivity shock $\widehat{A}_i$. Then:

$$\text{TFP}: \ \widehat{\Lambda} = \sum \frac{S_i}{Y} \widehat{A}_i = \sum \frac{\text{Sales}_i}{\text{GDP}} \widehat{A}_i$$

$$\text{GDP}: \ \widehat{Y} = \frac{1+\varphi}{\alpha} \widehat{\Lambda}$$

- **Proposition**: if $\widehat{A}_i$ is independently distributed. across sectors:

$$\begin{aligned} \sigma_{Yt} &= \mu \sqrt{\sum_{i=1}^{n} \left(\frac{S_{it}}{Y_t} \right)^2 \sigma_i^2} \equiv \mu \sigma_{Ft} \\ \mu &\equiv \frac{1+\varphi}{\alpha} \end{aligned}$$

- Note: $\varphi \simeq 2, \alpha = 0.66 \Rightarrow \mu \simeq 4.5$!

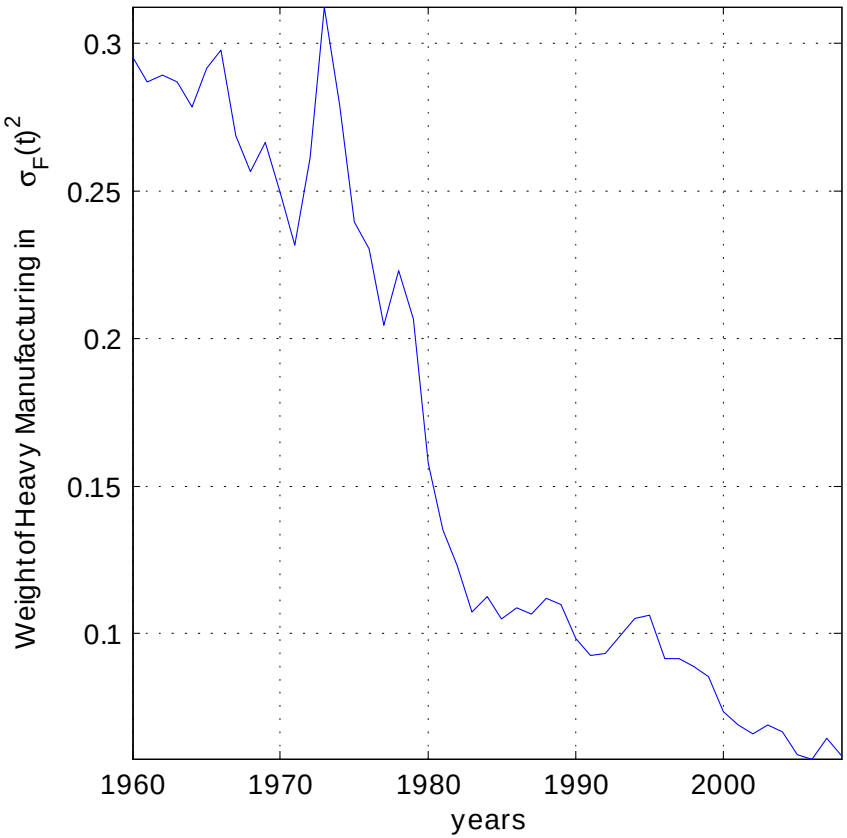
A Brief History of Fundamental Volatility

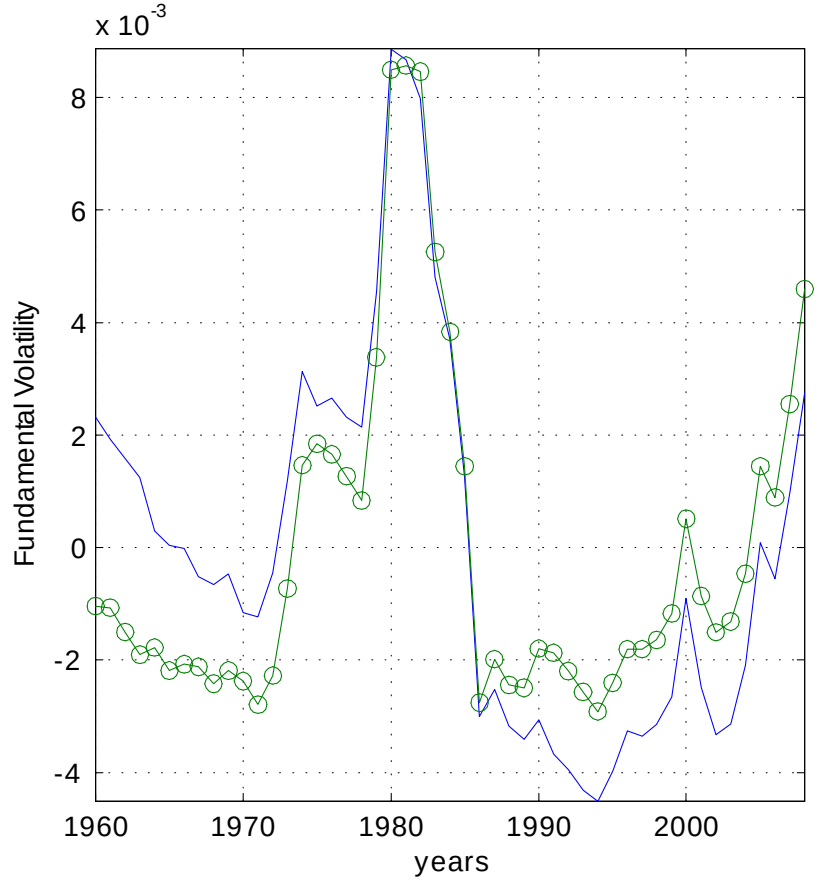
Macro Questions & Micro Answers for the U.S.

- What accounts for the long and large decline from 1960-mid 1990s?
  - A: Construction + 4 heavy-manufacturing sectors: Primary Metals, Fabricated Metal Products, Machinery (excluding computers) and Motor Vehicles.
- What accounts for the interruption of this trend from mid 70s to early 80s?
  - A: Energy related sectors: Oil and gas extraction and Petroleum and coal products
- What is behind the reversal of fundamental volatility trends and its increase since the mid 90s?
  - A: Depository Institutions, Non-Depository Financial Institutions (including Brokerage Services and Investment Banks), and Insurance Services.

A Brief History of Fundamental Volatility

1960-mid 1990s

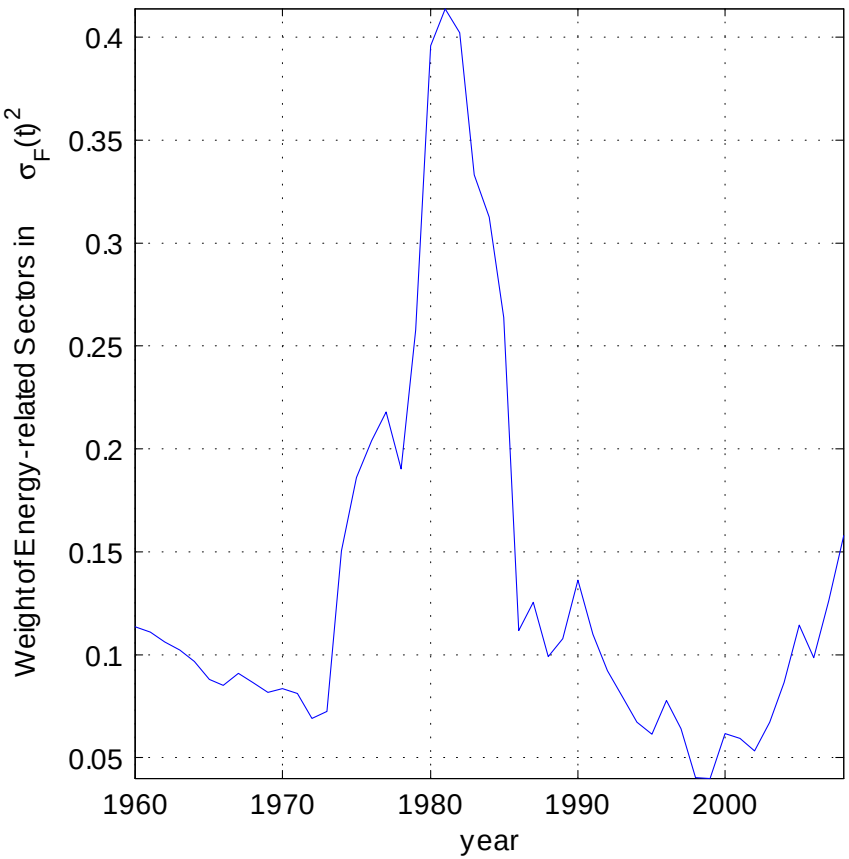


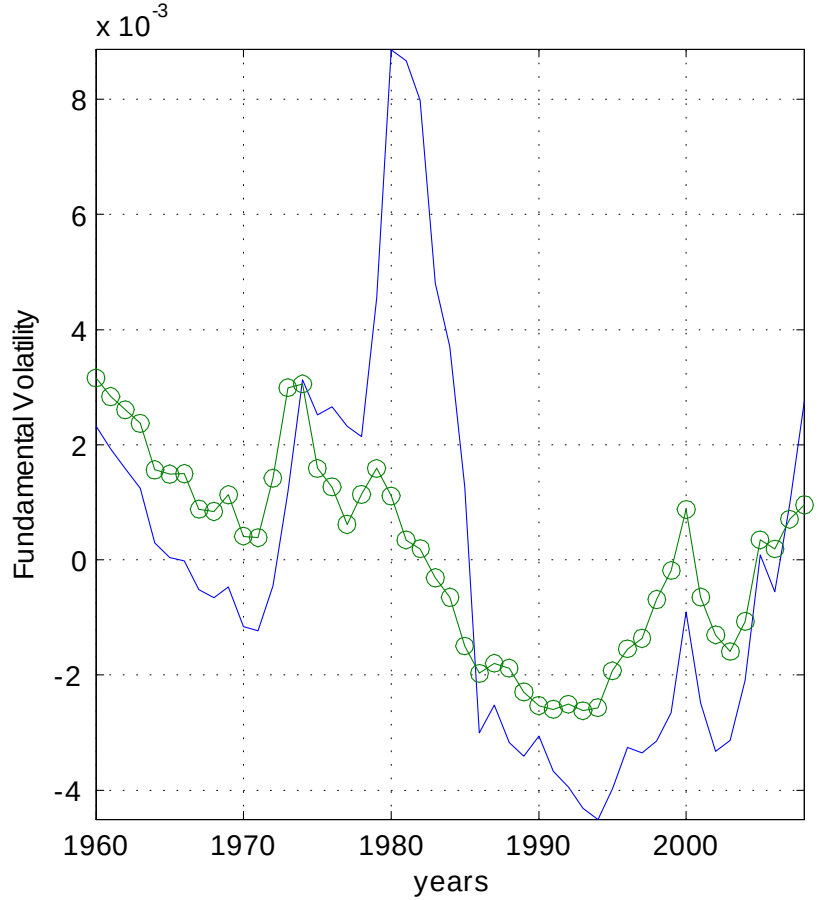


- LHS: Weight of 5 manufacturing sectors in $\sigma_F^2(t)$.
- RHS (Blue): baseline fundamental vol. $(4.5\sigma_F(t))$;(Green): counterfactual volatility (weights of manuf. sectors fixed)

A Brief History of Fundamental Volatility

Late 70s spike

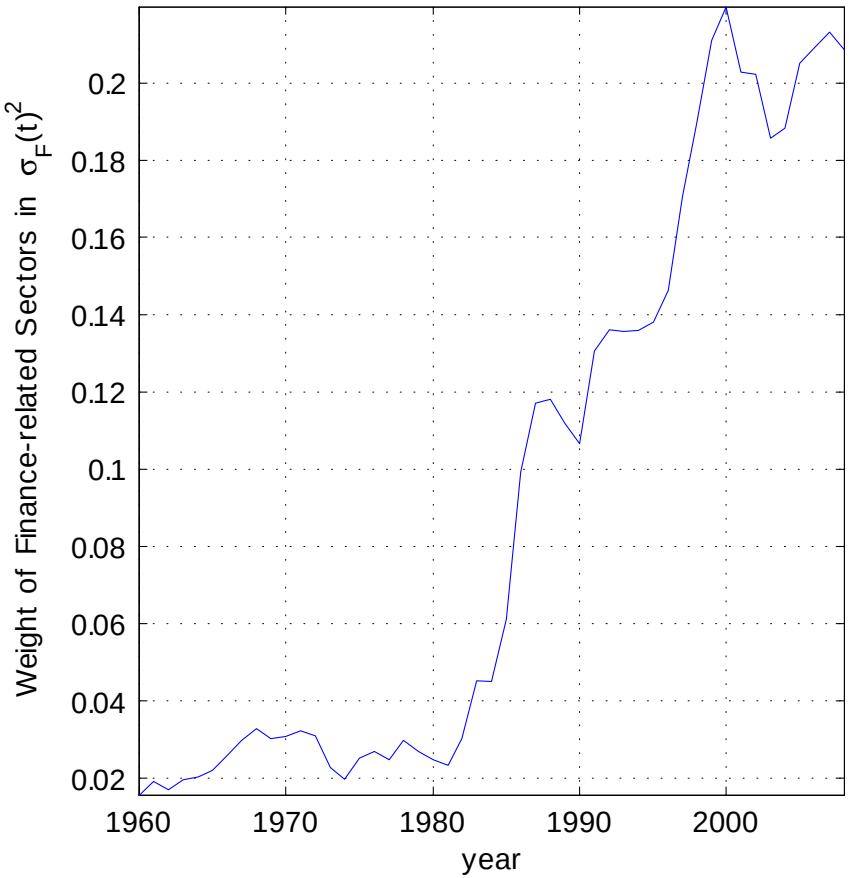


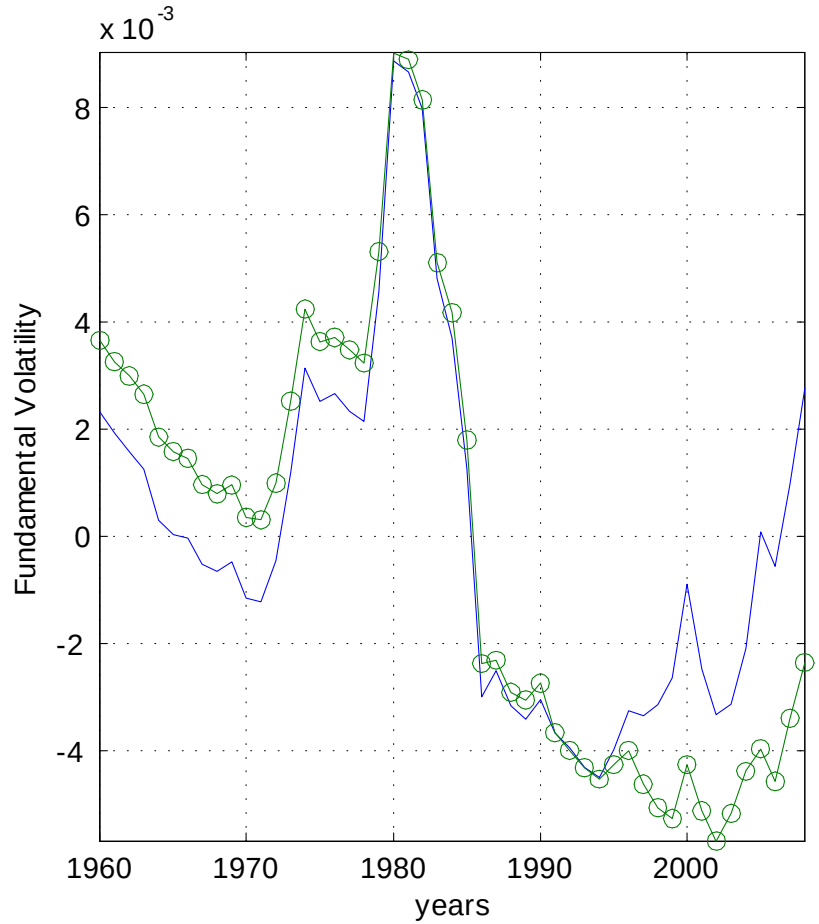


- LHS: Weight of energy related sectors in $\sigma_F^2(t)$.
- RHS (Blue): baseline fundamental vol ($4.5\sigma_F(t)$); (Green): counterfactual volatility (weights of energy sectors fixed)

A Brief History of Fundamental Volatility

Mid 90s-2008





- LHS: Weight of finance related sectors in $\sigma_F^2(t)$.
- RHS (Blue): baseline fundamental vol ($4.5\sigma_F(t)$); (Green): counterfactual volatility (weights of finance sectors fixed)

Tail Risk in the Aggregate Economy

Methods

- What is the probability of a large negative GDP growth event?
- To answer this:
  - Fix $\mu = 4.5$ and feed sample domar-weights in:

$$\Delta Y_t = \mu \sum_{i=1}^{N} \left(\frac{S_{i,t}}{Y_t} \right) \Delta TFP_{i,t}$$

  - At each $t, 10^4$ draws of $\Delta TFP_{i,t} \sim N(0, \sigma_i^2)$
  - Compute tail risk probability:

$$\Pr[\Delta Y_t < -1.64\overline{\sigma_Y}]$$

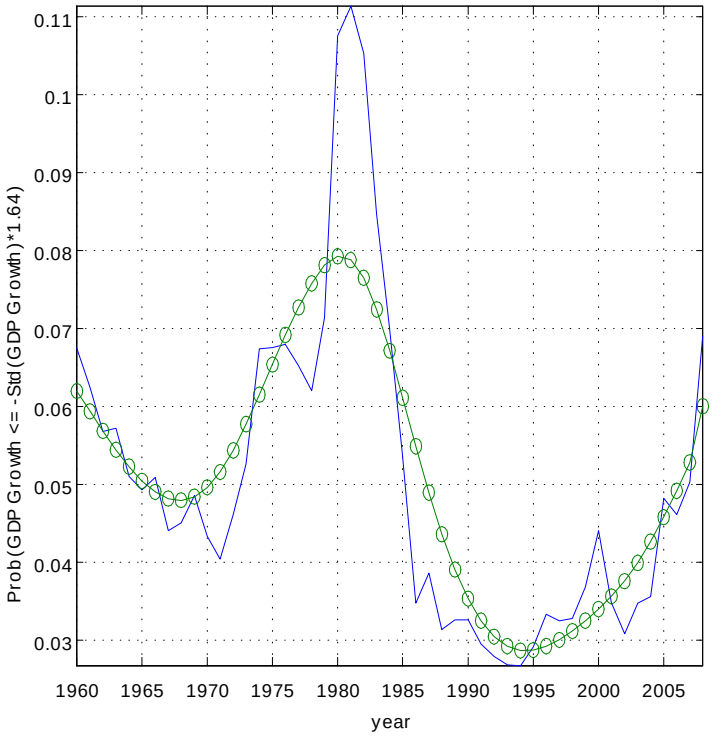
  - where $\overline{\sigma_Y}$ is model implied average GDP volatility (over full sample)

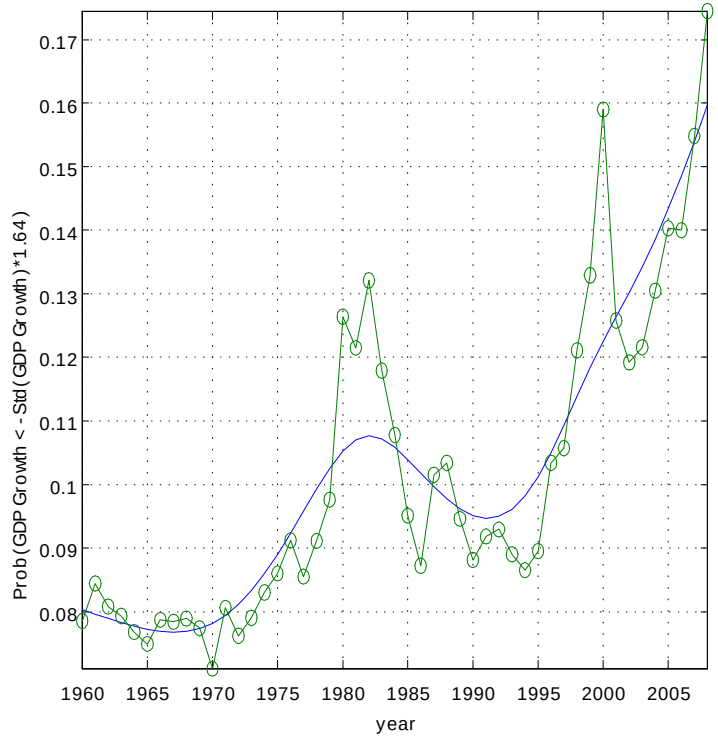
Fragility to Finance?

Methods

- However, this tail risk does not inform of fragility to *tail events in particular sectors* of the economy.
- What is the evolution of fragility to finance-related sectors?
  - Pick "Non-depository institutions, security and commodity brokers and investment banks"
  - For $\forall$ t and $\forall$ simulations: draw negative 2 std. deviation shock to TFP growth in this sector
  - All other shocks drawn from $N(0, \sigma_i^2)$

Tail Risk & Fragility in GDP Growth





LHS: Probability of negative GDP growth in excess of 1.64 st.dev., given the level of fundamental volatility.

RHS: Probability of negative GDP growth in excess of 1.64 st.dev., given two st.dev. shocks to the financial sector.

Conclusion

- Key to macroeconomic volatility might be found in local, microeconomic shocks.

- We find that macro volatility swings can be accounted for by fundamental volatility swings:
  - The evolution of fundamental volatility can account for the US "great moderation"
  - It can account for its recent undoing
  - It can account for heterogeneity in the evolution of macro volatility across major economies

- Looking ahead
  - Efficient diversification? Have some technologies "grown too large"? Is there a role for policy?
  - Can fundamental volatility serve as an early warning system?

Thanks... Now Vote !

- "Fundamental volatility" or:
  - Microeconomic volatility
  - Granular volatility
  - Incompressible volatility
  - [Insert your answer here]

- "The Great Diversification and its Undoing" or:
  - The Micro Origins of Macro Volatility Swings
  - Accounting for Aggregate Volatility Swings
  - The Fall and Rise of Aggregate Volatility
  - [Insert your answer here]