The Rise and Fall of US TFP Growth, 1899-2019: Ideas, Idea Processing, and Financial Market Effectiveness

Kevin R. James
Systemic Risk Centre
London School of Economics
k.james1@lse.ac.uk

Akshay Kotak
Systemic Risk Centre
London School of Economics
a.kotak@lse.ac.uk

Dimitri Tsomocos
Saïd Business School
Oxford
dimitrios.tsomocos@sbs.ox.ac.uk

21 August, 2024

Key Takeaways

- **Innovativity drives TFP Growth** (TFP = Total Factor Productivity);
- **Innovativity** is a function of **idea supply** and the economy's **idea processing capacity**;
- **Idea supply** is driven by the **traditional factors** associated with TFP growth (R&D spending, etc.);
- **Idea processing capacity** is driven by the **strategies that firms choose** to develop their projects;
- **Effective financial markets enable** firms to pursue long-horizon **Innovation strategies** that boost idea processing capacity;
- We show empirically that **US TFP growth fell** after 1970 due to **constraints on idea processing capacity**, **not idea supply**;
- **Increasing idea processing capacity by improving financial market effectiveness** therefore offers a **promising path to boost TFP growth**.

Outline

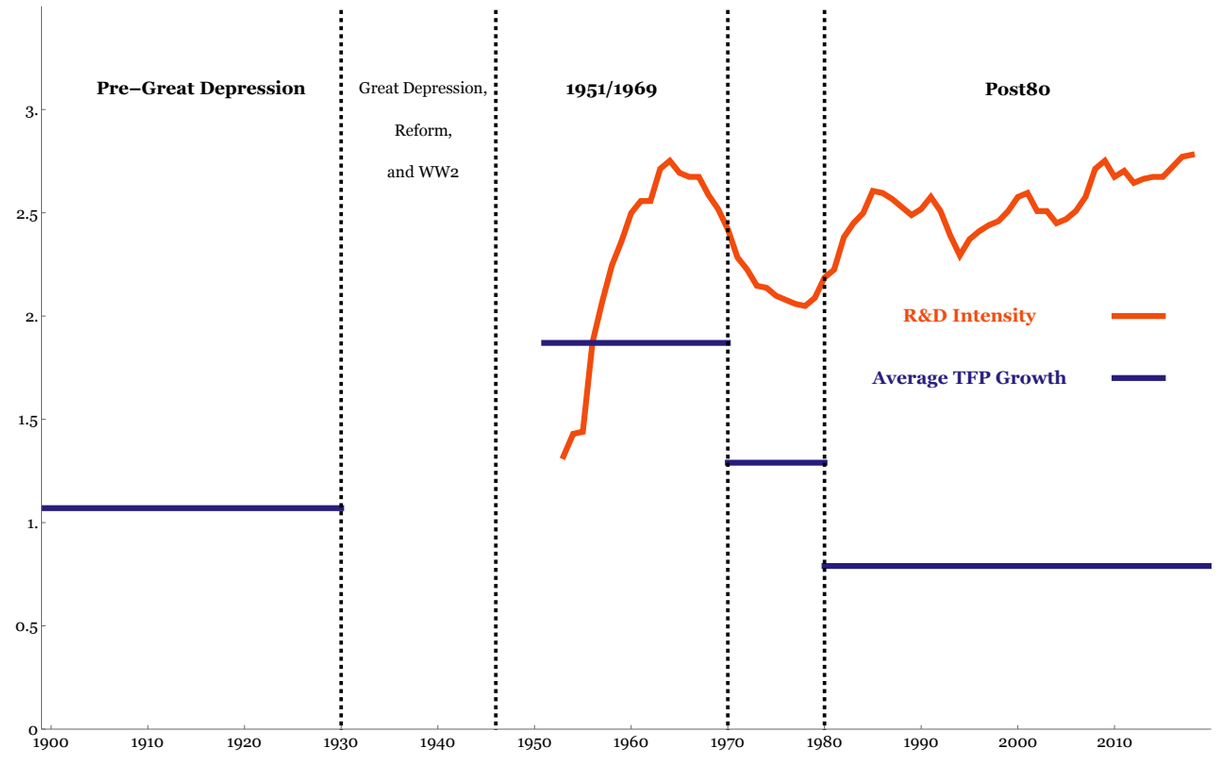
- The Puzzling Evolution of US TFP Growth
- Innovativity: TFP Growth Arises From Processed Ideas
- Measuring Innovativity

The Puzzling Evolution of US TFP Growth

The Puzzling Evolution of US TFP Growth

- Endogenous Growth Theory (EGT): “Economic growth arises from people creating ideas”;
  - Romer (1986,1990), Aghion and Howitt (1992), Jones (1995,2019), Bloom, Jones, Van Reenan, Webb (2020);
- R&D spending creates ideas;
- But, somehow, R&D spending is increasing while TFP growth is falling;

US TFP Growth



“Solving” the puzzle

- **Assume** that EGT is right;

$$\text{TFP Growth} = F[\text{Number of Ideas}],$$

Implying that

$$\text{TFP Growth} = \text{Number of Ideas} = \frac{\text{R\&D Spending}}{\text{Cost Per Idea}}$$

- So, if TFP Growth is falling while R&D spending is increasing, it **must** be the case that the Cost Per Idea is increasing;
- Hence, TFP Growth is falling because “we are running out of ideas”;
  - Gordon (2012, 2014), Jones (2019), Bloom, Jones, Van Reenen, and Webb (2020);
- But this is not an **explanation,** it is a **rationalization** for why the data doesn’t fit the theory;

Innovativity:

TFP Growth Arises From **Processed Ideas**

Innovativity

- An innovation requires both an idea and a firm to processes that idea into a new product and/or technique;
- The Weitzman (1998) Conjecture

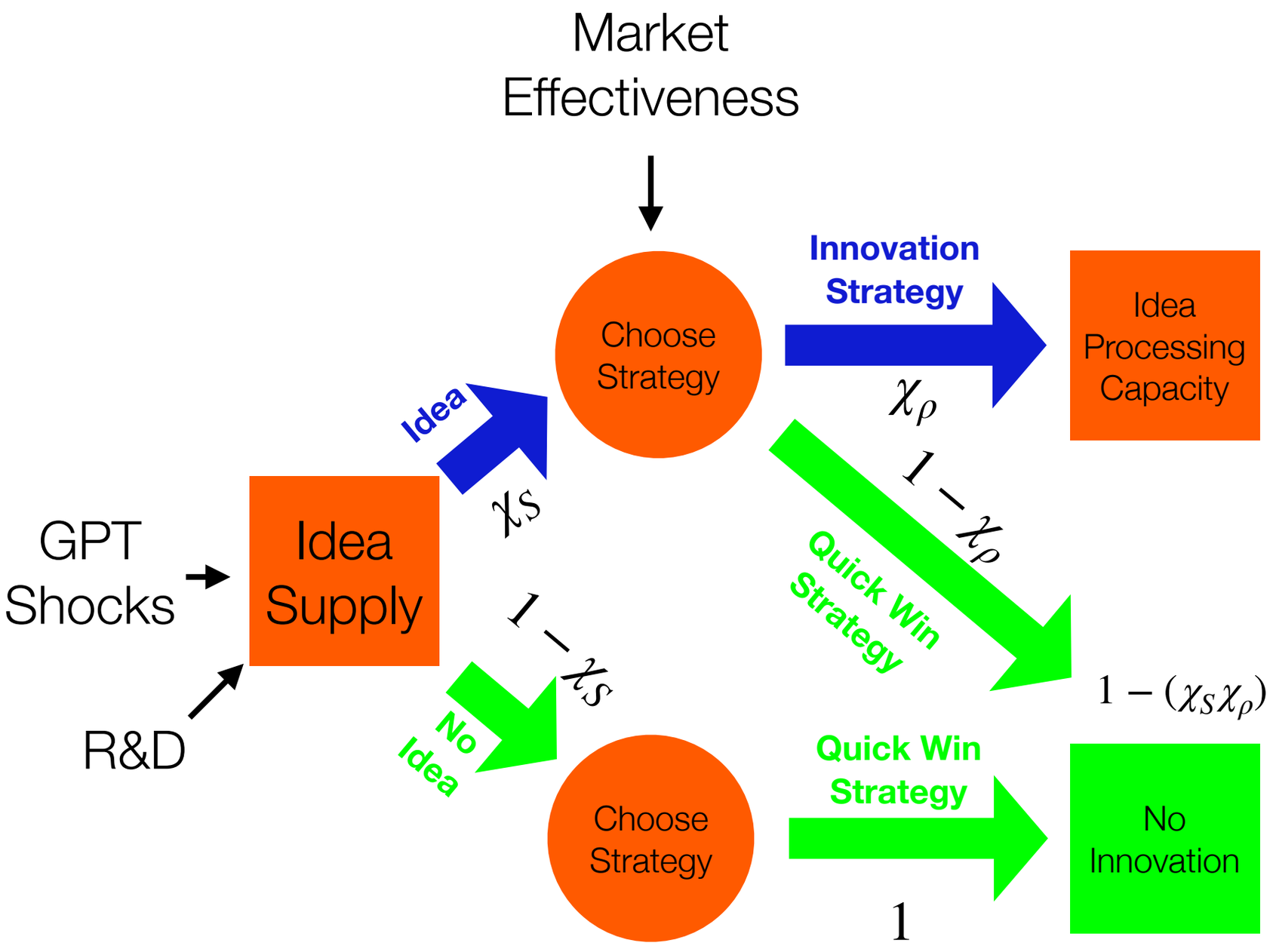
The ultimate limits to growth lie not so much in our ability to generate new ideas as in our ability to process an abundance of potentially new ideas into usable form.

- So

$$\text{TFP Growth} = F[\text{Innovativity}] = \text{ISupply} \times \text{IProcessing}$$

- ISupply = Probability that a firm has an idea;
- IProcessing Capacity = Probability that a firm is able to process an idea;
- A decline in TFP growth could be due to either a fall in idea supply and/or a fall in the economy's idea processing capacity;

Firms, Strategies, and Average TFP Growth



$$\bar{\gamma} = \Gamma[\chi_S\chi_\rho]$$

Strategies

- A firm can choose either an *Innovation* (*I*) strategy or a *Quick-Win* (*Q*) strategy to develop its project, and a firm chooses the strategy that maximizes its expected profit;
    - A firm produces profit if it is a commercial success, and it is a success if it: i) has a *Good* project; and ii) attracts an outside investment (skilled workers, financing, suppliers, etc.);
    - The prob that a firm attracts the outside investment depends upon the Market's estimate of the prob that it has a Good project;
    - The Market bases its estimate upon the strength of the signal that the firm sends. That signal is a function of: i) the firm's strategy; and ii) **Market Effectiveness**;
    - A long-horizon I strategy sends a weaker signal of project quality than a short-horizon Q strategy. The strength of the signal increases with Market Effectiveness;
    - Conditional upon success, a firm obtains a higher profit with an innovation producing I strategy than with a Q strategy;

Strategies, Market Effectiveness, and Innovativity

- The *Q*/*I* Trade-off:
  - Choosing an *I* strategy leads to higher profits conditional upon success (because of the innovation) but a lower probability of success (the long-horizon innovation strategy produces a weaker signal of project quality);
  - Choosing a *Q* strategy leads to lower profits conditional upon success but a higher probability of success (the short-horizon Quick-Win focus produces a stronger signal of project quality);
- But, as Market Effectiveness improves, all firms can produce stronger signals of project quality;
  - Reliable accounting enables outsiders to judge firm performance (Simon 1989), cleaner markets produce more accurate signals of fundamental prices (Pirrong 1995);
  - Market participants use that information to make better choices (Brogaard, Ringgenberg, and Sovich 2019, Choi, Choi, and Malik 2020);
- So, as Market Effectiveness improves, the relative advantage of the signaling focused *Q* strategy falls relative to the innovation focused *I* strategy;
- Idea Processing Capacity therefore improves with Market Effectiveness;

Reality Check: Strategies and Idea Processing

- The Q/I strategy choice is real;
  - Bhattacharya and Packalen (2020) study innovation in science and find that scientists too choose between short-horizon Quick-Win strategies and long-horizon Innovation strategies;
  - Scientists now prefer the Q strategy, and scientific innovation has stagnated. We find that firms now prefer the Q strategy, and economic innovation has stagnated;
- An I strategy enables a firm to process ideas;
  - Arora, Belenzon, Patacconi, and Suh (2019) examine idea processing and find that: i) "university research [requires] additional integration and transformation to become economically useful" ; and ii) Creating a fundamental innovation entails putting into place the capacity to take an idea and "access significant resources...integrate multiple knowledge streams...and direct their research toward solving specific practical problems";
  - We call this "idea processing";

Innovativity and TFP Growth

- So

$$\text{Long Run Average TFP Growth} = F[\text{Innovativity}], \text{ and}$$

$$F[\text{Innovativity}] = \text{ISupply} \times \text{IProcessing} = \frac{\text{Number of I Firms}}{\text{Number of I Firms + Q Firms}}$$

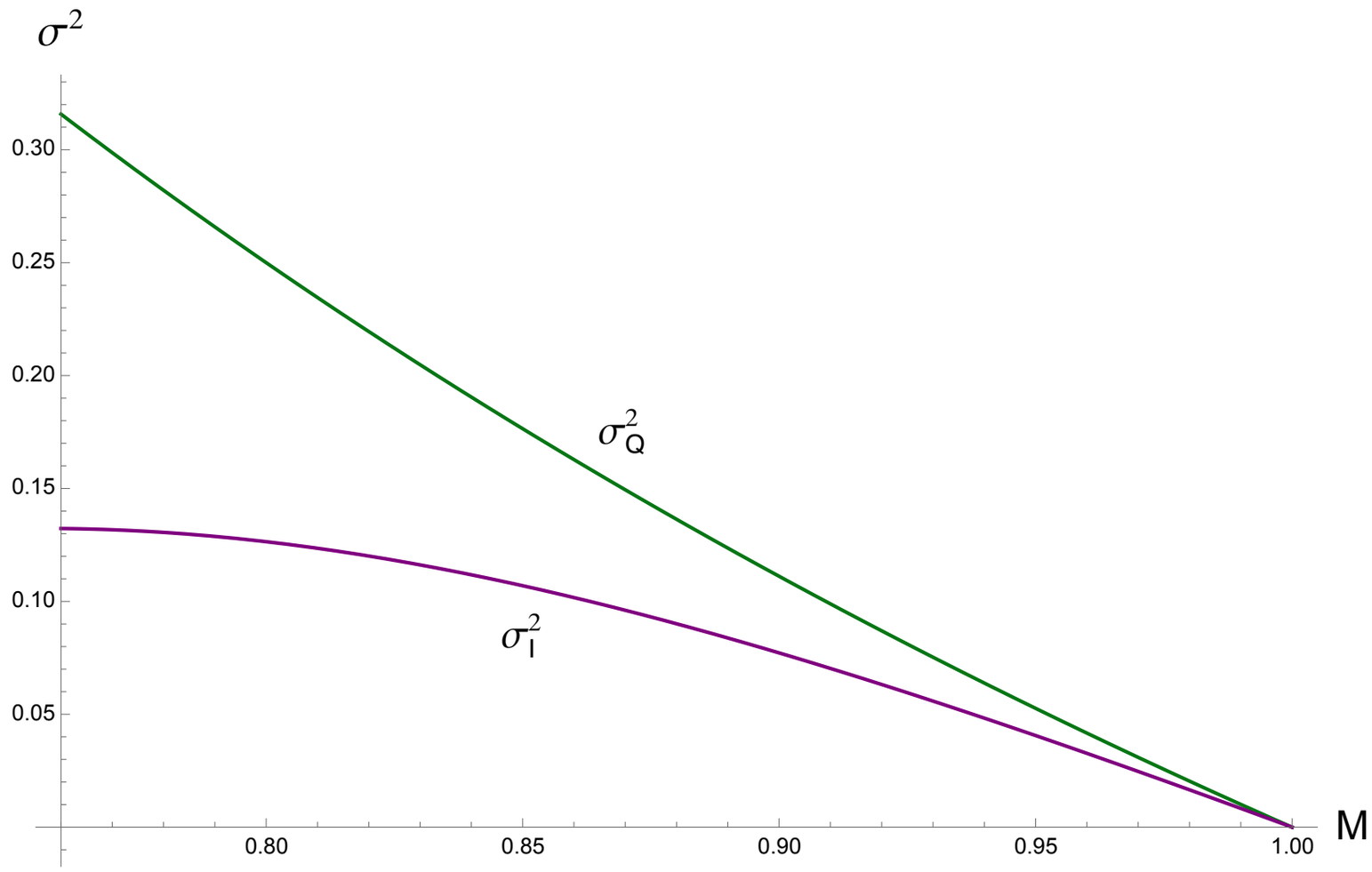
- A positive ISupply (GPT) shock:
  - Increases Innovativity if the ISupply constraint is binding;
  - Does not increase Innovativity if the ISupply constraint is not binding;
- A positive IProcessing (Market Effectiveness) shock:
  - Increases Innovativity if the IProcessing constraint is binding;
  - Does not increase Innovativity if the IProcessing constraint is not binding;

The Evolution of Innovativity and TFP Growth

An Empirical Measure of Innovativity

- We can't measure Innovativity directly, but we know that:
  - Innovativity increases as the ratio of I firms to Q firms increases;
  - I firms produce less information that Q firms;
  - Share prices respond to information; implying that
  - The share price of I firms will bounce around less than the share price of Q firms;
  - Or, in other words, the standard deviation of returns for I firms will be lower than the standard deviation of returns for Q firms;

Firm Strategies and the Return Variance



An Empirical Measure of Innovativity

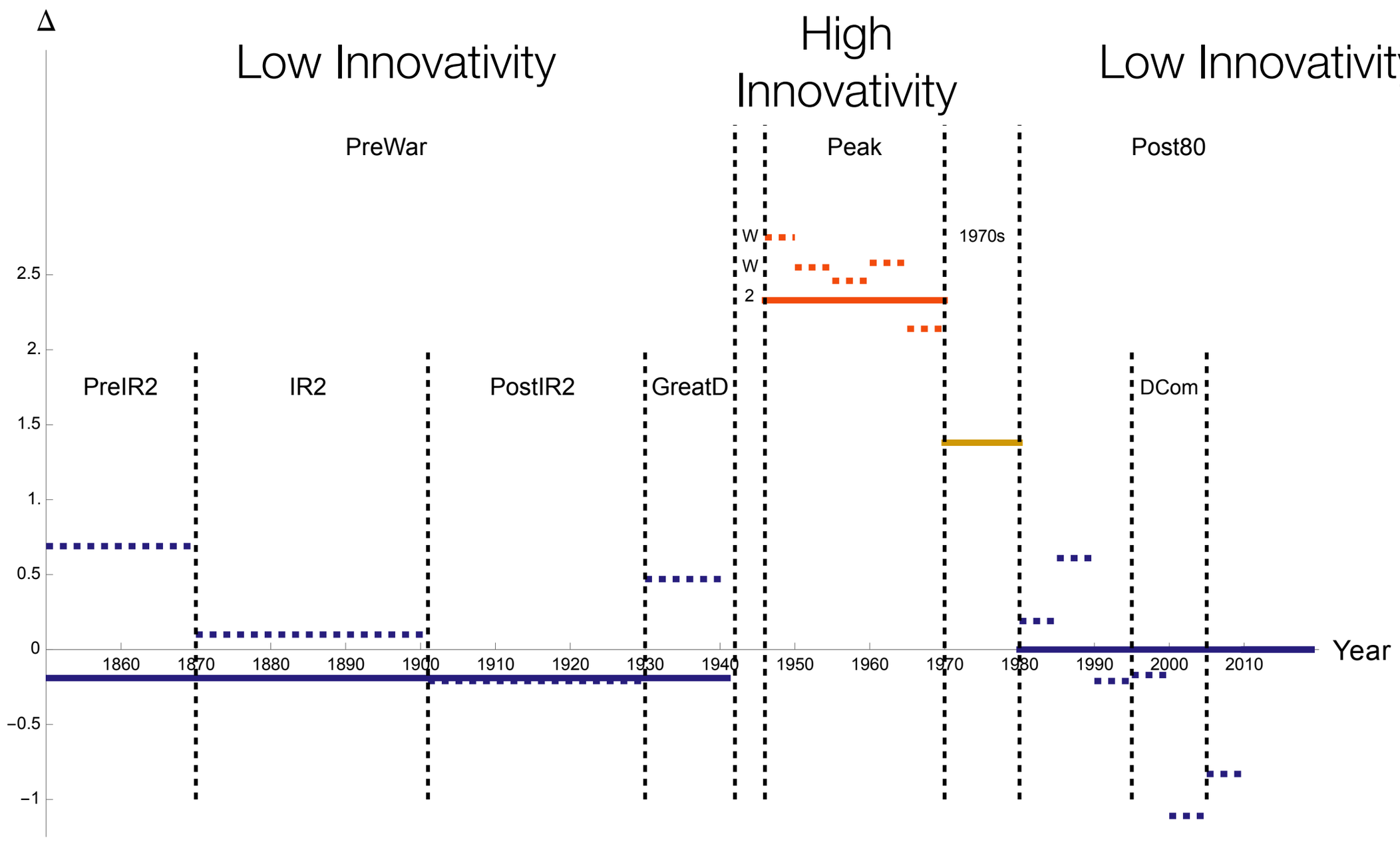
- So, we can measure the ratio of I firms to Q firms with the fundamental component of the standard deviation of idiosyncratic firm returns for the market as a whole (σ_{Market}) — as the ratio of I firms to Q firms increases, σ_{Market} falls;
- We measure Innovativity by Δ, with

$$\Delta = 1 - \sigma_{Market} ,$$

It follows that Innovativity increases with Δ.

This Measure of Innovativity Is Independent of the TFP Data Itself

Innovativity Regimes: 1850/2019



We find 3 innovativity regimes without looking at the TFP data itself

Technical Note

$$\Delta = \Delta_{t1/t2} + \text{Transitory Effects} + \text{Boom/Bust} + \text{error}$$

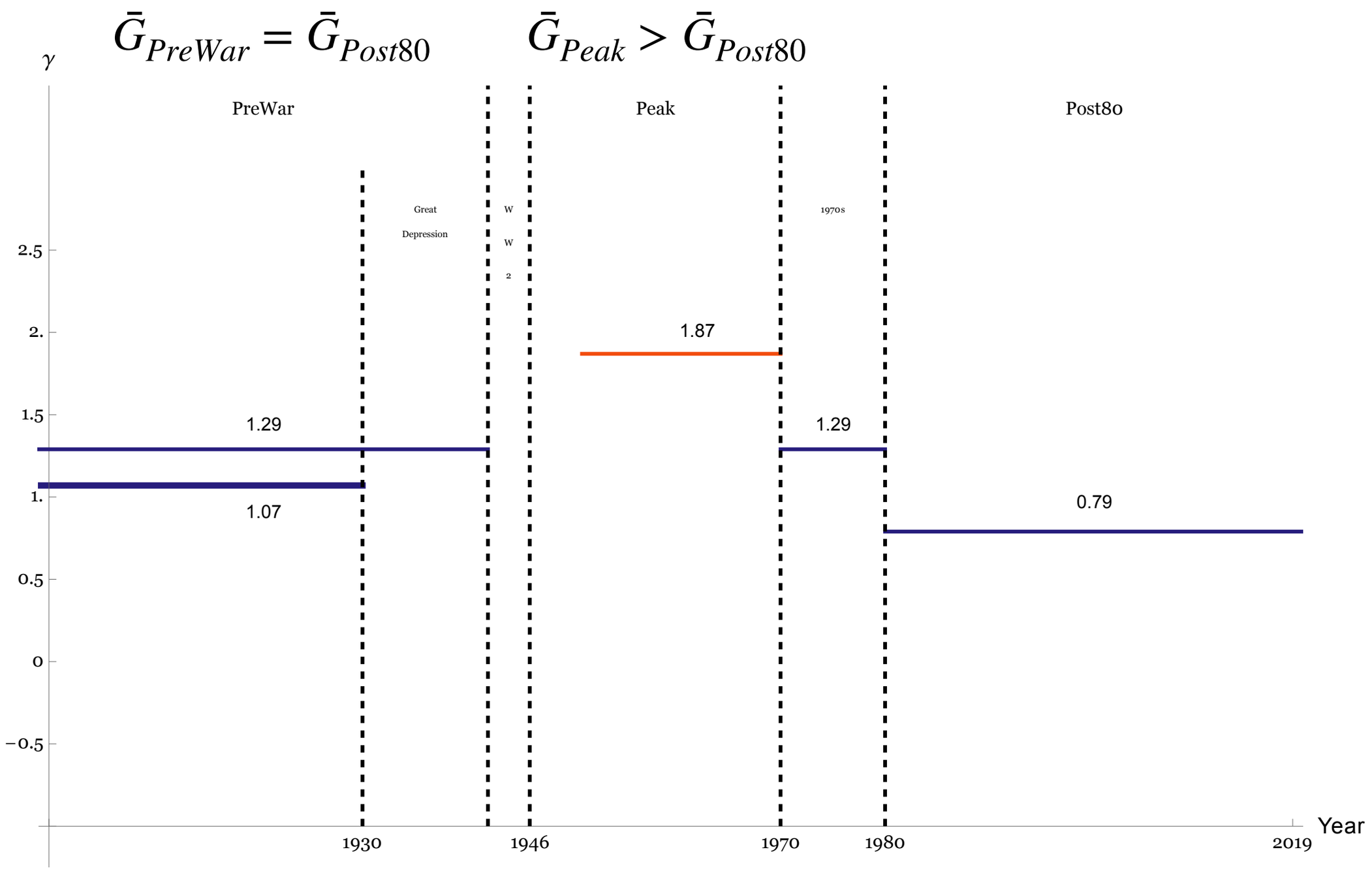
- We assume that Δ evolves slowly, so we estimate Δ with a series of time dummies ($\Delta_{t1/t2}$);
- We capture Transitory Effects with a Garch (1,1)/AR24 model;
  - All residuals are white noise;
  - We control for market Boom and Busts;
  - We set σ_{Market} = standard deviation of idiosyncratic firm returns, with idiosyncratic meaning net of industry returns;

- Sample: NYSE listed common shares, 1850/2019
  - Sources: i) 1926/2019: CRSP; ii) 1850/1925: Yale University SOM *Old New York Stock Exchange Project*

Innovativity: Predictions

- If Innovativity determines TFP growth, then:
  - Average TFP Growth in the PreWar period = Average TFP Growth in the Post80 period; and
  - Average TFP Growth in the Peak Period > Average TFP Growth in the Post80 period;

Innovativity By Regime



Innovativity successfully predicts the evolution of Average TFP Growth over the last 120 years, including the regime transition dates.

Innovativity Predictions: Technical Note

- To test these predictions, we:
  - Estimate the TFP Growth process for the Post80 regime;
  - Estimate the plausible range of TFP growth in the PreWar and Peak regimes given the Null that the Growth process in these regimes = the Growth process in the Post80 regime;
  - Accept the Null for the PreWar Regime if

$$\bar{G}_{Null,5} < \bar{G}_{PreWar} < \bar{G}_{Null,95}$$

  - Accept the Null for the Peak Regime if

$$\bar{G}_{Null,95} < \bar{G}_{Peak}$$

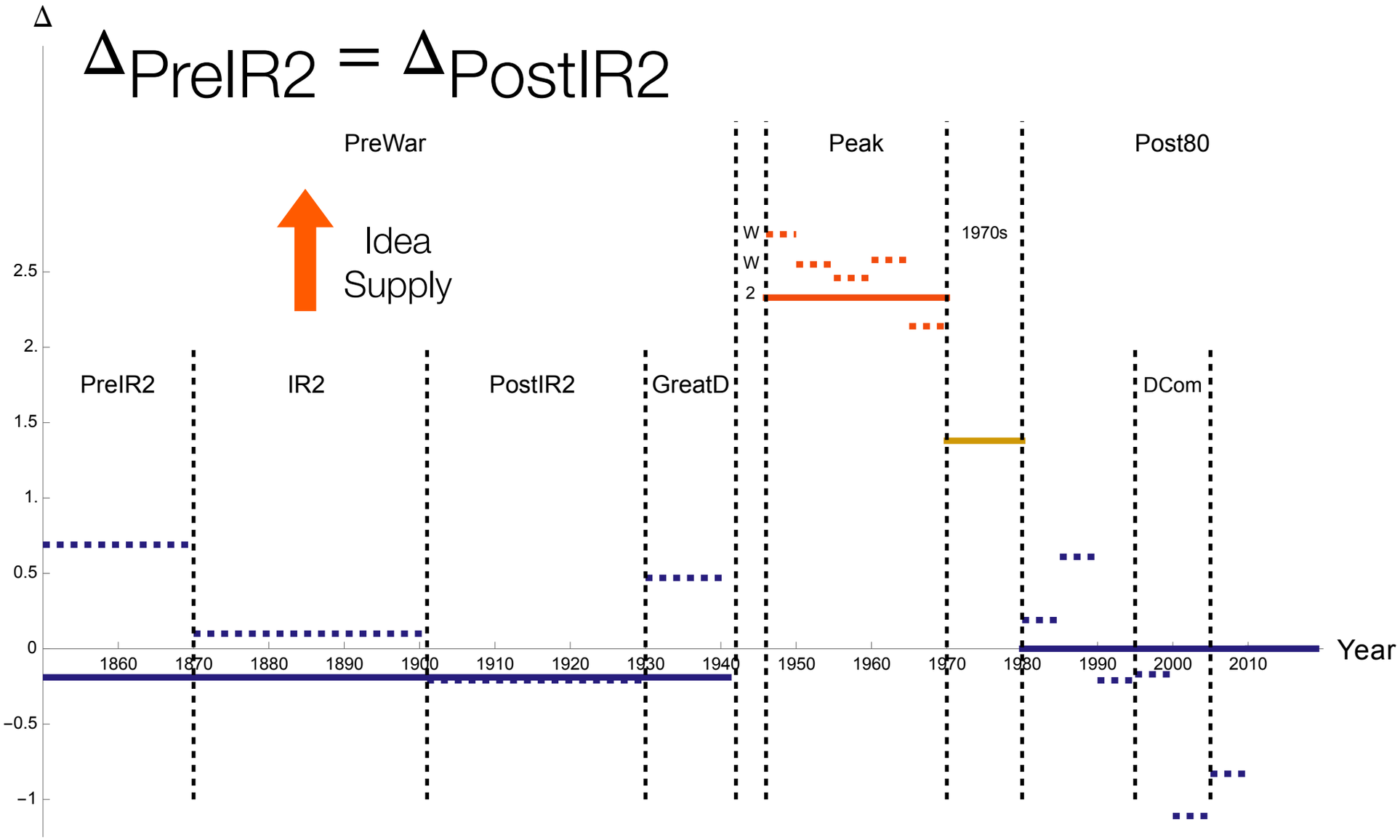
  - where $\bar{G}_{Null,q}$ is the qth percentile of the Average TFP growth distribution under the Null.

What Are We Running Out Of: Ideas or Idea Processing Capacity?

Explaining Innovativity

- ISupply and IProcessing evolve in response to exogenous shocks;
- ISupply: ISupply is affected by GPT shocks;
    - ISupply Shocks: i) The Second Industrial Revolution (IR2), 1870/1900 (Gordon 2012); ii) Positive GPT shock in 1945 (Nordhaus 2007); and iii) Positive GPT shock in 1985 (Nordhaus 2007);
- IProcessing Shocks: IProcessing is affected by Market Effectiveness Shocks
    - We assume that in the PreWar regime, Market Effectiveness was at is privately optimal level;
    - The Financial Market reforms of the 1930s/1940s (SEC, Fed, etc.) pushed Market Effectiveness away from its privately optimal level towards its socially optimal level;
    - This improvement created an incentive for market participants to find ways around the Market Reforms, leading to a negative Market Response shock;
- If a Shock to ISupply or IProcessing changes Innovativity, then that factor is a binding constraint on Innovativity;
- If a Shock to ISupply or IProcessing does not change Innovativity, then that factor is not a binding constraint on Innovativity;

What is the Binding Constraint on Innovativity in the PreWar Regime?

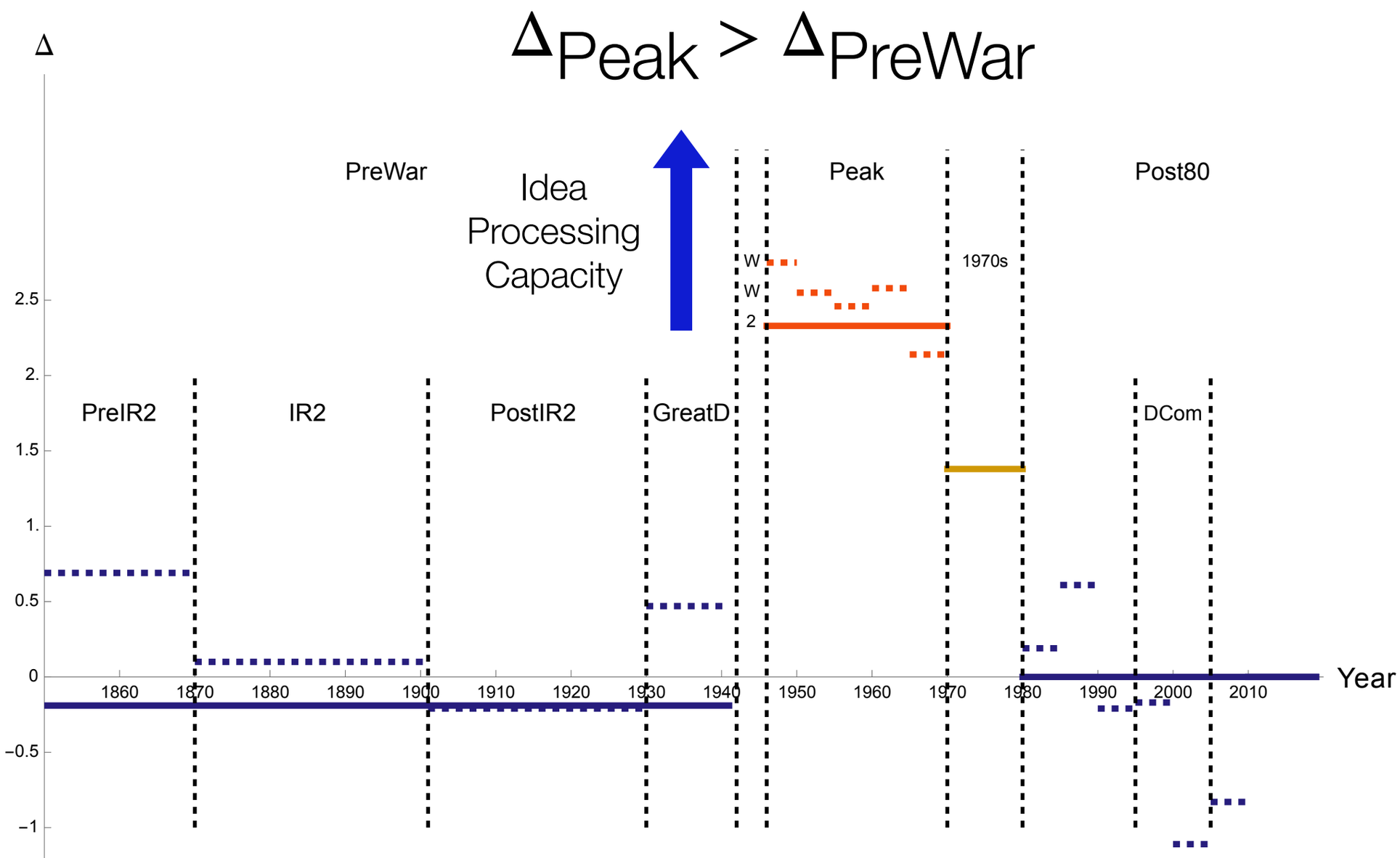


The IR2 Shock increased ISupply

but did not affect Innovativity

ISupply was not a binding constraint on Innovativity in the PreWar Regime

What Led the Peak Regime?

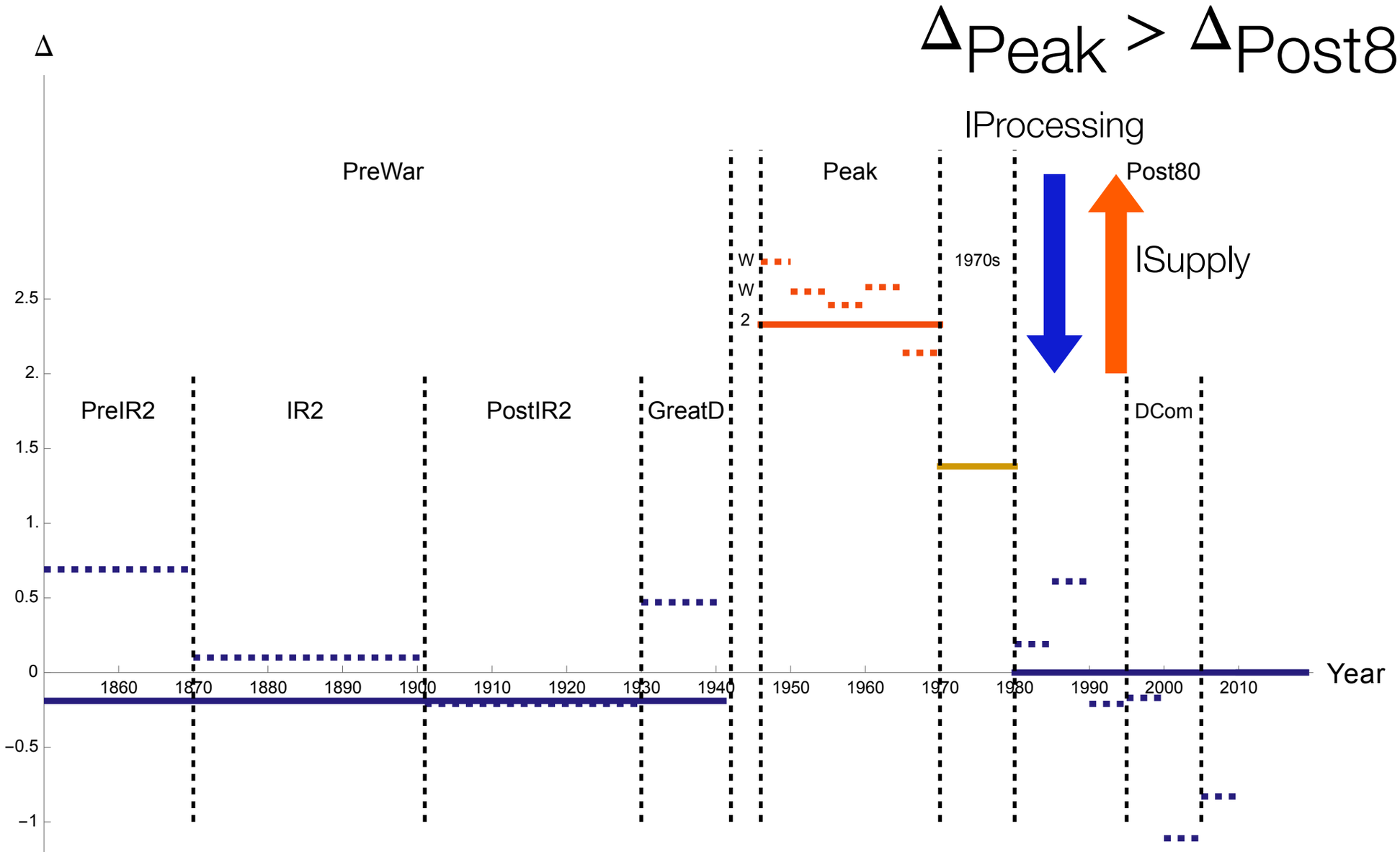


The 1930s/1940s Reform Shock increased IProcessing;

Innovativity Significantly Increased

IProcessing was a binding constraint on Innovativity in the PreWar Regime

Why Did Average TFP Growth Fall After 1970?



ISupply increased, but Innovativity fell. Our explanation: the Financial Reforms of the 1930s/1940s lost their efficacy.

We are not running out of ideas, we are running out of Idea Processing Capacity

Conclusion

Conclusion

- Long run economic stagnation will create an economic, political, and social catastrophe;
- Improving TFP growth is an urgent and vital task;
- It is plausibly the case that idea processing capacity — not idea supply — is the binding constraint on innovativity in the US;
- The policies/mechanisms that drive idea processing capacity are totally different than those that drive idea supply;
- We should think more about how to improve the economy's idea processing capacity;
    - Improving financial market effectiveness would be a good place to start;
    - The US spent $717 Billion on R&D in 2020, increasing that by 25% would take $180 billion;
    - A major effort to improve financial market effectiveness would cost rather less!
    - So, it is possible to round up the usual suspect and spend more on R&D **and** devote the rounding error on that expense to improve financial market effectiveness.