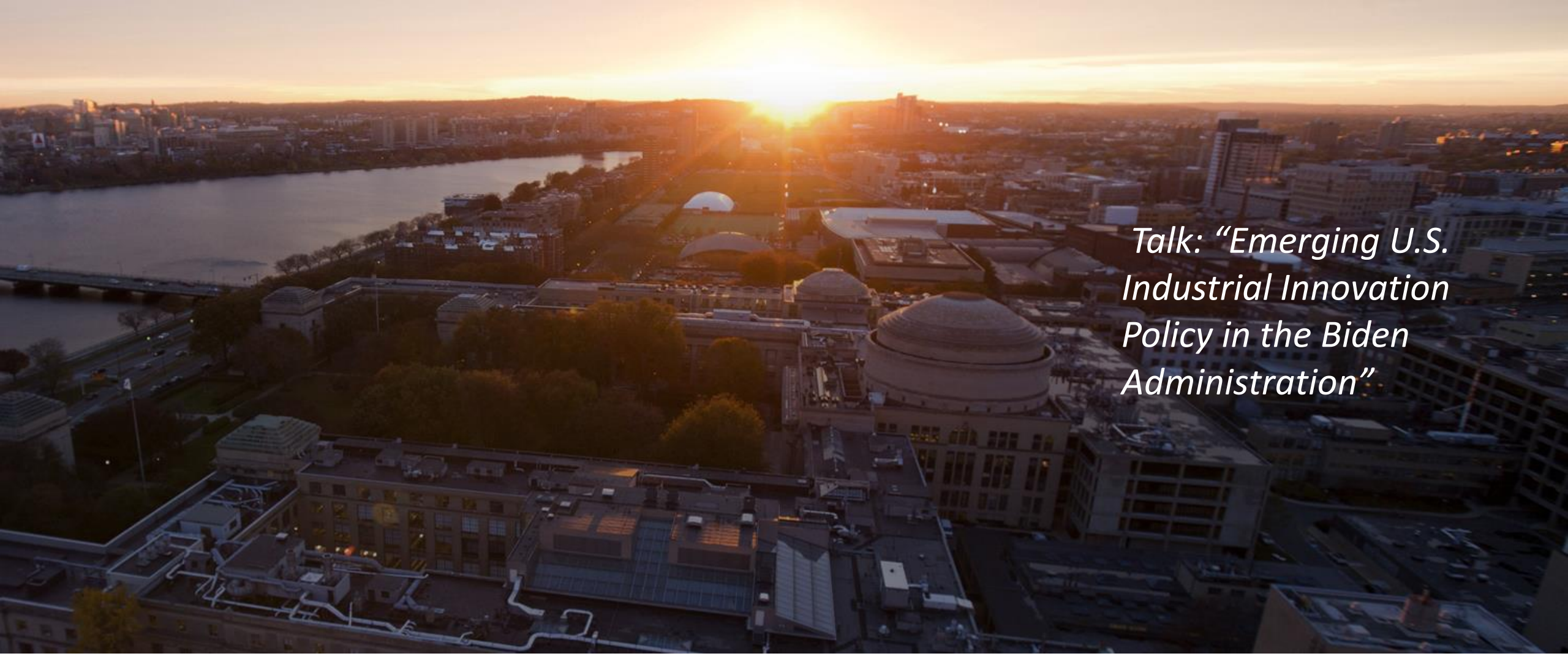


Brazilian Mobilization for Entrepreneurial Innovation (MEI) Dialogues

William B. Bonvillian

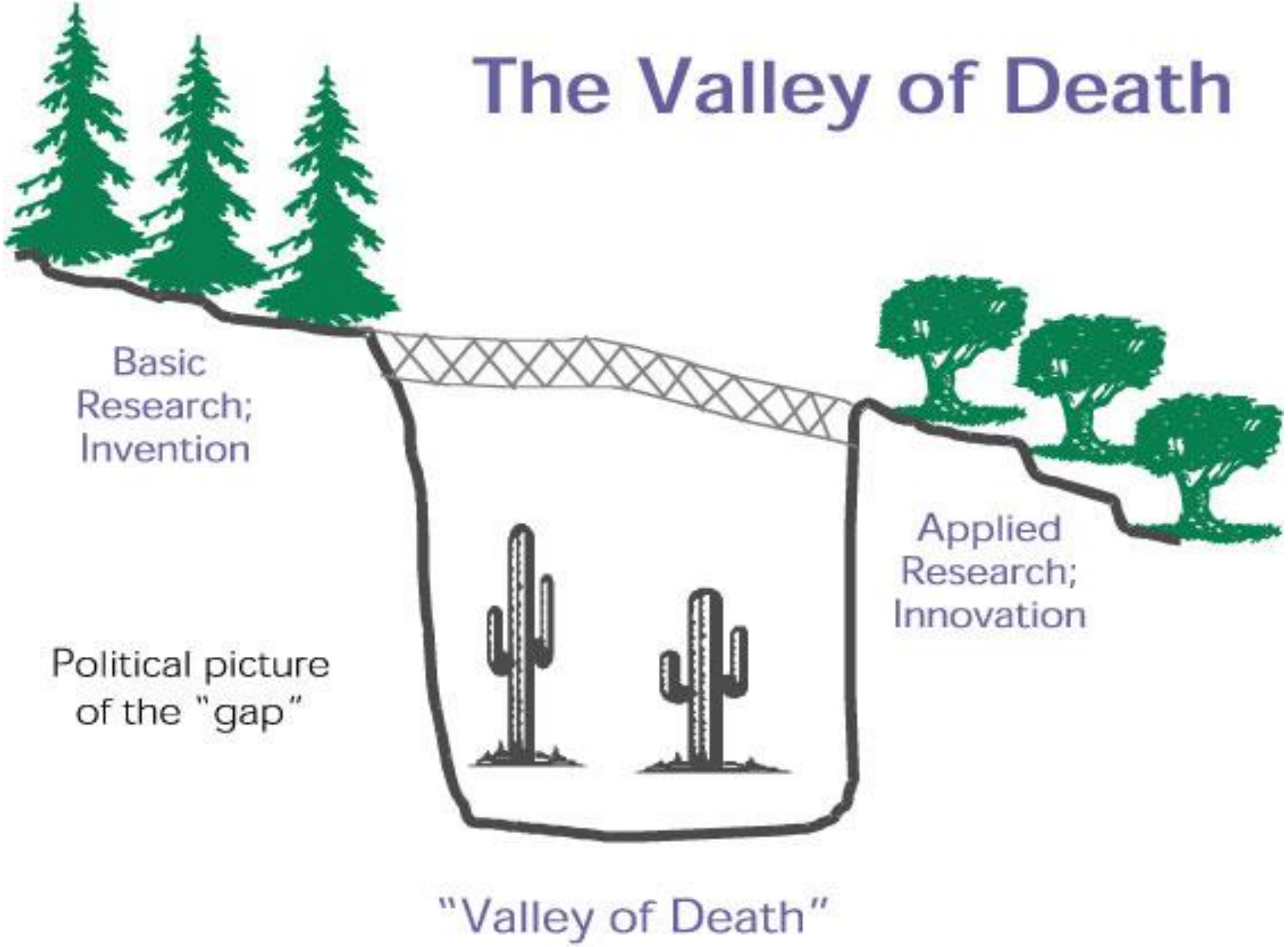
Lecturer, MIT - Senior Director, Special Projects, MIT Open Learning

November 7, 2022

1945 – Postwar: U.S. focuses its government support for innovation on basic research stage

- U.S. in 1945 was the world manufacturing leader – it didn't have to worry about manufacturing
- But it was catching up on basic research
- Decision in 1945: government role is to support BASIC Research – leave applied and development to industry – innovation system: no focus on mfg.
- "Pipeline theory" of technology development
- Separates science as a separate player from other innovation actors – against integrated model for science

---> U.S. postwar model institutionalizes the "Valley of Death" between research and later stage development

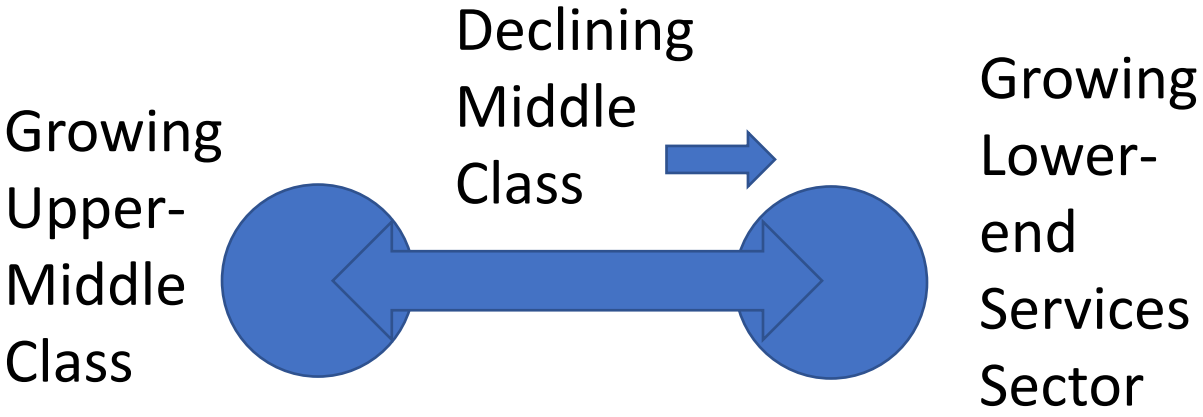


U.S. Manufacturing Decline – since 1970

- After WW2, US was world manufacturing leader – developed massive mass production system
- Focused innovation system on R&D not manufacturing
- US: research-led innovation – pipeline model
- Other countries: manufacturing-led innovation (Germany, Japan, Korea, Taiwan, China)
- *US lost one-third of its manufacturing jobs, shut down 60,000 factories between 2000 and 2019*
- US and China have traded manufacturing places
  - China produced 28.7% of world manufacturing output in 2019 while the US produced 16.8% - reversal of 15 years before
  - Manufacturing is 30% of China's total economic output and a $4 trillion sector compared to US where mfg. is 11% of GDP and a $2.3 trillion sector

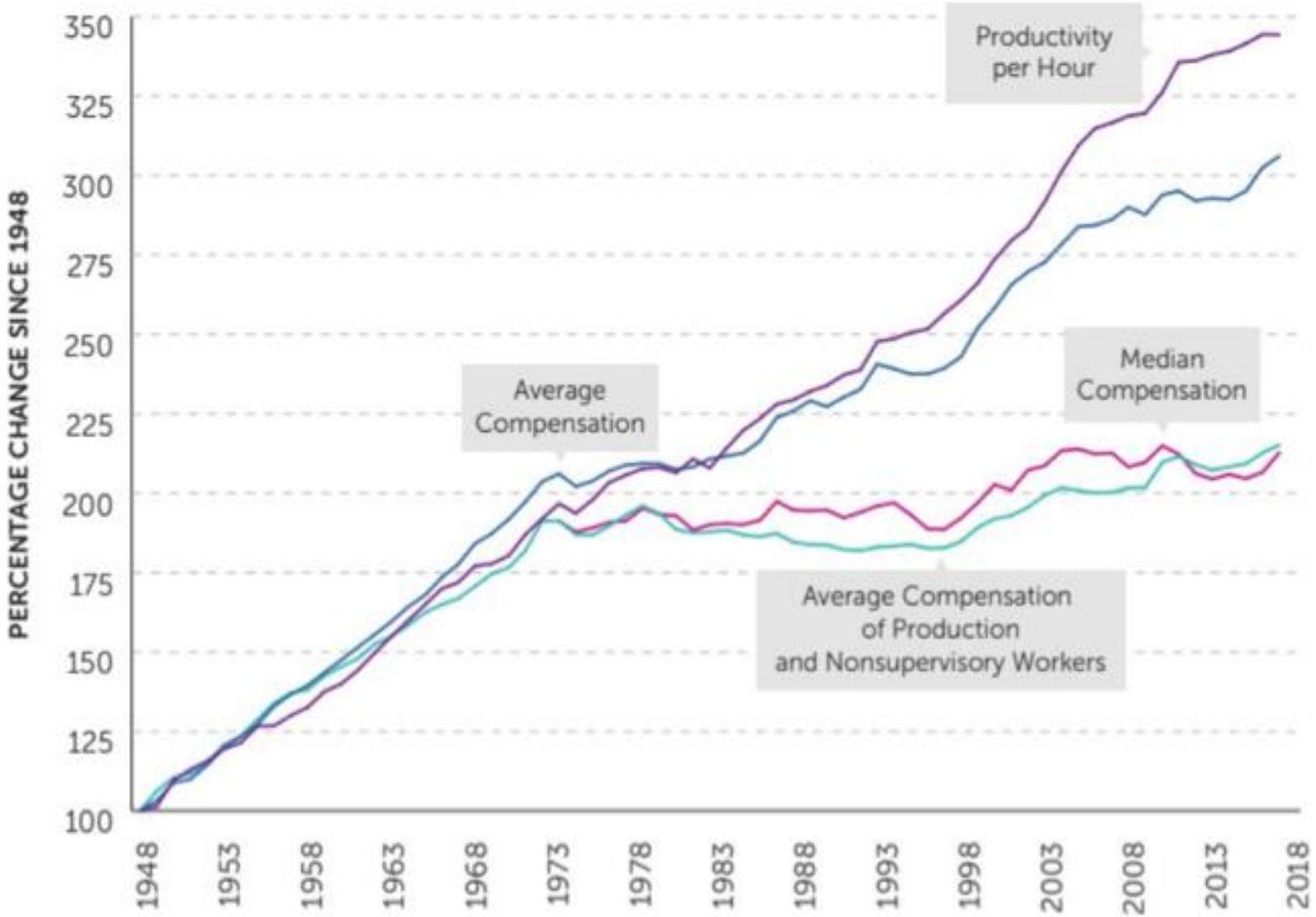
Manufacturing decline created major social disruption in the U.S.:

- We have increasing inequality, not economic convergence – a festering problem for 15 years.



- Above: the "Barbell" problem identified by economist David Autor
- The U.S. has famous IT companies (Google, Apple, etc.) but quite limited employment in the U.S.

The Wage Gap: for Median Income and Non-Supervisory and Production Workers:



Source for image: MIT final report on, "The Work of the Future: Building Better Jobs in the Age of Intelligent Machines"

What has evolved since this decline?

→ Models reaching further down the pipeline, requiring connections between R&D and implementation

- [See: W.B. Bonvillian, Encompassing the Innovation Panoply, *Issues in Science and Technology*, Winter 2022]

How far down the innovation pipeline does the Federal Government role go? …The DOD parallel universe

THE INNOVATION PIPELINE:
Research->Dev->Prototype->Demo->Testbed->Production->Market

NSF, DOE OS, NIH, etc.:

DOD:

DOD has a "Connected System"

US has had Five Periods where it has tried to better connect science and technology:

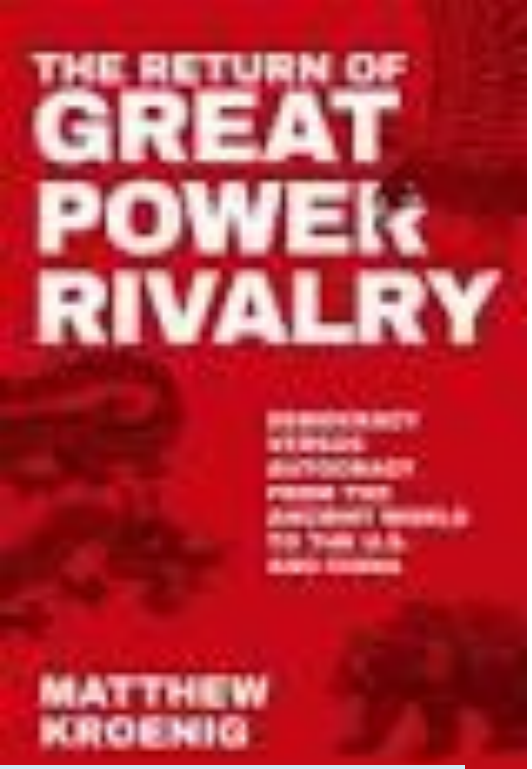
- **Period 1 – Postwar** - Moved from "connected" innovation system in WW2 to "disconnected" system with federal research role paramount
- **Period 2 – Sputnik** – DOD reconnected its innovation system – DARPA model (also NASA):
  - "right-left", use basic research capability to enable upfront" research visioning"
  - Take advantage of launching innovations into Defense innovation system-joins Risk/Innovation - Connected – DOD is a parallel universe to disconnected civilian science
- **Period 3 – 80s Competitiveness**
  - Series of models to better connect R&D to "back-end" – MEP, SBIR, Bayh-Dole, ATP, Sematech, R&D Tax Credit
- **Period 4 – Energy Challenge** –
  - ARPA-E model - DARPA Plus approach – deeper into implementation
  - Expanded EERE, EFRCs, HUBs, Adv'd Mfg. Office, Tech Trans. Off., Cyclotron Rd., Loan Office
- **Period 5? – Advanced Manufacturing**
  - 16 Manufacturing Institutes – industry/univ./gov't collaboration – testbeds around adv'd mfg. technologies plus workforce ed

Defining Industrial Policy in terms of the stages of innovation advance:

- Industrial *innovation* policy - define in terms of the well-known stages through which a technology must advance:
  - research, development, technology prototyping, testing, demonstration, product development, production financing, market entry, and expanded market creation.
  - Industrial innovation policy, then, *entails government intervention in one or more of these stages* in order to *further a technological advance.*

Emerging Industrial Innovation Policy Approaches

- US has long had *industrial **economic** policy* elements – ex's: agriculture (price controls, irrigation systems, land grants, extension agents), energy (hydropower, nuclear, fossil and renewable subsidies, power regulation), health (Medicare, Medicaid) – but limited in the *industrial **innovation** policy* area
- Industrial Innovation policy –
  - Definition: focus on post R&D stages: late stage development, prototyping, testing and demonstration, production prototype, production, initial market creation
  - *the US has long avoided it*
  - ***Neo-classical economists in the US oppose it as gov't interference in markets***
- But three new drivers:
    - *Technology competition with China*
    - *Climate change – new energy technologies required*
    - *Pandemic*
  - But barriers: Vannevar Bush organized US civilian science in the pipeline model for basic research only
  - Although in parallel: Defense research, alternative system, reaches all stages through market creation



The New Geopolitical Driver

- Moving into a new International system, with consequences for innovation policy – de-globalization is underway
  - Covid lessons for-domestication of supply chain, national supplier systems -- Heightened by growing int'l conflict
  - Old ideas on organizing industry - just in time inventory, core competency - are being replaced by resiliency, more vertically integrated firms
- Now: another period where democratic governments appear to be challenged by autocratic governments
  - Reality: the Ukraine War, China' support for Russia in that war, and ongoing potential threats to Taiwan
- Unstable situation – underscored view in the U.S. about need to reestablish supply chains and manufacturing leadership.
- Technology leadership drives national security leadership.
- Manufacturing is the crossroads between national security and economic security and the three are interdependent.

2020-22: Six major US industrial innovation policies:

- ***Operation Warp Speed: Most important of all***– massive intervention into vaccine development – guaranteed production contracts to industry, portfolio approach for range of vaccine technologies, technology certifications (EUAs), integration of federal officials into companies to speed development, control of distribution systems
- ***The CHIPS Act*** – restore US semiconductor leadership – US SC firms falling behind – Intel behind TSMC, Samsung – new funding for US fabs and foundries, advanced R&D, funding for mfg. and packaging technologies, SC workforce ed - $52B billion
- ***Infrastructure bill in 2021: Energy tech demonstration centers*** for carbon capture and sequestration, hydrogen, adv'd nuclear, critical minerals, renewables - $20 billion – new Technology Demonstration Office
- ***Assuring Domestic Supply Chains*** – June '21 WH plan, updated Feb. '22 – for pharmaceuticals and ingredients, advanced batteries, critical minerals, semiconductors – financing and supply chain rebuilding
- ***Inflation Reduction Act of 2022*** - $375B for new energy/climate challenges – tax and consumer incentives for implementation of efficient technologies, new lending to co's
- ***Endless Frontier/CHIPS and Science Act*** – funding for semiconductors, new authorization for applied science programs at NSF

Case Study 1: Operation Warp Speed

- Picked winners – OWS selected 2 co's leading in 4 vaccine technologies
- Guaranteed Contracts – start production while vaccines being developed
- Technology Certification – FDA's "Emergency Use Approval" assured immediate market entry
- Flexible contracting
  - Defense Production Act– compel supplies for emergency needs
  - Other Transactions Authority – fast contracting outside of normal procurement regs
- Mapped supply chains
- Supported production scale up at factories
- Integrated federal personnel into co's to speed regulatory compliance
- Undertook national distribution to states and localities
- Classic example of industrial innovation policy (took advantage of prior R&D)
- Saved millions of lives

Case Study 2: Where did Tesla Come From

Market value in 2021 of 1.06 trillion – larger than the top 5 auto manufacturers combined, and $53 billion in profit in 2021

Policy: Gov't wanted EV's – gov't role:

- Gov't R&D for developing and improving Li-Ion batteries
- $7500 tax incentives to consumers for purchasing EVs - market creation
- $465 million loan saved Tesla from bankruptcy - approved 2009, repaid 2013
- Charging station support - $7.5B in 2021 Infrastructure bill
- State of California clean air regs pushed EV's – Calif. law protected by EPA
- Covid hit auto sector in 2020 but California "zero emissions credits" sent $428m from other auto co.'s to Tesla keeping it in the black and scaling up
- State gov't support so far: $2.4B– includes $1.3B for Nevada Gigafactory, $750m in NY solar panel factory, etc.
- On the way: advanced battery support, gov't support on EV supply chain, etc.

Different models for industrial innovation policy:

- ***Top Down*** - Operation Warp Speed – gov't selected portfolio of winning co's, and supported them
  - Outcome: saved millions of lives
- ***Bottom Up*** – Electric Vehicle support - Tesla – gov't supported a network of incentives to scale electric vehicles
  - Up to companies to take advantage of them; Tesla saw the opportunity
  - Outcome; Telsa has driven all of the major world car co's to shift from internal combustion fossil fuel engines to electric vehicles

Case Study 3:
The "Endless Frontier"/"CHIPS & Science" Act ---

- Bipartisan cosponsors - $200 billion authorized (current & new programs)
- *Core Idea*: U.S. technology history is littered with technologies innovated *here* in the U.S., that did not scale-up here, and were produced *there*.
- A core goal of this bill is to get the new critical technologies into industry acceptance in the U.S. The new technologies require de-risking to get into the scope of risk and corresponding costs so industry can absorb and implement them.
- Intense competition for critical tech leadership with China –
  - Will pass the US in gov't R&D support soon
  - Has industrial subsidies and Guidance Funds – over $400 billion/year (2022 CSIS)
- Who will lead on AI, quantum, new high performance computing, robotics, biotechnology, cybersecurity, advanced materials, energy tech - top technologies in bill
- Full $52 billion funding for the CHIPS Act included in the bill – R&D and implementation (fabs/foundries)

Endless Frontier/Chips and Science Act – science provisions - has *many* of the follow-on stages to research:

New applied Technology Directorate at NSF, the broad-based US basic science agency – new agency within an agency - Must move through: research, development, prototype, testing, demonstration, scale-up/piloting, initial market, full production.

- ***R&D in 10 critical technology areas*** –"translational" research to be supported at the **new Directorate for Technology, Innovaton and Partnerships** - $20 billion over 5 years "Societal, National, Geopolitical" goals
- ***Societal goals*** added – Directorate to aid underperforming regions, broadening innovation. etc.
- ***Development and prototyping*** – at ***Translation Accelerators*** run by industry-university consortia
- ***Testing and demonstration*** – **test beds** to prove and demonstrate the new technology so they can get into the risk range that industry and other kinds of capital can work with.
- **Regional Innovation Engines/Hubs** – NSF already undertaking for spreading innovation capability (has no background in regional innovation)
- ***Scale-up*** Funding for Semiconductor Fabs but broad financing provision - *dropped*

Gaps in the 6 new initiatives:

- **Scale Up Financing**
  - Venture Capital does not support scale up outside software and biotech – hardtech takes too long (10/15 years to scale) and too risky
  - Still scattershot: funding in CHIPS Act and expanded Energy Dept. Loan Programs Office ($40B) in Inflation Reduction Act – missing in other initiatives
- **Support for Manufacturing stage**
  - Technologies to scale must be manufactured – US not adopting adv'd mfg.
  - Manufacturing Institute Program is not operating at sufficient scale
- **Cross Agency Collaboration**
  - Combined, cross-agency effort needed for many of the new technologies, but these are hard to established in the decentralized US R&D system
  - "Interagency collaboration is a contradiction in terms"

Is a New US Era of Industrial innovation Policy beginning?

- Defense Dept. has always done industrial policy – but now reaching into other critical areas of the economy
- Driven by Climate Change demands and China's technology acceleration challenge
- Bipartisan support for some of this
- Requires completely new thinking by scientists/engineers –
  - They have to learn the new system, from science through production

Industrial Innovation Policy Factors:

Need to build a new infrastructure for industrial innovation policy:

- Change agents
- Connections across research institutions
- Integration between agencies, industry and universities – committed firms
- Rebuild Manufacturing foundations
- Map Supply Chains – and filling supply chain gaps
- Technology Testing and Demonstration
- Technology certification and validation
- Flexible contracting mechanisms – Def. Prod. Act, Other Trans. Authority
- Apply gov't procurement programs to scale up new technologies
- Technology scale-up financing

Thank you!