The (Political and Financial) Economics of Technological Transformation

Dr. W. H. Janeway
Faculty of Economics/University of Cambridge
Warburg Pincus

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Economic Growth as an Evolutionary Process: I

"**Different abilities to innovate and imitate are central aspects and drivers of industrial evolution**, shaping the patterns of growth, decline and exit over populations of competing firms, as well as the opportunities of entry of new firms….evolutionary processes driven by the twin forces of (**often mistake-ridden**) idiosyncratic learning by persistently heterogeneous firms…and (**imperfect**) market selection delivering prices and penalties – in terms of profits, possibilities of growth, and survival probabilities – across such heterogeneous corporate populations…."

(G. Dosi and Nelson, R.R., "Technical Change and Industrial Dynamics as Evolutionary Processes," in B. Hall and Rosenberg, N. (eds.) *Handbook of the Economics of Innovation* (Amsterdam, Elsevier, 2010) p. 113)

Economic Growth as an Evolutionary Process: II

"We have…here the basic ingredients of an evolutionary interpretation of economic growth and development. Such an evolutionary account…would highlight the significant differences in the rates of progress at any time across different technologies and industries….[A]n important underlying variable seems to be the strength of the scientific fields that illuminate the technologies used in an area of practice….[P]rogress within a field of technology tends to become more narrowly focused and to slow down as the technology matures. **While repressed in neoclassical growth theory, the process of economic growth as we have historically experienced it has been driven by the continuing introduction of new products and new technologies, and the continuing shifting of resources from older industries where the rate of advance has slowed down to new industries**…."

(Dosi and Nelson, p. 112)

Schumpeter:
The Process of Creative Destruction

"**The essential point to grasp is that in dealing with capitalism we are dealing with an evolutionary process**….

"…The fundamental impulse that sets and keeps the capitalist process engine in motion comes from the new consumer goods, the new methods of production and transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates.

"…**This process of Creative Destruction is the essential fact about capitalism**. It is what capitalism consists in and what every capitalist concern has got to live with…."

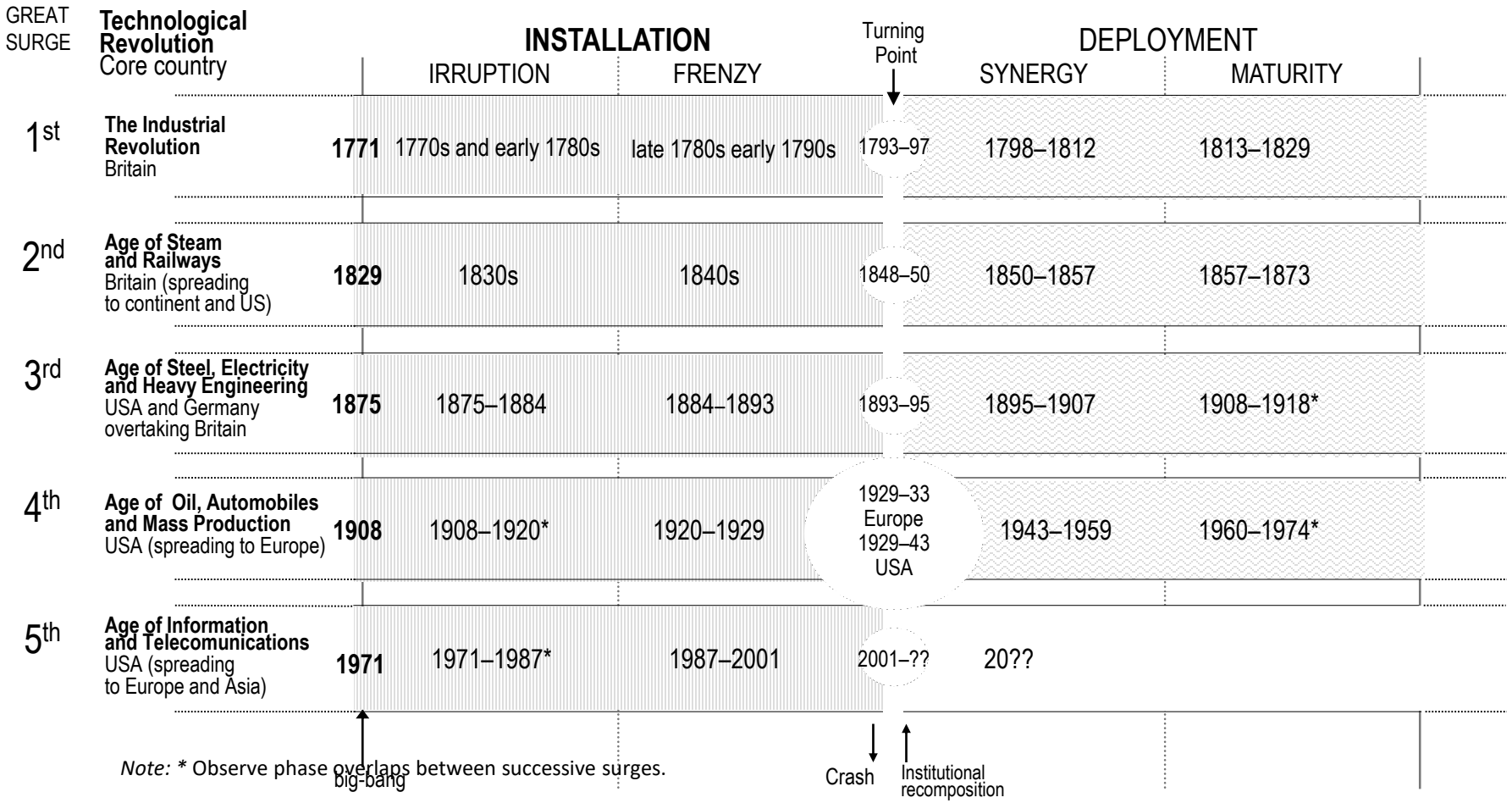
(Schumpeter, *Capitalism, Socialism and Democracy*, pp. 82-3)

Technology Paradigms and New Economies

"A full evolutionary account of economic growth would also take into account that **the historical time path of growth tends to be punctuated by "eras" characterized by the development and diffusion of specific constellations of "general-purpose" technologies, that is broad techno-economic paradigms**.... During a particular economic era , much of the economic growth is accounted for by innovation and productivity growth in the industries that produce the goods that directly incorporate the driving technological paradigms and also in the downstream industries that are able to use these goods as inputs (historically this was the case of **steam power**, later **electricity** and the **internal combustion** engine today it is the case of **ICT** technologies.)"

(Dosi and Nelson, p. 113)

Figure 5.2 Approximate dates of the installation and deployment periods of each great surge of development



(C. Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Cheltenham UK: Edward Elgar, 2002))

Sustained Technological Innovation: Shared, Contestable, Cumulative Knowledge

"**The central conclusion to take home about the first Industrial Revolution is that its historical importance as the fountainhead of modern economic growth was** not so much in the transformations in cotton and steam that occurred between 1760 and 1800, but in **the ability of the Western economies to sustain technological progress and somehow managed to avoid the negative feedbacks and hard constraints that had prevented a similar breakthrough after the great macro-inventions of the fifteenth century** (iron casting, printing and three-masted shipping, among others). **While much of the action in the first 40 years…took place in Britain, this was clearly a multinational effort**…, **an international 'invisible college' of men and (a few) women who shared their knowledge**….

(J. Mokyr, "The Contribution of Economic History to the Study of Innovation and Technical Change," in B. W. Hall and Rosenberg, N., *Handbook of the Economics of Innovation* (Amsterdam: Elsevier, (2010),, p. 22)

Financing the Innovation Economy

"…**Over some 250 years, economic growth has been driven by successive processes of trial and error and error and error**: **upstream exercises in research and invention, and downstream experiments in exploiting the new economic space opened by innovation**. Each of these activities necessarily generates much waste along the way: dead-end research programs, useless inventions and failed commercial ventures. **In between, the innovations that have repeatedly transformed the architecture of the market economy, from canals to the internet, have required massive investments to construct networks** whose value in use could not be imagined at the outset of deployment. **And so at each stage, the Innovation Economy depends on sources of funding that are decoupled from concern for economic return.**

(Janeway, *Doing Capitalism in the Innovation Economy*, 2nd ed., p.1)

The Role of the State: Demand Side
"War Made the Industrial Revolution"

"**Britain was in major military operations for for eighty-seven of the years between 1688 and 1815….War was the norm in this period. And it shaped the economy…**

"[T]he British state did much more than minimalistically provide the financial and transportation infrastructure for industrial revolution;…it consumed metal goods in the mass quantities that industrial revolution necessary and possible. Just its bulk demand for guns alone stimulated innovations in industrial organization and metallurgical technology with enormous ripple effects. **At the start of the eighteenth century, it contracted for tens of thousands of guns; by the early nineteenth century its needs were in the millions.** That shift in magnitude signifies industrial revolution in the metallurgical world…."

(P. Satia, *Empire of Guns: The Violent Making of the Industrial Revolution* (Penguin Press, New York: 2018),pp. 1, 6)

The Role of the State: Supply Side
The American System of Manufacturing

"The history of the United States is no different from that of other modern countries; **fighting wars and preparing for wars have been an absolutely critical spur of economic growth and development**. Many of the key industrial and organizational breakthroughs of the late eighteenth and nineteenth centuries came in industries that were developing weapons or other supplies, such as ships or uniforms, that were being procured on a large scale by the military. Starting with the Revolutionary War, continuing with the War of 1812, the wars against the Native Americans, and the Civil War, some of the most important innovations in production and organizational technologies came in the manufacture of guns and other weapons. In fact, **the rifle figures prominently in manufacturing history as one of the first instances of the use of interchangeable parts to facilitate expanded production. Moreover, the machine tools developed for weapons production then migrated to industries producing sewing machines, bicycles, and ultimately automobiles**."

(F. Block (2011), "Innovation and the Invisible Hand of Government" in F. Block and Keller, M.R. *State of Innovation: The U.S. Government's Role in Technology Development*, Boulder CO: Paradigm Publishers, p. 6)

The Role of the State-Both Sides
US DoD and the Digital Revolution

"**One mechanism** through which defense-related R&D investments can aid innovation is **military funding for new bodies of scientific or engineering knowledge that supports innovation in both defense-related and civilian applications**….This channel…is likely to produce the greatest benefits…in basic and applied research, rather than development.

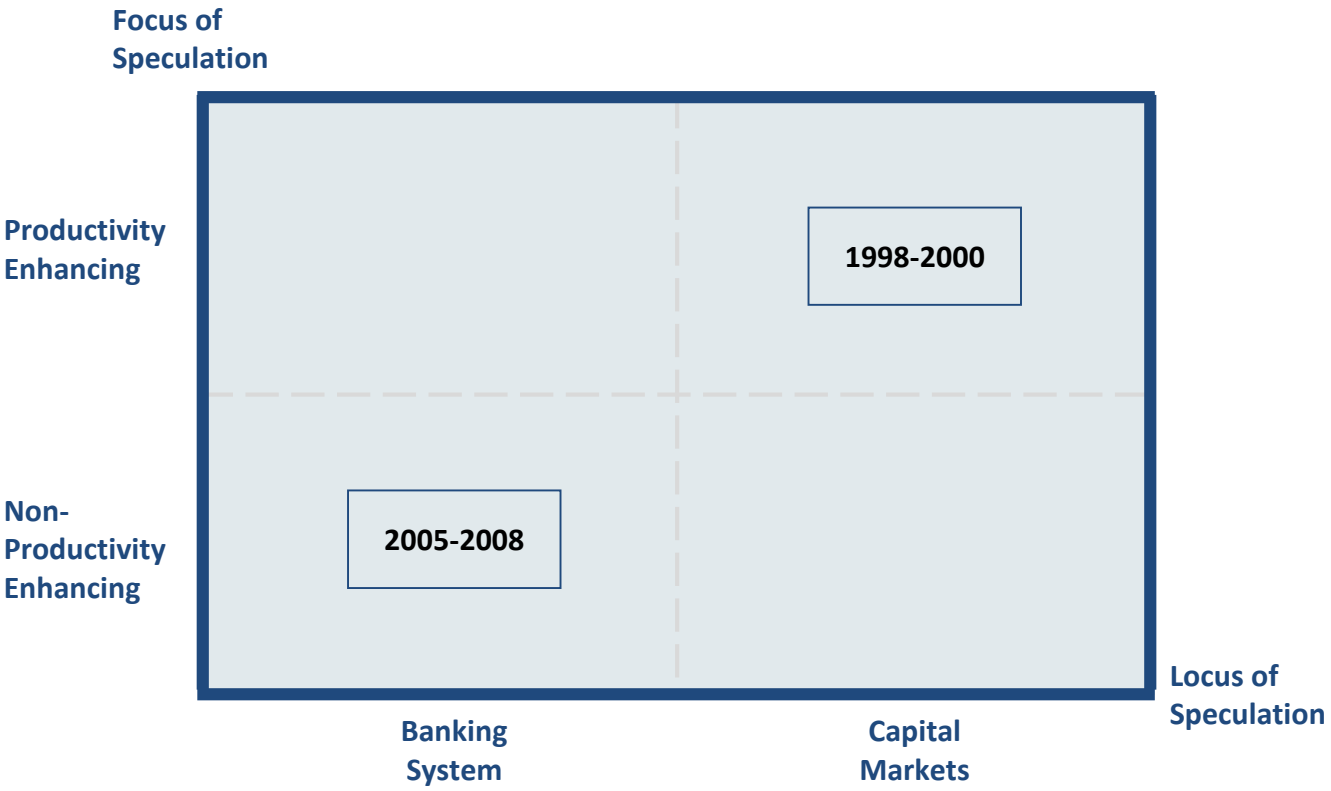
"A **second** important channel through which defense-related R&D affects civilian innovative performance are **the classic 'spin-offs**,'…[C]ivilian spin-offs…appear to be most significant in the early stages of development of new technologies…[before] civilian and military requirements…diverge….

"A **third** important channel…is **procurement**….The US military services…have played a particularly important during the post-1945 period as 'lead purchaser'….

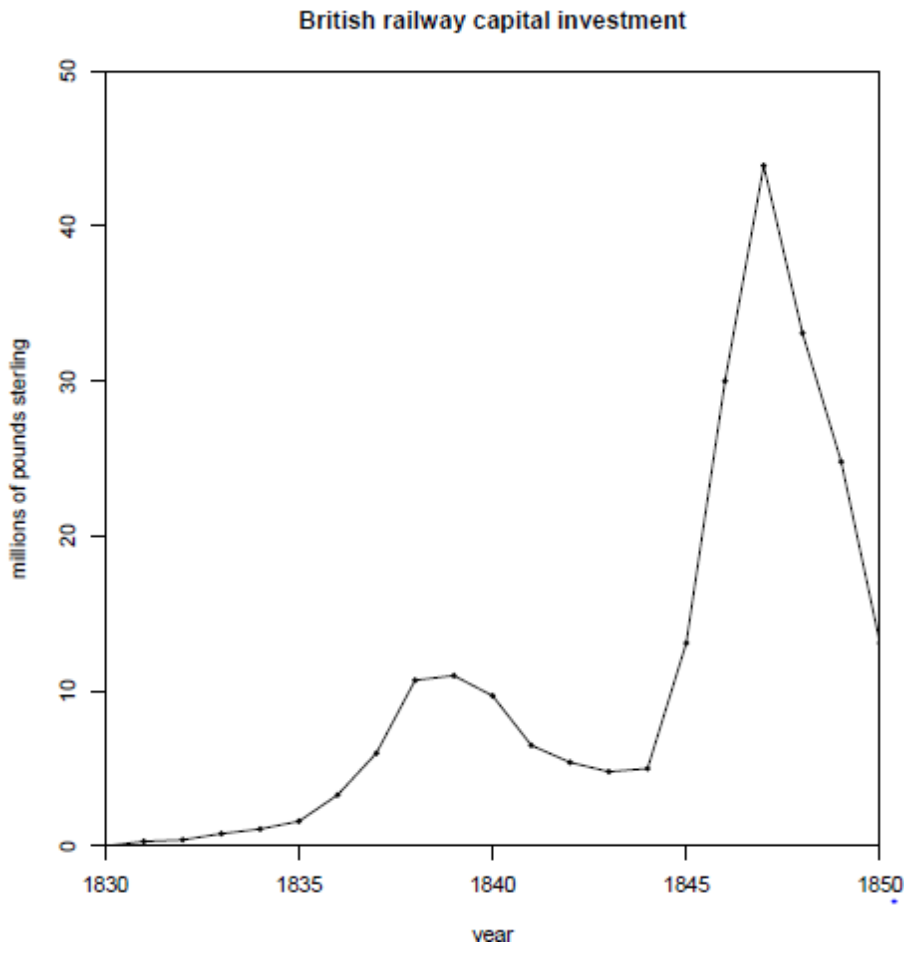
"Defense-related research spending contributed to **the creation of a university-based US 'research infrastructure'** during the postwar period that has been an important source of civilian innovations, new firms, and trained scientists and engineers…."

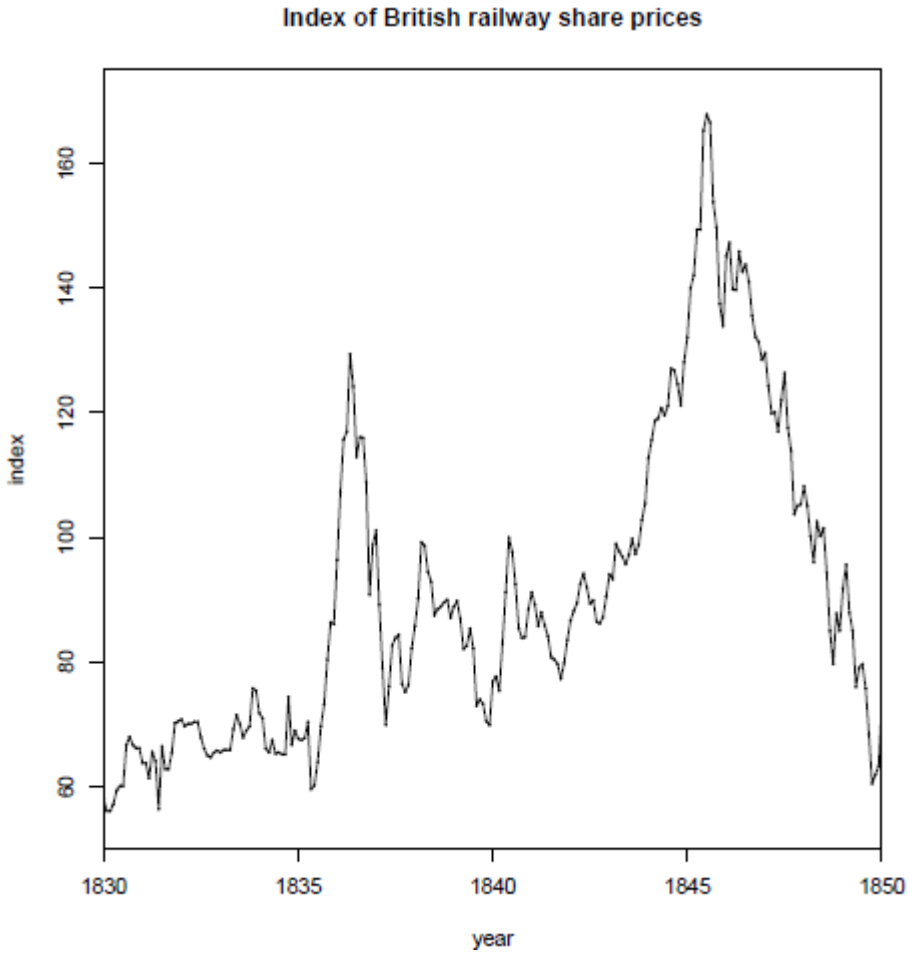
(D. C. Mowery, "Military R&D and Innovation," in B. W. Hall and Rosenberg, N., *Handbook of the Economics of Innovation* (Amsterdam: Elsevier, (2010), pp. 1236-7)

Productive versus Unproductive Bubbles



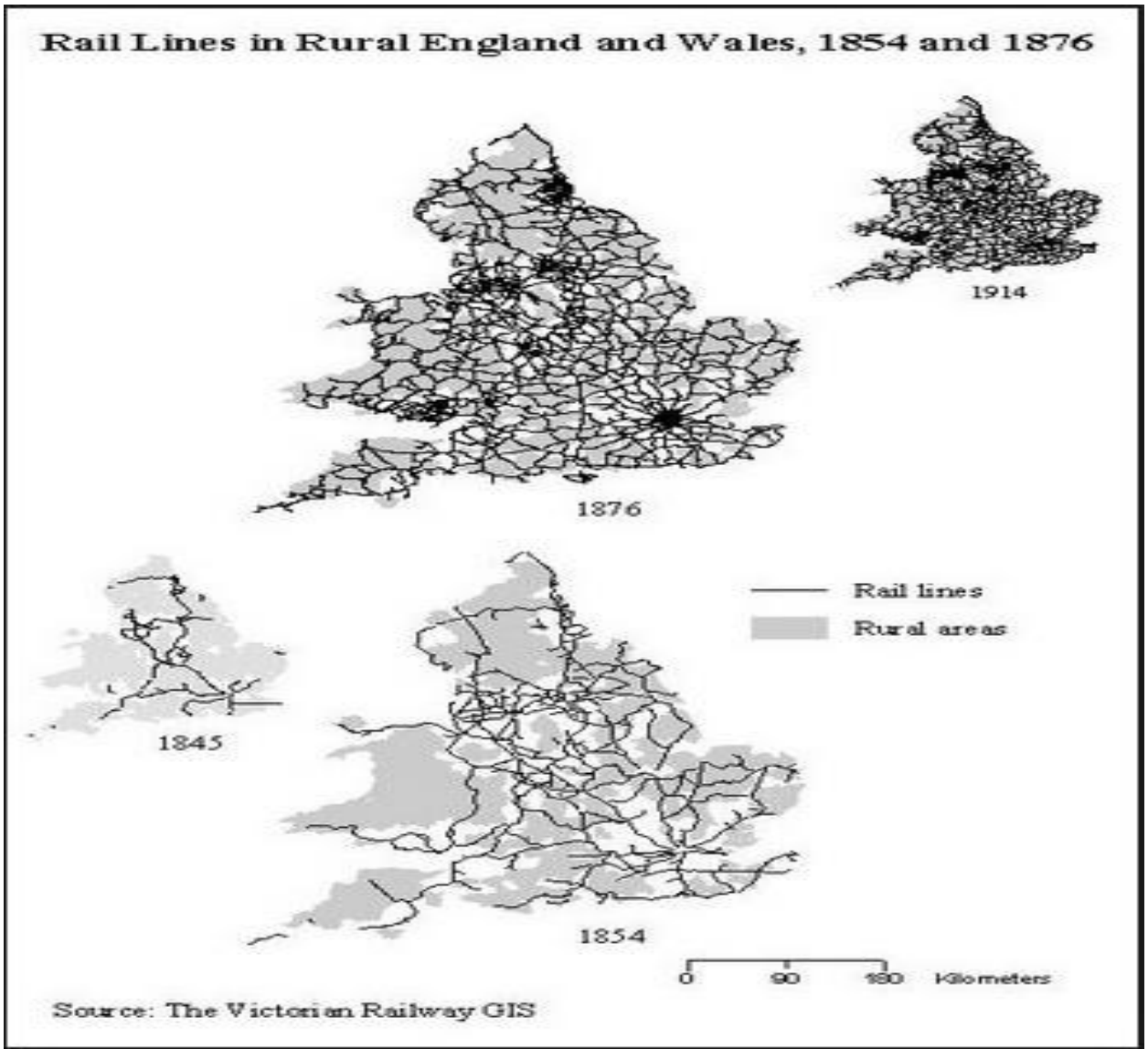
The British Railway Manias





Source: A. Odlyzko, "Collective hallucinations and inefficient markets: The British Railway Mania of the 1840s," available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1537338

English Railways 1845-1914



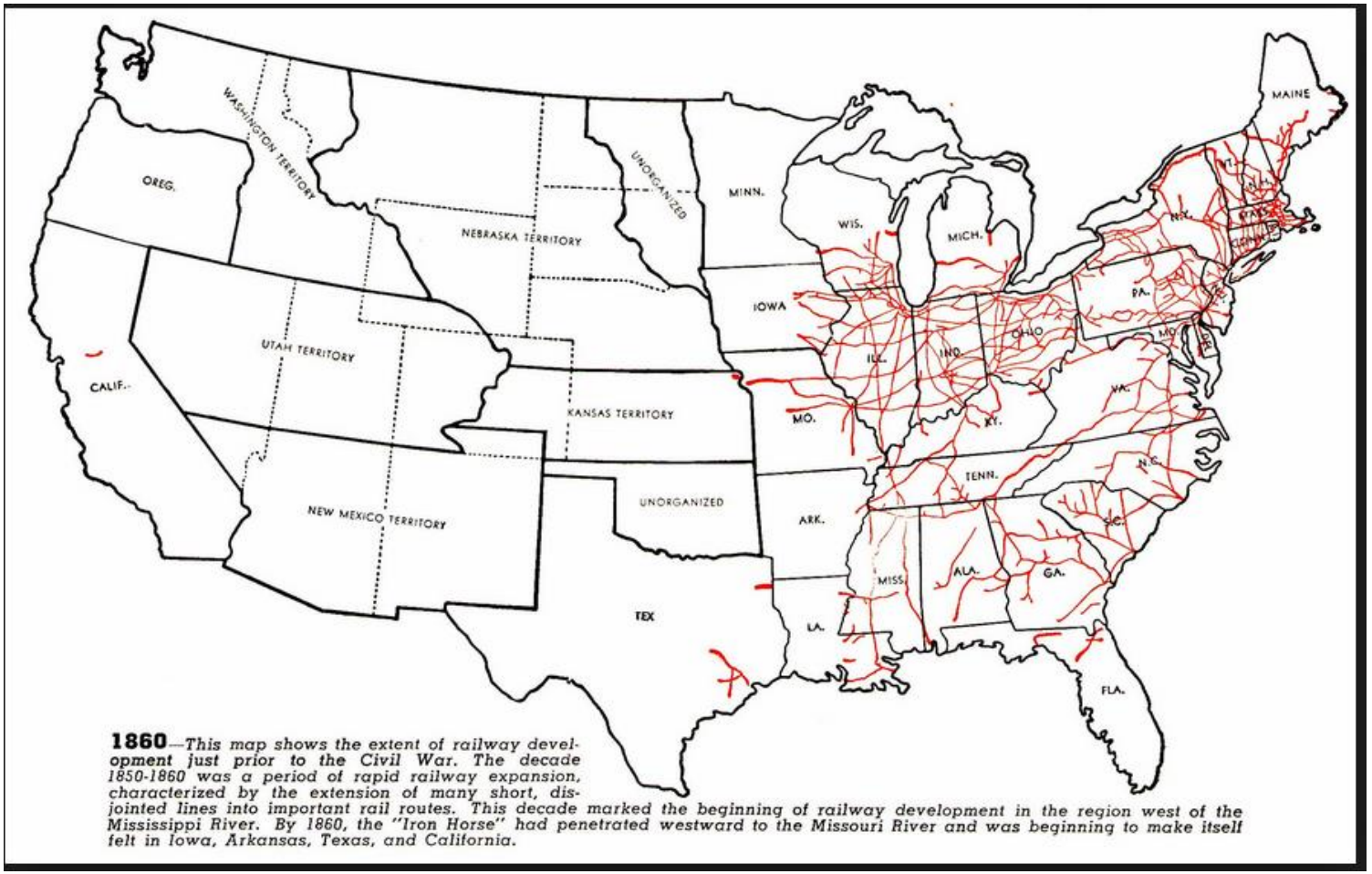
Financing the American Railroads

"**The demands of the railroads during the 1850s on American financial intermediaries and on construction contractors were unprecedented**. Railroads required far larger amounts of capital to build than did canals. The total expenditures for canals between 1815 and 1860 reached $188 million, of which 73 percent was supplied by state and local governments….**By 1859 the investment in the securities of private railroad corporations had passed the $1,100 million mark, and of this amount close to $700 million had been raised in the previous ten years**….

"As soon as the American capital market became centralized and institutionalized in New York City, all the present-day instruments of finance were perfected; so too were nearly all the techniques of modern securities marketing and speculation….

"**By the outbreak of the Civil War, the New York financial district, by responding to the needs of railroad financing, had become one of the largest and most sophisticated capital markets in the world**…" (Chandler, pp. 90-2)

US Railways 1860



1860—*This map shows the extent of railway development just prior to the Civil War. The decade 1850-1860 was a period of rapid railway expansion, characterized by the extension of many short, disjointed lines into important rail routes. This decade marked the beginning of railway development in the region west of the Mississippi River. By 1860, the "Iron Horse" had penetrated westward to the Missouri River and was beginning to make itself felt in Iowa, Arkansas, Texas, and California.*

Financing Electrification

"During the 1920s, **the public equity and debt markets played the critical role in funding the build-out of the systems that delivered electricity to industry and to households**, regionally and at length nationally. The public utility holding companies, initially created to transfer technical expertise to local generating and distribution companies, evolved into vehicles for providing the necessary finance for an industry whose capital intensity rivaled that of the railroads.

"So **electrification evolved through a dynamic feedback process that delivered, generally at the state and local level, both speculative capital and governmental regulation, the latter invoked to protect the prospective returns on the former**.…As the level of electrification for manufacturing industry and (nonrural) residential uses passed 50 percent in the early 1920s, consolidation of the industry into regional and even national holding companies was enabled by a frenzy on Wall Street terminated only by the Crash of 1929. **Before the frenzy ended, installed generating capacity in the United States had risen from 13 million to 33 million kilowatts**." (Janeway, *Doing Capitalism,* 2nd ed., p. 227*)*

The R&D Boom of the Late 1990s: Freed from Financial Constraints

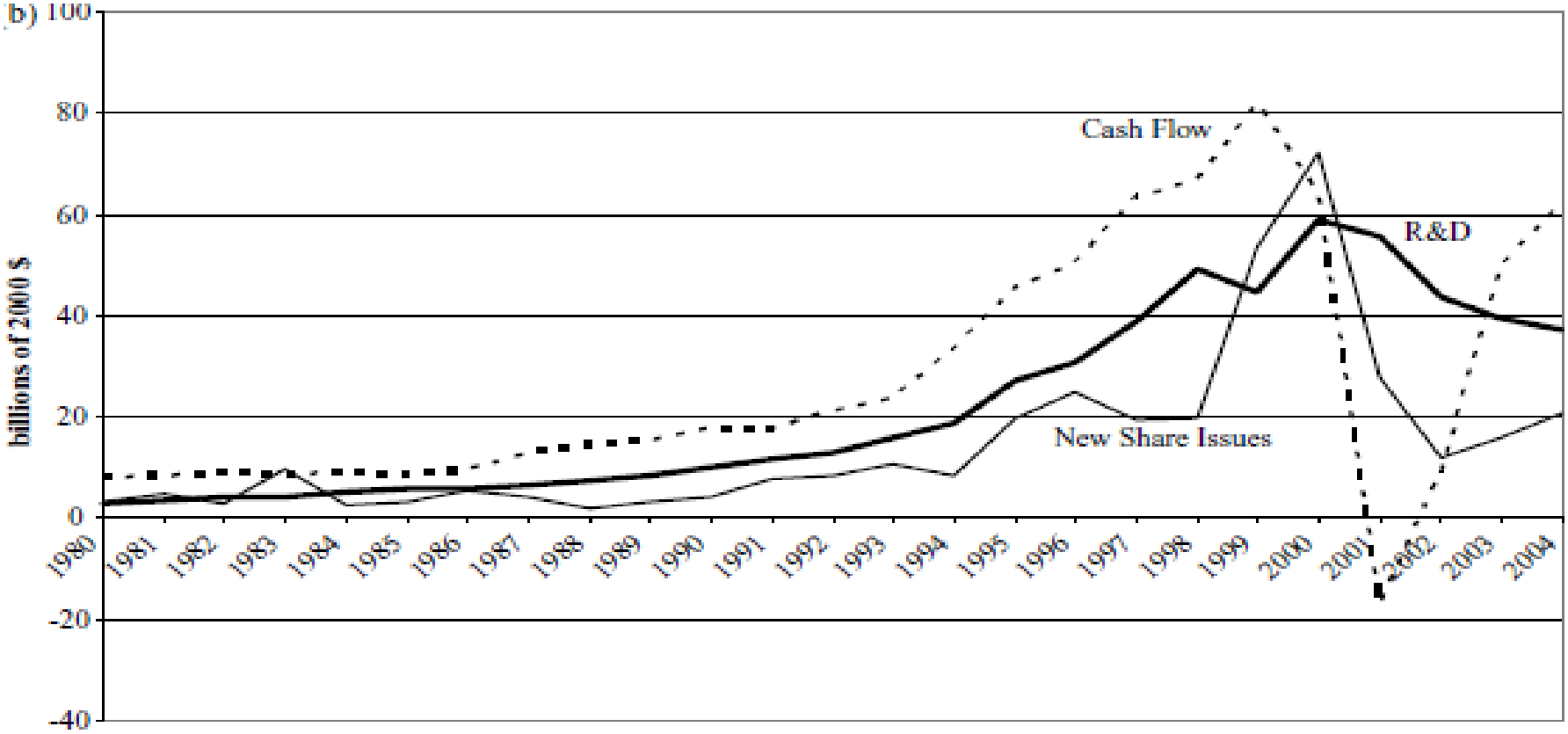


Figure 2b. High-tech R&D, cash flow, and new share issues (young firms). The sample is all young high-tech firms with coverage in Compustat. A firm is classified as young for the first 15 years following the year it first appears in Compustat with a stock price. The high-tech industries are SICs 283, 357, 366, 367, 382, 384, and 737. The heavy line plots the sum of R&D for all young high-tech firms, the dashed line plots the sum of gross cash flow, and the thin line plots the sum of net new stock issues with negative net issues set equal to zero.

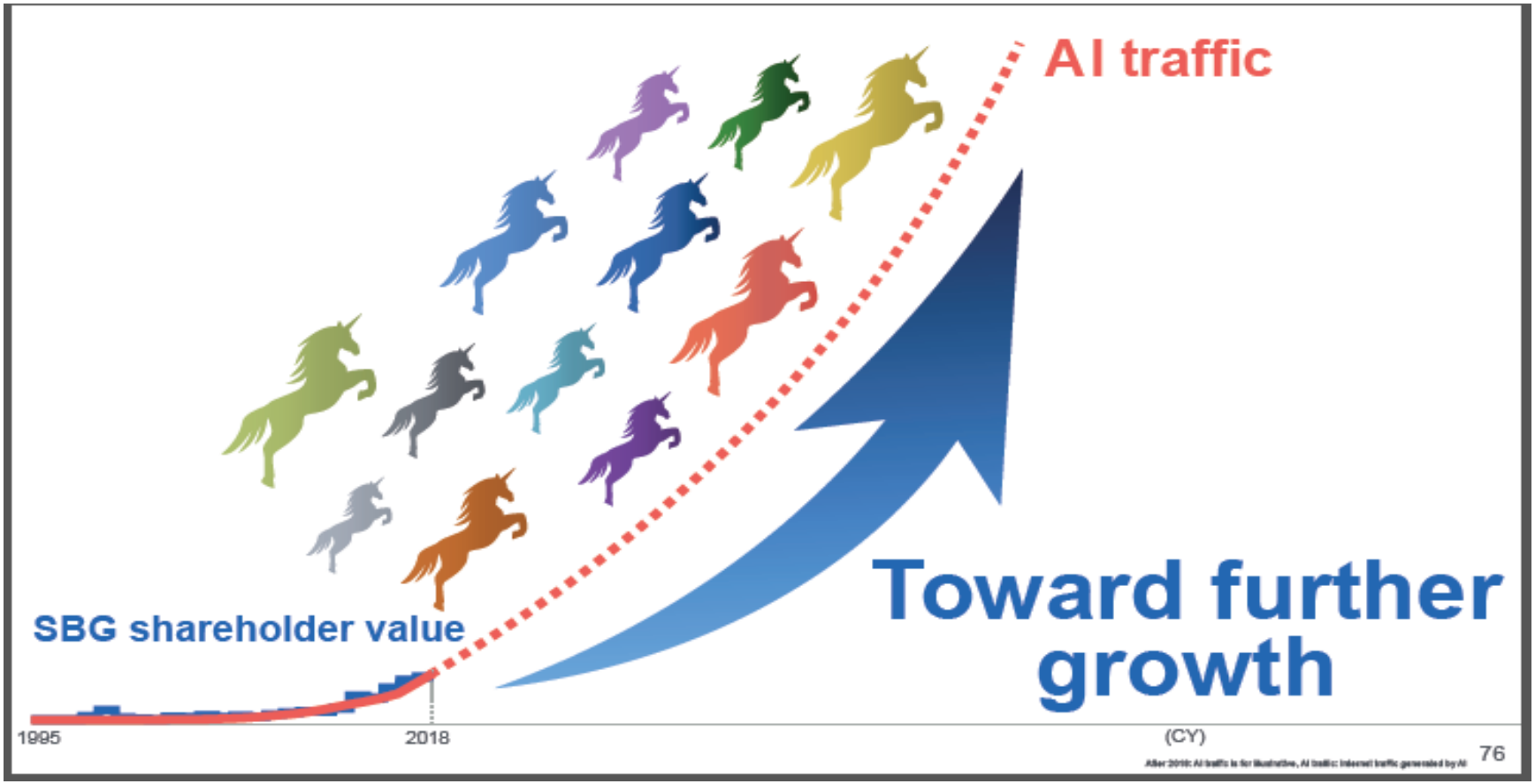
Hot Markets and Cool Stuff

"We find that **startups receiving their initial funding in more active investment periods were significantly more likely to go bankrupt** than those founded in periods when fewer startup firms were funded. However, **conditional on being successful, and controlling for the year they exit, startups funded in more active periods were valued higher at IPO or acquisition, led more patents in the years subsequent to their funding (controlling for capital received), and had more highly-cited patents** than startups funded in less active investment periods. That is, **startups funded in hot markets were more likely to be in the "tails" of the distribution of outcomes than startups funded in cold markets: they were both more likely to fail completely and more likely to be extremely successful and innovative**."

(R. Nanda, and Rhodes-Kropf, M., " Investment Cycles and Startup Innovation," *Journal of Financial Economics*, 110, no. 2 (November 2013) p. 4)

Extending the Digital Revolution: The Unicorn Bubble

Softbank Vision Fund:
Beyond Speculation



And yet: The Productivity Puzzle

Gavyn Davis, "Is Economic Growth Permanently Lower?" available at https://www.ft.com/content/3822867f-85bf-33a2-85a5-4a40974d7d9e

Technological Pessimism

- "Both the first two revolutions required about 100 years for their full effects to percolate through the economy." (p. 1)
- "At a minimum it took 150 years for IR#1 to have its full range of effects." (p. 3)
- "The inventions of IR#2 were so important that they took a full 100 years to have their main effect." (p. 4)
- "…[T]he productivity benefits of IR#3 evaporated after only eight years, compared to the 81 years (1891-1972) for the benefits of IR#2 to have their full impact…" (p. 13)

(R. Gordon, "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," NBER Working paper 18315, August 2012.)

"Profits of Doom"

"**Let is now praise famous men, the wild-eyed enthusiasts who begat the bubble-boom**. When the stock market hit the puke stage, conventional wisdom turned. The whole new economy thing had been a bad thing. Time, talent, and capital were thrown away on unsustainable enterprises like point-and-click pet food….

"Conventional wisdom…once rode side by side with the prophets of change.

"**Today's party line is that the gold rush brought both pain and gain**. Fortunes were poured into overflowing snake pits of fiber-optic cables, which, like Web-ordered groceries, proved to be profit-free zones. In just four years, the craze sucked up $600 billion of purchasing power….On the flip side, public markets paid for a build-out of the network infrastructure, and burn rates pushed the envelope of the culture at large….

(B. DeLong (2003), "Profits of Doom", *Wired* 11.04, p. 1]

The "Killer App" of the Railroads

"[A] curious thing happened as railroad bankruptcies and price wars put steady downward pressure pm shipping prices and slashed rail freight and passenger rates across the country: **New industries sprang up**.

"Consider…the old **Montgomery Ward and Sears Roebuck catalogs**….Mail a catalog to every household in the country. Offer the big-city goods at near big-city discounts. Rake in the money from satisfied customers. For two generations this business model—call it the 'railroad services' business model—was a license to print money, made possible only by the gross overbuilding of railroads, the resulting collapse of freight rates, and the fact that railroad investors had had to kiss nearly all their money good-bye….

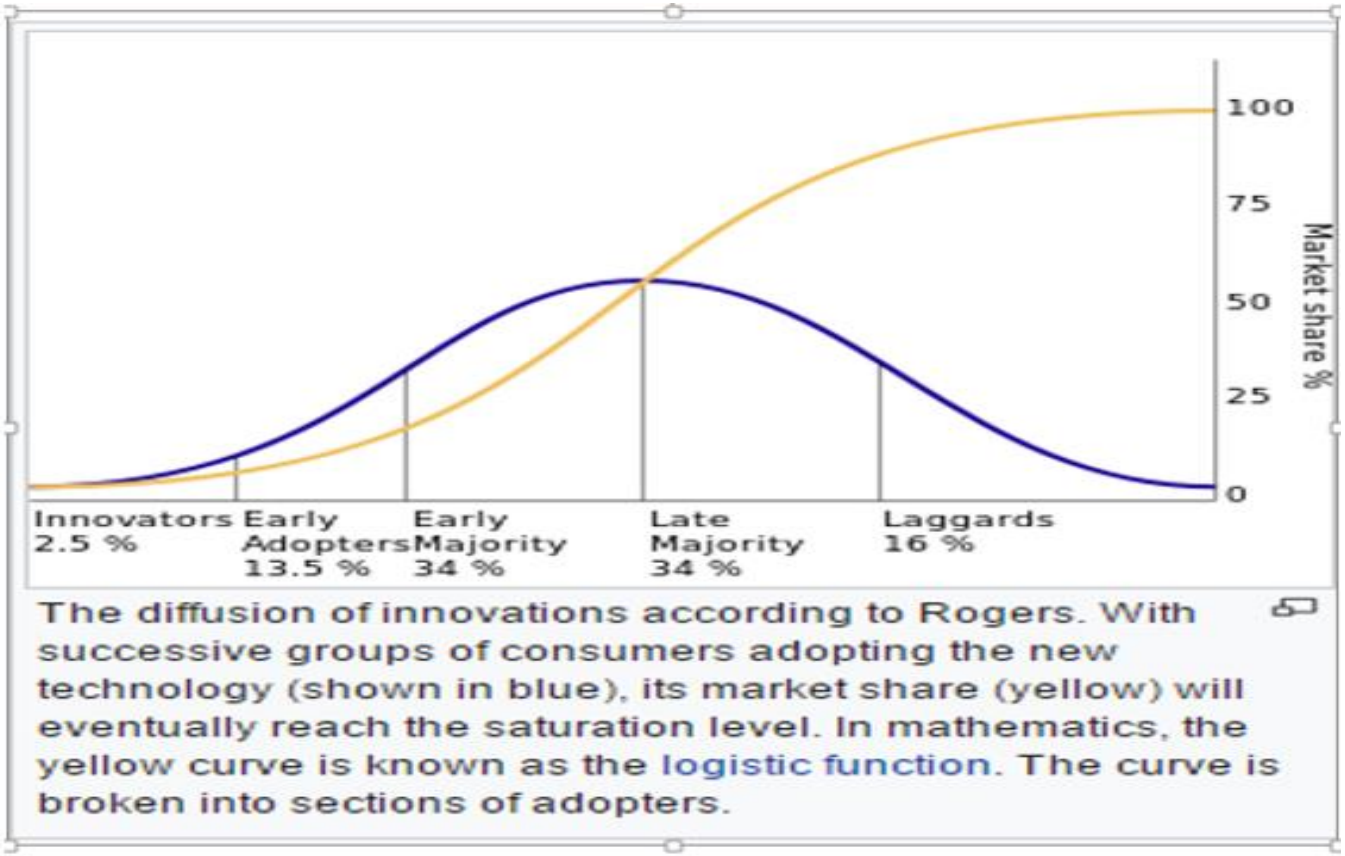
"**The same thing will happen with the froth that the bubble put on our 1990s boom. Investors lost their money. We now get to use all their stuff**…." (DeLong, pp. 1-2)

Mismeasurement?

"My evaluation focuses on **four pieces of evidence that pose challenges for mismeasurement-based explanations** for the productivity slowdown that the US economy has been experiencing since 2004. **Two patterns—the size of the slowdown across countries is uncorrelated with the information and communications technology intensities of those countries' economies, and the GDI–GDP gap began opening before the slowdown and in any case reflects capital income growth—are flatly inconsistent with the implications of the mismeasurement hypothesis. Two others—the modest size of the existing literature's estimates of surplus from internet-linked products and the large implied missing growth rates of digital technology industries that the mismeasurement hypothesis would entail—show the quantitative hurdles the hypothesis must clear** to account for a substantial share of what is an enormous amount of measured output lost to the slowdown (around $9,300 per person per year).

(C. Syverson, "Challenges to Mismeasurement Explanations for the US Productivity Slowdown," *Journal of Economic Perspectives*, 31:2, Spring 2017, pp. 182-3)

Diffusion

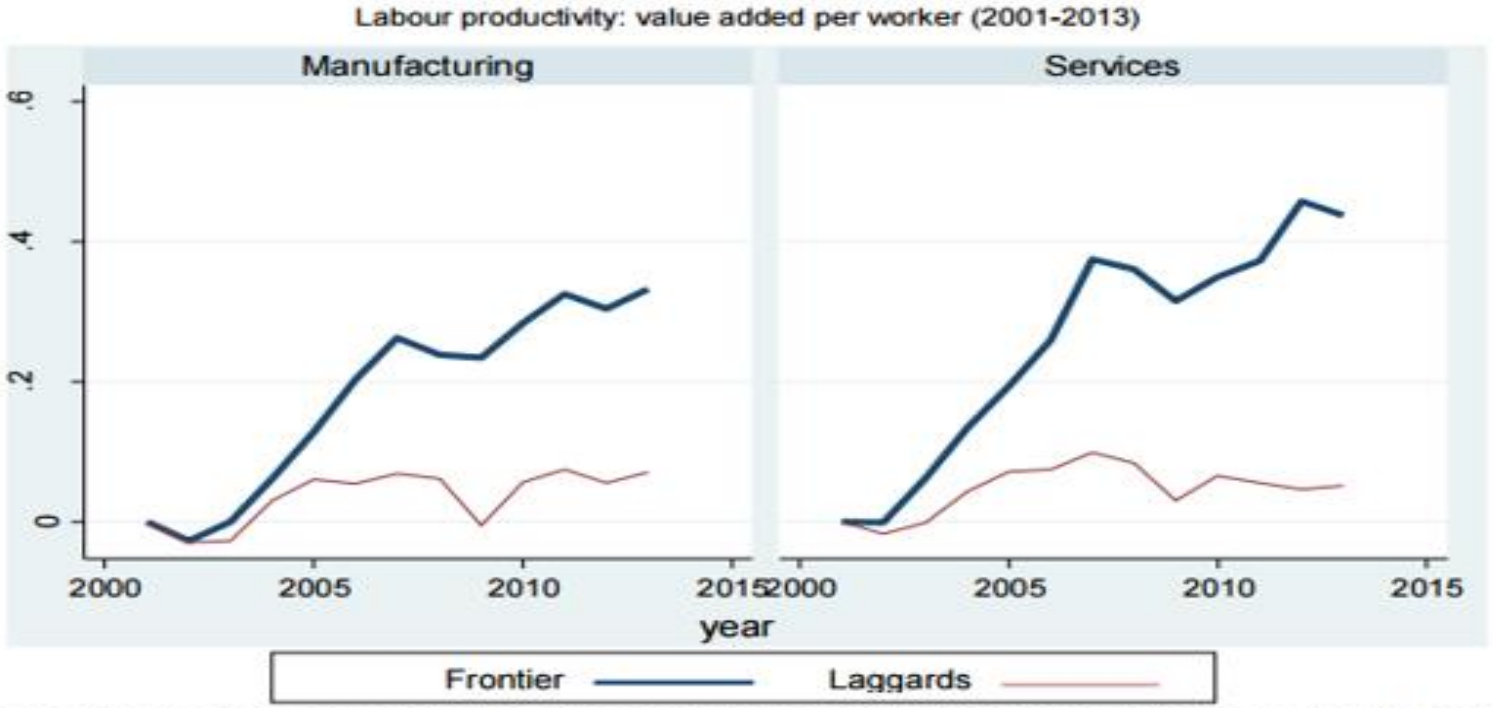


The diffusion of innovations according to Rogers. With successive groups of consumers adopting the new technology (shown in blue), its market share (yellow) will eventually reach the saturation level. In mathematics, the yellow curve is known as the logistic function. The curve is broken into sections of adopters.

https://en.wikipedia.org/wiki/Diffusion_of_innovations

(See: D. Comin and Hobujn, "An Exploration of Technology Diffusion," *American Economic review*, 100 (12/2010), pp. 2031-2059)

The Best versus the Rest: OECD



Notes: the global frontier is measured by the average of log labour productivity for the top 5% of companies with the highest productivity levels within each 2-digit industry. Laggards capture the average log productivity of all the other firms. Unweighted averages across 2-digit industries are shown for manufacturing and services, normalized to 0 in the starting year. The time period is 2001-2013. The vertical axes represent log-differences from the starting year: for instance, the frontier in manufacturing has a value of about 0.3 in the final year, which corresponds to approximately 30% higher in productivity in 2013 compared to 2001. Services refer to non-financial business sector services. See details in Section 3.3.

Source: Authors' calculations based on the recent update of the OECD-Orbis productivity database (Gal, 2013).

D. Andrews, Criscuolo C., and P. N. Gal, "The Best versus the Rest: the Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy," OECD, December 2016, available at http://www.oecd-ilibrary.org/economics/the-best-versus-the-rest_63629cc9-en;jsessionid=9ag8ukcclm7fb.x-oecd-live-03

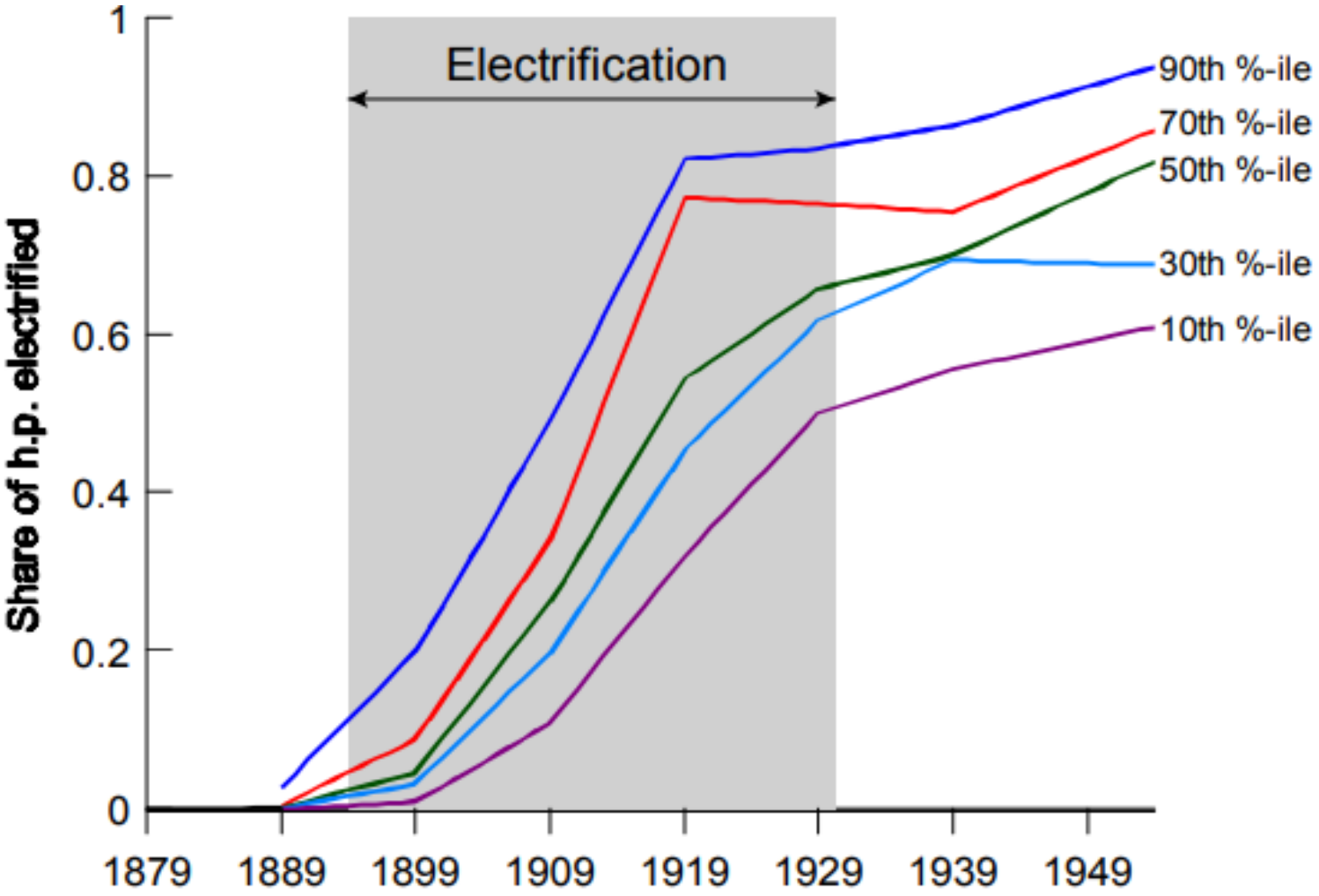
The Diffusion of Electrification

"**Certainly, the transformation of industrial processes by the new electric power technology was a long-delayed and far from automatic business**. It did not acquire real momentum in the United States until after 1914-17, when regional utility rates for electricity were lowered substantially…and central station generating capacity came to predominate over generating capacity in isolated industrial plants.

"In 1900 contemporary observers well might have remarked that the electric dynamos were to be seen "everywhere but in the productivity statistics."

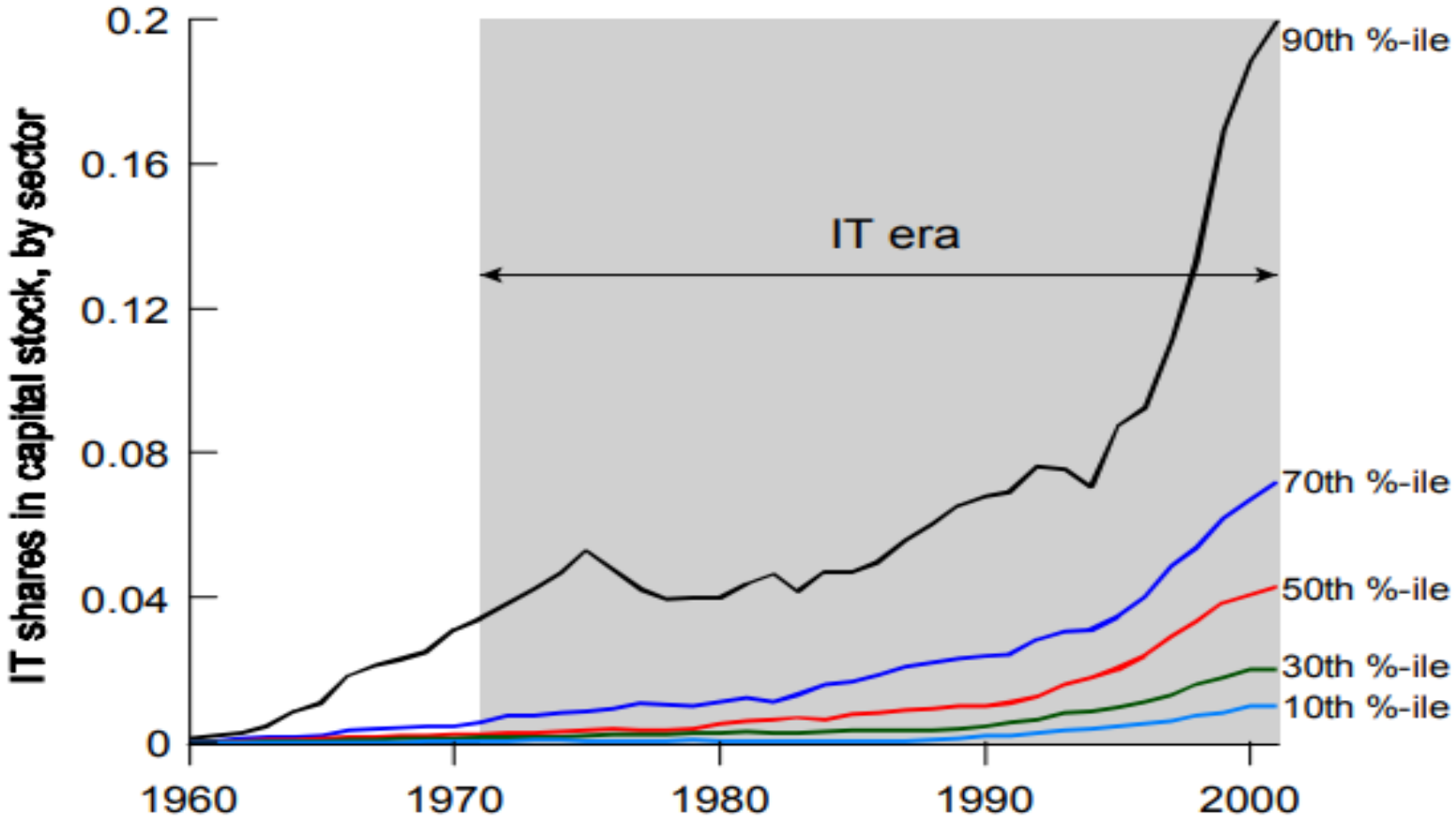
(P. A. David, "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox," *American Economic Review*, May 1990, p. 355)

Shares of Electrified Horsepower by Manufacturing Sectors in percentiles: 1890-1954



(B. Jovanovic and Rousseau, P. L., "General Purpose Technologies," NBER Working Paper 11093 (January 2005), p. 10.)

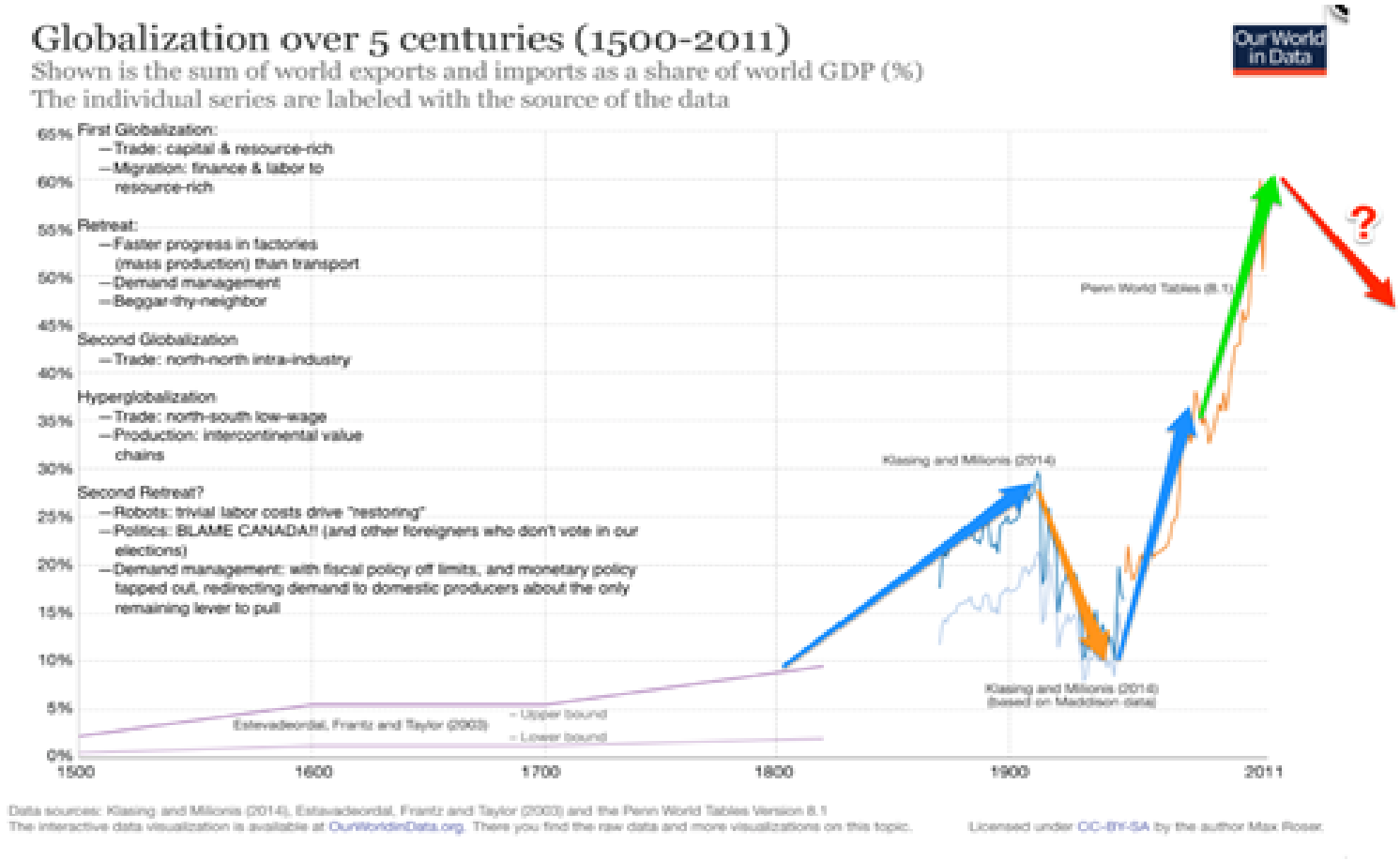
Shares of IT Equipment and Software in the Capital Stock by Sector in percentiles, 1960-2001



(B. Jovanovic and Rousseau, P. L., p. 12)

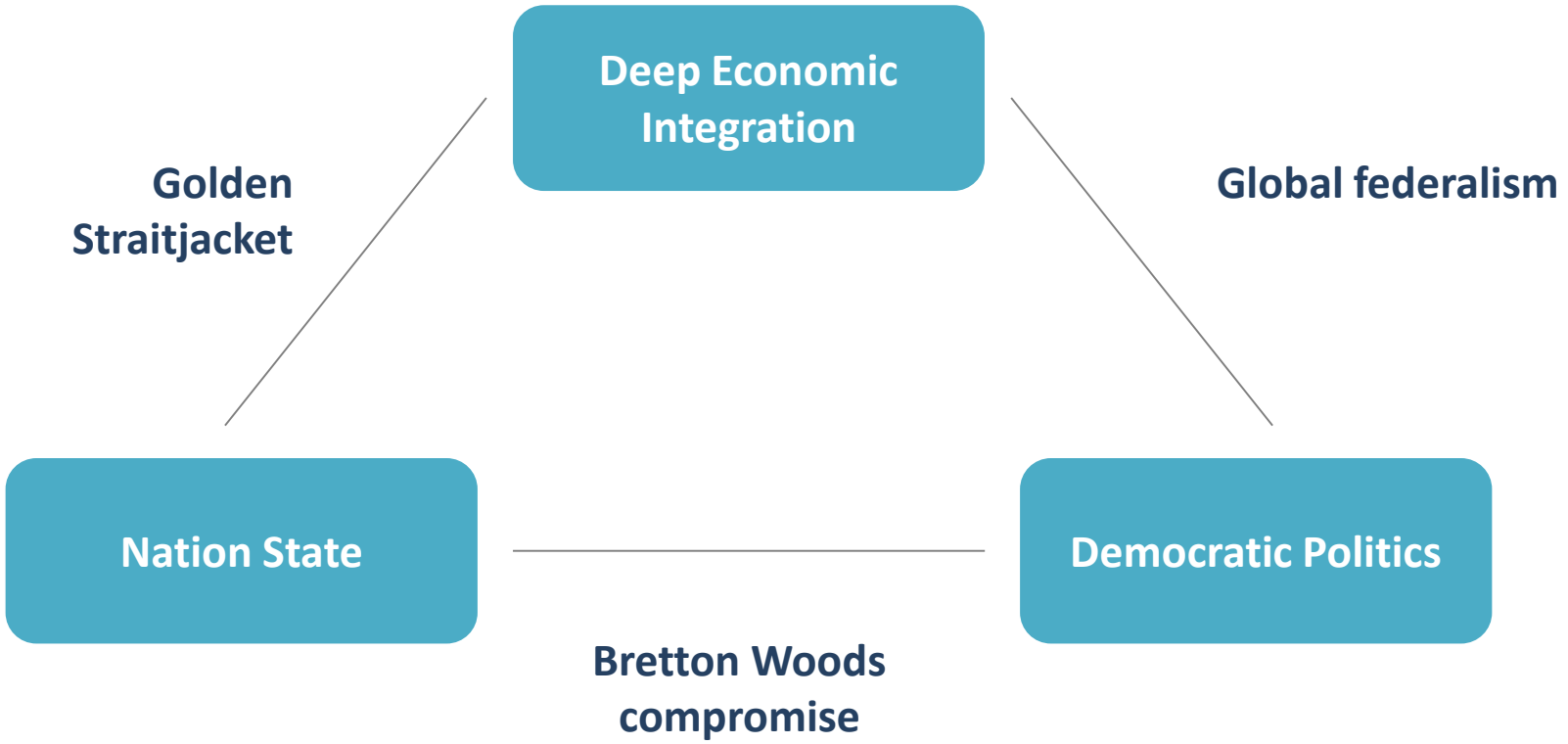
The Two (Modern) Globalizations

Courtesy of Brad Delong:



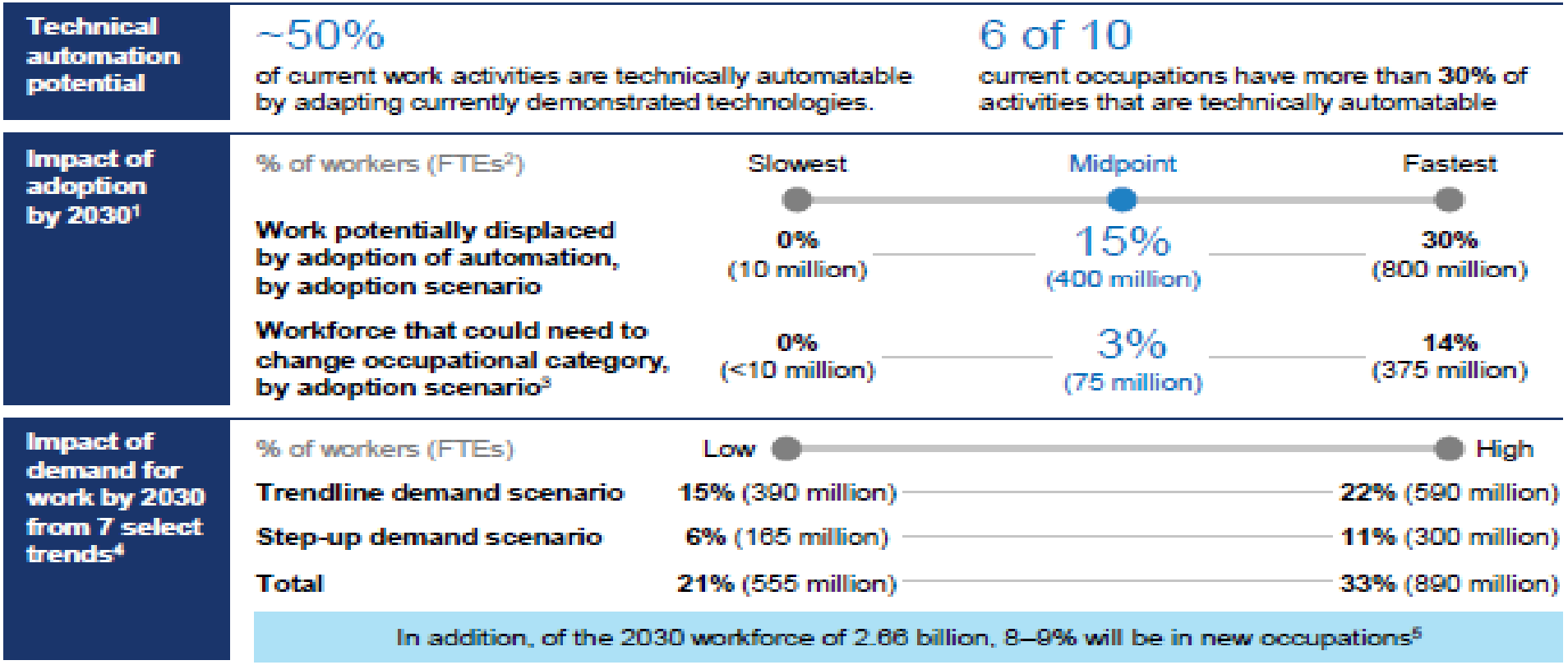
The Political Trilemma

The Political Trilemma of the World Economy



D. Rodrik, *The Globalization Paradox*

Potential Impact of Automation



1 "Slowest" and "fastest" adoption refer to the two extremes of the scenario range we used in our automation adoption modeling, the latest and earliest scenarios, respectively. See Chapter 1 for details.
2 Full-time equivalents.
3 In trendline labor-demand scenario.
4 Rising incomes; health care from aging; investment in technology, infrastructure, and buildings; energy transitions; and marketization of unpaid work. Not exhaustive.
5 See Jeffrey Lin, "Technological adaptation, cities, and new work," *Review of Economics and Statistics*, volume 93, number 2, May 2011.

SOURCE: McKinsey Global Institute analysis

Algorithmic Management in the Workplace

February 2019

ALEXANDRA MATEESCU, Researcher, Data & Society
AIHA NGUYEN, Labor Engagement Lead, Data & Society

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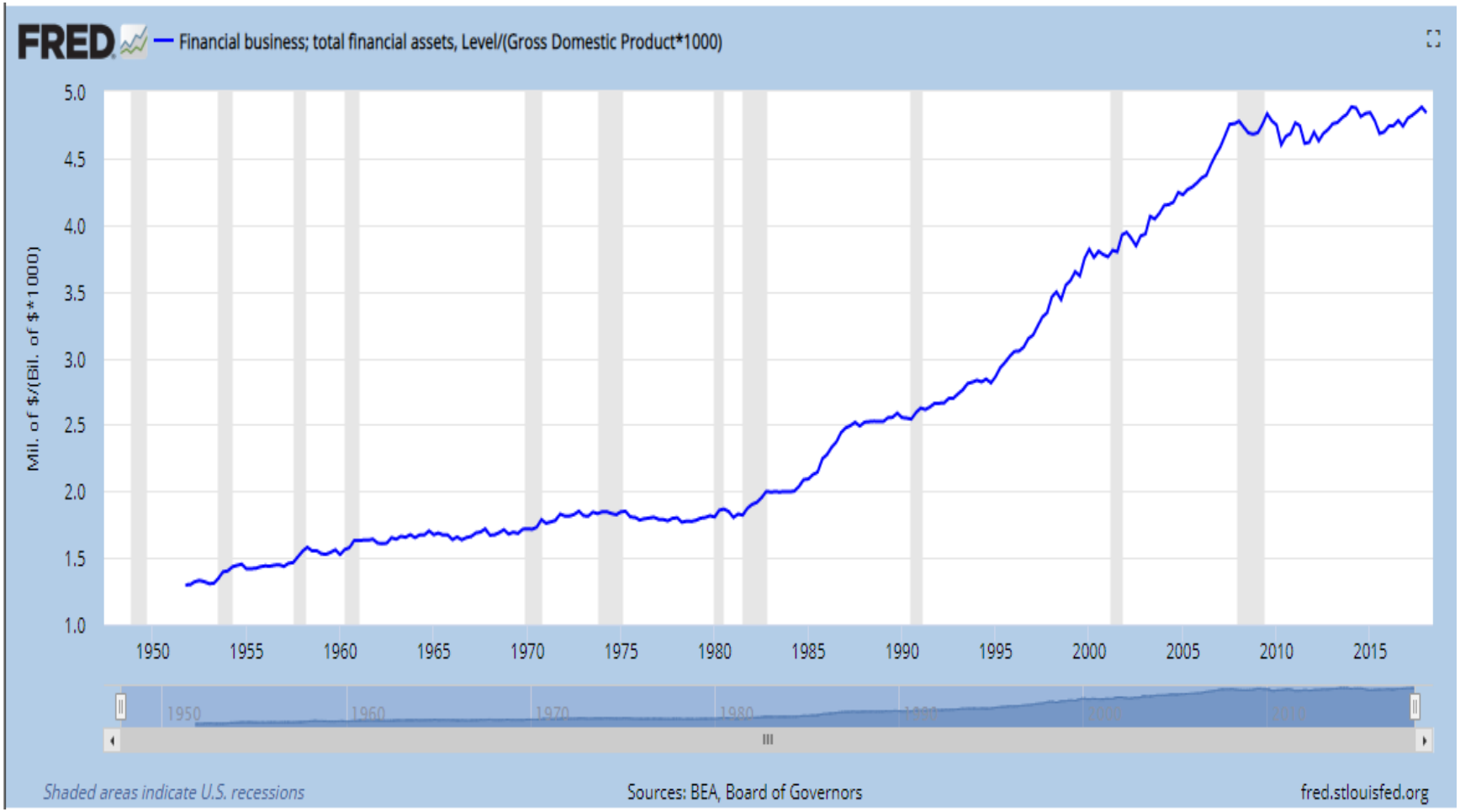
Financialization: I



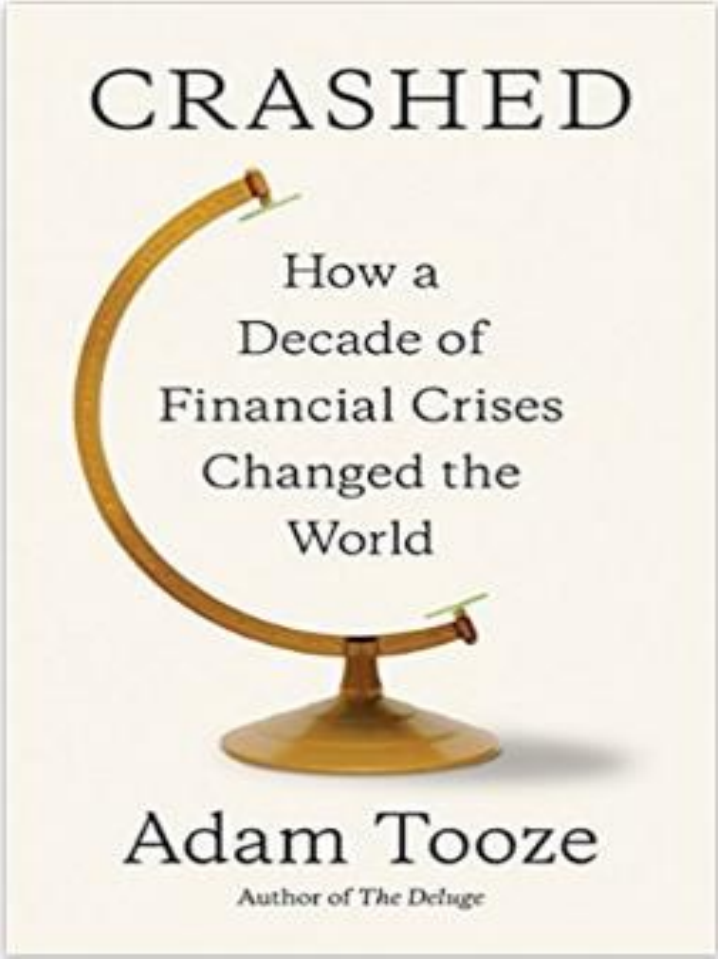
Financialization: II
The Role of IT in the Great Credit Bubble

"**Finally, the impact of modern finance theory on modern finance practice would never have been realized except for the IT revolution**. In no sector of the world economy did advances in computing have a more revolutionary effect than in finance. Here was a world peopled by smart, rich and intensely competitive players who were swimming in oceans of data. The trading desks rapidly moved beyond deploying computers merely to transact and record the growing volume of trades on the stock exchange. Traders mobilized computers to analyze data in order both to identify opportunities for profitable arbitrage and to create new instruments for trading, from swaps of currency and interest payments, to instantaneously updated stock indices, to asset-backed securities of all sorts, beginning with mortgages and extending to credit card receivables and student loans.

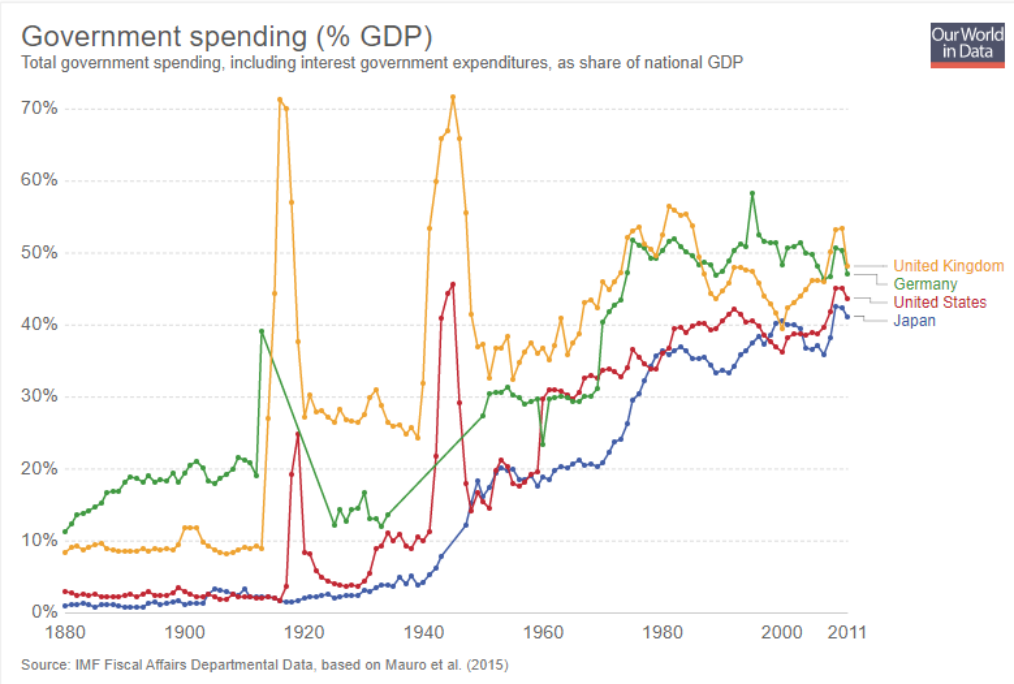
"...**By making it possible to transform credit instruments that had traditionally been bought and held by lenders into tradable securities, computerization enabled the extension of the originate-and-distribute model from the equity and bond markets across the entire spectrum of credit, even as it also offered the false promise of constructing insurance against loss**."

(Janeway, *Doing Capitalism*, 2nd edition, pp. 186-7*)*

The Global Financial Crisis



Public Sector Share of National Economy



ISSIE LAPOWSKY BUSINESS 05.22.19 01:00 AM

FAR-RIGHT PROPAGANDA FLOODS FACEBOOK AHEAD OF EU ELECTIONS

Wired, May 22, 2019

The Next, Needed Techno-Transformation

"Human-induced warming reached approximately 1°C (±0.2°C *likely* range) above pre-industrial levels in 2017, increasing at 0.2°C (±0.1°C) per decade (*high confidence*).

"Warming greater than the global average has already been experienced in many regions and seasons, with average warming over land higher than over the ocean (*high confidence*)….

"1.5°C-consistent pathways can be identified under a range of assumptions about economic growth, technology developments and lifestyles. However, **lack of global cooperation, lack of governance of the energy and land transformation, and growing resource-intensive consumption are key impediments for achieving 1.5°C-consistent pathways**. Governance challenges have been related to scenarios with high inequality and high population growth in the 1.5°C pathway literature."

(Intergovernmental Pact on Climate Change, "Global Warming at 1.5C°": Technical Summary, p. TS-4, 6, available at http://www.ipcc.ch/report/sr15/ .)

"The Irreversible Momentum of Clean Energy"

"Since 2008, the United States has experienced the first sustained period of rapid GHG emissions reductions and simultaneous economic growth on record. Specifically, CO_2 emissions from the energy sector fell by 9.5% from 2008 to 2015, while the economy grew by more than 10%. In this same period, the amount of energy consumed per dollar of real gross domestic project (GDP) fell by almost 11%, the amount of CO_2 emitted per unit of energy consumed declined by 8%, and CO_2 emitted per dollar of GDP declined by 18%."

(Barack Obama, *Science*, 13 January 2017)

American Government Abdicates

Statement by President Trump on the Paris Climate Accord

ENERGY & ENVIRONMENT | Issued on: June 1, 2017

★ ★ ★

"As President, I can put no other consideration before the wellbeing of American citizens. **The Paris Climate Accord is simply the latest example of Washington entering into an agreement that disadvantages the United States to the exclusive benefit of other countries**, leaving American workers — who I love — and taxpayers to absorb the cost in terms of lost jobs, lower wages, shuttered factories, and vastly diminished economic production.

"**Thus, as of today, the United States will cease all implementation of the non-binding Paris Accord and the draconian financial and economic burdens the agreement imposes on our country**. This includes ending the implementation of the nationally determined contribution and, very importantly, the Green Climate Fund which is costing the United States a vast fortune."

The Good News

"**Wind and solar are set to surge to almost "50 by 50" – 50% of world generation by 2050** – on the back of precipitous reductions in cost, and the advent of cheaper and cheaper batteries that will enable electricity to be stored and discharged to meet shifts in demand and supply. Coal shrinks to just 11% of global electricity generation by 2050.

"**By 2050, we expect only 29% of the electricity production worldwide to result from burning fossils fuels, down from 63% today**.

"The dramatic shift to "50 by 50" is being driven by cheap solar PV, sheap wind and falling battery costs. The cost of an average PV plant falls by 71% by 2050. Wind energy is getting cheaper, too, and we expect it to drop 58% by 2050. PV and wind are already cheaper than building new coal and gas plants. **Batteries are also dropping dramatically in cost**."

(Bloomberg New Energy Outlook 2018, available at https://bnef.turtl.co/story/neo2018?teaser=true .)

Ignorance or Indifference: Which is Worse?

"Trump administration sees a 7-degree rise in global temperatures by 2100"

"The draft statement, issued by the National Highway Traffic Safety Administration (NHTSA), was written to justify President Trump's decision to freeze federal fuel-efficiency standards for cars and light trucks built after 2020. While the proposal would increase greenhouse gas emissions, the impact statement says, that policy would add just a very small drop to a very big, hot bucket.

"**The amazing thing they're saying is human activities are going to lead to this rise of carbon dioxide that is disastrous for the environment and society. And then they're saying they're not going to do anything about it**," said Michael MacCracken, who served as a senior scientist at the U.S. Global Change Research Program from 1993 to 2002."

(J. Eilperin, Dennis, B., and Mooney, C., *Washington Post,* September 28, 2018.)

Will China Lead?

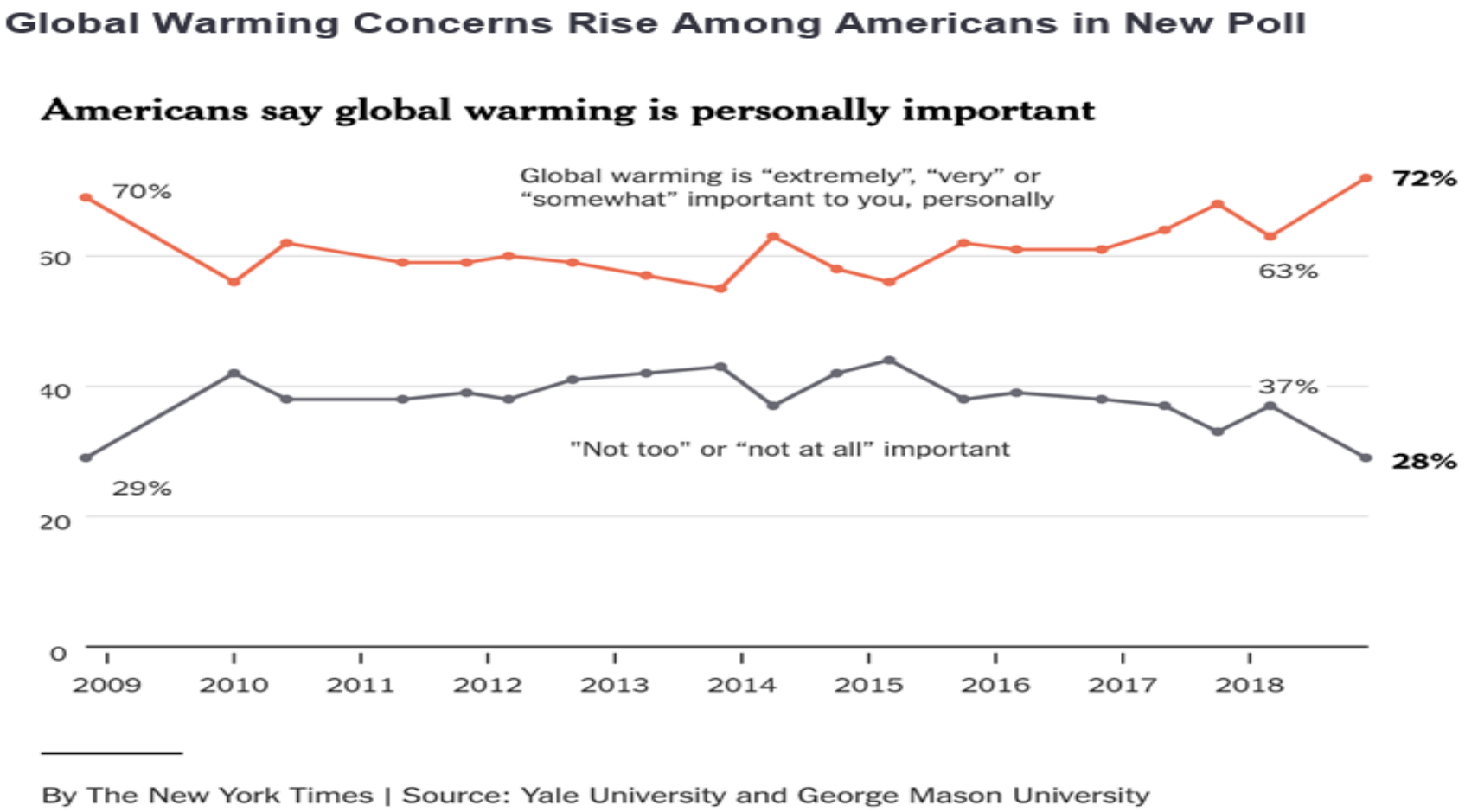
China emerges as global climate leader in wake of Trump's triumph

With the US president-elect threatening to withdraw from the Paris Agreement, Beijing is to ready to lead world's climate efforts, reports Environment 360

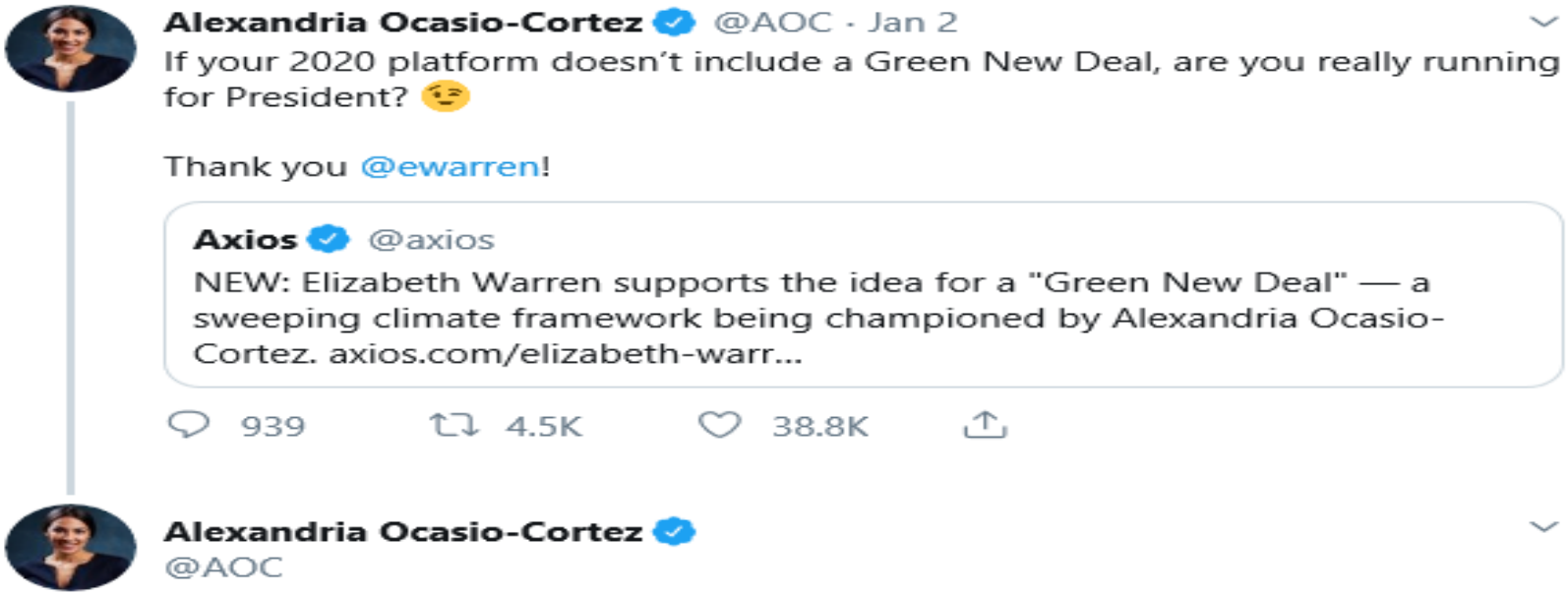
Xie Zhenhua, China's special representative for climate change affairs, delivers a speech. Photograph: Abdeljalil Bounhar/INBAR/AP

Source: *The Guardian*, 11/26/2016

And in America:
A New Hope?



A Green New Deal?



Alexandria Ocasio-Cortez @AOC · Jan 2

If your 2020 platform doesn't include a Green New Deal, are you really running for President? 😉

Thank you @ewarren!

> **Axios** @axios
> NEW: Elizabeth Warren supports the idea for a "Green New Deal" — a sweeping climate framework being championed by Alexandria Ocasio-Cortez. axios.com/elizabeth-warr...

939 4.5K 38.8K

Alexandria Ocasio-Cortez
@AOC

Many people ask what a Green New Deal entails.

We are calling for a wartime-level, just economic mobilization plan to get to 100% renewable energy ASAP.