Automation, Before and After the Pandemic

Daron Acemoglu

Federal Reserve Bank of Boston, November, 2022

Hopes of AI
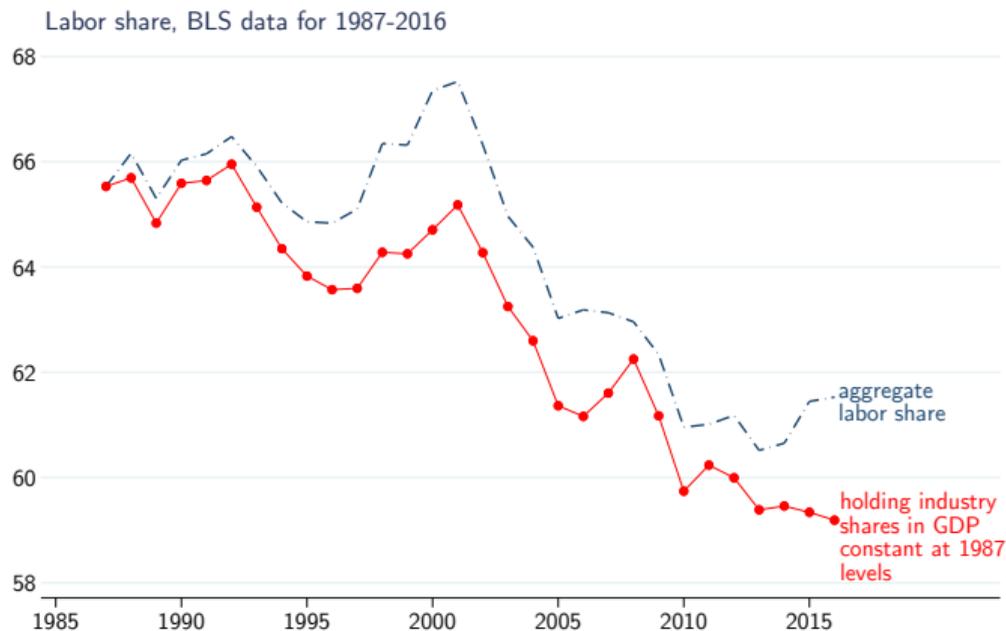
► Major advances in certain aspects of AI—especially those relying on machine learning tools applied to unstructured, huge data sets, and narrow, well-defined tasks, including quite complex ones such as chess and Go.

► Recent research showing that AI-related publications have shifted from the confines of computer science journals to a much broader range of application domains, indicating the onset of the more applied stage of the technology's advances.

► A lot of optimism. *The Economist* magazine recently argued that fears of job losses from AI are exaggerated and

"by lowering costs of production, [AI-based] automation can create more demand for goods and services, boosting jobs that are hard to automate. The economy may need fewer checkout attendance at supermarkets, but more massage therapists."

► McKinsey-Davos statement for 2022 also dismisses fears of automation from AI:

"with Fourth Industrial Revolution technologies driving productivity and growth across manufacturing and production at brownfield and greenfield sites. These technologies are creating more and different jobs that are transforming manufacturing and helping to build fulfilling, rewarding, and sustainable careers."

But Obviously Not All is Well, Even Before the Pandemic

Labor share, BLS data for 1987-2016

aggregate
labor share

holding industry
shares in GDP
constant at 1987
levels

▶ Declining labor share in the US; similar in Europe and the emerging world.
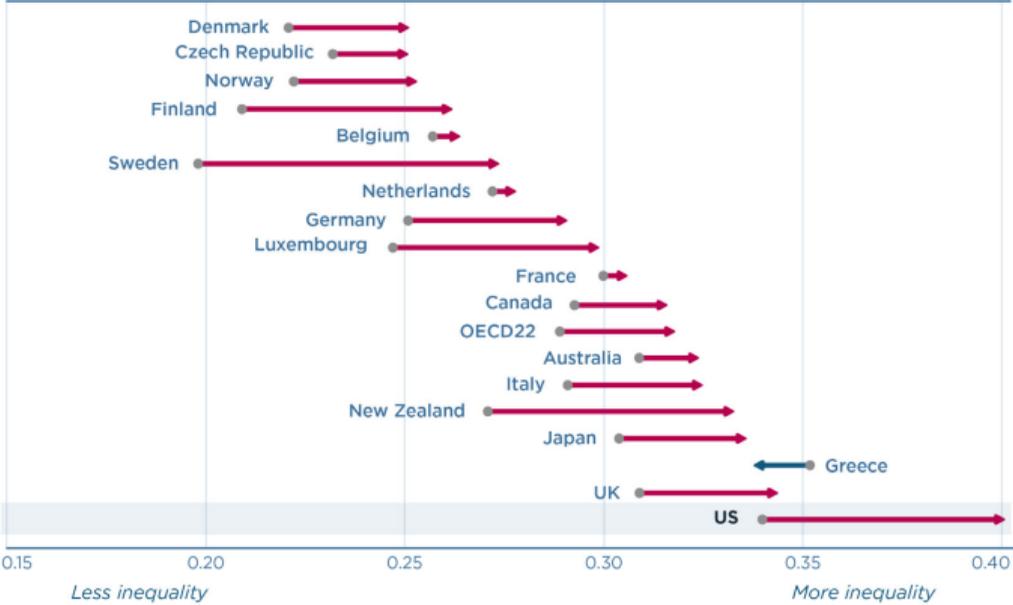▶ Closely connected to automation.

Even More Concerning: US Wages
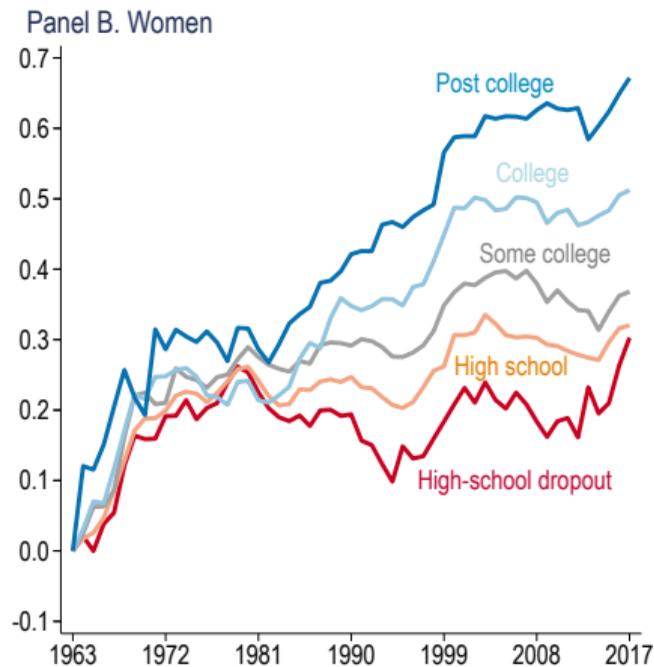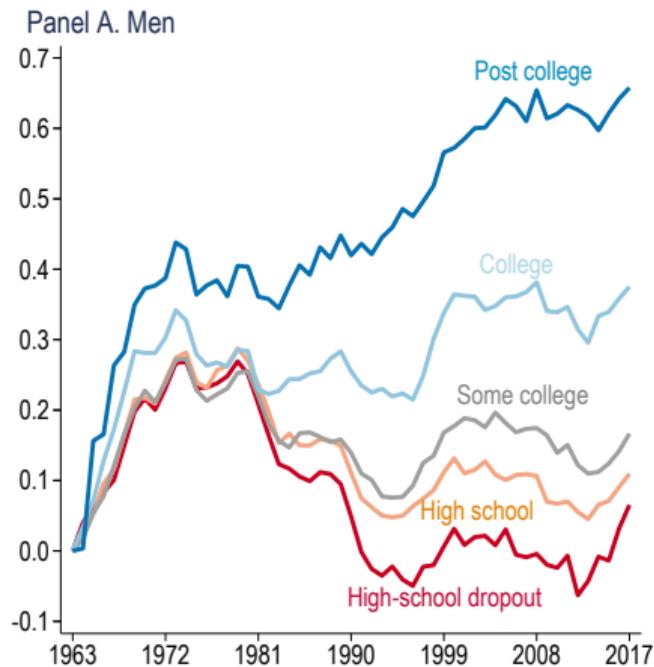
Source: Autor (AEA 2019)

▶ Huge increase in inequality, and significant declines in real wages for low-education groups.

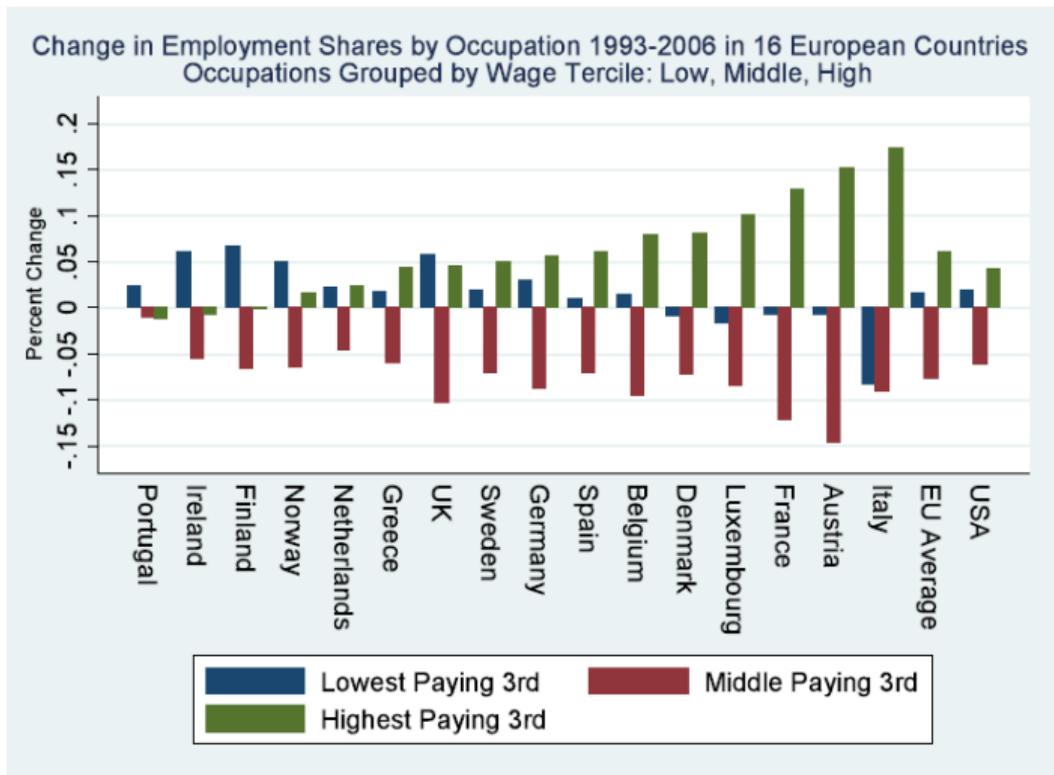# Inequality Is Not Just a US Phenomenon, But It is Worse in the US

Figure 1: Change in Gini coefficient, 1985 to 2013

| | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 |

Denmark, Czech Republic, Norway, Finland, Belgium, Sweden, Netherlands, Germany, Luxembourg, France, Canada, OECD22, Australia, Italy, New Zealand, Japan, Greece, UK, US
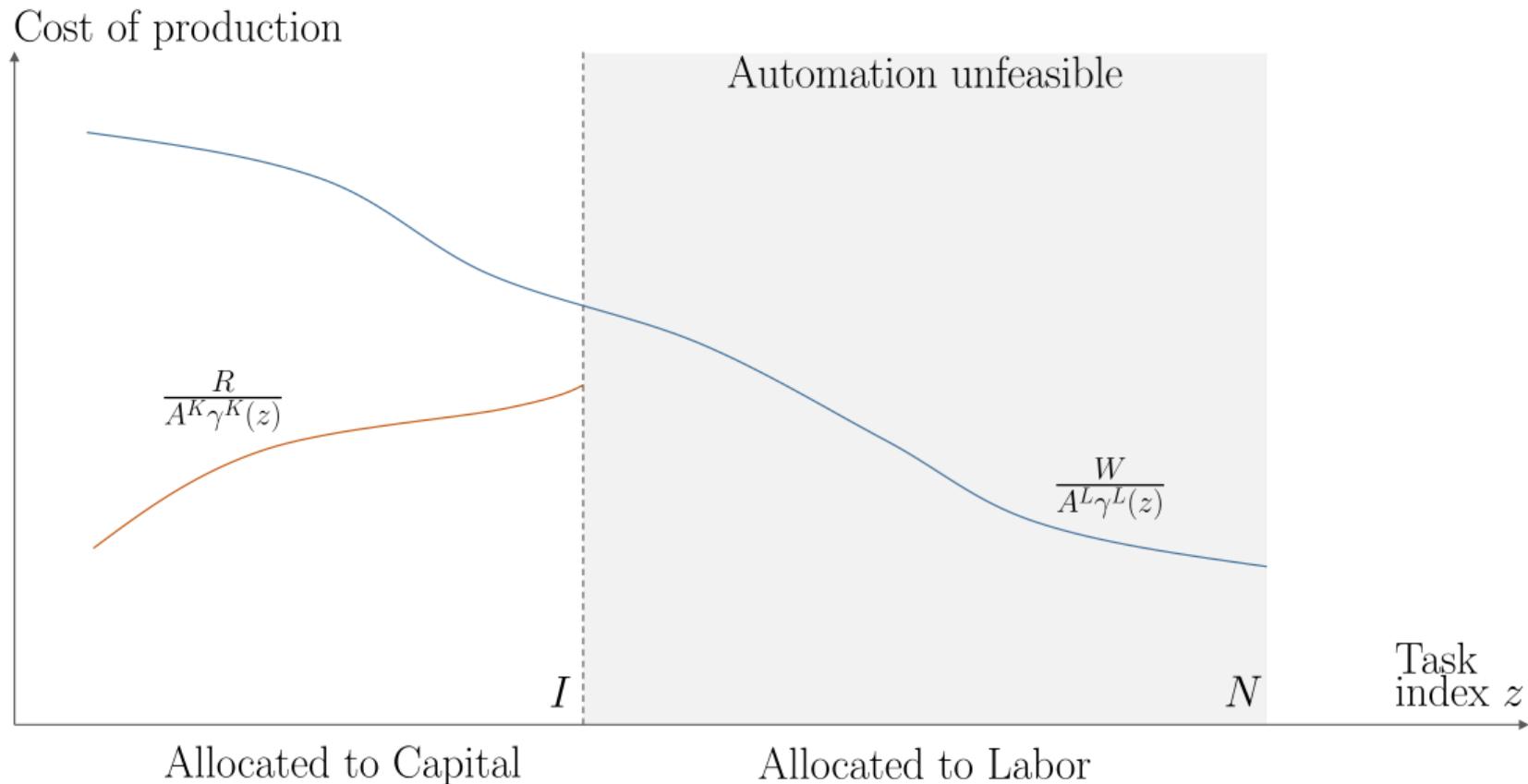
Less inequality — *More inequality*

Note: 1985 data refer to 1985 or closest available year. 2013 data refer to 2013 or nearest available year. The Gini coefficient measures how equally income is distributed across a population, from 0 (perfectly equal) to 1 (all income to one person).

Automation is Not Just a US Phenomenon

▶ Similar polarization of employment— but not of wages, indicating an important role for labor market institutions.

Change in Employment Shares by Occupation 1993-2006 in 16 European Countries
Occupations Grouped by Wage Tercile: Low, Middle, High

How to Think of the Labor Market Effects of Technologies?

Cost of production

Automation unfeasible

$\frac{R}{A^K\gamma^K(z)}$

$\frac{W}{A^L\gamma^L(z)}$

I

N

Task index z

Allocated to Capital

Allocated to Labor

Labor-Augmenting Technological Change

▶ Large productivity effects and small distributional implications.

Cost of production

Automation infeasible

$\frac{R}{A^K \gamma^K(z)}$

$\frac{W}{A^L \gamma^L(z)}$

"Labor augmenting tech."

I

N

Task index z
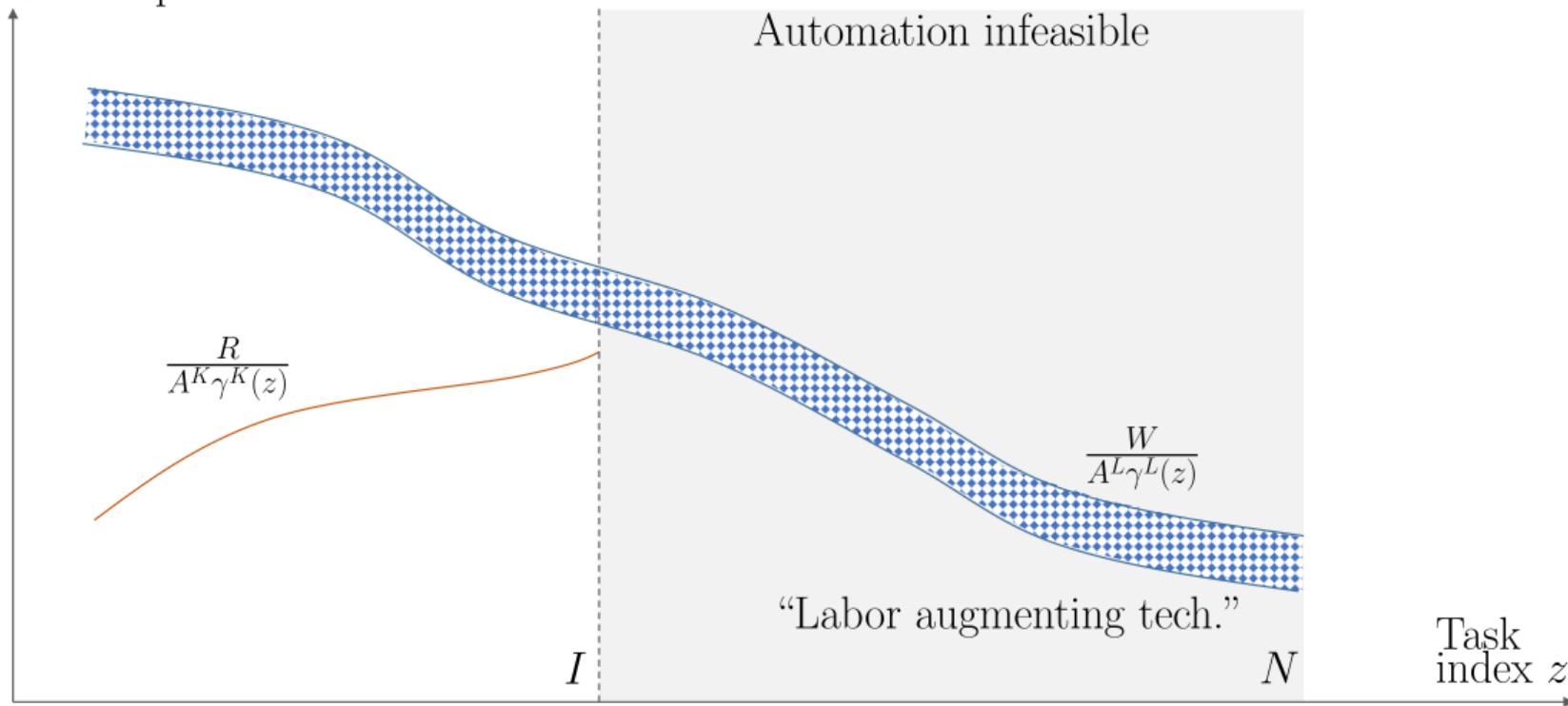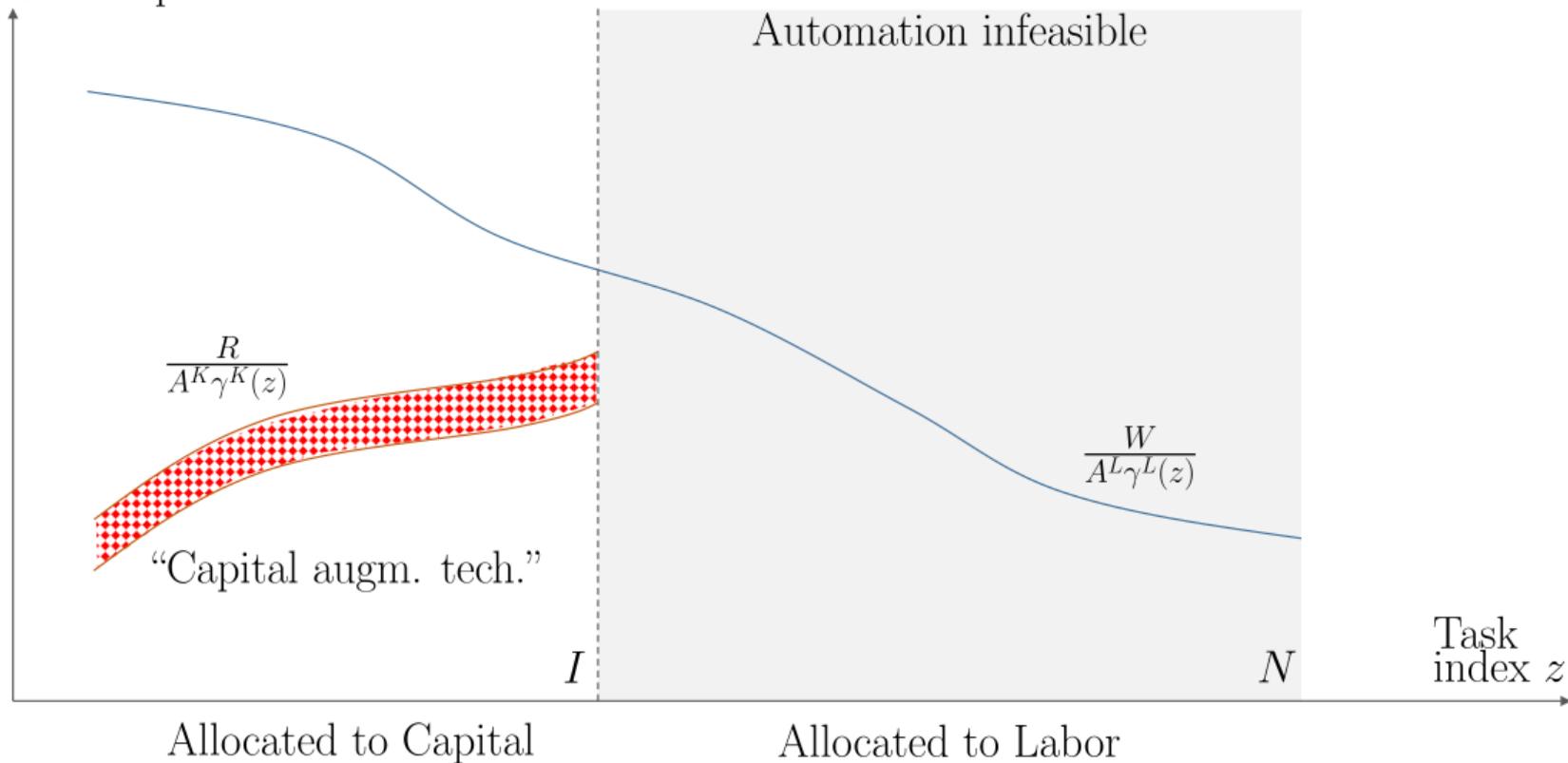
Capital-Augmenting Technological Change

▶ Large productivity effects and small distributional implications.
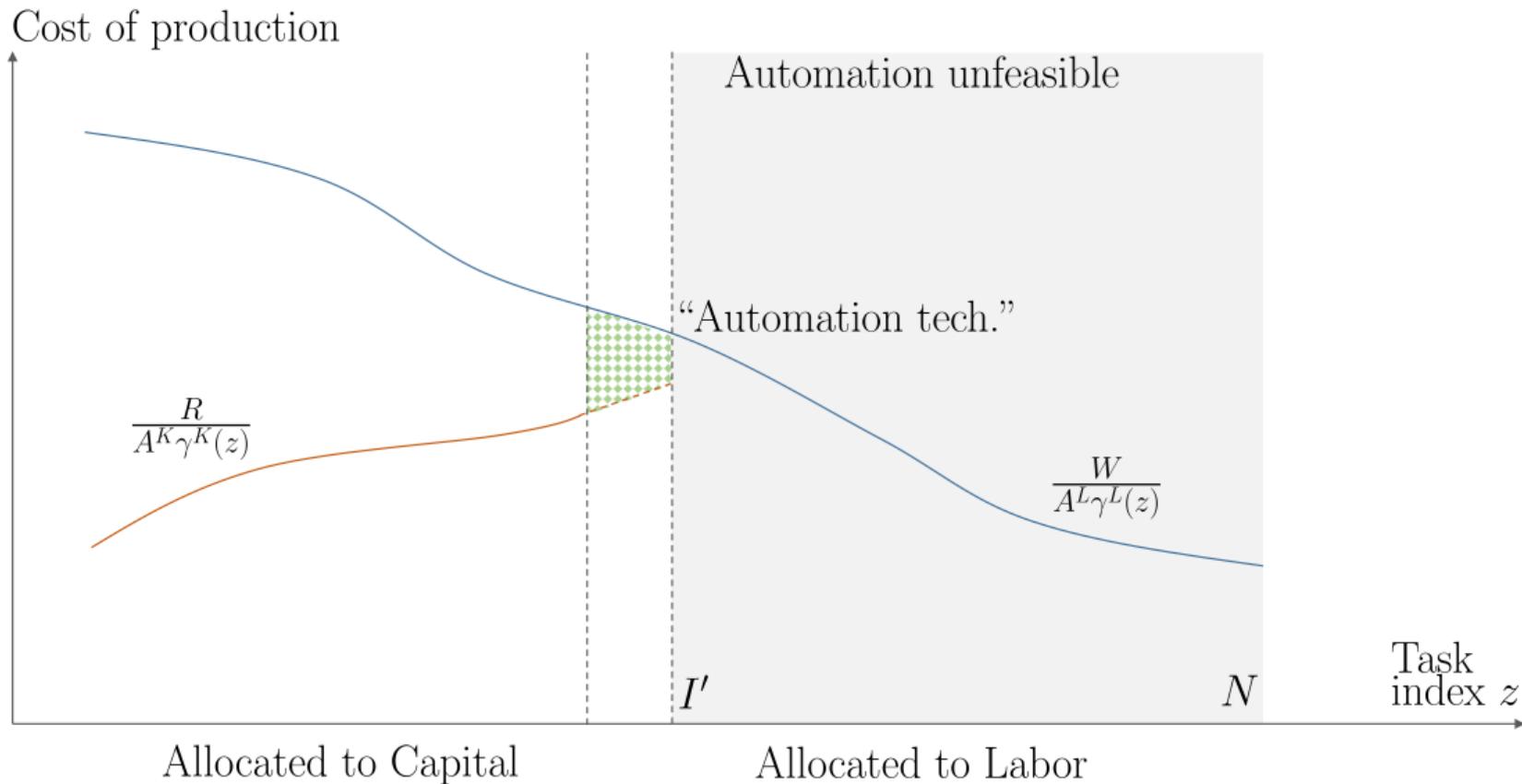

Cost of production

Automation infeasible
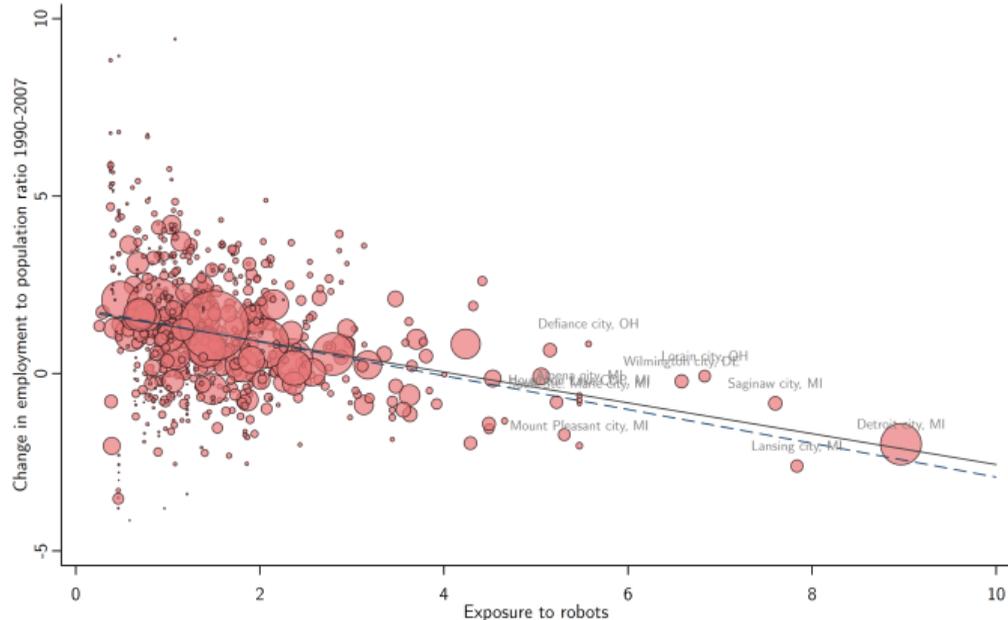
$\frac{R}{A^K \gamma^K(z)}$

"Capital augm. tech."

$\frac{W}{A^L \gamma^L(z)}$

I

N

Task index z

Allocated to Capital

Allocated to Labor

Automation

▶ **Small** productivity effects and **large** distributional implications.

Cost of production

Automation unfeasible

"Automation tech."

$\frac{R}{A^K \gamma^K(z)}$

$\frac{W}{A^L \gamma^L(z)}$

I'

N

Task index z

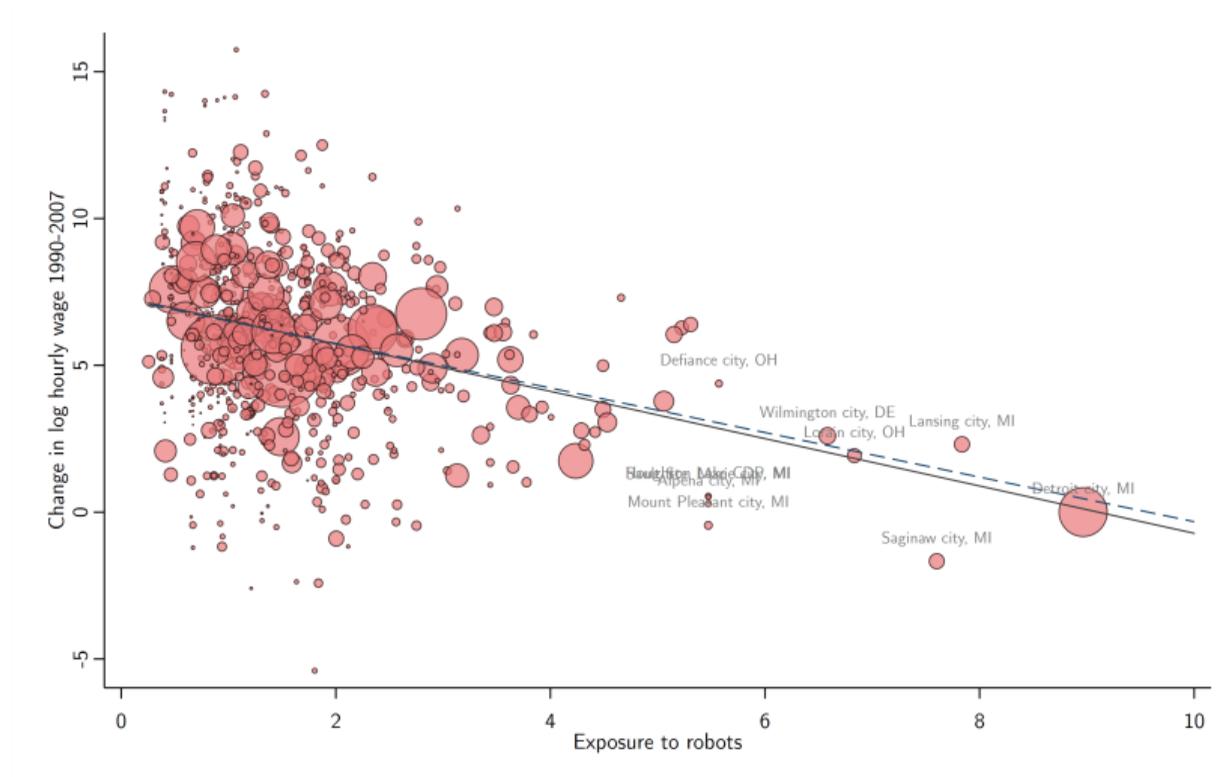Allocated to Capital   Allocated to Labor

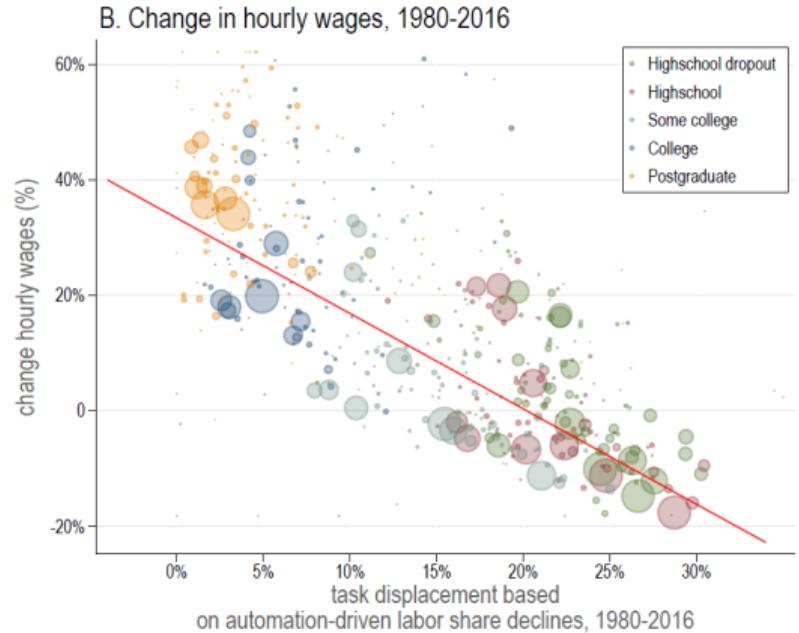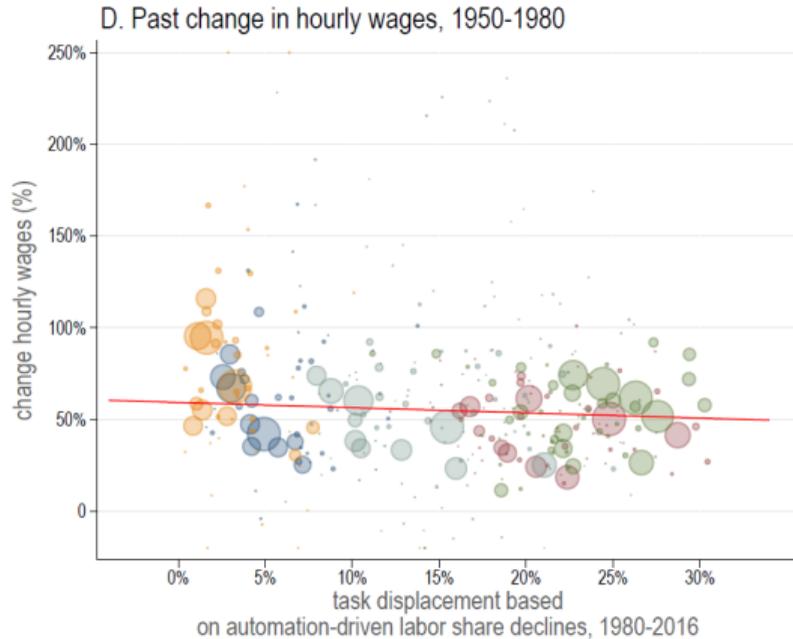# Pre-AI Automation and Local Employment

- ▶ Dashed line excludes the most exposed areas; thus the relationship is unchanged without the key parts of the industrial heartland.
- ▶ Major and very precise effects, but only a small part of national changes (because manufacturing is small).

Pre-AI Automation and Local Wages

- ▶ Dashed line excludes the most exposed areas.

Pre-AI Automation and Inequality: Main Finding

D. Past change in hourly wages, 1950-1980

B. Change in hourly wages, 1980-2016

Legend:
- Highschool dropout
- Highschool
- Some college
- College
- Postgraduate

task displacement based on automation-driven labor share declines, 1980-2016

Source: Acemoglu and Restrepo (Emet 2020)

▶ Across 500 demographic groups (distinguished by education, gender, age, ethnicity and foreign/domestic), **task displacement** from 1980 onwards explains between 50-70% of all wage structure changes from 1980 to 2016. No pretrends before 1980.

Arrival of AI

▶ Measure AI from its footprints in job postings.
▶ Huge increase in AI since 2015, across most sectors of the economy.

Share of AI Vacancies in Burning Glass   Share of AI Vacancies by Broad Industry
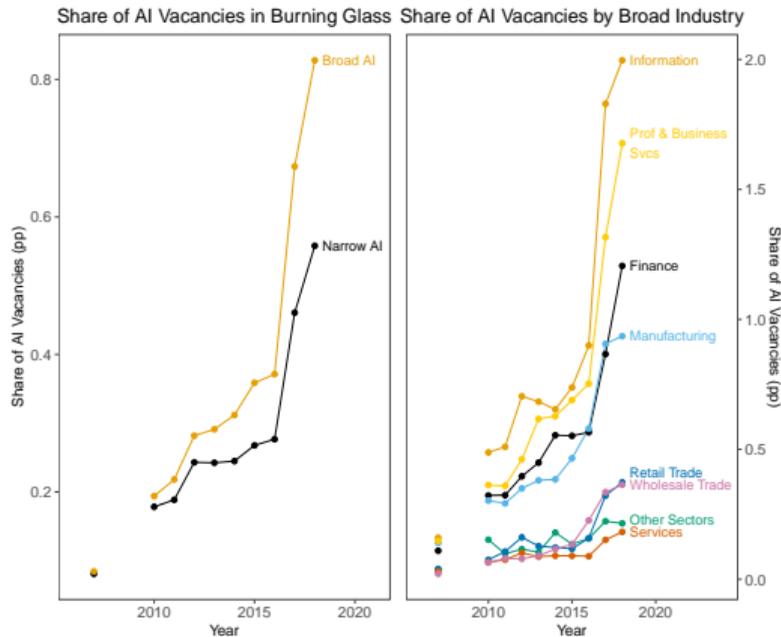
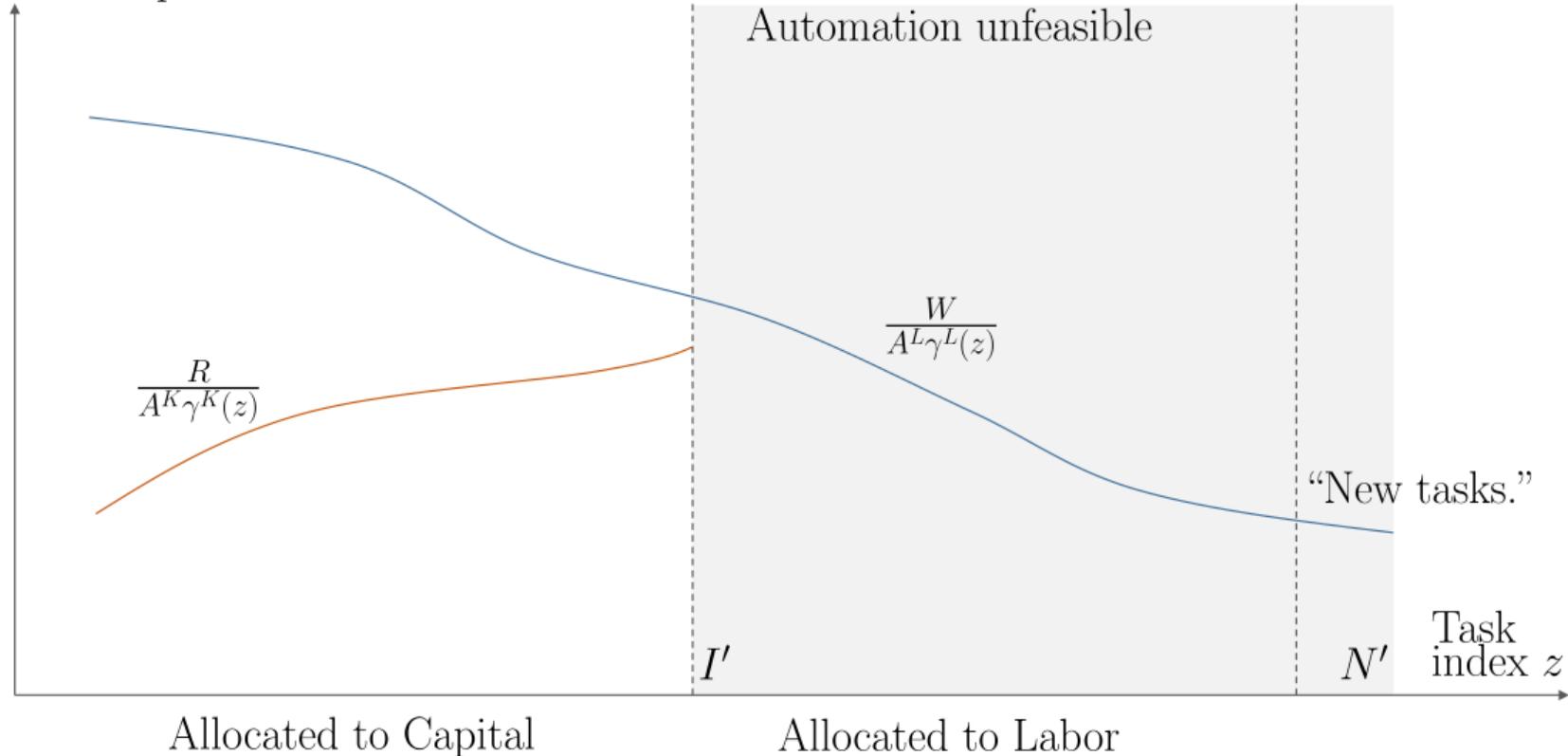Source: Acemoglu, Autor, Hazell and Restrepo (J. of Labor Econ. 2022)

▶ Narrow AI vacancies up from 0.1% to 0.6%.

AI Direction: Need for New Tasks

▶ AI need not be used for automation.

▶ Machine intelligence is a broad technological platform that can be used for many purposes, including for creating **new tasks**, complementing humans, facilitating trade and matchmaking, and reorganizing production.

▶ Norbert Wiener, Douglas Engelbart and JCR Licklider in the 1950s and 60s advocated machine intelligence to complement human abilities, or "human-machine symbiosis".

▶ Significant progress in this direction over the last six decades, some of it leading to huge breakthroughs in computer technology, including the mouse, graphic user interface, hyperlinks and the World Wide Web, etc.

▶ Also significant new platforms enabled by AI, such as Airbnb and ride-sharing apps.

▶ However, much of recent AI activity is focused on automation.

What Do New Tasks Do?

Cost of production

Automation unfeasible

$$\frac{W}{A^L \gamma^L(z)}$$

$$\frac{R}{A^K \gamma^K(z)}$$

"New tasks."

I'

N'

Task index z

Allocated to Capital

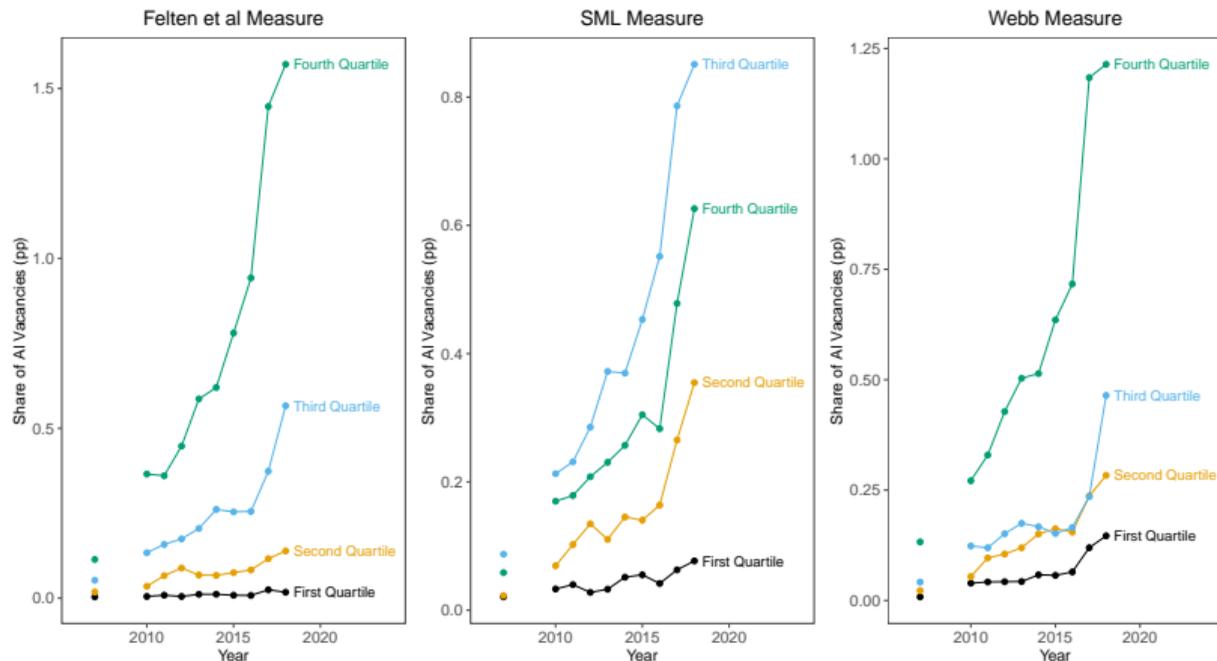Allocated to Labor

Establishment Share of AI Vacancies by Quartile of AI Exposure

▶ AI surge driven by establishments with more AI-replaceable tasks.

Source: Acemoglu, Autor, Hazell and Restrepo (J. of Labor Econ. 2022)

AI Negatively Associated with Establishment Hiring
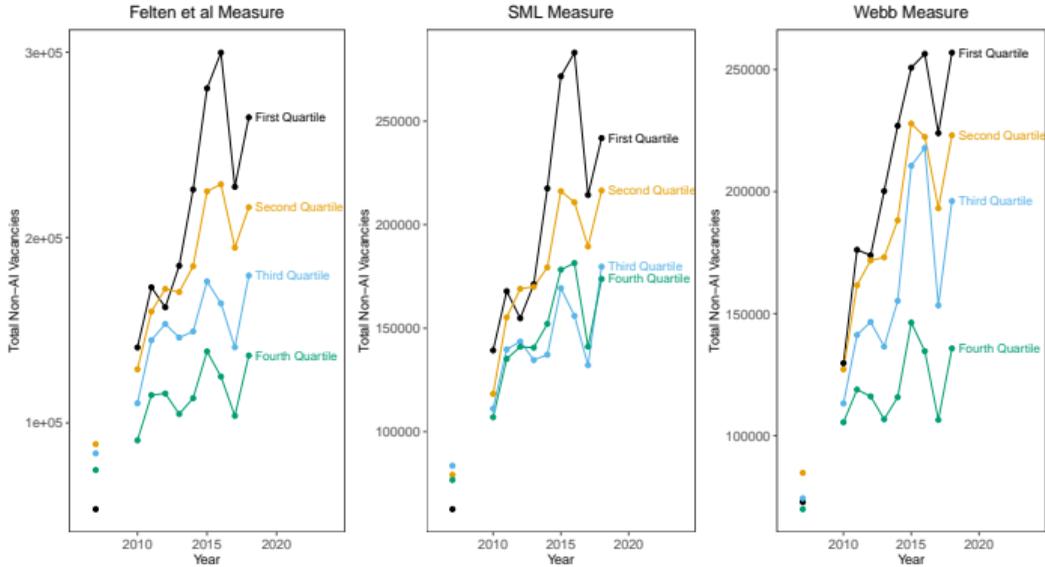
Source: Acemoglu, Autor, Hazell and Restrepo (J. of Labor Econ. 2022)

▶ This pattern is robust and quantitatively large: AI adoption, at the moment, going hand-in-hand with reduce hiring.

New Data on Automation

▶ Recent data collection effort under the auspices of the US Census Bureau to shed more light on adoption of advanced and automation technologies.

▶ First wave within the 2019 Annual Business Survey, with data collection on technology adoption from over 300,000 firms.

▶ Second wave now ongoing and will be more informative on pandemic-related trends.

▶ The 2019 wave studied in Acemoglu, Anderson, Beede, Buffington, Childress, Dinlersoz, Foster, Goldschlag, Haltiwanger, Kroff, Restrepo and Zolas (2022).

Recent (Pre-Pandemic) Trends in Automation

▶ Firms report using these advanced technologies (in particular, robotics, AI, specialized software and dedicated machinery) for automation, and already a significant fraction of US workers exposed to automation.
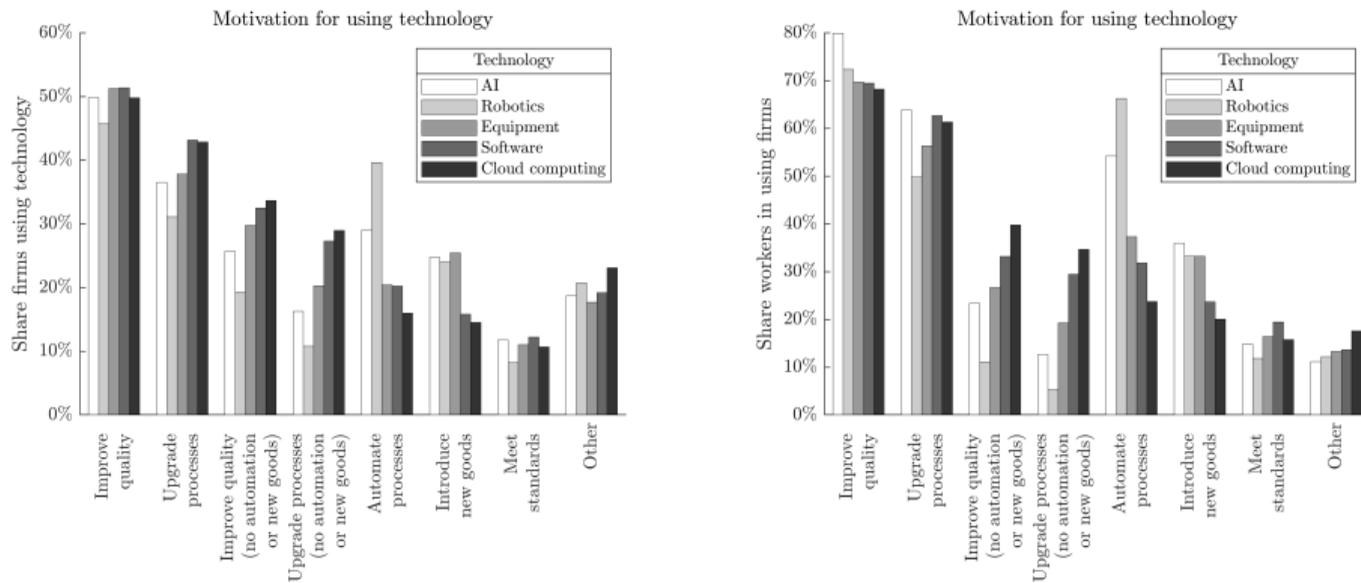
Figure: Motivation for technology adoption, ABS data for 2016–2018. Left panel share of firms, and right panel employment-weighted shares.

Recent (Pre-Pandemic) Trends in Automation (cont'd)

▶ By 2018 a sizable share of US workers exposed to automation technologies.

Share of US workers in firms using technology for automation
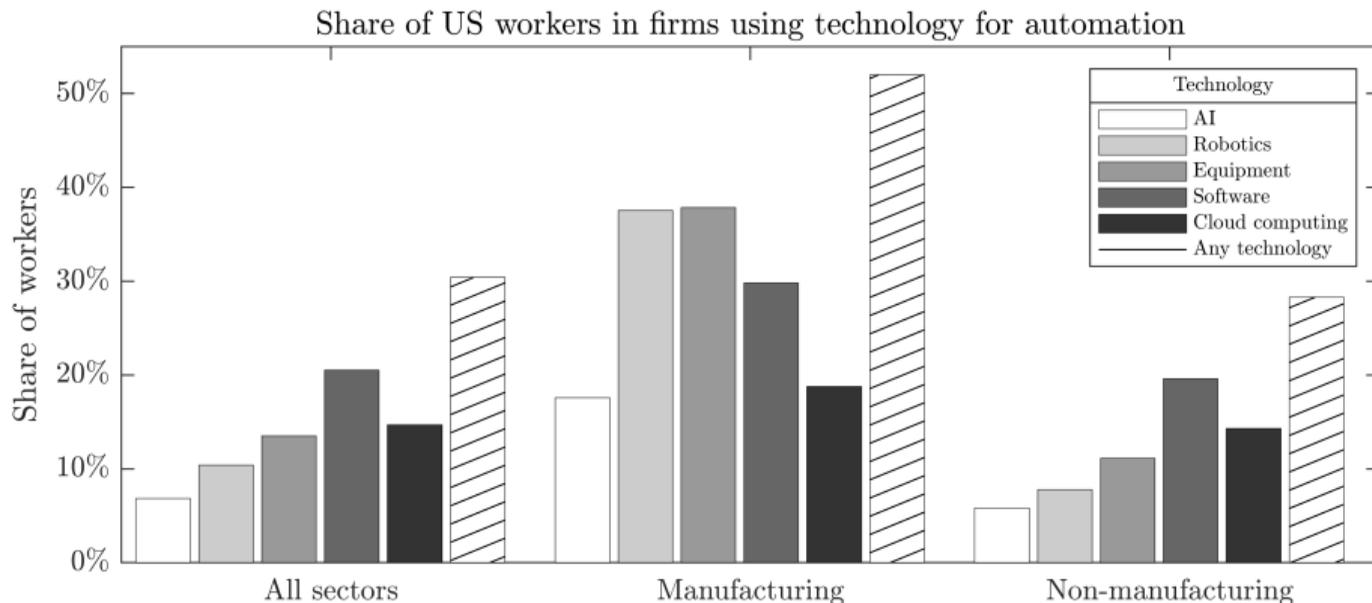
Figure: US workers' exposure to automation via advanced technologies, ABS data for 2016–2018. This exposure measure is computed as the share of the US workforce currently employed at firms using each technology for automation.

So-So Automation

▶ The real concern is if rapid automation turns out to be "so-so automation"—meaning that it displaces workers but creates little productivity gains we have

▶ In fact, if automation runs ahead of what is efficient, it could be **excessive** and may reduce rather than increase productivity.
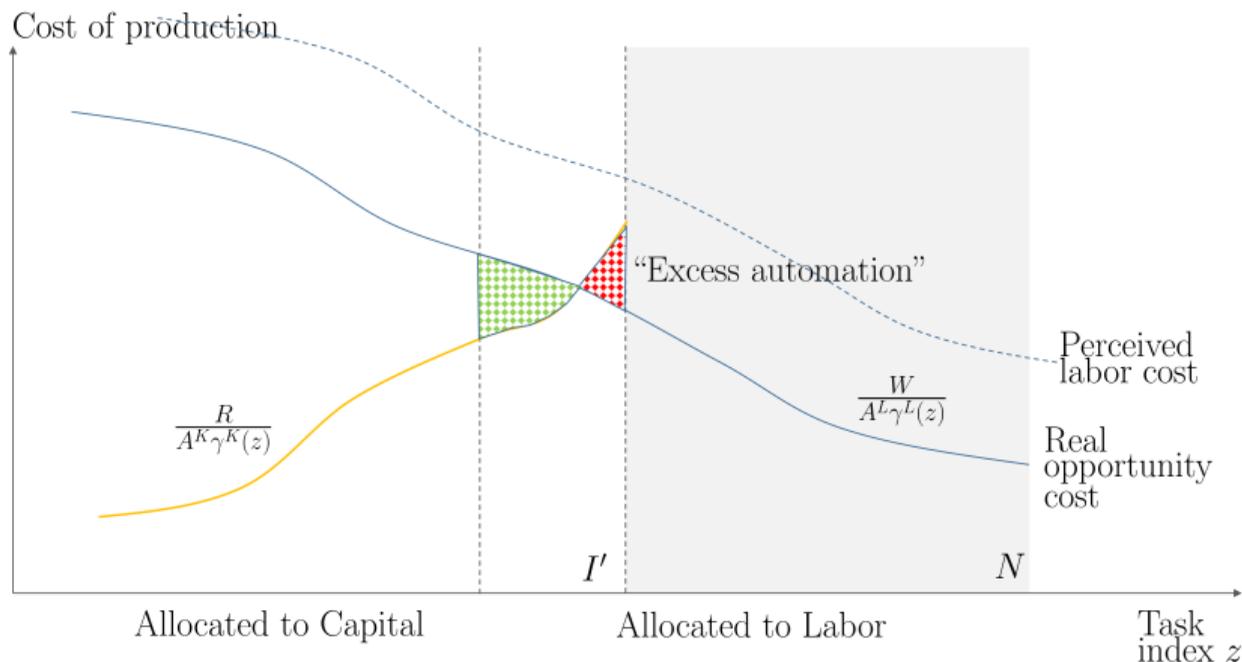
Why Excessive Automation?

▶ Excessive automation may also be fueled by additional factors:

1. Business models and growing size of Big Tech?
2. Excessive focus on cost-cutting.
3. Changing nature of government support for research (working much more to support established corporate priorities).

▶ The US tax code favors capital and powerfully encourages excessive automation.

Effective taxes in the US 1981–2018 (in %)

And Now the Pandemic

- ▶ Two related but distinct effects of pandemics in general (and the COVID-19 pandemic).
- ▶ Social distancing and worker absences increase the desirability of automation.
- ▶ Pandemics may also reduce labor supply, and the resulting shortage of labor and higher wages may encourage further automation.
  - ▶ In the context of the current pandemic, the "great resignation" and more generous unemployment insurance raised wages for many low-wage workers.

What Do We Know About Automation During Pandemics

▶ Sedik and Yoo (2021) study the effects of pre-COVID-19 pandemics using an event study methodology, focusing on robot adoption across countries and industries.

▶ Pandemics are associated with a significant pickup in robot adoption.

Robot Adoption and Pandemics
(Robot installation per 1000 employees in cumulative terms; T = pandemic year)

Source: Authors.
Note: Impulse responses are estimated using a sample of 18 industries in 40 economies over the period 2000-2014, using local projection method (Jorda, 2005). The estimates are based on: $R_{i,c,t+k} = \beta^k D_{c,t} + \theta^k X_{i,c,t} + Controls + \varepsilon_{i,c,t+k}$. The dependent variable R is new robot installation per 1000 employees in cumulative term between t and $t + k$; D is a dummy indicating pandemic years; X denotes three lags of the dependent variable and the pandemic dummy. We control for industry and country fixed effects, and five-year dummies, as well as global business cycle (world real GDP growth). Standard errors are clustered at the country-industry pair level.

What Do We Know About Automation During This Pandemic

▶ No comprehensive data.

▶ Frequent reports of many businesses increasing or intending to increase automation because of tight labor markets and social distancing.

▶ The New York Times reporting in 2021 that "Robot sales in North America have strongest year ever".

▶ Sectors leading this increase in automation include food services, fulfillment centers, warehouses, grocery stores, and manufacturing.

▶ Several leading companies are at the forefront of these new automation investments, including Amazon, Kroger, Tyson Foods, Arby's, Applebee's, Checkers, Yankee Candles, etc.

► World Economic Forum reports a summary measure of these intentions and practices From 2021:

Impact of COVID-19 on companies' strategy

Share of companies surveyed looking to adopt this strategy as a result of COVID-19

Accelerate the digitalization of work processes (e.g. use of digital tools, video conferencing)

91.5%

Provide more opportunities to work remotely

86.4%

Accelerate automation of tasks

57.6%

Accelerate the digitalization of upskilling/ reskilling (e.g. education technology providers)

54.2%

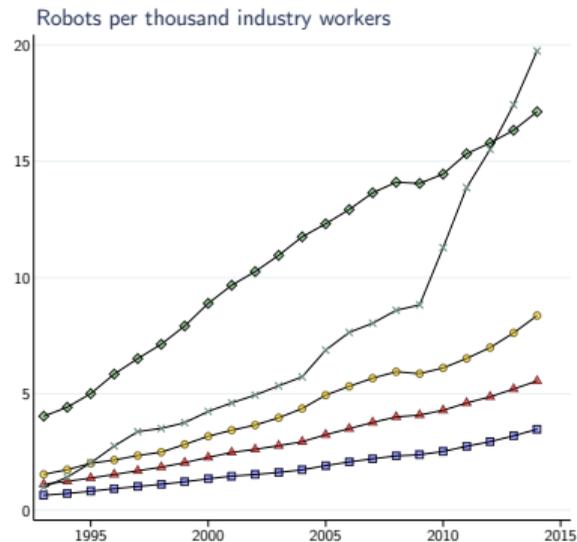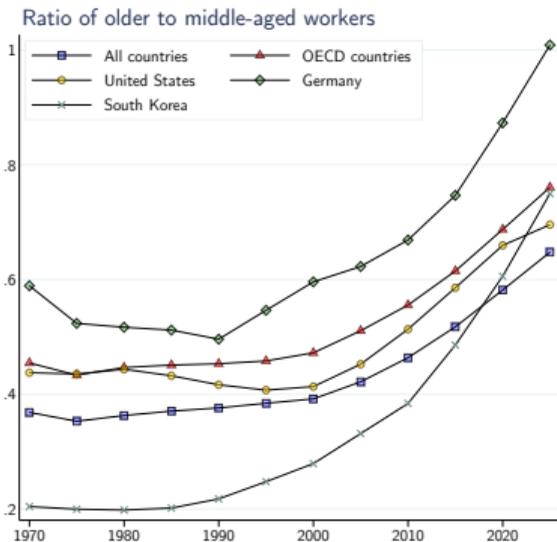Accelerate the implementation of upskilling/ reskilling programmes

44.1%

Is This A Cause for Concern?

- It depends.
- If new automation takes the form of more so-so automation, and especially excessive automation, and if it is not accompanied with new tasks, then it is bad news for workers and the economy.
- On the other hand, automation taking place in response to labor shortages may be more useful to the economy.
    - Key question: are these labor shortages temporary or permanent?
- Leading example: automation in response to aging populations has been a lifesaver for countries such as Germany, Japan and South Korea.

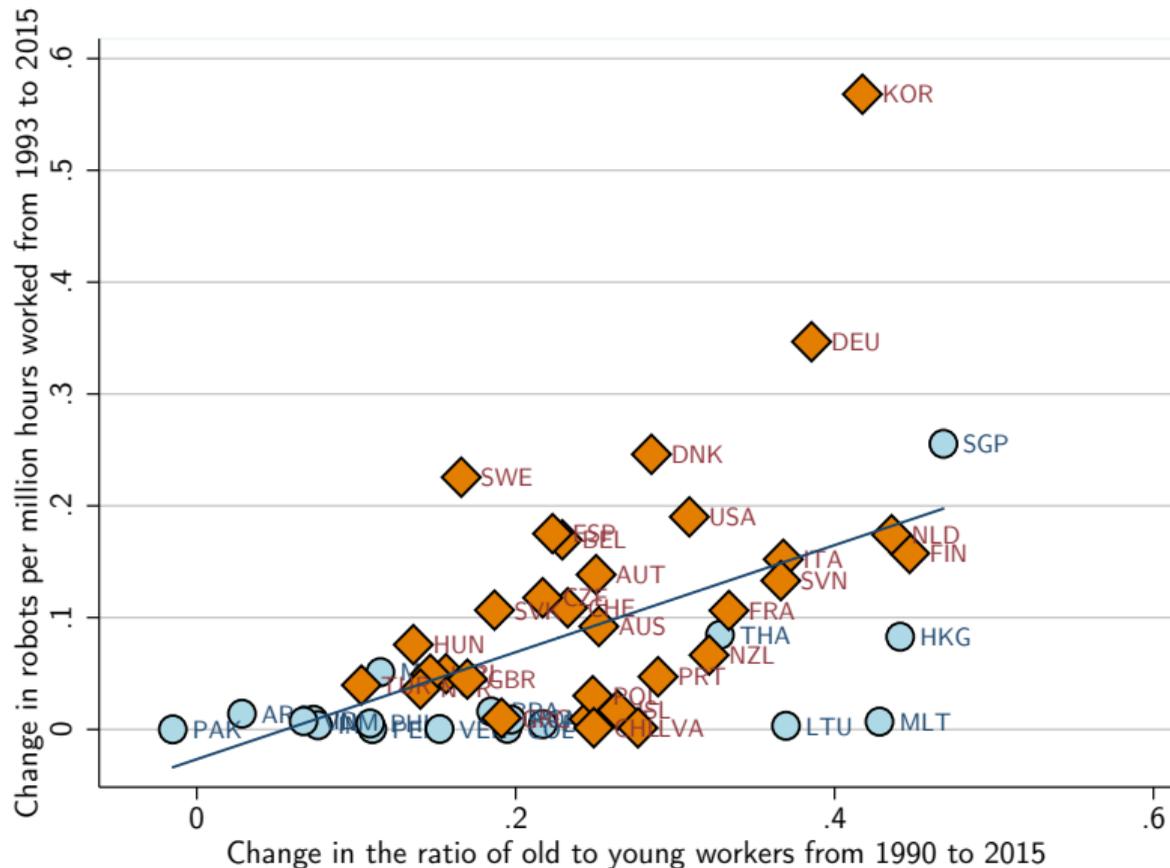# Costs of Demographic Change?

▶ Rapidly aging countries have not performed worse micro economically.

Why Not?

▶ Largely thanks to automation.

Ratio of older to middle-aged workers

Robots per thousand industry workers

Not Just Confined to Germany and South Korea

Scatterplot. X axis: Change in the ratio of old to young workers from 1990 to 2015 (0 to .6). Y axis: Change in robots per million hours worked from 1993 to 2015 (0 to .6). Country markers include KOR, DEU, SGP, DNK, SWE, USA, NLD, FIN, ESP, BEL, ITA, SVN, AUT, CHE, FRA, AUS, THA, HKG, HUN, NZL, GBR, PRT, POL, PAK, LTU, MLT, and others.

Conclusion: Implications for the Future of Work

▶ Two faces of automation—relevant for both AI and post-pandemic automation.

▶ Good automation — high-productivity automation technology needs to be accompanied with new tasks — can contribute to productivity and labor demand.

▶ But so-so automation tend to reduce employment growth and worsens the distribution of income — esp. when there is excessive automation due to policy or vision distortions.

▶ The problem is even worse when automation is not counterbalanced by new tasks.

▶ Preliminary evidence that AI is going very much in this direction of excessive (algorithmic) automation.

▶ If the future is one of ceaseless algorithmic automation and nothing else, then the future of work will not be bright. There would be lower and lower labor share across industries and in national income. And there would be no guarantee of sufficient job growth.

▶ Improving labor market institutions, by itself, cannot be the solution — if we push wages up, this will cause more automation, unless technology becomes more "human-friendly".

▶ But good automation, particularly when combined with rapid creation of new tasks for workers, can be powerful engine of growth and prosperity.