Productivity Dynamics and Technology: Developing Evidence from Micro Data

Lucia Foster, Chief of the Center for Economic Studies and
Chief Economist of the Census Bureau

Federal Reserve Bank of New York

Symposium *US Productivity Growth: Looking Ahead*

February 16, 2024

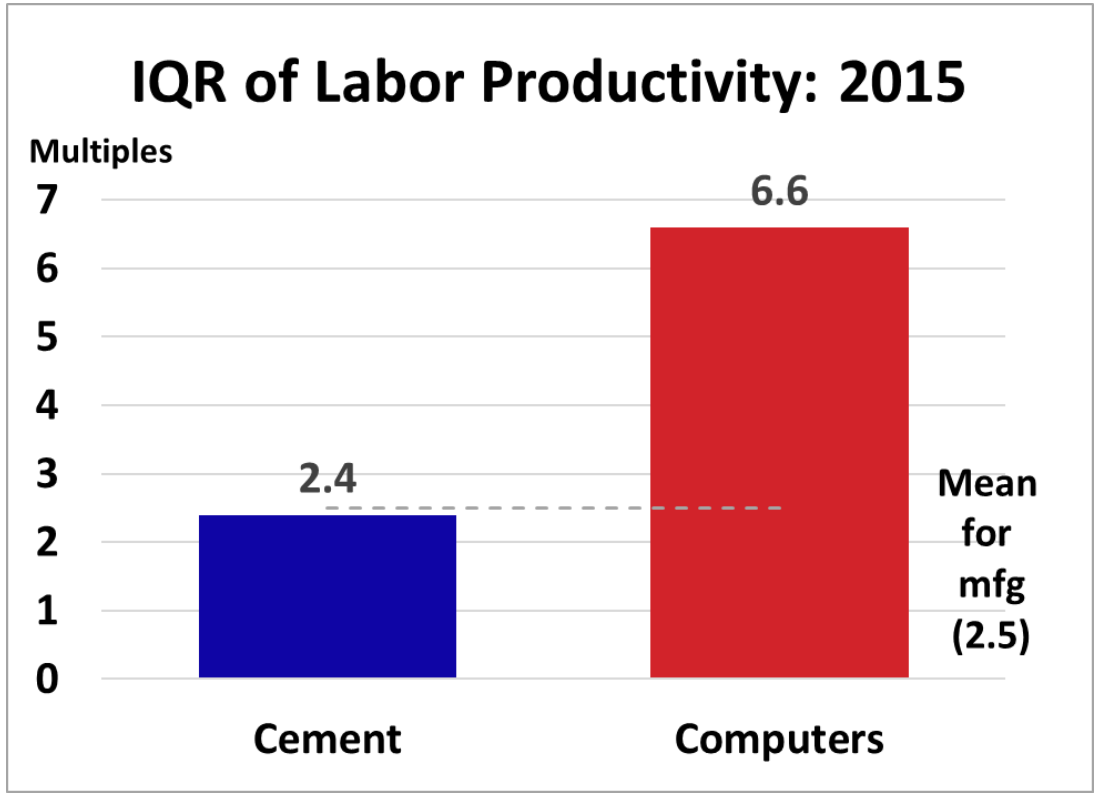
 All figures use publicly available data and/or previously published results and are cited. Emek Basker, Emin Dinlersoz, John Eltinge, Nathan Goldschlag, Cheryl Grim, John Haltiwanger, Henry Hyatt, and Erika McEntarfer provided helpful discussion.

United States® Census Bureau

Productivity Dynamics: Micro to Aggregate

Annual Survey of Manufactures, Economic Census

- Use Census Bureau establishment level data to understand aggregate productivity growth building on Foster, Haltiwanger, Syverson (2008).
- Tremendous productivity heterogeneity within narrowly defined industries
- Reallocation of economic activity *across* businesses within these narrowly defined industries -- shifting market shares across incumbent businesses or through entry and exit
- Reallocation is (usually) productivity enhancing

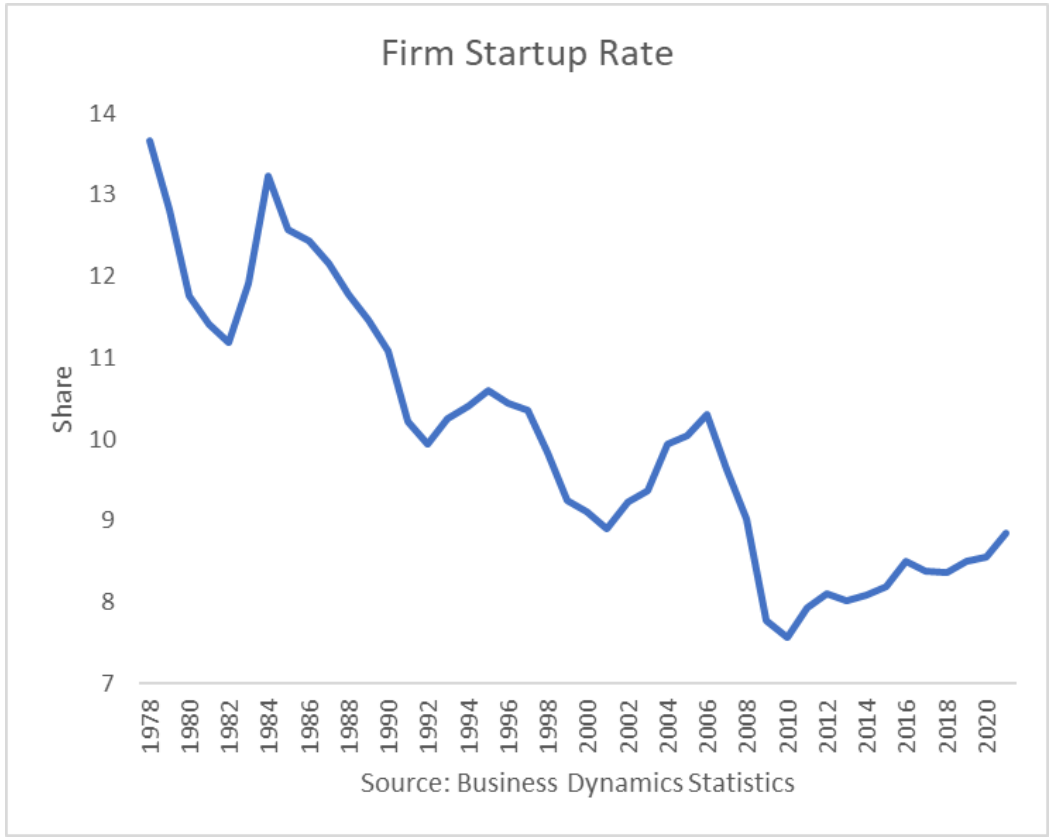


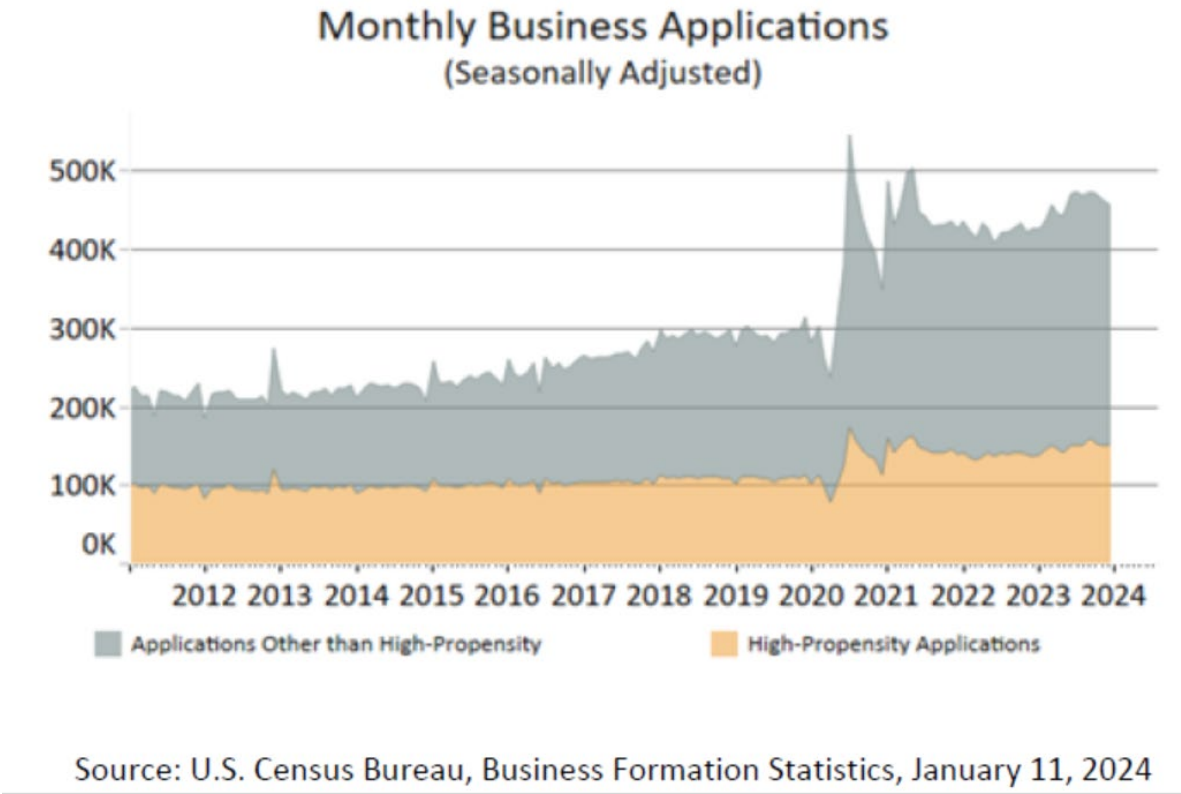
Source: presentation of Blackwood et al. (2022)

United States® Census Bureau

Declining Dynamism, High Applications

Business Dynamics Statistics, Business Formation Statistics





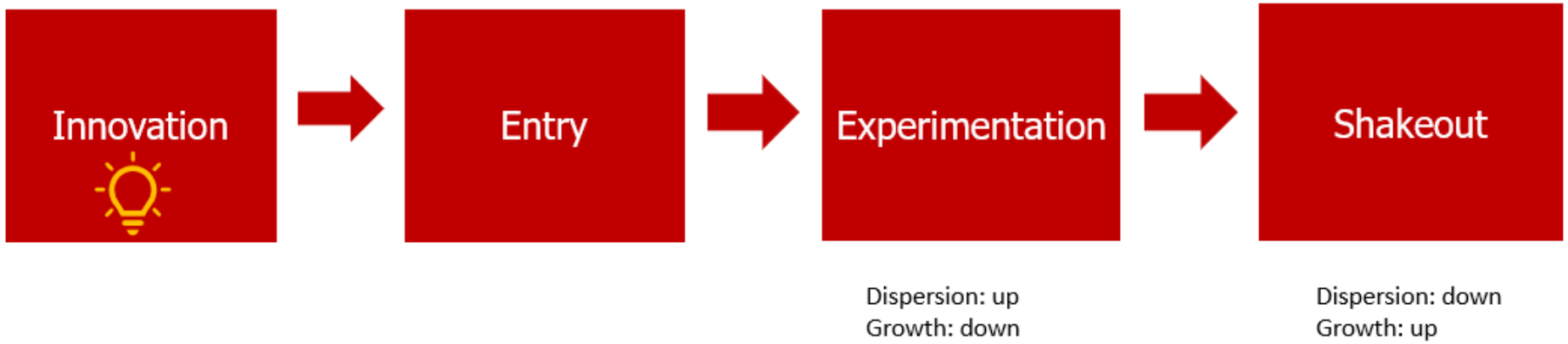
See also Decker et al. (2016)

See also Bayard et al. (2018)

Productivity Dynamics and Innovation

Longitudinal Business Database

- Foster, Grim, Haltiwanger, and Wolf (2021): Develop an indirect measure of innovation relying on framework of Gort and Klepper (1982). Look for patterns of entry, productivity dispersion, and productivity growth.
- Using economy-wide measure of labor productivity, find following a 1% change in entry, productivity growth increases but only with a lag of 7-9 years.



United States® Census Bureau

Technology Adoption: Artificial Intelligence

Annual Business Survey

- Annual Business Survey (ABS**):** 800K firms in 2018 (Economic Census year), 300K in most years in partnership with NCSES.
- ABS 2018: Module three questions concerning 9 advanced technologies developed with Brynjolfsson and McElheran.
  - automated-guided vehicles systems, machine learning, machine vision, natural language processing, voice recognition software
- McElheran et al. (2024): adoption is 6% but concentrated in large (and when control for size/industry, young). Startups using AI tend to have a growth-oriented business strategy, venture capital, and recent innovation.

Startup Firm Characteristics by AI Use Status (%)

Characteristics	Full	AI Yes	AI No
Flexible Hours	54.5	52.8	54.7
Best Avenue for Ideas	56.9	61.8	56.7
Funded by Venture Cap	0.9	2.9	0.8
Startup Cap <25K	38.4	38.2	38.4
Startup Cap 25K-1M	38.9	42.7	38.8
Startup Cap 1M+	2.5	3.8	2.4
No Startup Capital	8.4	6.3	8.5
Process Innovation	19.9	39.3	18.7
IP Important	19.5	40.4	18.1

United States® Census Bureau

Technology Adoption: Automation

Annual Business Survey

- Annual Business Survey 2019 (300K) module developed with Acemoglu and Restrepo.
- Use, reason, reported labor force impact of: AI, robotics, cloud computing, specialized software, dedicated equipment.
- Acemoglu et al. (2022): 2-3% adoption of AI and robotics; higher worker exposure (large firms).
  - Controlling for size, adoption also higher in younger firms.
  - Employment not changed, skills ↑
- Use of the 5 technologies associated with 11% higher labor productivity. Technology accounts for 16-30% of superstar productivity differential.

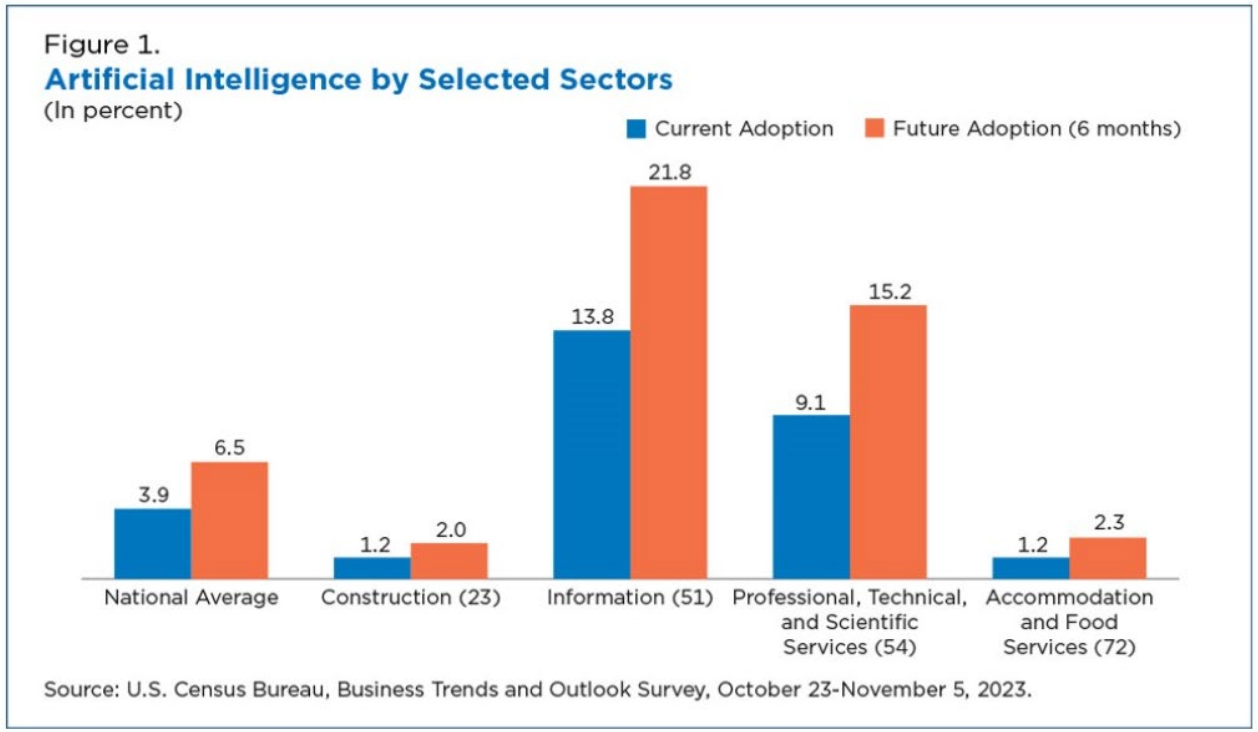
	AI Use	Robotics Use
Firms	3 %	2 %
Worker *Exposure*	13 %	16 %
Manufacture Worker *Exposure*	23 %	45 %

United States® Census Bureau

“Real-Time” Diffusion of Artificial Intelligence

Business Trends and Outlook Survey

- Business Trends and Outlook Survey (BTOS). Biweekly collection of ~ 200,000 businesses.
  - Pairs of questions about recent and expected changes in core concepts (employment, hours, prices) and AI use.
- National: current (3.9%), expected (6.5%)
- Construction: current (1.2%), expected (2.0%)
- Information: current (13.8%), expected (21.8%)



Source: Breaux and Dinlersoz (2023):

United States® Census Bureau

Potential Complements to Tech Adoption

Management and Organizational Practices Survey, Dispersion Statistics on Productivity

Management Practices

- Management and Organizational Practices Survey (MOPS): Supplement to Annual Survey of Manufactures sent to 50,000 plants (in 2010, 2015, 2021).
  - Index of structured management practices using 16 questions on monitoring, targets, and incentives.
- Bloom et al. (2019) find structured management practices are positively associated with productivity. Account for about 20% of the variation in productivity.

Skilled Workers

- Dispersion Statistics on Productivity: Joint BLS and Census project measures productivity dispersion and examines drivers of dispersion using Census plant-level manufacturing.
- Blackwood et al. (2022) preliminary work on adding worker skills and tasks. Create 5 types of measures using BLS' Occupational Employment and Wage Statistics; Occupational Information Network (O*NET); share of STEM workers.
  - Industry: within-industry dispersions of productivity and skill are strongly correlated – especially in high tech industries.
  - Micro: coming soon.

United States® Census Bureau

Summing Up

- Using Census Bureau micro data shows that one driver of aggregate productivity growth is the reallocation of economic activity from low productivity to high productivity businesses (through changes in shares of incumbents, entry, and exit). Entrants and young businesses are more productive than incumbents.
- Entrants and young businesses are more likely to adopt technology when conditioning on size. But advanced technologies are concentrated in large firms which could feed into the superstar phenomenon.
- Those entrants that do adopt are more likely to have a growth-oriented business strategy.
- Productivity impact of innovation likely to happen with a lag.
- Complementary inputs, such as structured management practices and skilled workers, may be important for technology adoption.

United States® Census Bureau

Thank you!

Lucia.S.Foster@census.gov

United States® Census Bureau

Additional Slides

Examples of Census Bureau products that can be used to inform research questions into:

- **Demographics**: Decennial (age of population), American Community Survey (mobility of population), Job-to-Job Flows (mobility of workers)
- **Environment**: Community Resilience Estimates, Environmental Impact Frame, Annual Business Survey
- **Global Economy**: Longitudinal Firm Trade Transactions Database (LFTTD), Business Dynamics Statistics-Goods Traders (BDS-GT)

United States® Census Bureau

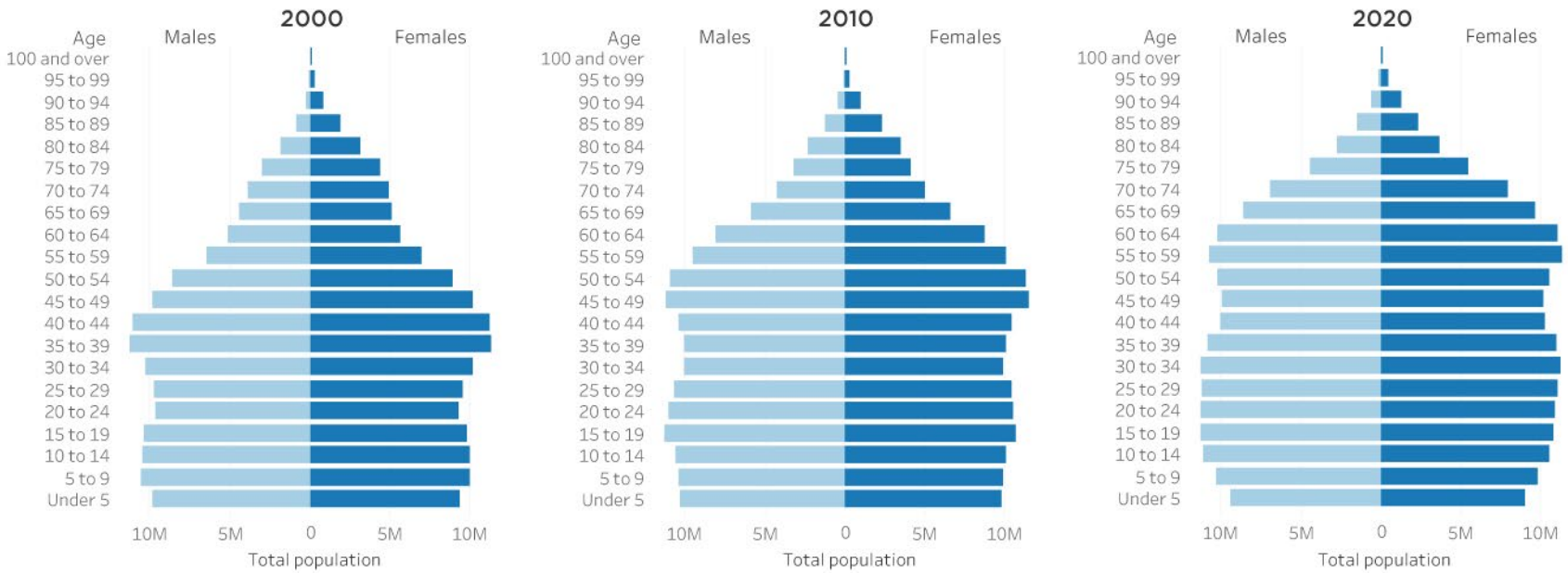
Demographics – Shifting Age Profile

Decennial Census

Figure 2.

Population Pyramids for the United States: 2000, 2010 and 2020

(In millions)



Source: U.S. Census Bureau, Census 2000 Summary File 1 (SF1), 2010 Census Summary File 1 (SF1) and 2020 Census Demographic and Housing Characteristics File (DHC).

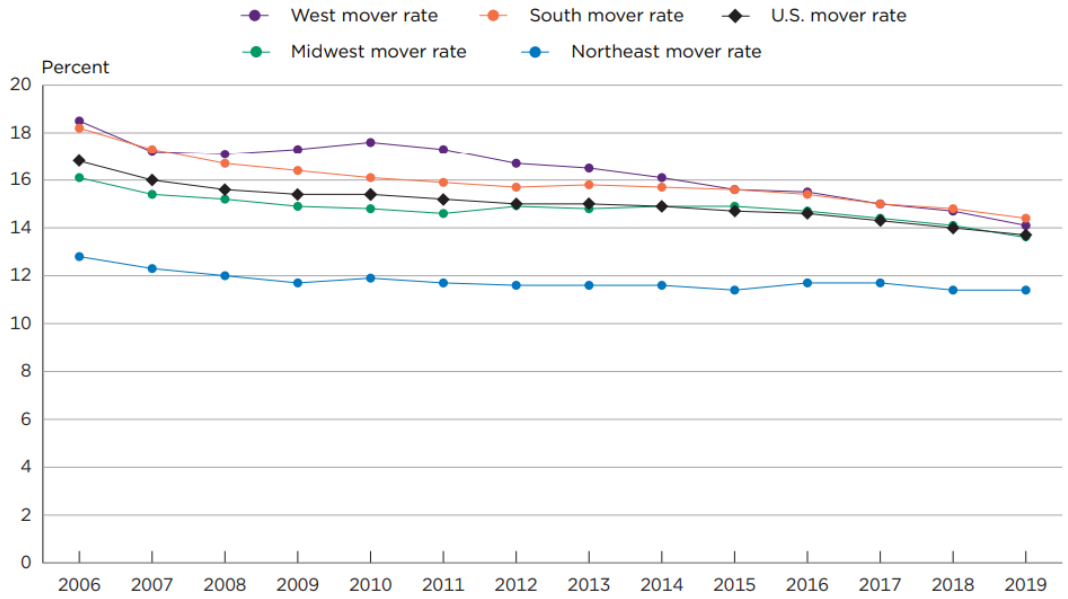
United States® Census Bureau

Source: [aging-united-states-population-fewer-children-in-2020-figure-2.jpg (1400×726) (census.gov)]

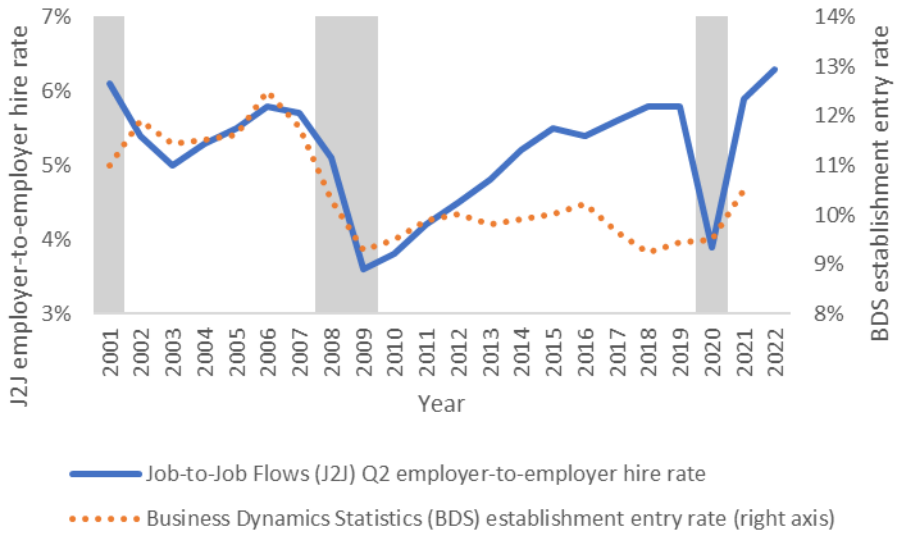
Demographics – Mobility of People & Workers

American Community Survey, Job-to-Job Flows

Figure 1.
National and Regional Mover Rates and Migration Numbers: 2006–2019
(Population at least 1 year of age living in the 50 states or the District of Columbia)



Source:
https://www.census.gov/content/dam/Census/library/publications/2023/acs/acs-53.pdf



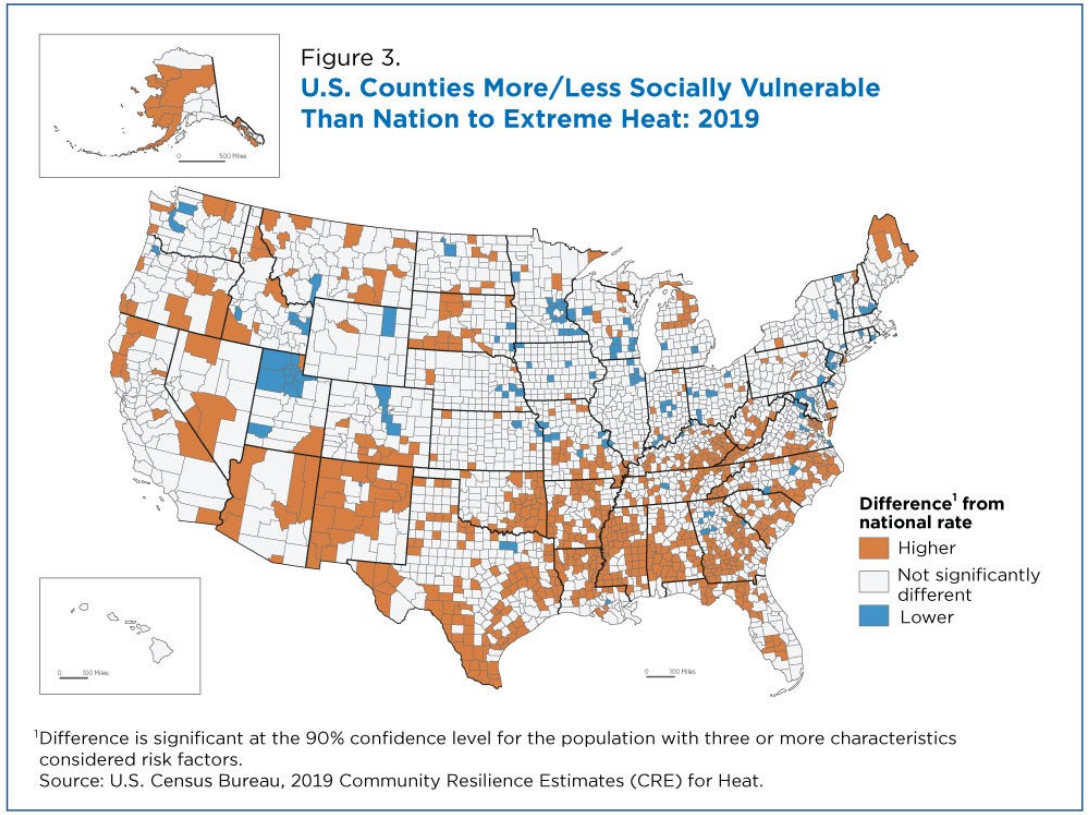
Source: Figure from Henry Hyatt using Census Bureau's J2J and BDS.

United States® Census Bureau

Environment -- Impact on Population

Community Resilience Estimates, Environmental Impacts Frame

- Community Resilience Estimates (CRE): Provides national, state, county, and census tract estimates of resilience to stresses including heat.
- Environmental Impacts Frame (EIF): Links together administrative data. A public product will be created.



Source: https://www.census.gov/library/stories/2023/07/almost-a-quarter-of-population-vulnerable-to-rising-heat.html

Environment – Impact on Businesses

Annual Business Survey

- Annual Business Survey: 2023 (800K firms)
- Section H: Sustainability and Climate Impact
- Eleven questions including whether they are tracking carbon emissions and questions about climate events (see right).

H.9 Extreme Weather Events and Impact

During the three years 2020 to 2022, has this business experienced monetary losses due to extreme weather events? ***For example, hurricanes, floods, droughts, wildfires, or heat waves.***

Include:
- Incurred costs
- Losses of sales or assets

☐ Yes

☐ No

☐ Don't know

H.10 Investments to Mitigate Risks

During the three years 2020 to 2022, has this business undertaken investments to reduce the risk of damages caused by extreme weather events? ***For example, hurricanes, floods, droughts, wildfires, or heat waves.***

☐ Yes

☐ No

☐ Don't know

H.11 Future Impacts Due to Extreme Weather

During the next decade, how likely is this business to experience negative impacts from extreme weather events? ***For example, hurricanes, floods, droughts, wildfires, or heat waves.***

☐ Not at all likely

☐ A little likely

☐ Somewhat likely

☐ Very likely

☐ Extremely likely

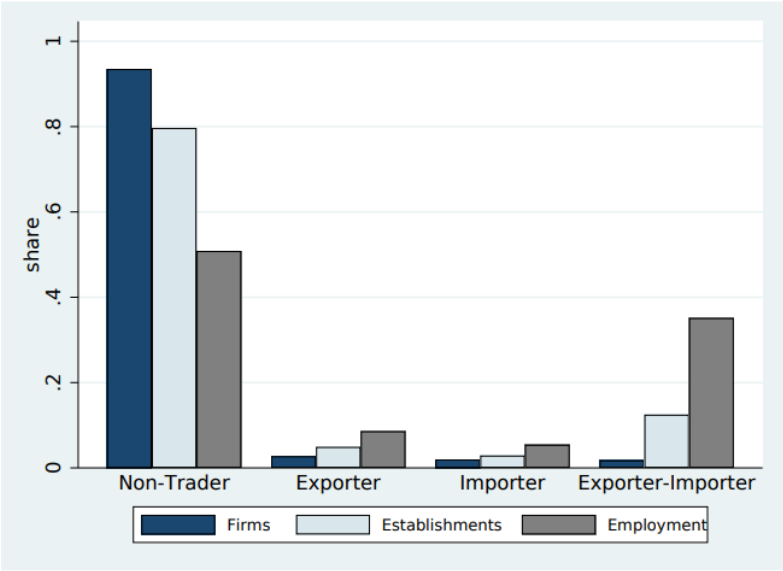
United States® Census Bureau

De-Globalization, Global Supply Chain

Longitudinal Firm Trade Transactions Database, Business Dynamics Statistics-Goods Trader

- **Longitudinal Firm Trade Transactions Database (LFTTD)**: links individual trade transactions to the US firms that make them. The export and import transactions are the universe of trade transactions data collected by the Customs Bureau during the importation or exportation process.
- **Business Dynamics Statistics-Goods Traders (BDS-GT)**: provides annual measures of business dynamics by four mutually exclusive goods-trading classifications: exporter only, importer only, exporter and importer, non-trader.

Figure 1. Share of Firms, Establishments, & Employment by Trader Status U.S. Economy, Average 1992-2019



Notes: This figure plots the average share of firms, establishments, and employment in the U.S. economy over 1992-2019 by four mutually exclusive goods-trading classifications (defined in Section 2.2.1). "Non-Trader" are firms that neither export nor import goods in year t; "Exporter" are firms that only export goods in year t; "Importer" are firms that only import goods in year t; "Exporter-Importer" are firms that both export and import goods in year t.

Source: Handley et al. (2021)

United States® Census Bureau

References

- Acemoglu, Daron, Gary Anderson, David Beede, Catherine Buffington, Eric Childress, Emin Dinlersoz, Lucia Foster, Nathan Goldschlag, John Haltiwanger, Zachary Kroff, Pascual Restrepo, and Nikolas Zolas. 2022. "Technology, Firms, and Workers: Evidence from the 2019 Annual Business Survey," NBER Working Paper 30659.
- Bayard, Kimberly, Emin Dinlersoz, Timothy Dunne, John Haltiwanger, Javier Miranda, and John Stevens. 2018. "Early Stage Business Formation: An Analysis of Applications for Employer Identification Numbers," NBER Working Paper 24364.
- Blackwood, Jacob, Cindy Cunningham, Matthew Dey, Lucia Foster, Cheryl Grim, John Haltiwanger, Rachel Nesbit, Sabrina Wulff Pabilonia, Jay Stewart, Cody Tuttle, and Zoltan Wolf. 2022. "Opening the Black Box: Task and Skill Mix and Productivity Dispersion," NBER Working Paper 30620.
- Bloom, Nicholas, Erik Brynjolfsson, Lucia Foster, Ron Jarmin, Megha Patnaik, Itay Saporta-Eksten, and John Van Reenen. 2019. "What Drives Differences in Management Practices?" *American Economic Review,* 109(5), 1648-1683.
- Breaux, Corey and Emin Dinlersoz. 2023. "How Many U.S. Businesses Use Artificial Intelligence?" America Counts Blog, Census Bureau. How Many U.S. Businesses Use Artificial Intelligence? (census.gov)

United States® Census Bureau

References (con't)

- Decker, Ryan, John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2016. "The Decline of High Growth Young Firms in the U.S.: Where Has All the Skewness Gone?" *European Economic Review* 86:4–13.
- Foster, Lucia, Cheryl Grim, John Haltiwanger, and Zoltan Wolf. 2021. "Innovation, Productivity Dispersion, and Productivity Growth," in Measuring and Accounting for Innovation in the Twenty-First Century, (eds. Carol Corrado, Jonathan Haskel, Javier Miranda, and Daniel Sichel. 103-136.
- Foster, Lucia, John Haltiwanger, and Chad Syverson. 2008. "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability," *American Economic Review*, 98(1), 394-425.
- Gort, Michael and Steven Klepper. 1982. "Time Paths in the Diffusion of Product Innovations," *Economic Journal*, 92 (367), 630–653.
- Handley, Kyle, Fariha Kamal, and Wei Ouyang. 2021. "A Long View of Employment Growth and Firm Dynamics in the United States: Importers vs. Exporters vs. Non-Traders" CES Working Paper 21-38.
- McElheran, Kristina, J. Frank Li, Erik Brynjolfsson, Zachary Kroff, Emin Dinlersoz, Lucia Foster, and Nikolas Zolas. "AI Adoption in America: Who, What, and Where?" *Journal of Economics & Management Strategy*, 2024:1-41.

United States® Census Bureau