Measuring Business Adoption and Use of Advanced Technologies, Artificial Intelligence, and Data

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FESAC

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United States® Census Bureau

Overview of Presentation

- Measurement Approach
- Challenges
- Examples
  - Digitization, Cloud, and Advanced Technologies (ABS)
  - Robotics (ASM, ACES)
  - Technology and Workforce (EC, ABS)
  - Technology and Business and Workforce Dynamics (BDS, QWI)
  - Productivity and Innovation (LBD)
  - Use of Data (MOPS, EC)
- Vision for the Future

Measurement Approach

- Identify Data Gap
  - Policymakers
  - Businesses and trade associations (NABE)
  - Academic and institutional researchers (FSRDC)
  - AEAStat, CRIW, FESAC, CSAC
- Research Approaches
  - Leverage Census expertise and outside experts
  - Coordinate with other Federal Statistical Agencies
- Develop New Content
  - Appropriate, Consistent, Optimal
- Testing
- Post-Collection Validation
- Dissemination
  - CES Working Paper (and peer-reviewed journals)
  - Presentations – for example AEA Stat Session →
  - Experimental data products
  - Official statistics

AMERICAN ECONOMIC ASSOCIATION

New Approaches to Measuring Technology and Innovation

Paper Session

Friday, Jan. 3, 2020   2:30 PM - 4:30 PM

Marriott Marquis San Diego, Presidio 1 - 2

Hosted By: AMERICAN ECONOMIC ASSOCIATION & COMMITTEE ON ECONOMIC STATISTICS
Chair: Ellen Hughes-Cromwick, University of Michigan

Measuring Technology Adoption in Enterprise-Level Surveys: The Annual Business Survey

David Beede, U.S. Census Bureau
Erik Brynjolfsson, Massachusetts Institute of Technology
Cathy Buffington, U.S. Census Bureau
Emin Dinerslov, U.S. Census Bureau
Lucia Foster, U.S. Census Bureau
Nathan Goldschlag, U.S. Census Bureau
Kristina McElheran, University of Toronto

Quantifying the Impact of AI on Productivity and Labor Demand: Evidence from United States Census Microdata

Dean Alderucci, Carnegie Mellon University
Lee Branstetter, Carnegie Mellon University
Ed Hovy, Carnegie Mellon University
Andrew Runge, Carnegie Mellon University
Nicolas Zolas, U.S. Census Bureau

Data Development and Measurement of the Economic Geography of Robotics

Nancy Green Leigh, Georgia Institute of Technology
Ben Kraft, Georgia Institute of Technology
Heon Yeong Lee, Georgia Institute of Technology

Discussant(s)

Pascual Restrepo, Boston University
Enghin Atalay, University of Wisconsin
Susan R. Helper, Case Western Reserve University

Multi-Dimensional Measurement Approach

- Survey Data
    - Annual Business Survey (ABS)
    - Annual Survey of Manufactures (ASM)
    - Annual Capital Expenditures Survey (ACES)
    - Management and Organizational Practices Survey (MOPS)
    - Economic Census (EC)

- Administrative Data
    - Business Dynamics Statistics (BDS), Longitudinal Business Database (LBD)
    - Quarterly Workforce Indicators (QWI)

- Alternative Data Sources => not yet, but could be used for validation
    - Firm technology profiles
    - Technology shipments

Some Challenges We Face

- Deciding *which technology* matters
- Determining the *timing* of when to add a new technology
- Precisely *defining* technology of interest ➡
- Determining *unit of interest*: establishment versus firm
- Picking relevant *frequency* for capturing adoption and diffusion (e.g., 1, 3, 5- years)
- Disclosure modernization

Robot → Robotic Equipment → Industrial Robotic Equipment
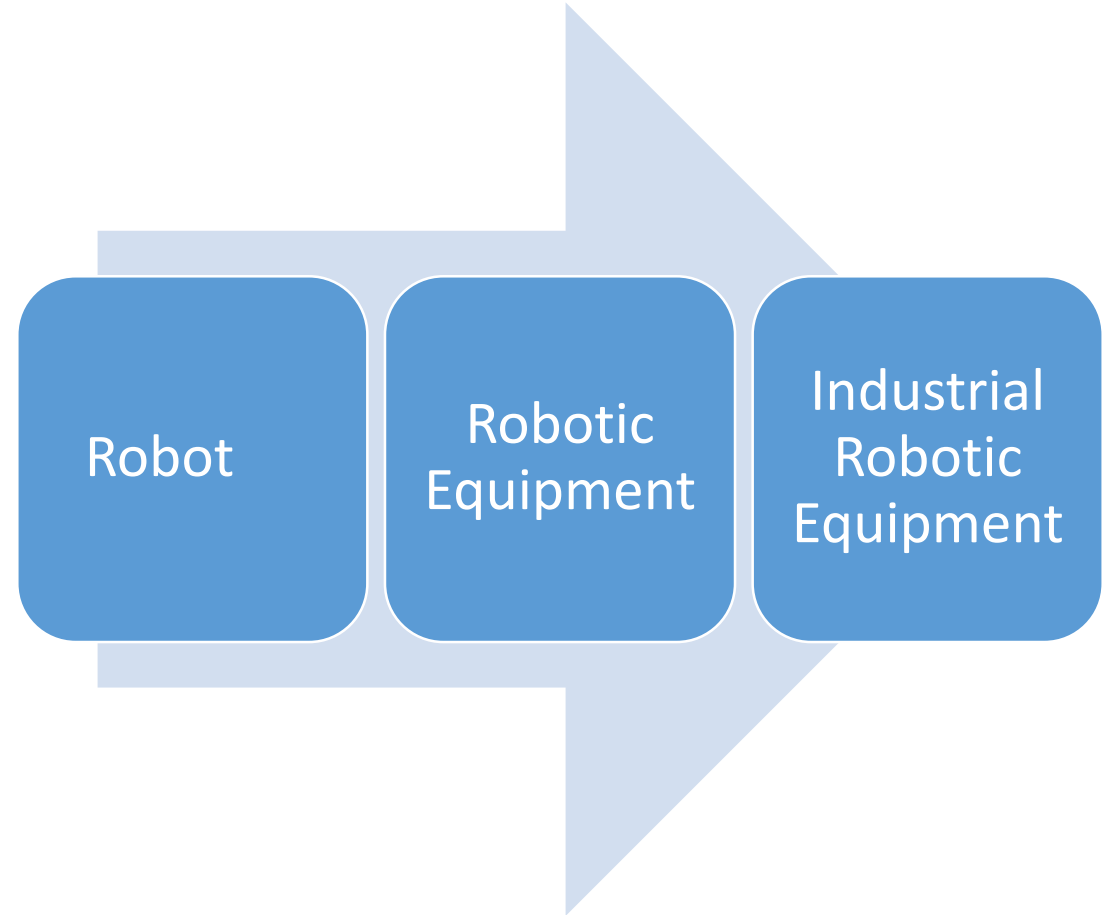
Digitization, Cloud, and Advanced Technologies
Annual Business Survey (2018, *2021*)

- **Sample:** 850,000 firms, non-ag sectors

- **Survey:** (NCSES) includes firm characteristics, innovation, R&D, and technology module

- **Research:** Brynjolfsson and McElheran

- **Questions:** digital share of business activities; cloud services purchases; business technologies for production of goods and services – including machine learning ➡️

- **Challenges:** unit of measure, frequency

- **Dissemination:** AEA Technology session will provide "first look"

BUSINESS TECHNOLOGIES

In 2017, to what extent did this business use the following technologies in producing goods or services? *Select one for each row.*

	No use	Testing, but not using in production or service	In use for less than 5% of production or service	In use for between 5% – 25% of production or service	In use for more than 25% of production or service	Don't know
A. Augmented reality	☐	☐	☐	☐	☐	☐
B. Automated guided vehicles (AGV) or AGV systems	☐	☐	☐	☐	☐	☐
C. Automated storage and retrieval systems	☐	☐	☐	☐	☐	☐
D. Machine learning	☐	☐	☐	☐	☐	☐
E. Machine vision software	☐	☐	☐	☐	☐	☐
F. Natural language processing	☐	☐	☐	☐	☐	☐
G. Radio-frequency identification (RFID) inventory system	☐	☐	☐	☐	☐	☐
H. Robotics	☐	☐	☐	☐	☐	☐
I. Touchscreens/kiosks for customer interface (Examples: self-checkout, self-check-in, touchscreen ordering)	☐	☐	☐	☐	☐	☐
J. Voice recognition software	☐	☐	☐	☐	☐	☐

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Robotic Equipment

Annual Survey of Manufactures (2018)

- **Sample**: 50,000 manufacturing establishments
- **Research:** Seamans, Helper, Brynjolfsson
- **Questions:** number of robots (in operation and purchased) and capital expenditures on robotic equipment
- **Challenge:** defining technology robots => industrial robotic equipment
- **Dissemination:** Buffington et al. (2018)

## Annual Capital Expenditures Survey (2018)

- **Sample:** 50,000 employer companies non-ag sectors
- **Research:** language consistent with ASM and may benchmark to published RIA data
- **Question:** capital expenditures for robotic equipment
- **Challenge:** units
- **Dissemination:** Census website

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Technology and Workforce
Economic Census (2017)

- **Sample:** Establishments in eleven selected Retail and Service industries
- **Research:** Basker et al. (2017), customer-employee substitution in gas stations
- **Question:** Do you provide self-checkout (self-service)?
- **Challenge:** Timing -- difficulty of measuring adoption and diffusion in the face of disruptive technology: Amazon Go ➡
- **Dissemination:** Basker et al. (2019)
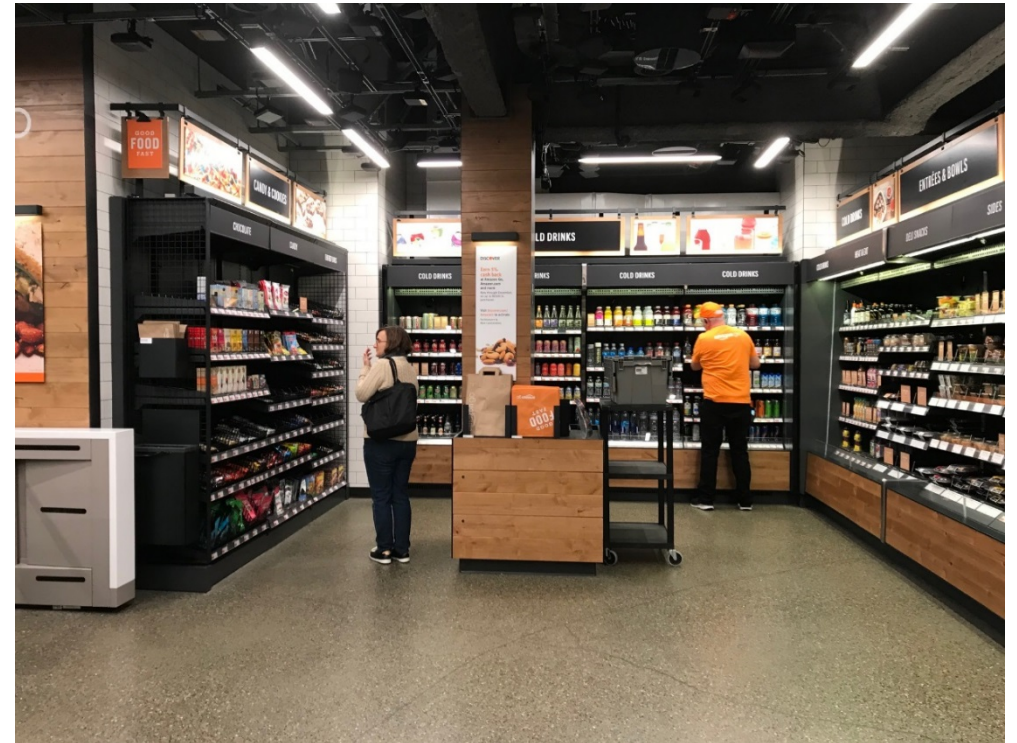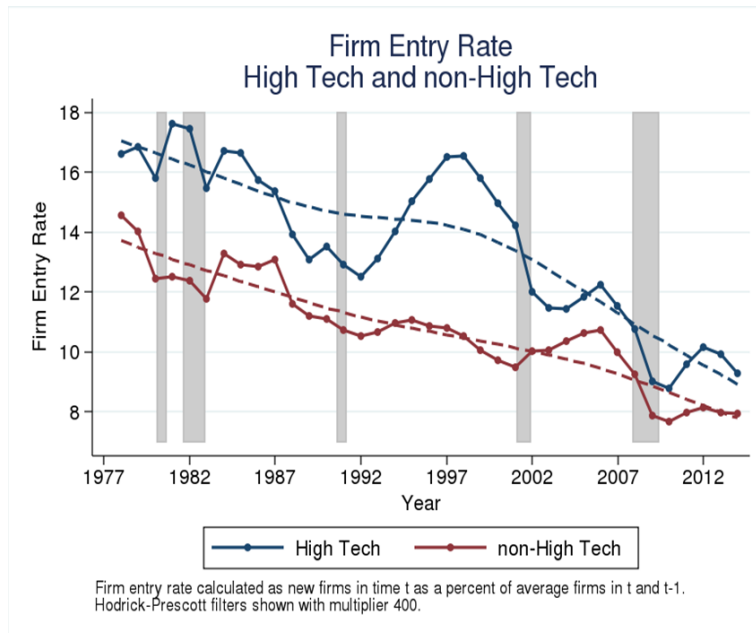
Technology and Workforce
Annual Business Survey (2019, *2022*)

- **Sample:** 300,000 firms across all non-ag sectors
- **Survey:** (NCSES) includes firm characteristics, innovation, R&D, and technology module
- **Research**: Acemoglu and Restrepo and NCSES
- **Questions:** 34 questions concern: (1) motivation, (2) challenges of adoption, (3) impact on workforce (including on skill levels) and (4) impact by worker types. Which cover use of and production of five technologies:
  - Artificial Intelligence
  - Cloud computing
  - Specialized software (excluding AI)
  - Robotics
  - Specialized equipment (excluding robotics)
- **Challenges**: Defining technology and worker types

Technology and Business and Workforce

Business Dynamics Statistics

- **Research:** Goldschlag and Miranda (2016) entry and exit of high tech businesses

- **Challenge**: Disclosure modernization

- **Dissemination:** Planned *future BDS tables*

Firm Entry Rate
High Tech and non-High Tech

Firm entry rate calculated as new firms in time t as a percent of average firms in t and t-1.
Hodrick-Prescott filters shown with multiplier 400.

Quarterly Workforce Indicators

- **Research:** Goldschlag (2017) employment dynamics at high tech businesses by demographics

- **Challenge:** Source data voluntarily provided by states

- **Dissemination:** QWI website

High Tech Share EoQ Employment Change by Sex
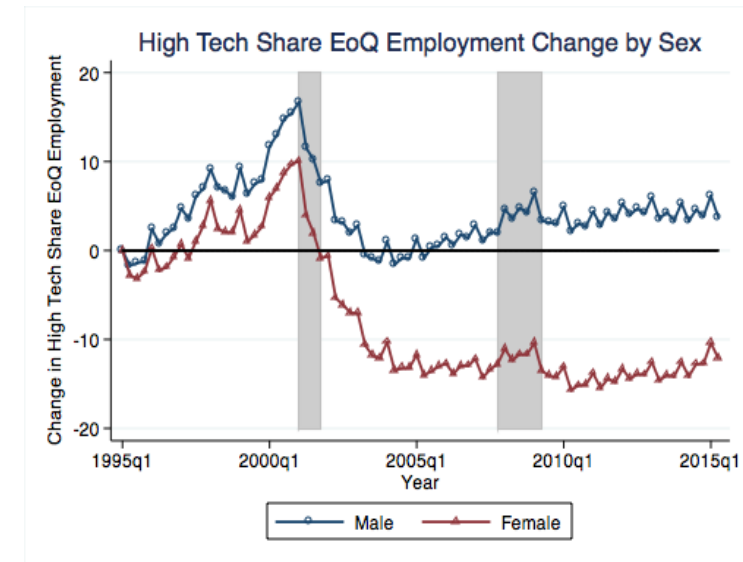
Productivity and Innovation
## Longitudinal Business Database

- **Research:** Foster et al. (2018) develop a framework for identifying areas of the economy where innovation has taken place using patterns in business entry and productivity dynamics => effects more pronounced in high-tech sectors

- **Challenge:** Measuring productivity at the micro-level

- **Dissemination**: Dispersion in Statistics of Productivity (DiSP) produced and hosted with BLS

Firm innovation and productivity: Searching for black holes

Lucia Foster, Cheryl Grim, John Haltiwanger, Zoltan Wolf 17 June 2018

Measuring innovative activity itself, rather than proxies such as R&D expenditures or patent volumes, is difficult. This column shows how patterns of economic activity can be used to measure increased innovative activity within firms. This 'searching for black holes' approach can be used to better understand the connection between innovation and productivity dispersion and growth.

Figure 1 Changes in productivity dispersion and growth from a 1% (one time) increase in entry rate in first sub-period (years 1-3)

VOX   CEPR Policy Portal
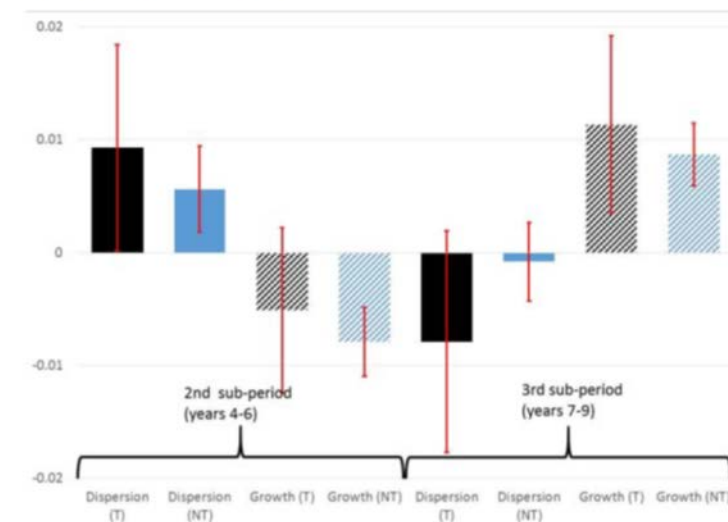
Use of Data
Management and Organizational Practices Survey (2010, 2015, *2020*)

- **Sample:** 30,000 manufacturing establishments (ASM supplement sponsored by researchers)

- **Survey:** management practices, organization, data and decision making

- **Research:** Brynjolfsson and McElheran (2019)

- **Questions:** availability of data, use of data, who chooses data, sources of data, activities using data, reliance on predictive analytics ➡

- **Challenge:** Defining technology (an absolute not a relative)

Section C - Data and Decision Making

24 In 2010 and 2015, what best describes the **availability** of data to support decision making at this establishment?

Mark one box for each year

	2010	2015
Data to support decision making are not available.	☐	☐
A small amount of data to support decision making is available	☐	☐
A moderate amount of data to support decision making is available	☐	☐
A great deal of data to support decision making is available	☐	☐
All the data we need to support decision making is available	☐	☐

27 a) Consider each of the following sources of data and rate how frequently each source was used in decision making at this establishment **in 2015**.

Mark all that apply

	Daily	Weekly	Monthly	Yearly	Never
Performance indicators from production technology or instruments	☐	☐	☐	☐	☐
Formal or informal feedback from managers	☐	☐	☐	☐	☐
Formal or informal feedback from production workers	☐	☐	☐	☐	☐
Data from outside the firm (suppliers, customers, outside data providers)	☐	☐	☐	☐	☐

28 a) How frequently was each of these activities influenced by data analysis at this establishment **in 2015**?

Mark all that apply

	Daily	Weekly	Monthly	Yearly	Never
Design of new products or services	☐	☐	☐	☐	☐
Demand forecasting	☐	☐	☐	☐	☐
Supply chain management	☐	☐	☐	☐	☐

Use of Data
Economic Census (2017)

- **Sample:** Establishments in 14 Health Care Services Industries

- **Research:** Bloom and Sadun

- **Questions:** measures of clinical performance (who sees, who chooses, review frequency) ➡️

- **Challenges:** Unit

- **Dissemination**: Basker et al. (2019)

- **Future work:** *MOPS-Hospitals*

1. Who sees your organization's measures of clinical performance? *Select ALL that apply.*

   Measures of clinical performance include counts, incidence rates, and other measures of specific clinical processes and outcomes.

   - ☐ Managers
   - ☐ Employees (non-managers)
   - ☐ Patients and their responsible parties
   - ☐ On public display

2. Who chooses which measures of clinical performance to collect? *Select ALL that apply.*

   - ☐ Managers at this establishment
   - ☐ Managers at other establishments and/or headquarters
   - ☐ Insurance providers
   - ☐ Government regulators or agencies
   - ☐ Board of Directors

3. How frequently did senior management at this organization review the measures of clinical performance?

   - ☐ Yearly or quarterly
   - ☐ Monthly or weekly
   - ☐ Daily or more often
   - ☐ Never

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Vision for the Future

- **More Coordinated and Collaborative Approach**
  - Within Census Bureau (Economic and Demographic)
    - Use economy-wide survey results to drive deeper-dive by
      - sector (e.g., warehousing, finance)
      - technologies (e.g., complements to labor such as cobots in surgery)
  - Across Federal Statistical Agencies
    - Technology and innovation => testing, adoption (NCSES)
    - Technology and workforce => training of workforce (BLS, NCES, NCSES)
    - Data => valuation of data (BEA)
  - With Stakeholders
    - More focused outreach to stakeholders and experts through AEAStat, CRIW, NABE, other opportunities?
- **Integration of Alternative Data Sources**
  - Starting with validation and research integration
- **Prioritize Importance of Repeated Views over Time**
  - ABS two sets of two waves of technology questions (3-yr time frame)
  - MOPS three waves of data questions (5-yr time frame)

Background Slides

References

- Basker, Emek, Randy A. Becker, Lucia Foster, T. Kirk White, and Alice Zawacki (2019) "Addressing Data Gaps: Four New Lines of Inquiry in the 2017 Economic Census," Center for Economic Studies Working Paper No. 19-28.

- Basker, Emek, Lucia Foster, and Shawn Klimek (2017), "Customer-Employee Substitution: Evidence from Gasoline Stations," *Journal of Economics and Management Strategy*, 1-21, 2017.

- Brynjolfsson Erik and Kristina McElheran (2019), "Data in Action: Data-Driven Decision Making and Predictive Analytics in U.S. Manufacturing," updates Center for Economic Studies Working Paper No. 16-06.

- Buffington, Catherine, Javier Miranda and Robert Seamans (2018), "Development of Survey Questions on Robotics Expenditures and Use in U.S. Manufacturing Establishments," Center for Economic Studies Working Paper No. 18-44.

- Foster, Lucia, Cheryl Grim, John Haltiwanger, and Zoltan Wolf (2018) "Innovation, Productivity Dispersion, and Productivity Growth," Center for Economic Studies Working Paper No. 18-08.

- Goldschlag, Nathan and Javier Miranda (2016) "Business Dynamics Statistics of High Tech Industries," Center for Economic Studies Working Paper No. 16-55.

- Goldschlag, Nathan (2017) "Direct and Indirect Measures of the Economic Impact of the Digital Economy," FESAC presentation, December.

Links to Census Products

- ABS: https://www.census.gov/programs-surveys/abs.html

- ACES: https://www.census.gov/programs-surveys/aces.html

- ASM: https://www.census.gov/programs-surveys/asm.html

- BDS: https://www.census.gov/programs-surveys/bds.html

- DiSP: https://www.census.gov/data/experimental-data-products/dispersion-statistics-on-productivity.html

- Economic Census: https://www.census.gov/programs-surveys/economic-census.html

- QWI: https://www.census.gov/data/developers/data-sets/qwi.html

Discontinued Surveys

- **Technology**
  - Survey of Manufacturing Technology (SMT) https://www.census.gov/econ/overview/ma0700.html
  - Information and Communication Technology Survey (ICTS) https://www.census.gov/programs-surveys/icts.html

- **Workforce**
  - National Employer Survey (NES) https://www.census.gov/econ/overview/mu2400.html