Advanced Technologies Adoption and Use by U.S. Firms: Evidence from the Annual Business Survey[1]

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Executive Summary

Advances in technology are important drivers of productivity growth and living standards. Thus, measuring advanced technology adoption is critical for understanding the state of the U.S. economy and planning for the future. However, owing to a lack of comprehensive data on firms' adoption and use of such technologies, we are "flying blind" into a rapidly digitizing world. This data gap hinders evidence-based decision-making at all levels of government and society.

The 2018 Annual Business Survey (ABS) was designed by the U.S. Census Bureau in collaboration with leading digital economy researchers to fill this gap. A nationally-representative survey of over 850,000 firms, covering all private, nonfarm sectors of the U.S. economy, the ABS includes a new set of questions on digitization, cloud computing, and "advanced business technologies"—a category which includes artificial intelligence (AI) and robotics. Leaning on its sample size, high response rates, and representative coverage of the economy, the ABS represents one of the largest and most current data sets on advanced technology adoption and use in the world.

This paper is the first-ever look at the ABS findings. Unsurprisingly, rates of digitization in the U.S. are quite high. Roughly 76% of respondent firms store information in digital format for at least one business function. Imputation suggests at least some degree of digitization of over 90% of the U.S.

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economy. Intensity varies by business activity: personnel and finance highly digitized among a majority of firms. At the lower end, production and supply chain rely intensively on data in third or more of firms (Table 6).

Cloud computing is also on the rise. Over 54% of respondents that use information technology (IT) also purchase at least one cloud service. Imputation puts this at over 78% of firms, economy-wide. This is conditional on IT use, suggesting that the scope for firms to adopt IT for the first time via the cloud is non-trivial. Use cases are diverse (Figure 3), though the top IT functions using cloud at least to some extent are billing (reported by over 50% of firms), security (over 49%), and collaboration and file synchronization (over 46%). Intensive reliance on cloud services is slightly less prevalent, both on average and across IT functions, yet over 18% of firms that engage in data analysis (the lowest-ranking of the main IT functions affected by the cloud) report using cloud intensively for this activity (Table 9).

Reports of AI's arrival may be exaggerated. Roughly 10% or less of U.S. firms adopt one or more of the listed advanced technologies, with the imputed adoption rate of AI-related technologies[2] being 6.6%. This rate climbs to more than 60% for firms with 10,000+ employees, highlighting the importance of scale for adopting emerging cognitive technologies. Robotics adoption is very low at around 1% (Table 13), though within the manufacturing sector, adoption of advanced technologies (including robotics) is far more prevalent, with adoption rates reaching the teens (Figure 7). Rates of testing to use are high for all advanced technologies, suggesting that firms are experimenting before committing (Figures 6 and 7).

Key patterns are worth noting. Adoption is dramatically skewed towards older, larger firms across the board. This is despite the survey's unusually good coverage of younger and smaller firms, which are underrepresented in many widely-used data sets. Concentration of U.S. employment in larger firms further means that worker exposure to new technologies exceeds these firm-level rates, sometimes substantially, as in the case of robotics and RFIDs (Table 19).

Adoption across technologies is also interlinked according to a "hierarchy of sophistication," from digitization to cloud computing to advanced business technologies. Firms that adopt the latter have typically adopted the former. This is potentially useful for understanding the pathways firms pursue to digitization and technological sophistication in the U.S. (Figure 9). We also find strong correlations between this sophistication and product and process innovation.
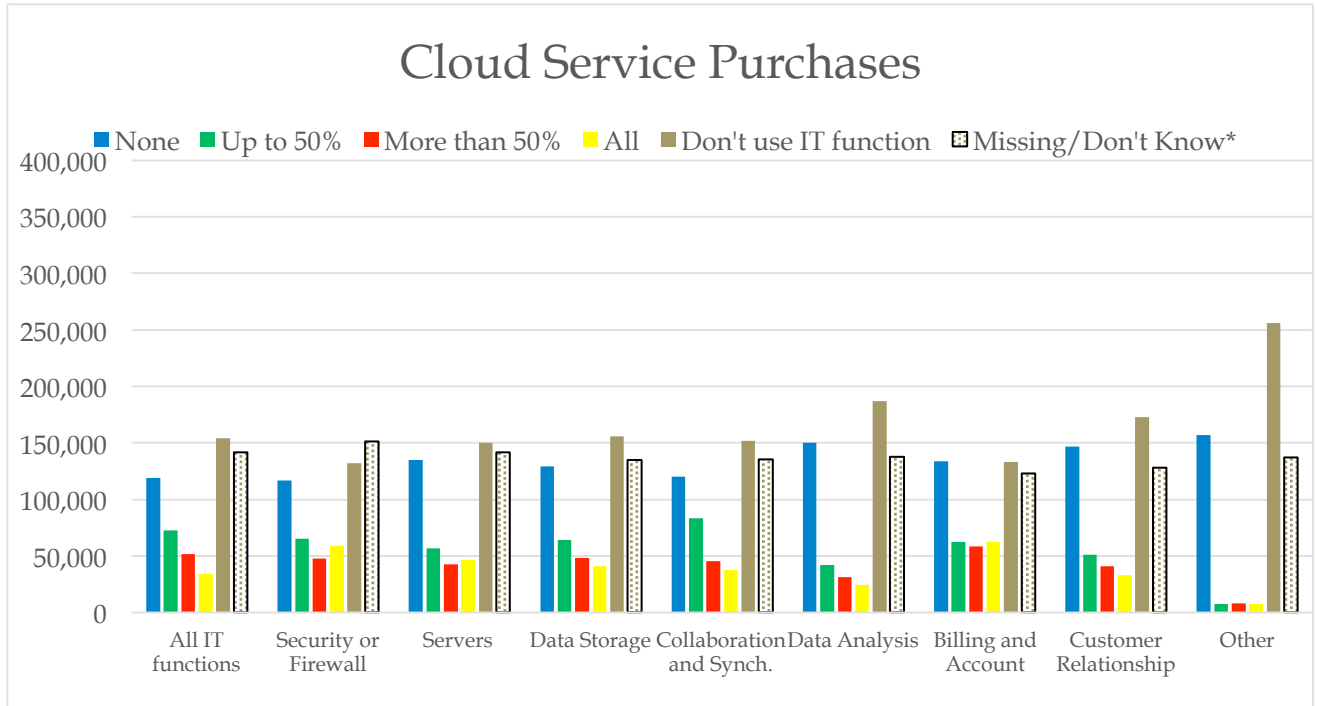
Finally, while the adoption of key technologies is closely associated with a number of readily observed firm characteristics, substantial firm-level heterogeneity cannot be explained by the available data. Much remains to be learned in ongoing data collection and research.

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[2] Defined as machine learning, machine vision, natural language processing, voice recognition or automated guided vehicles.
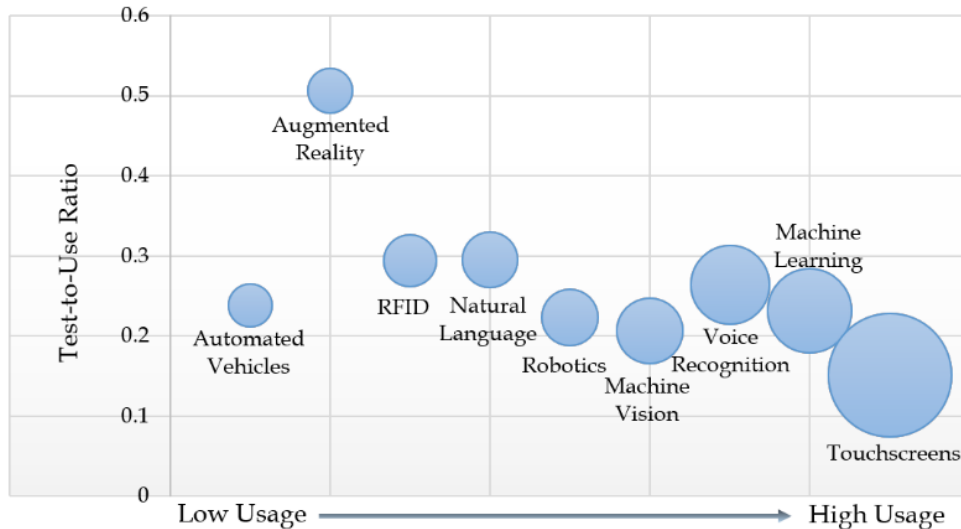
Key Tables and Figures

Figure 3: Firm Purchases of Cloud Services

Cloud Service Purchases

Legend: None, Up to 50%, More than 50%, All, Don't use IT function, Missing/Don't Know*

Note: Tabulations based on unweighted and unimputed responses.

Figure 6: Testing-to-Use Ratios

Note: "Use" is defined as having responded with "In use for less than 5% of production or service", "In use for between 5% - 25% of production or service" or "In use for more than 25% of production or service " for the categories listed on "Business Technologies" (excluding "Automated Storage and Retrieval Systems"). "Testing" is defined as having responded with "Testing but not using in production or service". Bubble size is determined by number of firms who respond to "Use" for the listed technology. All ratios here are calculated using imputed values for "Missing" responses.

Figure 7: Margins of Use and Testing Rates for Business Technologies by Sector
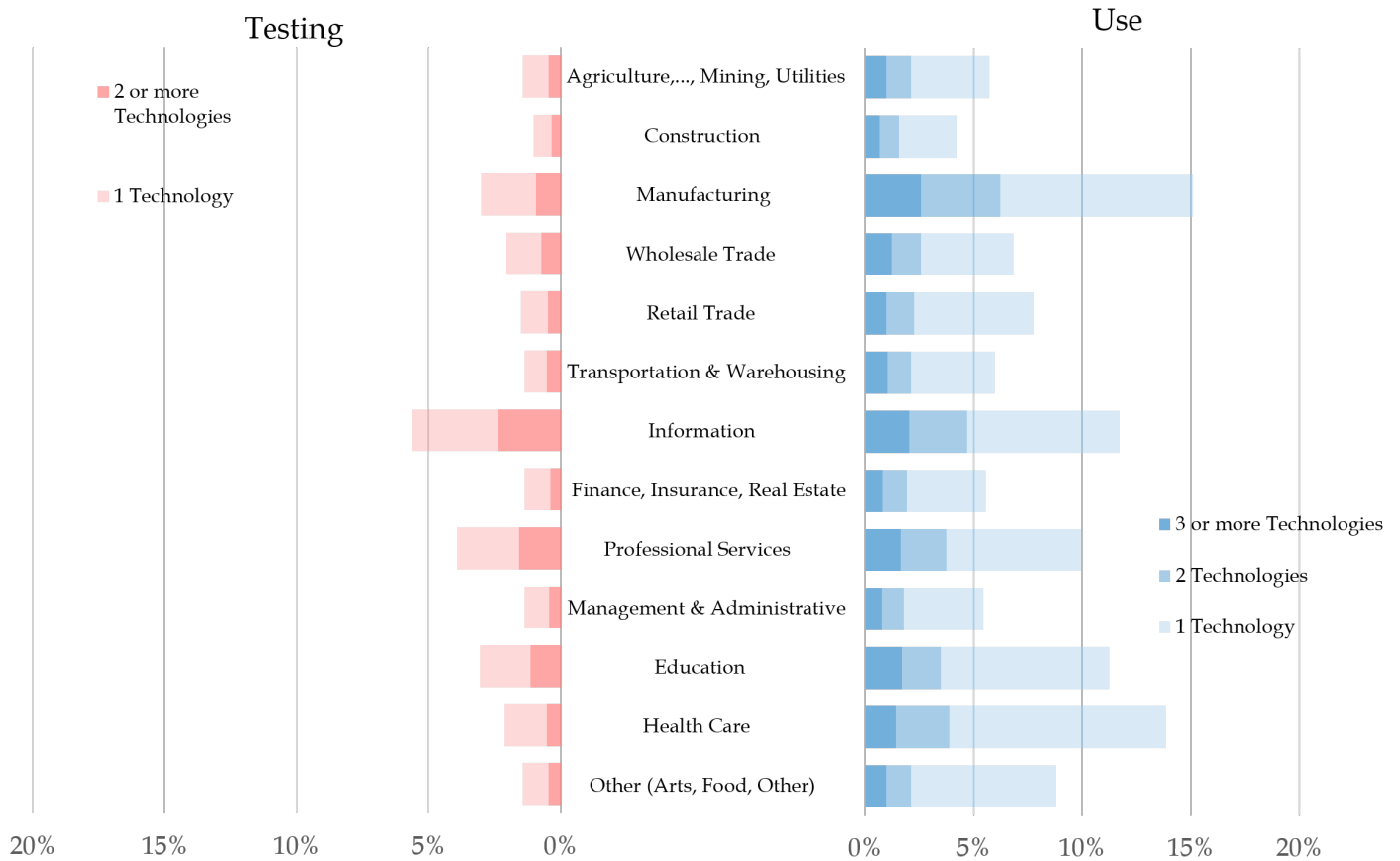

Notes: "Use" is defined as having responded with "In use for less than 5% of production or service," "In use for between 5% - 25% of production or service," or "In use for more than 25% of production or service" for the category listed on "Business Technologies" (excluding "Automated Storage and Retrieval Systems"). "Testing" is defined as having responded with "Testing but not using in production or service." Sectors are defined by combined 2-digit NAICS and assigned for multi-unit firms by largest payroll industry by firm. Original responses classified as "Missing" are imputed.

Figure 9: Technological Hierarchies
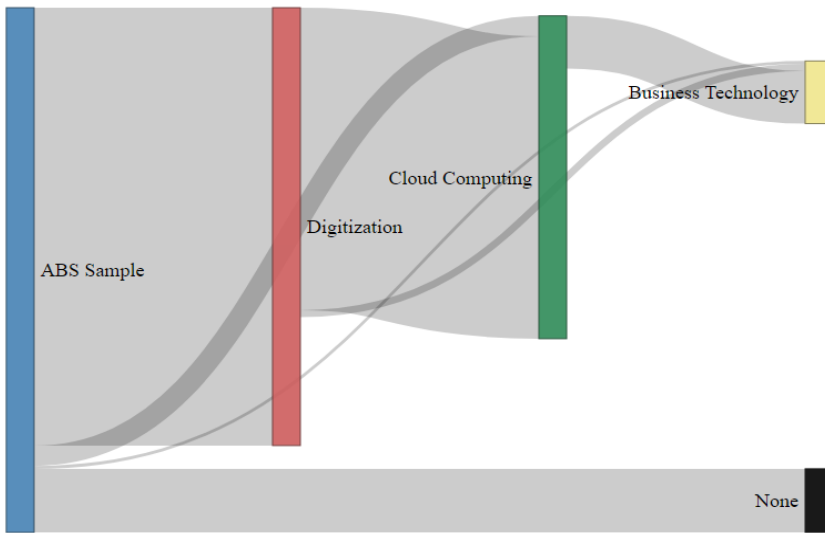
Notes: The Sankey diagram visually represents firm counts as they progress from no technology adoption to business technology and machine learning technology adoption. The size of the grey area is representative of the number of firm counts progressing to the next stage. Calculations are made using imputed responses for "Missing."

Table 6: Use of Digital Information by Business Function – Conditional

Business Function	% Use	% Intensive Use
Financial	83.8 (87.5)	70.8 (73.7)
Personnel	72.0 (76.2)	53.2 (56.4)
Marketing	61.2 (67.8)	44.1 (49.4)
Feedback	53.4 (59.9)	38.5 (43.6)
Production	46.4 (54.5)	36.4 (42.3)
Supply Chain	44.6 (53.8)	32.6 (39.0)
Other	14.2 (19.4)	11.7 (15.9)

Notes: "Use" is defined as having responded with "Up to 50%", "More than 50%" or "All" for the information category listed on "Digital Share of Business". "Intensive Use" is defined as having responded with "More than 50%" or "All". Shares are computed using the LBD tabulation weights of firm counts, divided by the total number of firms, conditional on collecting and storing the business function ("Don't Know" or missing responses were imputed). Listed shares are imputed shares, raw weighted values are in parentheses.

Table 9: Cloud Service Purchases by IT Function – Conditional

Cloud Service Purchased	% Use	% Intensive Use
Billing	50.8 (56.6)	33.8 (37.5)
Security	49.7 (58.1)	31.2 (36.3)
Synchronization	46.5 (53.6)	23.6 (27.2)
All IT	45.8 (54.0)	25.4 (29.9)
Data Storage	44.1 (51.7)	26.1 (30.5)
Servers	41.6 (48.5)	26.0 (30.1)
Customer Relations	37.6 (44.0)	22.4 (26.1)
Data Analysis	30.8 (37.6)	18.0 (22.0)
Other	8.7 (11.8)	5.9 (8.0)

Notes: "Use" and "Intensive" defined as above. Shares computed using the LBD tabulation weights of firm counts, divided by the total number of firms conditional on the firm performing the IT function ("Don't Know" or missing responses were imputed). Listed shares are imputed shares, raw weighted values are in parentheses.

Table 13: Business Technology Use Rates by Type

Business Technology	% Use	% Testing
Touchscreens	6.1 (6.0)	0.9 (0.9)
Machine Learning	2.9 (2.9)	0.7 (0.7)
Voice Recognition	2.5 (2.6)	0.7 (0.7)
Machine Vision	1.8 (1.8)	0.4 (0.4)
Robotics	1.3 (1.4)	0.3 (0.3)
Natural Language	1.3 (1.3)	0.4 (0.4)
RFID	1.1 (1.1)	0.3 (0.3)
Augmented Reality	0.8 (0.8)	0.4 (0.4)
Automated Vehicles	0.8 (0.8)	0.2 (0.2)

Notes: "Use" is defined as having responded with "In use for less than 5% of production or service", "In use for between 5% - 25% of production or service" or "In use for more than 25% of production or service " for the category listed on "Business Technologies" (excluding "Automated Storage and Retrieval Systems"). "Testing" is defined as having responded with "Testing but not using in production or service". Shares are computed using the LBD tabulation weights of firm counts, divided by the total number of firms (including those that left the responses as "Don't Know" or missing). Listed shares are imputed shares, with raw weighted values in parentheses.

Table 19: Firm-Weighted versus Employment-Weighted Adoption Rates for Advanced Business Technologies[**]

Business Technology	% Use (Tab-Weighted)	% Use (Employment-Weighted)	Difference Ratio
Touchscreens	6.1 (6.0)	25.4 (22.0)	4.2 (3.7)
Machine Learning	2.9 (2.9)	11.7 (8.5)	4.1 (2.9)
Voice Recognition	2.5 (2.6)	13.0 (9.6)	5.1 (3.8)
Machine Vision	1.8 (1.8)	6.8 (5.1)	3.8 (2.8)
Robotics	1.3 (1.4)	13.4 (10.3)	10.0 (7.6)
Natural Language	1.3 (1.3)	8.8 (5.6)	6.9 (4.4)
RFID	1.1 (1.1)	11.6 (7.9)	10.1 (7.0)
Augmented Reality	0.8 (0.8)	3.9 (2.3)	4.6 (2.7)
Automated Vehicles	0.8 (0.8)	3.6 (2.5)	4.4 (3.1)

Notes: "Use" is defined as having responded with "In use for less than 5% of production or service", "In use for between 5% - 25% of production or service" or "In use for more than 25% of production or service " for the category listed on "Business Technologies" (excluding "Automated Storage and Retrieval Systems"). "Testing" is defined as having responded with "Testing but not using in production or service". Shares are computed using the LBD tabulation weights of firm counts, divided by the total number of firms (including those that left the responses as "Don't Know" or missing). Employment weights are combined with the LBD tabulation weights and the difference ratio is computed by dividing the Employment Weighted Use rate by the LBD Tabulation-Weighted Use rate. Imputed values are listed, while raw weighted values are in parentheses.

[**]This table has been updated since the December 2020 NBER and CES working papers on which this summary is based. This is the most accurate version as of January 26, 2021.