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# **Perceived Impacts of Technology Use on the Productivity of US Manufacturing Businesses**

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## Perceived Impacts of Technology Use on the Productivity of US Manufacturing Businesses<sup>1</sup>

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**Abstract:** This paper examines the perceived effects of technology use on the employment, revenue, and productivity of US manufacturers. Results from a 2023 survey of US manufacturers (n=268) show that 48% of the surveyed businesses perceive that technology use has “no effect” on employment, 16% perceive positive impacts and 12% feel that technology use lowers the number of workers employed by the business. By contrast, only 21% of the surveyed US manufacturing businesses believe that technology use has no effect on the company’s annual revenue, 50% perceive positive impacts, while just 5% feel that technology use has a negative impact on revenue. Taken together, survey results suggest that technology use increases the productivity of a hypothetical US manufacturing business by an average of 9.2%. When companies that do not use technology are removed from the analysis, the perceived positive impact of technology use on productivity rises to an average of 12.1%. Future research will take a more in-depth look at the effects of technology on manufacturing productivity, with a focus on the differential impacts of specific types of technology.

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<sup>2</sup> Todd Gabe is a Professor in the School of Economics and author of the book *Pursuit of Economic Development: Growing Good Jobs in U.S. Cities and States*. In addition to the funding provided by the U.S. National Science Foundation, Gabe’s research is supported by the USDA National Institute of Food and Agriculture, Hatch Project Number ME0-22307 through the Maine Agricultural and Forest Experiment Station.

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<sup>5</sup> EDA UMaine Staff Papers disseminate research and analysis conducted by members of the EDA Center at the University of Maine.

<sup>6</sup> A future version of this report could be released to clarify any errors or omissions, or to incorporate new data.

## Perceived Impacts of Technology Use on the Productivity of US Manufacturing Businesses

### 1. Introduction

Technology is important to the competitiveness of businesses and the economic vitality of their surrounding communities. At the scale of a region or country, the technology use of businesses and other organizations impacts the broader macroeconomy (e.g., GDP per capita) and overall standards of living. At the scale of an individual company, the amount and types of technologies used by a business impact the ways in which employees work and how much output they produce. In addition to helping workers make higher levels of output, technology is sometimes a substitute for labor (West 2015; Dinlersoz and Wolf 2023). Taken together, this all means that technology use affects a company's productivity, measured as the value of output per worker, both through its impacts on the amount of revenue generated by the business and the number of workers that are employed.

This paper examines the perceived effects of technology use on the employment, revenue, and productivity of US manufacturers. Although companies in all sectors of the economy use various forms of technology, the connection between technology and competitiveness is particularly strong for manufacturing businesses. Indeed, research from the Brookings Institution asserts that technology (e.g., automation, robotics, and advanced manufacturing) is "one of the reasons" for a "resurgence" in US manufacturing (West 2015, 2016). The analysis is based on data collected from a survey of manufacturing businesses conducted at the end of 2023 (see data appendix for more details). In the sections that follow, we present mostly a summary of the survey results with some basic analysis of the data. Future research will take a more in-depth look at the

effects of technology on manufacturing productivity, with a focus on the differential impacts of specific types of technology. This paper is a companion to an earlier study that examined the technology adoption of US manufacturers, and related topics such as the barriers to technology use and the factors that are important to technology selection (Gabe, Hunt, and Crawley, 2024).

## 2. Survey Results

### 2.1 Technology Use of US Manufacturers<sup>7</sup>

Adoption rates by US manufacturers vary widely depending on the type of technology considered (Figure 1). Over one-half (54 percent) of the US manufacturers in our survey use computer-aided-design (CAD) technology, and about one-third use the technologies of numerically or computer-controlled machines (36 percent), programmable controllers / programmable logic controllers (33 percent), and 5-G Internet (31 percent).<sup>8</sup> Between 20 and 30 percent of US manufacturers indicated using industrial automation (25 percent), computer programming (24 percent), cloud computing (23 percent), cellular / lean / flexible manufacturing (21 percent), data analytics (21 percent) and additive manufacturing (i.e., 3-D printing) (20 percent). Technologies used by fewer than 1 in 5 of the US manufacturers covered by the survey include virtual and augmented reality (2 percent), collaborative robots (4 percent), AI or machine

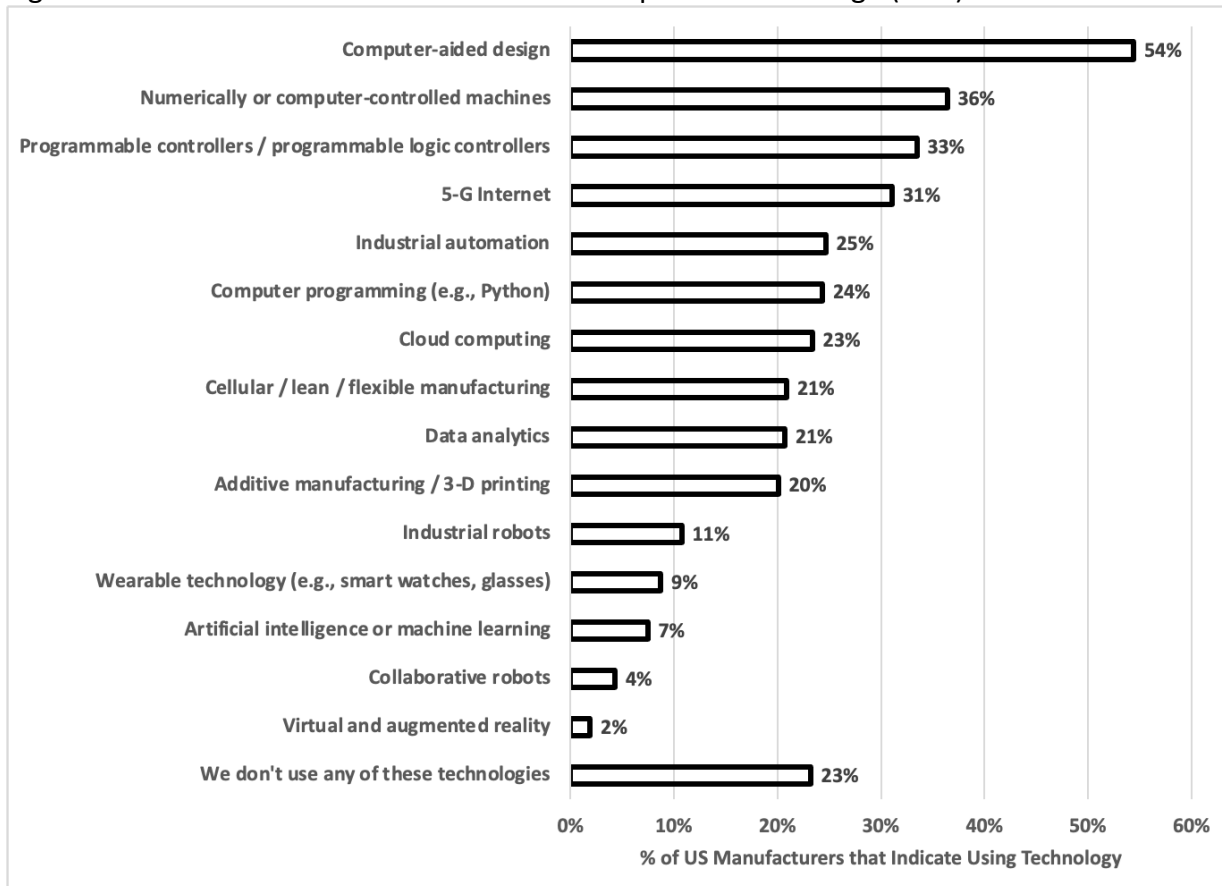
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<sup>7</sup> This subsection of the paper and Figure 1 are from the companion study, *Technology Use in US Manufacturing*, by Gabe, Hunt, and Crawley (2024).

<sup>8</sup> The estimate of 54 percent of US manufacturers that use CAD has a margin of error of plus or minus 6 percent, using a 95-percent confidence level. The estimates presented in the rest of the paper have margins of error that are no more than plus or minus 6 percent. The survey results presented throughout the paper are weighted by the employment size of the business (see data appendix for more details).

learning (7 percent), wearable technology (9 percent), and industrial robots (11 percent).<sup>9</sup> Finally, almost one quarter of the businesses surveyed noted that they do not use any of the technologies listed in Figure 1.

Figure 1. Over 50% of US manufacturers use computer-aided design (CAD).



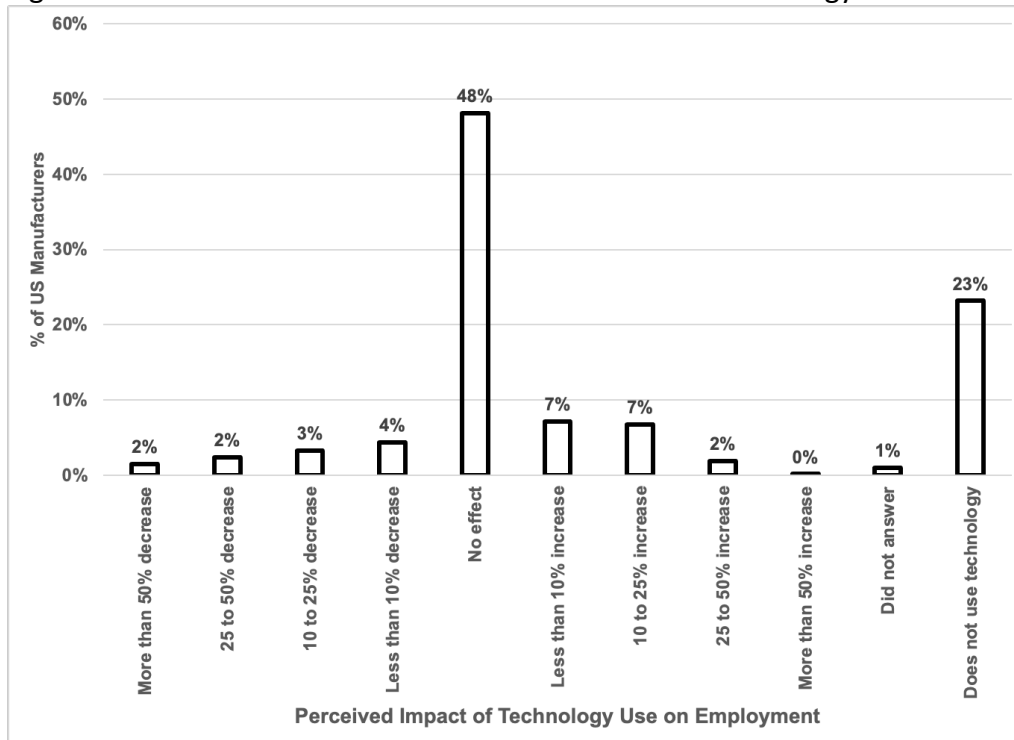
Notes. Data are from a 2023 survey of US manufacturers, n=268. Survey responses are weighted by business size.

<sup>9</sup> A 2018 technology use survey conducted by the US Census Bureau found that 6.6 percent of all US firms use “some form of AI in the workplace” (Zolas et al. 2021). The 7-percent adoption rate for AI or machine learning in our 2023 survey applies to US manufacturing businesses.

## 2.2 Perceived Effects of Technology Use on US Manufacturing Employment

Figure 2 presents information on the perceived impacts of technology use on the employment of US manufacturers. The results are from a two-part survey question that first asks about the overall impact of technology use on employment (i.e., no effect, positive or negative) and then asks the company to quantify the impact (for those who indicated a positive or negative impact) of technology on the number of people employed. As noted above, about one-quarter of the companies surveyed do not use any of the technologies shown in Figure 1 and about one-half replied that technology use has “no effect on employment.” Sixteen percent of the US manufacturers in the survey reported positive, and 12 percent indicated negative impacts of technology use on employment.

Figure 2. About 50% of US manufacturers believe that technology has no effect on employment.

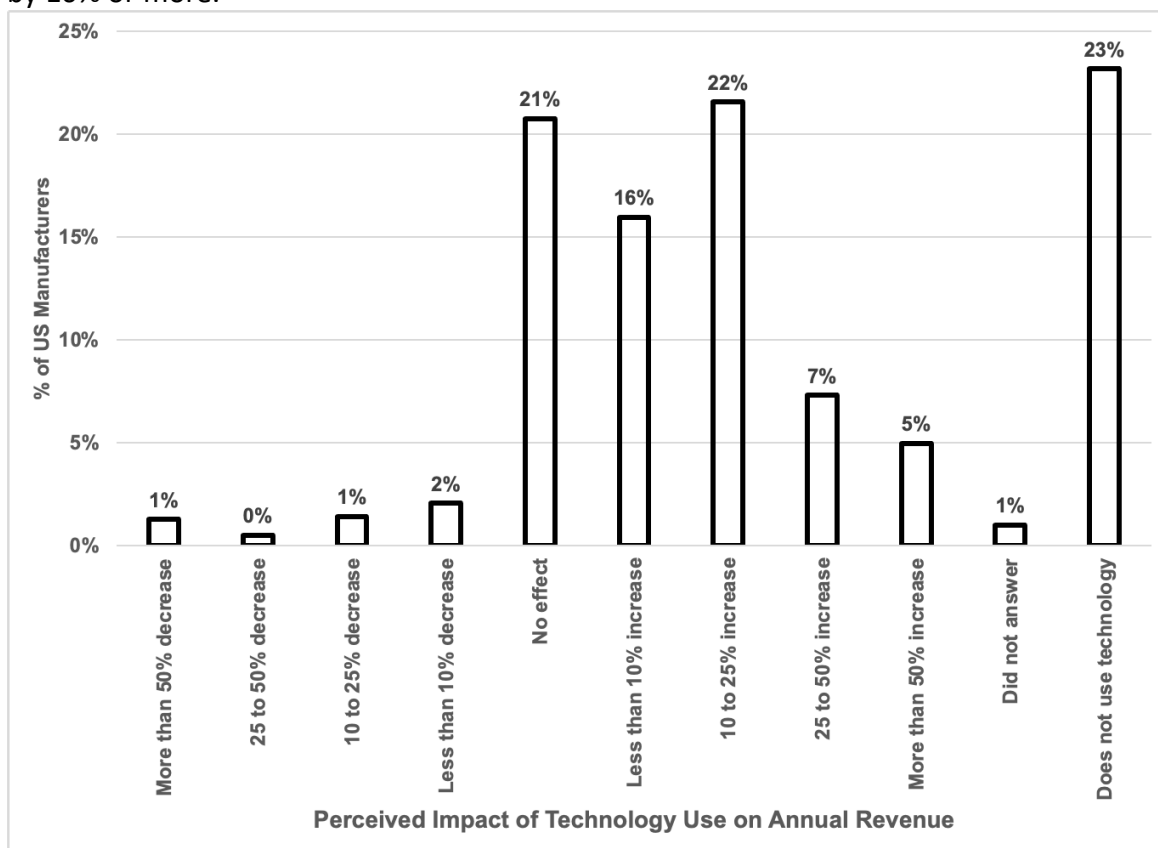


Notes. Data are from a 2023 survey of US manufacturers, n=268. Survey responses are weighted by business size.

### 2.3 Perceived Effects of Technology Use on US Manufacturing Revenue

Figure 3 shows survey results (based on a similar, two-part question) about the effects of technology use on the annual revenue of US manufacturers. While over 40 percent of the surveyed businesses either indicated that they do not use the technologies shown in Figure 1 (23 percent) or that technology use has no effect on revenue (21 percent), one-half reported that technology use has a positive effect on annual revenue. Only 5 percent of the businesses in the survey perceive that technology use has a negative effect on annual revenue.

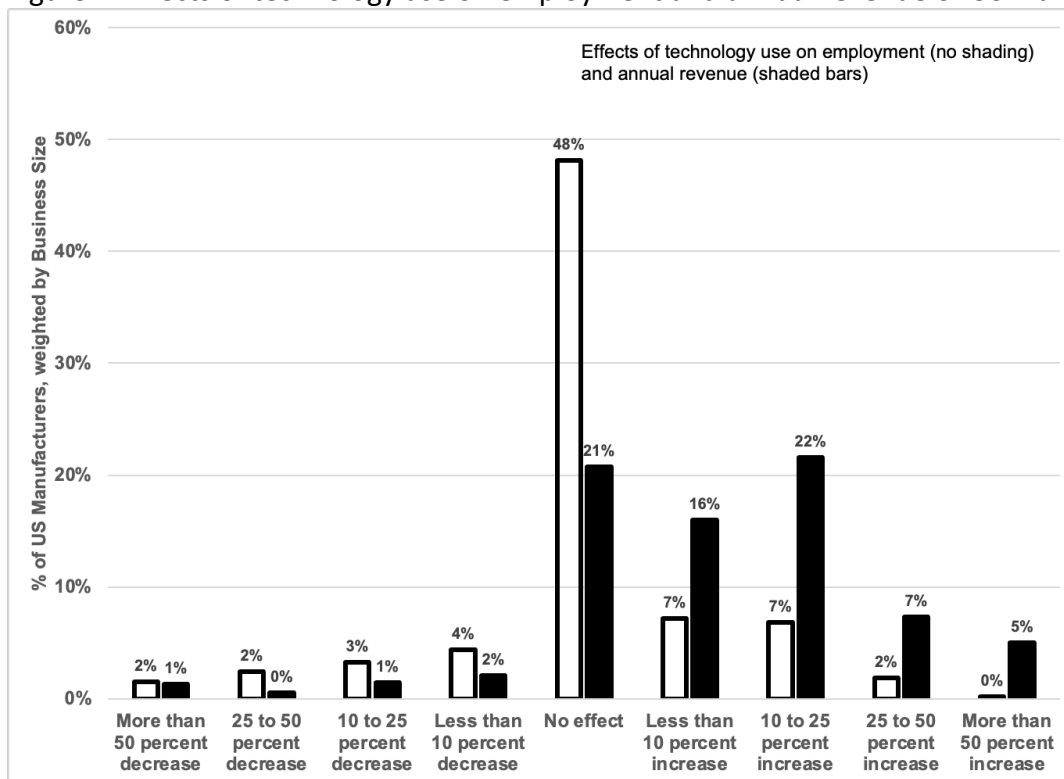
Figure 3. Over one-third of US manufacturers believe that technology increases annual revenue by 10% or more.



Notes. Data are from a 2023 survey of US manufacturers, n=268. Survey responses are weighted by business size.

The most common response of businesses that perceive a positive effect of technology use is that it increases annual revenue by 10 to 25 percent, which represents 22 percent of the businesses in the survey. Another 16 percent noted that technology use increases annual revenue by less than 10 percent, and 5 percent of the businesses in the survey indicated that technology use increases annual revenue by more than 50 percent. In fact, the percentage of businesses that noted these largest positive technology impacts of more than 50 percent is similar to the 5 percent of surveyed businesses that perceive negative impacts of technology on annual revenue.

Figure 4. Effects of technology use on employment and annual revenue of US manufacturers.



Notes. Data are from a 2023 survey of US manufacturers, n=268. Survey responses are weighted by business size. Figure does not show the results of companies that do not use any of the technologies listed in Figure 1 or those that did not answer the questions about the impacts of technology use on employment and revenue. This means that the percentages shown in the figure do not sum to 100 percent.



To aid in the comparison of the perceived impacts of technology use on employment relative to annual revenue, Figure 4 displays the survey results side by side and removes the companies that do not use any of the technologies (23 percent) and businesses that did not answer the questions about the impacts of technology (1 percent). Whereas almost one-half of the surveyed businesses perceive that technology use has no effect on employment, only 1 in 5 indicated that technology use does not impact a company's annual revenue. Other very noticeable differences between the effects of technology use on employment (no shading) and annual revenue (shaded bars) are observed on the right side of the figure that indicate positive effects of technology use. For example, over 1 in 5 US manufacturers in the survey indicated that technology use increases annual revenue between 10 and 25 percent, whereas only 7 percent noted an employment impact of this magnitude. While 1 in 14 of the surveyed companies noted positive impacts of technology use on revenue of between 25 and 50 percent, only 1 in 50 reported an impact of this size for employment.

#### 2.4 Perceived Impacts of Technology Use on US Manufacturing Productivity

We can use the results shown above to illustrate the perceived impacts of technology use on the productivity of a hypothetical manufacturing business, where productivity is defined as a company's annual revenue per worker. For this analysis, we develop a productivity index that has a baseline value of \$100,000 in revenue per worker for a company that does not use technology.<sup>10</sup> To see how technology affects productivity, we apply the numbers from Figures 2 and 3 to

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<sup>10</sup> This baseline index value of \$100,000 is arbitrary but using a round number makes it easier to interpret the impacts of technology use on productivity.

calculate the hypothetical impacts of technology use on employment and revenue, respectively. For example, the numbers shown in Figure 2 suggest that technology use increases employment by an average of 0.03 percent. This very small impact is calculated by applying the percentages of businesses that fall in each of the categories (e.g., 2 percent of companies indicated that technology use lowers employment by more than 50 percent, 7 percent noted positive employment impacts of 10 to 25 percent) to the magnitudes of the impacts (e.g., 50 percent decrease, 17.5 percent increase, which is the midpoint of 10 to 25 percent).<sup>11</sup> For the categories of “no effect on employment” and “we don’t use any of these technologies,” we use a zero percent rate of change.

Whereas the results presented in Figure 2 suggest that technology use has almost no impact on average employment (i.e., an increase of 0.03 percent is a very small impact), the numbers shown in Figure 3 show that technology use increases annual revenue by an average of 9.3 percent. These results together give a productivity index value of \$109,292 for the hypothetical business, compared to the baseline productivity of \$100,000 without the use of technology, which suggests that technology use increases productivity by an average of about 9.2 percent. If we remove the companies that indicated that they do not use any of the technologies shown in Figure 1, the impact of technology use on the productivity of a hypothetical business rises to an average of 12.1 percent.

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<sup>11</sup> For impacts of “more than 50 percent” and “less than 10 percent” we use values of 50 percent and 10 percent in the calculations.

### 3. Summary and Key Insights

The amount (and types) of technologies used by businesses affects how their workers make goods and services, and in turn affects a business' productivity. More broadly, the technology use across all businesses and organizations in a region affects an area's overall level of competitiveness, as well as standards of living. Based on a survey of US manufacturing businesses conducted at the end of 2023, we arrive at the following key insights related to the perceived impacts of technology use on employment, revenue, and productivity.

- ⇒ The technologies of computer-aided design, numerically or computer-controlled machines, and programmable controllers / programmable logic controllers are considerably more widespread in their adoption by US manufacturers than technologies such as virtual and augmented reality, robots, and AI / machine learning.<sup>12</sup>
- ⇒ About one-half of the US manufacturing businesses in the survey perceive that technology use has “no effect” on employment, 16 percent perceive positive impacts and 12 percent feel that technology use lowers the number of workers employed by the business.
- ⇒ About 20 percent of the surveyed US manufacturing businesses believe that technology use has no effect on the company's annual revenue, 50 percent perceive positive impacts, while only 5 percent feel that technology use has a negative impact on revenue.
- ⇒ Taken together, the perceived impacts of technology use on employment and annual revenue suggest that technology use increases the productivity of a hypothetical US manufacturing business by an average of about 9.2 percent. When companies that do not

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<sup>12</sup> This key insight about the technologies used by US manufacturers is from the companion study, *Technology Use in US Manufacturing*, by Gabe, Hunt, and Crawley (2024).

use technology are removed from the analysis, the positive impact of technology use on productivity rises to an average of 12.1 percent.

These key insights and the analysis presented in this paper provide a first look at the impacts of technology use on the employment, annual revenue, and productivity of US manufacturing companies. Future research will expand on these insights with additional in-depth analysis of how specific types of technology impact productivity.

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Appendix: Survey Data<sup>13</sup>

The information presented in this paper is based on the analysis of survey data collected from 268 US manufacturing businesses during the end of 2023. The survey was administered online via Qualtrics and the companies that were asked to complete the survey were identified from an email list of US manufacturers purchased from Data Axle. Overall, we sent email invitations (and reminders to nonrespondents) to 75,000 companies and 8,850 of these invitations were “undeliverable” due to invalid email addresses. In addition, it’s likely that an unknown number of email invitations to complete the survey were flagged by the individuals’ email server as spam messages and were never received by the intended recipient. Of the 66,150 surveys that were potentially received by the manufacturing companies (i.e., 75,000 original messages minus the 8,850 that were undeliverable), a total of 1,367 surveys were started by companies. This gives a response rate of 2.1 percent.

This low response rate is likely explained by a general disinterest in completing an unsolicited survey but is also influenced by the fact that an unknown number of email invitations did not make it into the inbox of the intended recipients (i.e., flagged as “spam”) and an unknown number of invitations to complete the survey were received by companies that would not self-identify as manufacturers. Related to this second point, the email list used to contact companies covers the manufacturing SIC code of 20-39.<sup>14</sup> Some of the companies classified in the email list as “manufacturers” could be, for example, small service businesses that offer printing services (e.g., might be classified as SIC 27), a retail bakery (classified as SIC 20) or a one person “business”

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<sup>13</sup> This data appendix is also used in the companion study, *Technology Use in US Manufacturing*, by Gabe, Hunt, and Crawley (2024).

<sup>14</sup> Data Axle uses SIC codes to classify businesses by industry.

that makes craft products (e.g., a person who makes wooded craft items could be classified as a wood product manufacturer, SIC 24).

From the 1,367 surveys that were started by companies, we arrive at our sample of 268 companies after removing observations with missing values for the number of workers employed by the business. The reason we removed these companies is because the survey responses are weighted by employment size. In particular, we weighted the observations using nine employment size categories (i.e., Establishments with less than 5 employees, Establishments with 5 to 9 employees, ..., Establishments with 1,000 employees or more) with manufacturing establishment counts from 2021 County Business Patterns data. Relative to the 283,015 manufacturing establishments covered in the 2021 County Business Patterns data, the 268 companies in our sample account for 1 out of 1,056 US manufacturing businesses.