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US Engineering Employment During the COVID-19 Pandemic

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Abstract

This paper analyzes the employment trajectories of engineering workers—both workers in occupations formally classified as engineering and workers in occupations not formally classified as engineering but where engineering knowledge is important—during the COVID-19 pandemic. We find that the employment rate of workers in engineering occupations fell by 6.6 percentage-points at the onset of the pandemic compared to a 13.1 percentage-point drop among workers in non-engineering jobs, and that workers in jobs where engineering knowledge is important were less likely to suffer employment loss during the pandemic, regardless of whether their occupation is formally classified as a STEM engineering occupation. This suggests that engineering knowledge is beneficial in reducing a worker's unemployment risk during recessions. We also find that industries with the highest share of engineers as workers tended to experience smaller percentage declines in employment during the pandemic compared to overall US employment, although employment in aerospace and motor vehicle manufacturing industries remained over 10% below pre-recession employment as of 2021Q4.

1 Introduction

Science and engineering workers are vital to US innovation and productivity, both for their direct role in R&D and their role in implementing new technologies at the firms where they work [1]. The COVID-19 pandemic led to a sudden spike in unemployment, pushing the US unemployment rate to its highest level since the Great Depression. Had the pandemic hit a few decades earlier, the job loss caused would likely have been worse — the development of digital technologies and infrastructure since the turn of the 21st century enabled many workers to transition from in-person to remote work, dampening what could have been an even greater decline in employment. Past research finds that workers employed in occupations with high remote-work potential prior to the pandemic tended to fare better in terms of employment during the pandemic [2, 3, 4]. While workers in STEM occupations tended to have both greater remote work capability and were less likely to suffer job loss at the onset of the pandemic compared to other workers, evidence suggests that the value of embodied STEM knowledge, rather than remote work capability, offers the greatest explanation for the resiliency of STEM employment during COVID-19 [4]. Additionally, workers

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in jobs that place a greater importance on STEM knowledge (including engineering knowledge) remained employed at greater rates compared to workers in jobs where STEM knowledge is less important, regardless of whether their job is formally classified as a STEM occupation [4].

In this paper, we focus on the impact of COVID-19 on engineering workers specifically and explore the employment trajectories of engineering-intensive industries during the COVID-19 recession and recovery. Person-level data show that the employment rate of workers in engineering occupations fell by 6.6 percentage-points at the onset of the pandemic compared to a 13.1 percentage-point drop among workers in non-engineering jobs, and that workers in jobs where engineering knowledge is important were less likely to suffer employment loss during the pandemic, regardless of whether their occupation is formally classified as a STEM engineering occupation. This suggests that engineering knowledge is beneficial in reducing a worker's risk of job loss during a pandemic recession and possibly during recessions generally.[2]

We then find that industries with the highest share of engineers as workers tended to experience smaller percentage declines in employment at the onset of the pandemic and a more rapid recovery in employment compared to the rest of the US economy, with employment in Scientific R&D Services 10% above its pre-pandemic level as of 2021Q4. However, employment in industries likely impacted by the international microchip shortage, such as electrical equipment manufacturing and aerospace and automotive-related manufacturing, remained at levels 10% below their pre-COVID peaks as of 2021Q4. It remains an open question whether employment in these industries will completely rebound, or whether employment loss will be more permanent as firms respond to recession-induced disruptions by adopting labor-saving technologies as in prior recessions [5, 6].

2 Engineering Employment Resiliency During COVID-19

To analyze the impact of COVID-19 on engineering employment in comparison with the broader US economy, we utilize person-level monthly data from the Bureau of Labors Statistics' *Current Population Survey* (CPS).[3] The CPS is a nationally-representative household level survey which collects data on the employment status and occupation of each respondent, allowing us to identify workers in engineering occupations and to track their employment over the course of the COVID-19 pandemic. Our analytical sample includes all workers who appeared in the survey both before and after the onset of the COVID-19 pandemic and who appeared in the CPS Annual Social and Economic Supplement (ASEC) which asks respondents for the occupation they occupied during

[2] [4] show that STEM workers as a group fared better during the Great Recession. They did not break out engineers separately.

[3] We utilize harmonized IPUMS-CPS data [7] available at `https://cps.ipums.org/cps/`.

Table 1: Engineering Occupations

Census Occupation Code and Title	
0300	Architectural and engineering managers
1310	Surveyors, cartographers, and photogrammetrists
1320	Aerospace engineers
1330	Agricultural engineers
1340	Biomedical engineers
1350	Chemical engineers
1360	Civil engineers
1400	Computer hardware engineers
1410	Electrical and electronics engineers
1420	Environmental engineers
1430	Industrial engineers, including health and safety
1440	Marine engineers and naval architects
1450	Materials engineers
1460	Mechanical engineers
1500	Mining and geological engineers, including mining safety engineers
1510	Nuclear engineers
1520	Petroleum engineers
1530	Engineers, all other
1540	Drafters
1550	Engineering technicians, except drafters
1560	Surveying and mapping technicians
4930	Sales engineers

Notes: Engineering occupations include engineers, engineering managers, and engineering technicians that are classified as STEM occupations by US federal agencies (`https://www2.census.gov/programs-surveys/demo/guidance/industry-occupation/stem-census-2010-occ-code-list.xls`).

their longest employment spell of 2019. We use this information to identify workers employed in the engineering occupations listed in Table 1 for their longest employment spell of 2019, and refer to these workers as "engineering workers".[4]

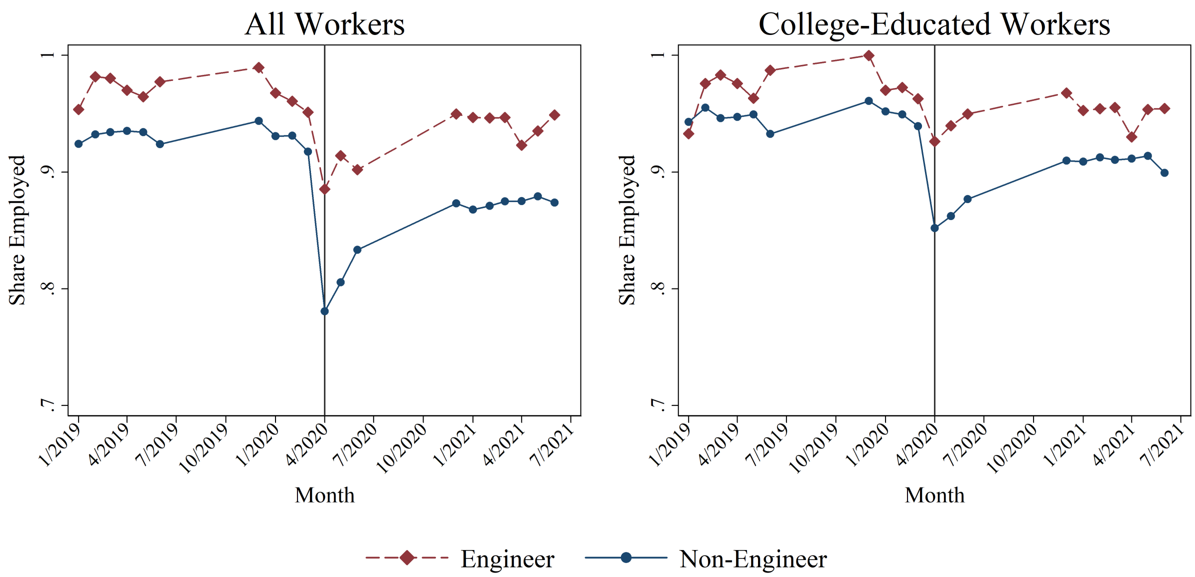
Figure 1 shows the employment rate of engineering and non-engineering workers in our analytical sample by month.[5] The pre-pandemic trends in employment rates of engineering and non-engineering workers appear relatively stable and parallel, with the employment rate of engineers roughly 3.6 percentage-points above non-engineers.[6] During the first full quarter of the pandemic (Apr-Jun 2020), the employment rate gap between engineering and non-engineering workers expanded as the employment rate of engineering workers fell by 6.6 percentage-points compared to a 13.1 percentage-point drop among workers in non-engineering jobs. Similar results hold when limiting to college-educated workers in our sample, with the employment rate of college-educated

[4]The full list of occupations, and whether an occupation is considered a STEM occupation (as determined by a US federal interagency committee) is available at `https://www2.census.gov/programs-surveys/demo/guidance/industry-occupation/stem-census-2010-occ-code-list.xls`. The engineering occupations identified in Table 1 are all STEM occupations pertaining to engineering.

[5]The CPS reference week for March 2020 preceded the first implementation of mitigation policies (e.g., school closures) in the US and so we treat April 2020 as the first month of the pandemic for purposes of this analysis. See notes to Figure 1 for additional sample details.

[6]Among college-educated workers, engineers experienced a 2.5 percentage-point higher employment rate prior to the pandemic.

Figure 1: Employment Rate Before and During COVID-19 Pandemic: Engineering vs. Non-Engineering



Notes: Sample limited to March 2020 CPS Annual Social and Economic Supplement (ASEC) respondents between the ages of 25 and 65 and who were observed both before and after March 2020 in monthly CPS data. These restrictions combined with the 4-8-4 rotating sampling scheme of the CPS mean that no members of the analytical sample are surveyed in July 2019 through November 2019, July 2020 through November 2020, or after June 2021. Each worker is classified by the occupation associated with the longest job occupied during 2019. CPS monthly basic survey weights used to compute weighted means.

engineers and non-engineers falling by 3.6 and 8.7 percentage-points, respectively.[7]

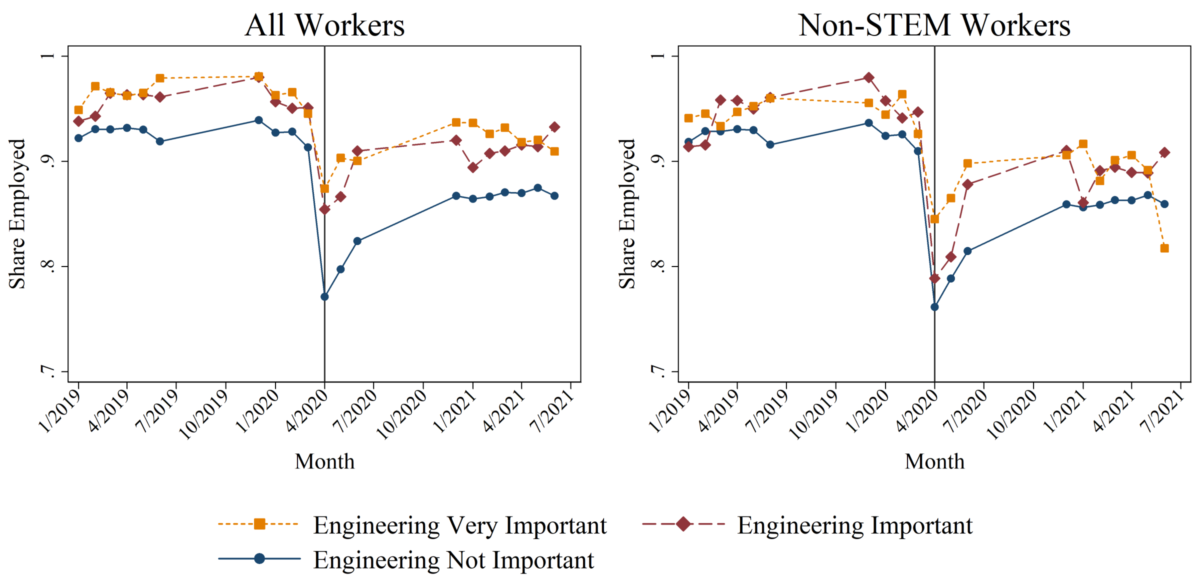
Next, we consider an alternative definition of engineering worker based on worker reports of the importance of engineering knowledge to one's job. These reports come from the "Knowledge" component of the Department of Labor's *O*NET* database which gives the importance of different fields of knowledge to different occupations based on the average rating of workers from within each given occupation.[8] Respondents rate each field of knowledge as either 1) not important, 2) somewhat important, 3) important, 4) very important, or 5) extremely important. We use these data to identify two types of engineering occupations: 1) occupations where "engineering and technology" knowledge is deemed to be "important" but not "very important" (occupations with an average score between 3 and 4) and 2) occupations where such knowledge is deemed to be at least "very important" (occupations with an average score of at least 4). Non-engineering occupations are defined as those where engineering knowledge is deemed to be less than important (i.e., occupations

[7] The difference in employment outcomes between engineering and non-engineering workers during the first full quarter of the pandemic are statistically significant at the 0.001 level of significance. In results available on request, we find that engineering workers and STEM workers outside engineering experienced similar employment rates throughout the sample period.

[8] *O*NET* 25.0 data are available at `https://www.onetcenter.org/` and the "Knowledge" questionnaire is available at `https://www.onetcenter.org/dl_files/MS_Word/Knowledge.pdf`.

with a score less than 3). This allows us to explore whether employment outcomes vary based on the importance of engineering knowledge, and also enables us to explore the employment patterns of non-STEM workers who are in jobs where engineering knowledge is nonetheless deemed important.[9]

Figure 2: Employment Rate Before and During COVID-19 Pandemic: By Engineering Knowledge Importance of Occupation



Notes: Sample limited to March 2020 CPS Annual Social and Economic Supplement (ASEC) respondents between the ages of 25 and 65 and who were observed both before and after March 2020 in monthly CPS data. These restrictions combined with the 4-8-4 rotating sampling scheme of the CPS mean that no members of the analytical sample are surveyed in July 2019 through November 2019, July 2020 through November 2020, or after June 2021. Each worker is classified by the importance of engineering knowledge to the occupation associated with their longest job occupied during 2019. Engineering knowledge importance of occupation is from O*NET. CPS monthly basic survey weights used to compute weighted means.

Figure 2 shows that, among all workers, those in occupations where engineering knowledge is important and those in occupations where such knowledge is very important experienced similar changes in employment rates during the COVID-19 pandemic, with both suffering smaller declines in the employment rate compared to workers in occupations where engineering knowledge is less than important. Among non-STEM workers, however, workers in occupations where engineering knowledge is very important appear to have experienced better employment outcomes compared to the other two groups during the first two months of the pandemic. The employment rate of those in

[9] According to data from the Bureau of Labor Statistics' *Occupational Employment and Wage Statistics* (OEWS), 2,665,580 workers were employed in engineering occupations in the US in 2019, with 136,157,120 workers employed outside those occupations listed in Table 1. By comparison, 14,349,550 workers were employed in an occupation where engineering knowledge was deemed at least important, with 3,244,805 of these workers in occupations where engineering is very important. When limiting to workers in non-STEM occupations, we find that 7,741,400 non-STEM workers are in job where engineering knowledge is at least important and 651,480 of these workers are in jobs where engineering knowledge is very important.

jobs where engineering is important (but not very important) recovered to a similar level as those in jobs where such knowledge is very important — and well above jobs where engineering knowledge is less than important — by the third month of the pandemic.[10] Altogether, workers who utilize engineering knowledge on the job, and not just those in jobs formally classified as engineering occupations, fared better in terms of employment during the pandemic, and there is some evidence that employment outcomes are increasing in the degree of importance among those in non-STEM occupations.[11]

3 Employment in Engineering-Intensive Industries During COVID-19

Table 2: Top Ten Engineering-Intensive Industries in US (2019)

NAICS Code	Industry (NAICS) Title	Engineers	
		Share of Industry Employment	Employment (Thousands)
5413	Architectural, Engineering, and Related Services	45.6%	730.4
3344	Semiconductor and Other Electronic Component Manufacturing	26.7%	99.3
3364	Aerospace Product and Parts Manufacturing	24.0%	128.2
3345	Electronic Instruments Manufacturing	23.6%	101.1
3342	Communications Equipment Manufacturing	19.7%	16.5
3343	Audio and Video Equipment Manufacturing	19.3%	3.1
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	19.2%	18.2
3341	Computer and Peripheral Equipment Manufacturing	16.4%	25.6
3353	Electrical Equipment Manufacturing	16.2%	23.9
5417	Scientific Research and Development Services	16.2%	122.1

Notes: The engineering-share of industry employment based on occupation-by-industry employment data from the Bureau of Labor Statistics' Occupational and Wage Statistics (OEWS). Engineering occupations include engineers, engineering managers, and engineering technicians that are classified as STEM occupations by US federal agencies (`https://www2.census.gov/programs-surveys/demo/guidance/industry-occupation/stem-census-2010-occ-code-list.xls`). Engineering employment calculated by multiplying 2019Q4 employment for each industry from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) by the engineering-share of the industry.

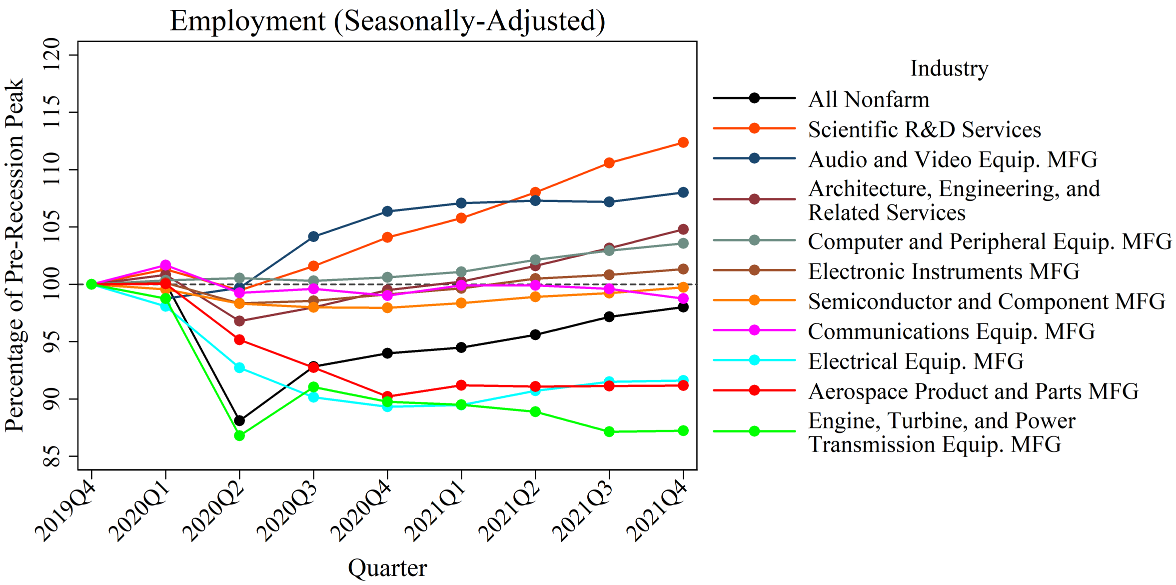
How have engineering-intensive industries fared during the COVID-19 recession and recovery? To answer this question, we identify the top ten engineering-intensive industries as defined by the share of workers within the industry that hold jobs in the engineering occupations listed in Table 1. To calculate the engineer-share of industry employment, we utilize occupation-by-industry employment data for 2019 from the Bureau of Labor Statistics' *Occupational Employment and*

[10] We define non-STEM occupations here as those occupations that are neither classified as STEM or STEM-related according to the US federal interagency committee classification of occupations.

[11] Only four non-STEM occupations associated with workers in our analytical sample are those in which engineering knowledge is (at least) very important: Construction managers (0220), Cost estimators (0600), Electrical and electronics repairers, industrial and utility (7100), and Tool and die makers (8130).

Wage Statistics (OEWS).[12] Table 2 shows that 45.6% of workers in Architectural, Engineering, and Related Services are engineers and that eight of the top ten engineering-intensive industries are manufacturing industries where the engineer share varies between 16% and 27%. The final column of Table 2 gives the number of engineers employed by each industry in 2019Q4 as calculated by multiplying the engineering share of industry employment from OEWS data by quarterly industry employment data from the Bureau of Labor Statistics' *Quarterly Census of Employment and Wages* (QCEW).[13] Over 120,000 engineers are employed in Scientific Research and Development Services, reflecting the important role of engineers in innovative activity.

Figure 3: Quarterly Employment in Engineering-Intensive Industries during COVID-19 Recession



Notes: Seasonally-adjusted quarterly employment from the US Bureau of Labor Statistics' Current Employment Statistics (CES). Industries plotted represent the ten most engineering-intensive industries as measured by the share of the industry's employment belonging to an engineering occupation as of 2019. The engineering-share of industry employment based on occupation-by-industry employment data from the Bureau of Labor Statistics' Occupational and Wage Statistics (OEWS).

Having identified the top ten most engineering-intensive industries, we then obtain monthly seasonally-adjusted employment data for each industry through December 2021 from the Bureau of Labor Statistics' *Current Employment Statistics* (CES).[14] After averaging monthly industry employment for each quarter, we plot the quarterly employment for each industry in terms of its value relative to the employment in the industry as of 2019Q4, which is when US employment hit its pre-recession peak value. As the pandemic only began at the tail end of 2020Q1, there is not much

[12]See `https://www.bls.gov/oes/oes_emp.htm` for OEWS data details.

[13]See `https://www.bls.gov/cew/overview.htm` for details on QCEW data.

[14]The advantage of CES over QCEW data is that data is published more frequently whereas QCEW data typically has a two quarter wait time. See `https://www.bls.gov/web/empsit/cesprog.htm` for details on CES data.

change in employment between 2019Q4 and 2020Q1, but in 2020Q2 total nonfarm employment dropped by over 10%. Meanwhile, seven of the ten most engineering-intensive industries saw decreases in employment of less than 5%. Since 2020Q2, employment in Scientific R&D Services shows consistent growth, indicating that the COVID-19 pandemic may have only had a mild effect on the *level* (but not necessarily the *direction*) of innovative activity. Employment in Audio and Video Manufacturing has also appeared strong, which may reflect increased demand from workers and firms transitioning to remote work. Meanwhile, three engineering-intensive industries have seen their employment level stagnate at around 10% below their pre-recession values: 1) Engine, Turbine, and Power Transmission Equipment Manufacturing, 2) Aerospace Product and Parts Manufacturing, and 3) Electrical Equipment Manufacturing. Aerospace Product and Parts Manufacturing may have experienced declines due to falling demand in the airline industry, but, along with the other engineering-intensive industries suffering persistently-lower employment, could also be due in part to the global microchip shortage.

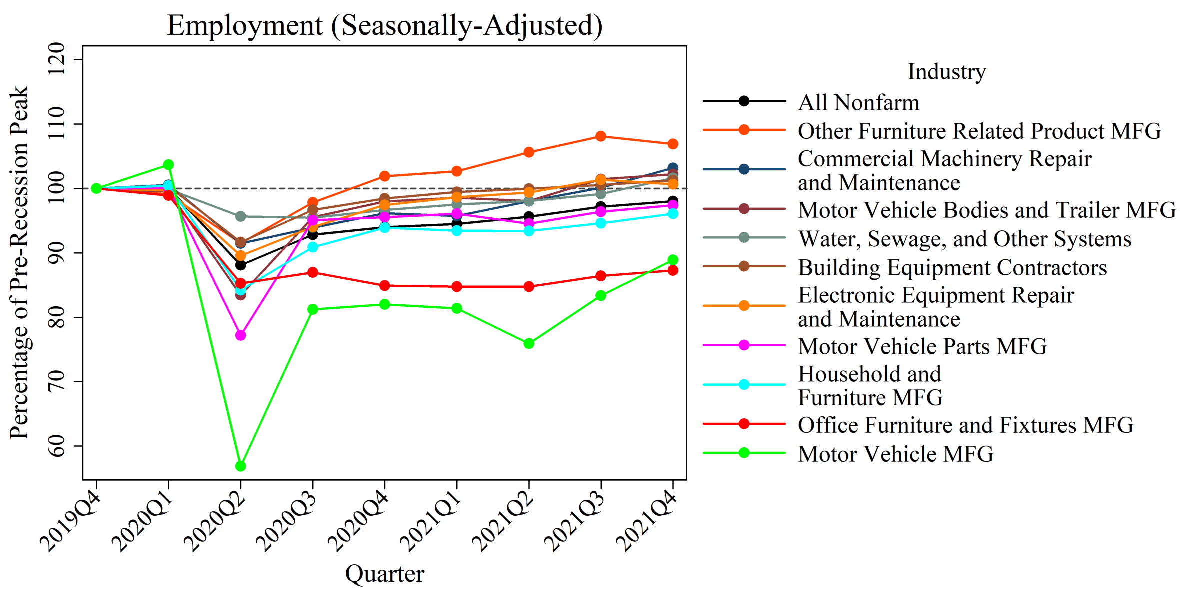
Table 3: Top Ten Industries in US by Share of Workers who are in Non-STEM Occupations where Engineering Knowledge is Important (2019)

NAICS Code	Industry (NAICS) Title	Non-STEM Engineering Knowledge Users	
		Share of Industry Employment	Employment (Thousands)
3361	Motor Vehicle Manufacturing	68.6%	154.4
8112	Electronic Equipment Repair and Maintenance	47.7%	51.4
2213	Water, Sewage, and Other Systems	45.1%	86.6
3379	Other Furniture Related Product Manufacturing	44.7%	15.0
8113	Commercial Machinery Repair and Maintenance	43.8%	96.8
3362	Motor Vehicle Bodies and Trailer Manufacturing	42.3%	67.5
2382	Building Equipment Contractors	41.9%	95.8
3363	Motor Vehicle Parts Manufacturing	40.6%	23.7
3371	Household and Institutional Furniture Manufacturing	39.7%	94.7
3372	Office Furniture and Fixtures Manufacturing	39.7%	42.4

Notes: Engineering knowledge importance for each occupation from the Department of Labor's O*NET database. The share of workers in an industry who are in non-STEM occupations where engineering knowledge is important calculated using the Bureau of Labor Statistics' Occupational and Wage Statistics (OEWS). Non-STEM occupations include those that are neither classified as STEM or STEM-related occupations by US federal agencies (`https://www2.census.gov/programs-surveys/demo/guidance/industry-occupation/stem-census-2010-occ-code-list.xls`). Non-STEM engineering knowledge user employment calculated by multiplying 2019Q4 employment for each industry from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) by the share of non-STEM workers in an that industry who are in occupations where engineering knowledge is important.

In Section 2 we found that workers in jobs where engineering knowledge is deemed important—and not just those in occupations conventionally classified as engineering occupations—were more likely to remain employed during COVID-19. Table 3 shows the top ten industries in terms of the share of workers in the industry who are in non-STEM occupations where engineering is deemed important, with Motor Vehicle Manufacturing topping the list with 68.6% of its workers employed in such occupations. Figure 4 shows that Motor Vehicle Manufacturing and Motor Vehicle Parts Manufacturing suffered the greatest declines in employment at the onset of the pandemic, with motor vehicle manufacturing falling by over 40%. All but two of the industries shown—Motor Vehicles Manufacturing and Office Furniture and Fixtures Manufacturing—have recovered to at least the extent, or close to the extent, as overall employment. While the reduction in Motor Vehicles Manufacturing may reflect the global chip shortage, the reduction in Office Furniture and Fixtures Manufacturing might reflect reductions in office space investment induced by an increase in remote work.

Figure 4: Quarterly Employment in Industries with Highest Share of Non-STEM Jobs where Engineering Knowledge is Important during COVID-19 Recession



Notes: Seasonally-adjusted quarterly employment from the US Bureau of Labor Statistics' Current Employment Statistics (CES). Industries plotted represent the top ten industries in terms of the share of its workforce that are in non-STEM occupations where engineering knowledge is important.Engineering knowledge importance for each occupation from the Department of Labor's O*NET database. The share of workers in an industry who are in non-STEM occupations where engineering knowledge is important calculated using the Bureau of Labor Statistics' Occupational and Wage Statistics (OEWS). Non-STEM occupations include those that are neither classified as STEM or STEM-related occupations by US federal agencies (`https://www2.census.gov/programs-surveys/demo/guidance/industry-occupation/stem-census-2010-occ-code-list.xls`).

4 Conclusion

Altogether, we find that workers in engineering occupations, as well as workers not formally classified as working in an engineering occupation but who nonetheless work in jobs where engineering knowledge is important, experienced smaller declines in employment relative to other workers. This evidence, in combination with the findings in [4], suggests that engineering knowledge confers a degree of recession resiliency to workers during economic downturns.[15] We also find evidence that COVID-19 impacted different engineering-intensive industries in different ways, but on average such industries have fared well relative to the overall US economy in terms of employment. Our findings join the body of work showing that workers in STEM fields tend to fare better during recessions [8, 9, 4], which may explain why students increasingly pursue such majors in response to economic downturns [10, 11, 12]. Future avenues of research include an examination of the impacts of the COVID-19 pandemic on the career trajectories of engineers who were students at the time of the pandemic, rather than workers who were already trained and in the labor market. Evidence suggests that remote instruction may have been less-effective for engineers where hands-on training is a key part of one's academic training [13], and learning deficits that result from reduced hands-on training could have long-lasting impacts on the engineering labor market and the economy more broadly.

[15][4] finds that workers who utilize STEM (including engineering) knowledge in their jobs were more likely to remain employed during the COVID-19 pandemic, and that such knowledge offered employment resiliency during the COVID-19 recession beyond any resiliency associated with greater remote work capability and educational attainment.

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