Changes in electricity use following COVID-19 stay-at-home behavior

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Overview

Using hourly electricity consumption data from the PJM Interconnection in the United States in a difference-in-predicted-differences strategy, this article shows that while in the first months of the COVID-19 pandemic total electricity consumption declined by 3.7-5.4% relative to a predicted counterfactual, in July and August 2020 electricity consumption was 2.9-4.6% higher than the predicted counterfactual. In addition, higher temperatures had an increased effect on electricity consumption in 2020 relative to previous years. Nationwide monthly data on electricity consumption by load class reveals that commercial and industrial consumption was below its expected baseline from March-November 2020, while residential consumption was above its expected baseline, peaking in July. This suggests that increased demand for residential cooling offset declines in commercial and industrial demand for electricity. Estimates of the total effect of the pandemic on electricity consumption from March through December 2020 suggest that early reductions in electricity use were almost perfectly offset by later increases, implying that any expected “silver lining" of decreased emissions from electricity production may be smaller than previously thought.

Methods

To evaluate the longer-term impact of staying at home on electricity consumption, I analyze data on hourly electricity use in the PJM Interconnection of the United States during 2020. The analysis uses a nonparametric matching algorithm to predict electricity consumption for 2020 based on weather patterns and hourly, daily, and monthly seasonality if 2020 consumption resembled consumption from the previous five years. In addition, to determine the source of the surplus demand, I analyze monthly nationwide reported electricity consumption data by sector at the utility level using a fixed-effects regression approach.

Results

After controlling for weather patterns and seasonality, the hourly data show that during the initial surge of COVID-19 cases and stay-at-home policies from March through May 2020, total electricity use was 3.7-5.4% lower than predicted consumption each month; however, after these policies expired in June 2020, total electricity use was roughly equal to the predicted baseline and in July and August was 2.9 and 4.6% higher than predicted consumption. I then estimate the summer temperature-electricity exposure-response relationship for 2014-2019 versus 2020 to test the hypothesis that cooling more residential homes during the day is more costly than cooling workplaces. I nd that in 2020, higher temperatures resulted in proportionally higher electricity consumption than in 2014-2019, though the effect is not large. Thus, it appears that the cost of cooling residential homes is driving some of the increased demand.

The nationwide utility-level data show that in March 2020 at the beginning of the pandemic, electricity use in all sectors was lower relative to the previous ve years after controlling for utility-specic unobservables, temperature, and seasonality. From April through August, residential electricity consumption was signicantly higher relative to expected consumption, peaking in July. During the same period, commercial and industrial electricity demand was below normal, initially outweighing increased residential demand from April through June. In July and August, residential demand peaked while industrial and commercial demand were at the highest levels since March. This suggests that the additional load came primarily from the residential sector, which could be driven by demand for cooling, demand for work-from-home purposes, or demand for electricity as an input for leisure. In addition, there is some evidence for a partial commercial and industrial recovery during this period.

Conclusions

Using hourly electricity consumption data in a difference-in-predicted-differences strategy, this article shows that while electricity consumption declined by 3.7, 5.4, and 4.0% in the first three months of the COVID-19 pandemic, electricity use was 2.9 and 4.6% higher in July and August 2020. Electricity consumption in September through November was roughly normal compared to the predicted baseline, while consumption in December was 2.6% higher than the predicted baseline. Nationwide monthly data on electricity consumption by load class reveals that commercial and industrial consumption was below its expected baseline from March-November 2020, while residential consumption was above its expected baseline, peaking in July. As a whole, the early reductions in electricity consumption were almost perfectly offset by the increases in July, August, and December, with estimates of the overall effect centered on zero across specifications, ranging from -0.10% to +0.13%.

These empirical findings suggest that initial reductions in electricity consumption were offset by increased consumption by residential users. This increased consumption is at least partially due to cooling responses to high summer temperatures. When more people are at home during the day, home HVAC systems are used more, drawing additional electricity. This increased residential consumption more than made up for reductions in industrial and commercial consumption, resulting in the pandemic counterintuitively increasing electricity consumption in the United States during the hottest months of the year. This explanation cannot explain increased demand in December, as cold weather did not have as large of an effect on electricity consumption as in previous years. The spike in December can only be attributed to unobserved differences in electricity consumption.

Increased electricity consumption has important implications for the growing literature examining ``silver linings'' of the pandemic. To the extent that electricity generation contributes to local and global air and water pollution, the gains will be smaller than expected due to increased demand for cooling in the summer months. Future work in this area should focus on air and water quality improvements from reduced commuter traffic and should acknowledge that the pandemic did not uniformly decrease electricity consumption.

Early in the pandemic, some scholars noted that electricity consumption changes were a better real-time measure of macroeconomic conditions than traditional metrics such as quarterly earnings reports (Bui and Wolfers, 2020). This was likely true in the short run when the relationship between electricity consumption and its underlying causes remained the same. At that time, a change in electricity consumption only reflected the reduction in the level of economic activity after controlling for other underlying determinants of electricity consumption. In the long run, behavior adapted to new conditions and the relationship between electricity consumption and its underlying causes changed. For example, a change in electricity consumption then reflects differences in the level of economic activity and the new relationship between temperature and electricity consumption. To use electricity consumption as a valid metric of macroeconomic health, the proposed metric should account for changes in the relationship between electricity consumption and its primitives in a full decomposition approach.