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# JUE Insight: Powering work from home☆

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A R T I C L E I N F O

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R11
R22
Q40
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G50

A B S T R A C T

This paper documents a shift in energy consumption toward residential usage during the COVID-19 pandemic in the United States. Focusing on electricity, I find a 7.9% increase in residential consumption, and a 6.9% and 8.0% reduction in commercial and industrial usage, respectively, from a monthly panel of electric utilities. Natural gas consumption also shifted toward residential use, so that aggregate electricity and gas expenditure only fell by 1% on net during a period in which GDP fell by 5%. Hourly smart meter data from Texas reveal how daily routines changed during the pandemic, with residential electricity usage during weekdays closely resembling those of weekends. In total, residential energy expenditures were an estimated $13B higher during Q2-Q4 2020, with the largest increases occurring in areas with a greater propensity to work from home. I find that transportation fuel consumption declined about 16%, so that total energy consumption in the U.S. economy fell by 8%.

## 1. Introduction

This paper estimates how energy consumption has changed in the United States during the COVID-19 pandemic, with a focus on electricity. Accompanying the public health crisis has been a major economic shock—one that has affected both the level and composition of economic activity. The reduction in economic activity is clear in patterns of energy use in transportation, industry, and commercial businesses, while there has been a striking shift towards greater residential usage.

To reduce the risk of exposure to the SARS-CoV-2 virus, roughly one-third of the American labor force has been working from home (Bick et al., 2020; Brynjolfsson et al., 2020; Dingel and Neiman, 2020). Household expenditures also changed dramatically, reflecting both the loss of income and consumption opportunities, and a shift toward household production (Baker et al., 2020; Cox et al., 2020). Whether under government orders to shelter-in-place, working remotely, or out of work and school, people are spending an inordinate amount of time at home (Chetty et al., 2020). Additional time and consumption at home requires significant increases in energy use. This represents an additional and essential expense at a time when many households are also experiencing severe economic hardship. On the other hand, the savings from reduced commuting in both time and energy are substantial (Barrero et al., 2020).

The COVID-19 economic shock is therefore unusual in the way it has shifted economic activity from workplaces to homes. Recent surveys find that U.S. employees are anticipating expanded work from home (WFH) opportunities post-pandemic (Bartik et al., 2020; Barrero et al., 2021), up to 20% of working hours from 5% pre-pandemic. What are the implications of such a shift on energy usage? The energy consumption of a city based on in-person work is structured around transportation to an urban core, where co-location permits the economical use of energy for heating, cooling, lighting, food service, etc. Thermostats in residences are turned down as commercial buildings are filled with workers, and cafeterias substitute for individually pre-heated ovens and open refrigerators. With a WFH posture, transportation plays a more limited role in the city's energy use profile, and co-location commands less of a premium. Energy consumption during the day shifts from businesses to homes, and the efficiency achieved through density falls, as space gains importance over proximity (Glaeser and Kahn, 2010; Glaeser, 2011).

I measure changes in energy consumption during the COVID-19 pandemic using data from the Energy Information Administration (EIA), with varying degrees of spatial and temporal resolution, depending upon availability. For electricity, I evaluate changes in usage over time within utility service territories, and control for fluctuations in heating and cooling demands. I find that residential electricity consumption rose by about 8% on average during Q2-Q4 2020, while commercial and industrial usage fell by 7% and 8%, respectively. A similar analysis at the state level for natural gas also reveals a shift away from commercial and industrial natural gas usage, toward residential consumption, which rose over 4%. As a result, aggregate electricity and natural gas consumption

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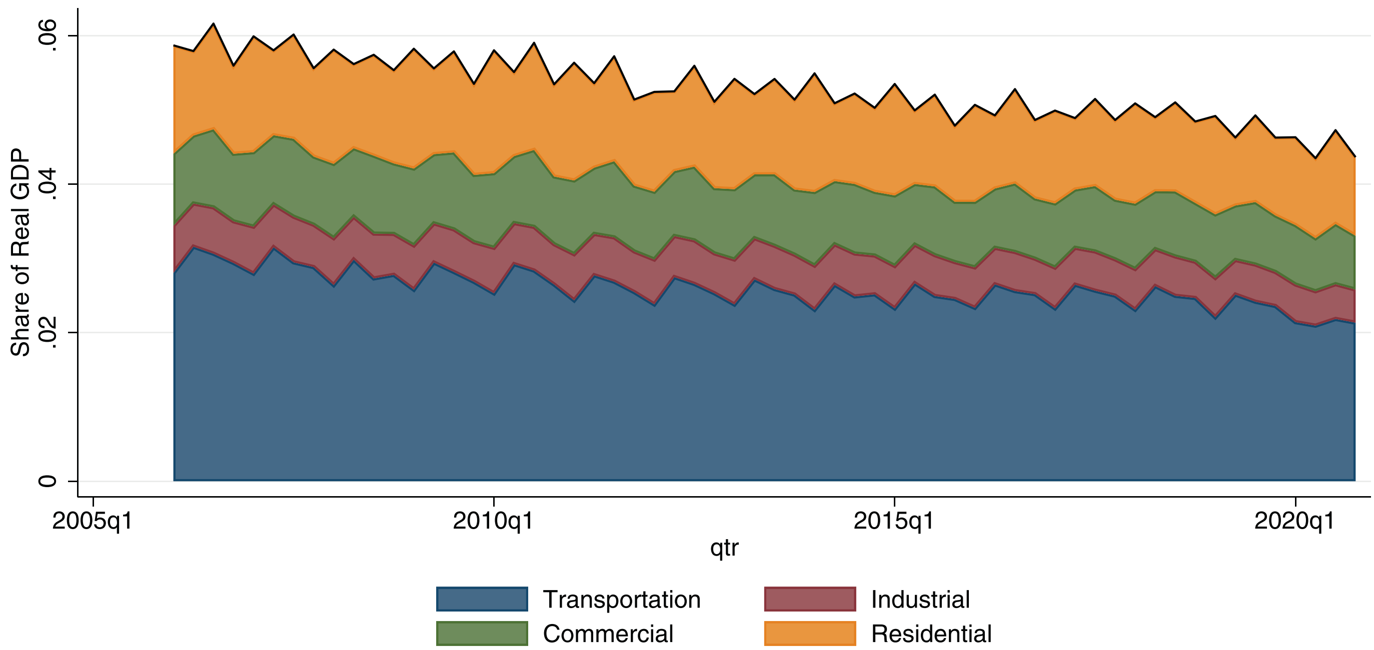



**Fig. 1.** Real Energy Expenditures per Dollar of GDP by Sector, 2006–2020. Note: Residential, Commercial and Industrial expenditures include retail electricity and natural gas consumption. Transportation includes gasoline, diesel, and jet fuel. GDP and energy expenditures are evaluated at 2019 prices. Electricity expenditures includes state-level adjustments calculated by EIA to reflect national aggregates. Sources: Federal Reserve Economic Data, EIA.

fell by 1% and 2%, respectively, over a period in which total output was 5% lower than the previous year. In other words, use of these sources increased in intensity per unit of GDP as economic activity shifted away from workplaces.

This shift toward residential energy consumption occurred in tandem with a significant reduction in travel: aggregate consumption of gasoline, diesel, and jet fuel fell by 15%, 5%, and 46%, respectively. In total, energy expenditure fell about 8% evaluated at 2019 prices, marginally larger than the fall in economic activity overall during this period.

I then evaluate the correlates of changes in electricity consumption, and find that residential electricity consumption rose more in areas more predisposed to work from home (WFH, Dingel and Neiman (2020)). This is especially true in warm climates. Higher unemployment is also associated with a shift toward residential electricity consumption, as are non-essential business closures during the pandemic. Highlighting the unusual nature of the COVID-19 shock, I show that an increase in residential electricity consumption is not a general feature of economic downturns—it did not occur during the Great Recession.

The shift from workplace to home energy usage is also a reallocation of financial burden, especially because residential retail rates tend to be higher. Tallying total expenditure changes over the nine-month period from April to December 2020, American households spent nearly $12B in excess residential electricity consumption and an additional $1B on natural gas. This increased expenditure reduces the net benefits of WFH associated with less commuting (Barrero et al., 2020; Brodeur et al., 2020) and improved environmental quality (Cicala et al., 2021; Gillingham et al., 2020; Quéré et al., 2020). The reduction in transportation fuel was $60B at 2019 prices, but this is not broken down by sector.[2] Electricity expenditures for commercial and industrial customers fell by $9B and $4B, respectively.

Finally, I evaluate hourly residential consumption from smart meters in Texas to reveal how usage has changed over the work week. I find that the patterns that used to distinguish work days from weekends have largely disappeared—residential electricity consumption during the pandemic rises later in the morning, and is 16% higher during weekday work hours, mirroring the pattern of weekend usage during normal times.

This paper also has important implications for the emergent literature that uses real-time electricity consumption to proxy for economic activity during the COVID-19 pandemic (Cicala, 2020; Benedikt and Radulescu, 2020; Buechler et al., 2020; Chen et al., 2020; Fezzi and Fanghella, 2020; Figer et al., 2020; International Association for Energy Economists, 2020; Leach et al., 2020; Richter de Almeida, 2020). The appeal of electricity consumption as an economic indicator is based on its real-time availability, universal use in economic activity, and lack of substitutes. This allows one to learn about high-frequency changes in economic activity by monitoring electricity consumption—but the appropriate conversion factor between changes in electricity and economic activity is yet to be determined. This paper provides evidence that higher residential usage is masking significant declines in commercial and industrial consumption.

While total U.S. electricity consumption returned to normal levels by July 2020, industrial and commercial usage remained 5–10% below normal for the remainder of 2020. This deviation from normal for commercial and industrial usage is similar to that of the sluggish state of the economy in early 2010, following the Great Recession. While the rise in residential electricity consumption highlights the distinct nature of the COVID-19 economic shock, the persistent reduction in commercial and industrial consumption indicates significant weakness in the economy in spite of what appear to be nominal levels of total usage. A hybrid work posture with both higher levels of residential usage and reopened commercial spaces is likely to entail a net growth in electricity consumption overall. This would present a false signal of economic strength in electricity-based indices.

The paper is organized as follows: I first describe the data sources in Section 2, then the econometric methods I employ in Section 3. The fourth section presents the results, focusing on electricity, and the final section concludes. Analogous results for natural gas and transportation fuels, as well as additional results and robustness checks, are presented in the Appendix.

[2] There was a $40B reduction in gasoline usage at 2019 prices, and about 30% of passenger miles are typically spent commuting (Davis and Boundy, 2021)).

**Table 1**
Change in $Log$(Electricity Consumption) by Customer Class.

| A. Residential | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | 0.045*** | 0.048*** | 0.053*** | 0.073*** | 0.076*** |
| | (0.016) | (0.018) | (0.020) | (0.016) | (0.015) |
| Utility FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| Utility-Weather | | | | Yes | Yes |
| Utility-Month FE | | | | | Yes |
| Clusters | 315 | 315 | 315 | 315 | 315 |
| $R^2$ | 0.024 | 0.982 | 0.989 | 0.995 | 0.998 |
| Obs. | 19,210 | 19,210 | 19,210 | 19,210 | 19,210 |
| B. Commercial | | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | –0.082*** | –0.079*** | –0.078*** | –0.075*** | –0.071*** |
| | (0.011) | (0.013) | (0.013) | (0.022) | (0.023) |
| Utility FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| Utility-Weather | | | | Yes | Yes |
| Utility-Month FE | | | | | Yes |
| Clusters | 294 | 294 | 294 | 294 | 294 |
| $R^2$ | 0.006 | 0.994 | 0.995 | 0.997 | 0.997 |
| Obs. | 17,931 | 17,931 | 17,931 | 17,931 | 17,931 |
| C. Industrial | | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | –0.093*** | –0.089*** | –0.087*** | –0.086*** | –0.083*** |
| | (0.011) | (0.010) | (0.011) | (0.011) | (0.012) |
| Utility FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| Utility-Weather | | | | Yes | Yes |
| Utility-Month FE | | | | | Yes |
| Clusters | 280 | 280 | 280 | 280 | 280 |
| $R^2$ | 0.002 | 0.984 | 0.984 | 0.990 | 0.992 |
| Obs. | 17,064 | 17,064 | 17,064 | 17,064 | 17,064 |
| D. Total | | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | –0.029*** | –0.027** | –0.023 | –0.013 | –0.010 |
| | (0.010) | (0.012) | (0.015) | (0.013) | (0.011) |
| Utility FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| Utility-Weather | | | | Yes | Yes |
| Utility-Month FE | | | | | Yes |
| Clusters | 361 | 361 | 361 | 361 | 361 |
| $R^2$ | 0.010 | 0.991 | 0.994 | 0.997 | 0.998 |
| Obs. | 22,017 | 22,017 | 22,017 | 22,017 | 22,017 |

Note: All specifications include month-of-year fixed effects. Column (3) controls for weather with single coefficients for heating and cooling degree hours, and a measure of distributed solar. Columns (4) and (5) estimate utility-specific coefficients for these controls. Standard errors clustered by utility in parentheses. * p<0.1, ** p<0.05, *** p<0.01

## 2. Data

In 2019, retail energy expenditures in the US topped $1T, or about 5% of GDP. About half was spent on transportation fuels, one quarter on residential electricity and gas, and the remainder on commercial and industrial electricity and gas (see Appendix Table A.1). Fig. 1 puts these statistics in historical perspective, plotting the real (2019 price) quarterly energy intensity of the U.S. economy going back to 2006. It shows a steady decrease in energy intensity throughout the period without any break in trend (including during the Great Recession). Previewing the results of this paper, this is also true during 2020: 2020-Q3 was right on the historical best fit line of the time series. The expenditure components, however, display a substantial shift away from transportation, commercial and industrial energy use, toward residential.

Monthly data on electricity consumption, revenues, and net-metered generation capacity come from the Energy Information Administration (EIA), Form EIA-861M (formerly EIA-826). These data are reported monthly by utility, state, and customer class, with an approximately two-month lag.[3] This form is based on a sample of utilities, but reporting is a balanced panel between 2016 and July 2020 for roughly two-thirds of consumption in the lower 48 states. Data from power marketers are not identifiable until nine months after the reporting period, making coverage in Texas in particular relatively sparse. Roughly three-quarters of residential consumption outside of Texas is reported comprehensively throughout the study period. EIA estimates consumption for the balance of non-reported consumption, but these predictions are dropped from the analysis.

[3] Delmarva Power, for example, reports its business in Delaware and Maryland separately. Only 10% of utilities report for multiple states, so I refer to a utility-state reporting unit as a utility for brevity, though all data remain at the utility-state level.

The bundled utilities reporting in EIA-861M spend roughly $250B per year on residential, commercial, and industrial electricity.[4] Appendix Fig. A.1 plots the monthly consumption and expenditure totals for these individually-reported utilities since 2016. Residential electricity consumption is highly seasonal, reflecting the importance of home heating and cooling. Overall, residential consumption is responsible for about 40% of consumption and half of expenditures. Industrial power is relatively cheaper, accounting for one-quarter of quantities and one-eighth of expenditures. Commercial power accounts for the remaining third of each. With approximately 90 million of the total 135 million residential customer accounts reported in these data, the typical monthly residential bill is about $110.

Consumption and prices of other fuels are reported to the EIA at a more aggregated level than electricity. Natural gas delivered to customers is reported separately by class and state on a monthly basis via Form EIA-857. Total gas expenditures are about one-third of those for electricity, with residential spending again representing nearly half of the total. Transportation fuels are reported as Prime Supplier sales by state and month on Form EIA-782C, with retail prices collected on Forms EIA-878, 888, and 782A. Retail gasoline accounts for roughly two-thirds of these expenditures. Separate consumption figures by customer class are not collected.

I use meteorological data from ERA5 (European Centre for Medium-Range Weather Forecasts, 2019), which combines observational data and atmospheric models to provide a high-frequency, high-resolution 'reanalysis' of the global climate. I calculate heating and cooling degrees (distance from 18C) and downward shortwave radiation flux (i.e., sunlight) at the hourly level for each US county, and then use population weights to aggregate up to utilities based on service territories reported in Form EIA-861, "Annual Electric Power Industry Report," or states. These measures are then aggregated to the monthly level to merge with consumption data.

Data on non-essential business closures come from Chetty et al. (2020), who compile the dates of state-level policy interventions from the New York Times and other sources. As documented in Goolsbee et al. (2020), state-level measures may miss local interventions, but more granular data are not readily available beyond the initial spring shutdowns. The Chetty et al. (2020) data cover the second wave of shutdowns later in 2020. In any case, the two measures are are highly correlated.

The share of the labor force that may be able to work from home is drawn from Dingel and Neiman (2020), who find that 37% of jobs could plausibly be conducted remotely based on surveys of occupation characteristics. The Dingel-Neiman data are reported by the census' core-based statistical areas (CBSAs). These are cross-walked to US counties and weighted by population up to utility service areas within states using Form EIA-861 as above with other county-level data. The measures of Dingel and Neiman (2020) are highly correlated with the state-level estimates the U.S. Census began collecting in July 2020 with its Household Pulse Survey. Results are generally invariant to the source of WFH intensity.

Hourly residential electricity consumption data come from Innowatts, a Houston-based utility analytics company. These data are derived from smart meters, and aggregated up to the hourly level for residential customers within the footprint of Texas' asynchronous electrical grid (ERCOT). These are proprietary data, obtained under a nondisclosure agreement with the company. Combined commercial and industrial hourly consumption is calculated by subtracting residential consumption from publicly-available hourly total system load data from ERCOT. These data cover from 2019-May 2020, so I focus on the months with two years of coverage.

[4] A relatively small amount of electricity is also reported in an "Other" category, and represents public lighting and transportation, railroads, and irrigation. It is omitted from the analysis.

## 3. Methods

### Monthly analysis

The monthly analysis is based on a panel of bundled U.S. utilities for electricity, and states otherwise. There is vast dispersion in the size of the electric utilities, from Florida Power & Light's 4.4M customers to small local cooperatives in the Dakotas serving 5,500. I estimate equations in logarithms and weight by 2019 quantities delivered. The meteorological data is collapsed from hourly to the monthly level, tabulating the total number of heating and cooling degree-hours that occurred in territory $i$ in month $m$, year $y$ ($heating_{imy} = \sum_{t \in my} heating_{it}$, for example).[5]

There is a minor complication in the analysis of residential electricity usage due to the explosive growth of distributed rooftop solar since 2016. This introduces a time-varying sensitivity of metered residential consumption to monthly sunlight ($flux_{imy}$). This can be accounted for by interacting $flux_{imy}$ with the capacity of rooftop solar. In areas with relatively little solar, however, this ends up fitting spurious, highly variable trends with the monthly data. This has little impact on the overall estimates, but widens the dispersion of the utility-specific measures. I therefore only include the $flux_{imy}$ measure for utilities with at least 500MW of distributed solar by 2019.

I estimate equations of the form

$$Log(Load_{imy}) = pandemic_{my}(\tau + X_{imy}\gamma) + X_{imy}\beta + \mu_m + \Gamma_i + u_{imy} \tag{1}$$

where $pandemic_{my}$ is an indicator that is one during Q2-Q4 2020, and $\mu_m$ and $\Gamma_i$ are month-of-year and territory fixed effects, respectively. Some specifications estimate utility- or state-specific month-of-year fixed effects and meteorological influences. $X_{imy}$ is a vector of heating degrees, cooling degrees, and solar flux to account for heating and cooling demand, as well as behind-the-meter rooftop solar panels. A separate slope for meteorological controls during the pandemic, $\gamma$, measures the extent to which heating and cooling became more/less energy intensive during the pandemic. The estimated total change in energy consumption is therefore the level shift, $\hat{\tau}$, plus the change in energy intensity during the pandemic, evaluated at the means during the pandemic, $\bar{X}_{post}\hat{\gamma}$. To avoid fitting spurious trends, meteorological controls are not included in the analysis of transportation fuel usage.

### Hourly analysis

I use hourly data to track changing patterns in electricity consumption over the day and week in Texas. I estimate equations separately by customer class of the form

$$Load_t = \tau_{hdy} + pandemic_t * X_t\gamma_h + X_t\beta_h + u_t \tag{2}$$

Each $\tau_{hdy}$ is a dummy variable for an hour of the week (hour $h$ and day of week $d$ of year $y$) in either 2019 or 2020, starting with midnight on Sunday. The sample is a time series from April and May (or January and February for comparison). $X_t$ is also a vector of heating degrees, cooling degrees, and solar flux to account for heating and cooling demand, as well as behind-the-meter rooftop solar panels. I include hour-of-day-specific controls for each variable. The interaction of these temperature controls with an indicator for the pandemic measures the change in electricity sensitivity during the pandemic in order to separate out how much of the change is coming from heating and cooling. When the $\hat{\tau}_{hdy}$ are plotted against hour of week, they trace out the mean weather-adjusted electricity consumption during the period in question. However, part of the change in electricity consumption may

[5] A heating-degree in hour $t$ is defined as the number of degrees the ambient temperature is below $18^oC$: $\max\{18 - temperature_{it}, 0\}$. It is defined analogously for cooling degrees when the ambient temperature exceeds $18^oC$.

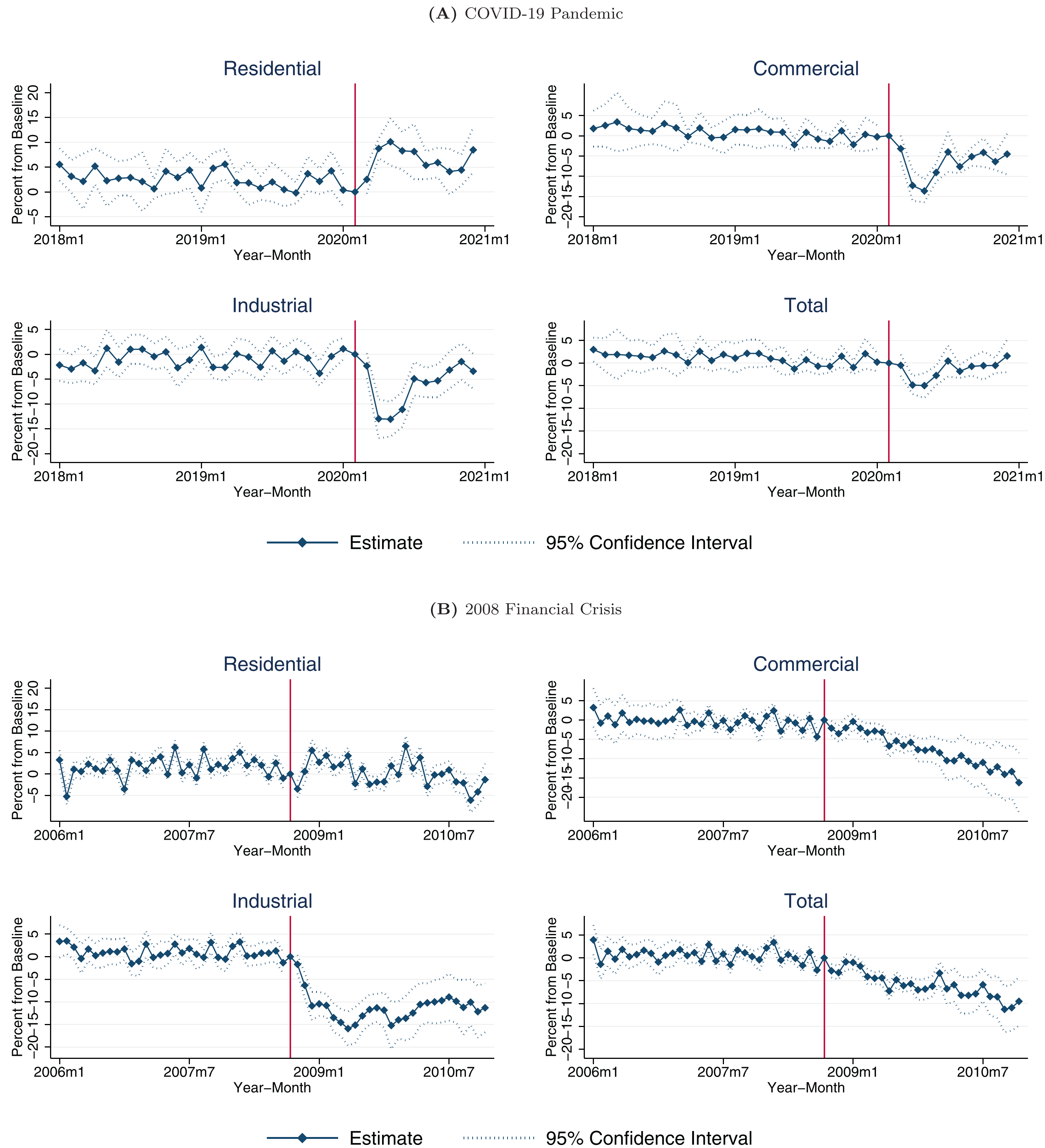



**Fig. 2.** Electricity Consumption During Crises by Customer Class. Note: Estimates are based on specification (5) of Table (1), which include utility-month-of-year fixed effects and utility-specific meteorological controls.

be in the responsiveness to temperature, so a temperature adjustment estimated during the pandemic may mask some of the change of interest. The full impact of the pandemic on consumption is calculated as $\hat{\tau}_{hdy} + \bar{X}_h \hat{\gamma}_h$. This is the mean weather-adjusted hourly consumption, plus the amount of consumption due to a change in the electricity intensity of heating and cooling, thereby applying pre-pandemic temperature adjustments.

## 4. Results

### *Monthly data from U.S. utilities*

Fig. 2 (a) plots the evolution of weather-adjusted electricity consumption for U.S. utilities by customer class relative to February, 2020. These figures expand upon the specification of column (5) of Table 1,

**Table 2**
Heterogeneity in $Log$(Electricity Consumption) Changes by Customer Class.

| | (1) Residential | (2) Commercial | (3) Industrial | (4) Total |
|---|---|---|---|---|
| 2020 Q2-Q4 | 0.078*** | −0.057*** | −0.105*** | −0.012 |
| | (0.018) | (0.021) | (0.015) | (0.015) |
| x Percent Work from Home x Hot Climate | 0.004*** | 0.000 | −0.005 | 0.002 |
| | (0.001) | (0.003) | (0.005) | (0.002) |
| x Percent Work from Home x Mild Climate | 0.002** | 0.003 | 0.006 | 0.005*** |
| | (0.001) | (0.002) | (0.005) | (0.001) |
| x Percent Work from Home x Cold Climate | 0.001 | −0.003 | 0.002 | 0.002 |
| | (0.001) | (0.002) | (0.006) | (0.003) |
| x Percent Unemployed | 0.004*** | −0.007*** | −0.017*** | −0.003** |
| | (0.001) | (0.001) | (0.003) | (0.001) |
| x Non-essential Business Closed | 0.007 | −0.039** | 0.042** | 0.001 |
| | (0.007) | (0.017) | (0.017) | (0.008) |
| Clusters | 315 | 294 | 280 | 361 |
| $R^2$ | 0.998 | 0.997 | 0.990 | 0.998 |
| Obs. | 18,491 | 17,331 | 16,352 | 21,017 |

Note: All specifications include utility-month-of-year fixed effects and utility-specific weather controls. The percent of workers unemployed and potentially working from home have been normalized to be mean zero for each month of the sample. Utilities lacking work from home estimates are omitted. Standard errors clustered by utility in parentheses. * p<0.1, ** p<0.05, *** p<0.01

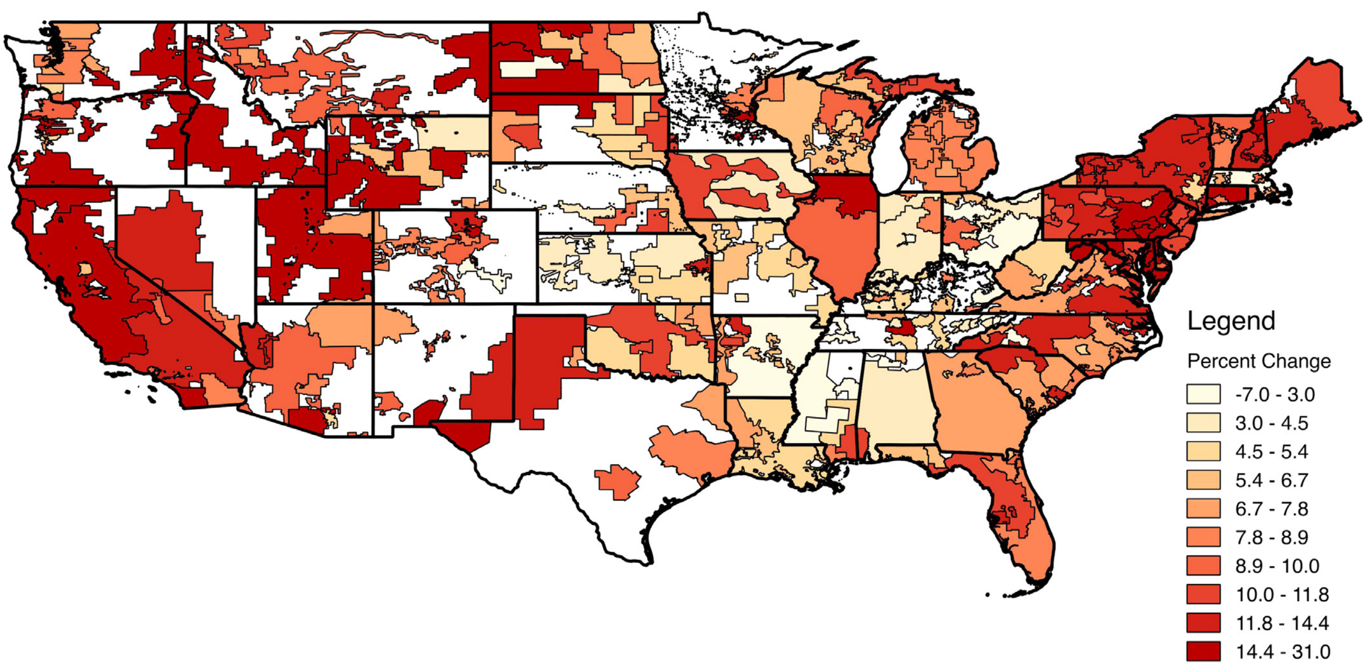



**Fig. 3.** Residential Electricity Consumption Anomaly in Percent: April-July, 2020. Note: Estimates report the interaction of utility dummies with a post-April, 2020 indicator from a pooled regression with utility-specific month-of-year and meteorological controls. Colors correspond to deciles of the distribution of utility-level estimates. White space on the map represents utilities that were not regular reporters in EIA-861M.

which presents the average change in consumption for Q2-Q4 of 2020 relative to February 2020.[6] The specification includes utility-month-of-year fixed effects and utility-specific meteorological controls, but estimates month-of-sample coefficients relative to February, 2020, so that the exact specification is:

$$Log(Load_{imy}) = \tau_{my} + X_{imy}\beta_i + \Gamma_{im} + u_{imy}$$

The small annual declines in electricity consumption since the Great Recession are barely perceptible in these figures. Instead, the months of the pandemic in 2020 stand out for their significant and unprecedented departures from recent consumption patterns. While there were substantial increases in commercial and industrial consumption in July 2020, residential consumption remained elevated, creating the impression that aggregate consumption was back to normal. This dynamic was not isolated to the depths of the spring lockdowns: even as the economy reopened in the summer and early fall, individual customer classes were 5–10% away from normal—though aggregates appeared nominal. Real GDP was about 3% lower in Q3-2020 than Q3-2019, meaning that the energy intensity of the economy was relatively *higher* than the prior year.

As summarized in Table 1, in Q2-Q4 2020 there was a 7.9% increase in residential consumption, a 6.9% decrease in commercial consumption, and an 8.0% reduction in industrial electricity usage. Regressing the total consumption across all sectors on the same controls, one finds a statistically insignificant 1% decline sustained over these nine

[6] The figures plot percent changes instead of logarithms, so the estimated coefficients are transformed by $100 * (e^{\hat{\tau}} - 1)$.

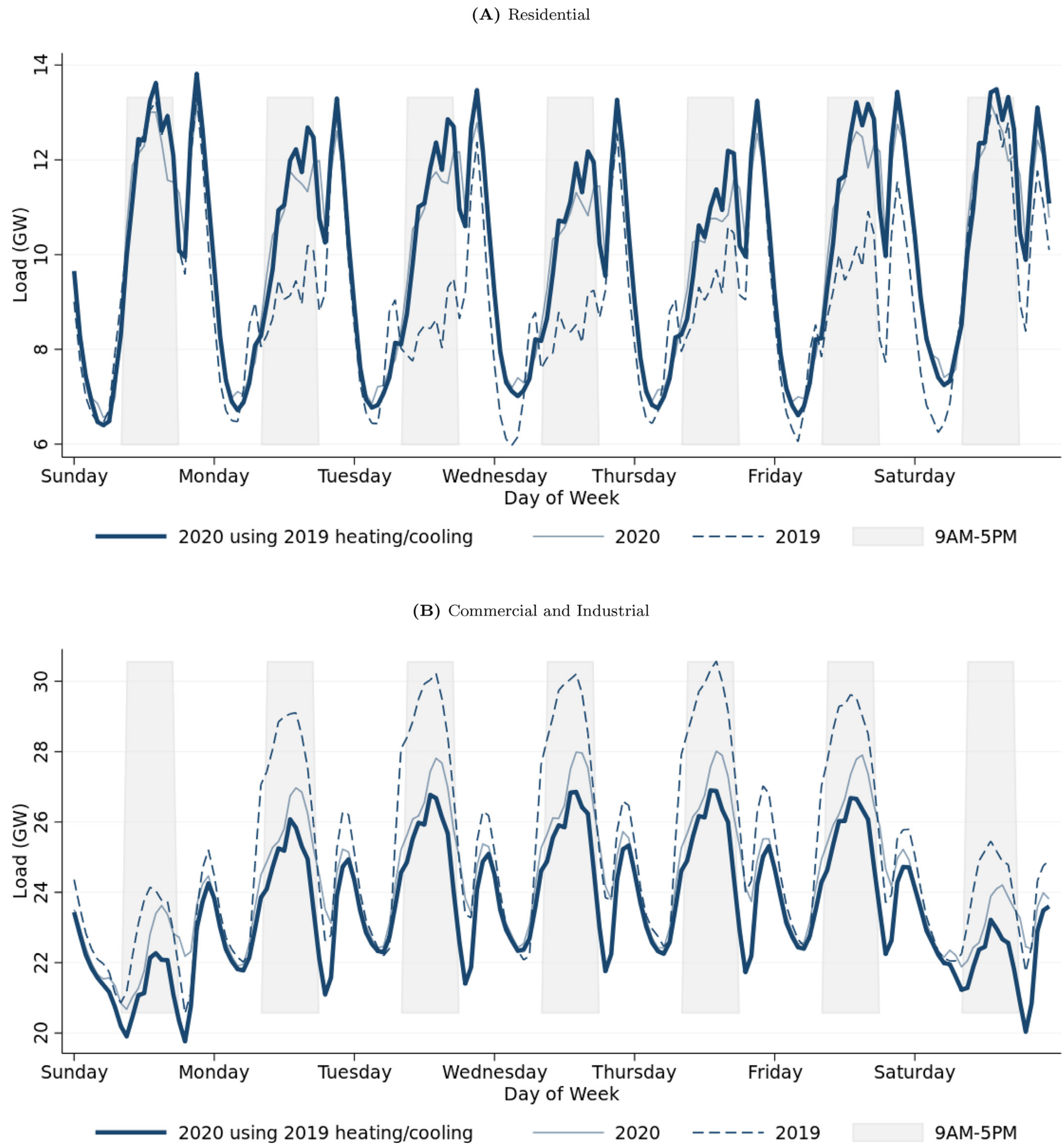



**Fig. 4.** Temperature-Adjusted Electricity Consumption in Texas by Customer Class: April/May, 2020 versus 2019.

months. Table 1 shows that these results are relatively stable across various specifications, even when only including month of year fixed effects (Column 1). Nearly all of the variation in monthly electricity consumption is accounted for with month-of-year and utility fixed effects.

Analogous results for natural gas and transportation fuels are presented in the Appendix, Figs. A.2 and A.3, as well as Tables A.2 and A.3. The patterns for natural gas parallel those of electricity, with residential consumption up over 4%, while commercial and residential use was down 6–7%. Transportation is not broken down by class of user, but as a whole reflects stark declines in usage: gasoline consumption was down 15%, diesel was down 5%, and jet fuel fell a whopping 46%. Weighted by volume, this amounts to a 14.4% reduction in transportation fuel use.[7]

[7] Consumption of gasoline, diesel, and jet fuel in the US in 2019 was 3.4B, 1.5B and 0.44B barrels, respectively. (EIA Product Supplied series and Bureau of Transportation Statistics).

Are these changes in energy usage normal for a fast-moving economic crisis? To contrast with the results during COVID-19, in panel (b) of Fig. 2 I present the analogous results for the time surrounding the financial crisis of 2008. The plots are normalized to September 2008 (i.e., the bankruptcy of Lehman Brothers). Industrial production responded quite swiftly during the financial crisis, falling 10–15% within a couple of months of the initial shock. On the other hand, reductions in commercial consumption accumulated much more gradually, not reaching -10% until over a year after the crisis began.

It is interesting that the magnitudes of the commercial and industrial shocks are similar to that of COVID-19, even if on a different time scale—because the similarities end there. In contrast to the sharp increase in residential usage during the COVID-19 pandemic, it is difficult to discern any significant change in residential usage from the noise during the 2008 financial crisis. This difference highlights the unique nature of the COVID-19 shock: it is not the case that increased unemployment during the Great Recession was associated with a significant rise in residential electricity consumption. Instead, it appears that a significant amount of activity has shifted towards homes during the pandemic, even as aggregate economic activity has declined.

There have, of course, been significant differences in experience across jurisdictions during the COVID-19 pandemic. To get a better sense of the heterogeneity in how consumers have been affected, Fig. 3 maps the results by utility by interacting utility indicators with a post-April 2020 dummy in a pooled regression with utility-specific month-of-year and meteorological controls. Parts of California, Connecticut and Pennsylvania saw some of the largest residential electricity growth overall, with 20–30% increases sustained over nine months. While nearly all utilities saw residential consumption increases of some form,[8] the smallest increases occurred through Appalachia and South-Central states.

To explore potential determinants of this heterogeneity, I build on the specification of Table 1, column (5), and interact measures of potential explanations with the indicator for the pandemic quarters of 2020. Both WFH and unemployment variables are in percents, and have been normalized to have zero mean during the pandemic. This means the main coefficient on Q2-Q4 2020 can be interpreted as the average change in electricity consumption without mandatory business closures for a workforce composition at the national average over the course of the pandemic.

The interaction terms correlate the intensity of electricity consumption changes during Q2-Q4 2020 with both cross-sectional characteristics of utilities and within-utility variation in unemployment and business closures. Each of the presented measures is likely correlated with other potential determinants of electricity consumption changes, so a fair amount of caution is warranted before making causal interpretations. The results are, however, informative for understanding where the changes in energy consumption have been largest.

The results for electricity are presented by customer class in Table 2. A larger share of the workforce potentially working from home is associated with greater increases in residential consumption, but these increases are especially concentrated in warmer climates. In the warmest third of utility service areas (roughly 100 territories), a 10% increase in WFH is associated with 4% higher residential consumption. Such a change in working from home is about the difference between the national average and the most (or least) WFH-intensive metro areas (Dingel and Neiman, 2020). This implies that residential consumption rose by 50% more than the national average in warm, high WFH areas such as Austin, TX, and Durham, NC. It was about 25% higher in mild climate, high WFH areas such as Washington, DC.[9] The association of WFH with electricity consumption is noisier for commercial and industrial consumption, with no clear pattern across climates and no estimates significantly different from zero at conventional levels. This suggests that even as many workers were remote, commercial and industrial heating and cooling patterns were not systematically affected in a way that this analysis can detect. This would be consistent with an open business having relatively fixed HVAC costs, so reduced capacity at offices does not meaningfully save on such expenditures.

That said, areas that experienced larger unemployment shocks and non-essential business closures did see large reductions in commercial electricity consumption. Industrial consumption appears to have been insulated from non-essential business closures. National unemployment rose approximately 10% between February and April 2020, and had recovered to 3% above pre-pandemic levels by December 2020 on a seasonally-adjusted basis. In other words, unemployment at its peak was associated with as large an increase in residential consumption as the amount maintained in warm, high WFH areas throughout the pandemic. That said, these coefficients are using different sources of variation—the WFH measure is time-invariant—so other time-varying determinants of electricity consumption may be loading on unemployment and business closures.

Analogous results for other fuels are presented in Appendix Table A.4. Unemployment stands out as the most pervasive correlate of natural gas and transportation consumption changes. As one might expect, greater WFH is associated with additional reductions in transportation fuel consumption. It does not appear that residential gas consumption was higher in colder climates with more WFH, but perhaps ending the panel in December 2020 limits the amount of post-pandemic winter heating in the data.

At prevailing prices (which were within 2% of normal on average during Q2-Q4 2020), increased residential electricity consumption cost U.S. households about $12B, or $1.5B/month.[10] With 137M total residential accounts in the United States, this translates to about $88/household. Fig. A.6 in the appendix presents the expenditure analog of Fig. 3, mapping the heterogeneity in residential expenditures. The expenditure pattern closely follows the change in quantities. Utilities with high prices (in California and New England) are also those with large increases in residential usage, driving expenditure increases that approach $250 per household over these nine months. One fifth of the population is serviced by a utility whose mean residential expenditure was at least $130 per customer.

Against this rise in residential expenditures, there have been significant reductions in commercial and industrial usage. Over Q2-Q4 2020, there was about $9B less spent on commercial, and $4B less spent on industrial grid power. While aggregate consumption may have fallen by 1%, the fact that per-unit rates are higher for residential customers means that overall finances for utilities were basically a wash–roughly $1B in lower revenues, or about $-0.5\%$.

In the broader context of energy consumption, it makes more sense to evaluate changes in use at 2019 prices, as the significant swings in natural gas and transportation fuels do not really inform changes in usage patterns outside of the unusual pricing patterns during the pandemic.[11] One could alternatively use an entirely quantity-based measure of energy usage, but one would have to make decisions on the conversion factors across fuels to account for the share of heat lost in the production of usable energy. An alternative metric is in terms of carbon emissions. In aggregate, the EPA estimates emissions by use as follows: 25%

[8] The exceptions include the Cleveland Electric Illuminating Company and Duke Energy of Ohio, and the Cities of Tupelo, MS and Independence, MO.

[9] Results are similar if one were to estimate separate coefficients based on terciles of cooling degrees rather than mean annual temperature.

[10] For this calculation I use the utility-specific estimates of Fig. 3 to calculate changes in quantities, and apply prices observed in each utility to calculate the total change in expenditure.

[11] For example, the abrupt fall in oil demand at the start of the pandemic outstripped the inertia of supply, so that prices for West Texas Intermediate turned negative in April 2020. Again, there were not meaningful changes in electricity prices, so using 2019 versus 2020 prices for electricity is not materially important.

in electricity, 27% in transportation, and 37% in gas heating/industrial use. Assuming the remaining 11% from agriculture were unaffected, my estimates imply a 4.9% reduction in emissions overall.

Using prices to make conversions between fuel types facilitates comparisons with economic activity directly. The shift toward (higher priced) residential usage for natural gas helped offset the declines in commercial and industrial revenue, so overall expenditures were about \$1.6B lower over three quarters of 2020, or about 2%. The reductions in transportation fuels were worth about \$40.1B, \$4.5B, and \$16.7B for gasoline, diesel, and jet fuel, respectively. This represents a 16% reduction in transportation fuel expenditure overall, so the total fall in energy usage from Q2-Q4 of 2020 was about 8% relative to Q2-Q4 of 2019. Real GDP was about 5% lower than 2019 over this period, so that the real energy intensity of the economy declined during the COVID-19 pandemic. That said, this relative reduction is modest in the context of the historical decline that has been underway for some time. The shift away from transportation was accompanied by a relative increase in the energy intensity of buildings, as the reduction in economic activity was substantially larger than the marginal decline in electricity and gas consumption of residences, businesses, and factories. Within buildings, residential electricity and natural gas consumption rose in absolute terms by about \$13B.

*Hourly data from texas*

We now turn toward results based on hourly electricity consumption data, which reveal intra-day changes in usage patterns. Fig. 4 shows how electricity consumption over the week has changed dramatically during the COVID-19 pandemic. The dashed lines represent mean temperature-adjusted consumption for April and May of 2019, $\tau_{hd2019}$ from equation (2). The thin solid lines represent the estimates of $\tau_{hd2020}$ from Eq. (2), which is analogous to the dashed line, similarly adjusted for heating and cooling. The potential change in heating/cooling intensity during the pandemic is part of the treatment effect, so the total quantity of interest is $\tau_{hd2020} + \bar{X}_h\gamma_h$. Estimates of these parameters are represented by the thick solid lines in Fig. 4. This additional adjustment accounts for the way that heating/cooling intensity has changed during the pandemic, and ensures that such changes are included as part of the total effect.

Focusing first on residential consumption, the dashed lines for 2019 indicate that residential consumption is usually quite different between weekdays and weekends during normal times. People tend to be home during the day on weekends, and this presence is reflected in higher midday consumption on the first and last days of the week. During the work week in normal times there is a sharp uptick in the mornings as people get up, a minor drop off as many leave the house for work, followed by relatively stable levels until people return home in the evening, when consumption peaks. The peaks on Friday and Saturday evenings are smaller than other days of the week, reflecting the tendency to go out on these nights.

During the COVID-19 pandemic, in the prescient words of Morrissey and Street (1988), Everyday Is Like Sunday. The morning upticks at 7AM are gone, with residential consumption almost 2GW lower as the day begins an hour or so later. With everyone home, midday residential electricity during the work week is 3–4 GW higher than normal, with distinct peaks at 1PM, 5PM, and 9PM. Friday and Saturday evening peaks are no lower than other days of the week, as days of the week become effectively indistinguishable.

Fig. A.5 undertakes the same exercise for January and February, showing that 2019 and 2020 had essentially the same patterns pre-pandemic, though consumption was slightly lower in 2020. This suggests a difference-in-difference estimation to account for the year-to-year changes: compare the spring-winter change in 2020 to that of 2019. The results for this estimation using the natural logarithm of consumption as the dependent variable is presented in Table A.5. It finds a roughly 8% increase in residential consumption when averaged over all hours, with increases during work hours of over 17%. Interestingly, a change in heating/cooling intensity appears to have played a modest role—though the data do not include the main summer cooling season. On average over all hours, there was a 1.25GW increase based on the double-difference estimates. This translates to about \$110M in additional monthly expenditures.[12]

Commercial and industrial electricity consumption during normal times reflects the work week: it is sharply higher Monday-Friday, 9AM-5PM. There is typically a second, smaller peak in the evening. While the daytime and evening peaks continue during the pandemic, they have been significantly muted with reduced activity in these sectors. In addition, it appears that reduced heating/cooling played a modest role in further lowering the mid-afternoon peaks of consumption.

Again, Fig. A.5 shows that January and February 2020 were unremarkable compared to 2019, though consumption was somewhat higher in 2020 across all hours of the week. Panel B of A.5 presents the difference-in-difference estimates for non-residential consumption, finding an 11% reduction overall, which translates to about 3GW and \$150M in reduced electricity expenditures per month. Offsetting the work-hour rise in residential consumption, business-hour load was down over 15% for commercial and industrial customers.

## 5. Conclusion

This paper estimates changes in residential, commercial, and industrial energy consumption during the COVID-19 pandemic. Using hourly data from Texas, I find significant disruptions to patterns of daily life as workplaces closed and more time was spent at home. These changes in daily rhythms are reflected in monthly data from utilities around the country, with residential electricity consumption rising by 7.9% on average, and commercial and industrial consumption falling by 6.9% and 8.0%, respectively, during Q2-Q4 2020. The rise in residential electricity consumption means that households spent nearly \$12B on excess electricity during this 9 month period.

There were an additional \$1B in excess residential natural gas expenditures, which worked to offset the larger reductions in use from commercial and industrial customers. The shift toward residential usage meant that energy usage of residences, businesses, and factories fell by only 1%, while economic output fell by 5%. Against this increase in the energy intensity of buildings was a significant fall in energy use for transportation. Evaluated at 2019 prices, I find a combined 16% reduction in expenditures on gasoline, diesel, and jet fuel. Together with electricity and natural gas, this yields an 8% reduction in energy use from Q2-Q4 2020.

Both businesses and workers are anticipating WFH to become a more common configuration in the labor market after the pandemic (Bartik et al., 2020; Barrero et al., 2021). This paper finds that WFH is associated with an increased energy intensity of buildings as use shifts to less efficient residences from the structures in which workers normally congregate. This higher intensity, coupled with an economic recovery, implies a net rise in electricity and natural gas consumption in a robust economy with more prevalent WFH. In other words, a hybrid work posture is likely to raise electricity and heating demand on net, especially to the extent that workplace energy usage reflects operating hours rather than occupancy.

While energy use in buildings has shifted to homes, there has been a drop in transportation fuel consumption. In addition to time and fuel savings from less commuting, there are likely to be net environmental benefits from reduced transportation (Cicala et al., 2021; Gillingham et al., 2020). So long as internal combustion engines dominate transportation, the environmental impacts of WFH are analogous to those of electrification, ultimately substituting from internal combustion engines

[12] The mean residential price in Texas is \$0.12/kWh. The mean price for commercial and industrial power in 2019 was \$0.07/kWh.

toward power plants (Holland et al. (2020). When calculating this substitution in the early days of the pandemic, Cicala et al. (2021) found significant reductions in mortality from reduced transportation-related local pollutants.

While this is a first step in estimating the short-term shifts in energy consumption under WFH, there are potential adjustment margins that might dominate in the longer-run if WFH becomes a permanent feature of the labor market. More time at home should raise the demand for residential space, reducing density and further increasing home energy use (Glaeser and Kahn, 2010; Glaeser, 2011). Fewer days commuting may make workers more willing to travel farther on their office-based days, dampening the overall reduction in transportation fuel use. Greater residential electricity consumption may accelerate the adoption of distributed solar in order to take advantage of favorable rates for owners of rooftop systems. These topics are suggested for future research.

## Appendix

**Table A.1**
Annual Energy Expenditures by Fuel and Customer Class (Billions USD).

| | 2019 | 2020 at 2019 Prices | 2020 |
|---|---|---|---|
| A. Electricity | | | |
| Residential | 185.8 | 190.3 | 191.6 |
| Commercial | 143.0 | 134.4 | 134.6 |
| Industrial | 63.9 | 62.0 | 60.2 |
| B. Transportation | | | |
| Gasoline | 349.2 | 305.5 | 257.8 |
| Diesel | 113.2 | 108.1 | 76.2 |
| Jet Fuel | 46.7 | 29.4 | 19.8 |
| C. Natural Gas | | | |
| Residential | 52.6 | 47.0 | 47.7 |
| Commercial | 27.8 | 23.5 | 23.3 |
| Industrial | 40.6 | 35.4 | 31.4 |
| Total | 1022.8 | 935.7 | 842.7 |

Note: All figures in billions of USD. Electricity totals include state-level adjustments that the Energy Infomation Administration calculates for utilities that do not report Form EIA-861M. Petroleum statistics come from forms EIA-782C, EIA-878, EIA-888, and EIA-782A.

**Table A.2**
Change in $Log$(Natural Gas Consumption) by Customer Class.

| A. Residential | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | 0.014 | 0.027* | 0.037*** | 0.046*** | 0.043*** |
| | (0.041) | (0.014) | (0.013) | (0.009) | (0.009) |
| State FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| State-Weather | | | | Yes | Yes |
| State-Month FE | | | | | Yes |
| Clusters | 49 | 49 | 49 | 49 | 49 |
| $R^2$ | 0.331 | 0.978 | 0.986 | 0.994 | 0.997 |
| Obs. | 2994 | 2994 | 2994 | 2994 | 2994 |
| B. Commercial | | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | –0.087** | –0.071*** | –0.077*** | –0.070*** | –0.071*** |
| | (0.037) | (0.013) | (0.010) | (0.010) | (0.009) |
| State FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| State-Weather | | | | Yes | Yes |
| State-Month FE | | | | | Yes |

(continued on next page)

**Table A.2** (*continued*)

| A. Residential | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | 0.014 | 0.027* | 0.037*** | 0.046*** | 0.043*** |
| | (0.041) | (0.014) | (0.013) | (0.009) | (0.009) |
| Clusters | 49 | 49 | 49 | 49 | 49 |
| $R^2$ | 0.236 | 0.967 | 0.985 | 0.994 | 0.996 |
| Obs. | 2995 | 2995 | 2995 | 2995 | 2995 |
| C. Industrial | | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| 2020 Q2-Q4 | –0.090** | –0.061*** | –0.064*** | –0.062*** | –0.065*** |
| | (0.045) | (0.009) | (0.009) | (0.012) | (0.012) |
| State FE | | Yes | Yes | Yes | |
| Weather | | | Yes | | |
| State-Weather | | | | Yes | Yes |
| State-Month FE | | | | | Yes |
| Clusters | 48 | 48 | 48 | 48 | 48 |
| $R^2$ | 0.008 | 0.993 | 0.994 | 0.997 | 0.998 |
| Obs. | 2900 | 2900 | 2900 | 2900 | 2900 |

Note: All specifications include month of year fixed effects. Column (3) controls for weather with single coefficients for heating and cooling degree hours. Columns (4) and (5) estimate state-specific coefficients for these controls. Standard errors clustered by state in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

**Table A.3**
Change in $Log$(Consumption) by Transportation Fuel.

| A. Gasoline | | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| 2020 Q2-Q4 | –0.160*** | –0.160*** | –0.158*** |
| | (0.013) | (0.013) | (0.012) |
| State FE | | Yes | |
| State-Month FE | | | Yes |
| Clusters | 49 | 49 | 49 |
| $R^2$ | 0.007 | 0.995 | 0.996 |
| Obs. | 3038 | 3038 | 3038 |
| B. Diesel | | | |
| | (1) | (2) | (3) |
| 2020 Q2-Q4 | –0.093** | –0.059* | –0.055* |
| | (0.045) | (0.034) | (0.033) |
| State FE | | Yes | |
| State-Month FE | | | Yes |
| Clusters | 40 | 40 | 40 |
| $R^2$ | 0.006 | 0.979 | 0.994 |
| Obs. | 2148 | 2148 | 2148 |
| C. Jet Fuel | | | |
| | (1) | (2) | (3) |
| 2020 Q2-Q4 | –0.630*** | –0.631*** | –0.625*** |
| | (0.058) | (0.055) | (0.056) |
| State FE | | Yes | |
| State-Month FE | | | Yes |
| Clusters | 48 | 48 | 48 |
| $R^2$ | 0.019 | 0.983 | 0.986 |
| Obs. | 2933 | 2933 | 2933 |

Note: All specifications include month of year fixed effects. Standard errors clustered by state in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

**Table A.4**
Heterogeneity in Energy Consumption Changes by Fuel and Customer Class.

| A. Natural Gas | | | |
|---|---|---|---|
| | (1) Residential | (2) Commercial | (3) Industrial |
| 2020 Q2-Q4 | 0.036*** | –0.074*** | –0.064*** |
| | (0.009) | (0.011) | (0.009) |
| x Percent Work from Home x Hot Climate | –0.003*** | –0.002 | –0.002 |
| | (0.001) | (0.002) | (0.003) |
| x Percent Work from Home x Mild Climate | 0.000 | 0.001 | 0.016 |
| | (0.003) | (0.005) | (0.010) |
| x Percent Work from Home x Cold Climate | –0.005 | –0.007** | –0.007 |
| | (0.003) | (0.003) | (0.004) |
| x Percent Unemployed | 0.006*** | –0.011*** | –0.009*** |
| | (0.001) | (0.002) | (0.003) |
| x Non-essential Business Closed | –0.002 | 0.028* | 0.007 |
| | (0.016) | (0.015) | (0.016) |
| Clusters | 49 | 49 | 48 |
| $R^2$ | 0.997 | 0.996 | 0.997 |
| Obs. | 2994 | 2995 | 2900 |

| B. Transportation | | | |
|---|---|---|---|
| | (1) Gasoline | (2) Diesel | (3) Jet Fuel |
| 2020 Q2-Q4 | –0.146*** | –0.062* | –0.680*** |
| | (0.008) | (0.035) | (0.060) |
| x Percent Work from Home | –0.005*** | –0.004 | –0.004 |
| | (0.002) | (0.005) | (0.019) |
| x Percent Unemployed | –0.020*** | –0.009** | –0.080*** |
| | (0.003) | (0.003) | (0.009) |
| x Non-essential Business Closed | –0.108*** | 0.003 | 0.034 |
| | (0.026) | (0.023) | (0.045) |
| Clusters | 51 | 40 | 50 |
| $R^2$ | 0.998 | 0.994 | 0.989 |
| Obs. | 3140 | 2148 | 3035 |

Note: All specifications include utility-month of year fixed effects and utility-specific weather controls. The percents of workers unemployed and potentially working from home have been normalized to be mean zero for each month of the sample. Utilities lacking work from home estimates are omitted. Standard errors clustered by utility in parentheses. * p<0.1, ** p<0.05, *** p<0.01

**Table A.5**
Texas Hourly Change in $Log$(Electricity Consumption) by Customer Class: Difference-in-Difference Estimates.

| A. Residential | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Apr/May 2020 | 0.116 | 0.082** | 0.119*** | |
| | (0.089) | (0.031) | (0.041) | |
| x Change in Heating/Cooling | | –0.008 | –0.039 | |
| | | (0.034) | (0.039) | |
| x M-F: 9AM-5PM | | | | 0.164*** |
| | | | | (0.044) |
| x Otherwise | | | | 0.043* |
| | | | | (0.023) |
| Weather | | Yes | | |
| Hour-Weather | | | Yes | Yes |
| Clusters | 34 | 34 | 34 | 34 |
| $R^2$ | 0.010 | 0.861 | 0.898 | 0.916 |
| Obs. | 1512 | 1512 | 1512 | 1107 |

| B. Non-Residential | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Apr/May 2020 | –0.115*** | –0.082*** | –0.069*** | |
| | (0.021) | (0.013) | (0.015) | |
| x Change in Heating/Cooling | | –0.035*** | –0.048*** | |
| | | (0.011) | (0.014) | |
| x M-F: 9AM-5PM | | | | –0.169*** |
| | | | | (0.012) |
| x Otherwise | | | | –0.094*** |
| | | | | (0.009) |
| Weather | | Yes | | |
| Hour-Weather | | | Yes | Yes |
| Clusters | 34 | 34 | 34 | 34 |
| $R^2$ | 0.599 | 0.747 | 0.812 | 0.869 |
| Obs. | 1512 | 1512 | 1512 | 1107 |

Note: All specifications include day of week, hour of day, year, and spring fixed effects. Column (2) controls for weather with single coefficients for heating and cooling degree hours, and a measure of solar radiation. Columns (4) and (5) estimate hour-specific coefficients for these controls. Column (5) includes an indicator for work hours and its interaction during the pandemic. Columns (2) through (5) estimate the change in heating, cooling, and solar radiation coefficients during the pandemic, and add these coefficients evaluated at the pandemic means to the main coefficients so they can be interpreted as controlling for pre-pandemic weather responses. Standard errors clustered by sample week in parentheses. * p<0.1, ** p<0.05, *** p<0.01

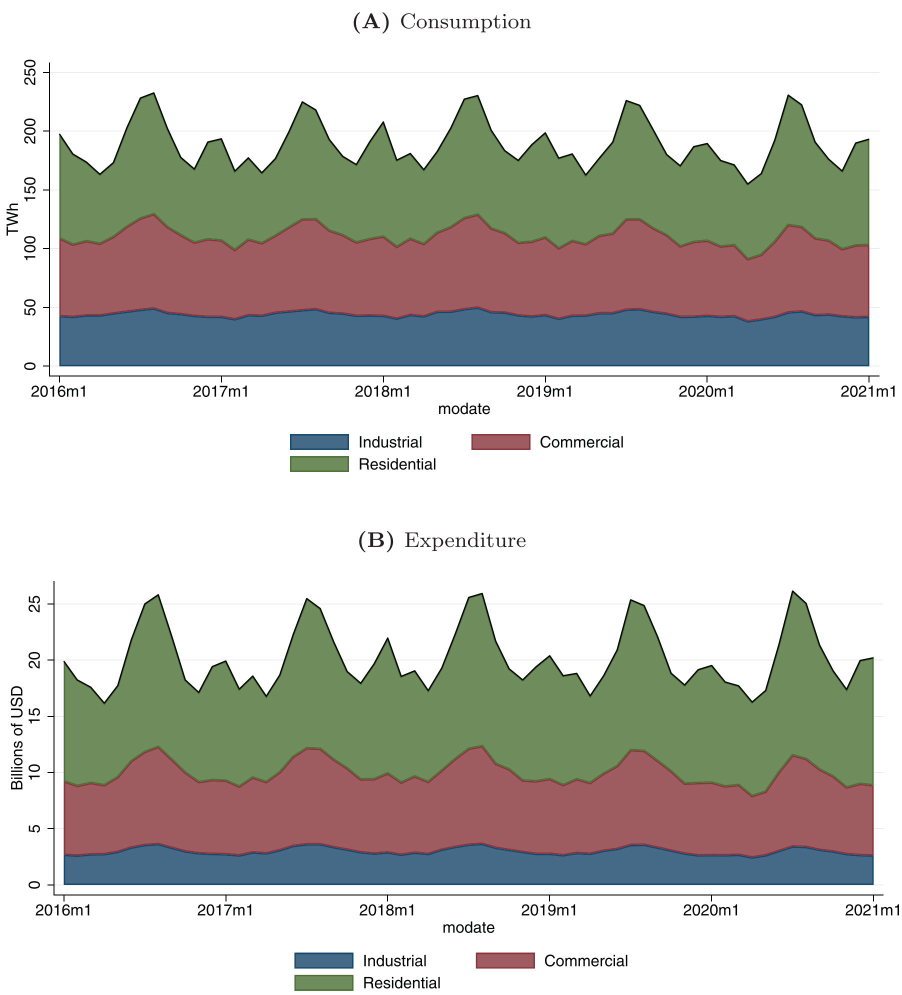
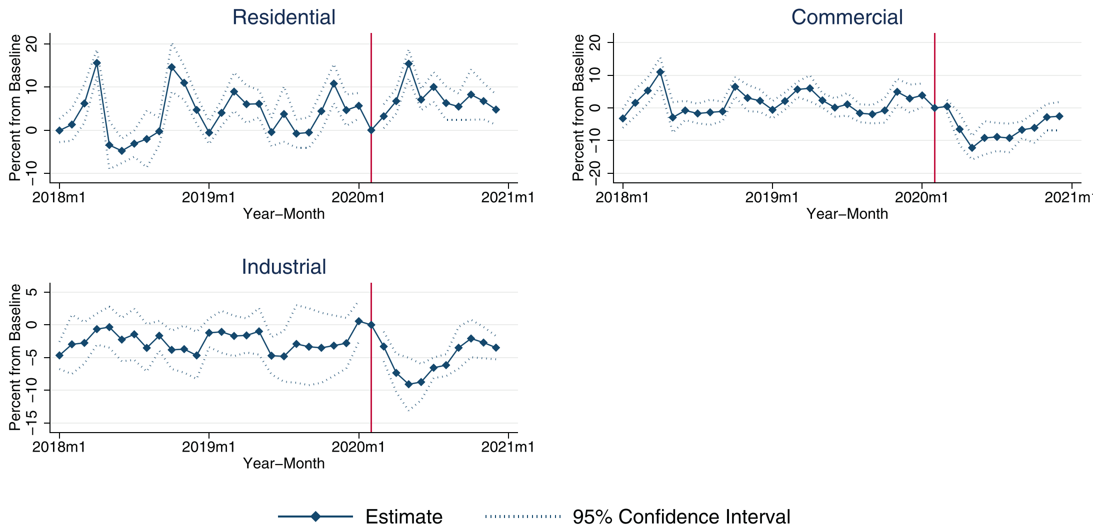



**Fig. A.1.** U.S. Monthly Electricity Consumption and Expenditures by Customer Class.

**(A)** COVID-19 Pandemic




**(B)** 2008 Financial Crisis

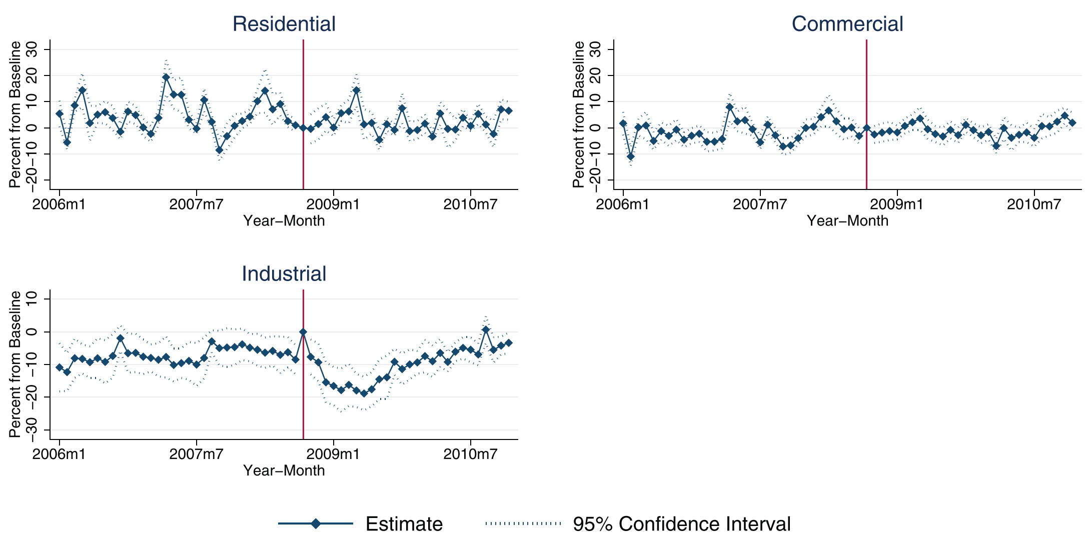



**Fig. A.2.** Natural Gas Consumption During Crises by Customer Class. Note: Estimates are based on specification (5) of Table (A.2), which include utility-month of year fixed effects and utility-specific meteorological controls.

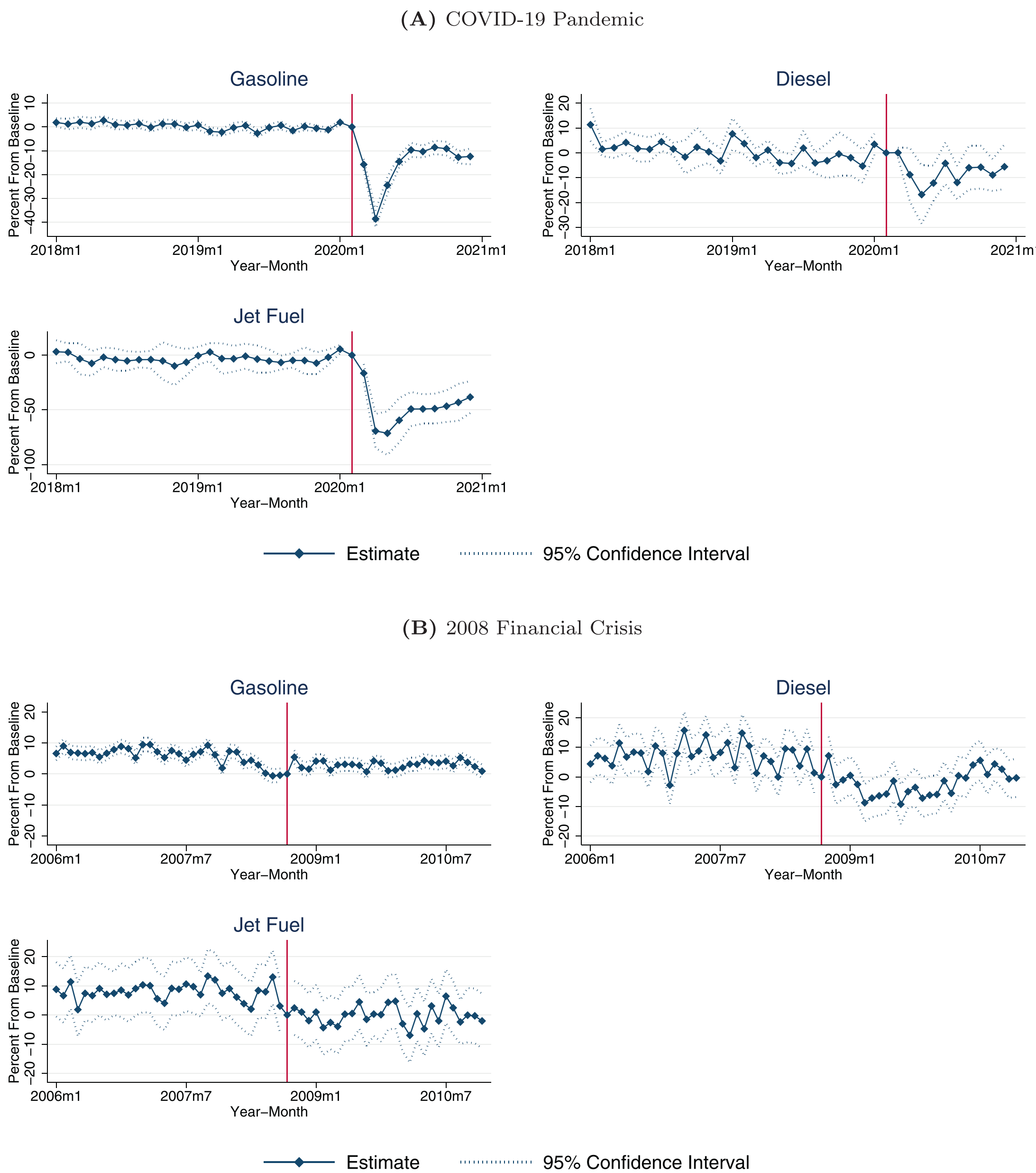
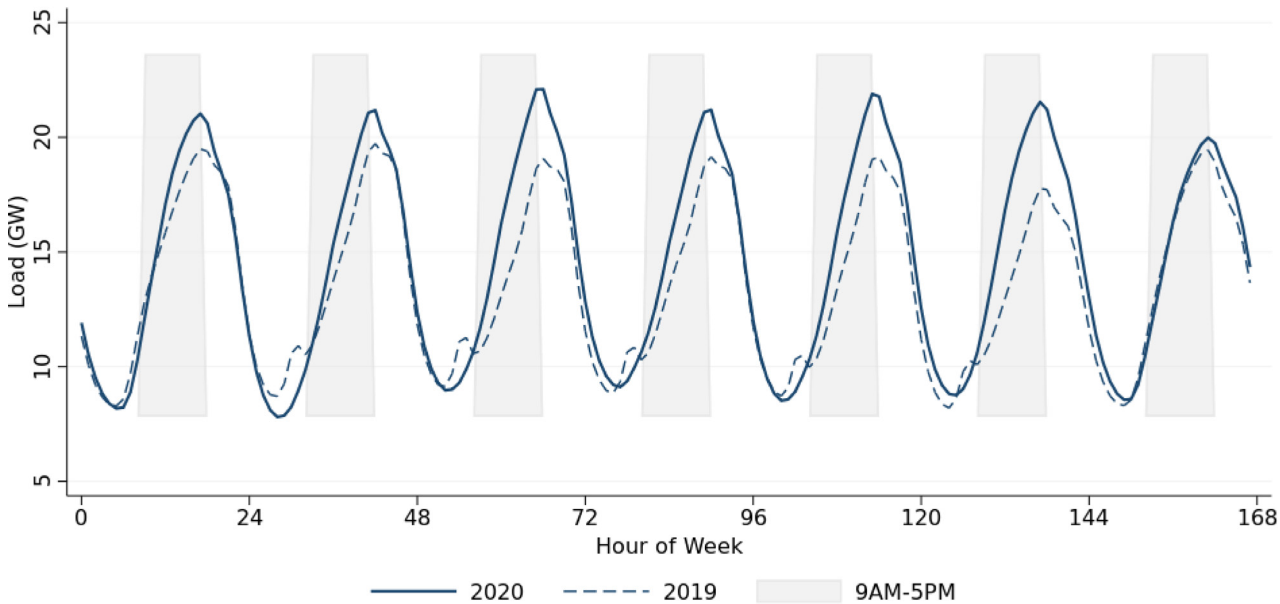



**Fig. A.3.** Transportation Fuel Consumption During Crises by Customer Class. Note: Estimates are based on specification (3) of Table (A.3), which include utility-month of year fixed effects and utility-specific meteorological controls.

**(A)** Residential




**(B)** Commercial and Industrial

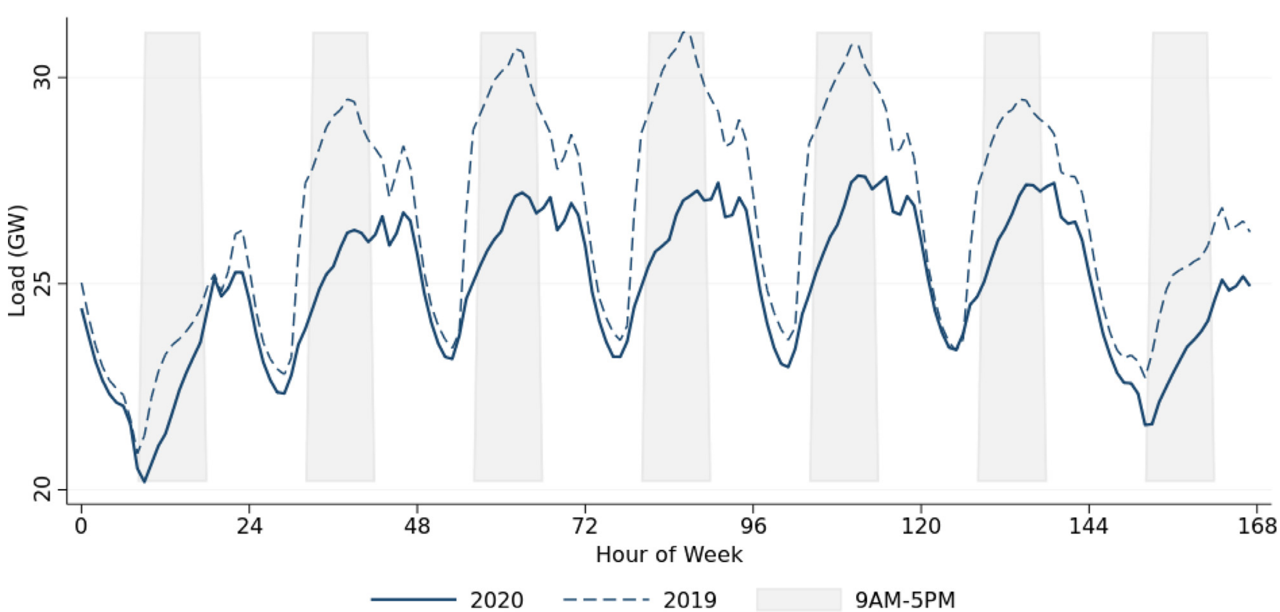
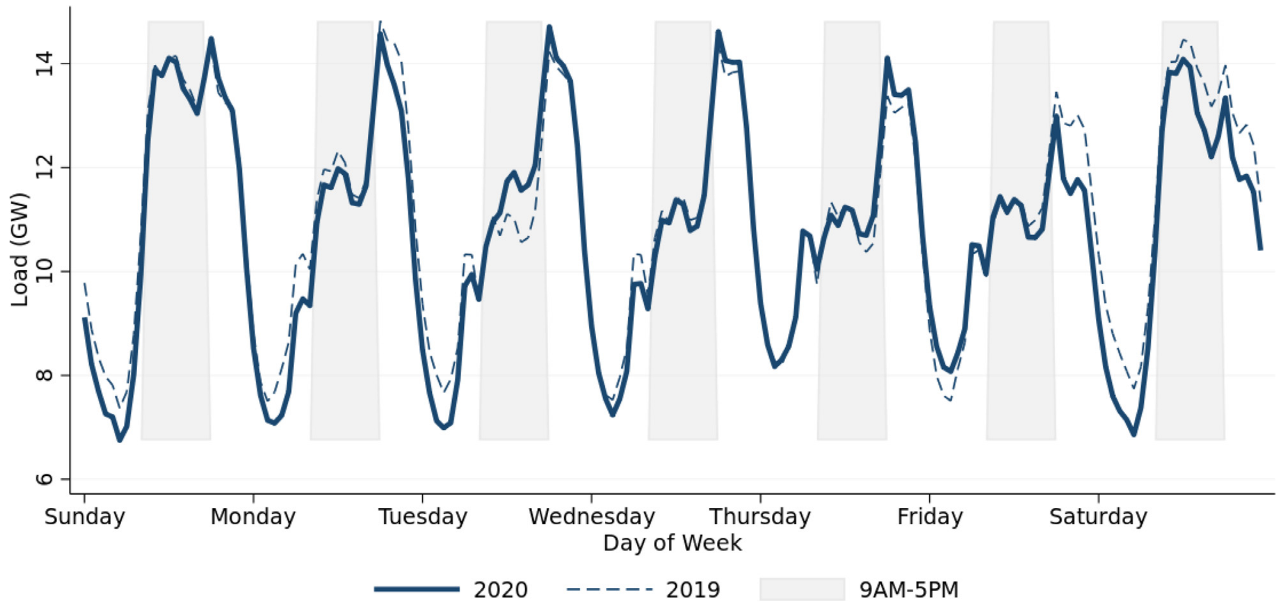



**Fig. A.4.** Raw Hourly Electricity Consumption in Texas by Customer Class: April/May, 2020 versus 2019.

**(A)** Residential




**(B)** Commercial and Industrial

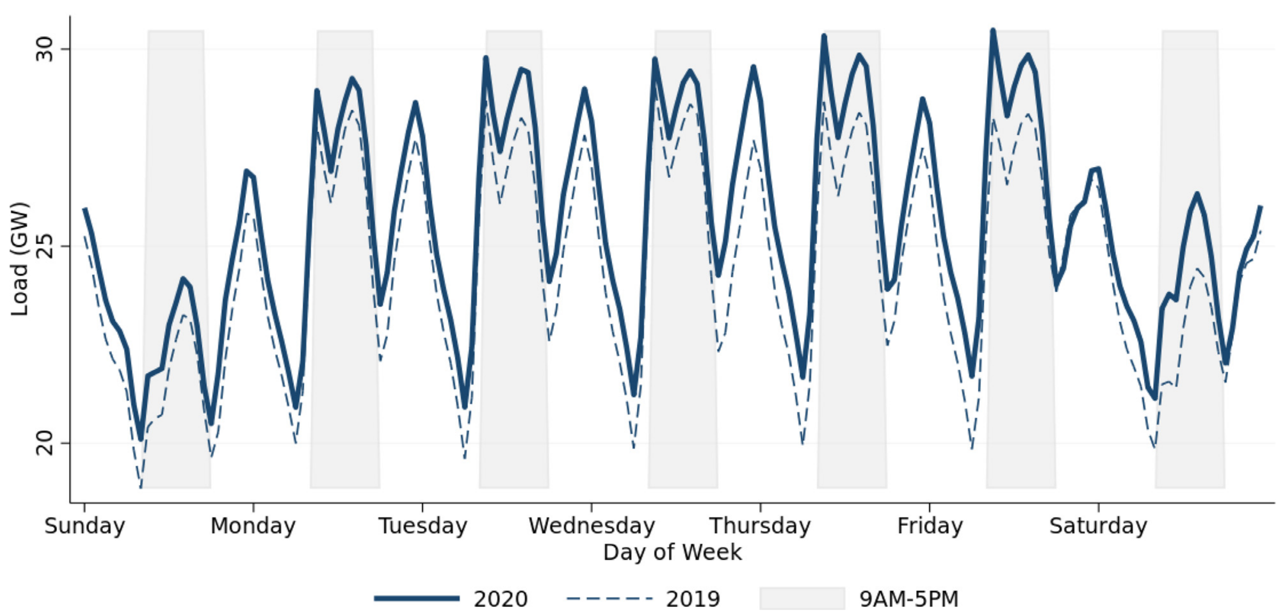



**Fig. A.5.** Temperature-Adjusted Electricity Consumption in Texas by Customer Class: January and February 2020 versus 2019.

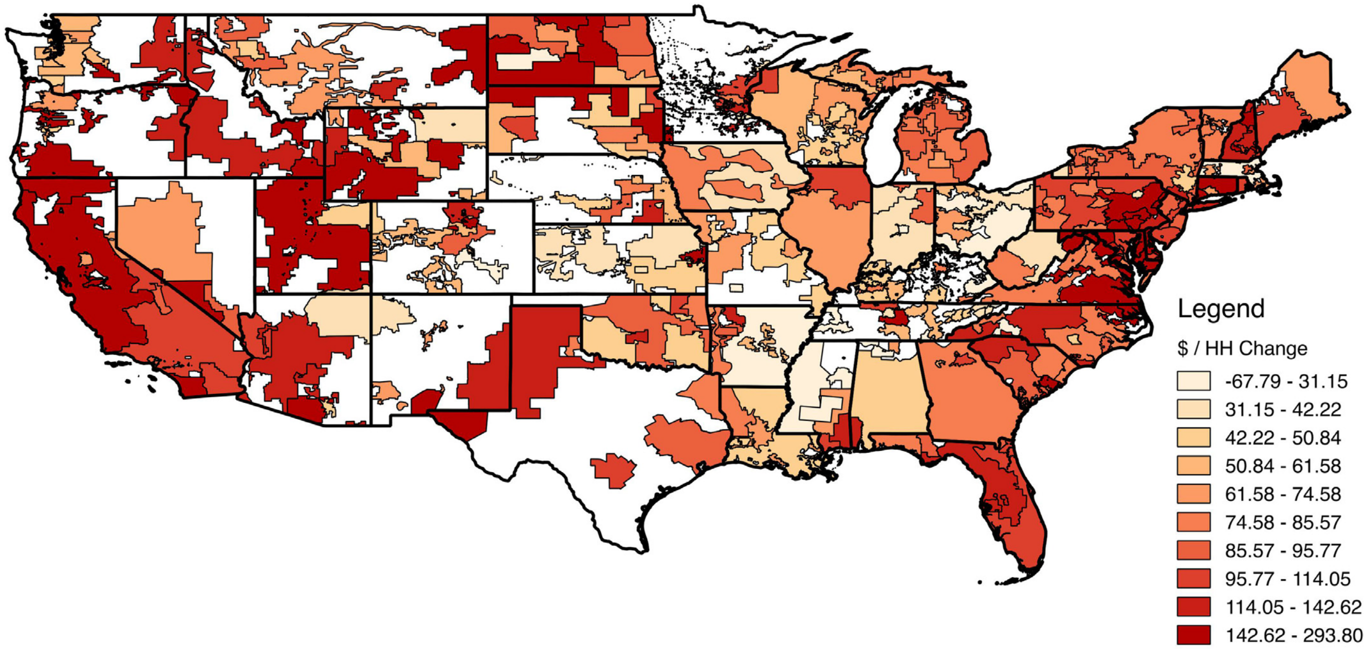



**Fig. A.6.** Residential Electricity Expenditure per Customer Anomaly: Q2-Q4 2020. Note: Quantity-based estimates from Fig. 3 are applied to observed quantities and prices to calculate excess expenditure. Colors correspond to deciles of the distribution of utility-level estimates. White space on the map represents utilities that were not regular reporters in EIA-861M.

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