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POLICY STUDY

CAN ELECTRICITY DEMAND HELP US MONITOR THE ECONOMY?

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PERC Policy Study 2202
July 2022

SUMMARY

The recent pandemic has emphasized the importance of high-frequency economic variables. Electricity consumption, particularly important as a production input, is one such variable. However, electricity consumption typically exhibits marked seasonal fluctuations, which mask the fluctuations that are interesting from a business cycle perspective. We show that after capturing the seasonal effects associated with weather and calendar events, electricity consumption can provide a rapid reflection of the state of the economy. This may be particularly valuable for measuring regional economic activity, where official statistics are slower to arrive.

ACKNOWLEDGEMENTS

Tatevik Sekhposyan is a Private Enterprise Research Center Fellow and an Associate Professor at Texas A&M University; Noah Kouchekinia is a Ph.D. student in Economics at the University of California at Irvine. Part of this work was completed when Tatevik Sekhposyan was visiting the Federal Reserve Bank of San Francisco, while Noah Kouchekinia was working there as a research assistant. Opinions expressed in this Policy Study do not reflect the views of the management of the Federal Reserve Bank of San Francisco or of the Board of Governors of the Federal Reserve System.

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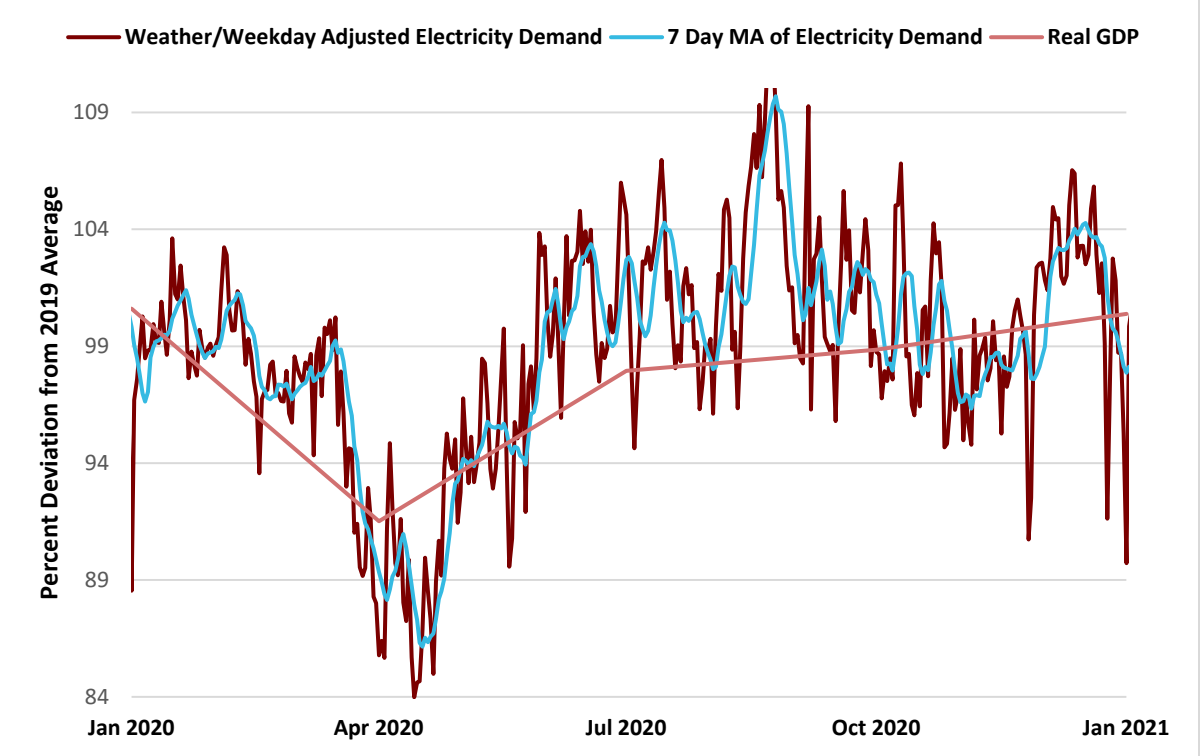
INTRODUCTION

On March 11th, 2020, the World Health Organization characterized COVID-19 as a pandemic. In the weeks before and after, the state and local governments and private businesses around the world announced various restrictions curtailing people's mobility and social contact, thus halting economic activity across the world. The spread of the virus and the rapid response to the pandemic emphasized the importance of the ability to get a reading of the economy in a frequent and timely manner. A consequence of COVID-19 in the academic and policy circles has been the explosion of the usage of high-frequency, often proprietary data sources, to measure compliance to public health recommendations as well as to quantify the economic impact of the non-pharmaceutical interventions to devise an appropriate policy response.

Figure 1. Changes in California Electricity Demand and Real GDP



Sources: Bureau of Economic Analysis, California Independent System Operator, and National Oceanic and Atmospheric Administration. 'MA' stands for moving average.

Researchers and policymakers have relied on credit card transactions data, mobility series collected and made publicly available through telecommunication companies, traffic data, and emission series, among others, to complement the more traditional data sources such as daily stock prices and weekly unemployment claims that economists relied on to track the economy in normal times. For example, Tarasewicz and Wilson (2021) consider the index of retail and restaurant visits from Google Mobility Reports as well as consumer spending based on credit card transactions as proxies for county-level economic activity when assessing the sensitivity of the local economies to the pandemic. Hale and Leduc (2020) investigate the short-run relationship between CO2 emissions and economic activity, particularly during the COVID-19 global pandemic. Here we consider how well electricity consumption captures state-level economic activity.

WHY ELECTRICITY CONSUMPTION?

Since electricity serves as a critical input in nearly all types of production, it is reasonable to expect a strong relationship between electricity consumption and economic activity. Figure 1 showcases the relationship between electricity usage and economic growth in 2020. It plots the percent deviation of electricity demand and real Gross Domestic Product (GDP) from 2019 averages in California. Electricity demand plummets below its 2019 average in March and April of 2020 but recovers quickly to the pre-pandemic level after the second quarter of 2020. Real GDP in California shows similar dynamics, though choppier, given the quarterly nature of the output data.

Electrical demand is available promptly at low levels of geographic aggregation across the US. In many regions, these data are publicly available directly through the Independent System Operators (ISO), which are charged with electricity market oversight. For example, electricity demand data for California is available through the California ISO (CAISO) at hourly intervals and with a mere one-hour delay. In the case of California, the CAISO control area roughly coincides with state boundaries making it easy to compare electric demand to more traditional economic indicators already calculated at the state level. For some of the states, a geographic aggregation across multiple ISO-s would be needed to arrive at a state-level series.

Since electricity consumption data is available at a high frequency and with very little delay, electricity consumption can be a good proxy for economic activity in real-time. The benefits of this data source are particularly important at a state level since measures of regional economic activity are released with a much longer delay than national-level measures. The first estimate of the GDP for the US is typically released with a one-month delay, while that for the states is available with a three-month delay. For instance, the Bureau of Economic Analysis (BEA) would release the first reading of the aggregate quarter one GDP in April of the reference year, while that for the states only in June.

ADJUSTING FOR SEASONALITY

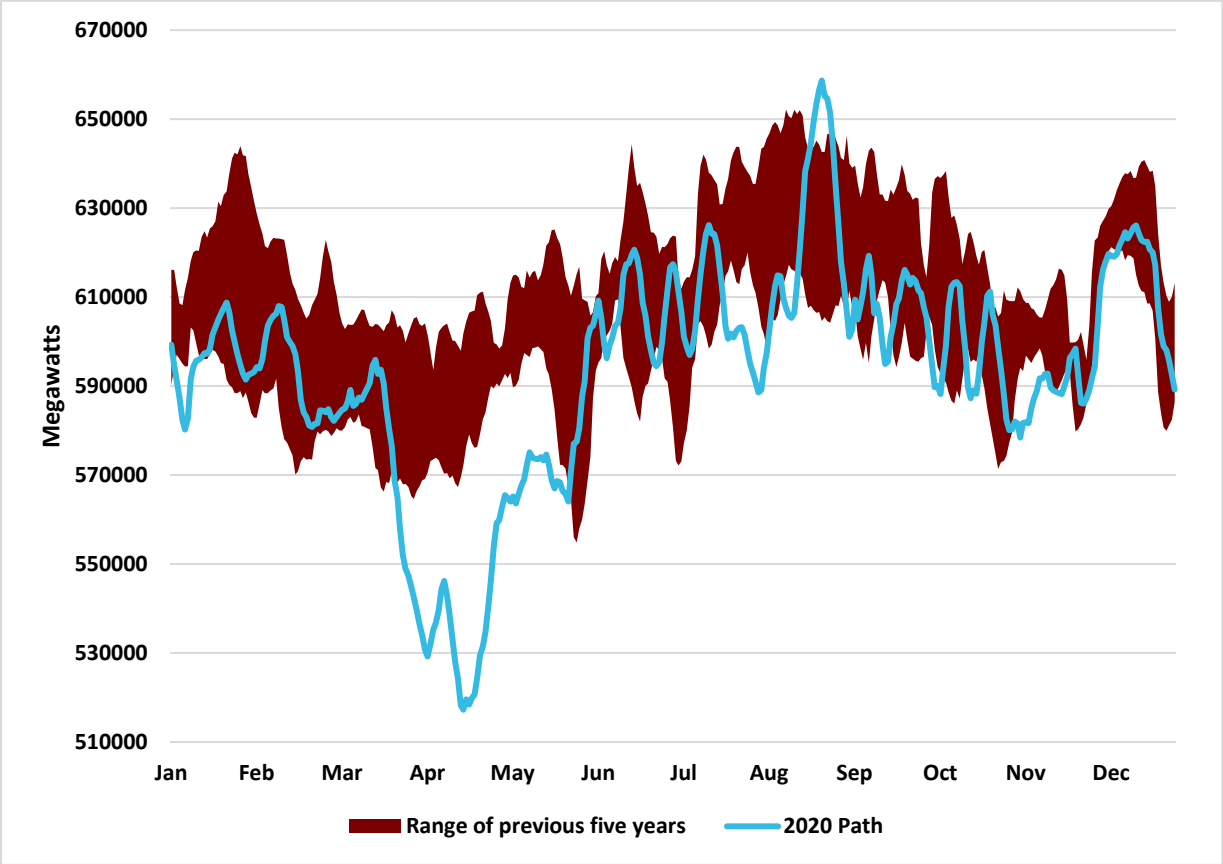
While we have good reason to expect electricity consumption to rise and fall with economic activity, there can be several confounding factors. In the short term, weekly consumption patterns and temperature fluctuations cause electric consumption to oscillate wildly. In the long term, adaptation and shifts in production can change the relationship between power use and production. Our analysis focuses on short-term prediction, so we broadly abstract from shifts in long-run dynamics.

Nonetheless, we take several steps to absorb seasonal fluctuations in the electricity demand. Daily electricity usage in California reaches lows of under five hundred gigawatts and highs of over nine hundred gigawatts. While lows are typically reached in the cooler months and highs in warmer months, it is no simple seasonal pattern. Day-to-day changes in weather cause significant variation even within the same month. These variations in the untreated series completely obfuscate the sharp decline in electricity usage at the onset of the pandemic. This highlights the inherent trade-off between the timeliness of the data and its quality. The statistical agencies typically release the data with a delay; however, they thoroughly adjust for seasonality and other factors.

To account for swings caused by heating and cooling weather cycles, we incorporate “degree days” into our model, which measures the variation in ambient temperature relative to comfortable room temperature. These degree days are weighted by population density within their geographic units to account for the concentration of economic activity in select geographic areas. For example, a heatwave

in densely populated Los Angeles will increase California's degree day measure by more than a heatwave in sparsely populated Monterey County. In addition, we allow for the effects of hot and cold degree days to be asymmetric. Since National Oceanic and Atmospheric Administration (NOAA) releases degree days with only a day delay and provides predictions up to a week ahead, accounting for weather effects does not change the real-time and high-frequency nature of our exercise.

Figure 2. California Electricity Consumption: Comparing Recent Years



Sources: California Independent System Operator, and National Oceanic and Atmospheric Administration.

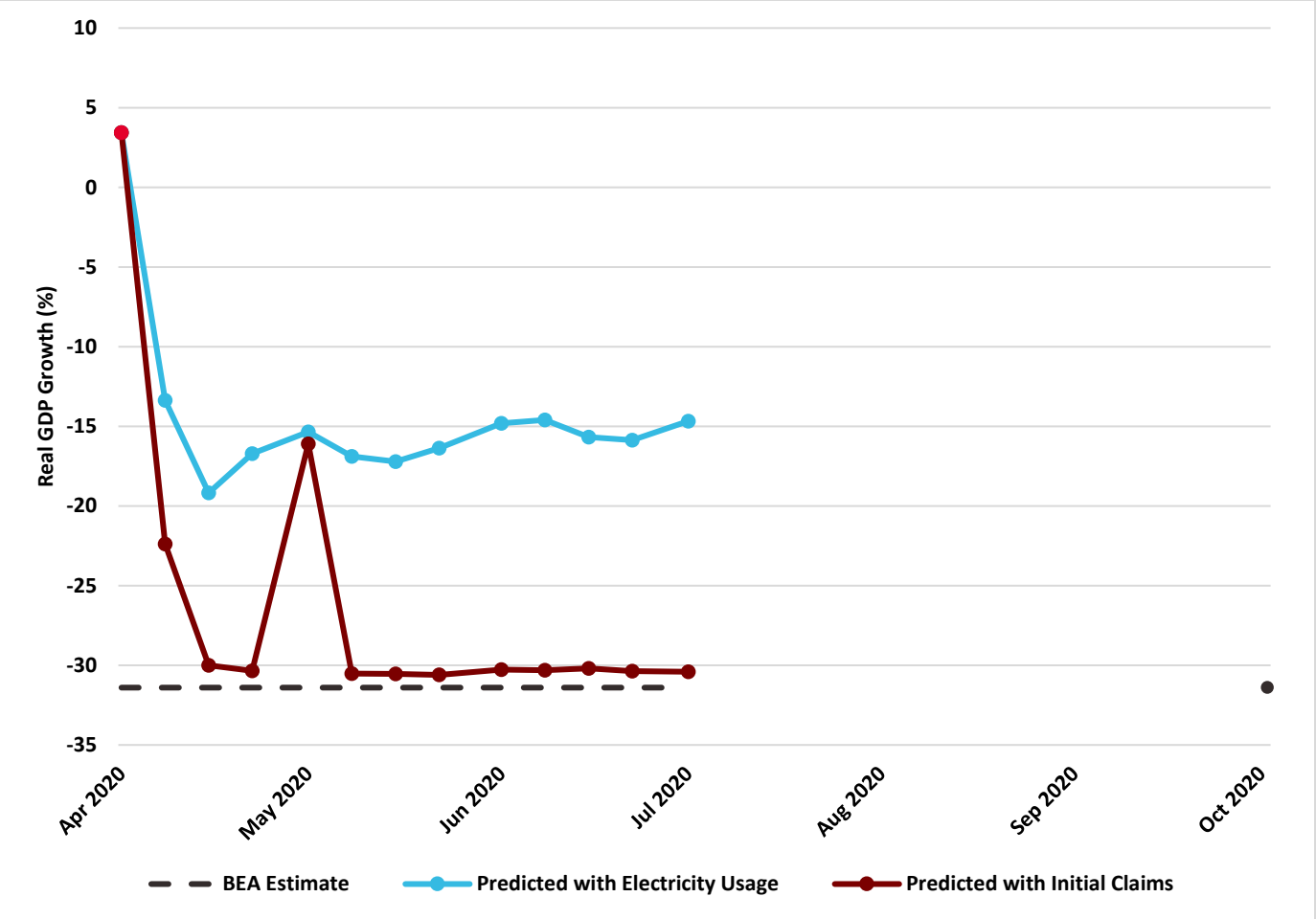
Another source of predictable seasonality is the workweek/weekend/holiday cycle. Electricity consumption is higher on workdays. We incorporate fixed effects for each day of the week and holidays into our model to remove this variation. This adjustment, combined with the degree day adjustments described above, accounts for 94% of the variation in electricity usage.

It is possible that adjustments for workdays and weather do not fully address the seasonal variation in electric consumption. To stabilize the remaining variation, we consider the seven-day moving average of the series in Figure 1. Figure 2, on the other hand, contrasts this series for 2020 (in solid blue) with the range of electricity consumption in the five years before 2020. Note that, in general, there is a dip in electric usage in March and there is a considerable variation throughout the year. However, the decrease in electricity usage associated with March-April of 2020 is well outside the typical range for that time of the year. In sum, though there is a great deal of variation in electricity usage, the pandemic-induced recession produced a drop that was well outside the norm, highlighting the usefulness of electricity usage in capturing severe downturns in real-time.

ELECTRICITY AS A PREDICTOR OF ECONOMIC ACTIVITY

Figures 3 and 4 formalize the use of electricity consumption for prediction. More specifically, we examine how well we could have predicted the state-level GDP for California in quarters two and three in 2020 had we used this data. We start each quarter by making a prediction with currently available releases of GDP for previous quarters. This is an autoregressive model (AR, marked with a light red dot), which, at the time of prediction is using the information at least two quarters back since given the data publication delays, the last quarter's reading of the GDP is not available yet.

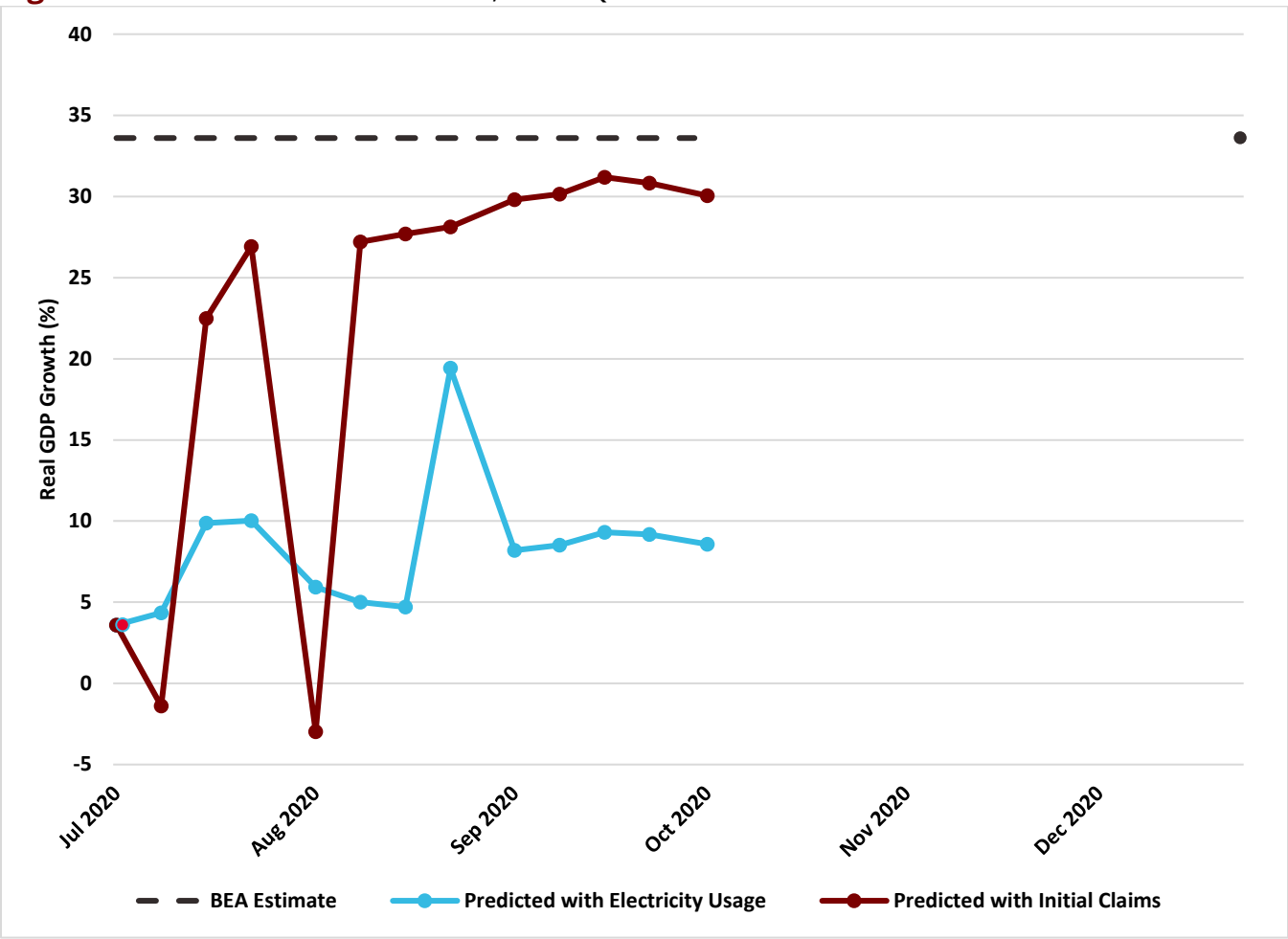
Figure 3. Predictions for California, 2020 Q2



Sources: Bokun et al. (forthcoming), Bureau of Economic Analysis, California Independent System Operator, Department of Labor, National Oceanic and Atmospheric Administration, and Hazell et al. (forthcoming).

As we move through the quarter, we obtain two sets of predictions. The first prediction (in blue) incorporates the electricity consumption information. Each week, a prediction is made based on a) previous releases of GDP growth for California b) electricity usage for complete months in the current quarter at a monthly frequency and c) electricity usage for additional complete weeks in the current quarter at a weekly frequency. The second prediction (in red) is constructed like the first one, but it uses weekly initial unemployment insurance claims data (available with a week delay) instead of electricity consumption. This model is intended for benchmarking our results, though electricity consumption data is more readily available -- it is available at a daily frequency, with less than a day delay. Finally, the black dashed lines in each figure correspond to the realized real GDP growth in California for that quarter, which is released with a three-month delay, marked with a (black) dot.

Figure 4. Predictions for California, 2020 Q3



Sources: Bokun et al. (forthcoming), Bureau of Economic Analysis, California Independent System Operator, Department of Labor, National Oceanic, and Atmospheric Administration, and Hazell et al. (forthcoming).

Figures 3 and 4 suggest that using high-frequency economic indicators improves the accuracy of the predictions relative to relying on the past performance of the real GDP growth only. The model that uses initial unemployment claims data appears to be overall better, though electricity consumption successfully picks up the speed though misses the level of contraction in the initial phase of the pandemic. Our results suggest that electricity consumption data is useful for monitoring the state economy, particularly if there is a need to do that at a high frequency and could be a useful indicator to track in severe downturns.

CONCLUSION

In this *Policy Study*, we examine electricity consumption as a potential indicator for monitoring economic activity. Electricity consumption has several valuable properties – it is a production input, available in real-time and with a high degree of geographic disaggregation. While electricity consumption is volatile, most volatility can be captured by weather and calendar events. Using the information on these factors in real-time, we show the usefulness of electricity consumption for monitoring the decline and rebound of California's economy at the onset of the pandemic. Forecasts that incorporate electricity consumption information provide timely information on the direction of change, yet in this episode, labor market indicators perform better at capturing the magnitude of the downturn.

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