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Electricity Use as a Real Time Indicator of the Economic Burden of the COVID-19-Related Lockdown: Evidence from Switzerland

Abstract

We employ hourly electricity load data for Switzerland as a real time indicator of the economic effects of the lockdown following the spread of SARS-CoV-2. Our findings reveal that following the drastic lockdown, overall electricity use decreased by 4 per cent, with a reduction of even 11.3 per cent in the Canton of Ticino where the number of confirmed cases per capita was one of the highest in Switzerland and also stricter measures such as closures of construction sites and industrial companies were implemented on top of federal regulations. Looking at working days only, we estimate a Swiss-wide decrease in electricity consumption of 6.3 per cent. Assuming industry, services, transport and agriculture account for 67 per cent of electricity demand, the 4 per cent decrease in electricity use implies a 6 per cent output reduction in these sectors. In addition, the reduced electricity imports and the change in the generation mix of neighbouring countries, also translates into reduced CO_2 emissions related to these imports.

JEL-Codes: C530, Q400, C300.

Keywords: COVID-19, economic indicator, electricity load, CO_2 emissions.

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1 Introduction

The COVID-19 pandemic poses tremendous challenges worldwide. Such an extreme disruption of the world economy encompassing both a supply and a demand side shock has not been encountered for decades.[1] The uncertainty about the nature and magnitude of these shocks makes it difficult for policy makers to design appropriate policies to address this unprecedented situation. Hence, real-time information on the state of the economy is valuable to inform them, as well as the general public about the economic repercussions of the mass lockdowns. One such real time indicator that can be used to assess the depth of the downturn is hourly electricity load data. Whereas standard economic indicators such as unemployment, price indices, interest rates or evolution of GDP are released with considerable delay and need a longer time frame to reveal the required information, hourly electricity load data is available in real time. Furthermore, statisticians admit the fragility of GDP estimates in times like these and suggest for instance introducing confidence intervals for these estimates, especially because GDP estimates during recessions are often revised downwards (The Economist, 30.05.2020). For instance, the fall is US GDP estimated during the last quarter of 2008 amounted to 3.8 per cent, but was then revised to a drop of more than 8 per cent. Hence, additional real time information can be especially valuable in times of crisis, when governments have to make important decisions with far reaching consequences under time pressure. As electricity load data is publicly available free of charge, the approach adopted in this paper can be applied to many countries worldwide. Furthermore, such an indicator can come handy especially for developing countries, where standard economic indicators provided by official bodies can be more easily manipulated and may be less accurate.

As shown by previous studies (Arora and Lieskovsky, 2014; Baranzini, Weber, Bareit and Mathys, 2013; Cicala, 2020; Chen, Igan, Pierri and Presbitero, 2020), electricity use is an appropriate indicator of economic activity. Hence, policy makers can use information on the change in electricity use to infer the economic repercussions of the COVID-19 related lockdown.

Our findings reveal the lockdown triggered a 4 per cent reduction in electricity use in Switzerland overall, with a large variation between cantons where some experienced extremely large drops of even -16.5 per cent (Valais) or -11.3 per cent (Ticino). The drastic reduction in Ticino for

[1] See for instance all papers in Baldwin and Weder di Mauro, ed. (2020) for an excellent presentation of the crisis, its effects and possible responses to it.

instance reflects the stricter rules adopted there such as the additional closure of industrial firms and construction sites, on top of federal regulations. If we focus on working days only, the Swiss-wide reduction even amounted to -6.3 per cent. Assuming for instance households account for around 33 per cent of overall electricity consumption in Switzerland (Swiss Energy Balance 2018, Swiss Federal Office of Energy), the 4 per cent decrease in electricity demand we find corresponds to approximately 6 per cent(=4/0.67) reduction in production. This estimate is rather conservative if we assume that due to the home office requirement, the share of households' electricity consumption in overall electricity consumption may even exceed 33 per cent.

As an alternative, we can use results on the income elasticity of electricity demand to translate the electricity reduction into the effects on output. Baranzini, Weber, Bareit and Mathys (2013) find a long run income (GDP) elasticity of electricity consumption of 0.9 for Switzerland. Csereklyei (2020) estimates a long run elasticity of industrial electricity use that ranges between 0.76 and 1.08 for European Union economies. Hence, a 4 per cent drop in electricity use as suggested by our estimation implies a 3.7-5.3 per cent decrease in output using these latter estimates.

At the same time, the dramatic shutdown of economies worldwide has highlighted an additional not least important aspect. As electricity consumption has considerably declined and electricity production has adjusted accordingly, associated CO_2 emissions have also recorded a significant drop. In 2017 for instance, CO_2 emissions linked to electricity and heat production accounted worldwide for approximately 40 per cent of CO_2 emissions from fuel combustion. Accordingly, a drastic decline in electricity demand and production has also triggered a considerable reduction in associated CO_2 emissions.

In this paper we address the above mentioned issues using primarily data for Switzerland overall and the 26 Swiss cantons. The Swiss context can be employed as a natural laboratory and offers several advantages in this respect. Swiss sub federal jurisdictions enjoy extensive autonomy, even though these were drastically limited by federal laws during the pandemic. Still, some cantons imposed additional drastic measures that affected their economies, and this heterogeneity is also reflected in our findings. Thus, by focusing on one country and its sub federal jurisdictions we can avoid a number of biases inherent in cross country studies. In the case of COVID-19, economies have enacted various types of restrictions and thus it is more difficult to compare the economic impact across countries.

The paper is structured as follows. Section two introduces a brief literature review, followed by a description of the data in Section three. Section four, five and six present the empirical strategy, the estimation results and a robustness check. Finally we conclude with a summary of our main findings in Section seven.

2 Literature

There is a broad literature body on the connection between energy consumption and economic growth. Arora and Lieskovski (2014) use annual US data since 1950 and quarterly data since 1976 and find a high and significant correlation of up to 89 per cent between electricity use and real GDP. They also show that during the recessions analysed, annual growth in electricity sales has moved closely with annual growth in real GDP. Hence, they conjecture that electricity use is an appropriate coincident indicator of economic activity. The link between energy use and economic activity for the case of Switzerland is the subject of Baranzini, Weber, Bareit and Mathys (2013) study. Using data between 1950 and 2010, the authors find a positive relationship between GDP per capita and electricity consumption. Tiba and Omri (2016) provide an extensive overview of empirical studies carried out on this topic.

Our work follows closely Cicala (2020) who employs hourly electricity load data for 20 European Union countries to assess the effect of COVID-19 on electricity consumption and hence on the wider economy. His findings suggest a 10 per cent reduction in electricity consumption in the EU on average relative to the baseline, with large variations between Italy (-25 per cent) and Denmark (less than -1 per cent).

3 Data

In this paper we resort to several data sources. First, data on electricity load is obtained from the monthly Energy Statistic Switzerland published by Swissgrid, the Swiss transmission system operator.[2] Among other things, the data includes aggregated 15 minutes resolution electricity consumption profiles of all Swiss cantons.[3] Electricity consumption data from Swissgrid are aggregated

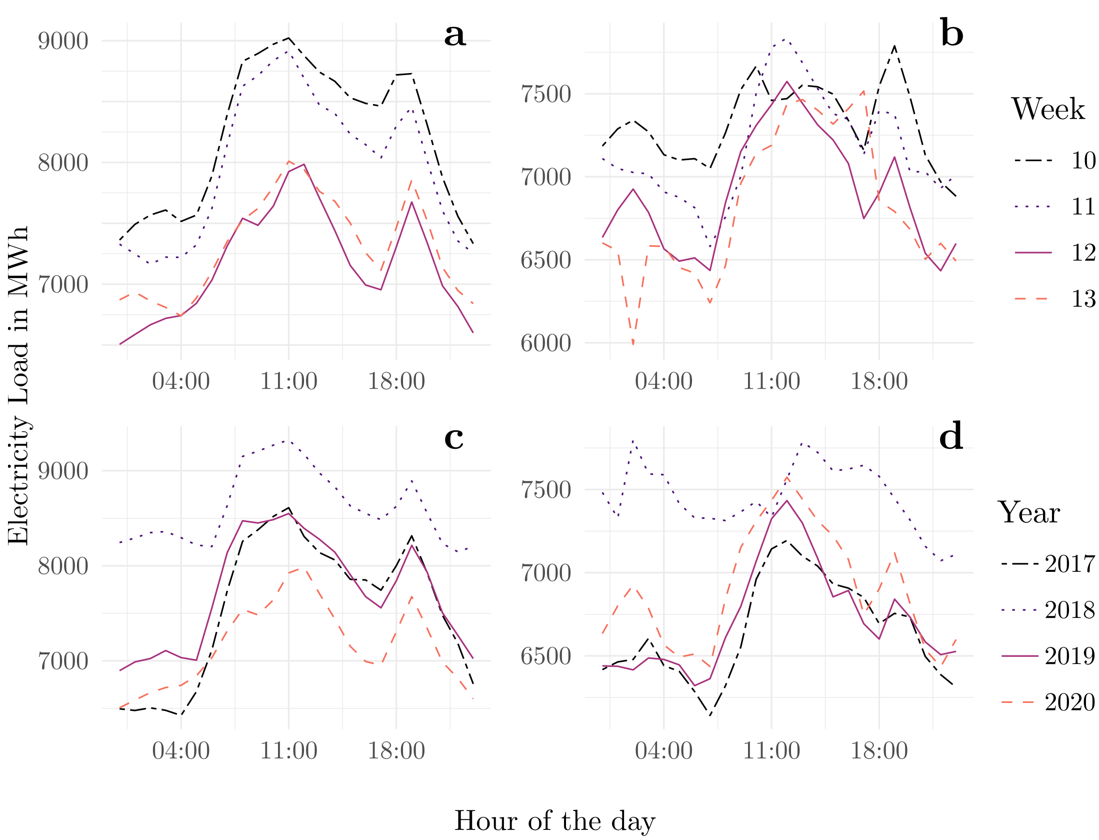
[2]https://www.swissgrid.ch/en/home/operation/grid-data/generation.html

[3]Although some cantons are reported as one entity e.g. Geneva (GE) and Vaud (VD).

on an hourly basis. Since the Swiss control block also covers regions that are not part of the territorial area of Switzerland, we exclude these observations. We also exclude observations that stem from electricity consumption across different cantons.

Figure 1 depicts the average daily load profile for working days and weekends in 2017-2020. The lockdown started on March 16th 2020, at the beginning of calendar week (CW) 12. Panels a and b depict this profile for CW 10-13 in 2020 whereas panels c and d compare the load profile for CW 12 only in different years. All graphs display a striking pattern. There is a pronounced downward shift in electricity load during weekdays but not so during weekends in CW 12 and 13 following the lockdown compared to CW 10 and 11 before. The reduction is very pronounced especially during peak hours where the load decreased from around 9000 MWh to 8000 MWh.

Figure 1: Average Daily Load Profiles in Switzerland



a: weekdays, 2020; b: weekends, 2020; c: weekdays, CW12; d: weekends, CW12

The same pattern can be observed if we compare peak load profiles in CW 12 for different years. Once again from Monday to Friday during CW 12 2020 the load was considerably lower than during the same time frame in 2017-2019.[4]

Second, temperature data is collected for every hour of the day from the National Oceanic and Atmospheric Association (NOAA) and matched with regard to their timestamp and location to the electricity consumption data. Since NOAA does not report temperature data for all Swiss cantons, unreported cantons are matched to the closest available weather station.

Third, data on physical cross-border flows, and electricity generation per production type, are retrieved from the European Network of Transmission System Operators for Electricity (ENTSO-E).[5]

Fourth, daily data on the current state of the pandemic in Switzerland is collected directly for each canton and Switzerland overall from the Swiss Federal Office of Public Health. In the regressions we include the cumulative count of cases per capita for every canton.

Fifth, data from the Google COVID-19 Community Mobility Reports are used to proxy for the degree of implementation of the lockdown measures. This index measures how visits and length of stay at different places change compared to a baseline. The baseline is the median value, for the corresponding day of the week, during the 5-week period Jan 3–Feb 6, 2020.[6] Hence, a lower value of the index reflects the decreased mobility following the lockdown. This index is available both for Switzerland overall as well as for each canton.

Sixth, data on cantonal electricity usage and sectoral composition are obtained from Eymann, Rohrer and Stucki (2014). Latest available observations are from 2014, but we expect the changes in industry structure to be negligible.

Finally, data on cross-border commuters are collected from the Swiss Federal Statistical Office.

[4] We can observe that the load profile in 2018 was considerably higher than in 2017 or 2019 for instance. Even though 2018 was the warmest year in Switzerland measured at that time, February and March 2018 were unusually cold with deviations of -3 °C and -1 °C from the normal period 1981 - 2010. All other observed years in our sample were comparable in terms of their median temperatures in March. For more information see https://www.meteoswiss.admin.ch/home/climate/the-climate-of-switzerland/monats-und-jahresrueckblick.html

[5] https://transparency.entsoe.eu/dashboard/show

[6] https://www.google.com/covid19/mobility/

4 Empirical Strategy

4.1 Electricity Consumption

For the estimation of changes in electricity consumption after the lockdown in Switzerland we use the following specification:

$$\ln(load)_t = \alpha + \beta D_t + \delta HD_t + \lambda CD_t + \eta Y_t + \varepsilon_t \tag{1}$$

where the dependent variable $\ln(load)_t$ is the natural logarithm of the hourly electricity load in Switzerland at time t. The independent variable of interest D_t is a vector containing dummies for each week/day after the lockdown and seven weeks prior to the lockdown. Thus D_t measures by how much load during a specific week after 16.03.2020 differed from prior years (2017-2019) within the same week of the year.[7]

Since parts of space and water heating in Switzerland are electric, demand for electricity is highly driven by outside temperatures. By including the variables HD (heating degree) and CD (cooling degree), we control for changes in electricity consumption induced by the need for heating or cooling buildings. Heating degree is defined as the difference between outside temperature and 18 °C, with outside temperatures above the threshold leading to a heating degree of zero. Cooling degree is calculated equivalently for temperatures above 18°C. The vector Y_t contains a full set of dummy variables indicating a holiday, the day of the week, the calendar week, and hour of the day, to account for time patterns that characterize the demand for electricity. We additionally normalize coefficients to be mean zero in the pre-treatment period (CW5 - CW11 2020)[8] and cluster standard errors at the month level. After controlling for temperature differences and the above mentioned fixed effects, β captures the percentage change in electricity consumption relative to the estimation window, before the lockdown was announced. The baseline pre lockdown period contains pooled data from the year 2017 to 2019.[9] The results of this regression are presented in Table 1 in Section 5.1 below.

In a second step we run eq. (1) separately for each canton i, to decompose the country-wide

[7] A similar interpretation applies if we compare load on a specific date with the electricity load during the same hour, of the same day, during the same week in previous years.

[8] See also Cicala (2020).

[9] We also use shorter time frames. The obtained effects are within a similar range.

effect on electricity consumption and analyse the regional differences in the magnitude of the effects between Swiss cantons. These estimates are presented in Figure 3 in Section 5.1.

Furthermore, to understand what drives the large variation in regional differences we observe in the data, we run an alternative regression where we also account for the severity of the pandemic, the change in mobility as well as the industrial structure in each canton. Some cantons in Western Switzerland and Ticino introduced even stricter measures on top of the regulations imposed by the Federal Council. For instance, the local government of the Canton of Ticino shut down construction sites and industrial companies starting with the 23rd of March until the 4th of May 2020.[10] Geneva and Vaud also closed some industrial enterprises and building sites temporarily. As an example, Rolex shut down production facilities in Geneva, Biel and Crissier for 10 days. This alternative specification we employ reads:

$$LoadChange_{it} = \alpha + \lambda \ln Cases_{it} + \eta Mobility_{it} + \rho X_{it} + \varepsilon_{it} \tag{2}$$

where $LoadChange_{it}$ denotes the daily change in electricity consumption in canton i at time t relative to the pre-lockdown period.[11] The dependent variable is the coefficient we retrieve for our main variable of interest from variants of eq.(1) which we run for each canton separately. Hence, a large degree of variation is already captured by the hour, weekday, week or holiday fixed effects employed in these regressions. We thus try to explain the remaining variation in the differences in the decline of electricity use across cantons. Even though a Swiss-wide lockdown was announced on the 16th of March 2020, it is likely that the degree of implementation of the policies in each canton was correlated with characteristics of the pandemic. The main variables of interest we consider are the ones accounting for this relationship. We estimate different specifications and include either the natural logarithm of the number of COVID-19 cases per capita or the Google Mobility Index to proxy for the degree/strictness of implementation. The corresponding coefficient λ captures the impact of changes in the severity of the pandemic and η the effect of mobility.

The vector X_{it} includes a number of further canton specific controls. Electricity consumption is mostly determined by the scale of economic activities, energy intensity, and the sectoral structure

[10] Companies in these sectors were still allowed to operate by federal law and remained open in many German speaking cantons.

[11] See also Chen, Igan, Bareit and Presbitero (2020) for a similar approach for European countries and the US.

of the economy. Since sectoral structure is highly inflexible in the short-run, and energy intensity is heterogeneous across sectors, the resulting changes in electricity consumption following the lock-down might differ across regions depending on their economic structure. We capture this effect by including measures that proxy the cantonal economic structure. The control variables are defined as the electricity usage of a certain sector (i.e. industry or service sector) in canton i relative to the total electricity consumption in the respective canton.

The vector X_{it} also includes the share of cross-border commuters per capita ($Commuter_{it}$). This accounts for the fact that Ticino borders Northern Italy where the European pandemic started and the situation was extremely severe already early in the year, as well as for a reduction in cross-border labor flows that might have impacted economic activities in cantons that rely on commute workers.

4.2 CO_2 Emissions Related to Electricity Imports

As mentioned above, the decrease in electricity use not only reflects the decline in economic activity but also potentially affects CO_2 emissions. Even though Swiss electricity generation is mostly based on hydro (55.4 per cent) and nuclear power plants (36.1 per cent) and thus the embedded CO_2 emissions are very low, Switzerland still relies during a number of months every year on electricity imports from abroad.[12] Hence, there is a link between domestic electricity use and emissions generated by power plants in France and Germany.

To capture the effect of reduced electricity domestic demand and hence imports on CO_2 emissions from imported electricity, we first estimate the share of a certain type of electricity (i.e. nuclear, coal, gas, hydro etc.) generated by production type j in country i at time t relative to total electricity generation in country i at time t. Using the obtained shares and estimates on g CO_2 equivalents per produced kWh of different production types from Stolz and Frischknecht (2017) we calculate the level of CO_2 emitted by the production of one kWh in country i at a time t. In a second step we employ data on physical cross-border electricity flows to Switzerland and calculate the share of country i's electricity exports to Switzerland relative to Switzerland's total electricity imports at time t. By matching data on CO_2 emissions per kWh and import weights

[12]Switzerland primarily imports electricity from Germany, France and Austria, and exports to Italy (Swiss Energy Balance 2018, Swiss Federal Office of Energy).

we can derive how many g CO_2 equivalents per kWh Switzerland imported from its neighbouring countries at any point in time during our observation period.

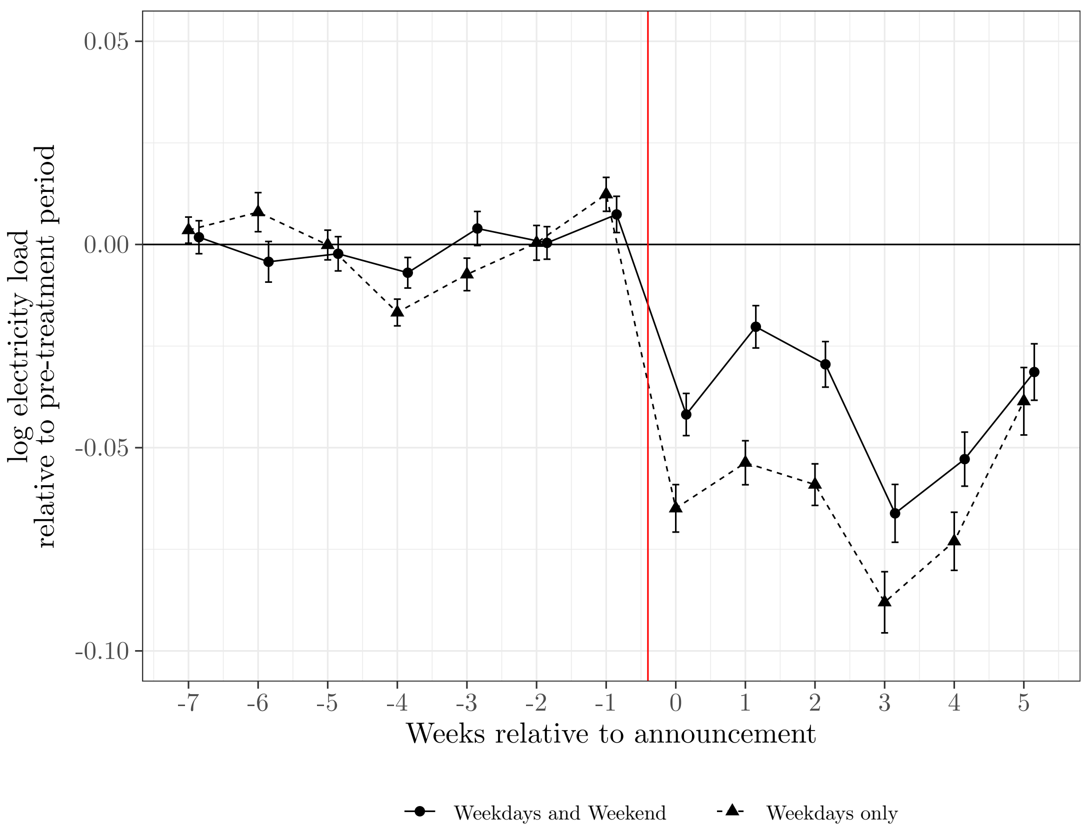
5 Results

5.1 Electricity Consumption

Figure 2 displays the change in weekly log electricity load for 7 weeks prior and 5 weeks after the lockdown (CW12 : 16.03.2020) for the overall week (continuous line) and working days (Monday-Friday) (dashed line) only. The graph shows a pronounced decline of between -2 and -6.6 per cent for the period including weekends and an even more drastic decline of between -3.9 and -8.8 per cent if we look at working days only.

Table 1 displays the results of our empirical exercise. In column (1) we present the coefficients for each calendar week after the lockdown whereas in column (2) we present the cumulative effect for the six weeks after March 16th 2020. In columns (3) and (4) we only use data on Monday-Friday since the load profile in Figure 1 showed a particularly visible effect during the week.

Figure 2: Changes in Weekly Electricity Load in Switzerland



In all specifications we account for week, day of the week, holiday and hour fixed effects and include information on cooling as well as heating degrees. The results show that electricity use declined by 4 per cent after the lockdown, with a gradual increase in the absolute effect per week. The effect is even more pronounced with 6.3 per cent if we focus on working days only. The gradual effect can also be due to the fact that immediately after the lockdown the industry still had manufacturing orders in the pipeline but no new orders came afterwards.

The following map depicts the results of estimating eq.(1) for each canton separately. The picture reveals stark differences in the effect of the lockdown between cantons. On the one hand, the most drastic decrease of -16.5 to -11 per cent is encountered in Valais or Ticino. On the other hand, the least pronounced reduction with less than -2.5 per cent decrease in electricity use is found in the north-eastern part of the country.

Table 1

Periods (CW)	*Dependent variable:* log($load_t$)			
	(1)	(2)	(3)	(4)
-7 (CW5)	0.002	0.002	0.004	0.004
	(0.440)	(0.478)	(1.098)	(1.100)
-6 (CW6)	−0.004	−0.004	0.008*	0.008*
	(−0.852)	(−0.842)	(1.654)	(1.662)
-5 (CW7)	−0.002	−0.002	−0.0001	−0.00005
	(−0.542)	(−0.503)	(−0.036)	(−0.012)
-4 (CW8)	−0.007*	−0.007*	−0.017***	−0.017***
	(−1.850)	(−1.832)	(−5.092)	(−5.103)
-3 (CW9)	0.004	0.004	−0.007*	−0.007*
	(0.937	(0.959)	(−1.840)	(−1.833)
-2 (CW10)	0.0004	0.0001	0.0004	0.0003
	(0.096	(0.013)	(0.095)	(0.068)
-1 (CW11)	0.007*	0.007	0.012***	0.012***
	(1.657)	(1.617	(2.956	(2.946)
0 (CW12)	−0.042***		−0.065***	
	(−8.060)		(−11.121)	
1 (CW13)	−0.020***		−0.054***	
	(−3.88)		(−9.915)	
2 (CW14)	−0.029***		−0.059***	
	(−5.261)		(−11.548)	
3 (CW15)	−0.066***		−0.088***	
	(−9.296)		(−11.702)	
4 (CW16)	−0.053***		−0.073***	
	(−7.941)		(−10.214)	
5 (CW17)	−0.031***		−0.039***	
	(−4.518)		(−4.646)	
CW12 - CW17		−0.040***		−0.063***
		(−15.921)		(−22.955)
CD	0.004***	0.004***	0.004***	0.004***
	(19.843)	(19.774)	(17.211)	(17.179)
HD	0.007***	0.007***	0.007***	0.007***
	(57.600)	(59.172)	(56.624)	(58.239)
Week fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Holiday fixed effects	Yes	Yes	Yes	Yes
Hour fixed effects	Yes	Yes	Yes	Yes
Observations	29,171	29,171	20,848	20,848
R^2	0.809	0.809	0.859	0.859
Adjusted R^2	0.809	0.808	0.859	0.858
Residual Std. Error	0.061 (df = 29074)	0.061 (df = 29079)	0.052 (df = 20753)	0.052 (df = 20758)
F Statistic	1,284.682*** (df = 96; 29074)	1,352.806*** (df = 91; 29079)	1,348.656*** (df = 94; 20753)	1,421.006*** (df = 89; 20758)

Note: In columns (1) and (2) we report estimates for the full sample, in columns (3) and (4) for working days only. *p<0.1; **p<0.05; ***p<0.01

Map: Average Electricity Load Change in Swiss Cantons Following the Lockdown

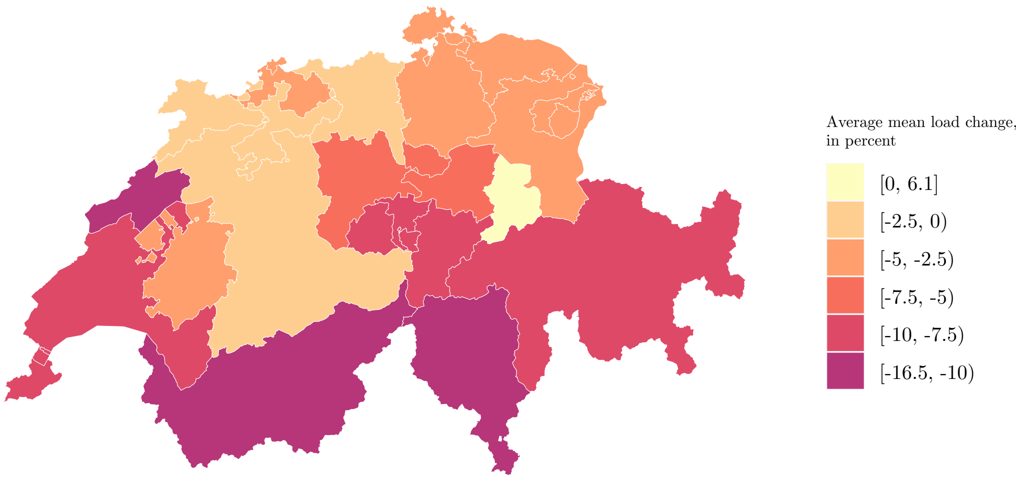


Table 2 depicts the estimation results for eq. (2) for six different specifications. Since our dependent variable measures the change in electricity load relative to the pre-lockdown period, most values of the dependent variables are negative. Hence, a positive sign of an explanatory variable means the negative effect of the lockdown is less pronounced whereas a negative sign exacerbates the negative effect. As expected, there is a positive relationship between mobility and changes in electricity load. The corresponding coefficient is positive and highly significant in all three specifications (columns 1-3 in Table 2). Looking at the number of confirmed COVID-19 cases per capita we observe a negative and highly significant effect at the 1 per cent level in columns (4) and (5) in Table 2.[13] In columns (3) and (6) we also include canton and date fixed effects. Furthermore, a higher share of industry electricity consumption in overall electricity consumption has a positive and significant effect on electricity load changes. The opposite applies for a higher share of service sector electricity consumption in overall electricity consumption. Thus, in cantons where the mobility of people was higher even after the lockdown, the number of per capita cases lower or the share of the industry sector higher, the negative effect of the lockdown on electricity use is less pronounced. On the contrary, a higher share of the service sector in overall electricity consumption or of work related commuters amplifies the negative effect.

[13] We also include the natural logarithm of the number of COVID-19 related deaths per capita and obtain a similiar but more pronounced effect.

Table 2

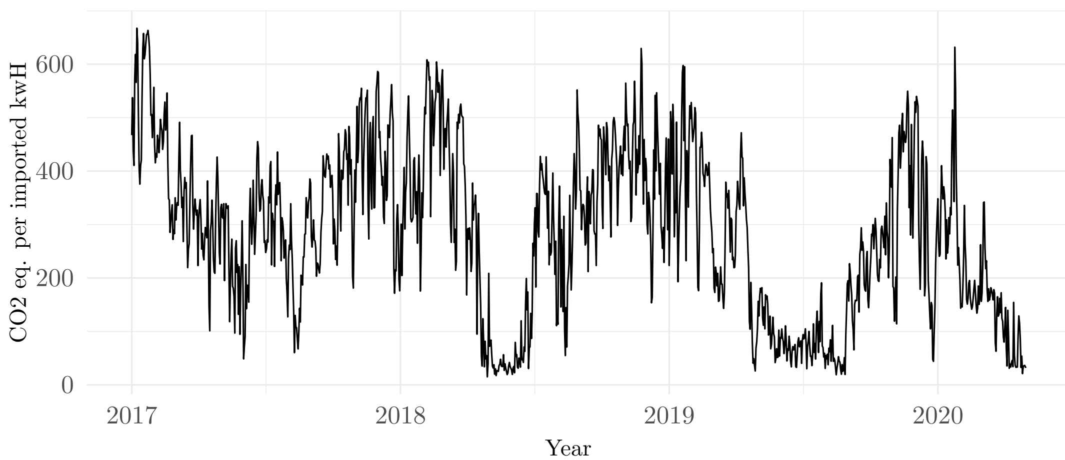
	Dependent variable:					
	Change in Electricity Consumption Relative to Pre-Lockdown Period (LoadChange_{it})					
	(1)	(2)	(3)	(4)	(5)	(6)
Mobility	0.002***	0.002***	0.003***			
	(6.322)	(7.923)	(5.731)			
log(Cases)				−0.011**	−0.019***	0.025
				(−2.321	(−4.190	(1.053
log(IndustryShare)	0.054***			0.077***		
	(3.703)			(5.259)		
log(ServiceShare)		−0.014			−0.033**	
		(−0.949)			(−2.246)	
log(Commuter)	−0.017***	−0.015***		−0.020***	−0.017***	
	(−6.242)	(−5.550)		(−6.977)	(−5.657)	
Constant	−0.002	−0.059**	0.034	−0.140***	−0.309***	0.246
	(−0.095)	(−2.134)	(1.462)	(−3.826)	(−9.532)	(1.152)
Canton fixed effects			Yes			Yes
Date fixed effects			Yes			Yes
Observations	836	836	836	836	836	836
R^2	0.163	0.150	0.474	0.128	0.104	0.453
Adjusted R^2	0.159	0.147	0.433	0.125	0.101	0.409
Residual Std. Error	0.103 (df = 832)	0.104 (df = 832)	0.085 (df = 774)	0.105 (df = 832)	0.107 (df = 832)	0.087 (df = 774)
F Statistic	53.818*** (df = 3; 832)	48.800*** (df = 3; 832)	11.437*** (df = 61; 774)	40.686*** (df = 3; 832)	32.322*** (df = 3; 832)	10.488*** (df = 61; 774)

Note: *p<0.1; **p<0.05; ***p<0.01

5.2 CO_2 Emissions Related to Electricity Imports

Figure 3 depicts the evolution of CO_2 equivalent per imported kWh between 2017 and end of April 2020. As mentioned above, Switzerland produces electricity with hydro and nuclear power plants and hence domestic CO_2 emissions linked to these electricity sources are extremely low. However, especially during January-March and October-December, it also imports electricity from its neighbours such as France or Germany. Thus, a drastic reduction in electricity demand which also implies decreasing imports is also reflected in lower CO_2 emissions given that electricity generation structures abroad also change.

Figure 3: g CO_2 Emissions per imported kWh



There are two reasons why we can expect a sharp decrease in g CO_2 eq per imported kWh. First, as shown in Section 5.1, the lockdown led to a reduction in electricity demand. Second, favourable weather conditions boosted the electricity production of renewable energy resources. Due to an increase in the supply of renewable energies and a simultaneous decline in demand, fossil fuel power plants are pushed up the merit order curve. With electricity prices below their marginal costs, conventional producers are forced to stop production. Therefore, the structural change in electricity generation and the associated change in emissions is particularly striking in Germany, where electricity production still heavily relies on fossil fuels.

Table 3 displays the quarterly CO_2 equivalent per produced and imported kWh between 2017 and 2020. The figures reflect a seasonal pattern with higher CO_2 equivalent per imported kWh in the first and last quarter of each year. The effect of the lockdown is also immediately visible. Thus, in the first quarter of 2020 the CO_2 equivalent amounted to 227.5 g and was thus 33.7 per cent lower than in the first quarter of 2019 or even 43.5 per cent lower compared to the average g CO_2 equivalent of Q1 2017-2019. In the lower part of the table we also report the results of a t-test (difference in means). The t-test and the associated p values show a statistically significant difference between average CO_2 equivalent per imported kWh in the first quarter of 2020 compared to the first quarter of 2019, 2018 or 2017.

Table 3: Quarterly g CO_2 eq. per produced or imported kWh

	CO2 eq. per kWh Production			CO_2 eq. per kWh Import
	Austria	France	Germany	Switzerland
2017				
Q1	234.70	100.05	593.32	438.54
	(76.89)	(22.63)	(100.55)	(124.26)
Q2	73.92	64.64	552.90	266.64
	(37.00)	(21.20)	(90.55)	(124.31)
Q3	60.49	70.13	563.49	277.99
	(26.62)	(24.44)	(88.38)	(137.30)
Q4	158.85	107.35	496.01	397.94
	(50.72)	(22.75)	(132.79)	(113.01)
2018				
Q1	185.59	75.35	591.80	426.93
	(39.21)	(22.44)	(130.86)	(120.29)
Q2	47.47	42.16	561.41	103.08
	(24.94)	(9.83)	(101.53)	(113.17)
Q3	77.98	65.34	610.39	305.91
	(40.36)	(14.22)	(81.83)	(181.84)
Q4	195.99	78.00	569.54	405.56
	(54.57)	(17.43)	(129.92)	(129.44)
2019				
Q1	167.40	70.23	504.25	343.15
	(55.48)	(16.85)	(156.55)	(143.40)
Q2	65.90	47.81	488.96	139.47
	(34.64)	(9.90)	(93.80)	(128.71)
Q3	106.88	59.57	491.58	106.35
	(41.83)	(11.42)	(103.29)	(96.23)
Q4	179.05	73.18	490.72	310.93
	(31.26)	(23.99)	(136.36)	(156.97)
2020				
Q1	170.97	64.72	384.93	227.49
	(49.53)	(12.65)	(135.55)	(127.27)
Q2	73.95	34.92	340.17	60.58
	(25.63)	(3.07)	(79.30)	(55.10)

Paired t-test

	Q12020-Q12019	Q12020-Q12018	Q12020-Q12017
t-statistic	31.471	47.989	84.974
p-value	- 2.2e-16	- 2.2e-16	- 2.2e-16

6 Robustness Check

We also run a placebo test and present the results in Table 4. For the placebo test we only keep data for 2017, 2018 and for the first 17 weeks of 2019. We then construct an indicator variable which is equal to 1 for the the time period CW12-CW17 2019 during which there was no pandemia or lockdown and 0 otherwise. Column (1) in Table 4 displays the results for using all week days whereas in column (2) we only use data for working days. As expected, we do not find any effects on electricity load, when using this falsification test instead.

Table 4: Placebo Test

	Dependent variable:	
	$\log(\text{load}_t)$	
	(1)	(2)
CW12 - CW17	−0.002	−0.004
	(−0.693)	(−1.569)
CD	0.003***	0.002***
	(12.090)	(8.158)
HD	0.007***	0.007***
	(53.507)	(53.289)
Week fixed effects	Yes	Yes
Weekday fixed effects	Yes	Yes
Holiday fixed effects	Yes	Yes
Hour fixed effects	Yes	Yes
Observations	20,395	14,566
R^2	0.830	0.877
Adjusted R^2	0.829	0.876
Residual Std. Error	0.058 (df = 20310)	0.049 (df = 14483)
F Statistic	1,176.827*** (df = 84; 20310)	1,255.742*** (df = 82; 14483)

Note: Observations up to one year prior the event are excluded. Column (1) reports estimates for the full subsample, column (2) for working days only. *p<0.1; **p<0.05; ***p<0.01

7 Conclusion

The COVID-19 pandemic constitutes an extreme shock for worldwide economies. To contain the dangerous exponentially growing spread of SARS-CoV-2, governments have resorted to unprecedented extreme measures. The countrywide lockdowns have hit economies very hard. To support policy makers who need to make fast decisions with far reaching consequences, we first need to assess the severity of adopted restrictions due to the pandemic. A real time economic indicator that can be employed in this respect is electricity use.

We estimate the repercussions of the lockdown using hourly data on electricity load for Switzerland overall as well as for each of the 26 cantons. Our findings reveal a decline in electricity consumption of 4 per cent (6.3 per cent if we focus on working days only) and a large variation between cantons. Whereas the decrease was less pronounced in German speaking cantons in the North-Eastern part of Switzerland, the drop was more dramatic in Ticino, Vaud or Valais where the decline in electricity use even reached -10 to -16.5 per cent. These differences are not only explained by the severity of the pandemic in terms of number of cases which were much higher in these regions but especially by the more drastic response of the local governments. For instance, Ticino enacted more stringent regulations on top of the ones decided by the federal government. Our study thus helps understand how a lockdown can affect the economy and to what extent the heterogeneity in the severity of the measures imposed is reflected into economic activity. The overall 4 per cent decline in electricity use can be translated into a 6 per cent output decrease, assuming households account for 33 per cent of electricity consumption. This is actually a lower bound estimate if, due to the required home office, the households' share in overall electricity consumption is higher than 33 per cent. An electricity demand decline of -11 or even -16 per cent as recorded in Ticino or Valais implies an output reduction of up to -16 or even -24 per cent. The approach and data employed are easily applicable to developing countries where other types of economic indicators can be less accurate and more easily subject to manipulation.

At the same time, a reduced electricity use which is reflected in lower electricity imports from France and Germany also implies lower CO_2 emissions linked to the generation of imported electricity. Thus, following the lockdown, the CO_2 equivalent of imported electricity amounted to 227.5 g and was thus 33.7 per cent lower than in the first quarter of 2019.

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