Economic Shadows of COVID-19: Electricity Trends in Tehran*

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Abstract

In the wake of the COVID-19 pandemic, understanding its economic repercussions has become increasingly important, particularly in megacities like Tehran, Iran. In this paper, I delve deeper into quantifying these impacts through the unique perspective of commercial electricity consumption. I aim to measure the pandemic's tangible economic costs by employing a difference-in-differences model. Initial observations indicate a significant reduction in electricity usage during the early phase of the pandemic, which signaled an immediate economic downturn. A gradual resurgence followed in electricity consumption as the situation stabilized. Through this investigation, I offer critical insights into the viability of using electricity consumption data as an effective tool for evaluating the economic fallout of major crises. Furthermore, this study contributes to the development of informed economic policies and recovery strategies in a post-pandemic world, highlighting the need for resilient economic planning and sustainable recovery pathways.

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1 Introduction

In the early months of 2020, the world grappled with the unprecedented public health and economic challenges posed by the COVID-19 pandemic. Iran, facing its own unique set of challenges, responded with stringent public health measures, including regional lockdowns and widespread home quarantines, to curb the virus's spread. These actions had a direct and profound impact on the country's economy. Critical sectors like manufacturing experienced halts in production, leading to a downturn in commercial activities. Illustrating this economic strain, Iran's Minister of Economy, Farhad Dezhpasand, declared on June 18, 2020, in the Islamic Council that the pandemic had inflicted a 15% blow to the nation's GDP (Gross Domestic Product). Yet, traditional metrics like GDP may not fully capture the scope of economic activity, particularly in developing nations (Chen and Nordhaus, 2011; Henderson, Storeygard, and Weil, 2012). This study seeks to bridge this gap by leveraging electricity consumption data from Tehran province as a novel indicator to assess the real economic impacts of COVID-19.

Electricity consumption is a key indicator of economic health. In simple terms, when electricity consumption drops, it often means businesses are shutting down, production is slowing, and financial resources are harder to access. This connection makes electricity use a useful tool for tracking economic activity. However, in the unique situation of COVID-19, there isn't a clear, established way to directly link changes in electricity usage to the pandemic's economic effects. Despite this, understanding this link is vital for addressing the ups and downs in the economy caused by the pandemic, which is a focus of our research proposal.

Related Literature. This study is situated at the intersection of two significant research domains. Firstly, it explores the dynamic relationship between economic performance and electricity consumption during the COVID-19 pandemic, a topic that has seen extensive scholarly attention since the onset of the pandemic. A substantial body of literature has emerged, focusing on the pandemic's multifaceted economic impacts. Altig, Baker, Barrero, Bloom, Bunn, Chen, Davis, Leather, Meyer, Mihaylov, et al. (2020) have delved into the measurement of economic uncertainty in the US and UK during the pandemic period. Similarly, Kong and Prinz (2020) utilized Google search data to analyze the effects of non-pharmaceutical interventions in the US. Research has also targeted specific market and sector shocks, including crude oil (Salisu and Adediran, 2020), financial markets (Zhang, Hu, and Ji, 2020), commodities (Chen, Qian, and Wen, 2021), international trade (Njindan Iyke, 2020; Vidya and Prabheesh, 2020), tourism (Gössling, Scott, and Hall, 2020), and environmental protection (He, Pan, and Tanaka, 2020; Magazzino, Mele, and Schneider, 2020; Ming, Zhou, Ai, Bi, and Zhong, 2020).

Particularly pertinent to this study is the body of work examining electricity market performance during the pandemic. Bahmanyar, Estebsari, and Ernst (2020) constructed a Demand Variation Index to analyze electricity consumption changes in Europe, finding a direct correlation with the severity of restrictive measures. A reduction of up to 37% in electricity consumption compared to the previous year was reported in Italy (Ghiani, Galici, Mureddu, and Pilo, 2020). Similarly, Abu-Rayash and Dincer (2020) noted a 14% decrease in Ontario, Canada, while Carvalho, Bandeira de Mello Delgado, de Lima, de Camargo Cancela, dos Siqueira, and de Souza (2021) used a joinpoint model to assess regional impacts in Brazil. In Spain, a 13.49% reduction was observed during a specific period (Santiago, Moreno-Munoz, Quintero-Jiménez, Garcia-Torres, and Gonzalez-Redondo, 2021). The approach of Elavarasan, Shafiullah, Raju, Mudgal, Arif, Jamal, Subramanian, Balaguru, Reddy, and Subramaniam (2020) and García, Parejo, Personal, Guerrero, Biscarri, and León (2021) also highlights significant consumption decreases, particularly in commerce and manufacturing.

A smaller but critical segment of this literature posits the use of electricity consumption decrease as a means to evaluate the economic costs of COVID-19 (Beyer, Franco-Bedoya, and Galdo, 2021; Fezzi and Fanghella, 2020). However, these studies lack a counterfactual framework, potentially underestimating economic costs. This study aims to address this gap by describing a methodology within a counterfactual framework, thereby contributing significantly to the ongoing research.

The second research domain relevant to this study is the long-established relationship between electricity consumption and economic growth. This line of inquiry, initiated by Kraft and Kraft (1978), has grown in relevance with technological advances and the burgeoning electronics industry. Numerous studies have focused on the link between electricity consumption and GDP, demonstrating a close correlation in many countries (Ferguson, Wilkinson, and Hill, 2000; Narayan and Singh, 2007; Shiu and Lam, 2004; Tang and Tan, 2013; Yoo, 2005). Concurrently, the role of electricity consumption in measuring the shadow economy has garnered attention, with Kaufmann and Kaliberda (2016) and Lackó (2000) demonstrating its efficacy as a yardstick for economic activity. The integration of remote sensing technology and night landscape lighting data to correct GDP estimates further underscores this relationship (Chen and Nordhaus, 2011; Egger, Loumeau, and Püschel, 2017; Henderson et al., 2012).

Our study contributes to these discussions by proposing a methodology within a counterfactual framework to estimate the economic costs of COVID-19. Unlike previous research, which lacks a robust method to quantify these costs accurately, our approach uses electricity consumption data and a DID model to provide a precise and straightforward assessment of the pandemic's economic impact. This research is innovative in its methodology and in its focus on the commercial units during the pandemic, especially in the context of Tehran Province. The study uses commercial electricity consumption data from Tehran, offering a unique perspective on how commercial units responded to the pandemic, a facet not extensively explored in existing literature.

2 Insitutional Background

In early 2020, the outbreak of the COVID-19 pandemic in China marked the beginning of a global health crisis with extensive socio-economic repercussions. This unprecedented epidemic rapidly spread worldwide, impacting public health and economies on a massive scale. By September 2021, COVID-19 had reached almost every corner of the globe, with over 230 million confirmed cases and 4.7 million deaths, sparing only a dozen countries and territories (WTO, 2020a). The pandemic's complexity was further compounded by the emergence of highly transmissible and virulent mutant strains like delta and lambda, surpassing previous epidemics like SARS and MERS in terms of infectivity and mutation rate.

The economic impact of the pandemic has been profound. The International Monetary Fund projected a 5.5% global economic growth in 2021, followed by 4.2% in 2022, while the World Trade Organization anticipated a 9.2% decline in global merchandise trade, signaling the worst recession since the Great Depression (WTO, 2020b). The International Labor Organization reported a significant rise in global unemployment, with an additional 33 million people unemployed in 2020, raising the unemployment rate to 6.5% (ILO, 2020). These statistics underscore the necessity of in-depth analyses to understand the full socio-economic impacts of Covid-19.

The virus was initially reported in Wuhan, China, in late 2019 (Zhu, Zhang, Wang, Li, Yang, Song, Zhao, Huang, Shi, Lu, et al., 2020), and quickly spread to other countries, including Iran. Iran officially confirmed its first cases in February 2020, quickly becoming a global hotspot for the virus. In response, the Iranian government implemented various public health measures, including a third-level quarantine. Despite these measures, the restrictions led to reduced economic activities and travel, particularly impacting Tehran, Iran's capital and economic hub. According to 2016 census data, Tehran had a population of approximately 8.7 million and contributed 22.1% to Iran's GDP in 2019. In 2021, Tehran's electricity consumption, a key economic indicator, was the highest in the country, with significant usage across various sectors.

This study focuses on Tehran to understand the economic costs of COVID-19, considering the city's importance in Iran's economy, particularly in the secondary industries sector. The experiences of Tehran in combating the pandemic offer valuable insights for other cities facing similar challenges. A comparative analysis is essential to estimate the pandemic's economic impact. The quarantine policy in Iran created a quasi-experimental setting, allowing for the use of a difference-in-differences (DID) model. This model compares electricity consumption in 2020 (the treatment group) with the same lunar calendar dates in 2019 (the control group), thus estimating the economic damages caused by COVID-19 post-quarantine implementation.

3 Empirical Model

The principle of causality, rather than mere correlation, is fundamental in establishing the relationship between dependent and independent variables. The difference-in-differences (DID) strategy, first introduced by Ashenfelter (1978), is based on quasi-experimental design and is instrumental in identifying causality and evaluating policy impacts (Atanasov and Black, 2020; Gu, Jiang, Zhang, and Zou, 2021; Huang and Zhang, 2021). The DID model constructs counterfactual outcomes for the treatment group using a control group, thereby estimating the causal effects of exogenous shocks.

The basic DID model can be represented as:[1]

$$Y_{it} = \beta_0 + \beta_1 treat_i + \beta_2 post_t + \beta_3 treat_i * post_t + \epsilon_{it} \quad (1)$$

This counterfactual framework helps to eliminate potential growth trends in the treatment group, thereby estimating a clean treatment effect. The treatment effect is the difference between the actual outcomes of the treatment group and its counterfactual, which represents the potential outcome had the treatment not been applied. However, this counterfactual cannot be observed directly; hence, the control group is necessary to estimate the treatment group's potential outcomes post-treatment.

From equation (1), β_3 captures the treatment effect. To obtain a clean treatment effect, two differentiations are needed. The first is based on the timing of the treatment, calculating the difference between the treatment group post- and pre-treatment. A similar method is applied to the control group. The second differentiation subtracts the control group's before-and-after differences from those of the treatment group, isolating the treatment effect. This process is summarized in Table 1, illustrating the steps to calculate ΔY_T and ΔY_C, and subsequently capturing the treatment effect.

	Before treatment	After treatment	Difference
Treatment group	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\Delta Y_T = \beta_2 + \beta_3$
Control group	β_0	$\beta_0 + \beta_2$	$\Delta Y_C = \beta_2$
Difference			$\Delta\Delta Y = \beta_3$

Table 1: The principle of DID model

In our empirical analysis, we employ the DID strategy using the Tehran COVID-19 pandemic date (1398-11-30) as the commencement of the treatment, with samples from 2019 as the treatment group. This approach assumes that the control group trends similarly to the treatment group before the intervention. Additionally, seasonal variations in electricity consumption, related to the Iranian New Year, are accounted for by offsetting the treatment group's New Year effect with that of the control group, thus excluding the New Year impact from the

[1]For convenience, the basic form is used to explain the principle of the DID model. The same result is the same in the general DID form, which is adopted in this research proposal.

analysis. The model is formulated as follows:

$$Y_{i,m,r} = \alpha + \gamma_m + \lambda_r + \delta\, post_{i,m,r} + \theta\, treat_{i,m,r} + \beta\, post_{i,m,r} * treat_{i,m,r} + \epsilon_{i,m,r} \tag{2}$$

Here, $Y_{i,m,r}$ represents the electricity consumption of commercial unit i on month m in the region r, and $post_{i,m,r}$ is equal to 1 for commercial unit i on month m in the region r post-COVID-19 pandemic and 0 pre-pandemic. $treat_{i,m,r}$ is equal to 1 for commercial unit i on month m in the region r that is in the treatment group and 0 in the control group. α is the constant, γ_m the monthly fixed effect, λ_r the region fixed effect, and $\epsilon_{i,m,r}$ the residual. β indicates the impact of COVID-19 on the economy.

4 Data

This study investigates the economic impact of COVID-19 using electricity consumption data from Tehran Province, Iran, spanning from 1397 to 1399. The dataset encompasses electricity usage information from 14,638 commercial units in the province, including the location of each unit, bi-monthly electricity consumption data, and unique unit identifiers.

The selection of this dataset was driven primarily by two factors. Firstly, the limited frequency of macroeconomic data, such as GDP, hinders the ability to promptly assess the economy's reaction to external shocks. In contrast, electricity consumption data offers a viable means to gauge the macroeconomic effects of COVID-19. This approach aligns with the understanding that electricity consumption closely mirrors economic activity, as outlined by Fezzi and Fanghella (2020). Secondly, electricity is a fundamental component of economic activities. Consequently, changes in electricity usage effectively reflect economic fluctuations.

For this research proposal, although daily consumption data would have been ideal for our analysis, we utilized bi-monthly consumption data for each unit due to certain restrictions and confidentiality concerns. Nonetheless, this data still provides a clear indication of consumption trends, allowing us to observe discernible decreases in electricity usage over the two months, thereby shedding light on the economic impact of COVID-19.

In this research, 1398-11-01 to 1399-01-31 constitutes the treatment group, while the control group consists of the corresponding samples in the previous year, matched according to the same lunar calendar dates. The Tehran COVID-19 epidemic serves as the external event shock under study. A fundamental premise of the Difference-in-Differences (DID) model is that, before the intervention (the start of the COVID-19 pandemic), the treatment and control groups would exhibit parallel trends. It's hypothesized that the electricity consumption patterns in 1399 should follow a trajectory similar to that of 1398, up until the point of the COVID-19 pandemic.

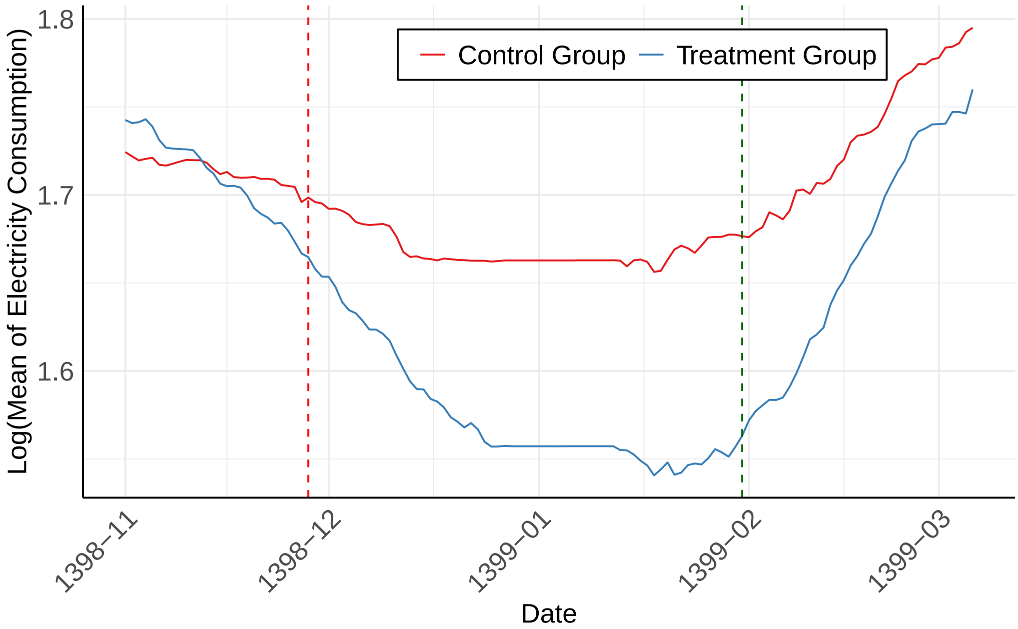

Figure 1: Electricity consumption trends for the treatment and control groups.

To validate this assumption, the study involved an analysis of the temporal trends of both groups. Figure 1 in the paper illustrates this comparison, indicating a close alignment between the control group's trends and those of the treatment group before the initial COVID-19 pandemic. This figure shows a comparison of the electricity consumption trends for the treatment and control groups. The vertical axis shows the mean electricity consumption expressed on a logarithmic basis. The horizontal axis indicates the date. The red vertical line represents the date of the Tehran COVID-19 epidemic (1398-11-28). The green reference line represents the date that most of the commercial units were reactivated following health protocols (1399-02-01).

The prolonged reduction in electricity consumption in the treatment group, which did not revert to its past year's counterpart's level until two months following the Tehran COVID-19 pandemic, further underscores the profound effect of the pandemic on the region's economic operations.

Table 2: Summary statistics

	count	mean	min	max	sd
Control Group					
id	1162369	7900.275	2	15732	4506.569
year	1162369	1397.34	1397	1398	.4736757
treat × post	1162369	0	0	0	0
treat	1162369	0	0	0	0
post	1162369	.7149305	0	1	.4514478
electricityconsumption	1162369	6.859393	0	45.83333	8.650187
LnElectricityConsumption	957190	1.423722	-4.882802	3.825011	1.484576
Treatment Group					
id	1260978	7891.84	1	15732	4510.759
year	1260978	1398.322	1398	1399	.4671628
treat × post	1260978	.6856194	0	1	.4642689
treat	1260978	1	1	1	0
post	1260978	.6856194	0	1	.4642689
electricityconsumption	1260978	6.358611	0	45.78688	8.301629
LnElectricityConsumption	1029512	1.356911	-5.236442	3.823998	1.452429
Total					
id	2423347	7895.886	1	15732	4508.75
year	2423347	1397.851	1397	1399	.6795638
treat × post	2423347	.3567591	0	1	.4790429
treat	2423347	.5203456	0	1	.499586
post	2423347	.6996786	0	1	.4583978
electricityconsumption	2423347	6.598814	0	45.83333	8.474298
LnElectricityConsumption	1986702	1.389101	-5.236442	3.825011	1.468384
N	2423347				

Table 2 provides a detailed breakdown of the descriptive statistics for the collected samples. The table is organized into three panels for ease of interpretation. The first panel delves into the details of the control group. The second panel specifically focuses on the treatment group, while the third panel offers an overview of statistics encompassing the entire sample set. This study compiled an extensive dataset comprising 2,423,347 observations of electricity consumption from 15,210 commercial units. These observations span from 28 days before the initial COVID-19 outbreak in Tehran (1398-11-01) to 63 days post-outbreak (1399-02-01), designated as the treatment group. The control group, in comparison, includes identical units and samples from the corresponding lunar calendar dates in the previous year.

Notably, the dataset originally recorded monthly electricity consumption. To align this with the research objectives, a conversion to daily consumption was executed. This was achieved by distributing the total electricity consumption recorded for each month evenly across the number of days in that month, thereby yielding daily consumption figures. The resulting analysis revealed that the mean electricity consumption in the control group was higher than that in the treatment group, a point of significant interest in understanding the impact of the COVID-19 pandemic.

5 Results

the level of economic activity in Iran dropped to a low level during the pandemic. The impact of the COVID-19 pandemic on the economy is observed from the supply side by measuring electricity consumption levels during the pandemic.

In the empirical analysis section of this paper, the economic impact of COVID-19 on Iran, particularly as reflected in electricity consumption levels, is thoroughly examined. The key findings, detailed in Table 3, involve the results of two regression models that estimate the pandemic's effect on electricity usage. The first model in Column (1) of the table does not include regional and monthly fixed effects. It indicates statistically significant coefficients for the post-treatment indicator, treatment group indicator, and their interaction term, alluding to COVID-19's notable impact on electricity consumption. However, the absence of fixed effects means this model might not fully account for unobservable, region-specific, or time-specific factors. Column (2) introduces fixed effects for regions and months to mitigate the potential influence of unobserved heterogeneity. After incorporating these fixed effects, the post-variable coefficient undergoes a significant change and loses its statistical significance, while the coefficients for treatment and the interaction term remain significant. This shift underscores the importance of considering regional and temporal factors in the analysis. The model's R-squared value also notably increases from 0.002 to 0.043, signifying an enhanced fit and robustness in assessing the pandemic's impact.

In terms of the main effect of COVID-19 on electricity consumption, the coefficient of the interaction term (treatment × post) in both models is particularly telling. In the adjusted model with fixed effects, this coefficient remains highly significant and negative, indicating a substantial and lasting impact of the pandemic on electricity usage. This suggests that COVID-19 has led to a considerable decrease in electricity consumption, reflecting its profound effect on economic activities.

Table 3: Regression Results

	(1)	(2)
post	-0.345^{***}	-0.010
	(0.017)	(0.038)
treat	-0.126^{***}	-0.125^{***}
	(0.020)	(0.020)
treat × post	-0.562^{***}	-0.563^{***}
	(0.024)	(0.023)
Constant	7.106^{***}	7.974^{***}
	(0.015)	(0.055)
Region FE	No	Yes
Month FE	No	Yes
Observations	2,423,347	2,423,347
R^2	0.002	0.043
Adjusted R^2	0.002	0.043
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$	

6 Discussion

It's also important to note that the reliability and precision of our estimates could be further enhanced with the inclusion of additional control variables and more granular data. Specifically, if variables such as weather conditions, economic indicators, public policy changes, and demographic characteristics were available and included in the model, they could help in isolating the specific impact of COVID-19 more accurately. These variables could account for other factors influencing electricity consumption that are not directly related to the pandemic. Furthermore, having access to daily data, as opposed to converting monthly data to daily, would allow for a more detailed and accurate analysis. The availability of daily data would enable us to capture short-term fluctuations and immediate impacts of the pandemic, which are likely lost or diluted in monthly aggregates. The combination of a richer set of control variables and high-resolution daily data could significantly improve the robustness of our findings, providing more nuanced insights into the complex dynamics between the COVID-19 pandemic and electricity consumption patterns.

7 Conclusion

This study, using electricity consumption data, reveals significant economic impacts of COVID-19, particularly in Tehran Province, Iran. The DID model analysis shows a substantial decrease in electricity usage after the COVID-19 pandemic compared to the previous year, indicating a marked economic downturn due to COVID-19 restrictions. This trend was particularly pronounced in commercial sectors. The study suggests that economic activities began to rebound as COVID-19 was controlled. Based on these findings, it is recommended that targeted governmental support and digital transformation strategies be employed to aid recovery, especially in sectors most affected by the pandemic. The research underscores the need for adaptable economic policies to mitigate such future crises.

References

Abu-Rayash, A. and I. Dincer (2020). Analysis of the electricity demand trends amidst the covid-19 coronavirus pandemic. *Energy Research & Social Science 68*, 101682.

Altig, D., S. Baker, J. M. Barrero, N. Bloom, P. Bunn, S. Chen, S. J. Davis, J. Leather, B. Meyer, E. Mihaylov, et al. (2020). Economic uncertainty before and during the covid-19 pandemic. *Journal of Public Economics 191*, 104274.

Ashenfelter, O. (1978). Estimating the effect of training programs on earnings. *The Review of Economics and Statistics 60*(1), 47–57.

Atanasov and Black (2020). The trouble with instruments: The need for pretreatment balance in shock-based instrumental variable designs. *Management Science 67*(2), 1270–1302.

Bahmanyar, A., A. Estebsari, and D. Ernst (2020). The impact of different covid-19 containment measures on electricity consumption in europe. *Energy Research & Social Science 68*, 101683.

Beyer, R. C., S. Franco-Bedoya, and V. Galdo (2021). Examining the economic impact of covid-19 in india through daily electricity consumption and nighttime light intensity. *World Development 140*, 105287.

Carvalho, M., D. Bandeira de Mello Delgado, K. M. de Lima, M. de Camargo Cancela, C. A. dos Siqueira, and D. L. B. de Souza (2021). Effects of the covid-19 pandemic on the brazilian electricity consumption patterns. *International Journal of Energy Research 45*(2), 3358–3364.

Chen, H., W. Qian, and Q. Wen (2021). The impact of the covid-19 pandemic on consumption: Learning from high-frequency transaction data. In *AEA Papers and Proceedings*, Volume 111, pp. 307–311. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

Chen, X. and W. D. Nordhaus (2011). Using luminosity data as a proxy for economic statistics. *Proceedings of the National Academy of Sciences 108*(21), 8589–8594.

Egger, P. H., G. Loumeau, and N. Püschel (2017). Natural city growth in the people's republic of china. *Asian Development Review 34*(2), 51–85.

Elavarasan, R. M., G. Shafiullah, K. Raju, V. Mudgal, M. T. Arif, T. Jamal, S. Subramanian, V. S. Balaguru, K. Reddy, and U. Subramaniam (2020). Covid-19: Impact analysis and recommendations for power sector operation. *Applied energy 279*, 115739.

Ferguson, R., W. Wilkinson, and R. Hill (2000). Electricity use and economic development.

Energy policy 28(13), 923–934.

Fezzi, C. and V. Fanghella (2020). Real-time estimation of the short-run impact of covid-19 on economic activity using electricity market data. *Environmental and Resource Economics 76*, 885–900.

García, S., A. Parejo, E. Personal, J. I. Guerrero, F. Biscarri, and C. León (2021). A retrospective analysis of the impact of the covid-19 restrictions on energy consumption at a disaggregated level. *Applied energy 287*, 116547.

Ghiani, E., M. Galici, M. Mureddu, and F. Pilo (2020). Impact on electricity consumption and market pricing of energy and ancillary services during pandemic of covid-19 in italy. *Energies 13*(13), 3357.

Gössling, S., D. Scott, and C. M. Hall (2020). Pandemics, tourism and global change: a rapid assessment of covid-19. *Journal of sustainable tourism 29*(1), 1–20.

Gu, Y., C. Jiang, J. Zhang, and B. Zou (2021). Subways and road congestion. *American Economic Journal: Applied Economics 13*(2), 83–115.

He, G., Y. Pan, and T. Tanaka (2020). Covid-19, city lockdowns, and air pollution: evidence from china. *MedRxiv*, 2020–03.

Henderson, J. V., A. Storeygard, and D. N. Weil (2012). Measuring economic growth from outer space. *American economic review 102*(2), 994–1028.

Huang, W. and C. Zhang (2021). The power of social pensions: Evidence from china's new rural pension scheme. *American Economic Journal: Applied Economics 13*(2), 179–205.

ILO, O. (2020). Ilo monitor: Covid-19 and the world of work.

Kaufmann, D. and A. Kaliberda (2016). Integrating the unofficial economy into the dynamics of post-socialist economies: A framework of analysis and evidence. In *The International Politics of Eurasia: v. 8: Economic Transition in Russia and the New States of Eurasia*, pp. 81–120. Routledge.

Kong, E. and D. Prinz (2020). Disentangling policy effects using proxy data: Which shutdown policies affected unemployment during the covid-19 pandemic? *Journal of Public Economics 189*, 104257.

Kraft, J. and A. Kraft (1978). On the relationship between energy and gnp. *The Journal of Energy and Development*, 401–403.

Lackó, M. (2000). Hidden economy–an unknown quantity? comparative analysis of hidden economies in transition countries, 1989–95. *Economics of transition 8*(1), 117–149.

Magazzino, C., M. Mele, and N. Schneider (2020). The relationship between air pollution and covid-19-related deaths: an application to three french cities. *Applied Energy 279*, 115835.

Ming, W., Z. Zhou, H. Ai, H. Bi, and Y. Zhong (2020). Covid-19 and air quality: Evidence from china. *Emerging Markets Finance and Trade 56*(10), 2422–2442.

Narayan, P. K. and B. Singh (2007). The electricity consumption and gdp nexus for the fiji islands. *Energy Economics 29*(6), 1141–1150.

Njindan Iyke, B. (2020). The disease outbreak channel of exchange rate return predictability: Evidence from covid-19. *Emerging Markets Finance and Trade 56*(10), 2277–2297.

Salisu, A. and I. Adediran (2020). Uncertainty due to infectious diseases and energy market volatility. *Energy Research Letters 1*(2).

Santiago, I., A. Moreno-Munoz, P. Quintero-Jiménez, F. Garcia-Torres, and M. Gonzalez-Redondo (2021). Electricity demand during pandemic times: The case of the covid-19 in spain. *Energy policy 148*, 111964.

Shiu, A. and P.-L. Lam (2004). Electricity consumption and economic growth in china. *Energy policy 32*(1), 47–54.

Tang, C. F. and E. C. Tan (2013). Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in malaysia. *Applied Energy 104*, 297–305.

Vidya, C. and K. Prabheesh (2020). Implications of covid-19 pandemic on the global trade networks. *Emerging Markets Finance and Trade 56*(10), 2408–2421.

WTO (2020a). Trade shows signs of rebound from covid-19, recovery still uncertain.

WTO (2020b). Trade shows signs of rebound from covid-19, recovery still uncertain.

Yoo, S.-H. (2005). Electricity consumption and economic growth: evidence from korea. *Energy policy 33*(12), 1627–1632.

Zhang, D., M. Hu, and Q. Ji (2020). Financial markets under the global pandemic of covid-19. *Finance research letters 36*, 101528.

Zhu, N., D. Zhang, W. Wang, X. Li, B. Yang, J. Song, X. Zhao, B. Huang, W. Shi, R. Lu, et al. (2020). A novel coronavirus from patients with pneumonia in china, 2019. *New England journal of medicine 382*(8), 727–733.