energies

MDPI

Article

The Impact of the COVID-19 Pandemic on Electricity Consumption and Economic Growth in Romania

Georgeta Soava [1], Anca Mehedintu [1], Mihaela Sterpu [2] and Eugenia Grecu [3,*]

[1] Department of Statistics and Economic Informatics, University of Craiova, A.I. Cuza 13, 200585 Craiova, Romania; georgeta.soava@edu.ucv.ro (G.S.); anca.mehedintu@edu.ucv.ro (A.M.)
[2] Department of Mathematics, University of Craiova, A.I. Cuza 13, 200585 Craiova, Romania; msterpu@inf.ucv.ro
[3] Department of Management, Politehnica University of Timisoara, Piata Victoriei 2, 300006 Timisoara, Romania
* Correspondence: eugenia.grecu@upt.ro; Tel.: +40-256-404-054

Abstract: This paper analyzes the impact of the COVID-19 pandemic on economic growth and electricity consumption and investigates the hypothesis of the influence of this consumption on the gross domestic product (GDP) for Romania. Using time series on monthly electricity consumption and quarterly GDP and a multi-linear regression model, we performed an analysis of the evolution of these indicators for 2007–2020, a comparison between their behavior during the financial crisis vs. COVID-19 crisis, and empirically explore the relationships between GDP and electricity consumption or some of its components. The results of the analysis confirm that the shock of declining activity due to the COVID-19 pandemic had a severe negative impact on electric energy consumption and GDP in the first half of 2020, followed by a slight recovery. By using a linear regression model, long-term relationships between GDP and domestic and non-household electricity consumptions were found. The empirically estimated elasticity coefficients confirm the more important impact of non-household electricity consumption on GDP compared to the one of domestic electricity consumption. In the context of the COVID-19 pandemic, the results of the study could be useful for optimizing energy and economic growth policies at the national and European levels.

Keywords: COVID-19; electricity consumption; economic growth; Romania; lockdown; household energy

Citation: Soava, G.; Mehedintu, A.; Sterpu, M.; Grecu, E. The Impact of the COVID-19 Pandemic on Electricity Consumption and Economic Growth in Romania. *Energies* **2021**, *14*, 2394. https://doi.org/10.3390/en14092394

Academic Editor: David Borge-Diez

Received: 5 March 2021
Accepted: 20 April 2021
Published: 23 April 2021

1. Introduction

In 2020, the sudden outbreak of the COVID-19 pandemic cast a shadow over the world and dealt a severe blow to the health and safety of people in all countries and to economic development, causing a global economic and social crisis [1]. Thus, the world economy is in one of the worst economic crises since the Great Depression (1929–1933), the forecasts of economists placing its impact even beyond the magnitude of that recorded during the Great Depression [2].

Emerging as a health crisis, the COVID-19 pandemic has brought societies around the world to their knees. This crisis has generated a number of severe circumstances for the economy [3], but also a lot of complex challenges [4] generated by the important shocks [5] that society has registered (closure of activities, drastic restriction of freedom of movement, physical distancing).

More than half of the world's population—over 4 billion people—have been stranded since the beginning of the pandemic, causing a sharp drop in economic output and implicitly a stagnation or a decrease in the economic growth rate of most countries. Disruptions in the economic activity also spread on the energy consumption, thus all the states register accentuated decreases of the GDP and of the energy consumption. The COVID-19 pandemic disrupted the global energy system. Global energy consumption came to a sharp halt in the upward trend observed since the last global shock in 2009.

However, with the advent of the COVID-19 pandemic, a new lifestyle has emerged around the world due to measures and restrictions taken by state governments to prevent the rapid spread of the epidemic in society. The combined effect of isolation measures in the first wave of the pandemic helped to reduce activity and, consequently, to reduce energy consumption.

The dramatic impact of the severe restrictions caused by the COVID-19 pandemic during 2020 has led to the total dismantling of economic forecasts. The energy system has seen a rapid and steady decline in electricity demand, with data on electricity consumption through lockdown periods resembling that of an "extended Sunday", all due to reductions in services and industry [6].

Thus, more and more researchers focused on analyzing the impact of the COVID-19 pandemic on the economic development of countries and implicitly on energy consumption [7,8].

The purpose of this research is to highlight the impact of the COVID-19 pandemic on economic growth and electricity consumption in Romania.

To this aim, the main indicators analyzed were nominal gross domestic product (GDP), domestic electricity consumption (DEC), household electricity consumption (HEC), and non-household electricity consumption (NHEC).

The study was conducted on the case of Romania, based on time-series for the indicators GDP, DEC, HEC, NHEC from 2007–2020, and focused on the following objectives:

- Analysis of the evolution of GDP and exploration of the impact of the COVID-19 pandemic on it;
- Analysis of the evolution of electricity consumption and exploration of the impact of the COVID-19 pandemic on it;
- Comparative analysis of the impact of the coronavirus crisis versus the financial crisis on electricity consumption, on a monthly basis, on the three components (DEC, HEC, NHEC);
- Analysis of the correlation between electricity consumption and economic growth.

The impact of COVID-19 on economic growth and how electricity consumption, which is one of the main pillars of ensuring the sustainable economic development of any state, will have long-term effects, yet are still unclear. This study provides an overview of the impact of the COVID-19 pandemic on economic growth and electricity consumption, for Romania, an emerging EU country, and could serve as arguments for establishing policy initiatives to address the pandemic and economic decline.

The implemented analysis model has as an element of originality the use of the seasonal adjustment technique on the studied economic indicators, which by linearizing the data series allowed us to obtain more significant results from an economic point of view in terms of behavior and correlations between them.

The analysis of the evolution of the indicators shows that the GDP registered a significant increase in the analyzed period, with a slight decrease during the COVID-19 pandemic. The electricity consumption registered different evolutions. Domestic electricity consumption experienced a modest increase in the analyzed period, while NHEC experienced a significant decrease and HEC a continuous increase. The COVID-19 pandemic significantly affected NHEC and DEC, an increase being registered only by HEC.

At the same time, the authors analyze the impact of electricity consumption on GDP, ascertaining the presence of a positive long-term relationship between economic growth non-household and domestic electricity consumption.

The second section of this paper begins with a review of relevant studies on economic growth, energy consumption, and the impact of the COVID-19 pandemic. The third section presents the data sets, model, and estimation methodology that were used to support the analysis. The fourth section presents a statistical analysis of the indicators, showing the evolution of Romania's real gross domestic product and electricity consumption during the analyzed period, the effects of the COVID-19 crisis on them, as well as a comparison with the effects of the financial crisis of 2008/2009. The impact of electricity consumption on economic growth is empirically investigated in Section 5, using a log multi-linear regression model. The estimation results show that non-household electricity consumption has a more significant impact on

economic growth than domestic electricity consumption, while household consumption does not have a significant influence on GDP. Finally, Sections 6 and 7 contain discussions and conclusions of this study.

2. Literature Review

2.1. The Influence of COVID-19 on GDP

Despite the differences between the crises in 2007 in the USA, and the COVID-19 pandemic triggered in 2020, the analysis of their typology constitutes a contribution to deciphering key issues [9] and possible measures to stimulate economic growth. The COVID-19 pandemic has called into question some conventional models of economic growth, economic developments uncertain future [10].

According to some authors, the global economic impact of the pandemic is extremely uncertain [11,12]. Gross domestic product (GDP) worldwide is estimated to decline between 1.3% and 5.8% in 2020 [13].

For emerging markets and developing economies, the GDP is estimated to decline by 2.5% and 1.0% in 2020, which will lead to deepening poverty in these countries. A more severe contraction of the economy in developed countries will devastate emerging and developing economies, so world GDP is projected to decline by 5.2%, which means entering the worst recession in the world after World War II and almost three times steeper than the recent global recession of 2009 [14].

The European Union (EU) has seen the sharpest decline in GDP in more than a decade, as the coronavirus lockdown has put Europe's economies at a standstill. Thus, in the first quarter of 2020, the decrease in GDP at the EU level (excluding the UK) was 4.4%, and in the second quarter compared to the same quarter of 2019 it was 16.65%. The largest declines in GDP in Europe were in France, Italy, Spain, and Slovakia, while only four countries reported positive growth in the first quarter of 2020, Ireland, Bulgaria, Sweden, and Romania [15]. In the second quarter of 2020, marked by the isolation measures taken by most EU Member States to stop the spread of the coronavirus pandemic, the GDP declined by 11.8% in the Euro area and 11.4% in the EU compared to the previous three months [16].

The eurozone economy showed signs of recovery in the third quarter but contracted again at the end of the year, amid a pandemic lockdown. According to the EU statistics agency Eurostat, GDP fell 0.7% in the fourth quarter leading to a 5.1% economic decline in 2020, while analysts expected a quarterly decline of 1.0%, and at an annual contraction of 5.4%, after a sharp recovery in the third quarter, when the euro area eased travel restrictions. For the main European countries in the fourth quarter of 2020, GDP either continued to decrease (France 1.3%, Italy 2.0%), or registered a slight increase (Spain 0.4%, and Germany 0.1%) [17].

According to the economic forecasts for autumn 2020, the Euro area economy will contract by 7.8% in 2020, followed by an increase of 4.2% in 2021 and of 3% in 2022, and the EU economy will contract by 7.4% in 2020, after which recovery is expected on the basis of an increase of 4.1% in 2021 and 3% in 2022, however, neither in the Euro area nor in the EU is production expected to return to pre-pandemic levels in 2022 [17].

The Romanian economy, given its dependence on global economic mechanisms and its integration into European and global value chains, has also been severely affected by the COVID-19 pandemic. The Romanian economy registers one of the largest contractions in Europe [16], being surpassed only by the states whose GDP is based on tourism (Spain, Croatia, Greece, Hungary, Portugal, France, Italy).

Following the global financial crisis of 2008, Romania received a USD 26 billion aid package from the International Monetary Fund and World Bank that allowed it to have one of the largest annual GDP increases in the EU in 2013–2017 [18]. With the presence of COVID-19, Romania entered an era of economic uncertainty like the rest of the world.

Romania's economy during COVID-19 regressed significantly. Romania has been and continues to be significantly affected by COVID-19. In addition, the economic impact of the lockdown procedures was extreme. Since the beginning of the pandemic, Romania

has witnessed a double reversal of its usual annual GDP growth. In 2019, Romania's GDP growth was 4.2%, down from 4.5% in 2018, while in 2020, GDP decreased by 4.8% [16].

According to the World Bank [14], the prolonged COVID-19 pandemic severely affected Romania's economic activity and short-term household income. Romania's GDP should decline by 5.7% in 2020, followed by a decline of 4.9% in 2021 when a slow growth of the economy is expected. The contraction of the Romanian economy in 2020 forecast by the World Bank is much stronger than the one of 3.8% expected by the government. Romanian government estimated a 3.9% decline of GDP in 2021, marking the beginning of the biggest crisis of the Romanian economy in the last 6 years [19].

In order to overcome the negative impact of the epidemic and continue to promote a full return to normal economic growth, governments need to introduce a series of response measures. The measures taken by governments to deal with the COVID-19 emergency have had a direct effect on both people's daily lives and the activities of most companies. The European Union's response has been more prompt and concerted than ever on both strategic axes: combating the COVID-19 pandemic and its economic effects. European states have reached a significant level of solidarity in joint interventions.

A number of studies have examined the measures implemented by governments to control the pandemic, from traffic restrictions to economy-wide shutdowns and have highlighted the need to implement effective policies for countries still facing outbreaks or a new wave of pandemic outbreaks [20–23]. The quality of government policies in managing the health aspects of the crisis influences cross-border differences in the economic impact of the pandemic so that governments that do well in managing the crisis will also have better results in terms of economic results [24]. At the same time, a series of studies analyze the impact of compulsory social distancing imposed by lockdown policies and social distancing on GDP [25].

The Romanian government responded quickly to the coronavirus pandemic in February/March 2020, implementing measures to delay the spread. However, since August, the country has been affected by another wave of growing infections, which has led to new restrictions and lockdown measures.

Although the economic contraction in 2020 appears to be less severe than initially estimated [16], uncertainty remains very high, given the recent evolution of the pandemic, and real output is unlikely to return to pre-crisis levels by the end of 2022.

2.2. The Influence of COVID-19 on Electric Energy Consumption

The decelerating economic growth which followed the financial crisis of 2008 has influenced both electricity consumption and energy efficiency. The largest reductions in electricity consumption were achieved by the countries most affected by the financial crisis (Greece, Romania, and Spain) [26].

Compared to 2007, energy consumption decreased significantly in 2009 and then in 2010, the reduction was more modest. In the following years, the structural effects and the increase of energy efficiency had a significant contribution to the stagnation or moderate increase of electricity consumption [27]. At the same time, the increased efficiency with which energy is used leads to a reduction or stagnation of energy consumption. EU-imposed standards on the need to increase energy efficiency will also help accelerate adoption and implement change in the energy mix [28].

Energy efficiency is a strategic priority for the EU, as it can clearly contribute to reducing electricity consumption with the adoption of new technologies with high energy efficiency. As a result, energy demand, despite the rapid growth in demand from households, is not growing significantly.

After experiencing the largest decline in decades, global electricity demand is expected to return modestly from 2021, mainly due to the recovery of the economy in China, India and other emerging economies. With the recovery of the world economy, it is estimated that electricity demand in 2021 will increase by about 3%, significantly weaker than the return of demand of more than 7% in 2010, the year following the global financial crisis.

The International Energy Agency estimates that energy consumption has fallen by up to 20% for each month of a national lockdown. Unfortunately, the restrictions are still in place or imposed in the second wave of the pandemic, continuing to influence electricity energy consumption, so that the return to a level of activity similar to that of 2019, that is, before the outbreak of the COVID-19 pandemic, has not yet been considered by international institutions for the next years [29].

The study of the impact of the COVID-19 pandemic on energy consumption shows that the pandemic disrupted and reduced energy consumption, creating significant uncertainty in terms of energy demand and supply [30–36].

Some researchers have studied the prospects for energy consumption during the pandemic and government-imposed restrictions and made various forecasts using various forecasting techniques [37,38].

Electricity consumption in Europe decreased by 11% in the second quarter of 2020, compared to the same period in 2019. Economic activity in European countries did not contract uniformly across the continent, the various isolation measures implemented by countries have had various consequences on energy consumption. The largest decreases in energy consumption were observed in the Member States with the strongest contractions in gross domestic product. Germany initially saw a smaller decline in consumption, due to less restrictive conditions than its neighbors and a resilient industrial sector with a relatively high share of GDP. In contrast, the countries of southern Europe (Italy, Spain, and France), have had significant decreases in energy consumption caused by measures that severely affected the tourism sector. Thus, in Italy energy consumption decreased by almost a third compared to the same period in 2019.

Energy consumption during lockdown has fallen by at least 15% in France, Spain, while in Italy, at the height of the outbreak, electricity demand has sometimes fallen to 75% [39].

Household global electricity consumption has increased by 40%, due to the fact that citizens have been forced to work from home in order to stop the spread of the virus, to the detriment of electricity consumption in non-household sectors [40]. In terms of household consumption, it is clear that it increases with the increase in household activities and proper energy management becomes a very important issue [15,41–43].

Domestic electricity consumption includes the delivered electricity by electrical energy producers to which is added the import of electricity and from which the export of electricity is deducted.

The electricity consumption of household customers consists of the electricity used for their own household consumption (excluding consumption for commercial or professional activities), and the electricity consumption of non-household customers includes the consumption of electricity other than the household [44].

As the patterns of life on the planet change in response to COVID-19, so do the energy profiles of states. Analyzing the impact of the various restrictions taken by European countries in response to COVID-19 on their electricity consumption profiles, it is found that the COVID-19 pandemic has reshaped the electricity consumption profile according to human activities [45–48].

At the same time, lockdowns caused by the COVID-19 pandemic have drastically changed the pattern of electrical energy consumption worldwide in favor of household consumption. The analysis of the impact of changes in human behavior caused by the COVID-19 pandemic on energy consumption in a household leads to the conclusion that there is a close link between energy consumption and the behavior of household residents [8,49]. There is a reduction in energy consumption in all sectors, with the exception of the residential sector where it is rising slightly due to the increased presence of residents in their homes caused by mandatory home confinement. At the beginning of summer, electricity consumption showed signs of returning to normal after the collapse of the second quarter [29].

Romania's national electricity consumption is decreasing, being 4% lower in the first 11 months of 2020, compared to the corresponding period of 2019, amid an increase in population consumption by 4.3% and a decrease in consumption in the economy by 6.3% [50].

Overall, electricity demand has fallen and is expected to remain lower as office buildings, factories, and other large electricity users slow down or shut down. With the closure of restaurants, shopping malls, factories, and office-based companies that introduced home-based work, many countries saw a decline in industrial and commercial consumption and an increase in residential demand. In this sense, some researchers have analyzed the dynamics of different patterns of energy use, climate change issues, and the relationship with social and psychological factors, concluding the need to adopt modern technology to manage problems in times of crisis [51].

The COVID-19 pandemic facilitated the discussion of some of the energy transition opportunities [35,52,53]. According to the International Energy Agency (IEA) projection for 2020, global energy consumption will be 6% lower in 2020 compared to 2019 [6], renewable energy consumption will increase by 0.8% in 2020, and electricity demand will return largely to 2019 to 2025 levels. Lower consumption, combined with an increase in renewable energy production, set renewable sources a quarterly record, accounting for 43% of the EU's energy mix [39].

The pandemic caused a drastic reduction in electricity consumption (by up to 37% compared to the same period last year) which had immediate effects on the electricity market, lowering the price and changing the characteristics of the energy mix. At the same time, there is a reduction of global gas emissions by about 8% compared to 2019, to the level they were a decade ago [54,55], having a positive impact on the global climate [56].

Using cross-sectoral information, it is found that the significant reduction in electricity consumption is strongly correlated with the number of COVID-19 cases, the degree of social distancing, and the level of commercial activity [57].

2.3. GDP and Electric Energy Consumption

The economic crisis sparked by the global financial crisis of 2007–2008 has had an impact on gross domestic product and energy consumption. From 2007 to 2014, energy consumption in the EU decreased, while GDP recovered its 2007 level after the decrease in 2009 [58].

Restrictions imposed at the level of states have severely disrupted their economic activity and also spread to energy consumption. As approximately 42% of final global electricity demand comes from industry and 22% from commercial and public services sectors, economic activity and electricity consumption are closely linked [59].

GDP growth has tended to be coupled with increasing electricity consumption, as the number of people generating more goods and services increases. Researchers have long believed that electricity stimulates global economic growth, believing that "electricity is the essence of the economy" [60].

Several authors have studied the relationship between GDP and energy consumption [61–64], providing a number of results in terms of causality, confirming the existence or non-existence of a causality (unilateral or bidirectional) [65–67]. Thus, since the 1970s, there has been a strong correlation (almost one to one) between electricity consumption and GDP, but after 1996, this correlation begins to fall apart significantly [68].

In recent years, economies, especially those of developed countries, tend to become service economies, which are less energy-consuming than production, and the energy intensity of service sectors is substantially lower than that of industrial sectors. At the same time, states are increasingly using production based on advanced techniques that lead to a substantial reduction in electricity. In this respect, GDP is often used to assess the financial effects of energy efficiency measures applied at the national and regionals level [69].

The investigation of the relationship between GDP per capita and electricity consumption was carried out for some of the countries in Southeast Europe (Bosnia and

Herzegovina, Croatia, Greece, Serbia, Slovenia, Romania, and Bulgaria) and the results show a very close relationship between GDP per capita and electricity consumption only for certain countries [70].

The analysis of the research papers shows that there is no clear consensus on the relationship between energy consumption and economic growth, which also depends on a number of other factors [71].

The impact of the COVID-19 pandemic on GDP, energy consumption, and climate change was analyzed and then forecasted by 2032 using the dynamic modeling approach [72].

The state of emergency in Romania amid the coronavirus pandemic, followed by locking down several sectors of economic activity, had a major impact on the evolution of electricity consumption, which experienced a significant decrease during the state of emergency.

3. Materials and Methods

The data used for the analysis in this paper concern the following macroeconomic indicators, for the 2007–2020 period for Romania:

- Quarterly nominal gross domestic product (GDP), expressed in million units of the national currency,
- Quarterly and monthly domestic electric energy consumption (DEC), expressed in TWh,
- Quarterly and monthly household electric energy consumption (HEC) expressed in TWh,
- Quarterly and monthly non-household electric energy consumption (NHEC) expressed in TWh.

The data time series for the quarterly GDP was extracted from Eurostat [73] by the use of SDMX-SOAP web services (Statistical Data and Metadata Exchange-Simple Object Access Protocol) that allowed to define the query structure, to establish data extraction criteria in the form of a multidimensional data cube and to integrate with EViews application through transfer functions data.

The time series for the electric energy consumption were extracted from the monthly reports of the Romanian National Energy Regulatory Authority (ANRE) [44]. The monthly data on electricity consumption were aggregated to match the quarterly data for the GDP.

For the entire obtained data set, an ETL (Extract-Transform-Load) process was performed to generate the quarterly values for the indicators in a format that would ensure the integrity and coherence of the database construction for the proposed model.

The time series containing 56 usable observations are given in Appendix A, Table A1.

Basic statistical analysis and linear time regression are used for each indicator, to analyze the evolution of GDP and electricity consumption during the period and the impact of the COVID-19 pandemic. For the statistical analyses, we used quarterly data on all indicators in Sections 4.1 and 4.2. The monthly data on electricity consumption are used in Section 4.3 only to perform the comparative statistical analysis of electricity consumption during the two crises-for the first year of the crisis and the previous year.

The impact of electricity consumption as a proxy for economic growth is investigated using a linear regression model, derived from a simplified neoclassical production function type model,

$$Y_t = c_0 + c_1 X_t + trend_t + u_t. \quad (1)$$

Here t refers to the time, u_t represents the estimation error, Y stands for the dependent variable $\log GDP$, while X stands for one or two of the explanatory variables $\log DEC$, $\log HEC$, $\log NHEC$. In some of the estimated equations in Section 4, the model includes a linear trend.

Similar models were used to explore the usefulness of other energy consumption-related indicators as proxies for economic growth in other countries [46,51,74].

The empirical analysis of the model is conducted as follows. First, the stationarity and the order of integration of the variables was established by means of unit root tests, such as Augmented Dickey-Fuller (ADF) [75]. Next, we test the co-integration relationship between the variables using the Johansen maximum likelihood method [76]. The existence

of cointegration indicates that there are long-run equilibrium relationships among the variables, and thereby, Granger causality exists among them in at least one direction.

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. A time series X is said to Granger-cause Y if it can be shown, that those X values provide statistically significant information about future values of Y. If a time series is a stationary process, the test is performed using the level values of two (or more) variables. If the variables are non-stationary, then the test is done using first (or higher) differences. In practice, it may be found that neither variable Granger-causes the other, or that each of the two variables Granger-causes the other [77].

The Granger causality test is used to find unidirectional or bidirectional causalities between the national real GDP and different classes of electricity consumption, in logarithmic form. Finally, the parameter estimates for the regression Equation (1) are evaluated using the least square (LS) regression method [78].

As only quarterly data on GDP were available, all tests and estimations in Section 5 used the quarterly data on electricity consumption.

All numerical investigations were performed using EViews 12 software product [79]. The data architecture in EViews has combined relational database technology with functions and commands through the integrated, object-oriented programming language.

At the same time, we performed a comparative analysis of the values of the indicators to assess the increase or decrease, as, according to the meaning of the variation of these indicators, the decisions of the government, of the enterprises but also of the individuals can be influenced. The data model was realized by constructing a dynamic data series consisting of parallel data series that highlights both the variation of the time characteristic and the variation in time of the studied indicators. Economic indicators were generated by logarithm as cross-sectional data series, grouped as a panel to apply group-level analysis techniques.

The dynamic series corresponding to the indicators used in the proposed model shows a cyclical variation that is repeated in certain quarters. As an element of originality in the analysis model, we used the seasonal adjustment technique and we used the method of Tramo/Seats mobile media used by Eurostat and currently recommended to the Member States of the European Union through which we linearized the series and decomposed them [62].

4. COVID-19 Pandemic Impact on Electricity Consumption and Economic Growth

4.1. Analysis of COVID-19 Impact on Economic Growth

The analysis of the evolution of Romania's GDP shows a permanent growth in the period 2007–2019, even during the crisis of 2009.

From this perspective, Romania emerged among European countries as a true "economic tiger". Unfortunately, the main engine of economic growth was represented by private consumption. To this were added tax cuts and salary increases, both in the public and in the private sector. But the sharp rise in private consumption has led to an increase in imports, and even if overall exports have increased, net exports have slowed real GDP growth.

Romania's GDP had a substantial growth rate during the analyzed period, as it increased by 148.75% in 2020 compared to 2007 (see Appendix A, Table A2). However, GDP growth slowed from +7.1% in 2017 to +4.4% in 2018 and +4.1% in 2019, indicating that the economic growth rate was on a downward trend [13]. This outlook was affected by the onset of the global COVID-19 pandemic in the first quarter of 2020, which further affected the Romanian economy since March 2020 (see Appendix A, Table A1. The decrease in the GDP growth rate from the previous years left Romania at the beginning of the crisis with weaker macroeconomic foundations than most of the member countries of Central Europe.

However, thanks to the good start of the economy in the first two months of 2020, the economy still managed to mark an upward trend which made GDP in the first quarter of 2020 maintain a growing but moderate trend, 6.62% compared to the first quarter of 2019 (see Appendix A, Table A2. Since March, however, Romania's GDP has felt the impact of the pandemic and of the state of emergency imposed by the Romanian authorities mid-

March, which led to economic stagnation in the first quarter of 2020 (−0.8%) compared to the level of GDP of the last quarter of 2019 (see Appendix A, Table A2).

Starting with March, production suddenly contracted, registering record rates in April. Thus, the second quarter of 2020 was the most affected by the pandemic, bringing a record economic decline of 12.86% compared to the first quarter, and 8.88% compared to the second quarter of 2019 (Figure 1). This figure represents a quarterly decrease in GDP not seen in the post-revolution history of the Romanian economy, exceeding the negative quarterly records of the economic-financial crisis of 2008–2009. The analysis of the quarterly evolution of the GDP value in the period 2009 compared to 2008 shows a very small variation compared to the change in the GDP value caused by the COVID-19 pandemic (Figure 2).

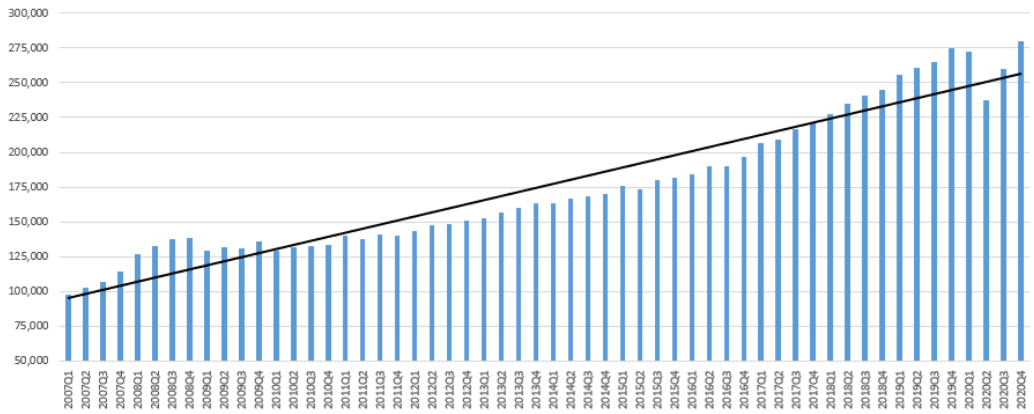


Figure 1. Evolution of GDP during the period 2007–2020.

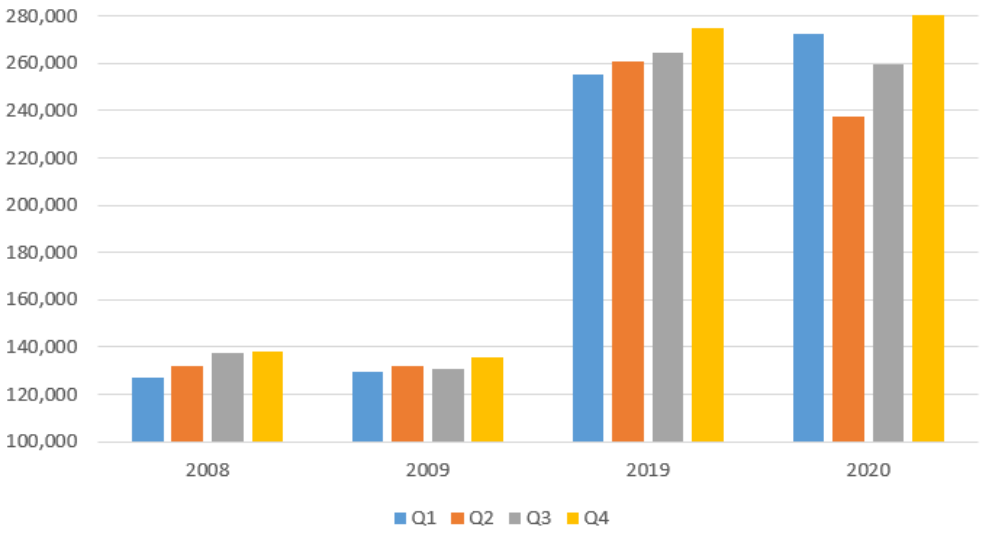


Figure 2. Evolution of GDP during financial crisis and COVID-19 crisis.

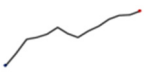
During the financial crisis (2008–2009), GDP registered the largest decrease in the 3rd quarter of 2009, compared to the similar quarter of 2008 (4.64%), while during the coronavirus crisis the largest decrease was 12.86% registered in the second quarter of 2020 compared to the previous quarter (see Appendix A, Table A2).

After this record decline, the economy began to show signs of a moderate recovery, with GDP growing by 9.33% in the fourth quarter compared to the previous quarter. Romania's GDP decreased by 1.9% compared to the third quarter of 2019, which is a decrease below the average of EU countries (4.3%).

In the second quarter of 2020 compared to the same period of 2019, GDP decreased by 8.88%, and compared to the first quarter of 2020 the decrease was 12.87%. Starting with the third quarter of 2020, there is a mitigation of the effects of the crisis due to the reduction of restrictive measures adopted by governments, so GDP increased by 9.34% in the third quarter compared to the second quarter and by 7.91% in the fourth quarter compared to the third (see Appendix A, Table A2).

The average GDP growth rate (both annually and quarterly), as well as the evolution in the period 2007–2019 shows a permanent increase even during the financial crisis, but from the second quarter of 2020, there is a slight decrease (Table 1). The actual growth rate in 2020 compared to 2019 being −0.55%, significantly greater than the forecasted one.

Table 1. Analysis of the average annual and quarterly rate (AGR) and the graph of the evolution of the indicators in the period 2007–2020.

	GDP		DEC		HEC		NHEC	
	AGR	**Evolution**	**AGR**	**Evolution**	**AGR**	**Evolution**	**AGR**	**Evolution**
Q1	8.20		0.41		2.64		0.21	
Q2	6.64		−0.52		2.80		−1.05	
Q3	7.09		0.11		2.90		0.14	
Q4	7.12		0.02		2.96		−0.05	
Annual	7.26		0.02		2.82		−0.17	

Note: AGR-Average Growth Rates.

Statistical analysis of GDP reveals a relatively heterogeneous structure, the coefficient of variation is 0.2775. GDP has a platykurtic distribution, asymmetric to the left, with values scattered over a larger range around the mean and a probability for extreme values lower (see Appendix A, Table A3).

4.2. Analysis of COVID-19 on Impact Electricity Consumption

Romania has an average energy consumption of 13.19 TWh (see Appendix A, Table A2), in the analyzed period presenting a consumption very close to the average value (see Appendix A, Table A1).

The analysis of the evolution of the internal energy consumption (Figure 3) shows a rather accentuated inter-quarterly variation. According to the EU strategy on reducing final energy consumption, it is observed that since Romania has accession to the EU, it has also reduced electricity consumption. DEC increased slightly in 2020 compared to 2007 (0.28%), partly due to the conditions imposed by the EU [28] to reduce energy consumption and also to increase energy efficiency.

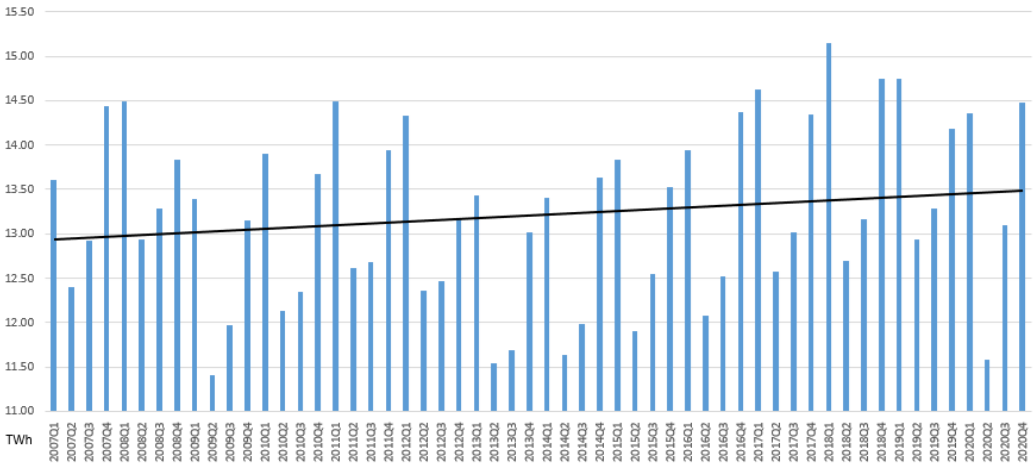


Figure 3. The evolution of electricity consumption in Romania during the period 2007–2020.

In 2014, the internal energy consumption was lower than the previous years, after which until 2018 it increased uniformly so in 2017 it would exceed the level of consumption from 2008. The year 2019 is marked by a slight decrease compared to 2018, while in 2020, starting with the second quarter, there would be significant decreases compared to the first quarter (19.4%) but also compared to the second quarter of 2019 (10.5%) which far exceed the decrease recorded in the same reference period of 2009 compared to 2008 (see Appendix A, Table A2).

During the financial crisis, the largest decrease in DEC was recorded in the second quarter of 2009 compared to the same period of 2008 (11.82%), and during the coronavirus crisis, the most pronounced decrease in DEC was recorded in the second quarter. of 2020 compared to the first (19.36%). In the third quarter of 2020, based on the slight recovery of the economy, there is also an increase in energy consumption by 13.1 compared to the second quarter, but there is a decrease compared to the same period of 2019 at 1.4%. Starting with the third quarter of 2020, a tendency of increase from one quarter to another was also noted (13.13% in the 3/2 quarter, respectively, 10.53% in the 4/3 quarter). The comparative analysis at the quarterly level indicates the seasonal character of the DEC evolution with the highest values in quarters 1 and 4 and the lowest in quarters 2 and 3 (see Appendix A, Table A2).

During the analyzed period, the domestic electricity consumption experienced an insignificant average annual growth rate (0.02%). At the quarterly level, it is observed that in the second quarter, the rate has a negative value, due to the sharp decrease in the 2 periods of crisis (Table 1).

The coefficient of variation (0.0733) reveals a homogeneous structure of internal energy consumption, with a platykurtic distribution, asymmetric to the left, with values scattered over a larger range around the mean and a probability for extreme values being lower (see Appendix A, Table A3).

Household energy consumption has experienced a slight upward trend every year, achieving an increase of 43.63% in 2020 compared to 2007 (Figure 4). In the first quarter of 2020, there is an increase of 6.6% compared to the fourth quarter of 2019, and 2.3% compared to the first quarter of 2019. This significant increase can be justified by the transfer of many activities to the teleworking system. In the second quarter of 2020, although household consumption increased by 2.2% compared to the same period of 2019, compared to the first quarter of 2020, it marked a decrease of 8.8% (see Appendix A, Table A2). The evolution recorded in this last period is the result of the partial resumption in the classical system of certain activities, but with the continued preservation of some activities in the telework system, which allows, practically, the domestic consumption of electricity to remain in an increase compared to the similar period from the previous year.

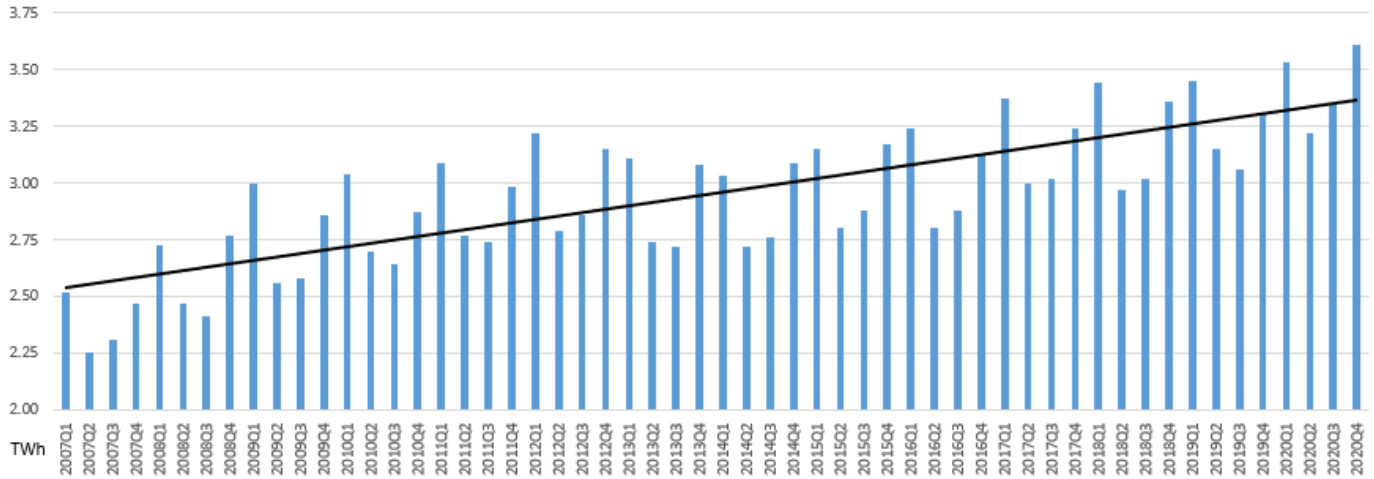


Figure 4. The evolution of household electricity consumption during the period 2007–2020.

The average annual growth rate of residential energy consumption was close to 3 (2.82%), a rate that had about the same values at the quarterly level (Table 1). The statistical analysis of household electricity consumption shows that the indicator has a relatively homogeneous structure, with a platykurtic distribution, asymmetric to the right (see Appendix A, Table A3).

In the case of non-household energy consumption, a slightly upward trend is observed (Figure 5). After the financial crisis of 2008, there was a drastic decrease in electricity consumption in 2009 (8.5%), especially for non-household consumption (13.68%), but with sharper decreases in the first three quarters. In the years following 2013, there was a slight increase, mainly due to non-household consumption.

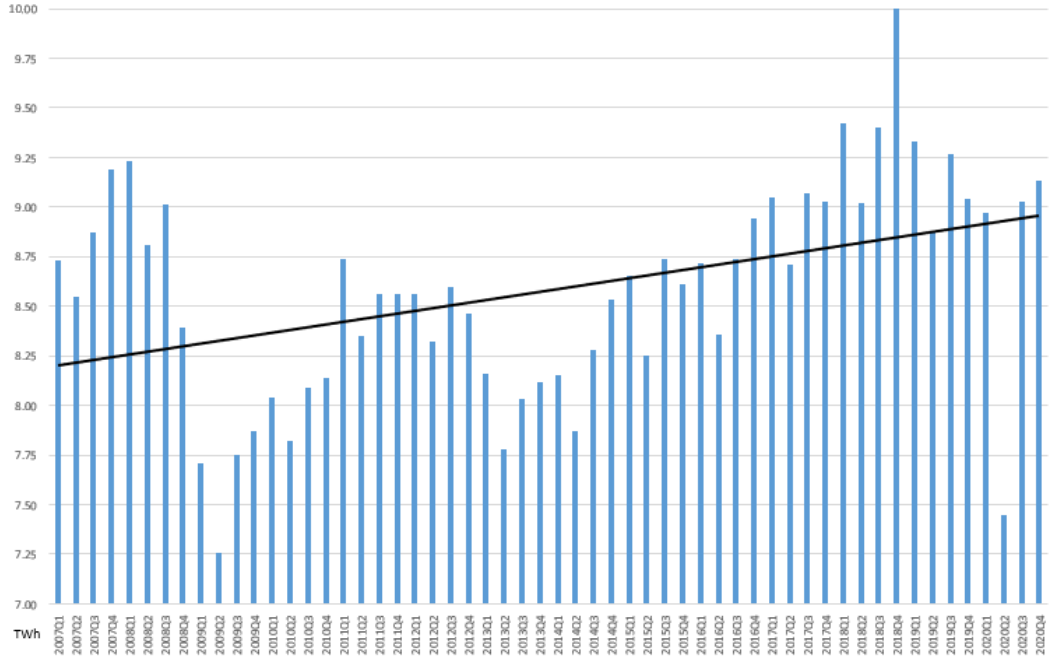


Figure 5. The evolution of non-household electricity consumption during the period 2007–2020.

After the decrease registered after EU integration, there was a significant decrease due to the financial crisis (see Appendix A, Table A1), after which non-household consumption increased permanently, but in 2019 non-household consumption decreased compared to the previous year. NHEC registered a slight decrease for 2020 as a whole compared to

2007 (2.15%), with a sharper decrease in the first three quarters of the financial crisis, but a smaller decrease during the coronavirus crisis, the most affected quarter being the second one, with a decrease of 16.10% compared to the same quarter of the previous year and of 16.95% compared to the first quarter of 2020.

The largest decrease is marked by the emergency situation imposed by government policy, so in the second quarter of 2020 non-household consumption decreased by 16.1% compared to the same period in 2019 and 16.9 compared to the first quarter of the year 2020. With the lifting of restrictions and the recovery of the economy, non-household consumption in the second quarter increased by 21.2% compared to the first quarter but continued to decline compared to the same period last year (2.6%).

Non-household consumption shows an average negative annual growth rate (−0.17%) due to both the transition from a production-based to a service-based economy and at the same time re-engineering using modern technologies with high efficiency (Table 1).

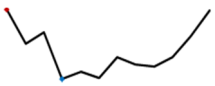
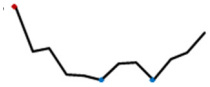
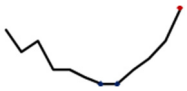
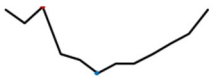
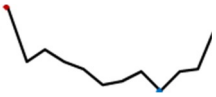
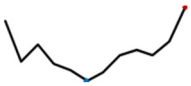
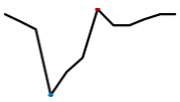
One can also observe the seasonality character of NHEC, but also the growth trend starting with the third quarter of 2020, as well as for the other three indicators analyzed. Statistical analysis of non-household electricity consumption shows that the indicator has a homogeneous structure (all values are close to each other and around the average), with an asymmetric distribution to the right, leptokurtic with several values concentrated around the average and high probabilities for the extreme values (see Appendix A, Table A3).

Our study shows that in Romania, as in other EU countries, the variation of economic growth and electricity consumption are correlated with each other.

4.3. Comparative Analysis of Electricity Consumption Evolution during the Financial Crisis vs. the COVID-19 Crisis

In order to compare the energy consumption in the two periods of crisis, we took into account the monthly values of three categories of electricity consumption (DEC, HEC, NHEC). The trends for these monthly electricity consumptions, related to the periods 2008–2009 and 2019–2020, are presented in Table 2.

Table 2. The monthly evolution of electricity consumption in the years 2008, 2009, 2019, and 2020.

Indicators	2008	2009	2019	2020
DEC				
HEC				
NHEC				

In both periods of crisis (financial and COVID-19), there is a seasonality of the evolution of all consumption analyzed (Figure 6).

Compared to the financial crisis of 2008–2009, the COVID-19 crisis marked an evolution characterized by a drastic decrease to a historical low point of both household and non-household consumption during the lock-down period (March–May 2020). However, for the same analyzed periods, in terms of household consumption, during the COVID-19 crisis, there is an increase generated by the transfer of activities from the classic system (face to face) to the teleworking system.

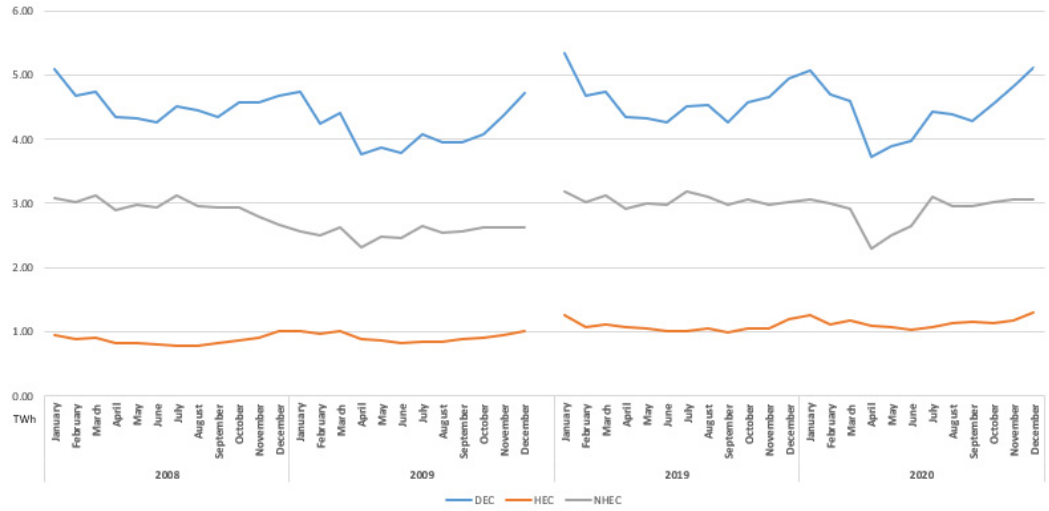


Figure 6. Comparative evolution of electricity consumption during the financial crisis vs. COVID-19 crisis.

Against the background of a seasonal evolution, the internal electricity consumption during the two crises was characterized by an important decline in the first year of the crises (2009, respectively 2020) (Figure 7).

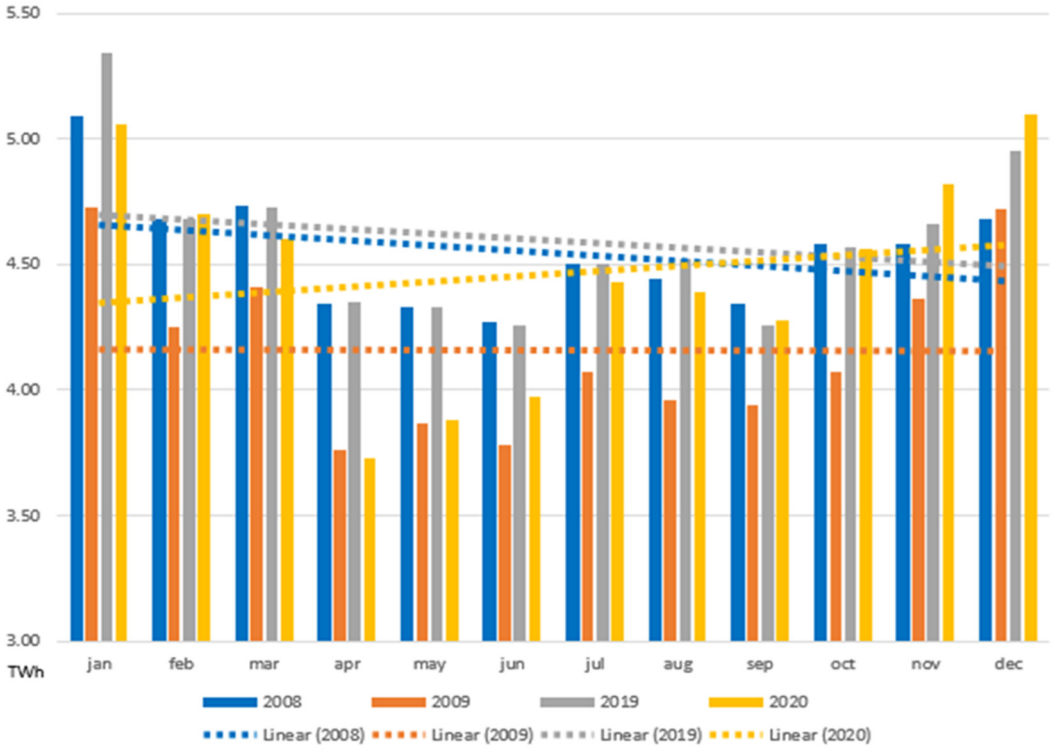


Figure 7. Comparative evolution of monthly domestic electricity consumption (DEC) during the financial crisis vs. the COVID-19 crisis.

Due to the lock-down period (March–May 2020) due to the COVID-19 pandemic, domestic electricity consumption slightly decreased in March, compared to the same period in 2019 (2.75%), so April marked a drastic decrease in energy consumption, compared to the same month of 2019 (14.25%) registering decreases even below the consumption of the same month of 2009 (0.8%). In the following months, there will be a slight increase due to the gradual resumption of economic activities.

The linearized values of domestic consumption in 2009 are constantly below those of 2008. Similarly, the values in 2020 are below those of 2019 for almost the entire year 2020, with a tendency to reverse the situation (corresponding to a slight return of activities generated by a relaxation of constraints) in the last quarter of 2020.

Household electricity consumption during both crises registered an increasing trend. If in January 2020 the value of consumption was the same as in 2019, starting with February there was a significant increase in household electricity consumption compared to the same period of the previous year, reaching the highest increase in December 2020, 8.33%, compared to the same month of 2019 (Figure 8).

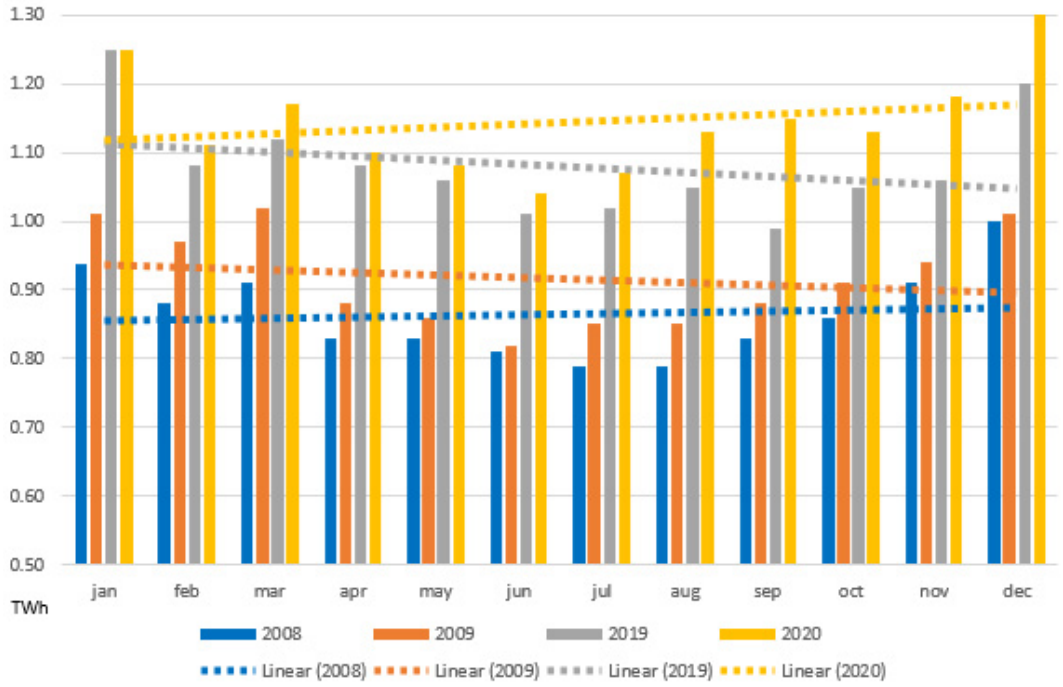


Figure 8. Comparative evolution of monthly household electricity consumption (HEC) during the financial crisis vs. the COVID-19 crisis.

This is justified by the sudden transfer of many activities to the work system from home (telework). The linearized representation of household consumption in 2020 in the COVID-19 crisis is above the representation similar from the previous year (2019), a situation that is comparable to the situation encountered in the previous financial crisis (when the linearized values of household consumption in 2009 were higher than in the previous year 2008). At the same time, the linearized values of the same household consumption during the COVID-19 crisis are well above the linearized consumption during the financial crisis, which may suggest the perpetuation of an increase in household consumption generated by the expansion of digitalization of more and more activities.

As for non-household electricity consumption, it decreased significantly during both crises. There is a slight decrease (4%), from the first month of 2020 compared to the same month of 2019 (Figure 9), followed by the most drastic reduction in non-household consumption of electricity of 21.31% to be recorded in April 2020 compared to 2019, being even lower by 1.3% than the one recorded in the same month of 2009. In the subsequent months, there is an impetuous increase in non-household consumption which corresponds to the removal of restrictions imposed on some of the economic and social activities.

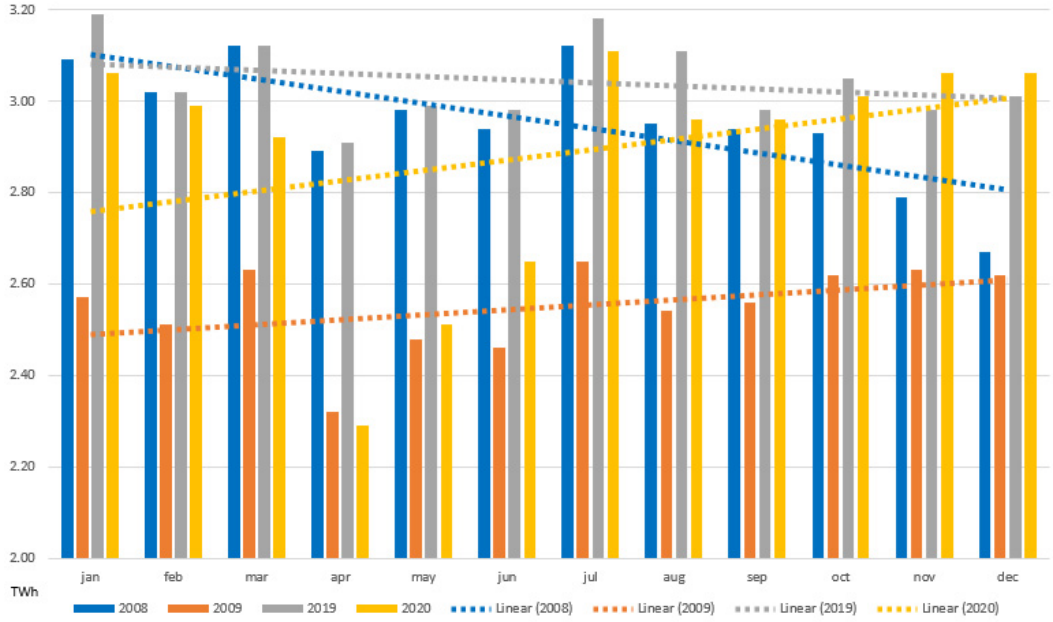


Figure 9. Comparative evolution of monthly non-household electricity consumption (NHEC) during the financial crisis vs. the COVID-19 crisis.

The linearized evolution of non-household consumption in the years preceding the onset of the crisis (financial, in 2008 and COVID-19, in 2019) have a downward trend, while the linearized evolution in the following years (for the financial crisis in 2009 and for the COVID-19 crisis in 2020) has an upward trend. Also, linearized evolutions of the non-household consumption from 2019–2020 are located in the great majority of the periods analyzed at higher levels than the similar evolutions from 2008–2009, which may indicate the permanence of an increasing trend of this type of consumption.

5. Electricity Consumption and Economic Growth. Empirical Results

In order to apply the statistical tests and empirical estimations described in Section 3, we used the quarterly data on the four indicators, the time series containing 56 useful observations for each variable, in logarithmic form.

Following the methodology presented in Section 3, we start with an ADF unit root test to test the integration properties of variables. The results, displayed in Table 3, indicate that the seasonally adjusted time series of the four variables are non-stationary. However, all first differences of these series are stationary at a confidence level of 1%, thus all-time series have the same order of integration, that is, I (1).

Table 3. Results of ADF unit root test.

Augmented Dickey-Fuller Test Statistic			L_GDP_S	L_DEC_S	L_HEC_S	L_NHEC_S
Level		t-Statistic	0.552099	−2.49664	−1.22816	−2.35955
		Prob.*	0.987	0.1218	0.656	0.1578
	Test critical values:	1% level	−3.56002	−3.55502	−3.55502	−3.55502
		5% level	−2.91765	−2.91552	−2.91552	−2.91552
		10% level	−2.59669	−2.59557	−2.59557	−2.59557
First differences		t-Statistic	−6.33128	−7.98405	−9.2574	−8.42594
		Prob.*	0	0	0	0
	Test Critical values:	1% level	−3.56002	−3.55747	−3.55747	−3.55747
		5% level	−2.91765	−2.91657	−2.91657	−2.91657
		10% level	−2.59669	−2.59612	−2.59612	−2.59612

In order to determine whether there is cointegration between electricity consumption and national GDP, a Johansen cointegration test was performed. The results given in Table 4 are indicating the existence of a cointegration relation at the 5% significance level.

Table 4. Results of Johansen cointegration test.

Sample (adjusted): 2007Q3 2020Q4
Included observations: 54 after adjustments
Trend assumption: Linear deterministic trend
Series: L_GDP_S L_DEC_S L_HEC_S L_NHEC_S
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.
None *	0.405	49.191	47.856	0.0022
At most 1	0.211	21.161	29.797	0.347
At most 2	0.139	8.346	15.494	0.389
At most 3	0.004	0.244	3.841	0.423

Trace test indicates 1 cointegrating eqn.(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level.

The cointegration test indicates the existence of long-term equilibrium relationships between variables in logarithmic form, and therefore there is at least one Granger causality between them in at least one direction. The Granger causality test gives a statistical answer to the question of whether one time series is useful to provide statistically significant information to forecast another. The results displayed in Table 5 show only unidirectional causality, namely domestic and non-household electricity consumption time series could be useful in forecasting GDP, while GDP time series only in forecasting household electricity consumption.

Table 5. Granger causality test.

Null Hypothesis:	F-Statistic	Prob.	Conclusion
L_DEC_S does not Granger Cause L_GDP_S	3.701	0.031	DEC causing GDP (significant at 5% level)
L_GDP_S does not Granger Cause L_DEC_S	0.825	0.444	Accept the null hypothesis
L_NHEC_S does not Granger Cause L_GDP_S	3.307	0.045	NHEC causing GDP (significant at 5% level)
L_GDP_S does not Granger Cause L_NHEC_S	0.815	0.449	Accept the null hypothesis
L_HEC_S does not Granger Cause L_GDP_S	0.137	0.872	Accept the null hypothesis
L_GDP_S does not Granger Cause L_HEC_S	4.429	0.017	GDP causing HEC (significant at 1% level)

These results indicate that both domestic and non-household electricity consumption have an impact on economic growth, while economic growth influences the level of electricity consumption in individual households.

The White's heteroskedasticity test performed showed an F-statistic probability value of 0.5965, thus the hypothesis of homoskedasticity cannot be rejected.

Finally, Table 6 shows the results of empirical estimations of Equation (1), in 9 different settings, regressing GDP on one or two of the electricity consumption variables, with or without trend or fixed effect. The value of the determination coefficient R^2 (R-squared) is indicated in the last column, while the standard errors of the estimated parameters are given in the parentheses. Note that for most of the equations in Table 6, the value of R^2 is close to 1, which can be attained when the estimated values match exactly the observed values.

The estimated coefficients are positive for all regressions, showing the presence of a long-term positive relationship between economic growth and electricity consumption.

Table 6. GDP, domestic, household, and non-household electricity consumption.

	Constant	Log DEC	Log HEC	Log NHEC	Linear Trend	R-Squared
(1) log GDP		1.269 *** (0.0037)				0.115
(2) log GDP		1.222 *** (0.0016)			0.016 *** (0.0005)	0.962
(3) log GDP	4.516 ** (1.767)	0.745 *** (0.1867)			0.016 *** (0.0005)	0.966
(4) log GDP				1.330 *** (0.0037)		0.195
(5) log GDP				1.284 *** (0.0023)	0.015 *** (0.0006)	0.927
(6) log GDP	8.353 *** (1.25)			0.357 ** (0.1387)	0.016 *** (0.0005)	0.96
(7) log GDP	10.817 *** (1.882)		0.096 (0.2402)		0.016 *** (0.0014)	0.956
(8) log GDP	4.838 * (2.6774)		0.357 (0.2411)	0.437 *** (0.1474)	0.014 *** (0.0014)	0.962
(9) log GDP			0.743 *** (0.1137)	0.637 *** (0.0988)	0.012 *** (0.0006)	0.96

Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Lines (1) and (2) from Table 6 show that domestic electricity consumption and national GDP vary together closely both without trends and fixed effect and as deviations around a trend. In both cases, the regressions are statistically significant at the 1% level, and their values are very close (1.269 to 1.222). For each percentage point increase/drop in electricity consumption, the national GDP increases/drops by 1.2%. The value of this elasticity coefficient is close to the one of 1.43 reported in [51] for Europe, or the one of 1.3 reported in [46] for India, including in the study both the financial crisis and the COVID-19 crisis, or the value 1.41 reported in [74].

Line (3) includes a fixed effect, and the results show again a positive long-term relationship.

Lines (4), (5), (6) replicate the regressions for non-household electricity consumptions. The results show the same evolutions as the ones for domestic electricity consumption. Remark that the elasticity coefficient is slightly bigger (1.330 to 1.284) compared to the ones in lines 1, 2. Thus, for each percentage point increase/drop in electricity consumption, the national GDP increases/drops by 1.3%. This implies that non-household electricity consumption has a more significant impact on economic growth than domestic electricity consumption.

In lines (7), (8), (9), we estimated equations including household electricity consumptions. The estimated coefficients are all positive, yet the ones corresponding to household electricity consumption are not all statistically significant. This confirms the results of the Granger causality test above, that HEC has no significant causality on GDP.

6. Discussions

The COVID-19 pandemic, although arose as a health crisis, has caused complex transformations in human society, the global economic impact of the pandemic being extremely uncertain.

The economic structure plays a major role in determining the impact of the pandemic on the economy and electricity consumption. Like for other emerging EU countries where electricity consumption is highest in residential sectors, in Romania electricity consumption was less affected, compared to developed countries where industrial (non-household) consumption is significant in total electricity consumption. At the same time, in Europe, the contribution of the services sector, especially the tourism and hospitality sector, to total energy consumption has led to a much greater impact on the economy and electricity consumption.

The decline in economic activity starting from the first and continuing strongly in the second quarter of 2020 can be detected in most European countries. Industrial activity and services registered a significant decrease, mainly in the second quarter, in Germany, Spain, France, Italy, and the United Kingdom, and thus non-household energy consumption decreased significant.

The Romanian economy, given its dependence on global economic mechanisms and its integration into European and global value chains, was strongly affected by the COVID-19 pandemic, registering one of the largest contractions in Europe. In the second quarter of 2020, compared to the first quarter of the same year, it registered a record economic decline of 12.86% never seen in the post-revolution history of the Romanian economy, far exceeding the quarterly negative records of the economic-financial crisis from 2008–2009 (4.3%). Although after this record decline, the economy has shown signs of recovery, leading to only a 0.55% contraction in 2020, compared to 2019.

The study of electricity consumption in Romania revealed that it has a seasonal character and that it generally keeps the same pattern as that of the emerging EU states. The analysis of electricity consumption over the period 2007–2020, showed that domestic electricity consumption and residential consumption generally had a positive growth rate as opposed to non-household consumption which experienced a permanent decrease, accentuated in periods of crisis. Restrictions and constraints on economic activity in Romania have had significant effects on energy consumption, significantly changing consumption profiles, as other authors have ascertained [7,31,45], as has happened in other European countries. In emerging economies, industry dominates, consuming about half of the final demand as opposed to the commercial and public services sector. Our analysis shows a decoupling of economic growth rates from changes in energy consumption.

The analysis of electricity consumption in Romania, after the financial crisis of 2008, shows a drastic quarterly decrease in 2009 in non-household electricity consumption (with a maximum of 17.6%) and domestic consumption (with an 11.8%), while household consumption increased steadily.

The decrease in non-residential consumption manifested itself in the following years, this being the consequence of a continuous transition of Romania from an industrial economy to a service-based economy but also through a significant increase in energy efficiency, due to technological improvements and behavioral changes. After the financial crisis of 2008, domestic electricity consumption in Romania registered a modest growth trend, which was interrupted by the beginning of the COVID-19 pandemic, the same as for other countries of the world [7,30,46]. This was caused by the lockdown of economic activity in several sectors, the most drastic decrease in domestic electricity consumption was recorded in the second quarter compared to the first quarter of 2020 (19.4%), which exceeds the decrease recorded in the same reference period of 2009 (14.8%).

Regarding the domestic consumption of electricity in Romania, as in other states [42,43,49], it is found that both during the financial crisis and the pandemic one it experienced a permanent growth trend, in 2020 this trend was even more significant.

Romania, like the other neighboring states, registers an increase in residential electricity consumption starting with the second quarter of 2020, which could be explained by the fact that people have carried out their activities at home.

Comparative analysis of the evolution of domestic electricity consumption during the financial crisis vs. COVID-19 crisis leads to the conclusion that, against the background of a seasonal evolution, domestic electricity consumption is characterized by a sharp decline during the onset of crises.

The estimation of the impact of electricity consumption on economic growth was carried out by using a multiple linear regression model. This involved the analysis of the stationarity of the variables and the testing of the cointegration relationship of the variables. The cointegration test indicated the existence of long-term equilibrium relations [65,66,71] consumption between GDP and domestic and non-household consumption electricity. The empirical estimations showed that the estimated coefficients are positive for all regressions,

ascertaining the presence of a positive long-term relationship between growth and electricity consumption, in accordance with a number of other studies [62–64]. It is observed that non-household electricity consumption has a more significant impact on economic growth [74] than domestic electricity consumption, and household electricity consumption does not have a significant influence on GDP [57].

7. Conclusions

Observing the downward trend of GDP at the beginning of the pandemic, we may conclude that the average GDP growth rate will be insufficient to recover Romania's development gaps compared to the EU average. The outlook for economic growth and electricity consumption remains uncertain, as the overall impact of the COVID-19 pandemic is not yet known. Thus, the shock of reduced activity will have a severe and lasting impact on non-household energy consumption.

Following the results of the analysis, we can affirm that non-household energy consumption is influenced by government policies and is a major factor influencing economic growth. The COVID-19 pandemic has highlighted the need for some governmental and European policies are needed to stimulate sustainable and sustainable economic growth, in response to the coronavirus pandemic to help Romania and other EU member states take appropriate measures to provide support to particularly affected sectors, and implicitly to the citizens.

Increasing consumption of renewable energy sources, changes in user mindsets, the fact that people are becoming more aware of their behavior and can benefit from a number of innovations (automatic sensors and controlled devices), increase the energy efficiency, which manifests itself in stagnation or even reduction of electricity consumption.

Author Contributions: All authors equally contributed to this research. All authors have read and agreed to the published version of the manuscript.

Funding: For authors Mihaela STERPU and Eugenia GRECU: This research was partially supported by Horizon2020–2017-RISE-777911 project.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The time series for the quarterly GDP was extracted from Eurostat: https://ec.europa.eu/eurostat/databrowser/view/NAIDQ_10_GDP__custom_744781/settings_1/table?lang=en, reference [73]. The time series for the electric energy consumption were extracted from the monthly reports of the Romanian National Energy Regulatory Authority (ANRE): https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica, reference [44].

Acknowledgments: The authors acknowledge the anonymous reviewers whose suggestions and comments helped improving the paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Time series for GDP and energy consumption (DEC, HEC, NHEC) for the period 2007–2020.

TIME		GDP [1]	DEC *	HEC *	NHEC *	TIME		GDP [1]	DEC *	HEC *	NHEC*
Year	Q					Year	Q				
2007	Q1	97,855.60	13.61	2.52	8.73	2014	Q1	163,071.00	13.41	3.03	8.15
	Q2	102,979.40	12.40	2.25	8.55		Q2	166,546.50	11.64	2.72	7.87
	Q3	106,593.40	12.92	2.31	8.87		Q3	168,402.70	11.98	2.76	8.28
	Q4	114,529.70	14.44	2.47	9.19		Q4	170,330.30	13.64	3.09	8.53
	Year	421,958.10	53.37	9.55	35.34		Year	675,609.80	50.67	11.60	32.83

Table A1. *Cont.*

TIME		GDP [1]	DEC *	HEC *	NHEC *	TIME		GDP [1]	DEC *	HEC *	NHEC*
Year	Q					Year	Q				
2008	Q1	126,849.70	14.50	2.73	9.23	2015	Q1	175,682.30	13.83	3.15	8.65
	Q2	132,214.10	12.94	2.47	8.81		Q2	173,002.10	11.90	2.80	8.25
	Q3	137,422.40	13.28	2.41	9.01		Q3	180,146.20	12.55	2.88	8.74
	Q4	138,299.00	13.84	2.77	8.39		Q4	181,706.10	13.52	3.17	8.61
	Year	534,785.20	54.56	10.38	35.44		Year	710,536.70	51.80	12.00	34.25
2009	Q1	129,320.60	13.39	3.00	7.71	2016	Q1	184,575.30	13.94	3.24	8.72
	Q2	132,136.50	11.41	2.56	7.26		Q2	190,319.50	12.08	2.80	8.36
	Q3	131,043.90	11.97	2.58	7.75		Q3	189,654.50	12.52	2.88	8.74
	Q4	135,955.70	13.15	2.86	7.87		Q4	197,084.50	14.37	3.12	8.94
	Year	528,456.70	49.92	11.00	30.59		Year	761,633.80	52.91	12.04	34.76
2010	Q1	129,311.30	13.90	3.04	8.04	2017	Q1	206,856.20	14.63	3.37	9.05
	Q2	132,105.50	12.13	2.70	7.82		Q2	209,498.70	12.57	3.00	8.71
	Q3	132,883.50	12.34	2.64	8.09		Q3	216,864.20	13.02	3.02	9.07
	Q4	133,403.80	13.68	2.87	8.14		Q4	221,414.40	14.35	3.24	9.03
	Year	527,704.10	52.05	11.25	32.09		Year	854,633.50	54.57	12.63	35.86
2011	Q1	139,898.60	14.49	3.09	8.74	2018	Q1	227,174.80	15.15	3.44	9.42
	Q2	137,695.30	12.61	2.77	8.35		Q2	234,720.60	12.70	2.97	9.02
	Q3	140,928.70	12.68	2.74	8.56		Q3	240,750.20	13.17	3.02	9.40
	Q4	140,145.00	13.94	2.98	8.56		Q4	245,001.50	14.75	3.36	10.09
	Year	558,667.60	53.72	11.58	34.21		Year	947,647.10	55.77	12.79	37.93
2012	Q1	143,789.00	14.33	3.22	8.56	2019	Q1	255,549.40	14.75	3.45	9.33
	Q2	147,707.80	12.36	2.79	8.32		Q2	260,560.00	12.94	3.15	8.88
	Q3	148,401.80	12.47	2.86	8.60		Q3	264,624.80	13.28	3.06	9.27
	Q4	150,543.50	13.16	3.15	8.46		Q4	274,682.90	14.18	3.31	9.04
	Year	590,442.10	52.32	12.02	33.94		Year	105,5417.00	55.15	12.97	36.52
2013	Q1	152,787.90	13.43	3.11	8.16	2020	Q1	272,475.20	14.36	3.53	8.97
	Q2	156,689.00	11.54	2.74	7.78		Q2	237,422.40	11.58	3.22	7.45
	Q3	159,866.20	11.69	2.72	8.03		Q3	259,597.20	13.10	3.35	9.03
	Q4	163,402.20	13.01	3.08	8.12		Q4	280,125.30	14.48	3.61	9.13
	Year	632,745.30	49.67	11.65	32.09		Year	104,9620.00	53.52	13.71	34.58

[1] expressed in million units of national currency–data from Eurostat database. * expressed in (TWh)-data processed by authors from the ANRE monthly reports.

Table A2. Analysis of the quarterly and annual evolution of the indicators.

Indicators	GDP (%)	DEC (%)	HEC (%)	NHEC (%)
2020/2007	148.7498	0.284815	43.63541	−2.15054
Q1(2020/2007)	178.4462	5.526161	40.35785	2.749141
Q2(2020/2007)	130.5533	−6.6129	43.11111	−12.8655
Q3(2020/2007)	143.5397	1.393189	45.02165	1.803833
Q4(2020/2007)	144.5875	0.277008	46.15385	−0.652884
Q1(2009/2008)	1.947896	−7.623318	9.970674	−16.468039
Q2(2009/2008)	−0.058693	−11.823802	3.643725	−17.593644
Q3(2009/2008)	−4.641529	−9.864458	7.053942	−13.984462
Q4(2009/2008)	−1.694372	−4.985549	3.249097	−6.197855
Q1(2020/2019)	6.623299	−2.644068	2.318841	−3.858521
Q2(2020/2019)	−8.879951	−10.510046	2.222222	−16.103604
Q3(2020/2019)	−1.899898	−1.355422	9.477124	−2.588997
Q4(2020/2019)	1.981339	2.115656	9.063444	0.995575
Q12020/Q42019	−0.803727	1.2693935	6.6465257	−0.77433628
2020(Q2/Q1)	−12.86458	−19.359331	−8.78187	−16.9453735
2020(Q3/Q2)	9.3398096	13.126079	4.0372671	21.2080537
2020(Q4/Q3)	7.9076739	10.534351	7.761194	1.10741971

Table A3. Statistical analysis of indicators.

Ind.	Mean	Max.	Min.	Skewness	Kurtosis	Jarque-Bera	Prob.	Coeff. of Variation
GDP	175,761	280,125	97,855.6	0.6125	2.230	4.8845	0.0870	0.2837
DEC	13.2142	15.15	11.41	−0.0171	2.036	2.1701	0.3379	0.0737
HEC	2.94934	3.61	2.25	−0.1083	2.555	0.5710	0.7516	0.1049
NHEC	8.57911	10.09	7.26	−0.0689	3.011	0.0446	0.9780	0.0641

References

1. IRENA—International Renewable Energy Agency. Global Renewables Outlook: Energy Transformation 2050. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf (accessed on 12 October 2020).
2. Chakraborty, I.; Maity, P. COVID-19 outbreak: Migration, effects on society, global environment and prevention. *Sci. Total Environ.* **2020**, *728*, 138882. [CrossRef]
3. Samuel, J.; Rahman, M.; Nawaz Ali, G.G.; Samuel, Y.; Pelaez, A.; Chong, P.H.J.; Yakubov, M. Feeling Positive About Reopening? New Normal Scenarios From COVID-19 US Reopen Sentiment Analytics. *IEEE Access* **2020**, *8*, 142173–142190. [CrossRef]
4. Rai, S.S.; Rai, S.; Singh, N.K. Organizational resilience and social-economic sustainability: COVID-19 perspective. *Environ. Dev. Sustain.* **2021**. [CrossRef]
5. Goodell, J.W.; Huynh, T.L.D. Did Congress trade ahead? Considering the reaction of US industries to COVID-19. *Financ. Res. Lett.* **2020**, *36*, 101578. [CrossRef]
6. IEA (International Energy Agency). Global Energy Review 2020: The Impacts of the Covid-19 Crisis on Global Energy Demand and CO_2 Emissions. Available online: https://www.iea.org/reports/global-energy-review-2020/electricity#abstract (accessed on 25 January 2021).
7. Mirnezami, S.R.; Rajabi, S. Changing Primary Energy Consumption Due to COVID-19: The Study 20 European Economies. *Int. J. Energy Econ. Policy* **2021**, *11*, 615–631. [CrossRef]
8. Aruga, K.; Islam, M.; Jannat, A. Efects of COVID-19 on Indian Energy Consumption. *Sustainability* **2020**, *12*, 5616. [CrossRef]
9. Wilkins, P.; Gilchrist, D.; Phillimore, J. Independent review of emergency economic stimulus measures: Global Financial Crisis and COVID-19. *Aust. J. Public Adm.* **2020**. [CrossRef]
10. Leach, M.; MacGregor, H.; Scoones, I.; Wilkinson, A. Post-pandemic transformations: How and why COVID-19 requires us to rethink development. *World Dev.* **2021**, *138*, 105233. [CrossRef]
11. Yu, K.D.S.; Aviso, K.B. Modelling the Economic Impact and Ripple Effects of Disease Outbreaks. *Process Integr. Optim. Sustain.* **2020**, *4*, 183–186. [CrossRef]
12. Obrenovic, B.; Du, J.G.; Godinic, D.; Tsoy, D.; Khan, M.A.S.; Jakhongirov, I. Sustaining Enterprise Operations and Productivity during the COVID-19 Pandemic: "Enterprise Effectiveness and Sustainability Model". *Sustainability* **2020**, *12*, 5981. [CrossRef]
13. McKibbin, W.; Fernando, R. The economic impact of COVID-19. In *Economics in the Time of COVID-19*; Baldwin, R., Di Mauro, B.W., Eds.; London CEPR Press: London, UK, 2020; pp. 45–52. ISBN 978-1-912179-28-2.
14. World Bank. Global Economic Prospects. Available online: https://openknowledge.worldbank.org/handle/10986/33748 (accessed on 25 September 2020).
15. IEA (International Energy Agency). The Coronavirus Crisis Reminds us That Electricity is More Indispensable Than Ever. Available online: https://www.iea.org/commentaries/the-coronavirus-crisis-reminds-us-that-electricity-is-more-indispensable-than-ever (accessed on 28 December 2020).
16. European Commission. Eurostat—European Statistics. Available online: https://ec.europa.eu/info/departments/eurostat-european-statistics_ro (accessed on 5 January 2021).
17. European Commission. Previziunile Economice din vara Anului 2020: O Recesiune și mai Profundă, cu Divergențe și mai Accentuate. Available online: https://ec.europa.eu/commission/presscorner/detail/ro/ip_20_1269 (accessed on 4 January 2021).
18. Pîrvu, R.; Bădîrcea, R.; Manta, A.; Lupăncescu, M. The Effects of the Cohesion Policy on the Sustainable Development of the Development Regions in Romania. *Sustainability* **2018**, *10*, 2577. [CrossRef]
19. World Bank. Europe and Central Asia Economic Update, Fall 2020: COVID-19 and Human Capital. Available online: https://openknowledge.worldbank.org/handle/10986/34518 (accessed on 10 November 2020).
20. Prol, J.L.; Sungmin, O. Impact of COVID-19 Measures on Short-Term Electricity Consumption in the Most Affected EU Countries and USA States. *iScience* **2020**, *23*, 101639. [CrossRef]
21. Qarnain, S.S.; Sattanathan, M.; Sankaranarayanan, B.; Ali, S.M. Analyzing energy consumption factors during coronavirus (COVID-19) pandemic outbreak: A case study of residential society. *Energy Sources Part A Recovery Util. Environ. Eff.* **2020**. [CrossRef]
22. Werth, A.; Gravino, P.; Prevedello, G. Impact analysis of COVID-19 responses on energy grid dynamics in Europe. *Appl. Energy* **2021**, *281*, 116045. [CrossRef]
23. Prol, J.L.; Sungmin, O. Impact of COVID-19 Measures on Electricity Consumption. *MPRA*. 2020. Paper 101649. Available online: https://mpra.ub.uni-muenchen.de/101649/ (accessed on 25 January 2021).

24. König, M.; Winkler, A. COVID-19 and Economic Growth: Does Good Government Performance Pay Off? *Intereconomics* **2020**, *55*, 224–231. [CrossRef]
25. König, M.; Winkler, A. COVID-19: Lockdowns, Fatality Rates and GDP Growth Evidence for the First Three Quarters of 2020. *Intereconomics* **2021**, *56*, 32–39. [CrossRef]
26. Andreoni, V. The energy metabolism of countries: Energy efficiency and use in the period that followed the global financial crisis. *Energy Policy* **2020**, *139*, 111304. [CrossRef]
27. Eurostat. Electricity Production, Consumption and Market Overview. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview#Household_electricity_consumption (accessed on 29 March 2021).
28. European Commission. Energy Efficiency Directive. Available online: https://ec.europa.eu/energy/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive_en#:~{}:text=The%202012%20energy%20efficiency%20directive%20Directive%202012%2F27%2FEU%20establishes,primary%20energy%20or%201086%20Mtoe%20of%20final%20energ (accessed on 29 March 2021).
29. IEA (International Energy Agency). An Energy World in Lockdown. World Energy Outlook 2020. Available online: https://www.iea.org/reports/world-energy-outlook-2020/an-energy-world-in-lockdown (accessed on 9 December 2020).
30. Awomuti, A.; Bin, X.; Rodriguez Torres, E.; Otonoku, T. Covid-19 and the Impact on Energy Consumption: An Environmental Assessment of Ontario Canada. *Int. J. Sci. Res. Publ.* **2020**, *10*, 857–865. [CrossRef]
31. Aktar, M.A.; Alam, M.M.; Quasem Al-Amin, A. Global economic crisis, energy use, CO 2 emissions, and policy roadmap amid COVID-19. *Sustain. Prod. Consum.* **2021**, *26*, 770–781. [CrossRef]
32. Czosnyka, M.; Wnukowska, B.; Karbowa, K. Electrical energy consumption and the energy market in Poland during the COVID-19 pandemic. In Proceedings of the 2020 Progress in Applied Electrical Engineering (PAEE), Koscielisko, Poland, 21–26 June 2020; IEEE: Piscataway, NJ, USA, 2020; pp. 1–5. [CrossRef]
33. Edomah, N.; Ndulue, G. Energy transition in a lockdown: An analysis of the impact of COVID-19 on changes in electricity demand in Lagos Nigeria. *Glob. Transit.* **2020**, *2*, 127–137. [CrossRef]
34. Jiang, P.; Fan, Y.; Klemeš, J.J. Impacts of COVID-19 on energy demand and consumption: Challenges, lessons and emerging opportunities. *Appl. Energy* **2021**, *285*, 116441. [CrossRef] [PubMed]
35. Halbrügge, S.; Schott, P.; Weibelzahl, M.; Buhl, H.U.; Fridgen, G.; Schöpf, M. How did the German and other European electricity systems react to the COVID-19 pandemic? *Appl. Energy* **2021**, *285*, 116370. [CrossRef]
36. Santiago, I.; Moreno-Munoz, A.; Quintero-Jiménez, P.; Garcia-Torres, F.; Gonzalez-Redondo, M.J. Electricity demand during pandemic times: The case of the COVID-19 in Spain. *Energy Policy* **2021**, *148*, 111964. [CrossRef] [PubMed]
37. Özbay, H.; Dalcali, A. Effects of COVID-19 on electric energy consumption in Turkey and ANN-based short-term forecasting. *Turk. J. Electr. Eng. Comput. Sci.* **2021**, *29*, 78–97. [CrossRef]
38. Alhajeri, H.M.; Almutairi, A.; Alenezi, A.; Alshammari, F. Energy Demand in the State of Kuwait During the Covid-19 Pandemic: Technical, Economic, and Environmental Perspectives. *Energies* **2020**, *13*, 4370. [CrossRef]
39. IEA (International Energy Agency). Exploring the Impacts of the Covid-19 Pandemic on Global Energy Markets, Energy Resilience, and Climate Change. Available online: https://www.iea.org/topics/covid-19 (accessed on 21 December 2020).
40. World Economic Forum. These 3 Charts Show What COVID-19 Has Done to Global Energy Demand. Available online: https://www.weforum.org/agenda/2020/08/covid19-change-energy-electricity-use-lockdowns-falling-demand/ (accessed on 29 September 2020).
41. Cheshmehzangi, A. COVID-19 and household energy implications: What are the main impacts on energy use? *Heliyon* **2020**, *6*, e05202. [CrossRef]
42. Snow, S.; Bean, R.; Glencross, M.; Horrocks, N. Drivers behind Residential Electricity Demand Fluctuations Due to COVID-19 Restrictions. *Energies* **2020**, *13*, 5738. [CrossRef]
43. Qarnain, S.S.; Muthuvel, S.; Bathrinath, S. Review on government action plans to reduce energy consumption in buildings amid COVID-19 pandemic outbreak. *Mater. Proc.* **2020**. [CrossRef]
44. ANRE—Autoritatea Naţională de Reglementare în Domeniul Energiei. Available online: https://www.anre.ro/ro/energie-electrica/rapoarte (accessed on 25 January 2021).
45. Bahmanyar, A.; Estebsari, A.; Ernst, D. The impact of different COVID-19 containment measures on electricity consumption in Europe. *Energy Res. Soc. Sci.* **2020**, *68*, 101683. [CrossRef] [PubMed]
46. Beyer, R.C.M.; Franco-Bedoya, S.; Galdo, V. Examining the economic impact of COVID-19 in India through daily electricity consumption and nighttime light intensity. *World Dev.* **2021**, *140*, 105287. [CrossRef]
47. Bulut, M. Analysis of the Covid-19 Impact on Electricity Consumption and Production. *Sak. Univ. J. Comput. Inf. Sci.* **2020**, *3*, 283–295. [CrossRef]
48. García, S.; Parejo, A.; Personal, E.; Ignacio Guerrero, J.; Biscarri, F.; León, C. A retrospective analysis of the impact of the COVID-19 restrictions on energy consumption at a disaggregated level. *Appl. Energy* **2021**, *287*, 116547. [CrossRef]
49. Cvetkovic', D.; Nešovic´, A.; Terzic´, I. Impact of people's behavior on the energy sustainability of the residential sector in emergency situations caused by COVID-19. *Energy Build.* **2021**, *230*, 110532. [CrossRef]

50. Agerpres. Consumul Final de Energie Electrică al României a Scăzut cu 4% în Primele 11 luni ale Anului Trecut. Available online: https://www.agerpres.ro/economic-intern/2021/01/15/consumul-final-de-energie-electrica-al-romaniei-a-scazut-cu-4-in-primele-11-luni-ale-anului-trecut--643512 (accessed on 19 November 2020).
51. Chen, S.; Igan, D.; Pierri, N.; Presbitero, A.F. *Tracking the Economic Impact of COVID-19 and Mitigation Policies in Europe and the United States*. Working Paper No. 20/125; International Monetary Fund Working Papers, Special Series on COVID-19. 2020, pp. 1–10. Available online: https://www.imf.org/en/Publications/WP/Issues/2020/07/10/Tracking-the-Economic-Impact-of-COVID-19-and-Mitigation-Policies-in-Europe-and-the-United-49553 (accessed on 25 January 2021).
52. Klemeš, J.J.; Fan, Y.; Jiang, P. COVID-19 pandemic facilitating energy transition opportunities. *Int. J. Energy Res.* **2021**, *45*, 3457–3463. [CrossRef]
53. Jin, S. COVID-19, climate change, and renewable energy research: We are all in this together, and the time to act is now. *Acs Energy Lett.* **2020**, *5*, 1709–1711. [CrossRef]
54. Ghiani, E.; Galici, M.; Mureddu, M.; Pilo, F. Impact on Electricity Consumption and Market Pricing of Energy and Ancillary Services during Pandemic ofCOVID-19 in Italy. *Energies* **2020**, *13*, 3357. [CrossRef]
55. Iqbal, S.; Bilal, A.R.; Nurunnabi, M.; Iqbal, W.; Alfakhri, Y.; Iqbal, N. It is time to control the worst: Testing COVID-19 outbreak, energy consumption and CO2 emission. *Environ. Sci. Pollut. Res.* **2020**. [CrossRef]
56. Saadat, S.; Rawtani, D.; Hussain, C.M. Environmental perspective of COVID-19. *Sci. Total Environ.* **2020**, *728*, 138870. [CrossRef]
57. Ruan, G.; Wu, D.; Zheng, X.; Zhong, H.; Kang, C.; Dahleh, M.A.; Sivaranjani, S.; Xie, L. A Cross-Domain Approach to Analyzing the Short-Run Impact of COVID-19 on the U.S. Electricity Sector. *Cornell Univ. Comput. Sci. Comput. Soc.* **2020**, arXiv:2005.06631. [CrossRef]
58. Ozturk, I.; Acaravci, A. Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries. *Appl. Energy* **2011**, *88*, 2885–2892. [CrossRef]
59. IEA (International Energy Agency). Global Overview: The Covid-19 Pandemic—Electricity Market Report—December 2020. Available online: https://www.iea.org/reports/electricity-market-report-december-2020 (accessed on 30 March 2021).
60. Dominion Virginia Power. Powering Virginia. Available online: http://www.dom.com/dominion-virginia-power/powering-virginia/index.jsp (accessed on 30 March 2021).
61. Abbasi, K.R.; Hussain, K.; Abbas, J.; Adedoyin, F.F.; Shaikh, P.A.; Yousaf, H.; Muhammad, F. Analyzing the role of industrial sector's electricity consumption, prices, and GDP: A modified empirical evidence from Pakistan. *Aims Energy* **2021**, *9*, 29–49. [CrossRef]
62. Zangoei, S.; Salehnia, N.; Khodaparast Mashhadi, M. A comparative study on the effect of alternative and fossil energy consumption on economic growth and foreign direct investment in selected countries using SUR approach. *Environ. Sci. Pollut. Res.* **2021**. [CrossRef]
63. Chontanawat, J. Dynamic Modelling of Causal Relationship between Energy Consumption, CO_2 Emission, and Economic Growth in SE Asian Countries. *Energies* **2020**, *13*, 6664. [CrossRef]
64. Kahouli, B. Does static and dynamic relationship between economic growth and energy consumption exist in OECD countries? *Energy Rep.* **2019**, *5*, 104–116. [CrossRef]
65. Liu, W.C. The Relationship between Primary Energy Consumption and Real Gross Domestic Product: Evidence from Major Asian Countries. *Sustainability* **2020**, *12*, 2568. [CrossRef]
66. Azam, A.; Rafiq, M.; Shafique, M.; Ateeq, M.; Yuan, J. Causality Relationship between Electricity Supply and Economic Growth: Evidence from Pakistan. *Energies* **2020**, *13*, 837. [CrossRef]
67. Dey, S.R.; Tareque, M. Electricity consumption and GDP nexus in Bangladesh: A time series investigation. *J. Asian Bus. Econ. Stud.* **2019**, *27*, 35–48. [CrossRef]
68. Hirsh, R.F.; Koomey, J.G. Electricity Consumption and Economic Growth: A New Relationship with Significant Consequences? *Electr. J.* **2015**, *28*. [CrossRef]
69. European Commission. Eficiența energetică. Fișe Descriptive Despre Uniunea Europeană. Available online: https://www.europarl.europa.eu/factsheets/ro/sheet/69/eficienta-energetica (accessed on 30 March 2021).
70. Džananović, E.; Dacić-Lepara, S. The Relationship between GDP and Electricity Consumption in Southeast European Countries. In *Advanced Technologies, Systems, and Applications. Lecture Notes in Networks and Systems*; Hadžikadić, M., Avdaković, S., Eds.; Springer International Publishing AG: Cham, Switzerland, 2017; Volume 3. [CrossRef]
71. Cvijovic, J.; Obradovic, T.; Knezevic, S. A literature survey on relationship between renewable energy consumption and economic growth. *Ekon. Poljopr. Econ. Agric.* **2020**, *67*, 991–1010. [CrossRef]
72. Khurshid, A.; Khan, K. How COVID-19 shock will drive the economy and climate? A data-driven approach to model and forecast. *Environ. Sci. Pollut. Res.* **2021**, *28*, 2948–2958. [CrossRef]
73. European Comission. Eurostat-Database. Available online: https://ec.europa.eu/eurostat/web/main/data/database (accessed on 25 January 2021).
74. Erdal, G.; Erdal, H.; Esengün, K. The Causality between energy consumption and economic growth in Turkey. *Energy Policy* **2008**, *36*, 3838–3842. [CrossRef]
75. Dickey, D.A.; Fuller, W.A. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* **1981**, *49*, 1057–1072. [CrossRef]
76. Johansen, S.; Juselius, K. Maximum likelihood estimation and inferences on co-integration with approach. *Oxf. Bull. Econ. Stat.* **1990**, *52*, 169–209. [CrossRef]

77. Engle, G.; Granger, C. Co-Integration and error correction: Representation, estimation, and testing. *Econometrica* **1987**, *55*, 251–276. [CrossRef]
78. Phillips, C.B.; Hansen, B. Statistical inference in instrumental variables regression with I (1) processes. *Rev. Econ. Stud.* **1990**, *57*, 99–125. [CrossRef]
79. EViews 12. Available online: http://www.eviews.com/home.html (accessed on 6 January 2021).