Impact of the COVID-19 Pandemic on the Romanian Electricity Consumption

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Abstract: In the paper we analysed the electricity consumption in Romania, during the period between March and December 2020. The SARIMAX econometric models are used in order to estimate the contrafactual for monthly electricity consumption during the COVID-19 pandemic. The research findings show that the total domestic electricity consumption fell between March and August 2020 and registered a slow recovery by the end of the year. This dynamic is explained by a drastic drop in non-household electricity consumption, while the electricity consumption of household customers is systematically above the long-term trend.

Keywords: Electricity consumption, SARIMAX models, COVID-19 pandemic
JEL Classification: C22, Q41, Q47

1. Introduction

The COVID-19 pandemic had a tremendous impact on almost all economic (and social) activities, all over the world. Energy production and consumption have not been bypassed by the impact of the pandemic. The International Energy Agency (IEA) estimates that, statistically, global energy demand has fallen on average by 5% in 2020 compared to 2019, and energy investment has fallen by 18% (International Energy Agency (IEA), 2020, p. 61) and, moreover, "the worst effects are felt among the most vulnerable" (p. 18).

Zong et. al. (Zhong, et al. 2020) tried to perform "a comprehensive review of the impacts that the pandemic has caused on the electricity sector" (p. 489). On the background of the general decrease in demand, they identified an increase in the share of renewable energy in total energy production and consumption, a reduction in investment and a higher pressure on system operators, generated by increasing uncertainty about the evolution of demand. Bahmanyar, Estebsari, & Ernst (2020) detects a strong impact of the COVID-19 pandemic on electricity consumption and production, maintenance of facilities, operational activities and development plans in some EU countries (Belgium, Italy, Netherlands, Spain, Sweden and UK). Studies show a sharp drop in demand for large energy consumers (factories, commercial buildings) and extra energy demands for residential sector (Zhong, et al. 2020, 490), (Jiang, Fan and Klemeš 2021, 2), (Bahmanyar, Estebsari and Ernst 2020, 3). García, et. al. (2021) showed that in Huelva (Spain) "residential customers have increased their consumption around 15% during full lockdown and 7.5% during the reopening period. In contrast, globally, non-residential customers have decreased their consumption by 38% during full lockdown and 14.5% during the reopening period" (García, et al. 2021, 1).

In the paper we analysed the impact of the COVID-19 pandemic on electricity consumption in Romania, between March and December 2020. First, the analysis was performed globally (monthly dynamics of domestic electricity consumption). Second, to explain the global dynamics, we conducted structural studies: the evolution of the pandemic consumption behaviour of household customers, on the one hand, and, on the other hand, the monthly dynamics of electricity consumption of non-household customers.

2. Data and methodology

To analyze the impact induced by the COVID-19 pandemic on electricity consumption, we used data published by Romanian National Energy Regulatory Authority (Autoritatea Națională de Reglementare în Domeniul Energiei, ANRE) in *Monthly Electricity Market Monitoring Reports*[1]. The data series analysed refer to "Domestic

[1] Data available at: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica (accessed on March 21, 2021)

electricity consumption", "Household consumption" and "Non-household consumption" in Terawatt-hour (TWh).

Usually, the impact analyses directly compare the data recorded for 2020 with the consumption data for 2019, or possibly with the average consumption of the two or three previous years (García, et al. 2021, 5). Unlike these approaches, in this paper we have estimated electricity consumption for 2020 under normal conditions using SARIMAX models (**S**easonal **A**utoregressive **I**ntegrated **M**oving **A**verage with e**X**ogenous factors). And the prospective estimates were considered as a benchmark (as counterfactual) for monthly electricity consumption and were compared with the data recorded in the special conditions induced by COVID-19 pandemic. To specify the structure of SARIMAX models, we examined, through HEGY seasonal unit root tests (Hylleberg, et al. 1990), the existence of seasonal and nonseasonal unit roots in a monthly time series related to electricity consumption in Romania (domestic consumption, household consumption, respectively, non-household consumption). The tests were applied both for the level data series and for the series from which the polynomial trends were eliminated.

The definition of the notions used in the paper is in accordance with the national practice, described in the *Law on electricity and natural gas* no. 123/2012. According to art. 3 of the respective law:

- ✓ *final customer* is "any natural or legal person who buys electricity for his own consumption" (paragraph 13);
- ✓ *household customer* is "the customer who buys electricity for his own household consumption, excluding consumption for commercial or professional activities (paragraph 15), and the
- ✓ *non-household customer* is "any natural or legal person who buys electricity that is not for his own household consumption; this category also includes electricity producers, network operators and wholesale customers" (paragraph 14).

2.1. Domestic electricity consumption

Domestic electricity consumption is calculated in Terawatt-hour (TWh), through a balance relationship:

$$\text{Domestic consumption} = \text{Electricity supplied} + \text{Import} - \text{Export} \quad (1)$$

The monthly dynamics of domestic electricity consumption, between 2011-2020, is presented in Fig. 1.

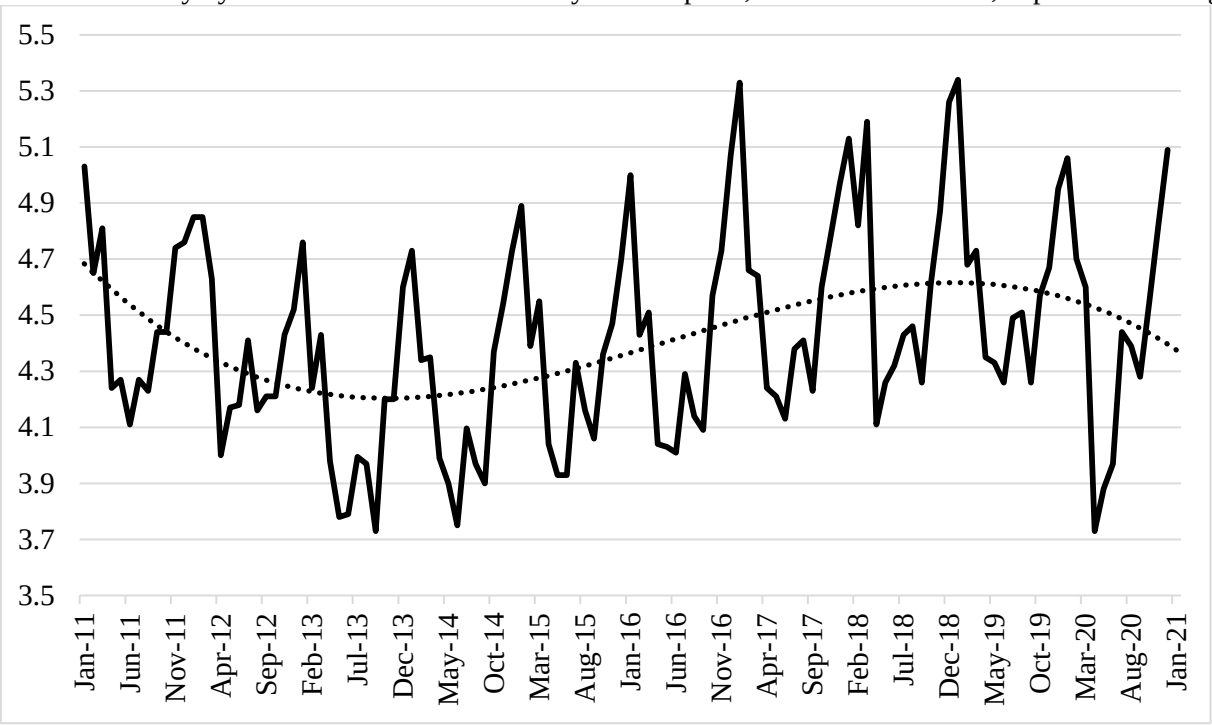

Figure 1. Domestic electricity consumption (TWh)

Source: National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica.

Figure 1 suggests the presence of a polynomial long-term trend, a strong seasonal fluctuation and the relative decrease in domestic electricity consumption between March and June 2020. Annex 1 details the results of the application of a HEGY type test for seasonal and nonseasonal unit roots in a monthly time series regarding the domestic electricity consumption in Romania between 2011 and 2020. The test results show both the existence of a non-seasonal root (at zero frequency) and the presence of seasonal unit roots with 3 and respectively 12 months per cycle. Similar conclusions are drawn if the polynomial trend is removed from the initial series.

2.2. The electricity consumption of household customers

The electricity consumption of household customers, in the period 2011-2020, is presented in Figure 2. The graph of the series suggests the presence of significant seasonal fluctuations, on the background of a polynomial trend, which is maintained in the conditions of the COVID-19 pandemic.

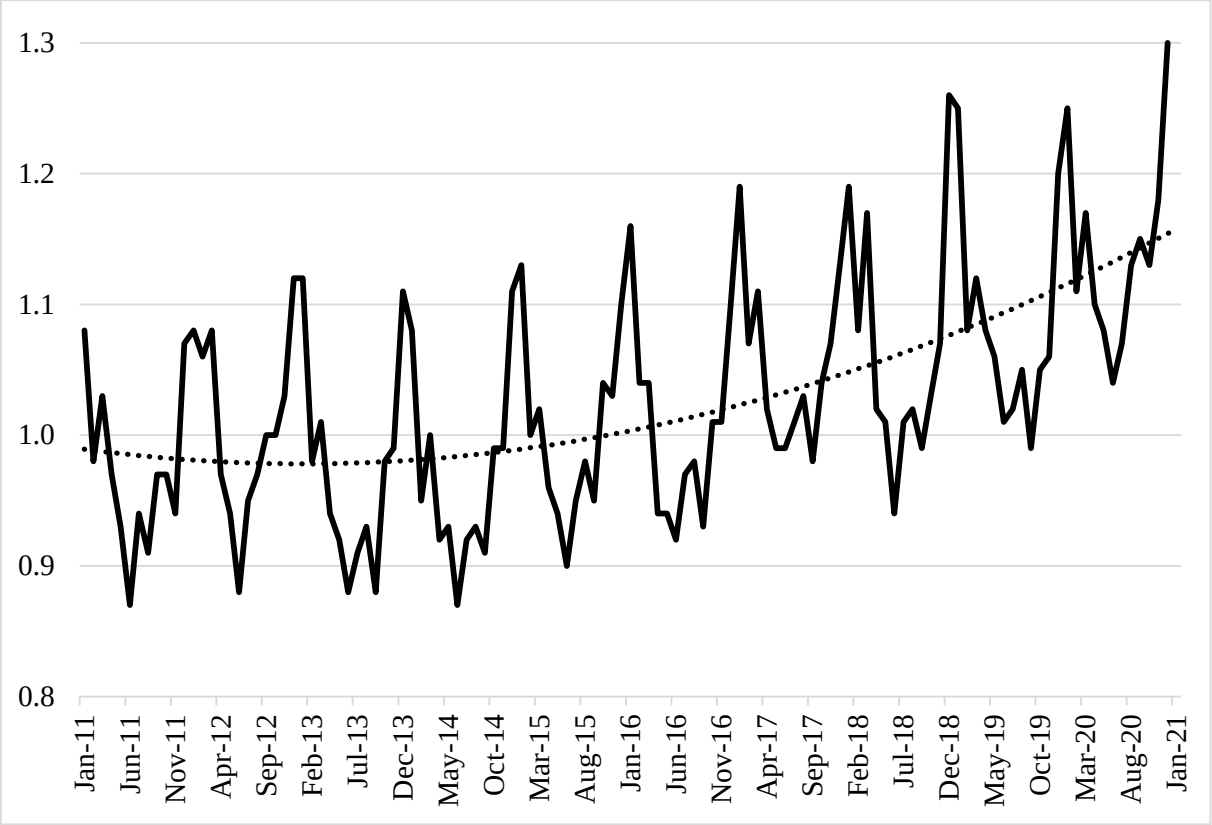

Figure 2. Electricity consumption of household customers

Source: National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica.

Annex 1 details the results of the application of a HEGY type test for seasonal and nonseasonal unit roots in a monthly time series regarding the electricity consumption of household customers. The HEGY test shows the existence of a non-seasonal root (at zero frequency), for the level series and the presence of seasonal unit roots with 12 months per cycle. If the polynomial trend is removed from the initial series, then the HEGY test identifies only seasonal unit roots with 12 months per cycle.

2.3. The electricity consumption of non-household customers

The behaviour of *non-household customers regarding electricity consumption* during the 2011-2020 period is shown in Figure 3. The graph of the non-household customers regarding electricity consumption series suggests the presence of significant seasonal fluctuations, against the background of a polynomial trend. Also, atypical values (outliers) appear in October 2018 and April, 2019.

Annex 1 details the results of applying a HEGY type test for seasonal and nonseasonal unit roots in a monthly time series related to non-household electricity consumption.

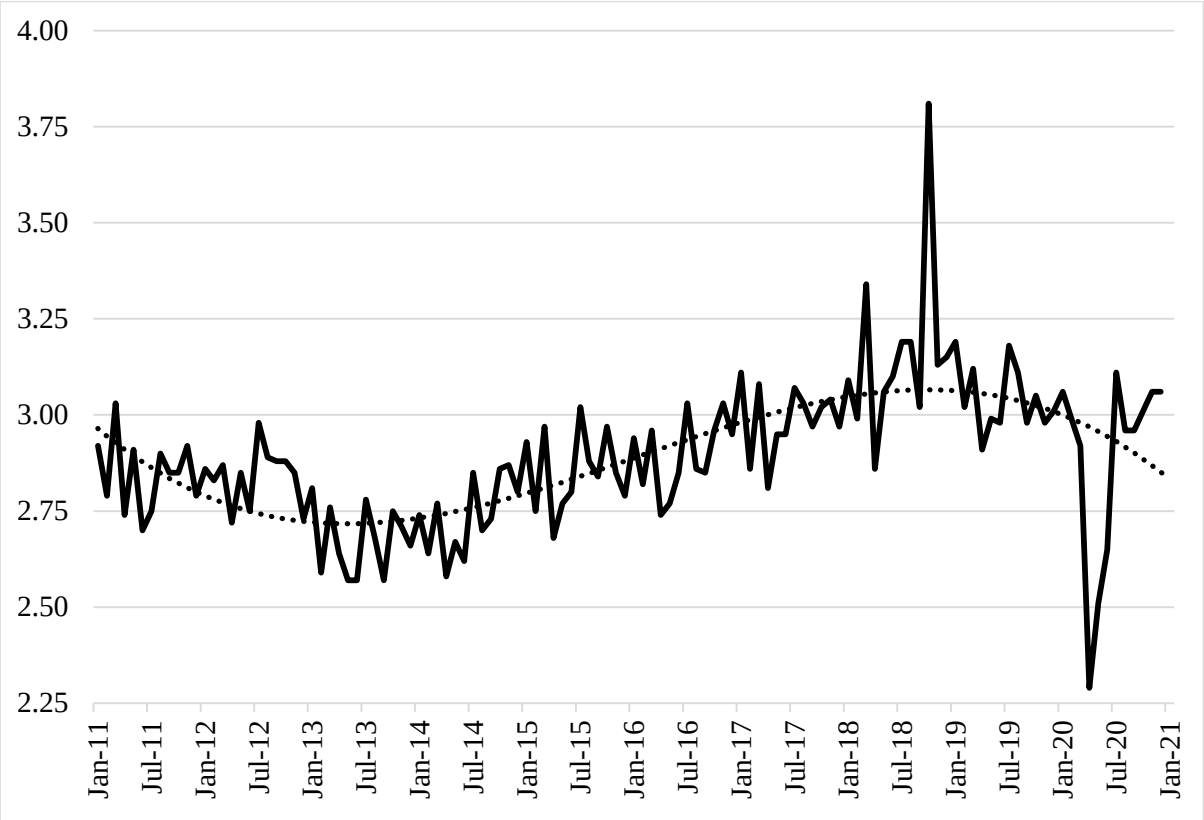

Figure 3. Non-household electricity consumption

Source: National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica.

The HEGY test does not signal the existence of an off-season root (at zero frequency), which means that the series is stationary in level. Instead, it identifies the presence of seasonal unit roots with 2.4, 4 and 12 months per cycle. The HEGY test identifies the same data structure (seasonal unit roots with 2.4, 4 and 12 months per cycle) also when the polynomial trend is removed from the initial series.

3. Econometric models

3.1. Domestic electricity consumption

Based on the results regarding the structure of the data generating process, we build the following model:

$$(1 - \phi_0 L)\,(1 - \phi_1 L - \phi_2 L^2 - \phi_3 L^3)\,(1 - \phi_{12} L^{12}) \cdot (\text{domestic consumption})_t = \\ = a_0 + [a_1 \ln(t) + a_2 \ln(t)^2 + a_3 \ln(t)^3] + \text{dummy}_{\text{months}} + \text{dummy}_{\text{outliers}} + e_t. \qquad (2)$$

In above equation, *dummy* $_{months}$ means 12 dummy variables corresponding the months (that take the value 1 for one of the months and zero for all the other months). $\text{Dummy}_{\text{outliers}}$ take the value 1 for some outliers. The symbol e_t means the error variable.

The model was solved by the Weighting Least Squares Method, in order to control for heteroskedasticity errors. Coefficients of terms with lag from 2 to 4 and from 14 to 16 are not significantly different from zero and have been removed from the model specification. For the same reason, the dummy variables for February, May and June have been removed.

$$\begin{aligned}(\text{Domestic consumption})_t = &\underset{(3.5186)}{17.2990} + \underset{(0.0572)}{0.4530}(\text{Domestic consumption})_{t-1} - \\ &- \underset{(0.0791)}{0.1290}(\text{Domestic consumption})_{t-12} + \underset{(0.0624)}{0.1216}(\text{Domestic consumption})_{t-13} \qquad (3) \\ &- \underset{(2.8682)}{11.8637} \cdot \ln(t) + \underset{(0.7703)}{3.0229} \cdot \ln(t)^2 - \underset{(0.0681)}{0.2502} \cdot \ln(t)^3 + \text{dummy}_{\text{months}} + \text{dummy}_{\text{outliers}} + u_t.\end{aligned}$$

The symbol u_t stands the error variable. Below estimators, in parentheses, standard error. The results are detailed in Annex 2.1. The remaining coefficients in the model are significantly different from zero, and the residues are independent and identically distributed (according to the BDS test, Annex 3). Based on these results, we forecast the monthly dynamics of domestic electricity consumption, for the period March - December 2020. The estimated values based on the model were compared with the statistically recorded values. The difference is explained by the impact of the COVID-19 pandemic. The results are shown in Table 1 and Figure 4.

Table 1. Impact of COVID-19 pandemic on domestic electricity consumption from March to December 2020

	2019	2020		Delta %
		statistic	forecast	
January	5.34	5.06		
February	4.68	4.70		
March	4.73	4.60	4.76	-3.4%
April	4.35	3.73	4.29	-13.1%
May	4.33	3.88	4.26	-8.8%
June	4.26	3.97	4.25	-6.5%
July	4.49	4.44	4.50	-1.2%
August	4.51	4.39	4.41	-0.6%
September	4.26	4.28	4.27	+0.2%
October	4.57	4.55	4.65	-2.2%
November	4.67	4.82	4.80	+0.4%
December	4.95	5.09	5.06	+0.5%

*) *delta % = (Statistic data – Forecast)/Forecast*
Source: our calculations based on econometric model

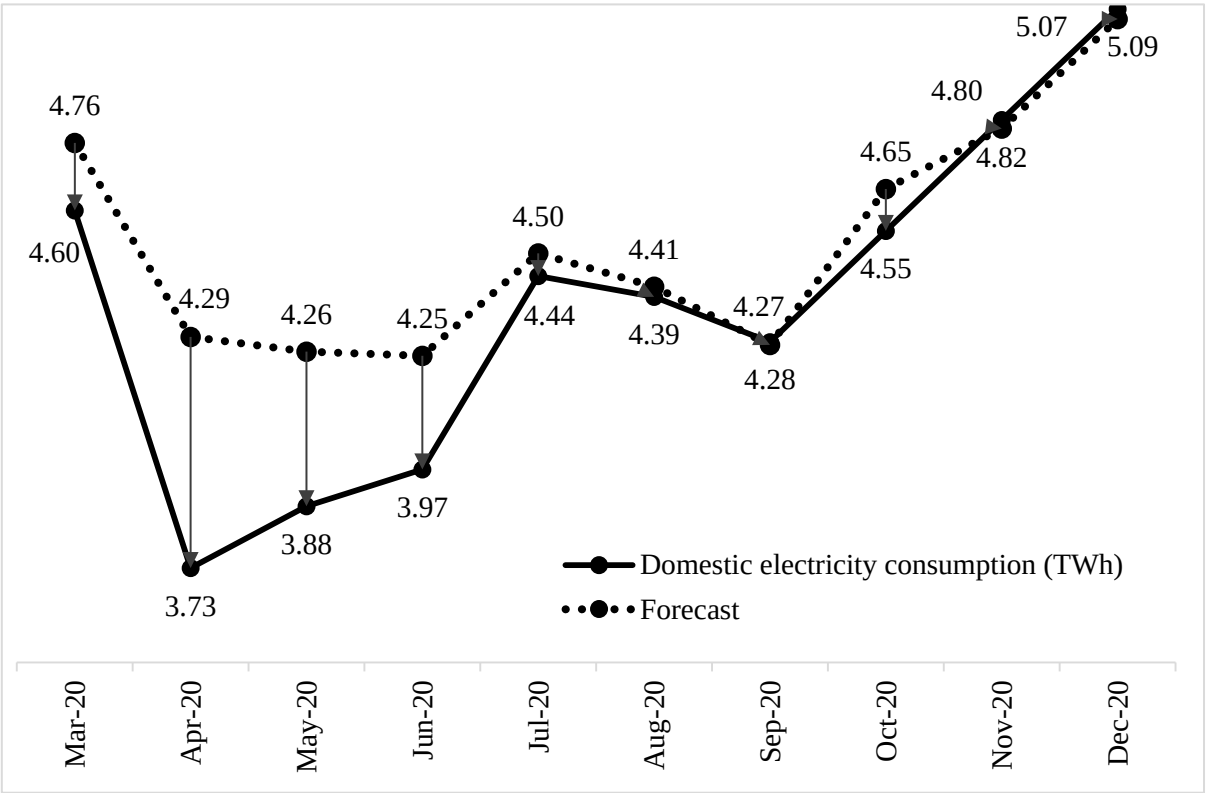

Figure 4. Impact of COVID-19 pandemic on domestic electricity consumption from March to December 2020

Source: our calculations based on econometric model

Domestic electricity consumption decreased by 13.1% in April, by 8.8% in May and by 6.5% in June. The decreases can be explained by the imposition of the state of emergency on the Romanian territory in the middle of March, the instituting of national lockdown (March, 24, 2020), of travel restrictions, closing of some activities, work from home, online school and others. The restrictions were gradually relaxed, starting with the second half of May (on May 14, a state of alert was declared for a period of 30 days, which implied less stringent measures than those imposed during the state of emergency). Since August 2021, domestic electricity consumption has returned to normal seasonal values.

3.2. Electricity consumption of household customers

Based on the results regarding the structure of the data generating process, we build the following model:

$$(1 - \phi_1 L)\,(1 - \phi_{12} L^{12}) \cdot (\text{Household consumption})_t = \\ = a_0 + [a_1 \ln(t) + a_2 \ln(t)^2 + a_3 \ln(t)^3] + \text{dummy}_{\text{month}} + e_t. \quad (4)$$

In above equation, $\text{dummy}_{\text{months}}$ means 12 dummy variables corresponding the months (that take the value 1 for one of the months and zero for all the other months). The symbol e_t means the error variable.

The model was solved by the Weighting Least Squares Method, in order to control for heteroskedasticity errors. Coefficients of terms with lag 12 and 13 are not significantly different from zero and have been removed from the model specification.

The results are detailed in Annex 2.2 and, in summary, are as follows:

$$\left(\text{Household consumption}\right)_t = \underset{(0.0940)}{0.3718}\left(\text{Household consumption}\right)_{t-1} + \underset{(0.0390)}{0.1434}\cdot \ln\left(t\right) \\ - \underset{(0.0165)}{0.0584}\cdot \ln\left(t\right)^2 + \underset{(0.0021)}{0.0076}\cdot \ln\left(t\right)^3 + \text{dummy}_{\text{months}} + u_t. \quad (5)$$

The symbols u_t stands for the residual variable. Below estimators, in parentheses, standard error. The remaining coefficients in the model are significantly different from zero, and the residues are independent and identically distributed (according to the BDS test, Annex 3). Based on these results, we forecast the monthly dynamics of electricity consumption of household customers, for the period March - December 2020. The estimated values based on the model were compared with the statistically recorded values. The difference is explained by the impact of the COVID-19 pandemic. The results are shown in Table 2 and Figure 5.

Table 2. Impact of COVID-19 pandemic on electricity consumption of household customers, from March to December 2020

	2019	2020		delta %*)
		statistic	forecast	
January	1.25	1.25		
February	1.08	1.11		
March	1.12	1.17	1.15	+1.4%
April	1.08	1.10	1.08	+1.9%
May	1.06	1.08	1.03	+4.3%
June	1.01	1.04	0.97	+6.8%
July	1.02	1.07	1.04	+2.9%
August	1.05	1.13	1.02	+10.6%
September	0.99	1.15	1.07	+7.8%
October	1.05	1.13	1.08	+4.5%
November	1.06	1.18	1.07	+10.4%
December	1.20	1.30	1.19	+9.1%

*) *delta % = (Statistic data – Forecast)/Forecast*

Source: our calculations based on econometric model

Household electricity consumption was above normal values, which means that the COVID-19 pandemic led to additional residential electricity consumption due to lockdown measures, work from home expansion and online education.

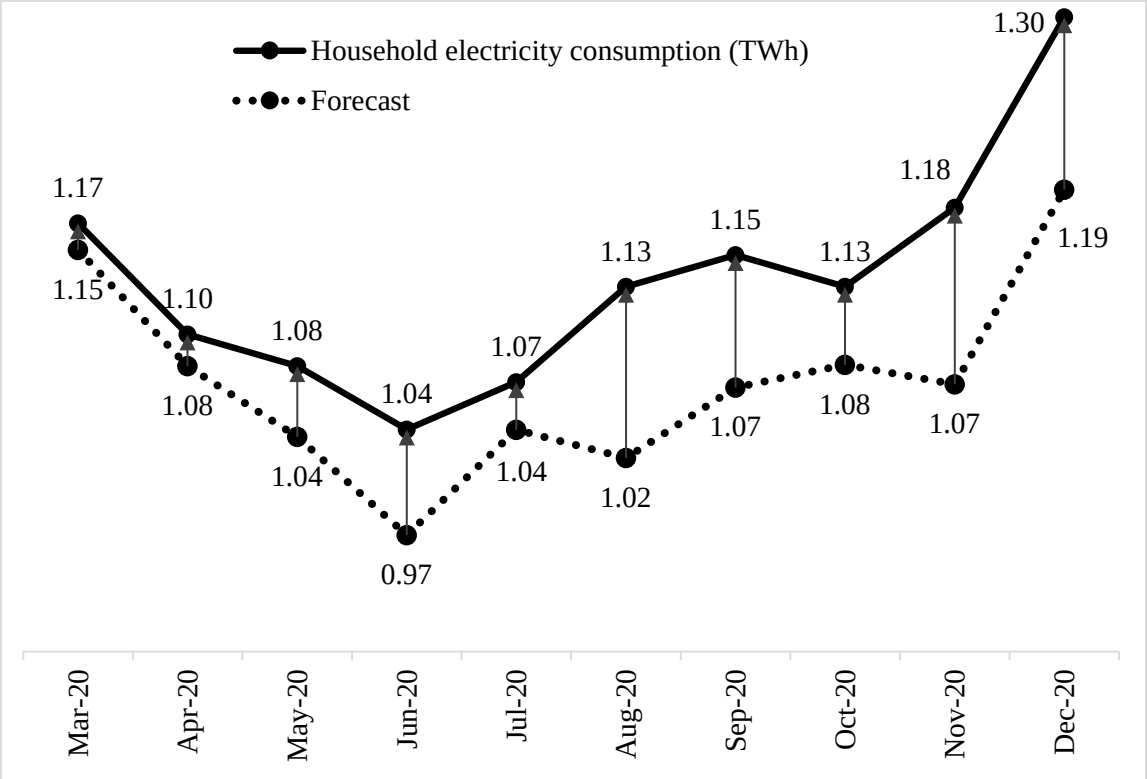

Figure 5. Impact of COVID-19 pandemic on electricity consumption of household customers, from March to December 2020

Source: our calculations based on econometric model

3.3. Non-household electricity consumption

Given the results of the HAGY test, we build the following model, for *non-household electricity consumption*:

$$(1 - \phi_3 L^3)\,(1 - \phi_4 L^4)\,(1 - \phi_{12} L^{12}) \cdot (\text{Non-household consumption})_t = \\ = a_0 + [a_1 \ln(t) + a_2 \ln(t)^2 + a_3 \ln(t)^3] + \text{dummy}_{\text{months}} + \text{dummy}_{\text{outliers}} + e_t. \quad (6)$$

In above equation, $\text{dummy}_{\text{months}}$ means 12 dummy variables corresponding the months (that take the value 1 for one of the months and zero for all the other months). $\text{Dummy}_{\text{outliers}}$ take the value 1 for some outliers. The symbol e_t means the error variable. Below estimators, in parentheses, standard error.

The model was solved by the Least Squares Method (the errors are homoskedastic). Coefficients of terms with lag 7, 15 and 16 are not significantly different from zero and have been removed from the model specification. The results are detailed in Annex 2.3 and, in summary, are as follows:

$$\begin{aligned}(\text{Non-household consumption})_t = {} & \underset{(0.0589)}{0.2124}(\text{Non-household consumption})_{t-3} \\ & + \underset{(0.0588)}{0.1556}(\text{Non-household consumption})_{t-4} \\ & - \underset{(0.0625)}{0.1230}(\text{Non-household consumption})_{t-12} \\ & - \underset{(0.0624)}{0.1875}(\text{Non-household consumption})_{t-13} \\ & - \underset{(2.8682)}{5.5021}\cdot\ln(t) + \underset{(0.7703)}{1.2734}\cdot\ln(t)^2 - \underset{(0.0681)}{0.0913}\cdot\ln(t)^3 \\ & + \text{dummy}_{\text{months}} + \text{dummy}_{\text{outliers}} + u_t.\end{aligned} \quad (7)$$

The symbols u_t means the residual variable. Below estimators, in parentheses, standard error. The coefficients in the model are significantly different from zero, and the residues are independent and identically distributed (according to the BDS test, Annex 3). Based on these results, we forecast the monthly dynamics of

electricity consumption of non-household customers, for the period March - December 2020. The values estimated based on the model were then compared with the statistically recorded values. The difference is explained by the impact of the COVID-19 pandemic. The results are shown in Table 3 and Figure 6.

Table 3. Impact of COVID-19 pandemic on non-household electricity consumption from March to December 2020

	2019	2020		delta %*)
		statistic	forecast	
January	3.19	3.06		
February	3.02	2.99		
March	3.12	2.92	3.14	-7.4%
April	2.91	2.29	2.95	-22.5%
May	2.99	2.51	3.05	-17.6%
June	2.98	2.65	3.06	-13.4%
July	3.18	3.11	3.25	-4.2%
August	3.11	2.96	3.16	-6.3%
September	2.98	2.96	3.11	-4.9%
October	3.05	3.01	3.24	-7.2%
November	2.98	3.06	3.24	-5.6%
December	3.01	3.06	3.18	-3.8%

*) *delta % = (Statistic data – Forecast)/Forecast*
Source: our calculations based on econometric model

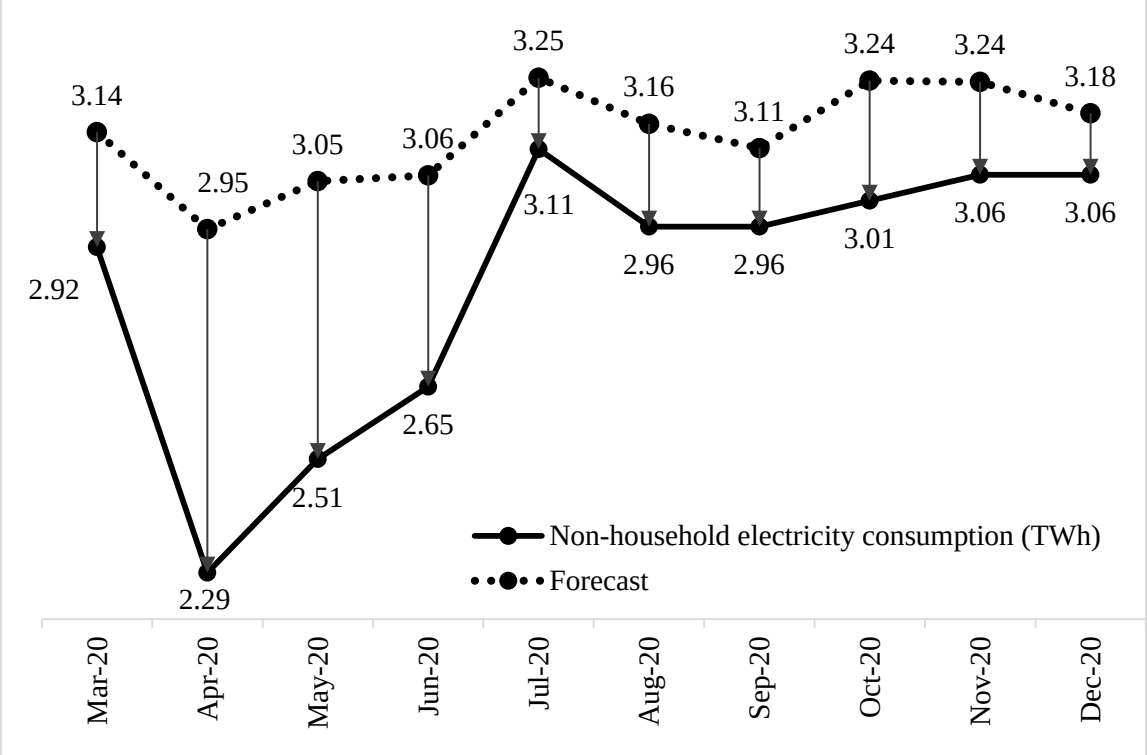

Figure 6. Impact of COVID-19 pandemic on non-household electricity consumption from March to December 2020

Source: our calculations based on econometric model

Non-household electricity consumption was below expected values under normal conditions, due to lockdown measures, quasi blocking of certain activities (e.g., tourism industries - especially accommodation, restaurants and food service activities, travel agencies, tour operators and other reservation services), the sharp

reduction in other activities (e.g., transport of people and goods) and, in general, due to the national economic recession. In fact, in 2020, there is a strong statistical correlation between the dynamics of industrial production and non-household electricity consumption (Figure 7). The linear correlation coefficient (Pearson) is 0.88.

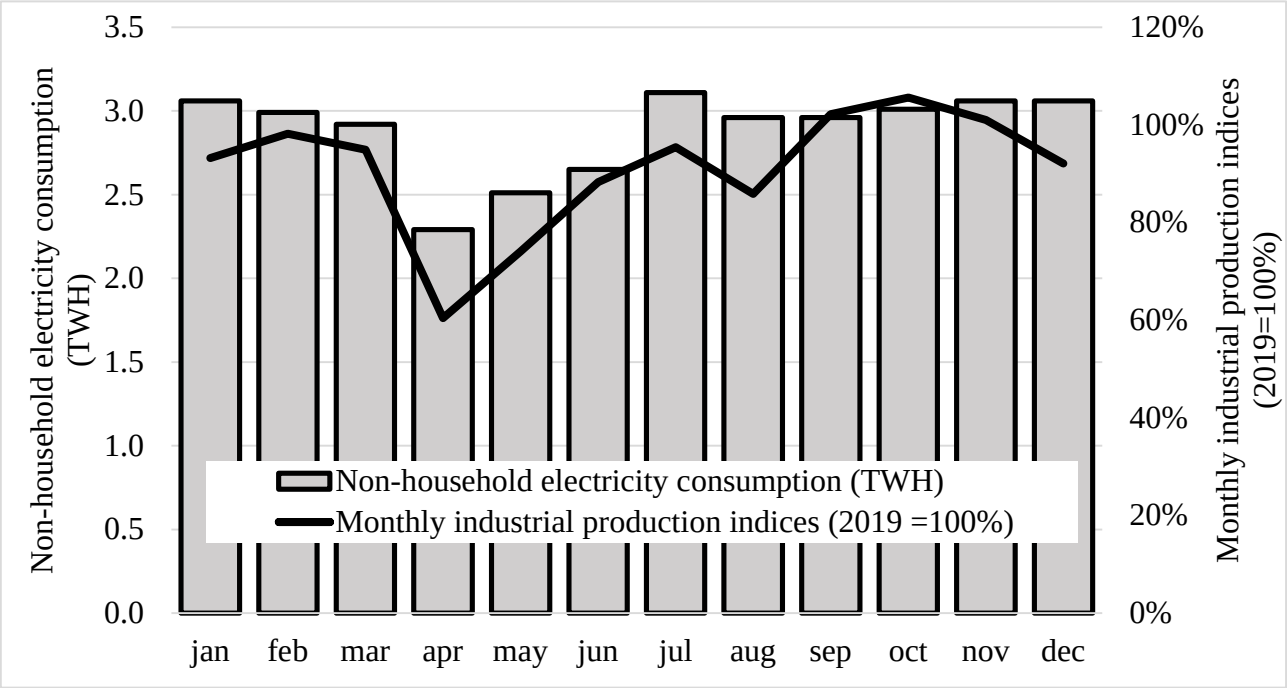

Figure 7. Relationship between non-household electricity consumption and monthly industrial production indices in 2020

Sources:

- ✓ for *non-household electricity consumption*: National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring: main data on the physical balance of electricity*, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica;
- ✓ for *monthly industrial production indices*: our calculations based on data from National Institute for Statistics, Tempo Online, table IND104K – *Monthly industrial production indices by industrial activities CANE Rev.2 - unadjusted series - base year 2015*. Retrieved March 21, 2021, from: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table.

Compared to normal values, the decrease in non-household electricity consumption was strong in April (-22.5%), in May (-17.6%) and June (-13.4%), and the dynamics remained negative throughout the analysed time interval.

Conclusions

The COVID-19 pandemic has severely affected the entire economy. In Romania, the gross domestic product decreased in 2020 by 3.9%, compared to 2019 (National Institute for Statistics 2021) and, globally (as a monthly average) the energy industry registered a decrease of 4.6% (National Institute for Statistics, 2021. Tempo Online, table IND104K). On this background, statistically the domestic consumption of electricity between March and December 2020 decreased by 4.1% against the same period of 2019 (-1.37 TWh).

In analysing the impact of the pandemic COVID-19 we tried to overcome the purely statistical approach, i.e., simply comparing the data recorded between March - December 2020 with the data recorded in the corresponding period of 2019. We started from the hypothesis that, under normal conditions, electricity consumptions (domestic consumption, household and non-household consumption) would have followed the growth trends recorded between 2011 and February 2020. To estimate those trends, we used type models SARIMAX (**S**easonal **A**utoregressive **I**ntegrated **M**oving **A**verage with e**X**ogenous factors). And the prospective estimates were considered as a benchmark (as counterfactual) for monthly electricity consumption and were compared with the data recorded by electricity consumptions in the special conditions induced by COVID-19 pandemic.

For *domestic electricity consumption*, we identified a decrease compared to the normal level by 13.1% in April, by 8.8% in May and by 6.5% in June. The decreases can be explained by imposing a state of emergency on the territory of Romania, in March, 16, 2020, for 30 days, (extended in April, 14 with another 30 days), the instituting of national lockdown (March, 24, 2020), travel restrictions, closing activities, work from home, online school, etc. Although the restrictions have been gradually relaxed starting with the second half of May, domestic electricity consumption has returned to normal seasonal values only since August 2021. *Household electricity consumption* was above normal values every month from March to December 2020, which means that the COVID-19 pandemic led to additional residential electricity consumption due to lockdown measures, the extension of work from home and online education. In contrast, *non-household electricity consumption* was below expected values under normal conditions, due to lockdown measures, sudden reduction going as far as blocking certain economic activities and, in general, due to the national economic recession (there is a statistical correlation between the dynamics of industrial production and non-household electricity consumption).

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Annexes

Annex 1. HEGY Seasonal Unit Root tests on electricity consumption series

	Simulated P-values (Monte Carlo simulations, 1000 replications)					
	Domestic consumption		Consumption of household customers		Non-household consumption	
Null hypothesis	Level	Without trend	Level	Without trend	Level	Without trend
Nonseasonal unit root	0.642	0.573	0.836	0.041	0.031	0.007
Seasonal unit root (2 months/cycle)	0.012	0.028	0.102	0.122	0.066	0.046
Seasonal unit root (4 months/cycle)	0.009	0.016	0.276	0.168	0.223	0.246
Seasonal unit root (2.4 months/cycle)	0.011	0.080	0.082	0.172	0.167	0.152
Seasonal unit root (12 months/cycle)	0.305	0.101	0.429	0.800	0.169	0.661
Seasonal unit root (3 months/cycle)	0.303	0.443	0.221	0.154	0.000	0.000
Seasonal unit root (6 months/cycle)	0.139	0.069	0.000	0.000	0.010	0.005

Selected lag using AIC

Source: our calculations based on National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica

Annex 2: Outputs of SARIMAX models

A2.1. Outputs of model on Domestic electricity consumption

Dependent Variable: Domestic consumption
Method: Least Squares
Sample (adjusted): 2012M04 2020M02
Included observations: 97 after adjustments
Weighting series: LOG(T)
Weight type: Inverse standard deviation (average scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	17.29902	3.518570	4.916492	0.0000
$(\text{Domestic consumption})_{t-1}$	0.452967	0.057195	7.919734	0.0000
$(\text{Domestic consumption})_{t-12}$	-0.128967	0.079118	-1.630051	0.1071
$(\text{Domestic consumption})_{t-13}$	0.121585	0.062413	1.948070	0.0550
ln(t)	-11.86372	2.868260	-4.136207	0.0001
$\ln(t)^2$	3.022908	0.770309	3.924280	0.0002
$\ln(t)^3$	-0.250164	0.068105	-3.673190	0.0004
$D_{2012m5} - D_{2012m12}$	0.153762	0.080062	1.920547	0.0584
$D_{2012m9} - D_{2012m10}$	0.272225	0.079717	3.414886	0.0010
$D_{2018m3} - D_{2018m4}$	0.371621	0.057624	6.449115	0.0000
January	0.654850	0.058075	11.27596	0.0000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
March	0.333544	0.046305	7.203173	0.0000
April	-0.221802	0.041349	-5.364089	0.0000
July	0.292392	0.040419	7.233971	0.0000
August	0.074079	0.033020	2.243424	0.0277
September	-0.065223	0.033720	-1.934264	0.0567
October	0.449822	0.046457	9.682567	0.0000
November	0.401014	0.043470	9.225058	0.0000
December	0.625795	0.054297	11.52535	0.0000
Weighted Statistics				
R-squared	0.962926	Mean dependent var		4.4310
Adjusted R-squared	0.954370	S.D. dependent var		0.8157
S.E. of regression	0.080553	Akaike info criterion		-2.0446
Sum squared resid	0.506122	Schwarz criterion		-1.5403
Log likelihood	117.2639	Hannan-Quinn criterion		-1.8407
F-statistic	112.5485	Durbin-Watson stat		1.8842
Prob(F-statistic)	0.000000	Weighted mean dep.		4.4490
Unweighted Statistics				
R-squared	0.958026	Mean dependent var		4.4127
Adjusted R-squared	0.948340	S.D. dependent var		0.3698
S.E. of regression	0.084061	Sum squared resid		0.5512
Durbin-Watson stat	1.853854			

Source: our calculations based on National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica

A2.2. Outputs of model on electricity consumption of household customers

Dependent Variable: Household consumption
Method: Least Squares
Sample (adjusted): 2011M02 2020M02
Included observations: 109 after adjustments
Weighting series: T
Weight type: Standard deviation (average scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$(\text{Household consumption})_{t-1}$	0.371810	0.094012	3.954895	0.0001
log(t)	0.143451	0.038997	3.678473	0.0004
$\log(t)^2$	-0.058397	0.016520	-3.535028	0.0006
$\log(t)^3$	0.007585	0.002147	3.532553	0.0006
January	0.578952	0.098847	5.857023	0.0000
February	0.504757	0.099079	5.094500	0.0000
March	0.567930	0.090225	6.294607	0.0000
April	0.477611	0.094712	5.042755	0.0000
May	0.459342	0.088957	5.163671	0.0000
June	0.413165	0.085568	4.828499	0.0000
July	0.501660	0.080361	6.242607	0.0000
August	0.458323	0.086158	5.319566	0.0000
September	0.508553	0.084568	6.013526	0.0000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
October	0.505531	0.088163	5.734037	0.0000
November	0.486884	0.089300	5.452201	0.0000
December	0.613308	0.088100	6.961524	0.0000
Weighted Statistics				
R-squared	0.942378	Mean dependent var		0.50798
Adjusted R-squared	0.933084	S.D. dependent var		0.84267
S.E. of regression	0.011891	Akaike info criterion		-5.89128
Sum squared resid	0.013149	Schwarz criterion		-5.49622
Log likelihood	337.0747	Hannan-Quinn criterion		-5.73107
Durbin-Watson stat	1.902545	Weighted mean dep.		0.97956
Unweighted Statistics				
R-squared	0.831887	Mean dependent var		1.01560
Adjusted R-squared	0.804772	S.D. dependent var		0.08476
S.E. of regression	0.037451	Sum squared resid		0.13044
Durbin-Watson stat	2.219666			

Source: our calculations based on National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica.

A2.3. Outputs of model on Non-household electricity consumption

Dependent Variable: Non-household consumption
Method: Least Squares
Sample (adjusted): 2012M02 2020M02
Included observations: 97 after adjustments
Weighting series: LOG(T)
Weight type: Inverse standard deviation (average scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$(\text{Non-household consumption})_{t-3}$	0.212420	0.058941	3.603948	0.0006
$(\text{Non-household consumption})_{t-4}$	0.155590	0.058783	2.646830	0.0099
$(\text{Non-household consumption})_{t-12}$	-0.122960	0.062470	-1.968298	0.0527
$(\text{Non-household consumption})_{t-13}$	-0.187462	0.062630	-2.993150	0.0037
log(t)	-5.502097	1.589273	-3.462022	0.0009
$\log(t)^2$	1.273406	0.441536	2.884038	0.0051
$\log(t)^3$	-0.091330	0.040618	-2.248495	0.0274
$d_{2018m10}$	0.262556	0.055802	4.705091	0.0000
d_{2018m3}	0.662260	0.057310	11.55568	0.0000
January	10.20052	1.853097	5.504578	0.0000
February	10.03520	1.850140	5.424022	0.0000
March	10.19774	1.848483	5.516815	0.0000
April	9.984045	1.850644	5.394904	0.0000
May	10.05059	1.851712	5.427729	0.0000
June	10.05049	1.852880	5.424256	0.0000
July	10.27470	1.849433	5.555592	0.0000
August	10.22031	1.848488	5.529011	0.0000
September	10.12362	1.850419	5.470989	0.0000
October	10.19344	1.851606	5.505187	0.0000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
November	10.18177	1.850454	5.502309	0.0000
December	10.13187	1.851079	5.473496	0.0000
R-squared	0.940900	Mean dependent var		2.9023
Adjusted R-squared	0.925348	S.D. dependent var		0.1894
S.E. of regression	0.051761	Akaike info criterion		-2.8954
Sum squared resid	0.203616	Schwarz criterion		-2.3380
Log likelihood	161.4251	Hannan-Quinn criterion		-2.6700
Durbin-Watson stat	1.604397			

Source: our calculations based on National Energy Regulatory Authority (ANRE), Monitoring Directorate, *Report on the results of electricity market monitoring*: main data on the physical balance of electricity, pp. 8-9. Retrieved March 21, 2021, from: https://www.anre.ro/ro/energie-electrica/rapoarte/rezultate-monitorizare-piata-energie-electrica.

Annexes 3: BDS Tests for Residuals in models on electricity consumption

BDS Test for RESID. Null Hypothesis: IID
Sample: 2011M01 2020M12
Included observations: 120
Raw epsilon: 1 - standard deviation
For bootstrap: 5000 repetitions

	Domestic consumption		Consumption of household customers		Non-household consumption	
Dimension	BDS Statistic	Bootstrap Prob.	BDS Statistic	Bootstrap Prob.	BDS Statistic	Bootstrap Prob.
2	0.006924	0.3162	0.003612	0.5028	-0.002779	0.8776
3	0.006481	0.3964	0.000151	0.8476	-0.002431	0.9894
4	0.007428	0.3096	0.000704	0.7572	-0.000454	0.8456
5	0.005137	0.3596	-0.000725	0.9256	0.001398	0.6846
6	0.003485	0.3846	0.001816	0.5100	0.001397	0.6302

Source: our calculations based on econometric models.