Chapter 10
The Economic and Social Impact of Increasing Electricity Prices: Estimates, Analysis and Predictions

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Abstract The current global energy crisis highlights the need to continue investigating the impact of energy prices on the budget of different types of consumers, by using appropriate modeling methods to substantiate the economic policies. The paper presents a research conducted by the authors, based on a case study structured in two parts: the first part aims to capture the dependencies between the electricity market, on the one hand, and the industry and construction sectors, on the other hand, but also the impact felt by the final consumer in relation to changes in the electricity market. The second part of the study aims to complete the conclusions obtained in the first part of the case study with the analysis of the indicators with monthly frequency to compare between energy price levels in different European Union (EU) countries and Romania, and to quantify the relations between imports, exports, net exports, supply, respectively the total production of electricity and the price of a kilowatt-hour of electricity. Finally, the authors characterise how changes in electricity prices might influence the following macroeconomic aggregates: gross added value at economy level and different economic sectors, gross domestic product, population consumption, government consumption, investment, trade balance.

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10.1 Introduction

The current global energy crisis highlights the need to continue investigating the impact of energy prices on the budgets of different types of consumers, by using appropriate modeling methods to substantiate economic policies. Increase of energy prices in general, and electricity prices in particular, have multiple causes and are reflected in rising product prices and service tariffs.

Liberalisation of the electricity market is a hot topic, which is still the subject of debate. The market has made progress in this area, including the opening of an energy exchange, the entry of energy trading companies and even the formalisation of the liberalisation of the energy market for domestic consumers in 2007. Regardless of the situation, however, the social component related to energy prices remains a sensitive topic addressed by all market participants [13], including the population.

Almost ten years ago, the Romanian Government, based on an agreement with the World Bank, the IMF and the EU, concluded an agreement on the liberalisation of the energy market, which involved the completion of intermediate stages, such as [1]:

- Preparing consumers through multiple programmes for disseminating information specific to the free market
- Restructuring, depoliticising and streamlining the institutions that are meant to ensure the functionality of the free market
- Establishment of an Entity for Alternative Dispute Resolution, between consumers and suppliers
- Implementing a strategy to reduce energy shortages and protect vulnerable consumers
- Gradual deregulation of energy prices, the only part of the actions partially implemented

In the last year, there have been factors that have changed the balance of the electricity market, such as: the change of GAZPROM policy on the supply of natural gas during the summer, when additional and cheap deliveries were made to Europe, the change of gas flows in the Balkans, which led to the relocation of the main gas import point in Romania to the west, on the border with Hungary, a lower capacity point and with a higher cost than in the rest of the points, speculations of suppliers who imposed higher prices and inappropriate contractual clauses.

The authors of this study conducted a case study for Romania that aims to capture the dynamics of the electricity market and the dependence of other sectors of activity, such as industry and construction, on energy. The role of statistical and econometric models is to quantify the impact that a change in the electricity market has on gross domestic product, consumption, investment, trade balance and other indicators of macroeconomic importance. For this study, the data were selected from

sources such as Eurostat [4], the National Institute of Statistics of Romania [9] and the World Bank [15]. Macroeconomic indicators were selected in the form of monthly, quarterly, half-yearly and annual time series for the analysis period January 2008–June 2021. Time series modeling using linear functions was used to fill in the missing values.

The case study was structured in two parts: the first part aims to capture the dependencies between the electricity market, on the one hand, and the industry and construction sectors, on the other hand, but also the impact felt by the final consumer in relation to changes in this market. The second part of the study aims to complete the conclusions obtained with analyses of the indicators with monthly frequency to compare between energy price levels in different EU countries and Romania, and to quantify the relations between imports, exports, net exports, supply, respectively the total production of electricity and the price of one kilowatt-hour of electricity. Finally, the authors characterised how changes in electricity prices might influence the following macroeconomic aggregates: gross added value at economy level and different economic sectors, gross domestic product, population consumption, government consumption, investment, trade balance.

10.2 Literature Review

Input-output (IO) models are often applied to assess the impact of prices increase of different cost elements, such as energy on the price of products and services. As a limitation of IO models is the assumption that input requirements are set. To overcome this limitation, Truchon [14] defined a method of updating the coefficients of the model due to the changes of prices. Lange [10] proposed a procedure for including technological alternatives in the IO model. Kratena [8] combined a conventional IO model with demand functions of econometric factors and price equations.

The models of energy supply and demand might include coefficients of elasticity to characterise how responsive the quantity demanded and supplied is to other relevant variables. On-demand price elasticities determine whether price increases will lead to an increase or decrease in total spending in a market, while revenue elasticities will determine how a product's budget share changes. Cross-price elasticities also might be used for indicating how related prices influence the quantity demanded or supplied from a specific good.

Hamilton [6] identified a relationship between the rise of oil prices and the economic recession. Kilian [7] showed that the source of rising oil prices (demand or supply) is significant for its impact on production and inflation. Li et al. [12] used translog (Transcendental Logarithmic) cost functions to analyse the potential for energy, capital and labour replacement in the Chinese economy between 1981 and 2017.

The impact of carbon tax on electricity prices was analysed by Lee et al. [11], following the example of the Korean energy sector, using the scenario technique, taking into account four groups of factors: demand, conversion efficiency, fuel and price. Gelos and Ustyugova [5] perform an analysis of the consumer basket from the calculation of the consumer price index focusing on the impact of the shock of rising energy prices, as well as the role of central banks in managing inflationary pressures.

In 2019, the European Commission analyses, in a special report [2] the evolution of energy prices and the stage of achieving the energy union, comparing the advantages and disadvantages of high energy prices. A comparison is made of the situation of the European economy from 1970–1980 generated by the oil shock. The framework strategy and the stage of achieving the objectives of the roadmap for an energy union are analysed.

The Intelligent Energy Organization publishes in June 2021 an analysis [3], on the increase of electricity and natural gas prices in the context of complete market liberalisation for domestic consumers, with emphasis on the ratio between the consumption served by the free market, respectively by the regulated one, but also on the difference between the market prices and those under regulated regime.

10.3 Research Methodology

The research aims to identify the dependencies between the electricity market, on the one hand, and the industry and construction sectors, on the other hand, but also the impact felt by the final consumer in relation to changes in this market.

For this study, the data were selected from sources such as Eurostat [4], the National Institute of Statistics of Romania [9] and the World Bank [15]. Macroeconomic indicators were selected in the form of monthly, quarterly, half-yearly and annual time series for the analysis period January 2008–June 2021. Time series modeling using linear functions was used to fill in the missing values. The indicators included in the analysis refer to the monthly evolution from January 2008 to June 2021 of imports (E1), exports (E2), net imports (E3), supply (E4) and total electricity production (E5).

Two indices were selected to characterise the construction sector: the construction works index (C1) and the construction cost index (C2). The dynamics of the industrial sector for the analysed period is described by means of four indicators: the labour productivity index in industry (I1), the value index of the turnover from the industrial units in total (internal market and external market) (I2), the industrial production index in total industry (I3) and the total industrial production price index (I4). The average monthly consumer price index (CPI) was introduced in the analysis to determine how the population feels the changes in the electricity market.

To determine the dependencies between the electricity market, the construction sector, the industrial sector and the final consumers, the correlation matrix was used.

Other objectives of the study were to compare between the energy price levels in EU countries and Romania and to quantify the relationship between imports, exports, net exports, supply, respectively total electricity production and the price of one kilowatt-hour of electricity. Finally, we looked at how changes in the price of electricity influence the following macroeconomic aggregates: gross added value at economy level and different economic sectors, gross domestic product, population consumption, government consumption, investment, trade balance The last objectives were achieved by using data with a half-yearly frequency (bi-annual), the indicators including observations from 2007S1–2021S1. Some of the data were obtained by aggregating either the monthly time series or the quarterly time series for various macroeconomic indicators.

10.4 Research Results and Discussions

To identify relationships between monthly indicators, the correlation matrix was developed (see Table 10.1).

Analysing the correlation matrix above, we can see that the monthly imports of electricity are strongly and directly correlated with the net imports of electricity, with the two indices for the construction sector, with the four indices for the industrial sector. Also, electricity imports have no impact on the consumer price index, the correlation coefficient in this case being zero.

There is a direct, medium-intensity link between electricity exports and total gross electricity production. The higher the domestic production, the more the export activity in this field will be stimulated. In addition, electricity exports are positively correlated, but the links are of medium to low intensity with all four indices for the industry sector.

Table 10.1 The correlation matrix for monthly indicators

	E1	E2	E3	E4	E5	C1	C2	I1	I2	I3	I4	IPC
E1	1											
E2	0.19	1										
E3	0.51	-0.74	1									
E4	0.27	0.1	0.09	1								
E5	-0.14	0.52	-0.55	0.77	1							
C1	0.47	-0.03	0.35	0.06	-0.22	1						
C2	0.77	0.02	0.5	0.16	-0.22	0.31	1					
I1	0.52	0.26	0.13	0.06	-0.04	-0.18	0.7	1				
I2	0.72	0.24	0.27	0.13	-0.1	0.13	0.88	0.89	1			
I3	0.57	0.36	0.07	0.19	0.09	-0.08	0.7	0.92	0.92	1		
I4	0.66	0.15	0.32	0.09	-0.16	0.07	0.91	0.82	0.87	0.77	1	
IPC	-0.01	-0.18	0.14	0.3	0.16	0.09	-0.04	-0.17	-0.14	-0.13	-0.14	1

The supply of electricity is directly correlated with the index of industrial production by total industry.

There are inverse links between the total gross electricity production and the two indices for the construction sector, of low intensity, the correlation coefficients being in both cases equal to −0.22.

Starting from the correlation matrix above, Table 10.2 presents a series of regression models in which the dependent variables are, in turn, indices from the industry sector and the construction sector. The factors are represented by the monthly indices (I1–I5) specific to the electricity market. Thus, the general case equation for the models below is as follows:

$$Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \beta_4 \cdot X_4 + \beta_5 \cdot X_5 + \varepsilon_t \tag{10.1}$$

The unifactorial and multifactorial regression models for the monthly time series of indicators for the electricity market, for the construction sector and for industry are presented in Table 10.2.

The evolution of the labour productivity index in industry (I1) is explained in proportion of 30% by the variations of the electricity import (E1) and the electricity export (E2) according to the equation of the model (M02). Value index of the turnover of industrial units on the total (internal market and external market) (I2) is influenced in proportion of 53% by the variations of the electricity import (E1) and electricity export (E2) according to the equation of the model (M05). The index of industrial production for the total industry is 40% impacted by both the import (I1) and the export of electricity (I2) according to the model (M09). The total industrial production price index (internal market and external market) (I4) is determined in proportion of 44% by imports (I1) of electricity, as shown in model (M13).

$$I_1 = 82.81–0.03 \cdot E_1–0.09 \cdot E_2–\varepsilon_t \tag{M02}$$

$$I_2 = 76.91–0.08 \cdot E_1–0.01 \cdot E_2–\varepsilon_t \tag{M05}$$

$$I_3 = 81.03–0.04 \cdot E_1–0.01 \cdot E_2–\varepsilon_t \tag{M09}$$

$$I_4 = 93.32–0.03 \cdot E_1–\varepsilon_t \tag{M13}$$

For the construction sector, the variation of the two characteristic indices, the construction works index, respectively the construction cost index, is explained by the models (M16), respectively (M19), in proportion of 24% and 61%, respectively, of the electricity import (E1) and total gross electricity production (E5).

Table 10.2 Unifactorial and multifactorial regression models

Model	Dependent variable	Model validity F-stat (P-F-stat)	Degree of determination R^2	Dependent variables and their coefficients					
				β_0 (prob)	β_1 (prob)	β_2 (prob)	β_3 (prob)	β_4 (prob)	β_5 (prob)
M01	I1	61.92 (0.00)	0.27	86.49 (0.00)	0.04 (0.00)	–	–	–	–
M02	I1	34.35 (0.00)	0.30	82.81 (0.00)	0.03 (0.00)	0.009 (0.00)	–	–	–
M03	I1	11.63 (0.00)	0.06	88.40 (0.00)	–	0.01 (0.00)	–	–	–
M04	I2	174.30 (0.00)	0.52	80.80 (0.00)	0.09 (0.00)	–	–	–	–
M05	I2	90.61 (0.00)	0.53	76.91 (0.00)	0.08 (0.00)	0.01 (0.05)	–	–	–
M06	I2	9.95 (0.00)	0.05	89.67 (0.00)	–	0.02 (0.00)_	–	–	–
M07	I2	13.56 (0.00)	0.07	104.63 (0.00)	–	–	0.02 (0.00)	–	–
M08	I3	80.89 (0.00)	0.33	87.03 (0.00)	0.04 (0.00)	–	–	–	–
M09	I3	54.12 (0.00)	0.40	81.03 (0.00)	0.04 (0.00)	0.01 (0.00)	–	–	–
M10	I3	35.92 (0.00)	0.40	77.20 (0.00)	0.04 (0.00)	0.01 (0.00)	–	0.00 (0.73)	–
M11	I3	25.20 (0.00)	0.13	87.01 (0.00)	–	0.02 (0.00)	–	–	–
M12	I3	6.2 (0.01)	0.03	60.57 (0.00)	–	–	–	0.007 (0.01)	–
M13	I4	126.53 (0.00)	0.44	93.32 (0.00)	0.03 (0.00)_	–	–	–	–
M14	I4	18.33 (0.00)	0.10	101.69 (0.00)	–	–	0.009 (0.00)	–	–
M15	C1	46.68 (0.00)	0.22	96.18 (0.00)	0.03 (0.00)	–	–	–	–
M16	C1	26.47 (0.00)	0.24	121.18 (0.00)	0.03 (0.00)	–	–	–	−0.004 (0.02)
M17	C1	8.39 (0.00)	0.04	138.94 (0.00)	–	–	–	–	−0.006 (0.00)
M18	C2	241.62 (0.00)	0.60	94.55 (0.00)	0.06 (0.00)	–	–	–	–
M19	C2	126.71 (0.00)	0.61	114.08 (0.00)	0.06 (0.00)	–	–	–	−0.003 (0.02)
M20	C2	8.66 (0.00)	0.05	145.87 (0.00)	–	–	–	–	−0.007 (0.003)

Table 10.3 Correlation matrix between the price of electricity and the quantities imported, exported, offered and produced in the period 2007–2021

	Import	Export	Net import	Offer	Total gross production	Price
Import	1					
Export	0.315548	1				
Net import	0.4781072	-0.6825629	1			
Offer	0.5549779	-0.2386672	0.6483827	1		
Total gross production	0.5725038	0.4225352	0.0498539	0.7222174	1	
Price	0.7541116	0.4208673	0.1912278	0.2290193	0.3293025	1

$$C_1 = 121.18–0.03 \cdot E_1–0.004 \cdot E_5–\varepsilon_t \quad \text{(M16)}$$

$$C_2 = 114.08 + 0.06 \cdot E_1–0.003 \cdot E_5–\varepsilon_t \quad \text{(M19)}$$

In conclusion, the industry and construction sectors are influenced by the changes taking place in the electricity market. The analysis by monthly time series, which summarises information on imports, exports, supply and total gross electricity production, shows that changes in the price index of consumer goods, and thus in inflation does not have a significant impact on short term, but might have an impact on long term.

The correlation matrix between electricity prices and imports, exports, net imports, supply and total gross electricity production is represented in Table 10.3. It can be seen that imports are strongly influenced by the level of electricity prices. The links between exports and prices, respectively between the total gross production and prices are directly proportional, but of medium intensity, the correlation coefficients having the values equal to 0.42, respectively to 0.32. Using raw data, $Q = f(P)$ functions may be developed for revealing the price dependence on electricity quantities.

The equation that describes the dependence between imports and price is as follows:

$$Q_{\text{import}} = -18623.133 + 107323.4 \cdot P + \varepsilon_t \quad (10.2)$$

The price variation explains 56.86% of the variation in the amount of imported electricity.

10.5 Conclusions

The literature review revealed that assessing the impact of changing energy prices on different types of consumers is a necessity, especially to substantiate economic policies during global energy crises. It was also revealed that the use of appropriate modeling methods brings great benefits in conducting these studies.

The authors of this paper have conducted a case study for Romania which aims to capture the dynamics of the electricity market and the dependence of other sectors of activity, such as industry and construction, on energy. The role of statistical and econometric models is to quantify the impact that a change in the electricity market has on gross domestic product, consumption, investment, trade balance and other indicators of macroeconomic importance. For this study, the data were selected from sources such as Eurostat, the National Institute of Statistics of Romania and the World Bank. Macroeconomic indicators were selected in the form of monthly, quarterly, half-yearly and annual time series for the analysis period January 2008–June 2021. Time series modeling using linear functions was used to fill in the missing values.

The main conclusions obtained from this study are the following:

(a) The industry and construction sectors are influenced by the changes taking place in the electricity market. The analysis by monthly time series, which summarises information on imports, exports, supply and total gross electricity production, shows that changes in the price index of consumer goods, and thus in inflation does not have a significant impact on short term, but might have an impact on long term.
(b) the evolution trend is similar both in the European context and in the Romanian economy, but the average price in the period 2017S1–2021S1 is 0.04 euro/kilowatt-hour lower in Romania, compared to the European average.
(c) Imports are strongly influenced by the level of electricity prices. The links between exports and prices, respectively between the total gross production and prices are directly proportional, but of medium intensity, the correlation coefficients having the values equal to 0.42, respectively to 0.32.

The authors intend to extend the research if the decision makers will show interest in nuanced assessments already made.

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