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Research Article

Energy Consumption Modeling in the Western Balkan Countries Using a Top-Down Approach

Dr. Aranit Shkurti

*College of Engineering and Technology,
American University of the Middle East, Kuwait*

Doi: 10.2478/ajis-2018-0056

Abstract

This paper investigates the relationships between energy consumption and GDP growth for 6 Western Balkan countries over 10 years period from 2005 to 2014. The countries under consideration are: Albania, Bosnia and Herzegovina, Croatia, Serbia, Montenegro, and Macedonia, FYR. The aim of this study is to evaluate the energy demand across time and within these countries. The other variables that are considered in the model are the Electricity use per capita, the Oil price referred to Crude Oil International markets price expressed in USD and the exchange rate. Recently, numerous empirical studies have been conducted to detect this relationship, but not specifically to the Western Balkan region. There are general characteristics, due to the common historical background, but also specific patterns of the economic structure shaping the energy demand of each country. The main approaches to energy demand modeling are the Bottom-up and Top Down approaches. Currently important research is conveying also toward the Hybrid models. The demand in this countries is very susceptible to external oscillations, leading to severe exogenous impacts on the long term equilibrium, fitting more towards a top down macroeconometric model.

Keywords: *energy demand, economic growth, renewable energy, electricity supply, outages*

1. Introduction

Energy is a key input for social and economic development of countries. Currently the energy policy and the sustainable use of available resources is a hot topic in every government agenda. Developments of social and economic activities increase the demand for energy, but the supply of energy is not infinite and does not follow the free market mechanisms. Regulations and inter regional agreements take place to control the energy market. Currently there is a large economic literature on energy demand in the EU area and the candidate countries. The European Union is very attentive towards the energy provisions and the energy security, so it is pushing the application of EU directives not only within the member countries but also towards bordering and potential candidate countries. One of the successful examples of this collaboration is the ENTSO-E, European Network of Transmission System Operators, representing 43 electricity transmission system operators (TSOs) from 36 countries across Europe. All of the Western Balkan countries in this study are part of the ENTSOE-E. Recently the ENTSOE-E was under pressure, following also the transmission grid dispute between Serbia and Kosovo (Xypolytou et al. 2018).

Among other major international agreements and treaties in the Energy field, it is important to mention that all the Western Balkan countries have signed the Energy Charter Treaty, the Energy Community Agreement, the United Nations Framework Convention and the Kyoto Protocol.

Table 1: Energy use (kg of oil equivalent per capita)

Year	Albania	Bosnia and Herzegovina	Croatia	Montenegro	Macedonia, FYR	Serbia
2005	719,5844	1332,788	2194,355	1745,974	1359,378	2159,574
2006	706,8594	1402,326	2183,136	1913,556	1421,322	2300,733
2007	679,8618	1405,428	2272,141	1927,979	1464,694	2248,155
2008	710,7485	1583,999	2215,901	2067,968	1461,054	2289,995
2009	732,3167	1659,514	2145,363	1646,312	1360,635	2070,229
2010	729,1544	1741,317	2124,919	1898,288	1390,534	2141,055
2011	764,9686	1937,06	2140,436	1815,53	1506,138	2237,461
2012	687,8963	1832,144	2020,752	1711,797	1427,79	2020,395
2013	801,33	1790,293	1983,868	1580,418	1301,026	2080,973
2014	808,4558	2194,056	1897,841	1538,264	1262,557	1859,429

Notes: Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Source: IEA Statistics © OECD/IEA 2014 (http://www.iea.org/stats/index.asp)

Albania has the lowest Energy use per capita among the Western Balkan countries, even though this demand is increasing steadily in the past years from 0.720 toe/per capita to .809 toe per capita (Table 1). The demand is mainly interesting the residential and the transport sector, meanwhile the industrial sector is relatively smaller compared to the neighboring countries. The electricity is generated mainly through hydropower plants, so the share of the renewable energies over the total is higher than the other countries under analysis (De Cian et al., 2007; Zogolli, 2015). The gap in the power supply is simply filled by unplanned and unpredicted outages. The economy is one of the most dynamic in the region, struggling to recover after a long transition. According to official statistics the Albanian Economy had only positive growth during the past years, being the only country in the region not to face recession.

Bosnia-Herzegovina had in the past years ambitious plans about hydropower investments, anyway currently few of these projects have started. The government has provided several concessions to private companies, though the progress is limited. Bosnia-Herzegovina is depending mainly on hydropower and biomass energy; the rest of the demand is filled by carbon fossil sources. The total energy demand in the past years has doubled from 1.333 to 2.194 toe/capita. It is the highest increase in the area for the 10 years' period. Important to note that energy demand in the inner continental areas is more dependent on weather conditions rather than disposal income. It is commonly known that the energy demand has a low elasticity coefficient in colder countries during winter seasons (De Cian, Lanzi, & Roson, 2007), meanwhile they benefit from milder mid-seasons and, instead, are not significantly sensitive to summer temperatures (Avdakovic, Ademovic, & Nuhanovic, 2013).

After a six-year recession, Croatia had a positive GDP growth only in 2015, following the European Union adhesion of 2013. As a new member, Croatia was forced to adapt new energy policies following a broader *acquis communautaire* convergence towards the EU standards and directives. The total energy demand in 2004 has fallen from round 2194 to 1,897 toe/capita of 2014. The decrease in the energy demand during the period under observation (Table 1) can be related to the Economic crises of 2009, that had the heaviest impact over the Croatian economy -7.38% in 2009 (Table 2). Anyway the adhesion process had started earlier, so the drop in energy demand can be linked also to a general energy efficiency outperformance (Bukarica & Robić, 2013; Lipošćak et al., 2006).

Table 2: GDP growth (annual %)

Year	Albania	Bosnia and Herzegovina	Croatia	Serbia	Montenegro	Macedonia, FYR
2005	5,72	8,76	4,16	5,54	4,18	4,72
2006	5,43	5,38	4,79	4,90	8,57	5,14
2007	5,90	5,73	5,15	5,89	6,81	6,47
2008	3,76	5,58	2,05	5,37	7,22	5,47
2009	3,35	-2,99	-7,38	-3,12	-5,80	-0,36
2010	3,71	0,87	-1,42	0,58	2,73	3,36
2011	2,55	0,96	-0,33	1,40	3,23	2,34
2012	1,42	-0,82	-2,24	-1,02	-2,72	-0,46
2013	1,00	2,35	-0,65	2,57	3,55	2,93
2014	1,77	1,15	-0,10	-1,83	1,78	3,63

Source: IEA Statistics © OECD/IEA 2014 (http://www.iea.org/stats/index.asp)

Macedonia energy sector is characterized by a relatively flat demand and low variation. The energy use dropped from 1.359 in 2005 to 1.263 toe/capita in 2014. The Economic crisis had limited effect on the Macedonia GDP, the recession interested only year 2009 (-0.36%) and year 2012 (-046%). Anyway peripheral factors, whether of political, or economic nature, have the potential to alter Macedonia's energy supply. There is an open discussion whether the crisis in Ukraine has stunned the political equilibriums and consequently the energy security in Macedonia (Kovacevic, 2009; Shasivari & Zejneli, 2013). Several legislation initiatives have been implemented to boost the energy sector and to increase the energy autonomy (Energy Regulatory Commission, 2013).

Montenegro has a compact energy demand, due to a small population and territory. Energy demand in Montenegro for 2014 was approximately 1.815 toe/capita (Table1). The majority of electricity is produced at the Pljevlja coal-fired Thermal Power Plant, and few hydro power plants. Since June 2006, the Montenegrin Parliament declared the independence of Montenegro, confirming the result of a previous referendum. Important investments were implemented after the independence, including also the energy sectors [9]. Significant reforms are approved in the field of energy efficiency for residential and accommodation buildings, due also to the strategic interest for the tourism sector (Assenova, Georgiev & Dunjic, 2016). The economic crisis had a strong negative impact in 2009 (Table 2), anyway the country economy recovered quickly.

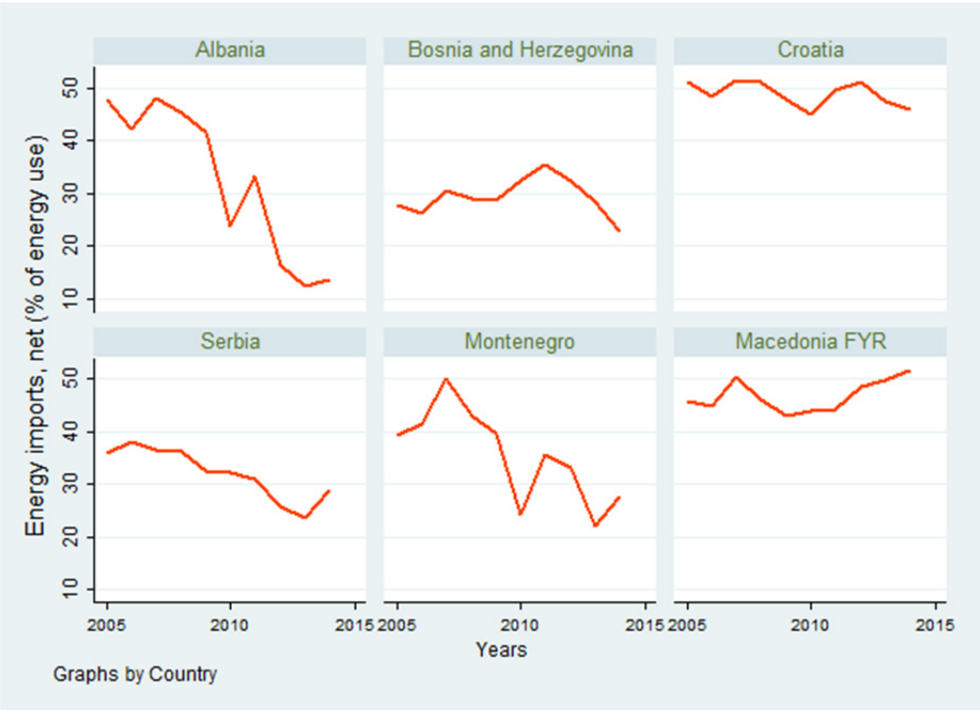
Serbia energy demand has fallen from 2.159 to 1897 toe/capita (Table 1) in the period under observation. The demand structure is largely dependent on imports of energy resources. The country has very limited oil and gas reserves, except the coal resources. There are important investments projects like the Southstream pipeline to transport natural gas of the Russian Federation through the Black Sea to Bulgaria and through Serbia, further to European countries (Kovacevic, 2009). The country struggled to exit from the Economic crises with discrete growth rates in the recent years (Table 2). There are ambitious plans to expand the renewable energy sources and the energy efficiency, through legislative reforms and fiscal incentives [Lopičić et al. 2017; Golusin, Tesic, & Ostojic, 2010).

2. Literature Review

In the past 40 years a lot of research is focused on the Energy demand modeling. The main approaches are the Bottom-up and Top Down modeling [15]. Generally, the top down models follow an econometric approach, meanwhile the bottom up models are engineering models using optimization techniques or accounting models (Suganthi & Samuel, 2012). Top-down models are based on macroeconomic time series and may be used to forecast energy demand entirely from an economic criterion, including the available technology as an exogenous covariate among other independent variables. Top down models are generally a good starting points for small open economies that have important interaction within a specific region. The main inconvenience is the absence of response variables from the microeconomic units of the energy system.

In a bottom up model the energy demand is determined by the sum of averages of microeconomic units. Within the bottom up approach, significant contributions were dedicated to the energy system optimization models (ESOM). ESOMs are simulation tools, often used to reproduce the operation of given energy-system to supply a given set of demands, and can be referred to as bottom-up given their focus on analyzing specific energy technologies and the associated investment options (Connolly et al. 2010). The bottom up approach faced in the past constant criticism for not being able to incorporate exogenous information determined in the macroeconomic level, or moreover in the international markets (Böhringer, 1998). The bottom up approach could be suitable in a closed or semi-closed energy system with only a few operators, but the global energy planning is intrinsically influenced by the introduction of liberalization processes, removal of trade and non trade barriers and political efforts towards the reductions of greenhouse gas emissions. In the recent years the bottom up models have converged toward the Hybrid models, integrating top down information. Special efforts are implemented within the International Energy Agency (IEA, n.d), since 1993 the IEA has developed the World Energy Model (WEM) that is basically a hybrid model, using several scenarios for the energy projections (Statistics, I. E. A. 2011).

The Western Balkan countries rely heavily on imports to guarantee the energy supply (Fig. 1). If the transport sector generally is regulated by the market mechanisms of oil prices, the electricity supply generally is regulated by central governments, through subsidiaries. In case of electricity shortage, the gap is filled by unplanned outages of power supply.



Net energy imports are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter

Figure 1: Energy imports, net (% of energy use)
Source: IEA Statistics © OECD/IEA 2014 (http://www.iea.org/stats/index.asp), subject to https://www.iea.org/t&c/termsandconditions/

3. Methodology

3.1 Econometric Models

The energy demand in Western Balkan countries is portrayed by limited generation/production capacity, and the energy supply is depending on imports. The region is very susceptible to external oscillations, leading to severe exogenous impacts on the long term equilibrium. All the above characteristics pilot this study towards a top down macroeconometric model.

The data used in the analysis consist of 6 Western Balkan Countries over the 2005-2014 period. The data were collected from World Development Indicators web site. STATA 11 was used to perform the panel data regression.

An energy demand model in logarithmic form is adopted based on:

$$Ln\_Energy = \beta_0 + \beta_1\ GDP\_growth + \beta_3\ Ln\_Electr + \beta_4\ Ln\_Exchange\ \ \beta_5\ Ln\_OilPrice$$

Where:

Ln_Energy is natural logarithm of the Energy use (kg of oil equivalent per capita)

GDP_growth is the annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.

Ln_Electr is the natural logarithm of the Electric power consumption (kWh per capita)

Ln_Exchange is the Official exchange rate referred to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

Ln_OilPrice is the natural logarithm of the average annual crude Oil in the New York commodity market. Note that Oil price is within the countries invariant variable.

Estimated Coefficient Model is given in table 3, results are compared between e fixed effects linear model and a random effects linear model:

Table 3: Panel data linear model of Ln_Energy

Variable	Fixed Effects			Random Effects		
	Coef.	S. Error	p-value	B	S. Error	p-value
GDP_growth	.0025	.0027	0.357	.0038	.002891	0.194
Ln_Electr	.4858	.0696	0.000***	.4636	.072744	0.000***
Ln_Exchange	-.3850	.1036	0.001***	-.1054	.0472	0.026***
Ln_OilPrice	-.0381	.0400	0.346	-.0306	.0434	0.481
constant	4.4730	.5551	0.000	3.9432	.5842	0.000
sigma_u	.7628			.2235		
sigma_e	.0631			.0630		
rho[1]	.9932			.9262		

[1]*fraction of variance due to u_i*
****Significant at 5% level.*

In both models, the GDP growth and the Oil price is not influencing the Energy use per capita. Meanwhile the Electricity consumption and the Exchange rate are significant at 5%. It is very clear that the Exchange rate has a negative impact on the Energy demand due to the fact that all the Western Balkan Countries are depending on imports for the energy supply.

In order to decide between the two models a Housman test is applied, applying the below hypothesis:

H_o: random effects preferred; H_1: fixed effects preferred.

From table 4 the difference in coefficients is not systematic with a probability of 95%, (P-value=0.074) the null hypothesis is not rejected, so the random effects model is preferred to fixed effects.

Table 4 Housman Test Fixed vs. Random effects

Variable	Fixed Effects	Random Effects		
	Coef. (b)	(B)	b-B	S. Error
GDP_growth	..0025	.0038	-.00126	.
Ln_Electr	.4858	.4637	.02222	.
Ln_Exchange	-.3849	-.1054	-.2796	.09223
Ln_OilPrice	-.0381	-.0306	-.00748	.
chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 8.53				
Prob>chi2 = 0.0740 (V_b-V_B is not positive definite)				

Following this result, we can conclude that an increase in 1% in the Electric power consumption (kWh per capita) in each country, will increase the Energy use per capita by 0.4636%, and an increase of 1% in the local exchange rate of each country will decrease the Energy use per capita by -.1054%.

4. Conclusion and Results

During the 1990s, the Western Balkans have been characterized by violent conflicts and lack of cooperation within the countries. The weak presence of the EU and the lack of a long term strategy led these countries to approach non–EU alliances, that were not directly interested in the stability of the region. In the mid 2000 the EU identified the integration as a conflict prevention strategy, opening the path to the Stabilization and Association Process (SAP). Important reforms were implemented in every single country, to meet the SAP requirements and to guarantee the *acquis communautaire* convergence towards the EU standards and directives.

Anyway the current adhesions seem to be following a lenitive pathway, considering that only Croatia and Slovenia have joined the Union. The rest of Western Balkan countries are in the waiting list for the EU membership, and the next deadlines are not before 2025. The inner debates within the EU have delayed considerably the process. The Western Balkan countries start to find themselves vulnerable and consider the SAP as a worthless, costly investment. A good reason to shaken the EU credibility was also the energy crisis, beside the migration problems that marginally affected also the Western Balkans. The current Russian-Ucraine gas crises has created further obstacles in the energy supply and questioned the energy security in the entire region.

The Energy demand can be modeled through Top Down (Econometric), Bottom up (End-use), or Hybrid models. The energy demand in all these countries is constrained by the limited generation capacity, the vulnerability of the energy supply and the heavy dependence on energy imports. All these characteristics led to the decision to apply a top down macroeconometric model rather than following a bottom up approach.

A linear random effects panel data econometric model was chosen. In the current study the elasticity of energy demand is significantly depending on the Exchange rate and the Electricity Consumption per capita. The GDP per capita and the Oil Price seem that are not significant in the static model, further investigation can be implemented applying dynamic models for the forecasting.

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