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Article

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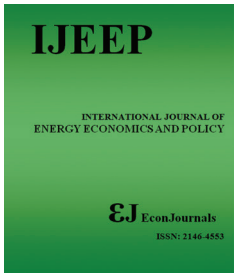

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An Aggregated Energy Security Index of Russia, 1990–2015

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ABSTRACT

The paper analyzes energy security performance made by the Russian Federation in 1990-2015 on the basis of an aggregated index that includes the total of four dimension, namely (a) energy "affordability" and (b) "availability," (c) "energy and economic efficiency" and (d) "environmental stewardship." Each energy dimension is operationalized with three indicators that allow to quantitatively measure energy security performance of Russia each 5 years since the year of 1990. The analysis gives the opportunity to measure the overall development of Russia's energy security over the last 25 years and track the progress made each 5 years in every dimension. Thus, the paper gives not only a general understanding of how the energy security of one of the largest oil and gas producers in the world was developing in 1990–2015, but also gives insights on how every aspect of its energy security was changing. The paper concludes that Russia worsened its energy security in 2015 by 3.2 points (if compared to 1990). There was a steady decline in Russia's energy security performance in the period of 1995–2010, with a modest growth in 1990–95 and 2010–15. The worst decrease in Russia's energy security was observed in 1995–2000, with an overall decline of 3.8 points. The most venerable dimension of Russia's energy security was the energy "affordability" dimension because of the constantly rising costs on energy resources. Also, Russia performed poorly in the "economic and energy efficiency" dimension, but it demonstrated a positive growth over 25 years under analysis in the energy "availability" and "environmental stewardship" dimensions.

Keywords: Energy Security, Russia, Security of Supply
JEL Classifications: Q2, Q3, Q4

1. INTRODUCTION

The issues of energy security are very relevant for both national states and interstate integration entities. There is a great number of papers published on general aspects of energy security (Yao et al., 2018; Hache, 2017; Kisel et al., 2016), as well as energy security of national states (Laldjebaev et al., 2018; Pavlović et al., 2018; Jones et al., 2017; Biresselioglu, 2017; García-Gusano and Iribarren, 2018) and interstate unions (Umbach, 2010; Jonsson et al., 2015; Lucas et al., 2016; Gökgöz and Güvercin, 2018). Our research also made an effort to quantitatively evaluate energy security of the Eurasian Economic Union (EAEU) in 2000–2014 (Bogoviz et al., 2017), relying on the methodology developed by (Brown et al., 2014). The index of energy efficiency performance was constructed to evaluate the five EAEU countries (Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia) according to the following dimensions of energy security: (1) "Availability" of energy resources (oil, natural gas, coal); (2) financial "affordability" of electricity and gasoline; (3) "energy and economic efficiency" (renewable energy consumption, gross domestic product (GDP) per unit of energy use, electric power consumption); and (4) "environmental stewardship" (SO_2 emissions, CO_2 emissions). The data analyzed showed that the EAUE countries, if taken together, had demonstrated weak energy security performance because of the existing disparities in their national energy markets. At the same time, Russia and Kazakhstan, two countries of the

Union with very rich natural resources, demonstrated high results in almost all dimensions, expect the "environmental stewardship dimension" mainly because of high CO_2 emissions. Belarus and Armenia only worsened their performance over the years due to lack of own resources and issues with energy affordability.

Despite the aforementioned research gave us the opportunity to look at the overall energy security performance of a number of countries, we clearly understood that it would be also helpful to narrow our focus and look into dynamics of one particular country instead of evaluating a group of them. Such a narrowed focus would allow to even expand the time period due to the availability of data and make more precise observations, leading to a better understanding of energy security performance of a particular EAEU member. Since we had already studied the Energy Security Doctrine of Russia and formed a qualitative understanding of Russia's strategic goals in this field (Bogoviz et al., 2018), we decided to conduct a quantitative analysis of Russia's energy security performance over the period of 25 years (1990–2015) by constructing an aggregate index of 12 indicators capturing the four energy security dimensions: "Availability," "affordability," "energy and economic efficiency," and "environmental stewardship." The goal of this research is to quantitatively analyze dynamics in energy security performance of Russia in 1990–2015.

On the basis of the literature review conducted, we state that our research is the first one that comprehensively and quantitatively analyzes Russia's energy security performance over the quarter of a century. One group of scholars focuses on diverse aspects of Russia's energy security, such as environment (Proskuryakova, 2018), the Russian gas and transport system (Edelev, Senderov and Pyatkova, 2015; Vatansever, 2017), energy relations with the ASEAN countries (Vatansever, 2017), and general quantitative studies of Russia's energy security (Trubitsyn and Atamanyuk, 2013; Zhiznin, 2010; Ershov, 2010; Bogoviz et al., 2018; Dubrovin and Dubrovin, 2011). Another Group of studies briefly mentions Russia with respect to the world and EU energy security or with respect to general issues of the concept under consideration, without analyzing or discussing the state of energy security in Russia itself (Matsumoto et al., 2018; Augutis et al., 2017; Stulberg, 2017; Zeng at al., 2017; Radovanović et al., 2017; Bompard et al., 2017; Narula and Reddy, 2015; Kratochvíl and Tichý, 2013; Kazantsev, 2012; Cherp and Jewell, 2011; Kaveshnikov, 2010; Kruyt et al., 2009; Spanjer, 2007; Van de Graaf and Colgan, 2007; Baran, 2007; Asif and Muneer, 2007; Bahgat, 2006).

In comparison with our previously published research that also reviews Russia's energy security performance (Bogoviz et al., 2017), the current paper is distinguished in a number of ways. First, the period under analysis is longer by 10 years than it was in our previous paper (Bogoviz et al., 2017). Second, we conduct a study of only one country with an interval of each 5 years (1990; 1995; 2000; 2005; 2010; 2015), instead of focusing only on 2 times periods (2000 and 2015) without studying the existing dynamics between them. Such an approach allows us to deeply analyze how Russia's energy efficiency performance was gradually changing over a longer period of time. Third, we employ two more indicators. Namely, we use an additional indicator "pump price for diesel fuel" for the "affordability" dimension and one more indicator, "energy related methane emissions," for the "environmental stewardship" dimension.

Thus, our research significantly contributes to the contemporary scholarship by providing a comprehensive analysis of the development of energy efficiency performance of Russia, one of the largest oil and gas world exporters, over the last 25 years.

The paper is structured as follows. First, we discuss the data and methods used to conduct the research. Then, results of the research are provided, including tables and graphs. Third, we discuss the results obtained and make conclusions.

2. DATA AND METHODOLOGY

An aggregated energy security performance index is constructed by us in order to capture the development of Russia's energy security in 1990–2015. Fully relying on the methodology developed by (Brown and Sovacool, 2010) and already used by us in (Bogoviz et al., 2017), we identify the total of four dimensions of energy security and then operationalize them with qualitative indicators (to be discussed below). Then we use the Z-score normalization (Brown et al., 2014; Obadi and Korcek, 2017) in order to capture relative magnitudes of change in the indicators between 1990 and 2000, as well as every 5 years within this period. Comparing Z-scores of the indicators allows us to identify how well Russia performs in energy security in general and in each energy security dimension.

The first energy security dimension we analyze is the energy "availability" dimension, which is operationalized with the following indicators: (a) "Oil import dependency;" (b) "natural gas import dependency;" (c) "coal import dependency." The data fully comes from the International Energy Agency (IEA, 2018a; 2018b; 2018c). The dependency on fossil fuels is calculated according to the methodology developed by (Eurostat, 2017).

Energy "affordability" is the second energy security dimension we use in our aggregate index. "Electricity prices for households," "pump process for gasoline," and "pump prices for diesel fuels" are used as proxies to measure energy "affordability" in Russia. The data was obtained mainly from (World Bank, 2018d; 2018e; 2018f) and (RFSSS, 2017). In order to achieve comparable values, we adjusted prices for purchasing power parity (Hedenus, Azar, Johansson, 2010).

With the purpose of reflecting the "energy and economic efficiency" dimension, we use the following indicators: (a) "Renewable energy consumption;" (b) "GDP per unit of energy use;" and (c) "electric power consumption." The data was fully obtained from (World Bank, 2018a; 2018b; 2018c).

Lastly, we measure the "environmental stewardship" dimension with the three proxies, namely (a) "CO_2 emissions per unit of GDP;" (b) "energy related methane emissions;" and (c) "SO_2 emissions" (MNRERF, 2018; RFSSS, 2016). In our opinion, these indicators allow to measure the dimension with respect to the fuel and energy complex of Russia, resulting in the opportunity to

capture the overall development in this field.

All the original data, calculations, and research results are presented in full in the next section and in the Appendix to the paper (Tables A1-A4).

3. RESULTS AND DISCUSSION

Results of the Z-score normalization are presented in Table 1 and Figures 1 and 2.

The results obtained give valuable insights into Russia's energy security performance over the last 25 years and allow making following conclusions. The first important aspect is that the overall energy security index decreased by 0.8 since 1990. Thus, Russia's energy security also slightly weakened over the period under analysis, according to our data and methodology. One may observe a gradual decline of energy security performance on the period of 1995–2010, with exceptions in 1990–1995 and 2010–2015 because of increases by 3.8 and 1 points, respectively. Such a dramatic increase in the period of 1990–1995 is due to much better performance in the "economic and energy efficiency" dimension by 5.7 points: All three indicators demonstrated significant growth by 2.868 ("renewable energy consumption"), 0.561 ("GDP per unit of energy use"), and 2.233 points ("electric power consumption"). The period of 2010–15 was marked by the growing "environmental stewardship" (0.55, due to lower CO_2 and SO_2 emissions) and "affordability" (1.68, while still being negative) dimensions, with the decreasing "availability" and "efficiency" dimensions (each of them lost 0.6 point).

With respect to the decreasing trend in 1995–2010, the total loss was 8.06 points, while an average decrease constituted 0.57 point per year. Russia had the worst energy security performance in the period of 1995–2000, with an overall decrease of 3.79 points. Such a negative trend continued in 2000–05 (−1.64) and 2005–10 (−2.63). In 1995–00, the most poorly performed dimensions were the "availability" and "economic and energy efficiency," while other two dimensions ("affordability" and "environmental stewardship") dropped slightly. In turn, in the period of 2000–05, the worst performance was made in the "affordability" dimension (−4.52) due to rising prices on electricity, gasoline, and diesel. The growth was observed only in the "availability" dimension because of the growing oil and natural gas production (in the context of rising demand on energy sources in domestic and world markets). Other two dimensions also performed poorly in this period, but their decline was not so severe as it was with respect to the energy "affordability" dimension. In 2005–10, the total decline in Russia's energy security was 2.63 points, with modest decrease in all dimensions expect "environmental stewardship," which showed a slight growth of 0.48.

Table 1: An aggregated energy security performance index, Z-score normalization results (with reversed signs), 1990–2015

Year	Availability	Efficiency	Affordability	Stewardship	Total
1990	−0.127471169	−1,573059952	2.87086213	−0.290094408	0,880236601
1995	−0.312171359	4,089719288	2.461600224	−1.552558521	4,686589632
2000	−2.181832813	1,528211525	2.395800252	−0.841239725	0,900939239
2005	1.722590542	−0,723918122	−2.125827224	0.389022329	−0,738132475
2010	0.751945198	−1,359268787	−3.636664773	0.874280043	−3,369708319
2015	0.146939602	−1,961683953	−1.965770609	1.420590282	−2,359924678

Figure 1: (a-c) Shifts in the aggregated energy security performance index of Russia, 1990–2015

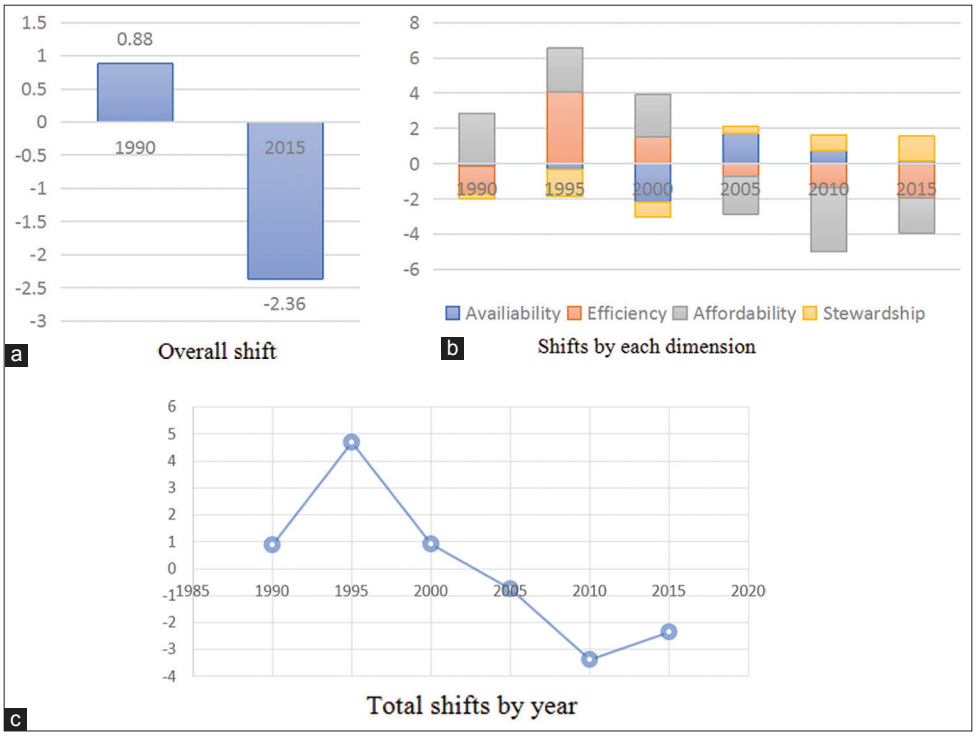
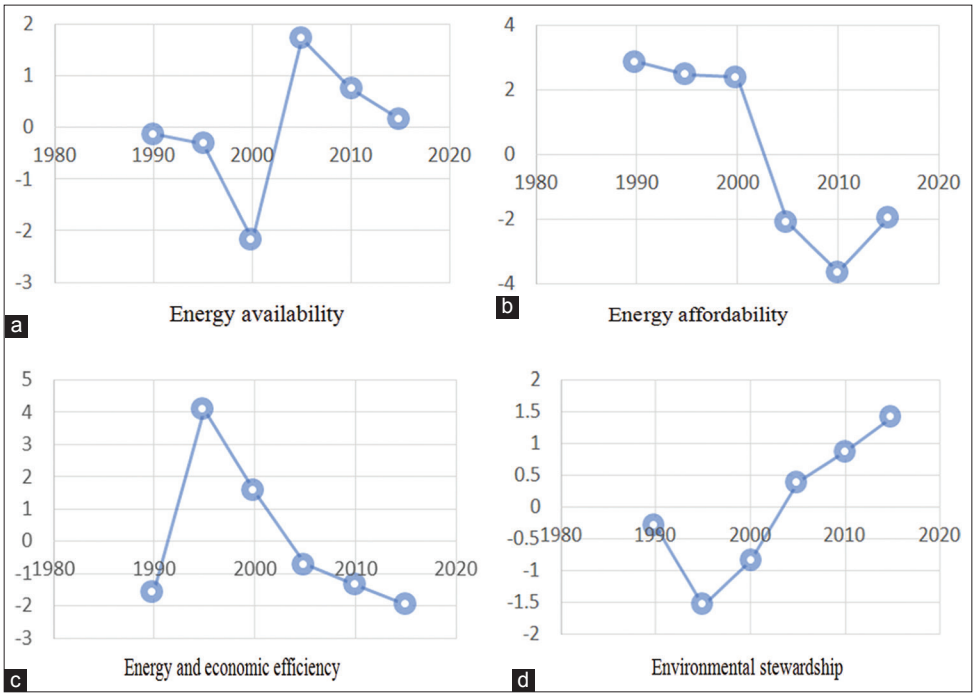


Figure 2: (a-d) Shifts in the aggregated energy security performance index of Russia by each energy security dimension, 1990–2015



The weakest energy security performance was observed in the following dimensions and time periods: (a) With its best performance in 2005, the "availability" dimension had its worse period in 1995–2000; (b) Russia also experienced the biggest decline in the "economic and energy efficiency" dimension in 1995–2000, with the prior highest value of 4.08 points in 1995; (c) the energy "affordability" dimension was constantly declining over the 20 years (1990–2010) and performed just slightly better in 2015 (in our opinion, because of the devaluation of national currency), having the best performance in 1990; and (d) the "environmental stewardship" dimension experienced the worst decline in 1990–95 and since then was constantly growing until 2015, when it had the highest value of 1.42, making the overall growth of 1.72 points.

4. CONCLUSION

In summary, we conducted a comprehensive review of Russia's energy security performance over 25 years, relying on extensive quantitative data being collected for 12 indicators. The analysis shows that Russia worsened its energy security performance by 3.2 points, having the poorest performance in the energy "affordability" dimension due to the constantly rising costs on energy resources. The most significant growth was observed in the "environmental stewardship" dimension because of lowering mainly the CO_2, SO_2 emissions.

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APPENDIX

Table A1: "Availability" dimension indicators and Z-scores, Russia, 1990–2015

Year	Oil import dependency, %	Coal import dependency, %	Natural gas import depend., %	Z-scores: Oil import depend	Z-scores: Coal import depend	Z-scores: Natural gas import depend	Total (not reversed)
1990	−320.3	−197.15	−97.34	−1.439443441	0.479696297	1.087218313	0.12747117
1995	−297.8	−121.34	−116.3	−0.8752672	0.759716648	0.427721911	0.31217136
2000	−221.23	−56.23	−124.66	1.044687235	1.000214275	0.136931303	2.18183281
2005	−269.15	−283.79	−178.2	−0.156882786	0.159673039	−1.725380795	−1.7225905
2010	−239.15	−548.98	−143.76	0.595352202	−0.819862602	−0.527434798	−0.7519452
2015	−229.73	−754.62	−111.32	0.831553989	−1.579437658	0.600944067	−0.1469396
Median	−254.15	−240.47	−120.48				
Mean±SD	−262.8933333	−327.0183333	−128.5966667				
	39.88115478	270.7303226	28.74920915				

SD: Standard deviation

Table A2: "Affordability" dimension indicators and Z-scores, Russia, 1990–2015

Year	Electricity price for households, US$/100 kWh[1]	Pump price for gasoline, US$/L	Pump price for diesel fuel, US$/L	Z-scores: electricity price	Z-scores: Gasoline price	Z-scores: Diesel fuel price	Total (not reversed)
1990	4.4	0.31	0.26	−0.970896212	−0.939935197	−0.960030721	−2.8708621
1995	4.96	0.35	0.28	−0.827249745	−0.77032283	−0.864027649	−2.4616002
2000	5.36	0.33	0.29	−0.724645125	−0.855129014	−0.816026113	−2.3958003
2005	8.79	0.77[2]	0.66[2]	0.155189487	1.010607016	0.960030721	2.12582722
2010	12.4	0.84	0.72	1.081196178	1.307428657	1.248039938	3.63666477
2015	13.2	0.59[3]	0.55[3]	1.286405417	0.247351368	0.432013825	1.96577061
Median	7.075	0.47	0.42				
Mean±SD	8.185±3.898459952	0.531666667±0.235831861	0.46±0.208326667				

SD: Standard deviation

Table A3: "Energy and economic efficiency" dimension indicators and Z-scores, Russia, 1990-2015

Year	Renewable energy consum, % of total	GDP per unit of energy use, 2011 PPP $ per kg oil equivalent	Electric power consumption, kWh per capita	Z-scores: Renewable energy consumption	Z-scores: GDP per unit of energy use	Z-scores: Electric power consumption	Total (not reversed)
1990	3.752	3,481	6673.179	1.155683704	−0,596767464	1.014143711	1,573059952
1995	2.871	2,986	5101.555	−1.71236515	−1,158720339	−1.218633799	−4,089719288
2000	3.497	3,326	5198.417	0.325544705	−0,772732506	−1.081023725	−1,528211525
2005	3.615	4,256	5770.112	0.709687458	0,283057744	−0.268827081	0,723918122
2010	3.343	4,795	6409.895	−0.175794141	0,894961986	0.640100942	1,359268787
2015	3.304	5,196[4]	6602.858[4]	−0.302756576	1,350200578	0.914239951	1,961683953
Median	3.42	3,8685	6090.0035				
Mean±SD	3.397±0.307177473	4,006666667±0,88085678	5959.336±703.8874195				

SD: Standard deviation

Table A4: "Environmental stewardship" indicators and Z-scores, Russia, 1990–2015

Year	CO_2 emissions per unit of GDP, kg CO_2/2010USD[5]	Energy related methane emissions (% of total)	SO_2 emissions, thousand tons	Z-scores: CO_2 emissions	Z-scores: Methane emissions	Z-scores: SO_2emissions	Total (not reversed)
1990	1.536	67.692	5782	0.618457086	−1.529509442	1.201146764	0.29009441
1995	1,76	72.276	5501	1.285231133	−0.483389339	0.750716728	1.55255852
2000	1,55	72.487	5407	0.676437438	−0.435236778	0.600039064	0.84123972
2005	1,16	76.335	4797	−0.454179423	0.442919888	−0.377762795	−0.3890223
2010	1	78.243	4512	−0.918022238	0.878346842	−0.834604647	−0.87428
2015	0,9[4]	79.332	4197	−1.207923997	1.12686883	−1.339535114	−1.4205903
Median	1.345	74.411	5102				
Mean±SD	1.316666667	74.39416667	5032.666667				
	0.34494444	4.381906043	623.8482722				

SD: Standard deviation

1 Prices are adjusted to PPP, 2011US$.
2 Data for 2006.
3 Data for 2016.
4 Data for 2014.
5 CO2 emissions from fuel combustion only.
6 Data for 1992.