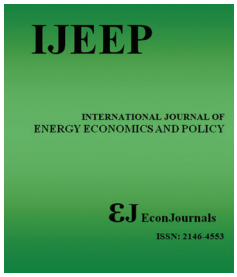

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Research on the Concentration of Companies in the Electric Power Market of Russia

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ABSTRACT

The article is devoted to the issues of determining the structure and type of the industrial market of the Russian electric power industry. A comprehensive analysis of competition was conducted based on empirical data on installed capacities, production volumes and economic results of Russian power generating companies for 2016. The most common indices and coefficients for assessing the concentration of the industry market are critically evaluated taking into account the criteria of consistency, efficiency, intuitivity and the power of behavioral response. Based on them, a ranking approach of an integrated market type definition is proposed. The obtained results show that the Russian electricity market is classified as a diffused oligopoly with a tendency to monopolistic competition. The market is dominated by 9 significant players, who control more than 70% of electricity generation collectively. An important feature of the market is the absence of participants independent of the state and not affiliated with large industrial groups. The unclear type of the market indicates a possible change in the medium term subject to a number of conditions. This is facilitated by a stable long-term trend towards a reduction in market concentration by the Herfindahl-Hirschman index. At the same time, the probability of a significant redistribution of market shares is low until the structural problems of the industry are resolved. The revealed specificity of the industry is the existence of a significant market potential, even with a small amount of the player's market share (<10% sometimes). These circumstances point to the prospect of comparing the RSI residual supply indices between players in the regional market and between zones of free electricity flow in Russia. The results of the research open wide heuristic opportunities in the development of practical recommendations on the organization of corporate management and state regulation in the industry.

Keywords: Market Concentration, Electric Power Industry, Competition, Market Structure
JEL Classifications: L94, D401.

1. INTRODUCTION

The stability and security of the national economy depend on the state and development of its key industries. The electric power industry has technological and organizational specifics requiring special attention. The power industry is undergoing deep restructuring globally. The actual transition to a new technological structure is associated with an intensive growth of investment activity. Investments are required not only to maintain global trends but also to prevent loss of competitiveness (Orekhova and Kuzmin, 2017). Changes are also related to the expansion of new technologies and energy sources, as well as to the management structure reorganizations.

Under conditions of globalization, the state of the electric power industry and maintaining its export potential are of strategic importance for the national economy of Russia. This is what the relevance of this study is driven by. Russia ranks 4th in the world in

terms of electricity generation, being behind the US (by 5 times), China (by 4 times) and India and being roughly on par with Japan. In 2016, all Russian power plants produced 1,091 billion kWh of energy; domestic consumption was about 1,078 billion kWh (Rosstat, 2018). At the same time, the average annual utilization factor of the installed capacity of all power plants in Russia is about 54.7% (Antipov, 2016).

A distinctive feature of the energy industry in Russia lies in the unique combination of market and non-market regulatory mechanisms. The development of the industry is hampered by structural problems, including a low level of price elasticity, a slow reaction of the market to a shortage of generating capacities at peak loads, the duration of construction and start-up of new power plants, etc., (Smagina and Nestulayeva, 2015). It is obvious that the understanding of the structure and characteristics of the industry is necessary to ensure long-term sustainable growth (Strielkowski et al., 2017). These circumstances predetermined the purpose of this study, which is to deliver an opinion about a certain type of industrial market based on the rank approach proceeding from the values of the integrated assessment of multiplier coefficients.

2. LITERATURE REVIEW

Significant steps towards a modern understanding of the issues of the organization of the industrial market and competition in it were Schumpeter's entrepreneurial theory (Schumpeter, 1947) and the functional theory of competition of the neo-Austrian school (Caldwell and Boehm, 1992; Littlechild, 1990; Menard, 2005; Williamson, 1996). A serious revision of the concepts turned out to be in demand with the transition to a new structure of the economy. Roy Harrod got interested in the phenomenon of inequality of markets. According to Harrod, the variability of the number of market players is due to the difference in goals with which firms enter the market (Harrod, 1934). His approach was developed by the representative of the Harvard school Bain (1956), who became one of the first researchers of market barriers. The Harvard school approaches the analysis of the industry market from the position of the structure and its connection with the behavior of market participants (Faccarello and Kurz, 2016; Romanova, 2010), and therefore is of greater interest in terms of this study.

The conceptualization of the efficiency of markets took place in the second half of the twentieth century. The most notable works of this period are Harvey Leibenstein's theory of X-efficiency (Leibenstein, 1978), Robert Wilson's research (Wilson, 1977), the structural efficiency of the market by Scherer (1983), and Weiss (1989). Economists sought optimal models of state regulation. The share of players in the market began to be considered as a fundamental basis for analyzing its structure and boundaries. The coordination of economic activities significantly increases costs relative to operating costs, and the cost of this coordination is the source of market boundaries, as well as the boundaries of the firm (Kuzmin, 2014; Kuzmin, 2017). The boundaries of the industry market imply the precise definition of a set of agents included in the field of research (Avdasheva and Rozanova, 1998); with those being electricity producers in our case.

The market power of electricity producers is determined by four main factors (Newbery, 1995; Biggar and Hesamzadeh, 2014; Ji and Yépez-García, 2017): the volume of the company's generating capacity; distribution network constraints; market conditions of supply and demand; price elasticity of demand. However, the assessment of the market power of players in Russia is complicated by the lack of research tools that take into account the distribution, condition, and ownership of production capacities.

Technological conditions make a high level of monopolization an inevitable feature of the energy industries. Those are under the close control of the state in developed countries. Obviously, the competitiveness of the industry essentially depends on the level of concentration and pricing features. The same parameters are also used in assessing the effectiveness of state industry regulation (Knyazeva and Svitych, 2015). Modern research shows that the minimization of state regulation of the industry and price liberalization are by no means desirable as long as price liberalization can have catastrophic consequences under existing market conditions with a low level of price elasticity. It is necessary to search for the optimal, but not the minimum level of regulation (Aizenberg, 2014).

Large industrial structures tend to be vertically integrated, which is determined in the market by transaction costs, on the one hand, and by striving to expand their control over generating capacities and ensure their entry into new markets, on the other hand (Serdyukov, 2011). Possible negative effects are associated with restrictive commercial practices. Therefore, the reason for the state's increased attention is not only the significant influence of large companies on the national economy but also their social significance, i.e., the fact that large enterprises mainly form both aggregate demand and supply (Haan and Sturn, 2002).

The development of competition in the Russian power industry is connected with the restructuring that has been carried out since 2003 (Antipov, 2016). The refusal of the national vertically integrated management structure was intended to give the wholesale electricity market competitive features. The liberalization of the market was thereby accelerated and territorial generation companies appeared, along with which independent regional suppliers now operate (Makarov and Barbashina, 2016). At the same time, none of the regional integrated energy systems in Russia has any significant players that are independent of the state and not affiliated with large industrial groups (Samochadin and Pykhteev, 2015). More details of control systems were considered by Salimonenko and Shindina (2013). This brief review allows concluding that the regulation of integration processes in the power industry of Russia is very uneven (Chubais, 2009), and the industry's prospects are very uncertain (Makarov et al., 2013; Makarov and Barbashina, 2016; Barinov, 2013; Barinov et al., 2017).

At the same time, the global electric power industry clearly traces the trend towards the integration of electric power systems into interethnic and geographically conditioned "supergrids" (Marzooghi et al., 2016). In this regard, the need for the optimization of the regulatory system against a background of

a large number of companies, as well as the diversification of technologies for the production of electricity and a variety of energy carriers, is clearly indicated among the tasks of developing the Russian fuel and energy complex (Dezellus et al., 2015). This situation leads us logically to the study of concentration in the electricity market.

3. METHODS

The level of concentration of the industrial market is one of the key characteristics of its structure. Other characteristics of the market are taken into account along with concentration. Together they determine the type of the market when demand is relatively constant (Table 1). The structure of the industry market is revealed by three basic indicators - the number of suppliers *N*; the suppliers' market share *S* and the market concentration indicators. As a rule, market concentration is estimated based on the share of sales or products output in value or in volume terms.

Let us consider some of the indicators that constitute the core of generalized market type perception in more detail.

The distribution of market shares is clearly visualized by the Lorentz cumulative curve. The concentration coefficient *CR* relates the amount of market shares of the largest players ($n<N$) to the total sales volume. But this indicator does not take into account the ratio of the shares of the largest suppliers, as well as the share of other market participants, which leads to the inadequate comparison of different industries. Thus, the verification by the known additive method is not carried out (Avdasheva and Rozanova, 1998). The problem is solved by calculating additional indicators, including the Herfindahl-Hirschman index (HHI), the market shares dispersion, the relative concentration coefficient, etc.

The variance of market shares σ^2 shows the uneven distribution of the shares of all suppliers in the market. The higher the variance value, the greater the level of market concentration. The disadvantage of this indicator is its ignoring the number of players (Avdasheva and Rozanova, 1998). The *HHI* solves the above-mentioned dispersion problem by means of a quadratic form (Hirschman, 1964):

$$HHI = \sum_{i=1}^{N} S_i^2 = N\sigma^2 + \frac{1}{N} \quad (1)$$

The value of the HHI index tends to zero in the hypothetical case of perfect competition, with 1 being the total monopoly. The Federal Antimonopoly Service of Russia (Order of the FAS of Russia No. 220, 2010) gives preference to the first type CR_3 and *HHI* indicators in its calculations, considering the remaining ones as additional, and distinguishes three levels of market concentration: high - $CR_3 > 0.70$, $HHI > 0.20$; moderate - $CR_3 > 0.45$, $HHI > 0.10$ and low - $CR_3 < 0.45$, $HHI < 0.10$.

The relative concentration ratio CRR_n is calculated as the ratio of the aggregate share of the *n* largest players S_n^A in the market to the share of their sales Q_n^A (Besanko et al., 2009). The maximum share index I_{Smax} compares the share of the market leader S_{max} with the average share S_a. The index is zero for perfect competition and 1 for a complete monopoly. In its simplicity, it takes into account both the degree of inequality and the number of players, but is insensitive to the ratio of outsiders among themselves (Cowell, 2011).

The *Gini* index is closely related to the mentioned Lorentz curve and is calculated as the proportion of the area of the triangle that appeared between the direct graph and the statistically constructed curve. Along with the dispersion of market shares, the Gini index is used to assess the inequality in the size of firms. The *Hall-Tideman/Rosenbluth* index uses the ranking of companies by share. With perfect competition, the value of the indicator tends to 1, and as the concentration of the market increases, it decreases (Hall and Tideman, 1967).

The *Linda* index compares $n > 1$ market leaders and estimates their inequality based on the ratio of the market share of each player *i* to the market share, which is occupied by leaders from the first to the *n*-th (Linda, 1976):

$$L_{ind} = \frac{1}{n(n-1)} \sum_{i=1}^{n} \frac{S_i(n-i)}{(S_n^A - S_i)i} \quad (2)$$

The *Linda* index value is nonmonotonic relative to *n*. From $n = 2$, as *n* increases, L_{ind} decreases. The value of *n*, after which L_{ind} begins to grow, is the number of market leaders according to the index.

The I_{inv} index of inverse values of shares compares the sum of the inverse values of the market players' shares (in percent) with $N^2/100$. The values of this index from 0.75 to 1 are considered to be related to competitive market; from 0.5 to 0.75 - to monopolistic competition; from 0.25 to 0.5 - to oligopoly (Cowell, 2011).

The coefficient of absolute entropy *ER* estimates the average share of the player in the industry in question and reflects the disorder of shares distribution (Shannon, 1948). The higher the *EA*, the lower the concentration of the market and the less the market power of each individual supplier. The *relative entropy* index *ER* is applied when comparing the previous indicator between the markets. The closer *ER* is to 0, the higher market concentration is (Clarke et al., 1984):

Table 1: Characteristics of main types of industrial markets

Market type	Supply structure	Output	Barriers
Competition	Large number of suppliers with negligible shares	Standardized	Low
Monopolistic competition	Big number of suppliers with small shares	Differentiated	Low
Oligopoly	Several suppliers with significant shares	Standardized/differentiated	Significant
Monopoly	Single supplier	Unique	High

Avdasheva and Rozanova, 1998

$$ER = \frac{\sum_{i=1}^{N} S_i \ln\left(\frac{1}{S_i}\right)}{\ln N} \quad (3)$$

All described indicators can be divided into actual concentration indices - CR_n, *CRR, HHI, HT*; and indicators reflecting the inequality of shares - *ER, Gini,* L_{ind}, I_{Smax}, I_{inv}, σ^2. Summarizing the described features of various indices, let us draw attention to the fact that each of them has its advantages and disadvantages by certain criteria (Table 2). This leads to the need to integrate the values of indicators in order to smooth out the disproportionate estimates. Author's ranking approach is suggested in this study for a more balanced analysis. Similar methods were used in other studies on industry-specific markets (Stapova, 2009).

The most recent available data on installed capacities, production volumes and economic results of generating companies in Russia for 2016 from the Energy Base information system (Energy Base, n.d.) and SPARK-Interfax (n.d.) are used as the calculation base. Totally, according to the research sample, they provide more than 87% of electricity production. The structure of production by sources of energy in Russia is represented by thermal power stations (64%), nuclear power plants (19%), hydroelectric power stations (17%) and renewable sources (Rosstat, 2018). There are 700 power stations of various types at the regional level. The current work considers the data on 591 facilities.

In the framework of the ranking approach, the values of all ten indicators are calculated (according to Table 2), and the concentration coefficient CR_n is defined for several n = {3, 4, 6, 8}, while the CRR_n is defined for n = {3, 4}; thus, the total number of indicators is 14. Since different indicators sometimes give opposite estimates of the market type, the final decision is made on the basis of the sum of the indications of all indices with the principle of rank division.

4. RESULTS AND DISCUSSION

Data on 79 economic entities with a generation volume ranging from 7 million kWh to 146,000 million kWh were used for calculations. The total output of these companies is 953.4 billion kWh, or 87.6% of the total electricity produced in Russia in 2016 (Rosstat, 2018).

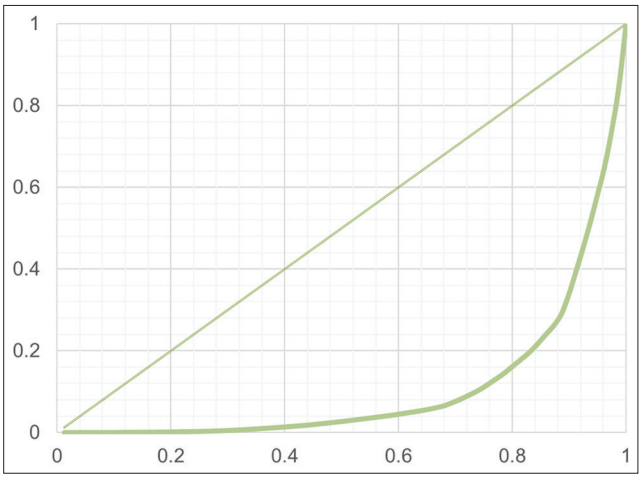
Fragmentary calculation of the selected parameters values indicates that the most "monopolistic" position is shown by the maximum share index, the inverse value index of shares and the Gini index. The maximum share index shows a peculiarity, which consists in the fact that the indicator considers significant only the share of the leader (the share of the leader of the electric power market of Russia exceeds 15%). The index of inverse values takes all the shares into account, and its sensitivity to unevenness is further enhanced by the hyperbolic function underlying it if compared to *HHI*. The Gini index does not have strict criteria for referring to the type of market. The Lorenz curve was constructed in order to calculate the Gini index (Figure 1).

The Linda index was calculated in compliance with the recommendations of the European Commission. The minimum value was achieved with the number of market leaders equal to 9 (details in Table 3). This allows speaking of a "diffused oligopoly." It should be noted that the key participants in the competition in the Russian electricity market are territorial generating companies (14 enterprises in the country) and wholesale generation companies (7 enterprises).

Changes if compared with the period before the beginning of reforms (2003) are obvious. There is a steady tendency to reduce the market concentration by the HHI (Figure 2).

Since in this case the values of all the indices fall into three main variants: Monopoly (MP), oligopoly (OP) and monopolistic competition (MC), 1.5 points are allocated to each index within the rank approach. 1 point is given to the type of market, which the index indicates consistently. Another 0.5 points are awarded in favor of the type of market to which this index gravitates or can correspond under certain assumptions. All calculated results are presented in Table 4.

Figure 1: The Lorentz curve for the Russian electricity generation market, 2016



Source: Authors' calculations

Table 2: Advantages and disadvantages of concentration indices

Comparison parameter	*Indicator*									
	CR_n	*CRR*	*HHI*	*HT*	*ER*	Gini	L_{ind}	I_{Smax}	I_{inv}	σ^2
Consistency (considers changes among outsiders)			+	+	+				+	+
Efficiency (reflects the variability of S)			+	+	+	+				+
Intuitivity (allows representing N and nonequivalence)	+	+					+	+	+	
Behavior consideration (reflects the variability of N and integrity)					+		+			+

Table 3: L_{ind} for n={2 . 10} of the Russian electricity market for 2016

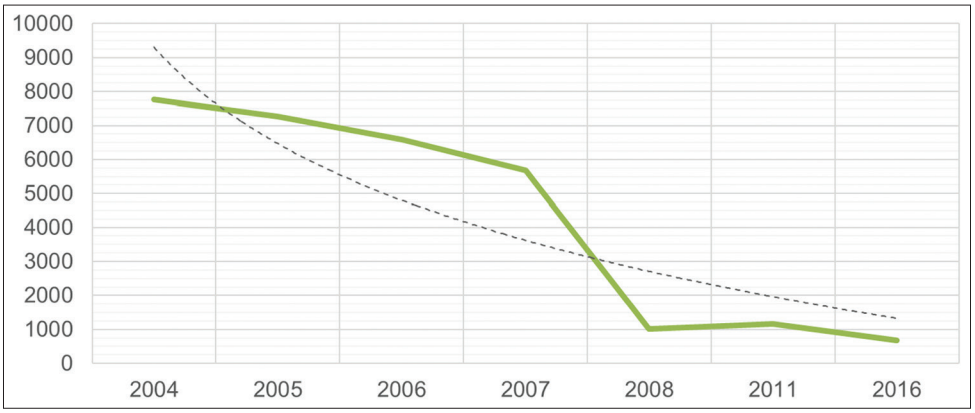
n	2	3	4	5	6	7	8	9	10
L_{ind}	0.709	0.310	0.189	0.114	0.079	0.057	0.043	0.038	0.046

Table 4: Aggregated data on the type of electricity market in Russia for 2016

Index	Value (%)	Criterion (%)	MP	OP	MC
Concentration coefficient	CR_3=35.0	<45	0.0	0.5	1.0
Concentration coefficient	CR_4=42.0	<45	0.0	0.5	1.0
Concentration coefficient	CR_6=55.0	>45	0.0	1.0	0.5
Concentration coefficient	CR_8=66.5	>45	0.0	1.0	0.5
Relative concentration coefficient	CRR_3=0.90	<1	0.0	0.5	1.0
Relative concentration coefficient	CRR_4=0.84	<1	0.0	0.5	1.0
Herfindahl-Hirschman index	*HHI*=687.7	<1000	0.0	0.5	1.0
Variation coefficient	σ^2=3.4	<33	0.0	0.5	1.0
Gini ratio	*Gini*=0.78	Floating	0.5	1.0	0.0
Hall-Tideman Index	*HT*=0.059	<0.1	0.0	0.5	1.0
Relative entropy	*ER*=71.1	Floating	0.0	1.0	0.5
Maximum share index	I_{Smax}=0.85	>0.75	1.0	0.5	0.0
Linda index at n=9	L_{ind}=0.038	9 leaders	0.0	1.0	0.5
Inverse shares values index	I_{inv}=0.015	<0.25	1.0	0.5	0.0
Total			2.5	9.5	9.0

MP: Monopoly, OP: Oligopoly, MC: Monopolistic competition

Figure 2: The *Herfindahl-Hirschman index* value of the electric power industry in Russia for 2004–2016



Source: (Lymar, 2010; Vanadzina, 2016), authors' calculations

After the final calculations are done it is clear that the market of the electric power industry in Russia cannot be classified as monopolistic. However, the preferred type of "oligopoly" takes an unstable position. It is enough for 6 leaders to lose a total of a few percent of the market in favor of those catching up - and the concentration ratio of CR_6 will amount to <45%, thereby changing the type of market for monopolistic competition. On the other hand, if traditional CR_{10} = 73.7% and CR_{25} = 93.3% are added to the consideration, then, according to the FAS of Russia, this will add two points in favor of the monopolistic type of the market and one point in favor of oligopoly, thereby strengthening the position of the latter.

The high dynamics of the seasonal demand level in the electricity market establishes a number of research limitations. Indices calculated over a long period of time cannot take into account the market power that grows with manufacturers due to the critical network loads. Calculation of the concentration indices of the electricity market is based on the amount of generation and does not take into account the volume of enterprises' capacity. This means that the market power of enterprises that have large reserve capacities can show up during periods of increased demand for electricity, and remain invisible to indices during the usual period of time. Hence the legitimate conclusion is that the specificity of the Russian electric power industry lies in the great potential of market power even with a small amount of the player's market share (sometimes <10%). In order to compensate for this shortcoming of the calculation model of the study, it is possible to use the *RSI* residual supply index and derived indices based on it in addition to the concentration indices.

In general, the results obtained are in line with the conclusion made by Samochadin and Pykhteev (2015), when they described the state of the wholesale electricity market as an oligopoly with elements of localization. The fact is that all considered indices do not take into account the regional and structural distribution of demand. If there is one supplier in each of 85 regions, then under the assumption that the regions are the same, the methodology of the FAS of Russia demonstrates an exemplary level of competition (*HHI* = 0.0118, CR_3 = 3.5%). At the same time, the real picture

leads to defining such market as the monopoly of each individual supplier in its territory of functioning (under the condition of high transportation costs or the presence of other economic cross-territorial barriers for consumers). The unified energy system being a network theoretically provides the possibility of electricity transmission, but in reality, the actual transmission of electricity or capacity is associated with an additional increase in losses and, correspondingly, costs, which makes it economically inefficient to transfer high power between the entities.

Thus, regional markets within the free power transfer zones are closed, and it is advisable to conduct a concentration level analysis for individual regions. A regional survey of the Russian electricity market may be the subject of future research. The most critical is the fact that none of the selected indices takes into account the regional distribution of suppliers and consumers. This affords grounds for replacing the calculation base with the number and market shares of players in each zone of the free flow of electricity to be considered as parameters.

5. CONCLUSION

The study of the concentration of Russian electric power industry enterprises led to the conclusion that this industry market belongs to the oligopoly type with a tendency to monopolistic competition. The change in the type of market will inevitably affect the approaches and principles of its state regulation. First of all, this will affect large industrial structures that are prone to vertical integration. The results show that the market is dominated by 9 players that control more than 70% of electricity generation collectively. The share of the leader of the electric power market of Russia is about 15%. This allows speaking of a "diffused oligopoly." An important feature of the market is the absence of significant state independent players, which are also not affiliated with large industrial groups. It should be noted that the key competition participants in the Russian electricity market are territorial generating companies (14 enterprises in the country) and wholesale generation companies (7 enterprises). Therefore, it is necessary to take into account the affiliation of the subjects even with them being economically independent for a more correct identification of the market in future research.

The unclear type of the market indicates its possible change in the medium term, subject to a number of conditions. One of the scenarios for changes may be a slight loss of market power among the first 6 market leaders - the total loss of a few percent of the market share in favor of those catching up will lead to a decrease in CR_6; thus, the market type will be replaced by monopolistic competition according to the rank model. This is facilitated by a stable long-term trend towards a reduction in market concentration according to the HHI. At the same time, the probability of a significant redistribution of market shares is low, until the structural problems of the industry remain unresolved. Outsiders need strategic investments in order to grow. Investors receive state guarantees of return of capital investments within 10–20 years provided that the generating facilities are commissioned on time. However, today such measures lead to an increase in reserve capacity of major players as well as higher tariffs for end-users (Vanadzina, 2016). Thus, another feature of the Russian electric power industry is the large potential of market power, even with a small amount of the player's market share (sometimes <10%). These circumstances indicate the prospect of comparing the RSI residual supply indices between players in the regional market and between zones of free electricity flow in Russia. The *RSI* directly affects pricing processes and, as a consequence, it affects the difference in the profitability of enterprises of different sizes and also their investment potential. This area of research has broad heuristic capabilities when developing practical recommendations for the organization of corporate management and government regulation in the industry.

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