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Application of the Fuzzy VIKOR Method to Assess Concentration and its Effects on Competition in the Energy Sector

Kęstutis Peleckis

Department of Economics Engineering, Faculty of Business Management, Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania; k.peleckis@vilniustech.lt; Tel.: +37-06-169-8745

Abstract: Background: Understanding the market competition is one of the most important factors for examining and assessing competition issues, and is of growing interest in business sustainability research. Markets in the energy industry, which are notoriously harder to monitor, are often presented with scenarios in which the strength of various market parties varies, making harmonization a significant problem. This article's aim is to find the feasibility of measuring the HHI in the implementation of business strategies in order to avoid market distortions in the energy industry. The uniqueness of this article is that it outlines the capabilities of the fuzzy VIKOR approach for assessing the HHI in order to avoid a distorted market by examining the most important economic parameters in the energy market. This paper's contribution is compiling the HHI evaluation system in the energy sector, with the goal of identifying the market conditions of corporate entity and assisting in the attainment of long-term market competitiveness. The results demonstrate that a comparison of the fuzzy VIKOR (VlseKriterijuska Optimizacija I Komoromisno Resenje) approach with probability theories proved that it is possible to measure the HHI-based performance of the energy sector.

Keywords: competition; evaluation of concentration; fuzzy VIKOR method; energy sector; HHI index; market concept

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1. Introduction

This article is focused on market concept, which is one of the most important tools for examining and assessing competition issues accordingly in order to balance the competition of international business. Unfortunately, there is no common concept of the market, and also the factors determining the competition in a distorted market are treated differently. Analysis of market power concept demonstrated the importance of market concept in assessing the transport market concentration and its impact on competition; it can be stated that market concept is an essential element in order to properly determine the transport market power of business entities in distorted markets and their impact on competition.

Market concept has been included in competition law in order to help competition authorities to assess the transport market power, allowing them to determine anti-competitive effects and enforce competition law. This tool was developed in response to the question of the existence, creation and strengthening of market power in a historical context, with a certain vision about available competition problems and how they should be analyzed. In this article is given a review of market concept, its importance for assessing market concentration and its impact on competition, the strength of restrictions of competition faced by transport companies, and analysis of the extent to which market concept is integral to the law. The study contributes to the literature by showing that market concept in business competition can differ across countries.

Fuzzy VIKOR (VlseKriterijuska Optimizacija I Komoromisno Resenje) is currently a widely used decision-making method; in the fuzzy VIKOR decision-making model, all decision-makers apply the same evaluation criteria to all schemes [1]. This study provides

a decision-making model that uses a fuzzy VIKOR and applies it to the choice of a business in a competitive situation in the real energy industry in order to consider the opinions of all decision makers and acquire an ideal solution in a shorter amount of time. This research proposes a decision-making model based on fuzzy VIKOR, which allows different decision makers to evaluate all schemes using different evaluation criteria systems. Based on this, this research proposes a decision-making model that can effectively avoid making decisions using the same criteria system. Additionally, since the coefficient of selection mechanism, the weight of decision-making, and the weight of evaluation criteria are not sensitive in this decision-making model, the decision outcomes are highly stable. The decision-making model suggested in this study is capable of obtaining the best possible outcome while avoiding poor solutions. In this study, the fuzzy VIKOR approach for problem solving was used to assess the concentration of business enterprises that affect the competitive economic situation. For 2015–2019, 15 economic performance indicators from 18 Lithuanian and Slovenian Energy sector companies were chosen for analysis. Given the diversity of criteria addressed in the competition issues, multi-criteria analysis was used with the help of experts.

Market definition can fundamentally change the results of research, no matter which method we use. If the key object of the analyzed problem is understood differently, then the results of the research may not be achieved. Even if the object is properly understood, then appropriate means are needed to evaluate it, and we intend to use a multi-criteria approach for this purpose. This study will try to answer the following questions:

1. What is the market concept's role in assessing the energy sector's market concentration?
2. What are the alternative methods in energy sector competition assessment?
3. Is it possible to use the fuzzy VIKOR method for assessing the degree of market concentration in the energy sector?

This article's aim is to find out the possibility of assessing the HHI in the implementation of business strategies in order to evade market distortions in the energy sector.

The originality of this article consists of describing the capabilities of the fuzzy VIKOR approach for assessing the HHI in order to avoid a distorted market by examining the major economic parameters of the energy market. This paper's contribution is constructing the assessment system of the HHI in the energy sector and trying to identify the market situation of the business entity and help to attain sustainable market competition.

In the empirical section, the model was deployed and evaluated, with the goal of assisting in the development of company strategies based on market concentration evaluations. The fuzzy VIKOR model was used to test a typical industry: the energy sector. The model was used to study market concentration, make strategic decisions, and assess market concentration. Multi-criteria analysis was utilized with the help of specialists due to the large number of factors addressed in the competition difficulties. The ultimately best-suited choices were chosen from two out of five options. Regrettably, the performance of the other three possibilities was not adequate. The robustness of the solution derived with this model was evaluated, making it scientific and capable of avoiding a sub-optimal result. In conclusion, the model presented here is fairly scientific and robust, and it can be used to select a scheme for building a company plan in the energy sector in order to reach an ideal result.

2. The Importance of Market Concept in Assessing the Energy Sector's Market Concentration

Currently in the scientific literature, there is no consensus with regard to the concept of the market and the elements that characterize it [2–4]. There is no acceptable system for the identification and classification of established market features. This demonstrates the necessity for the development and customization of appropriate ideas and criteria for the sake of modern competitive balancing. Because there is no universally accepted understanding of the market, the factors affecting competitiveness in a distorted market

are handled in a variety of ways. Therefore, there are problems related to the adequacy of the assessment of the energy market power of business entities and the effectiveness of the competition interaction of international business entities—in our case, Lithuanian and Slovenian market concentration issues.

Market concept is one of the most important tools for examining and assessing competition issues accordingly in order to balance the competition of international business [3,5,6]. Competition authorities attempt to determine the power of businesses in the energy market by defining the relevant market, calculating and allocating specific market shares to market participants in order to better understand the level of competition and the impact on competition dynamics in the energy market. The concept of the relevant market helps to identify market participants, to define the boundaries of the market and to determine the extent of effective competition available [7,8]. Market concept has changed the thinking of competition practitioners (due to a narrow understanding of the market definition). Market concept is related to the law of competition with reference to public policy [9–11].

Traditionally, the analysis of each competition starts with the concept of the relevant market, the identification of the relevant competitors, and the calculation and allocation of market shares [11–13]. Indeed, the requirement of market dominance in many competition laws around the world, including, for example, the competition laws of Lithuania and Slovenia can be partially explained by a strong concern for market power, which is thought to be directly related to market size, as well as other factors. When market concept was introduced, it made it possible to calculate statistical measures of concentration, such as the concentration ratio (and later, the Herfindahl–Hirschman index) (HHI) [13–15]. At the time when market concept and concentration measures were described in the competition analysis, the main concern in the competition process was collusion in concentrated areas, such as the energy sector, which severely distorted the balance of competition power in the market. Therefore, the market concept was more or less for industrial companies with the same products. In subsequent years, industries producing differentiated products such as branded consumer goods and services have gained importance in industrialized countries, and mergers have been recognized in these markets to cause other competition issues that are different from collusion or concerted behavior [14–17].

It was shown that in the energy industry, the intensity of competition between business entities was much more important than the market share or concentration [15,18,19]. Competitors producing similar substitutes were found to be subject to strong restrictions relating to competition [20–23]. Mergers of these companies, even in cases where the merged entity had a small market share, removed these restrictions on competition, and the merged entity had an incentive to increase the price of at least one of its products due to a lack of compensatory efficiencies. These effects, on the other hand, are not dependent on coordination between energy companies, but are the result of an independent pricing decision, and are referred to as unilateral effects. Economic theory progressed in tandem with these economic shifts and developments. Fuzzy VIKOR and other multicriteria methods have made important advances in the theory of industrial organizations in analyzing the behavior of enterprises in imperfect competitive marketplaces [24–26]. The competitive behavior of firms was also examined, taking into account in great detail, inter alia, the strategic implications and reactions of competitors. In most cases, the efficiency framework can at least partially explain the observed behavior. The competition authority must decide which is more relevant in a given case (whether pro-competitive or anti-competitive). Thus, more weight is given to the real competitive impact of a particular behavior [27]. New technologies have been developed in conjunction with these changes and economic progress in the context of mergers and business behavior. These technologies have had a significant impact on the availability of economic data, the processing of these data, and the empirical methods used to analyze these data. Cash register scanners are now able to collect massive volumes of information about customer purchasing behavior, pricing response, and surrogate behavior. The processing of these data was made possible by advancements in computer technology. As a result, multicriteria approaches used to evaluate markets

and estimate the demand function, such as the fuzzy VIKOR method, have seen significant advancements [28]. Market concept-based methods for assessing competition create uncertainty about the predictability of competition law for professionals and competition authorities. [22,29]. Therefore, the exclusion of these alternative measures may mean that the use of these methods will not provide the best predictors of possible anti-competitive effects, at least in some cases. There is a trade-off between a flexible approach that suggests using a now cost-effective tool to address the problem at hand and legal certainty and the status of the market concept in competition law.

2.1. The Role and Importance of Market Power Concept in Economics

The data required by econometric methods to assess the residual demand function and its price elasticity may be missing or unsuitable due to poor quality and the long collection period. [23]. Often, it is not possible to estimate the relevant expenses, even at a rough level of accuracy. It is possible that approximate marginal costs, which are estimated as a measure of the price of an average variable, for example, will be deceptive. Furthermore, in the majority of circumstances, the multicriteria evaluation is difficult to complete. Although data standards are satisfied, the time limits under which competition regulators must function are sometimes exceedingly stringent, even if the data are accurate. Market concept plays an important role in analyzing competition because it provides a raw first image and classifies competitive situations, in particular mergers or abuses of dominance/monopoly, and those that are of concern relating to the level of competition or that even raise serious competition concerns, and as a result, any cases that have not yet been touched upon should be examined in greater depth. If the merger does not constitute an abuse of a dominant position, it is not necessary in this case to assess whether the undertaking has market power, and no further analysis of such cases is necessary [28–31].

Such reviews reduce the research burden of competition for supervisory authorities and can also mitigate the risk of misstatements [27,31]. However, any simple review cannot perfectly balance situations due to problems that increase/do not increase competition. Therefore, when thresholds are exceeded, it is necessary to perform more detailed assessment of competition problems and more detailed competitive analysis, which must be carried out in order to determine or confirm one competition problem or the other.

There may be cases where there are enough data in order to directly assess market power [26,31]. Therefore, the concept of the relevant market becomes redundant. In other cases, convincing evidence of abuse may be found. If markets are defined too broadly, then products are associated with restrictions of competition, although it does not really constrain the behavior of energy companies, and therefore existing market power may be underestimated [24,31]. This must be taken into consideration since the market concept is not just an economic activity, but it is also a concept that is incorporated into competition legislation. It is vital to consider the legal element of the market concept when determining whether the market concept may be amended or supplemented by other tools and techniques of competition analysis. Among the topics covered are features of the market concept in competition law, beginning with legislative requirements and the use of this word in a secure setting or in calculating fines for the sake of legal certainty and the value of precedents, among other things. The final step in any competition analysis is to determine if a certain agreement or action has anti-competitive consequences. The analysis of legal aspects is mostly conceptual—the comments set out below contribute to the ongoing debate, providing an analysis of the objective legal consequences, which can provide permission for alternative measures together with the market concept [19,25,31].

If alternative methods such as the fuzzy VIKOR multicriteria method are permitted under competition law, this may necessitate a rethinking of the method of antitrust analysis and the manner in which it should be carried out by lawyers, economists, practitioners and legislators, depending on the extent to which market concept concepts have permeated competition law. As the prior discussion has demonstrated, a fundamental shift in

mentality—which means that this notion may be outlawed entirely—is nothing more than a pipe dream at this point.

2.2. Analysis of Alternative Methods Application in Energy Sector's Competition Assessment

Nevertheless, even when supplementing the market concept with alternative methods (fuzzy VIKOR) or when replacing it in certain situations, it is necessary to consider the extent to which the market definition is inseparable from competition law and may not be used. In fact, market concept has gained a life that goes beyond the role of an instrument allowing one to predict probable anti-competitive harm in any particular case in many jurisdictions [24]. Alternative instruments can be included in the analyst's portfolio, and whether these measures can be allowed to change or supplement the market concept first and foremost will determine the answers to the following two questions: (1) to what degree is the notion of the market needed by law; and (2) to what extent has the concept of the market gained a life of its own as a result of concept condensation? It is necessary to distinguish between the legal requirement to use market concept in analyzing possible anti-competitive harm in any particular case and the market concept as a concept that is not used for a specific purpose case impact analysis, such as defining the scope of the law in the case of a safe ports law, Article 102 of the EU Treaty, or even as a necessary ingredient in the calculation of fines in order to respond to these two questions. It was decided to integrate the market concept in competition law in order to assist competition authorities in assessing the power of the energy market, allowing them to detect anti-competitive consequences and enforcing competition law. This tool was developed in response to the question of the existence, creation, and strengthening of energy market power in a historical context, with a specific vision about the available competition problems and how they should be analyzed [15,32]. In other cases, the authorities may be able to abandon the market concept because it is the first stage in the merger examination process if the required information is provided. In situations of misuse, it was suggested that the market concept be abandoned entirely and that it be replaced with a direct effect analysis. However, this is only applicable in circumstances where there is clear proof of anti-competitive impacts. It is important to exercise caution when using this equipment, because it is specialized and intended for usage in certain situations. Price pressure indicators, for example, can produce deceptive findings if they are applied to contexts for which they were not designed [8,9,32].

When applied to differentiated product markets marked by mergers, multicriteria methods such as fuzzy VIKOR may perform well. However, when applied to consumers who are worried about competition, they require information on consumer substitution and company margins evaluations. From a purely economic standpoint, it would appear to make sense not to concentrate on a single strategy. Extending the scope of the analysis and allowing multicriteria methods (such as fuzzy VIKOR) in order to improve accuracy in analyzing potential anti-competitive effects may be beneficial, but it is also necessary to consider the consequences of the predictability of competition law in order to ensure that the analysis is accurate. When evaluating the potential negative influence on legal certainty, it is necessary to consider the flexibility in adopting alternative ways that can be substitutions for or complements to existing approaches.

Multicriteria approaches such as fuzzy VIKOR, data envelopment analysis (DEA), complex proportional assessment (COPRAS), and the preference ranking organization method for enrichment evaluation (PROMETHEE) were taken into consideration for this investigation. The COPRAS method's typical properties allow it to be used to implement the comparison and evaluation of variables describing hierarchically structured complex magnitudes, positioning them on the same hierarchical level [31–33]. However, due to the fact that the COPRAS method is less stable than the DEA and fuzzy VIKOR methods, caution should be exercised when using it. However, when the raw data (for example, sales, the number of workers, assets, profits, and so on) and ratios (for example, returns on investment) are not included in a single model, there are possible concerns with regard to the DEA technique [34]. Furthermore, depending on the outputs and inputs that have

been determined, the measurement findings may be sensitive. This method does not require proportionate criteria, nor does it necessitate data transformation for the purpose of minimizing the variables or data transformation in the event that the data are not distorted by this method [34,35]. However, this method requires the assignment of measures, despite the fact that it does not provide an understandable framework for assigning values to the variables. The fuzzy VIKOR method is based on the principle of a multicriteria decision making (MCDM) system's compromise programming and is used to assist multicriteria decisionmakers in situations where they are insecure or have no idea how to express their preferences, such as at the beginning of the system's development [35]. Additionally, due to the fact that the fuzzy VIKOR approach is used to determine the stability intervals in weights, and that an effect analysis is carried out from the perspective of all variables' weights on a proposed compromise solution, the calculation results may be highly sensitive to variations in the data [34–36]. The importance of market concept in assessing the concentration of business entities and its impact on competition can be summarized as follows: market concept is an essential element in order to properly determine the market power of distorted-market business entities and the impact of distorted-market businesses on competition. Therefore, we introduce a method known as the fuzzy VIKOR approach in the next section, which will assist us in determining the effects of market power on competition. The fuzzy VIKOR decision-making approach is now extensively employed. All decision-makers in the fuzzy VIKOR decision-making model use the same assessment criteria for all schemes. This research provides a decision-making model which uses a fuzzy VIKOR and applies it to the choice of a business scenario—competition in the actual energy sector—in order to weigh the views of all decision makers and find an optimal solution in a shorter amount of time.

3. Methods and Data

The fuzzy VIKOR method used in this study sought to assist in the formulation of business strategies based on market analysis. It was modified for use in the energy sector. Assessment was carried out with the help of experts. The experts were chosen using the following criteria:

1. An energy company's management qualification.
2. A minimum of ten years' experience in the energy sector.
3. The energy sector's competence being harmed by skewed market competitiveness.

In this study, 10 experts were chosen. The number of experts was chosen based on the qualitative research methodology—when the quantity of experts is 10 or more, this number does not impact the precision and credibility of the results.

The evaluation of market power in the energy sector, as well as the impact of the energy sector on GDP, is crucial. The fuzzy VIKOR approach was used to evaluate the market power of enterprises in the Slovenian and Lithuanian energy sectors. In addition, characteristics for 18 companies in the energy sector from 2015 to 2019 were shown.

The following are the paper's hypotheses:

1. The fuzzy VIKOR approach can analyze the most efficient ways to harmonize the power of corporate entities in a distorted market by utilizing the HHI index to discover appropriate solutions.
2. Because of the unique nature of the energy sector, HHI is an effective tool for analyzing the competitive position.
3. Over time, HHI has influenced the firms' ability to avoid market distortions with respect to rivals.

A number of illegal cartels have been identified in recent years, which adversely affected the competitive situation on the market. Given the significance of this sector to the Lithuanian and Slovenian economies, applying the suggested methodology to the evaluation of the market power of corporate entities in the Lithuanian and Slovenian

energy sectors makes sense. Below are presented the performance indicators of energy sector companies in 2015–2019.

The fuzzy VIKOR approach was used to score 15 criterion [32–36] and 5 market concentration alternatives in this research. Multiple experts participated in the evaluation; the kind of criteria and the weight allocated to each criterion are shown in Table 1, representing the arithmetic mean of all experts.

Table 1. Criteria arithmetic mean of all experts.

	Name	Type	Weight
1	Businesses entities and markets the HHI	–	(0.033, 0.067, 0.067)
2	Turnover from energy activities	+	(0.033, 0.067, 0.067)
3	Gross operating profit	+	(0.133, 0.330, 0.330)
4	Number of hours worked by employees	+	(0.002, 0.002, 0.067)
5	Notional number of employees	+	(0.067, 0.067, 0.133)
6	Total expenditure on supplies and services	+	(0.067, 0.133, 0.133)
7	Revenue from energy subcontracting	+	(0.067, 0.067, 0.067)
8	Sold tangible fixed assets	–	(0.067, 0.133, 0.133)
9	Sales revenue value difference	+	(0.067, 0.067, 0.067)
10	Cost of sales value difference	+	(0.067, 0.133, 0.133)
11	Operating costs value difference	–	(0.067, 0.067, 0.067)
12	Liabilities of companies value difference	–	(0.002, 0.033, 0.067)
13	Equity of companies value difference	–	(0.002, 0.002, 0.133)
14	Corporate assets value difference	–	(0.067, 0.067, 0.067)
15	Debt ratio value difference	–	(0.033, 0.033, 0.033)

Table 2 shows the fuzzy scale used in the model.

Table 2. Fuzzy scale.

No	Linguistic Terms	L	M	U
1	Very Low	0	0	0.25
2	Low	0	0.25	0.5
3	Medium	0.25	0.5	0.75
4	High	0.5	0.75	1
5	Very High	0.75	1	1

The choices are weighed against several criteria, and the decision matrix's outcomes are shown as follows. Note that as multiple experts participated in the evaluation, the matrix (Table 3) below represents the arithmetic mean of all experts.

Table 3. Decision matrix.

	HHI Index Ratio	Turnover from Energy Activities	Gross Operating Profit	Number of Hours Worked by Employees	Notional Number of Employees	Total Expenditure on Supplies and Services	Revenue from Energy Subcontracting	Sold Tangible Fixed Assets	Sales Revenue Value Difference	Cost of Sales Value Difference	Operating Costs Value Difference	Liabilities of Companies Value Difference	Equity of Companies Value Difference	Corporate Assets Value Difference	Debt Ratio Value Difference
alternative1	(0.000, 0.000, 0.250)	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.250, 0.500, 0.750)	(0.000, 0.000, 0.250)	(0.000, 0.000, 0.250)
alternative2	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.000, 0.000, 0.250)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)
alternative3	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.000, 0.000, 0.250)	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)	(0.500, 0.750, 1.000)	(0.000, 0.000, 0.250)	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.500, 0.750, 1.000)
alternative4	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)
alternative5	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.500, 0.750, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.500, 0.750, 1.000)	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)

4. Results

The following are the positive and negative ideal solutions for each of the criteria. If the criterion is positive, the following relations may be used to produce the positive ideal solution ($\widetilde{f}^*$) and the negative ideal solution ($\widetilde{f}^{\circ}$):

$$\widetilde{f}_j^* = \underset{i}{Max}\ \widetilde{f}_{ij}\ i = 1, 2, \ldots, n \quad (1)$$

$$\widetilde{f}_j^{\circ} = \underset{i}{Min}\ \widetilde{f}_{ij}\ i = 1, 2, \ldots, n \quad (2)$$

If the criterion is negative, the positive ideal solution ($\widetilde{f}^*$) and negative ideal solution ($\widetilde{f}^{\circ}$) can be obtained using the following relations:

$$\widetilde{f}_j^* = \underset{i}{Min}\ \widetilde{f}_{ij}\ i = 1, 2, \ldots, n \quad (3)$$

$$\widetilde{f}_j^{\circ} = \underset{i}{Max}\ \widetilde{f}_{ij}\ i = 1, 2, \ldots, n \quad (4)$$

Table 4 below shows the positive and negative ideal values.

Table 4. Positive and negative ideal solutions of the criteria.

	Positive Ideal	Negative Ideal
Businesses entities and markets the HHI	(0.000, 0.000, 0.250)	(0.250, 0.500, 0.750)
Turnover from energy activities	(0.750, 1.000, 1.000)	(0.250, 0.500, 0.750)
Gross operating profit	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)
Number of hours worked by employees	(0.500, 0.750, 1.000)	(0.000, 0.250, 0.500)
Notional number of employees	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)
Total expenditure on supplies and services	(0.750, 1.000, 1.000)	(0.250, 0.500, 0.750)
Revenue from energy subcontracting	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)
Sold tangible fixed assets	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)
Sales revenue value difference	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)
Cost of sales value difference	(0.750, 1.000, 1.000)	(0.000, 0.000, 0.250)
Operating costs value difference	(0.000, 0.250, 0.500)	(0.500, 0.750, 1.000)
Liabilities of companies value difference	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)
Equity of companies value difference	(0.250, 0.500, 0.750)	(0.750, 1.000, 1.000)
Corporate assets value difference	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)
Debt ratio value difference	(0.000, 0.000, 0.250)	(0.750, 1.000, 1.000)

Based on the positive and negative ideal solutions, a normalized decision matrix can be calculated by means of the following relation:

$$\widetilde{d}_{ij} = \left(\widetilde{f}_j^* \ominus \widetilde{f}_{ij}\right) / \left(r_j^* - l_j^{\circ}\right) \text{ Positive ideal solution} \quad (5)$$

$$\widetilde{d}_{ij} = \left(\widetilde{f}_{ij} \ominus \widetilde{f}_j^*\right) / \left(r_j^{\circ} - l_j^*\right) \text{ Negative ideal solution} \quad (6)$$

where

$$\widetilde{f}_j^* = \left(l_j^*, m_j^*, r_j^*\right) \quad (7)$$

$$\widetilde{f}_j^{\circ} = \left(l_j^{\circ}, m_j^{\circ}, r_j^{\circ}\right) \quad (8)$$

Table 5 below shows the normalized values of the evaluation matrix.

Table 5. The normalized decision matrix.

	HHI Index Ratio	Turnover from Energy Activities	Gross Operating Profit	Number of Hours Worked by Employees	Notional Number of Employees	Total Expenditure on Supplies and Services	Revenue from Energy Subcontracting	Sold Tangible Fixed Assets	Sales Revenue Value Difference	Cost of Sales Value Difference	Operating Costs Value Difference	Liabilities of Companies Value Difference	Equity of Companies Value Difference	Corporate Assets Value Difference	Debt Ratio Value Difference
alternative1	(−0.333, 0.000, 0.333)	(0.000, 0.667, 1.000)	(−0.250, 0.000, 0.250)	(0.000, 0.500, 1.000)	(−0.250, 0.250, 0.500)	(0.000, 0.667, 1.000)	(−0.250, 0.000, 0.250)	(−0.500, 0.000, 0.500)	(−0.250, 0.250, 0.500)	(−0.250, 0.000, 0.250)	(−0.500, 0.000, 0.500)	(0.250, 0.750, 1.000)	(−0.667, 0.000, 0.667)	(−0.250, 0.000, 0.250)	(−0.250, 0.000, 0.250)
alternative2	(−0.333, 0.000, 0.333)	(−0.333, 0.000, 0.333)	(0.250, 0.750, 1.000)	(−0.500, 0.000, 0.500)	(0.500, 1.000, 1.000)	(−0.333, 0.000, 0.333)	(0.250, 0.750, 1.000)	(0.000, 0.500, 1.000)	(0.500, 1.000, 1.000)	(0.250, 0.750, 1.000)	(0.000, 0.500, 1.000)	(−0.250, 0.000, 0.250)	(0.000, 0.667, 1.000)	(−0.250, 0.000, 0.250)	(0.500, 1.000, 1.000)
alternative3	(−0.333, 0.333, 0.667)	(−0.333, 0.333, 0.667)	(0.500, 1.000, 1.000)	(−0.250, 0.250, 0.750)	(−0.250, 0.000, 0.250)	(−0.333, 0.333, 0.667)	(0.500, 1.000, 1.000)	(−0.250, 0.250, 0.750)	(−0.250, 0.000, 0.250)	(0.500, 1.000, 1.000)	(−0.250 ,0.250, 0.750)	(0.500, 1.000, 1.000)	(−0.333 ,0.333, 1.000)	(0.500, 1.000, 1.000)	(0.250, 0.750, 1.000)
alternative4	(0.000, 0.667, 1.000)	(−0.333, 0.000, 0.333)	(−0.250, 0.000, 0.250)	(0.000, 0.500, 1.000)	(−0.250, 0.250, 0.500)	(−0.333, 0.000, 0.333)	(−0.250, 0.000, 0.250)	(−0.500, 0.000, 0.500)	(−0.250, 0.250, 0.500)	(−0.250, 0.000, 0.250)	(−0.500, 0.000, 0.500)	(0.250, 0.750, 1.000)	(0.000, 0.667, 1.000)	(0.250, 0.750, 1.000)	(0.500, 1.000, 1.000)
alternative5	(−0.333, 0.333, 0.667)	(−0.333, 0.333, 0.667)	(0.250, 0.750, 1.000)	(−0.500, 0.000, 0.500)	(−0.250, 0.000, 0.250)	(−0.333, 0.333, 0.667)	(0.250, 0.750, 1.000)	(0.000, 0.500, 1.000)	(−0.250, 0.000, 0.250)	(0.250, 0.750, 1.000)	(0.000, 0.500, 1.000)	(0.500, 1.000, 1.000)	(−0.333, 0.333, 1.000)	(0.500, 1.000, 1.000)	(−0.250, 0.000, 0.250)

It is necessary to first convert the normalized matrix to the weighted normalized decision matrix, and then to calculate the values $\widetilde{S}_i$ and $\widetilde{R}_i$ as follows:

$$\text{If } \widetilde{R}_{\text{i}} = \left(R_i^l, R_i^m, R_i^r\right) \text{ and } \widetilde{s}_{\text{i}} = \left(s_i^l, s_i^m, s_i^r\right) \tag{9}$$

$$\widetilde{S}_i = \sum_{\text{j}=1}^{\text{J}} \left(\widetilde{w}_j \otimes \widetilde{d}_{ij}\right) \tag{10}$$

$$\widetilde{R}_i = \max_j \left(\widetilde{w}_j \otimes \widetilde{d}_{ij}\right) \tag{11}$$

The value of Q can be calculated as follows.

$$\text{If } \widetilde{Q}_i = \left(Q_i^l, Q_i^m, Q_i^r\right) \tag{12}$$

$$\widetilde{Q}_i = v\frac{(\widetilde{s}_i \ominus \widetilde{s}^*)}{s^{\circ r} - s^{*l}} \oplus (1-v)\frac{\left(\widetilde{R}_i \ominus \widetilde{R}^*\right)}{R^{\circ r} - R^{*l}} \tag{13}$$

where

$$\widetilde{s}^* = \min_i \widetilde{s}_i \tag{14}$$

$$s^{\circ r} = \max_i s_i^r \tag{15}$$

$$\widetilde{R}^* = \min_i \widetilde{R}_i \tag{16}$$

$$R^{\circ r} = \max_i R_i^r \tag{17}$$

According to the findings of this study, the variable v, which represents the highest group utility, is equal to 0.5.

The fuzzy numbers S, R, and Q may be turned into crisp numbers by applying the following formula to their values.

$$\text{If } \widetilde{A} = (\text{l},\ \text{m},\ \text{r}) \left(\widetilde{A} \text{ is expreseed as a fuzzy number}\right) \tag{18}$$

$$Crisp\left(\widetilde{A}\right) = \frac{2m + l + r}{4} \tag{19}$$

Table 6 below shows the fuzzy values S, R, and Q.

Table 6. The fuzzy values S, R, and Q.

	Fuzzy R	**Fuzzy S**	**Fuzzy Q**
alternative1	(0.001, 0.089, 0.133)	(−0.204, 0.193, 0.803)	(−0.543, 0.060, 0.543)
alternative2	(0.034, 0.248, 0.330)	(0.088, 0.666, 1.252)	(−0.394, 0.462, 0.995)
alternative3	(0.067, 0.330, 0.330)	(0.064, 0.795, 1.258)	(−0.352, 0.631, 0.997)
alternative4	(0.017, 0.050, 0.133)	(−0.167, 0.189, 0.833)	(−0.506, 0.000, 0.554)

Table 7 below shows the crisp values S, R and Q and ranks the alternatives based on R, S and Q.

Table 7. The crisp values S, R, Q and ranking of alternatives.

	Crisp Value of R	Rank in R	Crisp Value of S	Rank in S	Crisp Value of Q	Rank in Q
alternative1	0.078	2	0.246	1	0.03	2
alternative2	0.215	3	0.668	4	0.381	4
alternative3	0.264	4	0.728	5	0.477	5
alternative4	0.063	1	0.261	2	0.012	1
alternative5	0.215	3	0.664	3	0.38	3

It is decided at this stage based on the values R, S, and Q for the options that are sorted in decreasing order, as shown in the diagram. In order to reach a conclusion, two requirements must be met, and a range of compromise options might be presented in the aftermath of these two factors being satisfied.

The first condition is an acceptable benefit. $Q(A^{(2)}) - Q(A^{(1)}) \geq 1/(m-1)$ where $A^{(1)}$ is the alternative with first position and $A^{(2)}$ is the option that ranks second in the ranking list according to Q, where m is the number of alternatives. The second condition is acceptable stability in decision-making: The alternative $A^{(1)}$ must also be the best-ranked option by S and/or R in order to be acceptably stable in decision-making. If one of the prerequisites is not met, a set of compromise alternatives is provided, which includes the following options:

First solution. Alternatives $A^{(1)}$, $A^{(2)}$, ..., $A^{(M)}$ if Condition 1 is not satisfied; alternative $A^{(M)}$ is determined by $Q\left(A^{(M)}\right) - Q\left(A^{(1)}\right) < 1/(m-1)$ for maximum M (the positions of these alternatives are "in closeness").

Second solution. Alternatives $A^{(1)}$ and $A^{(2)}$ if only condition 2 is not satisfied.

Third solution. After determining that all requirements are met, if the alternative with the lowest Q value is chosen as the best alternative, the alternative with the highest Q value is chosen as the best alternative according to the findings of the survey, which are presented in Table 8.

Table 8. Result of the conditions survey.

Condition 1	Non Acceptance.
Condition 2	-
Selected solution	Solution 1

Therefore, alternative 4 and alternative 1 are selected as the final alternatives.

5. Discussion

The analysis of market concept is performed in order to properly describe the processes, phenomena and problems relating to energy business competition. Energy business entities participate in distorted competition market conditions, where reaching the balance of competition power is a task that is difficult to accomplish. This poses additional challenges for assessing the energy market concentration of business entities and stakeholders, and for modeling and supporting business strategic decisions. This circumstance raises the need to look for new ways of modeling, to strike a balance of market power and to have a more effective understanding of the competition context.

In this article, 15 criteria and 5 market concentration alternatives were ranked based on the fuzzy VIKOR method. Positive and negative ideal solutions of the criteria were obtained. Alternative 4 and alternative 1 are selected as the final best suitable alternatives. Unfortunately, alternatives 2, 3 and 5 showed unacceptable inferior performance. Based on the experts' evaluations, alternatives 4 and 1 could be used for preparing final business strategies, taking into account that the market has a disrupted competition situation.

Alternative 3 had marginal results, but this alternative was not further considered. So, the first hypothesis was confirmed.

Previous authors, as in our study, successfully applied the fuzzy VIKOR method to address multi-criteria challenges. Li and Zhao [34] analyzed the weight determination and aggregating function for conventional fuzzy VIKOR in the evaluation of eco-industrial thermal power plants, which involved subjective assessments of qualitative characteristics within an undefined context. Their work also included the main economical business entities parameters, as in our study. Suganthi [33] integrated fuzzy AHP and VIKOR/DEA for the multicriteria evaluation of energy investments for sustainable development. This author also examined the suitability of AHP and DEA methods for HHI index analysis. Rani and colleagues [35] provided research in which they constructed a technique for evaluating renewable energy systems that incorporates divergence and entropy measurements from PFSs as well as the VIKOR. The work by Zhu et al. [36] presented a fuzzy rough number extended multi-criteria group decision-making approach to establish a more rational rank of failure modes by integrating the fuzzy rough number, AHP, and VIKOR. This technique is intended to determine a more reasonable rank of failure modes. The works of these authors also confirm that the fuzzy VIKOR method can be applied to solve complex issues in order to find the optimal solution.

A sensitivity analysis is also performed in this study to verify that the solution is optimal. The results of the analysis confirm the scientific nature of this model. This study proposes a model for selecting a design scheme for a broken tender using a fuzzy VIKOR. Because the model allows various decision makers to assess all schemes using different sets of evaluation criteria, the model may be used to balance the opinions of all decision makers in a given situation. It is more adaptive to the real decision-making process that occurs in the organization. The most significant restriction of this study is that the HHI score values for the relevant time were acquired purely from current data, and no projections were made available for the period under consideration. Because it changes so regularly, it is difficult to estimate the size of a market that is continually undergoing reorganization. Exact projections may be made when a large number of energy businesses and their respective market shares are available for analysis. All business criteria should be included in the computation of the HHI index, and a lack of data on extremely tiny enterprises may be neglected because they have little influence on the bottom line of the organization. However, when compared to rivals, the change in the HHI index over time has an impact on a corporate entity's capacity to avoid market distortions in the long run. Two further limitations of this study are the use of the fuzzy VIKOR approach and the selection of expert groups. It is inevitable that subjective bias will be present in the selection of professionals in scientific and corporate networks. Given this study's purpose of impartiality and the careful attention devoted to the consistency and complementarity of the selected profiles, it is impossible to completely eradicate these constraints.

6. Conclusions

There is no common concept of the market, and the factors determining the competition in a distorted market are treated differently. Market concept is one of the most important tools for examining and assessing competition issues accordingly in order to balance the competition of energy sector business. Thus, market concept, including the calculation of market shares and the measurement of concentration, is not an end in itself, but a very important tool for determining the strength of restrictions on competition faced by the company and assessing the creation or strengthening of market power and the possibilities and probabilities of possible anti-competitive effects in energy sector. Restrictions of competition are caused by the products and services of other companies or by various regional aspects. Thus, the relevant energy market needs to be defined in terms of product and geographic dimensions; shares of the market and concentration measures would be reliable indicators of market power, and it is obvious that the market needs to be defined in such a way. The results show that HHI is appropriate for assessing the competitive

situation, due to the particularity of the energy market, which confirms our hypothesis. Additionally, the assessment shows that HHI influences the ability of the firm to evade market distortions in coherence to competitors over the period.

Analysis performed on market power concept demonstrated the importance of market concept in assessing the concentration of energy business entities and its impact on competition. It can be stated that market concept is an essential element in order to properly determine the market power of distorted-energy market business entities and their impact on competition.

Market concept has been included in competition law in order to help competition authorities to assess the market power, allowing them to determine anti-competitive effects and enforce competition law. This tool was developed in response to the question of the existence, creation and strengthening of market power in a historical context with a certain vision about available competition problems and how they should be analyzed.

The model was used and evaluated in the empirical section, and it is meant to aid in the creation of company plans based on evaluations of market concentration. The fuzzy VIKOR technique was put to the test in a typical corporate environment—the energy services industry. Market concentration, strategic activities, and strategic decisions are all assessed using the fuzzy VIKOR technique. Because of the large number of factors addressed when considering competition concerns, a multi-criteria analysis was conducted with the support of industry specialists. The ultimately best-suited alternatives were chosen from a pool of five potential candidates. Unfortunately, the other three solutions demonstrated much lower performance that was not acceptable.

Since this model has been tested, it can be relied on to provide a scientifically sound answer that will prevent a sub-optimal solution from being acquired in the future. In conclusion, the model is highly scientific and solid, and it can be applied broadly in the selection of a scheme for building a company plan in the energy sector in order to obtain the best possible result. The study's main limitation is that the HHI score findings for the relevant time are based exclusively on current data, with no projections provided. Because it changes so regularly, determining the size of a market that is continually undergoing reorganization is difficult. Specific projections may be produced when a large number of firms in the energy industry and their market shares are known. The lack of data on extremely small enterprises may be neglected since they have little influence on the bottom line, but all company factors should be included in the HHI index computation. When compared to rivals, however, the change in the HHI index over time has an impact on a company's capacity to avoid market distortions. The study's other shortcomings include the fuzzy VIKOR approach and the expert group selection. Subjective bias is always present in the selection of professionals in scientific and business networks.

Using the fuzzy VIKOR method, further research should extend the remaining concentration indices in order to assess the competitive situation in the energy industry in the future. In addition, the applicability of these methods to various levels of the distorted market should be evaluated. Future study should extensively assess and compare the findings, interviewing not just company representatives but also field researchers, as well as conducting a detailed analysis of the data. Despite the widespread usage of the HHI in a distorted industry, further study should be conducted in order to analyze the competitive scenario in the energy sector using the fuzzy VIKOR approach, according to the authors. It is also necessary to evaluate the applicability of these strategies to various levels of the distributed market.

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