



Review

AN INTEGRATED ASSESSMENT OF LITHUANIAN ECONOMIC SECTORS BASED ON FINANCIAL RATIOS AND FUZZY MCDM METHODS

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Abstract. The aim of this study was to offer a novel procedure for integrated assessment and comparison of Lithuanian economic sectors on the basis of financial ratios and fuzzy MCDM methods. The complex of interrelated issues regarding integrated assessment of economic sectors is discussed in the paper. The object of research is financial indicators of different Lithuanian economic sectors. The proposed procedure for multi-criteria comparison of economic sectors encompasses: 1) the indicator system, 2) application of fuzzy MCDM methods, and 3) inter-sectoral comparison based on ranks provided by fuzzy MCDM methods. The research covers period of 2007–2010, starting at the very beginning of the economic recession and, hopefully, ending with the upcoming recovery. The application of the three MCDM methods was successful. The results suggested the best performing sector being that of forestry and logging. Furthermore, enterprises operating in trade sector, hospitality sector, mining and quarrying sector, information sector, or manufacturing sector can be considered as working more efficiently than an average Lithuanian enterprise. At the other end of spectrum, construction, real estate, and transportation sectors were those severely damaged by the economic crisis: they were ranked below the average alternative. Meanwhile, relatively low positions of utilities sectors may be caused by their specifics. Finally, the transport sector can be considered as the typical victim of economic downturn.

Keywords: financial ratios, economic sectors, Lithuania, fuzzy number, VIKOR, TOPSIS, ARAS, strategic management.

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1. Introduction

The economic processes can be analyzed at three levels, namely those of enterprise, economic sector, or state. The renowned international organizations have developed respective methods for inter-state comparison, focused on competitiveness, innovativeness etc. The inter-sectoral comparison, however, remains virtually underdeveloped area, for there had been only investigations on specific areas of energy efficiency or international trade. Moreover, Lithuanian economy is even less researched. Our study is hence oriented towards solving the problem of the lack of general framework for inter-sectoral comparison of efficiency. In addition, we employ Statistics Lithuania data and fuzzy multi-criteria decision making methods for aforementioned purpose for the first time. The proposed multi-criteria assessment model might provide a rationale for a variety of stakeholders—politicians, businessmen, employees, and investors—who needs to appropriately aid its decisions. To conclude, this paper introduces the application of fuzzy multi-criteria decision making methods and financial ratios in evaluation of Lithuanian economic sector efficiency.

This paper analyzes the performance of main Lithuanian economic sectors from the viewpoint of financial ratios. For certain financial ratios identify both the efficiency and competitiveness of national economic sectors. Obtained from financial statements of enterprises, these ratios can help to ascertain whether the enterprises are operating effectively, are able to meet their liabilities, etc. (Peterson Drake, Fabozzi 2010). In addition, the Statistics Lithuania disseminates the surveys of the investigated enterprises' balance sheets on a regular basis. These data provide basis for a valid research. The summarized data therefore enable to investigate these peculiarities at the inter-sectoral level or their evolution over the time at the sectoral level.

The topic of portfolio management has been discussed in many studies (Markowitz 1952, 1959; Elton *et al.* 2007; Zopounidis, Doumpos 2002; Xidonas *et al.* 2010b, 2011). Consequently, one general trend can be outlined: the mean-variance method offered by Markowitz (1952) is being superseded by more robust multi-criteria analysis which pays respect to various financial indicators and ratios. The appropriately employed analysis of financial ratios can thus result in a robust portfolio selection as well as other business or government decisions. Financial ratio analysis has been widely applied in recent studies (Ginevičius, Podvezko 2006; Ocal *et al.* 2007; Wang 2008; Wu *et al.* 2009; Wang, Lee 2010; Mackevičius, Valkauskas 2010). Indeed, these studies were aimed at comparison of different enterprises. Misiūnas (2010) analyzed the performance of Lithuanian economic sectors on the basis of financial ratios. As it was proved by previous studies (Xidonas, Psarras 2009; Xidonas *et al.* 2009b, 2010a), the application of multi-criteria decision making methods significantly improves the robustness of financial analysis and business decisions in general. This study hence puts forward the practice of inter-sectoral comparison based on financial ratios analysis by introducing the application of fuzzy multi-criteria decision making (MCDM) methods. Whereas single financial ratio hardly provides the required information, a set of financial ratios has been defined and applied in the analysis.

As some authors (Kahraman 2008; Norkus 2009) argued, fuzzy set theory (Zadeh 1965) plays an important role in social sciences and humanities since it can cope with ambiguities,

uncertainties, and vagueness that cannot be handled by crisp values. Consequently, three fuzzy MCDM methods were applied in this study: VIKOR (Kaya, Kahraman 2011), TOPSIS (Zavadskas, Antucheviciene 2006; Yu, Hu 2010), and ARAS (Turskis, Zavadskas 2010). The results of such studies can successfully aid strategic management decisions, namely those made by either public or private stakeholders. Moreover, the application of fuzzy number enables to take into account the dynamics of time series of the investigated indicators in a more robust way.

The *object* of research is financial indicators of different Lithuanian economic sectors. The *aim* of this study was to offer a novel procedure for integrated assessment and comparison of Lithuanian economic sectors on the basis of financial ratios and fuzzy MCDM methods. The following *tasks* were therefore raised: 1) to define the indicator system as well as coefficients of significance of certain criteria, 2) to apply fuzzy MCDM methods, and 3) to perform inter-sectoral comparison based on ranks provided by the three fuzzy MCDM methods. The research covers *period* of 2007–2010, starting at the very beginning of the economic recession and, hopefully, ending with the upcoming recovery. The data was obtained from Statistics Lithuania database (accessible on-line (<http://db1.stat.gov.lt/>), see tables M4032207, M4032208, M4032209).

The paper is hence organized in the following manner. Section 2 discusses the financial ratios used for the research and thus provides with criteria and alternatives for MCDM. Section 3 describes MCDM methods in general as well as fuzzy MCDM methods applied in the research. Finally, Section 4 brings in the comparison of Lithuanian economic sectors.

2. Measuring the efficiency of economic sectors: financial ratios

The object of our research—the efficiency of Lithuanian sectors—is closely interrelated with, albeit not limited to, the problems of corporate performance evaluation and multi-criteria portfolio selection (management). As Xidonas *et al.* (2010b) pointed out with reference to Maginn *et al.* (2007), portfolio management is a process peculiar with the following stages: 1) identification and specification of investment objectives and constraints, 2) development of investment strategies, 3) detailed decision on portfolio composition, 4) initiation of portfolio decisions and implementation thereof by traders, 5) measurement and evaluation of portfolio performance, 6) monitoring of investor and market conditions, and 7) implementation of any necessary rebalancing. Moreover, the portfolio management encompasses the following three steps: planning, execution and feedback. The considered model for multi-criteria inter-sectoral comparison can hence be considered as a decision aiding tool for the planning step. Here we cannot deal with the problems of portfolio management; however, one can find comprehensive reviews on the matter in other reference works (Markowitz 1952, 1959; Elton *et al.* 2007; Zopounidis, Doumpos 2002; Xidonas *et al.* 2009c, 2010b, 2010c, 2011). Nevertheless, one general trend can be outlined: the mean-variance method offered by Markowitz (1952) is being superseded by more robust multi-criteria analysis which pays respect to various financial indicators and ratios. The appropriately employed analysis of financial ratios can thus result in a robust portfolio selection as well as other business or government decisions.

Like all the remaining management decisions and analyses, financial ratio analysis can be performed at different levels of management, namely at those of enterprise, sector, or state.

Our study is focused on the two latter options; hence certain Lithuanian economic sectors will be intercompared on the basis of financial ratios.

Financial statements provide with much information, which can lead to the calculation of multiple financial ratios. Consequently, different scientists offer different ratios as well as their classifications. For instance, Misiūnas (2010) classified the financial ratios into 1) income security ratios, 2) financial leverage ratios; and 3) cash flow to financial leverage (i.e. coverage) ratios. Peterson Drake and Fabozzi (2010) present the following classification: 1) liquidity, 2) profitability, 3) activity, 4) financial leverage, and 5) return on investment. Hence, it is important to choose the most appropriate financial ratios identifying the situation of certain economic sector.

The indicator system was constructed on the basis of expert evaluation. Firstly, the wide list of financial ratios found in relevant studies (Ginevičius, Podvezko 2006; Ocal *et al.* 2007; Wang 2008; Wu *et al.* 2009; Wang, Lee 2010; Mackevičius, Valkauskas 2010; Peterson Drake, Fabozzi 2010; Xidonas *et al.* 2009a) was presented to the expert group, which consisted of businessmen, academicians, and officials. The experts identified nine indicators they considered the most appropriate for evaluating the efficiency of separate Lithuanian economic sectors, namely 1) gross profit margin, 2) profitability ratio, 3) return on assets ratio, 4) debt ratio, 5) leverage ratio, 6) current ratio, 7) receivables turnover ratio, 8) fixed assets turnover ratio, 9) equity turnover ratio. However, the correlation analysis exhibited the existing inter-correlation among these indicators. Hence, three indicators (profitability ratio, debt ratio, and fixed assets turnover ratio) were excluded from further analysis.

With respect to the expert evaluation and correlation analysis, the following financial ratios were chosen for analysis: 1) gross profit margin, 2) return on assets ratio, 3) leverage ratio, 4) current ratio, 5) receivables turnover ratio, 6) equity turnover ratio. Noteworthy, such pattern of ratios enables one to avoid the multicollinearity problem. More specifically, the gross profit margin shows gross profit per currency unit of sales (gross profit / sales). The return on assets ratio shows pre-tax profit per currency unit of assets (pre-tax profit / assets). The leverage ratio shows how many times owner's equity covers his liabilities (equity / liabilities). The current ratio measures current assets available to cover current liabilities (current assets / current liabilities). The receivables turnover ratio indicates how rapidly an enterprise receives payments for goods and services delivered (sales / amounts receivable in one year). The equity turnover ratio identifies how efficiently the owner's equity is used when generating income (sales / equity). These indicators are measured in different dimensions, namely per cent or times, hence the application of MCDM methods is actual. Main characteristics of the proposed criteria system are summarized in Table 1. As we can see, leverage ratio is the sole cost criterion, whereas the remaining criteria are benefit ones.

Currently Statistics Lithuania uses NACE 2 economic activity classification system. Consequently, twelve NACE 2 positions were chosen for further analysis, eleven of them describing certain economic sector and one describing Lithuanian enterprises (i.e. all economic sectors) in general. Therefore, there are $i = 1, 2, \dots, 12$ alternatives and $j = 1, 2, \dots, 6$ criteria to be considered in the MCDM analysis. Moreover, respective coefficients of significance were obtained for each of criteria. It was assumed that financial ratios peculiar with higher degree of variance and thus variation tend to be less important for some sectors. On the other

Table 1. Financial ratios for multi-criteria evaluation of economic sectors

Financial ratios	Units of measurement	Direction of optimization	Possible negative value	Coefficient of significance (w_j)
1. Gross profit margin	Per cent	Max	+	0.21
2. Return on assets ratio	Per cent	Max	+	0.08
3. Leverage ratio	Times	Min	-	0.12
4. Current ratio	Times	Max	-	0.23
5. Receivables turnover ratio	Times	Max	-	0.23
6. Equity turnover ratio	Times	Max	-	0.13

hand, those ratios with low variation can be considered as being of the uniform importance for all sectors and thus more important in general. Firstly, coefficients of variation c_{vj} were computed for all j . Secondly, the reciprocal values were computed and added up. Thirdly, the weights were obtained:

$$w_j = \frac{1/c_{vj}}{\sum_{j=1}^6 1/c_{vj}}, \forall j. \quad (1)$$

The results of the analysis are rather well-grounded: return on assets ratio, leverage ratio, and equity turnover ratio appeared to have the lowest significance. Actually, different economic sectors do not need the same amount of assets to generate profit and hence the importance of the return on assets ratio might be reduced. The same can be applied for the remaining two financial ratios. Since the further analysis is based on triangular fuzzy numbers, respective fuzzy significance coefficient will be defined according to crisp values obtained by Eq. 1: $\tilde{w}_j = (w_j; w_j; w_j), \forall j$.

3. MCDM methods

Multiple criteria decision making (MCDM) methods enable to choose the best alternative from either finite or infinite set of alternatives. Multiple attribute decision making (MADM) methods are applied when dealing with the former class of problems. The term MCDM will henceforth refer to MADM methods in this article. Noteworthy, MCDM methods can be applied when performing multi-dimensional analysis, as these methods evaluate the alternatives according to system of indicators rather than certain single indicator. The latter practice would lead to mono-criterion analysis which may be unsuitable for some complex issues.

Roy (1996) presented the following pattern of MCDM problems: 1) α *choosing* problematique – choosing the best alternative from a set of available alternatives, 2) β *sorting* problematique – classifying alternatives of a set of available alternatives into relatively homogenous groups, 3) γ *ranking* problematique – ranking alternatives of a set of available alternatives from best to worst, 4) δ *describing* problematique – describing alternatives of a set of available alternatives in terms of their peculiarities and features.

The field of MCDM has been robustly developing since 1960s. MacCrimmon (1968) described the first multi-criteria evaluation methods (e.g. SAW – Simple Additive Weighing), whereas Keeney and Raiffa (1976) advanced in field of MCDM studies by employing multi-

ple attribute utility function in analysis. Moreover, MacCrimmon (1968) described the two stages of *weighing*, namely 1) voting in an executive committee for *significance coefficients* of each criterion, and 2) *normalizing* the values of criteria. Hence, the MCDM methods differ in 1) selection of significance coefficients, 2) normalization procedures, which can be either internal or external (Brauers 2007), 3) selection of the best alternative, 4) scaling the objectives, and 4) additional parameters affecting the solution (Zavadskas, Turskis 2010; Zavadskas *et al.* 2010c).

However, the rank correlation methods were the first to be applied in multi-criteria analysis. Rank correlation was first introduced by psychologist Spearman (1904) and later taken over by statistician Kendall (1970). ELECTRE (Roy 1968; Ulubeyli, Kazaz 2009; Xidonas *et al.* 2009a), NAIADE (Munda *et al.* 1995; Munda 1995, 2005), PROMETHEE (Brans, Mareschal 1992; Behzadian *et al.* 2010; Podvezko, V., Podviezko, A. 2010) are families of MCDM methods based on outranking preferences. Analytic Hierarchy Process (AHP) was proposed and developed by Saaty (1980, 1997). It enables to obtain significance coefficients for criterion used in multi-criteria decision making. Application of AHP is discussed by Krajnc and Glavič (2005) and Podvezko (2009). Buckley (1985) updated AHP with fuzzy number theory. A new method for estimation of significance coefficients—SWARA—has been developed (Keršulienė *et al.* 2010). The Reference Point approach is applied in such methods as TOPSIS, COPRAS, VIKOR and MOORA. Technique for the Order Preference by Similarity to Ideal Solution (TOPSIS) was introduced by Hwang and Yoon (1981) and modified by applying grey numbers (Lin *et al.* 2008), fuzzy numbers (Wang *et al.* 2003) or Mahalanobis distance (Antuchevičienė *et al.* 2010). Practice of these two latter methods covers various studies (Zavadskas *et al.* 2010a; Ginevičius, Podvezko 2009). Method of Complex Proportional Assessment (COPRAS) (Zavadskas *et al.* 1994) was improved by applying grey number technique (Zavadskas *et al.* 2008a, 2008b, 2009b, 2010a) as well as fuzzy numbers (Zavadskas, Antuchevičienė 2007), and used in many studies (Ginevičius, Podvezko 2009; Zavadskas *et al.* 2009a; Tupenaite *et al.* 2010). VIKOR method is based on linear normalization (Opricovic, Tzeng 2002, 2004; Antuchevičienė, Zavadskas 2008). Cevikcan *et al.* (2009) discussed application of fuzzy VIKOR method. Multi-Objective Optimization by Ratio Analysis (MOORA) method was offered by Brauers and Zavadskas (2006) on the basis of previous researches (Brauers 2004). This method was further developed (Brauers, Zavadskas 2010) and became MULTIMOORA (MOORA plus the full multiplicative form). Numerous examples of application of these methods are present (Brauers *et al.* 2010; Brauers, Ginevičius 2009, 2010; Baležentis *et al.* 2010). Brauers *et al.* (2011) have also presented fuzzy MULTIMOORA. In addition, there are well known additive methods developed. Simple Additive Weighing (SAW) method (MacCrimmon 1968) was modified in these ways: simplified (Ginevičius *et al.* 2004; Ginevičius, Podvezko 2009) and updated with grey numbers technique (Zavadskas *et al.* 2010b) and extended into fuzzy environment (Chou *et al.* 2008). New Additive Ratio Assessment (ARAS) method was introduced by Zavadskas and Turskis (2010) and subsequently extended into fuzzy environment (Turskis, Zavadskas 2010). A more detailed overview of MCDM methods is presented by Guitouni and Martel (1998).

As it was mentioned above, the three fuzzy methods, namely VIKOR, TOPSIS, and ARAS, will be applied in the analysis. This section, therefore, continues with describing the fuzzy set theory and the fuzzy MCDM methods.

3.1. The fuzzy set theory and triangular fuzzy numbers

Zadeh (1965) introduced the use of fuzzy set theory when dealing with problems involving fuzzy phenomena. Noteworthy, fuzzy sets and fuzzy logic are powerful mathematical tools for modelling uncertain systems. A fuzzy set is an extension of a crisp set. Crisp sets only allow full membership or non-membership, while fuzzy sets allow partial membership. The theoretical fundamentals of fuzzy set theory are overviewed by Chen (2000).

In a universe of discourse X , a fuzzy subset \tilde{A} of X is defined with a membership function $\mu_{\tilde{A}}(x)$ which maps each element $x \in X$ to a real number in the interval $[0; 1]$. The function value of $\mu_{\tilde{A}}(x)$ resembles the grade of membership of x in \tilde{A} . The higher the value of $\mu_{\tilde{A}}(x)$, the higher the degree of membership of x in \tilde{A} (Keufmann, Gupta 1991). Noteworthy, in this study any variable with tilde will denote a fuzzy number.

A fuzzy number \tilde{A} is described as a subset of real number whose membership function $\mu_{\tilde{A}}(x)$ is a continuous mapping from the real line \mathfrak{R} to a closed interval $[0; 1]$, which has the following characteristics: 1) $\mu_{\tilde{A}}(x) = 0$, for all $x \in (-\infty; a] \cup [c; \infty)$; 2) $\mu_{\tilde{A}}(x)$ is strictly increasing in $[a; b]$ and strictly decreasing in $[d; c]$; 3) $\mu_{\tilde{A}}(x) = 1$, for all $x \in [b; d]$, where a, b, d , and c are real numbers, and $-\infty < a \leq b \leq d \leq c < \infty$. When $b = d$ a fuzzy number \tilde{A} is called a triangular fuzzy number represented by a triplet (a, b, c) . Triangular fuzzy numbers will therefore be used in this study to characterize the alternatives. In addition, the parameters a, b , and c in can be considered as indicating respectively the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event (Torlak et al. 2010: 3).

Let \tilde{A} and \tilde{B} be two positive fuzzy numbers (Liang, Ding 2003). Hence, the main algebraic operations of any two positive fuzzy numbers $\tilde{A} = (a, b, c)$ and $\tilde{B} = (d, e, f)$ can be defined in the following way (Wu et al. 2009):

1. Addition + :

$$\tilde{A} + \tilde{B} = (a, b, c) + (d, e, f) = (a + d, b + e, c + f); \quad (2)$$

2. Subtraction -:

$$\tilde{A} - \tilde{B} = (a, b, c) - (d, e, f) = (a - d, b - e, c - f); \quad (3)$$

3. Multiplication \times :

$$\tilde{A} \times \tilde{B} = (a, b, c) \times (d, e, f) = (a \times d, b \times e, c \times f); \quad (4)$$

4. Division \div :

$$\tilde{A} \div \tilde{B} = (a, b, c) \div (d, e, f) = (a / f, b / e, c / d). \quad (5)$$

The vertex method can be applied to measure the distance between two fuzzy numbers. Let $\tilde{A} = (a, b, c)$ and $\tilde{B} = (d, e, f)$ be two triangular fuzzy numbers. Then, the vertex method can be applied to measure the distance between these two fuzzy numbers:

$$d(\tilde{A}, \tilde{B}) = \sqrt{\frac{1}{3}[(a - d)^2 + (b - e)^2 + (c - f)^2]}. \quad (6)$$

Fuzzy numbers can be applied in two ways when forming the response matrix of alternatives on objectives. First, fuzzy numbers can represent the values of linguistic variables

when deciding either on the importance of criteria or performing qualitative evaluation of alternatives. For the latter purpose Chen (2000) describes the following fuzzy numbers identifying values of linguistic variables from scale Very poor to Very good: Very poor – (0, 0, 1); Poor – (0, 1, 3); Medium poor – (1, 3, 5); Fair – (3, 5, 7); Medium good – (5, 7, 9); Good – (7, 9, 10); Very good – (9, 10, 10). Second, the fuzzy numbers can represent monetary (quantitative) terms. It can be done either through direct input of certain fuzzy numbers into the response matrix or by aggregation of raw data (e.g. time series). For example, if there are costs “approximately equal to \$200” estimated, the sum can be represented by triangular fuzzy number (190, 200, 210). Moreover, the fuzzy numbers can embody expected rate of growth. For example, if there is level of unemployment of 5 per cent with expected growth of 10 per cent, a triangular fuzzy number (5, 5.5, 6.1) can summarize these characteristics. As for time series data, a fuzzy number can represent the dynamics of certain indicator during past t periods:

$$\left(\min_p \{a_p\}, \frac{\sum_{p=1}^t a_p}{t}, \max_p \{a_p\} \right), \tag{7}$$

where a_p represents the value of certain indicator during period $p = 1, 2, \dots, t$. Moreover, the application of two–tuple linguistic representation would enhance the heterogeneous data fusion (Liu, Zhang 2011).

The results of comparison of alternatives based on fuzzy numbers are also expressed in fuzzy numbers. The fuzzy numbers therefore need to be converted into crisp ones in order to identify the most promising alternative. There are four defuzzification methods commonly employed: (i) the centroid method (or centre of area – COA); (ii) Mean-of-maximum (MOM); (iii) α -cut method; and (iv) signed distance method (Zhao, Govind 1991; Yao, Wu 2000).

3.2. Fuzzy MCDM methods

Let us assume we have the fuzzy decision making matrix $\tilde{X} = \tilde{x}_{ij}$, where $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$ denote the number of alternatives and criteria respectively. In our study, we have $m = 12$ and $n = 6$. The j^{th} criterion of the i^{th} alternative is represented by triangular fuzzy number: $\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3})$. Moreover, each j^{th} criterion is assigned with respective coefficient of significance \tilde{w}_j . Benefit criteria are members of benefit criteria set B , whereas cost criteria are members of respective set C .

This subsection further describes each of the three methods applied in the analysis: fuzzy VIKOR, fuzzy TOPSIS, and fuzzy ARAS.

3.2.1. Fuzzy VIKOR

Fuzzy VIKOR (Chen, Wang 2009; Kaya, Kahraman 2011) was developed on a basis of crisp VIKOR introduced by Opricovic and Tzeng (2002, 2004). VIKOR is based on measuring the closeness to the ideal alternative according to separate cases of L_p metric.

First of all, the fuzzy best values \tilde{f}_j^* and the fuzzy worst values \tilde{f}_j^- are found:

$$\begin{aligned}\tilde{f}_j^* &= \max_i \tilde{x}_{ij}, \forall j \in B; \quad \tilde{f}_j^* = \min_i \tilde{x}_{ij}, \forall j \in C; \\ \tilde{f}_j^- &= \min_i \tilde{x}_{ij}, \forall j \in B; \quad \tilde{f}_j^- = \max_i \tilde{x}_{ij}, \forall j \in C.\end{aligned}\quad (8)$$

Subsequently, the distances of each alternative from the ideal one are determined:

$$\tilde{S}_i = \sum_{j=1}^n \tilde{w}_j (\tilde{f}_j^* - \tilde{x}_{ij}) / (\tilde{f}_j^* - \tilde{f}_j^-), \forall i; \quad (9)$$

$$\tilde{R}_i = \max_j \left[\tilde{w}_j (\tilde{f}_j^* - \tilde{x}_{ij}) / (\tilde{f}_j^* - \tilde{f}_j^-) \right], \forall i. \quad (10)$$

The reference point is defined by computing values of \tilde{S}^* , \tilde{S}^- , \tilde{R}^* , and \tilde{R}^- , which, in turn, enable to obtain the final summarizing ratio \tilde{Q}_i :

$$\tilde{S}^* = \min_i \tilde{S}_i; \quad \tilde{S}^- = \max_i \tilde{S}_i; \quad \tilde{R}^* = \min_i \tilde{R}_i; \quad \tilde{R}^- = \max_i \tilde{R}_i; \quad (11)$$

$$\tilde{Q}_i = \nu (\tilde{S}_i - \tilde{S}^*) / (\tilde{S}^- - \tilde{S}^*) + (1 - \nu) (\tilde{R}_i - \tilde{R}^*) / (\tilde{R}^- - \tilde{R}^*), \forall i, \quad (12)$$

where $\nu \in [0, 1]$ stands for weight of the strategy of the maximum group utility and usually is chosen such that $\nu = 0.5$. The fuzzy number $\tilde{Q}_i = (q_{i1}, q_{i2}, q_{i3})$ is defuzzified by employing the following equation (Kaya, Kahraman 2011):

$$Q_i = \frac{q_{i1} + 4q_{i2} + q_{i3}}{6}. \quad (13)$$

The best alternative, therefore, is found by minimizing value of Q_i .

3.2.2. Fuzzy TOPSIS

The fuzzy TOPSIS method (Yu, Hu 2010) relies on the vertex method. First of all, the aspired level and the worst level values obtained by Eq. 8 are used when normalizing the data:

$$\tilde{r}_{ij} = \frac{|\tilde{x}_{ij} - \tilde{f}_j^-|}{|\tilde{f}_j^* - \tilde{f}_j^-|}, \forall j, i, \quad (14)$$

with \tilde{r}_{ij} being the normalized value of the j^{th} criterion of the i^{th} alternative. The normalized matrix is therefore weighed by multiplying each \tilde{r}_{ij} from respective fuzzy coefficient of significance:

$$\tilde{v}_{ij} = \tilde{w}_j \times \tilde{r}_{ij}, \forall j, i. \quad (15)$$

The positive ideal solution A^+ as well as the negative ideal solution A^- are found:

$$A^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \dots, \tilde{v}_n^+); \quad (16)$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-),$$

where

$$\tilde{v}_j^+ = \max_i \tilde{v}_{ij}, \forall j; \quad \tilde{v}_j^- = \min_i \tilde{v}_{ij}, \forall j. \quad (17)$$

Afterwards, distances of each alternative from the ideal solutions are measured by employing Eq. 6:

$$d_i^+ = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^+), \forall i; \quad d_i^- = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^-), \forall i, \quad (18)$$

with d_i^+ and d_i^- being the distance from the positive and negative ideal solutions respectively. Finally, the relative proximity to the positive ideal solution is computed as follows:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}, \forall i. \quad (19)$$

The best alternative, hence, is found by maximizing the value of closeness coefficient CC_i .

3.2.3. Fuzzy ARAS

The fuzzy ARAS (Turskis, Zavadskas 2010) is based on comparing every alternative with the hypothetical ideal one. With $\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3})$, the ideal alternative is described in the following way:

$$\tilde{x}_{0j} = \max_i x_{ij3}, \forall j \in B \quad \tilde{x}_{0j} = \min_i x_{ij1}, \forall j \in C. \quad (20)$$

Subsequently, the normalized values $\tilde{\tilde{x}}_{ij}$ are obtained:

$$\begin{aligned} \tilde{\tilde{x}}_{ij} &= \frac{\tilde{x}_{ij}}{\sum_{i=0}^m \tilde{x}_{ij}}, \forall j \in B; \\ \tilde{\tilde{x}}_{ij} &= \frac{\tilde{1} / \tilde{x}_{ij}}{\sum_{i=0}^m \tilde{1} / \tilde{x}_{ij}}, \forall j \in C. \end{aligned} \quad (21)$$

Each $\tilde{\tilde{x}}_{ij}$ is weighted by computing elements of the weighted–normalized matrix:

$$\tilde{\hat{x}}_{ij} = \tilde{\tilde{x}}_{ij} \times \tilde{w}_j, \forall j, i, \quad (22)$$

where \tilde{w}_j is coefficient of significance and $\tilde{\hat{x}}_{ij}$ is the weighted–normalized value of the j^{th} criterion of the i^{th} alternative. The overall utility \tilde{S}_i of the i^{th} alternative is computed in the following way:

$$\tilde{S}_i = \sum_{j=1}^n \tilde{\hat{x}}_{ij}, i = 0, 1, \dots, m. \quad (23)$$

Since $\tilde{S}_i = (s_{i1}, s_{i2}, s_{i3})$ is a fuzzy number, the COA method is applied for defuzzification:

$$S_i = \frac{s_{i1} + s_{i2} + s_{i3}}{3}, i = 0, 1, \dots, m. \quad (24)$$

Finally, the relative utility of the i^{th} alternative K_i is found:

$$K_i = S_i / S_0, i = 0, 1, \dots, m, \quad (25)$$

where $K_i \in [0, 1]$. The best alternative is found by maximizing value of K_i .

4. Comparing the efficiency of Lithuanian economic sectors

This section presents the comparison of the selected economic sectors based on financial ratios described in Section 2 and application of MCDM methods discussed in Section 3.

As Table 1 suggests, gross profit margin and return on assets can be expressed in negative numbers. These indicators can be transformed by adding modulus of the lowest negative value of certain indicator to all values of that indicator. After summarizing the initial data (Annex A, Table 3), we realized that the problem occurred for the latter ratio only (the lowest value of -5.4 per cent was observed). Hence, all the values of that indicators for all economic activities were transformed by adding 5.4 percentage points (0.054) to their initial values.

The transformed initial data were summarized into the fuzzy decision matrix (Annex B, Table 4) by employing Eq. 7. Henceforth, the three fuzzy MCDM methods were applied. Fuzzy VIKOR began with Eq. 8 applied for finding respective minima and maxima. The proximity to the ideal solution was measured as defined by Eq. 9 and Eq. 10. The reference point was found by applying Eq. 11. Finally, summarizing ratios were obtained according to Eq. 12 and subsequently defuzzified by employing Eq. 13 (Table 2). Fuzzy TOPSIS method was applied by normalizing and weighting the data according to Eq. 14 and Eq. 15 respectively. The ideal solutions were determined by applying Eq. 16 and Eq. 17. The distances from those solutions were computed according to Eq. 18 and summarized by employing Eq. 19. Table 2 presents the summarized data. As we can see, the application of the three MCDM methods was successful: the ranks of certain alternatives (i.e. economic sectors) are highly correlated. These ranks enable us to evaluate relative position of certain economic sector amidst the remaining sectors.

As Table 2 suggests, the best performing sector was that of forestry and logging. That may be caused by relatively high values of gross profit margin, current ratio, and receivables turnover ratio. These ratios indicate smooth settlements of receivables and thus generation of sufficient flow of income. Indeed, enterprise operating in trade sector, hospitality sector, mining and quarrying sector, information sector, or manufacturing sector can be considered

Table 2. Comparison of Lithuanian economic sectors efficiency according to different MCDM methods, 2007–2010

Economic sectors	Fuzzy VIKOR		Fuzzy TOPSIS		Fuzzy ARAS		Final ranks
	Q_i	Rank	CC_i	Rank	K_i	Rank	
A02 Forestry and logging	0.000	1	0.741	1	0.643	1	1
G Wholesale and retail trade; repair of vehicles	0.576	4	0.487	2	0.510	2	2
I Accommodation and food service activities	0.734	8	0.476	3	0.496	3	3
B Mining and quarrying	0.485	2	0.464	4	0.409	4	4
J Information and communication	0.491	3	0.458	5	0.402	5	5
C Manufacturing	0.667	5	0.384	6	0.384	6	6
Total (all enterprises)	0.682	6	0.341	7	0.341	8	7
F Construction	0.734	7	0.327	8	0.373	7	8
L Real estate activities	0.898	12	0.323	9	0.325	9	9
H Transportation and storage	0.768	9	0.306	10	0.310	10	10
D Electricity, gas, steam and air conditioning supply	0.895	11	0.222	11	0.248	11	11
E Water supply; sewerage, etc.	0.840	10	0.213	12	0.247	12	12

as working more efficiently than average Lithuanian enterprise. For all these sectors possess higher ranks than alternative summarizing financial ratios of all Lithuanian enterprises, namely row *total* with rank of 6. Indeed, one of the best performing sectors, namely the hospitality sector, required exemptions from value added tax. However, analysis of financial ratio suggests such an exemption being unnecessary for this particular sector.

Construction, real estate, and transportation sectors were those severely damaged by the economic crisis: they were ranked below the average alternative. More specifically, construction sector was peculiar with relatively low values of gross profit margin during 2007–2010. Furthermore, both construction and real estate sectors experienced rather low values receivables turnover ratio suggesting delay in settlements peculiar for these sectors. It may be caused by common economic difficulties and shrunk aggregate demand. Relatively low positions of utilities sectors may be caused by their specifics. For instance, due to extensive and sometimes overvalued facilities networks, these sectors are peculiar with relatively high volumes of equity, which, in turn, causes relatively low equity turnover ratios. On the other hand, investments raised from borrowed funds lead to substantial level of the leverage ratio. Finally, the transport sector can be considered as the typical victim of economic downturn. For decreased sales lead to decreasing profits, and even losses in 2009.

Concluding all the above, the study proved that financial ratios can be successfully used in inter-sectoral comparisons. Survey data confirm the validity of the research. More specifically, Statistics Lithuania summarizes opinions of methodically chosen respondents active in certain economic sector. As of May 2011, the following confidence indicators were presented (Statistics Lithuania 2011): manufacturing – 1 per cent; trade – 10 per cent; construction – 14 per cent; services – 28 per cent. Here, the higher values of indicator mean more positive prospective expected by businessmen in certain sector. Indeed, these findings generally coincide with results provided by our model. However, currently it is impossible to perform further validation of the obtained results, for the required data covering years 2010 and 2011 are not yet available. The further studies, hence, should be aimed at the verification. The inter-sectoral comparisons, in turn, can be performed on a basis of fuzzy MCDM methods. As a result effective strategic management decisions can be made by stakeholders at various management levels.

5. Conclusions

Appropriate financial ratios identify both the efficiency and competitiveness of national economic sectors. Obtained from financial statements of enterprises, these ratios can help to ascertain whether the enterprises are operating effectively, are able to meet their liabilities, etc. The summarized data, therefore, enabled to investigate these peculiarities at the inter-sectoral level or their evolution over the time at the sectoral level.

In accordance with expert evaluation and correlation analysis, the following financial ratios were chosen for analysis: 1) gross profit margin, 2) return on assets ratio, 3) leverage ratio, 4) current ratio, 5) receivables turnover ratio, 6) equity turnover ratio.

Fuzzy methods can cope with ambiguities, uncertainties, and vagueness that cannot be handled by crisp values. Hence three methods were applied in the analysis: fuzzy VIKOR, fuzzy TOPSIS, and fuzzy ARAS. Indeed, the application of the three MCDM methods was

successful: the ranks of certain alternatives (i.e. economic sectors) were highly correlated. The following advantages can be, therefore, attributed to the proposed framework:

- The applied MCDM methods enabled to simultaneously consider multiple objectives identified by respective indicators (financial ratios). Indeed, a single financial ratio is not sufficient for robust analysis and decision aiding.
- The employed fuzzy MCDM methods enable to tackle uncertainties and vagueness peculiar for corporate performance analysis.
- The time series analysis can be carried out due to application of the fuzzy MCDM methods. Hence, triangular fuzzy numbers resembled not only a cross-section data at a certain period of time, but the generalized trend of the investigated indicators throughout the investigation period.
- Given certain sectors are peculiar with specific values of financial ratios, the coefficients of significance were given to each indicator according to its variation among sectors. However, further studies might be aimed at applying more sophisticated tools for estimation of weights, for instance, those based on linear programming.
- The introduction of a dummy alternative (total economy) virtually enables to define two groups of sectors, namely that encompassing relative efficient sectors, and another encompassing relatively inefficient ones.

The proposed framework for integrated efficiency assessment of economic sectors is, however, a generalized and tentative one. The further analysis, therefore, remains important. Such analysis could be based on data envelopment analysis or index decomposition analysis, both of which enable to identify the underlying factors (i.e. specific indicators) influencing efficiency of certain sector. The MCDM methods generally cannot handle this issue. Furthermore, the application of outranking-based MCDM methods, e.g. families of PROMETHEE and ELECTRE, NAIADE etc., would enable to avoid reasonless comparisons of alternatives. Additionally, one should be aware of trend breaks in the analyzed time series, for they can result in biased ranking.

The results suggested the best performing sector being that of forestry and logging. Furthermore, enterprises operating in trade sector, hospitality sector, mining and quarrying sector, information sector, or manufacturing sector can be considered as working more efficiently than average Lithuanian enterprise.

Construction, real estate, and transportation sectors were those severely damaged by the economic crisis: they were ranked below the average alternative. Relatively low positions of utilities sectors may be caused by their specifics. Finally, the transport sector can be considered as the typical victim of economic downturn. For decreased sales lead to decreasing profits, and even losses in 2009.

The proposed multi-criteria assessment framework can provide a rationale for interested stakeholders: government institutions and politicians; investors, financial institutions, and businessmen; employees and trade unions; clients and suppliers related with certain sectors. More specifically, the government can impose some additional fiscal measures for the best performing sectors, namely those of forestry and logging; wholesale and retail trade; repair of vehicles; hospitality etc. The investors, in turn, should opt for long-term investments in relatively inefficient sectors, i.e. construction and real estate sectors, transportation, facilities sectors. The short-term investments should be directed in the relatively efficient sectors. As

for employees and their trade unions, they could successfully insist on increase in remuneration as well as other benefits only if their sector is an efficient one. Otherwise, these actions may lead to unsustainable decisions. Finally, clients and suppliers dealing with inefficient sectors should consider additional means for reducing risk of insolvency; for instance, credit insurance. Thus, a proper assessment of sector activity can improve the decisions of all the interested stakeholders and somehow mitigate their risks.

The study hence proved that financial ratios can be successfully used in inter-sectoral comparisons based on fuzzy MCDM methods. Consequently, effective strategic management decisions can be made at various management levels.

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Annex A. Initial data

Table 3. The financial ratios of Lithuanian economic sectors, 2007–2010

Direction of optimization Economic sectors (NACE 2)	1. Gross profit margin			2. Return on assets ratio			3. Leverage ratio			4. Current ratio			5. Receivables turnover ratio			6. Equity turnover ratio											
	MAX	2008	2010	MAX	2007	2010	MIN	2007	2008	2010	MAX	2007	2008	2010	MAX	2007	2008	2010									
Total (all enterprises)	0.212	0.191	0.188	0.190	0.106	0.043	-0.010	0.022	1.16	1.11	1.30	1.27	1.49	1.44	1.47	1.42	6.57	6.07	5.09	4.07	2.32	2.17	1.47	1.22			
A02 Forestry and logging	0.621	0.551	0.517	0.614	0.224	0.028	0.007	0.081	5.11	4.79	6.29	7.51	3.50	3.16	4.46	4.99	14.50	10.53	9.65	9.98	1.53	1.24	0.89	0.76			
B Mining and quarrying	0.433	0.448	0.366	0.437	0.184	0.171	0.020	0.099	3.29	2.84	2.27	2.18	3.10	3.36	1.91	2.01	4.63	5.02	3.39	3.53	1.03	0.90	0.67	0.73			
C Manufacturing	0.183	0.134	0.144	0.148	0.084	0.037	0.003	0.040	0.96	0.91	1.00	1.04	1.47	1.39	1.39	1.38	7.14	7.77	6.54	5.44	3.11	3.42	2.56	2.24			
D Electricity, gas, steam and air conditioning supply	0.123	0.079	0.112	0.090	0.023	0.009	-0.054	0.005	3.36	2.81	2.69	2.65	2.43	2.26	2.52	2.12	3.58	4.35	4.06	2.92	0.59	0.71	0.72	0.53			
E Water supply; sewerage, waste management and remediation activities	0.192	0.199	0.221	0.223	0.003	0.014	0.003	0.020	6.21	2.85	2.61	2.70	1.42	1.30	1.23	1.52	5.55	6.29	3.76	2.70	0.32	0.70	0.53	0.44			
F Construction	0.222	0.194	0.153	0.153	0.148	0.080	-0.032	-0.007	0.72	0.58	0.70	0.68	1.52	1.52	1.62	1.69	4.92	3.99	2.38	1.82	3.36	3.40	1.58	1.27			
G Wholesale and retail trade; repair of motor vehicles and motorcycles	0.179	0.179	0.176	0.176	0.164	0.079	0.017	0.036	0.58	0.55	0.60	0.63	1.37	1.37	1.36	1.35	8.26	7.34	6.44	5.29	6.58	6.51	5.02	3.75			
H Transportation and storage	0.220	0.176	0.168	0.200	0.067	0.017	-0.005	0.026	1.52	1.21	1.33	1.46	1.50	1.28	1.16	1.30	6.80	6.19	5.33	4.01	1.52	1.65	1.26	1.03			
I Accommodation and food service activities	0.492	0.474	0.460	0.467	0.046	-0.003	-0.039	-0.010	0.50	0.45	0.38	0.39	1.09	1.08	0.82	0.86	9.24	9.49	6.85	5.87	2.16	2.37	2.02	1.49			
J Information and communication	0.421	0.449	0.410	0.430	0.149	0.110	0.061	0.068	2.04	1.32	1.09	1.25	2.37	2.03	1.55	1.40	4.16	4.82	4.81	3.31	1.37	1.57	1.49	1.06			
L Real estate activities	0.432	0.512	0.464	0.437	0.088	0.024	-0.017	0.010	0.86	0.83	0.75	0.71	1.33	1.06	1.14	1.31	2.89	1.85	1.37	1.11	0.50	0.32	0.32	0.23			
Minimum	0.079				-0.054				0.375				0.817				1.106				0.234						
C_v	0.530				1.322				0.892				0.491				0.485				0.846						
$1 / C_v$	1.887034				0.756339				1.120835				2.03627				2.06096				1.182154						
$\bar{\Sigma}$									9.043592																		
$w_j = (1 / C_j) / \Sigma$	0.21				0.08				0.12				0.23				0.23				0.13						

Annex B. Fuzzy MCDM

Table 4. The initial fuzzy decision matrix

	1. Gross profit margin		2. Return on assets ratio		3. Leverage ratio		4. Current ratio		5. Receivables turnover ratio		6. Equity turnover ratio	
	MAX		MAX		MIN		MAX		MAX		MAX	
w_j	(0.21, 0.21, 0.21)		(0.08, 0.08, 0.08)		(0.12, 0.12, 0.12)		(0.23, 0.23, 0.23)		(0.23, 0.23, 0.23)		(0.13, 0.13, 0.13)	
Total	(0.188, 0.195, 0.212)		(0.044, 0.094, 0.16)		(1.106, 1.209, 1.298)		(1.421, 1.456, 1.494)		(4.066, 5.45, 6.571)		(1.221, 1.795, 2.32)	
A02	(0.517, 0.576, 0.621)		(0.061, 0.139, 0.278)		(4.793, 5.926, 7.508)		(3.158, 4.028, 4.991)		(9.652, 11.166, 14.503)		(0.755, 1.102, 1.532)	
B	(0.366, 0.421, 0.448)		(0.074, 0.172, 0.238)		(2.183, 2.645, 3.286)		(1.913, 2.597, 3.363)		(3.392, 4.143, 5.024)		(0.668, 0.832, 1.034)	
C	(0.134, 0.152, 0.183)		(0.057, 0.095, 0.138)		(0.905, 0.974, 1.037)		(1.381, 1.406, 1.466)		(5.436, 6.722, 7.774)		(2.242, 2.834, 3.421)	
D	(0.079, 0.101, 0.123)		(0, 0.049, 0.077)		(2.645, 2.876, 3.364)		(2.118, 2.333, 2.521)		(2.922, 3.727, 4.352)		(0.531, 0.636, 0.718)	
E	(0.192, 0.209, 0.223)		(0.057, 0.064, 0.074)		(2.609, 3.594, 6.211)		(1.228, 1.366, 1.516)		(2.703, 4.575, 6.289)		(0.322, 0.497, 0.702)	
F	(0.153, 0.181, 0.222)		(0.022, 0.102, 0.202)		(0.583, 0.67, 0.718)		(1.521, 1.588, 1.687)		(1.817, 3.278, 4.925)		(1.271, 2.402, 3.399)	
G	(0.176, 0.177, 0.179)		(0.071, 0.128, 0.218)		(0.546, 0.591, 0.634)		(1.349, 1.362, 1.373)		(5.291, 6.831, 8.257)		(3.746, 5.466, 6.581)	
H	(0.168, 0.191, 0.22)		(0.049, 0.08, 0.121)		(1.214, 1.383, 1.522)		(1.162, 1.31, 1.503)		(4.01, 5.582, 6.798)		(1.028, 1.364, 1.649)	
I	(0.46, 0.473, 0.492)		(0.015, 0.053, 0.1)		(0.375, 0.429, 0.5)		(0.817, 0.96, 1.089)		(5.874, 7.866, 9.494)		(1.493, 2.012, 2.366)	
J	(0.41, 0.428, 0.449)		(0.115, 0.151, 0.203)		(1.091, 1.424, 2.042)		(1.399, 1.836, 2.367)		(3.314, 4.276, 4.822)		(1.062, 1.375, 1.569)	
L	(0.432, 0.461, 0.512)		(0.037, 0.08, 0.142)		(0.714, 0.79, 0.86)		(1.063, 1.21, 1.329)		(1.106, 1.805, 2.892)		(0.234, 0.344, 0.503)	
\tilde{f}_j^*	(0.517, 0.576, 0.621)		(0.115, 0.172, 0.278)		(0.375, 0.429, 0.5)		(3.158, 4.028, 4.991)		(9.652, 11.166, 14.503)		(3.746, 5.466, 6.581)	
\tilde{f}_j^-	(0.079, 0.101, 0.123)		(0.000, 0.049, 0.074)		(4.793, 5.926, 7.508)		(0.817, 0.96, 1.089)		(1.106, 1.805, 2.892)		(0.234, 0.344, 0.503)	