TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY

2010
16(4): 613–640

REGIONAL DEVELOPMENT IN LITHUANIA CONSIDERING MULTIPLE OBJECTIVES BY THE MOORA METHOD

Willem Karel M. Brauers[1], Romualdas Ginevičius[2], Valentinas Podvezko[3]

[1, 2, 3]Vilnius Gediminas Technical University,
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
E-mails: [1]willem.brauers@ua.ac.be; [2]romualdas.ginevicius@vgtu.lt;
[3]valentinas.podvezko@vgtu.lt

Received 16 April 2010; accepted 20 October 2010

Abstract. The inequality between the regional incomes in a nation with a developed fiscal and parafiscal regime including social security will be equilibrated automatically by transfer payments from the richer to the poorer regions. The automatic system is not a guaranty for success. Internationally a project oriented system of the international organizations is known instead of an automatic system but the final goal is not always very clear. Multiple Objectives Optimization looks more robust to obtain regional and international development. Moreover a system of transfer payments is not sufficient to measure the well being of a regional population. In the well-being economy, each individual would have to feel good concerning material wealth, health, education, all kind of security and concerning the environment. With other words, multiple objectives have to be fulfilled. However, these different multiple objectives are expressed in different units. Weights are most of the time used to equalize these different units. Introduction of weights means introduction of subjectivity. In order to avoid this dilemma, the internal mechanical solution of a ratio system, producing dimensionless numbers, is preferred: MOORA. In addition, this outcome creates the opportunity to use an additional non-subjective reference point theory. The choice and importance of the objectives is also non-subjective if all stakeholders involved come to an agreement. This theory is applied on the different counties of Lithuania. At that moment it is no more only a question of redistribution of income but also of a national policy of new constructions, of tourism development, of pollution abatement and of energy renewables, after the European Commission "related to the promotion of local employment".

Keywords: MOORA (Multiple Objectives Optimization by Ratio Analysis), ratio system, Reference Point Theory, regional development, redistribution of income, labor drain.

Reference to this paper should be made as follows: Brauers, W. K. M.; Ginevičius, R.; Podvezko, V. 2010. Regional development in Lithuania considering multiple objectives by the MOORA method, *Technological and Economic Development of Economy* 16(4): 613–640.

ISSN 1392-8619 print/ISSN 1822-3613 online doi: 10.3846/tede.2010.38
http://www.tede.vgtu.lt

1. Introduction

The economic relations between the regions of a country are usually regulated by structural and automatic transfer payments from the richer to the poorer regions, consequently a mono-objective relationship. This automatic system is not a guaranty for success. Moreover a system of transfer payments is not sufficient to measure the well being of a regional population. In the well-being economy, each individual would have to feel good concerning material wealth, health, education, all kind of security and concerning the environment. With other words, multiple objectives have to be fulfilled. However, Multi-Objectivity poses many problems such as:

- the method to be followed;
- the normalization of the units of the different objectives;
- the importance of an objective compared to the other objectives;
- the final ranking of the objectives.

2. The Method to be followed

For the researcher in multi-objective decision support systems the choice between many methods is not very easy. Indeed numerous theories were developed since the forerunners: Condorcet [the Condorcet Paradox, against binary comparisons, 1785, LVIII], Gossen (Law of decreasing marginal utility 1853), Minkowski (Reference Point 1896, 1911) and Pareto (Pareto Optimum and Indifference Curves analysis 1906, 1927) and pioneers like Kendall (ordinal scales, since 1948), Roy *et al.* (ELECTRE, since 1966), Miller and Starr (Multiplicative Form for multiple objectives 1969), Hwang and Yoon (TOPSIS 1981) and Saaty (AHP, since 1987–1988).

We intend to assist the researcher with some guidelines for an effective choice. In order to distinguish the different multi-objective methods from each other we use the qualitative definition of robustness.

In 1969 the statistician Huber considered robustness as purely cardinal as a compromise between a normal distribution and its light deviations[1]. Casella and Berger call a robust alternative the median absolute deviation for a sample x_1,……, x_n (2002: 509). Moreover, from the beginning Bayesian analysis could be characterized as cardinal, nevertheless with a high grade of arbitrariness. This arbitrariness could be softened by considerations on robustness[2].

By 1953, which is quite recent for statistics[3], robust became a statistical term as "strong, healthy, sufficiently tough to withstand life's adversities" (Stigler 1973: 872). Indeed, we observe a move to a more vague and qualitative definition of robustness, namely to the meaning

[1] At a later time, namely in 1981, Huber wrote a more complete book on Robust Statistics. In 1994 at the occasion of Huber's birthday his colleagues edited a book on Robust Statistics (editor: Rieder 1996).

[2] A good overview of this problem of robustness and Bayesian Analysis is brought by Ruggeri 2008.

[3] As well known, statistics already existed in Roman times with the census of population.

of common language[4]: from a cardinal towards a qualitative scale: the most robust one, more robust than…, as robust as……, robust, weak robust, less robust than…, not robust etc.

3. Conditions of Robustness in Multi-Objective Methods

The most robust multi-objective method has to satisfy the following conditions:

1. the method of multiple objectives in which all stakeholders are involved is *more robust than* this one in which only one decision maker or different decision makers defending only their limited number of objectives are involved. All stakeholders mean everybody interested in a certain issue (Brauers 2007: 454–455). Sooner or later, the method of multiple objectives has to take full account of the consumer-stakeholder (consumer sovereignty), either through private or through public consumption. Consequently, the method taking into consideration consumer sovereignty is *more robust than* this one which does not respect consumer sovereignty**.** Consumer sovereignty is measured by community indifference loci. Solutions have to deliver points inside the convex zone of the highest possible community indifference locus;
2. the method of multiple objectives in which all non-correlated objectives are considered is *more robust than* this one with a limited number of objectives;
3. the method of multiple objectives in which all interrelations between objectives and alternatives are taken into consideration at the same time is *more robust than* this one in which the interrelations are examined two by two (for the proof of this statement, see: Brauers 2004: 118–122);
4. the method of multiple objectives which is non-subjective is *more robust than* this one which uses subjective estimations for the choice and importance of the objectives and for normalization.

   4.1. For the choice of the objectives

   A complete set of representative and robust objectives is found after Ameliorated Nominal Group Technique Sessions. The Ameliorated Nominal Group Technique representing all the stakeholders consists of a sequence of steps, each of which has been designed to achieve a specific purpose, here to determine the objectives (Appendix A furnishes more details).

   4.2. For giving importance to an objective

   Weights and scores mix importance of objectives with normalization. On the contrary Delphi determines importance of objectives separately from normalization. In addition, as all stakeholders concerned are involved, the Delphi method is non-subjective.

   The Delphi Method is a method for obtaining and processing judgmental data. It consists of a sequenced program of interrogation (in session or by mail) interspersed

[4] Webster's new Universal Unabridged Dictionary: robust: strong; stronger, strongest.

with feedback of persons interested in the issue, while everything is conducted through a steering group (Appendix B furnishes more details).

4.3. For Normalization

The method of multiple objectives which does not need external normalization is *more robust than* this one which needs a subjective external normalization (Brauers 2007: 445–460). Consequently, the method of multiple objectives which uses non-subjective dimensionless measures without normalization is *more robust than* this one which uses subjective weights (weights were already introduced by Churchman *et al.* in 1954 and 1957) or subjective non-additive scores like in the traditional reference point theory (Brauers 2004: 158−159);

5. the method of multiple objectives based on cardinal numbers is *more robust than* this one based on ordinal numbers: "an ordinal number is one that indicates order or position in a series, like first, second, etc." (Kendall *et al.* 1990: 1). Robustness of cardinal numbers is based first on the saying of Arrow (1974): "Obviously, a cardinal utility implies an ordinal preference but not *vice versa*" and second on the fact that the four essential operations of arithmetic: adding, subtracting, multiplication and division are only reserved for cardinal numbers;
6. the method of multiple objectives which uses the last recent available data as a base is *more robust than* this one based on earlier data;
7. once the previous six conditions fulfilled the use of two different methods of multi-objective optimization is more robust than the use of a single method; the use of three methods is more robust than the use of two, etc.

The multi-objective optimization by ratio analysis method (MOORA) satisfies the first six conditions. In addition, MOORA satisfies partially the seventh condition by using two different methods of multi-objective optimization. MOORA is the most robust method as no other method satisfies the seven conditions better until now.

4. The MOORA Method

The method starts with a matrix of responses of all alternative solutions on all objectives:

$$[x_{ij}], \tag{1}$$

with: x_{ij} as the response of alternative j on objective or attribute i, $i = 1, 2, \ldots, n$ as the objective or the attributes, $j = 1, 2, \ldots, m$ as the alternatives.

In order to define objectives better we have to focus on the notion of *attribute*. Keeney and Raiffa (1993: 32) present the example of the objective "reduce sulfur dioxide emissions" to be measured by the attribute "tons of sulfur dioxide emitted per year". An objective and a correspondent attribute always go together. Consequently, when the text mentions "objective" the correspondent attribute is meant as well.

The MOORA method consists of two parts: the ratio system and the reference point approach.

4.1. The Ratio System as a Part of MOORA

We go for a ratio system in which each response of an alternative on an objective is compared to a denominator, which is representative for all alternatives concerning that objective[5]:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{j=i}^{m} x_{ij}^{2}}}, \tag{2}$$

with: x_{ij} – response of alternative j on objective i, j= 1, 2, ..., m; m the number of alternatives, i = 1, 2, …, n; n the number of objectives, x_{ij}^{*} – a dimensionless number representing the normalized response of alternative j on objective i.

Dimensionless Numbers, having no specific unit of measurement, are obtained for instance by multiplication or division. The normalized responses of the alternatives on the objectivės belong to the interval [0; 1]. However, sometimes the interval could be [–1; 1]. Indeed, for instance in the case of productivity growth some sectors, regions or countries may show a decrease instead of an increase in productivity i.e. a negative dimensionless number[6]**.**

For optimization, these responses are added in case of maximization and subtracted in case of minimization:

$$y_{j}^{*} = \sum_{i=1}^{g} x_{ij}^{*} - \sum_{i=g+1}^{n} x_{ij}^{*}, \tag{3}$$

with: i = 1,2,…, g as the objectives to be maximized; i = g+1, g+2,…, n as the objectives to be minimized; y_{j}^{*} – the normalized assessment of alternative j with respect to all objectives; y_{j}^{*} can be positive or negative depending of the totals of its maxima and minima.

An ordinal ranking of the y_{j}^{*} shows the final preference. Indeed, cardinal scales can be compared in an ordinal ranking after Arrow (1974): "Obviously, a cardinal utility implies an ordinal preference but not *vice versa*".

4.2. The Reference Point Approach as a part of MOORA

Reference Point Theory will go out from the ratios found in formula (2), whereby, a Maximal Objective Reference Point is also deduced. The Maximal Objective Reference Point approach is called realistic and non-subjective as the co-ordinates (r_i), which are selected for the reference point, are realized in one of the candidate alternatives. In the example, A (10;100), B (100;20) and C (50;50), the maximal objective reference point R_m results in: (100;100). The

[5] Brauers and Zavadskas, 2006, prove that the most robust choice for this denominator is the square root of the sum of squares of each alternative per objective**.**

[6] Instead of a normal increase in productivity growth a decrease remains possible. At that moment the interval becomes [–1, 1]. Take the example of productivity, which has to increase (positive). Consequently, we look for a maximization of productivity e.g. in European and American countries. What if the opposite does occur? For instance, take the original transition from the USSR to Russia. Contrary to the other European countries productivity decreased. It means that in formula (2) the numerator for Russia was negative with the whole ratio becoming negative. Consequently, the interval changes to: [–1, +1] instead of [0, 1].

Maximal Objective Vector is self-evident, if the alternatives are well defined, as for projects in Project Analysis and Project Planning.

Given the dimensionless number representing the normalized response of alternative *j* on objective *i*, namely x_{ij}^* of formula (2) and in this way arriving to:

$$\left(r_i - x_{ij}^*\right), \tag{4}$$

with: $i = 1, 2, \ldots, n$ as the attributes, $j = 1, 2, \ldots, m$ as the alternatives, r_i = the i^{th} co-ordinate of the reference point, x_{ij}^* = the normalized attribute i of alternative *j*, then this matrix is subject to the *Min-Max Metric of Tchebycheff* (Karlin and Studden 1966)[7]:

$$\min_j \left\{ \max_i \left| r_i - x_{ij}^* \right| \right\}, \tag{5}$$

$\left| r_i - x_{ij}^* \right|$ means the absolute value if x_{ij} is larger than r_i for instance by minimization.

Concerning the use of the maximal objective reference point approach as a part of MOORA some reserves can be made in connection with consumer sovereignty. Consumer sovereignty is measured with the community indifference locus map of the consumers (Brauers 2008b: 92–94). Given its definition the maximal objective reference point can be pushed in the non-allowed non-convex zone of the highest community indifference locus and will try to pull the highest ranked alternatives in the non-allowed non-convex zone too (Brauers, Zavadskas 2006: 460–461). Therefore an aspiration objective vector can be preferred, which moderates the aspirations by choosing smaller co-ordinates than in the maximal objective vector and consequently can be situated in the convex zone of the highest community indifference locus. Indeed stakeholders may be more moderate in their expectations. The co-ordinates q_i of an *aspiration objective vector* are formed as:

$$q_i \leq r_i,$$

$(r_i - q_i)$ being a subjective element we don't like to introduce subjectivity in that way again. Instead, a test shows that the min-max metric of Tchebycheff delivers points inside the convex zone of the highest community indifference locus (Brauers 2008b: 98–103).

4.3. The Importance given to an Objective

The normalized responses of the alternatives on the objectives belong to the interval [0; 1] (see formula 2). Nevertheless, it may turn out to be necessary to stress that some objectives are more important than other ones. In order to give more importance to an objective its normalized responses on an alternative could be multiplied with a *Significance Coefficient*:

$$\ddot{y}_j^* = \sum_{i=1} s_i x_{ij}^* - \sum_{i=g+1} s_i x_{ij}^*, \tag{6}$$

[7] Brauers 2008b proves that the Min-Max metric is the most robust choice between all the possible metrics of reference point theory.

with: $i = 1, 2, \ldots, g$ as the objectives to be maximized, $i = g+1, g+2, \ldots, n$ as the objectives to be minimized, s_i = the significance coefficient of objective i, $\ddot{y}_j^*$ = the normalized assessment of alternative j with respect to all objectives with significance coefficients.

The *Attribution of Sub-Objectives* represents another solution. Take the example of the purchase of fighter planes (Brauers 2002). For economics, the objectives concerning the fighter planes are threefold: price, employment and balance of payments, but there is also military effectiveness. In order to give more importance to military defense, effectiveness is broken down in, for instance, the maximum speed, the power of the engines and the maximum range of the plane. Anyway, the Attribution Method is more refined than that a significance coefficient method could be as the attribution method succeeds in characterizing an objective better. For instance, for employment two sub-objectives replace a significance coefficient of two and in this way characterize the direct and indirect side of employment.

Of course at that moment the problem is raised of the subjective choice of objectives in general, or could we call it robustness of choice? The Ameliorated Nominal Group Technique will gather all stakeholders interested in the issue to determine the objectives in a non-subjective and anonymous way (see: Appendix A) and Delphi Technique will indicate their relative importance (for Delphi see Appendix B).

5. The Data on the Lithuanian Counties

Vilnius Gediminas Technical University creates a tradition in studying multiple criteria, sustainable development or social indicators in relation to the Lithuanian cities and counties. Let us illustrate this statement with some examples. In 2007, Zavadskas. Viteikiene and Saparauskas studied 22 indices defining the aspects of sustainability in the different residential districts of the city of Vilnius. In the same publication Zagorskas *et al.* evaluated the compactness of the Kaunas city districts. In the International Journal of Environment and Pollution Juskeviciius and Burinskiene studied quality factors of the residential environment in urban planning in the municipality regions of Lithuania. In the same publication Zavadskas *et al.* recommended how to improve the situation for sustainability in Vilnius with special emphasis on pollution (2007).

Another group of researchers at VGTU emphasized rather the evaluation of the sustainable development of the Lithuanian counties like Ginevicius *et al.* in Ekonomika (2004) and Ginevicius and Podvezko in Environmental research, Engineering and Management in the same year. Brauers and Ginevicius studied robustness in regional development studies of Lithuania (2009). Already at that moment the subjectivity was stressed for instance in the choice of the raw data connected with the choice of the objectives, criteria or indicators.

Not only the method to handle the different objectives expressed in different units had to be non-subjective but also the choice of the objectives, starting with the data underlying the objectives. What is meant with non-subjective?

In physical sciences, a natural law dictates non-subjectivity without deviations. In human sciences, for instance in economics, an economic law will state the attitude of men in general with very exceptionally individual deviations. Outside these human laws in the human sciences unanimity or at least a certain form of convergence in opinion between all stakeholders, which

means everybody concerned in a certain issue, will lead to non-subjectivity[8]. Consequently, the choice of the data concerning the Lithuanian counties, leading to the objectives, would mean bringing together the representatives of the national government, of the counties, of the inhabitants, of the workers and entrepreneurs and of the specialists from the academic world. Instead of this considerable undertaking the authors themselves made a broad choice of data in the different fields of interests. For instance, for migrations of population the emigration is taken as negative and the immigration as positive. Further are considered:

- the unemployment rate;
- for income and expenditure: the municipal budget and the monthly earnings;
- for housing and other floor space: useful floor space and completed dwellings;
- for education: number of pre–schools and of schools;
- for production and commerce: animal production, investments, construction and retail trade;
- for justice: criminal offenses.

The number of physicians is considered for health care. On the national level mostly the number of hospital beds is counted, which has no sense on the regional level as many patients prefer treatment in large towns sometimes outside the own district.

For pollution the following average emissions in kg per km^2 are taken into account: solid emissions, SO_2, NO_x, CO, volatile organic compounds (VOC) and some others.

We don't mention the greenhouse gas emission (CO_2) as Lithuania has still a reserve for 2020 of 15% above the 2005 figure[9]. Consequently, we suppose that also the Lithuanian districts have no problem with the greenhouse effect[10].

Table 1 shows all the data**.**

6. The Geographical-Automatical-Structural System of Transfer Payments

A note on terminology is needed to clarify the issue. Gross Domestic Product (GDP) in a certain year is the value added created on the national territory, being a territorial concept. On the contrary, Gross National Product (GNP) is related to the civilians and the permanent residents of a nation. Interpolated for a region, the Gross Regional Domestic Product (GRDP) signifies the value added created on a regional territory during a given year and the Gross Regional Product (GRP) means the value added created by the permanent residents of a region during that year. The Gross Regional Product is composed of the Regional Private Income

[8] This convergence of opinion has to be brought not by face to face methods but rather by nominal methods such as the Ameliorated Nominal Group Technique or by the Delphi Method (See Appendices A and B).

[9] Lithuania greenhouse gas emission limited by 2020 compared to 2005: 18,429,024 tons of CO_2 equivalent or 15% above the 2005 emission; cf. other Baltic States: Latvia 17%, Estonia 11% (Commission of the European Communities, decision to reduce emissions, SEC 2008).

[10] A huge literature exists on pollution and climate change. A number of the Journal of Economic Perspectives (Spring 2009, Symposium on Climate Change) presents a large uptodate literature on pollution and climate change. In addition we have to mention the International Journal of Environment and Pollution, especially volume 30 with as guest editors Zavadskas and Burinskiene.

Table 1. The statistical data on economic-social development of Lithuanian Counties for 2008

	Units	Alytus	Kaunas	Klaipėda	Marijampolė	Panevėžys	Šiauliai	Tauragė	Telšiai	Utena	Vilnius
1. Population migration (net migration) per 1000 inhabitants	1000 p.	–5.345	–2.550	–0.812	–0.369	–4.996	–7.379	–6.894	–4.941	–4.941	3.003
2. Municipal budget's revenue (average amount per capita)	1000 LTL	2.221	2.175	2.111	2.116	2.109	2.190	2.294	2.142	2.889	1.956
3. Municipal budget's expenditure (average amount, social security)	LTL	189.39	185.18	180.36	193.31	190.04	230.21	254.38	198.20	206.22	203.48
4. Unemployment rate	%	4.1	5.9	7.2	2.8	5.6	5.5	5.7	6.6	5.4	6.3
5. Average gross monthly earnings	LTL	1874	2062	2114	1738	1835	1821	1637	2004	1946	2450
6. Average useful floor space per capita	m^2	27.1	24.0	22.7	23.6	26.9	24.1	24.0	23.1	30.1	25.4
7. Number of pre – school establishments (places per 100 children)	number	109	94	96	97	108	92	96	86	99	98
8. Number of schools (per 1000 of students)	number	3.11	2.52	2.82	3.45	3.21	3.33	3.53	3.37	3.74	2.99
9. Animal products recalculated in terms of milk (100 kg per 100 ha of agricultural land)	100 kg	674	683	788	832	658	661	891	722	621	603
10. Indicators of activity of retail trade enterprises (per capita)	LTL	4954	5857	6982	4408	5129	5065	4207	4492	4743	9859
11. Investment in tangible fixed assets (per capita)	LTL	4560	6265	7761	3527	5308	4752	2887	9115	4824	10729
12. Own–account construction work carried out within the country (per capita)	LTL	2687.2	3036.0	4434.8	2074.7	2354.2	2846.5	1878.0	2477.2	2848.6	5337.6
13. Dwellings completed (per capita)	m^2	0.243	0.354	0.335	0.142	0.077	0.123	0.057	0.097	0.090	0.739
14. Registered criminal offences (misdemeanors per 100000 inhabitants)	number	112	164	173	130	130	144	169	98	122	287
15. Physicians per 10000 population	number	24.3	51.3	33.1	20.7	28.1	23.2	13.3	17.6	13.0	48.4
16. Average pollutant emissions per km^2	kg	244.1	1374.9	1552.5	380.6	346.1	681.1	278.3	7204.7	189.6	664.8

Source: Department of Statistics to the Government of the Republic of Lithuania (Statistics Lithuania).

(also called Primary Incomes of the Households) plus the cash flows of the regional companies before taxes but after distribution of dividends and the indirect taxation on both groups. As the last group is mostly not estimated the Gross Regional Product is assumed to be equal to the Regional Private Income. Finally, the Disposable Income per head equals the Private Income per head after paying taxes and receiving or giving transfer payments.

Transfer Payments do not create Value Added but are a transfer of value without counterpart like gifts or aid. Transfer payments are quite common in daily life such as in all kind of insurances, but transfer payments which are considered here are geographical. First of all geographical transfer payments can be automatic through fiscal or para-fiscal channels such as social security. They can also be seasonal, cyclical or structural. Off season on the sea side in Klaipèda can ask for additional but temporal transfer payments. Regions with a cyclical economy could need additional transfer payments in recession times. Structural transfer payments between regions are maintained under all circumstances and form an essential and enduring financial instrument for a state or a region, however becoming an element of stagnation for that region or nation. This kind of transfer payments is very much contested in Western Europe: "do not kill the goose that lays the golden eggs". In Belgium it caused even an *Income Paradox* at least until 1996: by the transfer payments the richer Flemish inhabitants came worst off compared to the other Belgians as shown in Table 2.

Table 2. Income Paradox in Belgium (1996)

in BEF*	GRP per head	Disposable Income per head
Flanders	869, 976	676, 743
Wallonia	752, 452	692, 883
Brussels	839, 913	698, 809
Belgium (total)	828, 693	684, 076

*1 € equaled 40.3399 BEF

Calculations in: W K. Brauers: het Bruto Regionale Product van Vlaanderen. Wallonië en Brussel (the GRP of Flanders, Wallonia and Brussels) Working Paper 99/2, RUCA, Faculty Applied Economics, University of Antwerp, 8–18.

For Lithuania the average gross monthly earnings for 2008 as mentioned in table 1, sub 5 approaches more or less the notion of Regional Income. Table 3 classifies the regions by this notion.

However, the computation of the Regional Income is not sufficient. The RI per capita could be biased. Furthermore, regional income is a typical exponent of the Economics of Welfare of Pigou (1920). The well-being economy goes further. In the wellbeing economy each individual would have to feel good concerning material wealth, health, education, all kind of security and concerning the environment. Therefore, multiple objectives have to be fulfilled. Multiple objectives, realized simultaneously, will measure well being. The 16 data of Table 1 become attributes and when optimized, either as maxima or minima, objectives. At that moment, the MOORA method will be operational.

Table 3. Classification of the Lithuanian Counties by the average gross monthly earnings per capita for 2008 (in Litas)

1	Vilnius	2450
2	Klaipėda	2114
3	Kaunas	2062
4	Telšiai	2004
5	Utena	1946
6	Alytus	1874
7	Panevėžys	1835
8	Šiauliai	1821
9	Marijampolė	1738
10	Tauragė	1637

7. Application of the MOORA Method on the data of the Lithuanian Counties

7.1. The part of the Ratio System in MOORA

In order to apply the MOORA program the statistical data of Table 1 are rearranged in sub-Table 4a as objectives and alternative districts under the form of the matrix:

$$[\boldsymbol{x}_{ij}]. \tag{1}$$

Next, in sub Tables 4b and 4c formula (2) starts from this matrix:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{j=i}^{m} x_{ij}^{2}}}, \tag{2}$$

where by: x_{ij} = response of alternative j on objective *i*, $j = 1, 2, ..., m$; *m* the number of alternatives, $i = 1, 2, \ldots, n$; *n* the number of objectives.

In addition, after formula (3) the objectives are then added in case of maximization and subtracted in case of minimization (sub Table 4c):

$$y_{j}^{*} = \sum_{i=1}^{g} x_{ij}^{*} - \sum_{i=g+1}^{n} x_{ij}^{*}. \tag{3}$$

The last column of sub Table 4c gives the final ranking for the ratio system in MOORA.

7.2. The part of the Reference Point Theory in MOORA

Reference Point Theory starting from the dimensionless numbers of Table 4c is non-subjective, also by using the Maximal Objective Reference Point, as expressed in formula (5):

$$\min_{j}\left\{\max_{i}\left|r_{i} - x_{ij}^{*}\right|\right\}, \tag{5}$$

with: r_i as the normalized Maximal Objective Reference Point, $i = 1, \ldots, n$ as the objectives, x_{ij}^{*} as the dimensionless numbers of Table 4c.

The last column of sub Table 4e gives the final rank for the Reference Point Theory in MOORA.

Table 4. MOORA applied on 16 objectives for the 10 Lithuanian Counties for 2008

4a. Matrix of Responses of Counties on Objectives: (x_{ij})

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	migra–tion	revenue	expen–diture	unem–ploym.	earnings	floor–space	pre–schools	schools	animal products	retail trade	Invest–ment	construc–tion	dwell–ings	criminal acts	Physi–cians	total pollution
	MAX	MAX	MAX	MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MIN	MAX	MIN
Alytus	–5.345	2.221	189.39	4.1	1874	27.1	109	3.11	674	4954	4560	2687.2	0.243	112	24.3	244.1
Kaunas	–2.55	2.175	185.18	5.9	2062	24	94	2.52	683	5857	6265	3036	0.354	164	51.3	1374.9
Klaipėda	–0.812	2.111	180.36	7.2	2114	22.7	96	2.82	788	6982	7761	4434.8	0.335	173	33.1	1552.5
Marijampolė	–0.369	2.116	193.31	2.8	1738	23.6	97	3.45	832	4408	3527	2074.7	0.142	130	20.7	380.6
Panevėžys	–4.996	2.109	190.04	5.6	1835	26.9	108	3.21	658	5129	5308	2354.2	0.077	130	28.1	346.1
Šiauliai	–7.379	2.19	230.21	5.5	1821	24.1	92	3.33	661	5065	4752	2846.5	0.123	144	23.2	681.1
Tauragė	–6.894	2.294	254.38	5.7	1637	24	96	3.53	891	4207	2887	1878	0.057	169	13.3	278.3
Telšiai	–4.941	2.142	198.2	6.6	2004	23.1	86	3.37	722	4492	9115	2477.2	0.097	98	17.6	7204.7
Utena	–4.941	2.889	206.22	5.4	1946	30.1	99	3.74	621	4743	4824	2848.6	0.09	122	13	189.6
Vilnius	3.003	1.956	203.48	6.3	2450	25.4	98	2.99	603	9859	10729	5337.6	0.739	287	48.4	664.8

Sub-Tables 4b and 4c: the part of the MOORA Ratio System for the 10 Lithuanian Counties (2008)

4b. Sum of squares and their square roots

Alytus	28.569	4.9328	35869	16.81	3511876	4.448	36115	31.36	454276	24542116	20793600	7221043.8	0.05905	12544	590.49	59584.81
Kaunas	6.5025	4.7306	34292	34.81	4251844	576	8836	9.6721	466489	34304449	39250225	9217296	0.12532	26896	2631.69	1890350
Klapėda	0.6593	4.4563	32530	51.84	4468996	515.3	9216	6.3504	620944	48748324	60233121	19667451	0.11223	29929	1095.61	2410256
Marijampolė	0.1362	4.4775	37369	7.84	3020644	557	9409	7.9524	692224	19430464	12439729	4304380.1	0.02016	16900	428.49	144856.4
Panevėžys	24.96	4.4479	36115	31.36	3367225	723.6	11664	11.903	432964	26306641	28174864	5542257.6	0.00593	16900	789.61	119785.2
Šiauliai	54.45	4.7961	52997	30.25	3316041	580.8	8464	10.304	436921	25654225	22581504	8102562.3	0.01513	20736	538.24	463897.2
Tauragė	47.527	5.2624	64709	32.49	2679769	576	9216	11.089	793881	17698849	8334769	3526884	0.00325	28561	176.89	77450.89
Telšiai	24.413	4.5882	39283	43.56	4016016	533.6	7396	12.461	521284	20178064	83083225	6136519.8	0.00941	9604	309.76	5190770
Utena	24.413	8.3463	42527	29.16	3786916	906	9801	11.357	385641	22496049	23270976	8114522	0.0081	14884	169	35948.16
Vilnius	9.018	3.8259	41404	39.69	6002500	645.2	9604	13.988	363609	97199881	115111441	28489974	0.54612	82369	2342.56	441959
Σ	220.65	49.86	417094	318	38421827	5618	119721	126	5168233	33655906	41327345	10032289	0.90469	259323	9072.34	5755179
root	14.854	7.0615	645.83	17.827	6198.534	74.95	346.01	11.244	2273.375	18345.546	20329.128	10016.132	0.95115	509.238	95.2488	7586.29

4c. Objectives divided by their square roots and MOORA

																	sum	rank
Alytus	-0.36	0.3145	0.2933	0.23	0.30233	0.362	0.315	0.277	0.296	0.270	0.224	0.268	0.255	0.220	0.25512	0.032176	2.3228	7
Kaunas	-0.172	0.308	0.2867	0.331	0.332659	0.32	0.2717	0.2241	0.300434	0.3192601	0.3081785	0.303111	0.37218	0.32205	0.53859	0.181235	2.8792	3
Klapėda	-0.055	0.2989	0.2793	0.4039	0.341048	0.303	0.2775	0.2508	0.346621	0.3805828	0.3817675	0.4427658	0.3522	0.33972	0.34751	0.204645	2.9999	2
Marijampolė	-0.025	0.2997	0.2993	0.1571	0.280389	0.315	0.2803	0.3068	0.365976	0.2402763	0.1734949	0.2071359	0.14929	0.25528	0.21733	0.050169	2.6475	4
Panevėžys	-0.336	0.2987	0.2943	0.3141	0.296038	0.359	0.3121	0.2855	0.289438	0.2795774	0.2611032	0.2350408	0.08095	0.25528	0.29502	0.045622	2.3352	6
Šiauliai	-0.497	0.3101	0.3565	0.3085	0.293779	0.322	0.2659	0.2961	0.290757	0.2760888	0.2337533	0.2841916	0.12932	0.28278	0.24357	0.08978	2.1238	8
Tauragė	-0.464	0.3249	0.3939	0.3197	0.264095	0.32	0.2775	0.3139	0.391928	0.22932	0.142013	0.1874975	0.05993	0.33187	0.13963	0.036685	1.8924	9
Telšiai	-0.333	0.3033	0.3069	0.3702	0.323302	0.308	0.2485	0.2997	0.31759	0.2448551	0.4483714	0.247321	0.10198	0.19244	0.18478	0.9497	1.4900	10
Utena	-0.333	0.4091	0.3193	0.3029	0.313945	0.402	0.2861	0.3326	0.273162	0.2585369	0.237295	0.2844012	0.09462	0.23957	0.13648	0.024992	2.4471	5
Vilnius	0.2022	0.277	0.3151	0.3534	0.395255	0.339	0.2832	0.2659	0.265244	0.5374056	0.5277649	0.5329004	0.77695	0.56359	0.5081	0.087632	4.2213	1

Sub-Tables 4d and 4e: the part of the MOORA Reference Point Theory for the 10 Lithuanian Counties (2008)

4d. Reference Point Theory with Ratios: co-ordinates of the reference point equal to the maximal objective values

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
r_i	0.2022	0.4091	0.3939	0.1571	0.395255	0.402	0.315	0.333	0.391928	0.537406	0.527765	0.532900	0.77695	0.1924	0.53859	0.024992

4e. Reference Point Theory: Deviations from the reference point

																max	rank min
Alytus	0.562	0.095	0.1006	0.0729	0.092925	0.04	0	0.0560	0.0955	0.2674	0.3035	0.2646	0.5215	0.0275	0.28347	0.007184	0.561994	4
Kaunas	0.3738	0.1011	0.1071	0.1739	0.062595	0.081	0.0434	0.1085	0.0915	0.2181	0.2196	0.2298	0.4048	0.1296	0	0.156242	0.404772	2
Klaipėda	0.2568	0.1102	0.1146	0.2468	0.054206	0.099	0.0376	0.0818	0.0453	0.1568	0.1460	0.0901	0.4247	0.1473	0.19108	0.179653	0.42475	3
Marijampolė	0.227	0.1095	0.0946	0.000	0.114866	0.087	0.0347	0.026	0.025953	0.2971293	0.35427	0.3257645	0.62766	0.063	0.32126	0.025177	0.62766	5
Panevėžys	0.5385	0.1105	0.0996	0.1571	0.099217	0.043	0.0029	0.047	0.102491	0.2578282	0.2666617	0.2978595	0.696	0.0628	0.2436	0.020629	0.69600	7
Šiauliai	0.6989	0.099	0.037	0.1515	0.101476	0.08	0.0491	0.036	0.101171	0.2613168	0.2940116	0.2487088	0.64764	0.0903	0.29502	0.064788	0.69892	8
Tauragė	0.6663	0.0843	0	0.1627	0.13116	0.081	0.0376	0.019	0	0.3080857	0.3857519	0.3454028	0.71702	0.1394	0.39896	0.011692	0.71702	9
Telšiai	0.5348	0.1058	0.087	0.213	0.071952	0.093	0.0665	0.033	0.074339	0.2925506	0.0793935	0.2855793	0.67497	0.000	0.35381	0.924708	0.92471	10
Utena	0.5348	0	0.0746	0.1458	0.08131	0	0.0289	0.0329	0.118766	0.2788688	0.2904699	0.2484991	0.68233	0.0471	0.4021	0	0.68233	6
Vilnius	0	0.1321	0.0788	0.1963	0	0.063	0.0318	0	0.126684	0	0	0	0	0.3711	0.03045	0.062639	0.37114	1

7.3. The Ranking of the Lithuanian Districts after their Well Being

Comparing sub Tables 4c and 4e the ranking is quite similar for the head and tail of the last column. However, the remark could be made that only the data for one year are observed. Therefore, having the figures for 2002 (Ginevicius, Podvezko 2004) and for 2005 (Brauers, Ginevicius 2009) a comparison is made with these years. In that manner the 2002 pre-European Union year is compared to the European Union years, 2005 and 2008.

In Table 5 the income approach represents the measurement of the average increase of material wealth of the inhabitants of a district but not of their well-being. The well being is rather effectively measured by MOORA using the multiple objectives concerning these inhabitants. MOORA shows some differences between the ratio system and the reference point versions. Nevertheless, a general tendency is present, even compared with a pre-European Union year. Three well-being districts, Vilnius, Klaipėda and Kaunas, are in sharp contrast with Telšiai, Tauragė and Šiauliai, regions with a rather poor well being.

Table 5. Ranking of the Lithuanian Counties after their general Well-Being

Regions	Income 2008	MOORA Ratio System 2008	MOORA Reference Point 2008	MOORA Ratio System 2005	MOORA Reference Point 2005	MOORA Ratio System 2002	MOORA Reference Point 2002
Vilnius	1	1	1	1	1	1	1
Klaipėda	2	2	3	2	2	4	6
Kaunas	3	3	2	3	3	2	2
Marijampolė	9	4	5	4	8	3	3
Utena	5	5	6	5	6	5	5
Panevėžys	7	6	7	6	5	7	8
Alytus	6	7	4	7	4	6	4
Šiauliai	8	8	8	8	7	10	10
Tauragė	10	9	9	9	9	8	7
Telšiai	4	10	10	10	10	9	9

A reversed ranking will start with the most vulnerable regions concerning their General Well-Being, the District of Telšiai on the first place.

1) Telšiai

Telšiai is the last classified county concerning general well-being. A slight deterioration seems even to be present since the pre-European Union period. Nevertheless, Telšiai has one of the highest average gross monthly earnings per capita of the country, probably biased by the well known high salaries of the petroleum industry. Indeed, the oil refinery of "Mažeikių nafta", the only oil refinery of the Baltic States, is located in the town of Mažeikiai (Telšiai). On the other side the pollution in the district is the highest in the country but mainly concentrated around the town of Mažeikiai and it concerns mainly gaseous and liquid air pollutant emissions. In 2005 the refinery started with the introduction of an environment management system (web "Mažeikių nafta" 2008), but the situation remains stationary, as shown in next Table 6.

Table 6. Average Pollutant Emission in kilograms per km^2 in the County of Telšiai

year	pollution
2002	7716
2005	7803
2008	7205

Strange enough the unemployment rate of 6.6% is the second worst in the country. It is also the case with floor space per capita, whereas investment in fixed assets, own construction work and completed dwellings are also rather low rated. Health care is the third worst.

2) Tauragė

Tauragė is the second worst concerning general well-being. A deterioration seems to be present since the pre-European Union period.

Anyway Tauragė has the lowest income per capita of all the Lithuanian counties over the period 2003–2008[11]. The second highest emigration quota of the country is then an understandable outcome. Tauragė is also the worst in investment, in construction and in the completion of dwellings and the second worst in health care.

Tauragė has to attract more investments with more construction also for private housing. The retail trade has to be developed, for instance around an important highway, when trade with Russia could develop.

3) Šiauliai

Šiauliai is the third worst concerning general well-being. It is also the worst in emigration, probably a result of being the third worst in income over the period 2003–2008.

4) Alytus

Alytus is the sixth in ranking for income but is the third worst in emigration and in investment.

5) Panevėžys

Panevėžys ranks only the seventh what income is concerned, is bad in completed dwellings (2nd worst) and is the third worst in construction.

6) Utena

General Well-Being classifies Utena more or less in the middle of the ranking of the 10 counties. It is the fifth in ranking for income but the worst of all counties for health care and the third worst for completed dwellings, a slight amelioration compared to 2005 when it was the second worst after Šiauliai.

The existence of the atomic plant of Ignalina of the type of Chernobyl presents a weak point for the Utena County. This nuclear power plant was built by the Sovjets between 1978

[11] *Economic and Social Development in Lithuania 2003*, Statistics Lithuania. Vilnius, 2004.
Counties of Lithuania 2004. Statistics Lithuania, Vilnius, 2005.
Counties of Lithuania 2005. Statistics Lithuania, Vilnius, 2006.
Counties of Lithuania 2006. Statistics Lithuania, Vilnius, 2007.
Counties of Lithuania 2007. Statistics Lithuania, Vilnius, 2008.

and 1983. At a certain moment the reactors now stopped produced 80% of Lithuania's electricity. Presenting a potential danger the European Union ordered the closing down of the plant. First it was planned for 2005 but it is believed that the process will take another 25–30 years. Huge amounts are allocated to the closure project. Nevertheless since 2005 pollution emission is the lowest from of all Lithuanian Counties. Concerning Income and General Well Being Utena is situated in the middle of the classification of all Lithuanian Counties.

One day may be a later closed atomic plant, if safely protected, can attract disaster tourists and industrial archeologists, industrial archeology being the last modern branch of modern history. For the other visitors one could think of a permanent exhibition on all sources of energy for which Chernobyl was a bad example. A special place could be given on an exhibition on renewables for energy a point so much accentuated by the European Union.

7) Marijampolė

Marijampolè is the second worst in income over the period 2003–2008 and the second worst in investment and in construction.

8) Kaunas

Kaunas is the third best ranked in General Well-Being. It is also the third ranked in income due to its industrial activity, which nevertheless explains its third worst position in pollution emissions.

9) Klaipėda

Klaipėda is the second best ranked in General Well-Being. Although Klaipėda has the second highest income of all districts it ranks the worst in the unemployment level, the worst in floor space and the second worst in criminal acts. Being the second worst in pollution, mainly gaseous and liquid pollutant emissions, it could be influenced by the neighborhood of the oil refinery of "Mažeikių nafta" in Telšiai.

10) Vilnius

Vilnius, the capital of the country, ranks first in General Well-Being. It also ranks first in the income level, is a source of immigration but ranks first in criminal acts. Strange enough it is classified third worst in unemployment.

8. Project Management for the Lithuanian Counties

8.1. The Labor Drain

The labor drain to the county of Vilnius represents a serious problem. In 2002 an immigration surplus still existed in the counties of Alytus, Kaunas, Marijampolė, Utena and Vilnius. In 2005 and 2008 only the county of Vilnius remained with an immigration surplus. The capital of a country or another main city as the only attraction pole is a general world phenomenon, but has to be corrected. However some fluctuations per county took place in that period, as shown in next Table 7.

Thirty eight thousand persons emigrated abroad in 2005 and thirty five thousand in 2008. All these important migration flows ask for investment projects in industry, construction and commerce, which was already clear from the analysis per county.

Table 7. Migration flows per Lithuanian County

	2005	2008
Alytus	–5277	–5345
Kaunas	–3636	–2550
Klaipėda	–1435	–812
Marijampolė	–3791	–369
Panevėžys	–4627	–4996
Šiauliai	–5748	–7379
Tauragė	–5986	–6894
Telšiai	–5522	–4941
Utena	–4663	–4941
Vilnius	2238	3003

8.2. Projects for Industrialization and Construction

As was already suggested above structural transfer payments of an automatic nature in order to solve the weaknesses of the counties have to be avoided as much as possible. Instead some suggestions for Project Management and Investments can be made.

1. The spin-offs of applied research of universities supported by the government in research parks outside campus namely in the less developed counties could lead to new products and applications. In this way a kind of Lithuanian Silicon Valley could be created.
2. The European Commission foresees a 23% part of renewables in the final energy demand of Lithuania by 2020. These renewables could come from non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. The European Commission remarks: "are related to the promotion of local employment and opportunities for small and medium sized enterprises, regional and rural development, stimulating economic growth and increasing global European industry leadership"[12]**.** Anyway it would mean an opportunity for industrialization of the Lithuanian counties.
3. The average useful floor space per capita is certainly satisfactory in all counties, but may be that the quality of the habitation can be ameliorated. Renovation and new construction is perhaps necessary.

8.3. Projects for Commerce and Tourism

Development of tourism all over the Lithuanian territory would be very good.

1. Following the Swedish and Finnish example fishing in the many lakes and fitness centers around the lakes will certainly attract foreign tourists.

[12] Commission of the European Communities, COM 2008, version 15.4.

2. The rocket base near Plateliai (Telšiai) can be an attraction pole for all European and Turkish tourists as they were threatened by the rockets one day.

9. Conclusion

The remark that significance of robustness depends *on the context* is specified in different ways. First, robustness can be defined as cardinal or qualitative.

Concerning the most robust method of multi-objective optimization the following conditions are to be satisfied:

1. The method of multiple objectives in which all stakeholders are involved is *more robust than* one in which only one decision maker or different decision makers defending only a limited number of objectives are involved. All stakeholders mean everybody interested in a certain issue. All production will finally end in consumption. Consequently, the method of multiple objectives which takes into consideration consumer sovereignty is *more robust than* this one which does not respect consumer sovereignty. Consumer sovereignty is measured with community indifference loci. Solutions have to deliver points inside the convex zone of the highest community indifference locus;
2. The method of multiple objectives in which all non-correlated objectives are considered is *more robust than* this one in which only a limited number of objectives is considered;
3. The method of multiple objectives in which all interrelations between objectives and alternatives are taken into consideration at the same time is *more robust than* this one in which the interrelations are only examined two by two;
4. The method of multiple objectives which does not need separate normalization is *more robust than* this one which needs a subjective outside normalization. Consequently, a method of multiple objectives which uses non-subjective dimensionless measures with inside normalization is *more robust than* this one which for normalization uses subjective weights or subjective non-additive scores like in the traditional Reference Point Theory;
5. The method of multiple objectives based on cardinal numbers is *more robust than* this one based on ordinal numbers: an ordinal number is one that indicates order or position in a series, like first, second, etc. The robustness of cardinality is based on the saying of Arrow: "Obviously, a cardinal utility implies an ordinal preference but not *vice versa*" and also on the fact that the four fundamental operations of arithmetic: adding, subtracting, multiplication and division are only reserved for cardinal numbers;
6. The method of multiple objectives which uses the last recent available data as a base in the response matrix is *more robust than* this one based on earlier data;
7. Once the previous six conditions are fulfilled the use of two different methods of multi-objective optimization is more robust than the use of a single method; the use of three methods is more robust than the use of two, etc.

The Multi-Objective Optimization by Ratio Analysis Method (MOORA) satisfies the first six conditions. In addition, MOORA satisfies partially the seventh condition by using two different methods of Multi-Objective Optimization. MOORA is the most robust

method as no other method satisfies the seven conditions better. For all these reasons we selected MOORA.

In a country economic development can differ from region to region. A policy of smoothing out the differences in economic development may not result in a killing disadvantage for the richer regions. On the contrary, any project of industrialization or commercialization has to be a win-win-operation for all regions.

Next question is how to measure any redistribution. The computation of the Regional Income, being an exponent of the welfare economy of Pigou, is not sufficient for the measurement of the well being of the regional population. A well-being economy goes further than a welfare economy. In the wellbeing economy each individual would have to feel good concerning material wealth, health, education, all kind of security and concerning the environment. With other words, multiple objectives have to be fulfilled. However, these different multiple objectives are expressed in different units, which means that a problem of normalization is posed. For this purpose the attribution of weights, scores or exponents can be used, which means introduction of subjectivity. Therefore, an internal mechanical procedure is operated in order to escape from that subjective problem, namely Multi-Objective Optimization by Ratio Analysis (MOORA). Dimensionless numbers obtained in this manner will also form the basis for Reference Point Theory, the second part of MOORA.

Given all the objectives MOORA measures finally the well being differences between the ten districts of Lithuania. Three well being districts are in sharp contrast with some districts with a rather poor well being. In addition, the labor drain to the district of Vilnius from all the other districts represents a serious problem.

An automatic redistribution of income has to be condemned, whereas rather commercialization and industrialization of the regions has to occur.

Does the regional application of Lithuania satisfy the seven conditions of robustness?

1. First condition of robustness

The choice of the objectives and their respective importance has to be made by all the stakeholders involved in the issue. As this procedure is rather cost and time consuming the authors have taken the responsibility to choose objectives for all the counties. Consequently, this condition also respects consumer sovereignty.

2. Second condition of robustness

All objectives were taken into consideration as much as possible. The choice of the objectives for all counties is representative for the fields of migration of the population, unemployment rate, income and expenditure, housing and other floor space problems, education, production, commerce, justice and health care problems. For pollution the following average emissions in kg and per km^2 are taken into account: solid emissions, SO_2, NO_x, CO, and volatile organic compounds. The greenhouse effect (CO_2) is not included as Lithuania may still exceed its actual emission level. On the contrary, the production of renewable energy will form an opportunity for further industrialization of Lithuania. Significance coefficients are too subjective to characterize the importance of an objective. Instead, sub-objectives, heightened to objectives, were introduced in order to give importance to a certain objective.

3. Third condition of robustness

All interrelations between objectives and alternatives were involved at the same time under the form of a matrix of responses considered as a whole and as a starting point for the application of MOORA.

4. Fourth condition of robustness

The use of dimensionless measures is a more robust method than subjective methods of normalization. In the application MOORA's dimensionless ratios satisfied this condition.

5. Fifth condition of robustness

The method of multiple objectives based on cardinal numbers is *more robust than* this one based on ordinal numbers. The application was entirely based on cardinal numbers.

6. Sixth condition of robustness

The last available data were used up until now.

7. Seventh condition of robustness

All the previous six conditions are fulfilled and also the seventh condition as two different methods of Multi-Objective Optimization were used. No other Multi-Objective Optimization Method exists which uses more than two Multi-Objective Optimization Methods and fulfill the previous six conditions.

In this way the regional research on Lithuania satisfies all conditions on robustness. Is it possible to draw some conclusion for policy making? Structural transfer payments of an automatic nature in order to solve the weaknesses of the counties have to be avoided as much as possible. Instead some suggestions for Project Management can be made.

Further industrialization and commercialization will diminish the labor drain to the Capital Vilnius and to abroad and would take away many weak points in the well being of the inhabitants of the counties.

References

Arrow, K. J. 1974. General economic equilibrium: purpose, analytic techniques, collective choice, *American Economic Review* June: 256.

Brauers, W. K. M.; Ginevicius, R. 2009. Robustness in regional development studies. The case of Lithuania, *Journal of Business Economics and Management* 10(2): 121–140. doi:10.3846/1611-1699.2009.10.121-140

Brauers, W. K. 2008a. Group decision making with Multi-Objective optimization, *Foundations of Computing and Decision Sciences* 33(2): 167–179.

Brauers, W. K. 2008b. Multi-Objective decision making by reference point theory for a wellbeing economy, *Operations Research International Journal* 8: 89–104.

Brauers, W. K. 2007. What is meant by normalization in decision making?, *International Journal of Management and Decision Making* 8(5/6): 445–460. ISSN 1462–4621

Brauers, W. K. M.; Zavadskas, E. K. 2006. The MOORA Method and its application to privatization in a transition economy, *Control and Cybernetics* 35(2): 445–469. Systems Research Institute of the Polish Academy of Sciences. ISSN 0324-8569

Brauers, W. K. 2004. *Optimization Methods for a Stakeholder Society. A Revolution in Economic Thinking by Multiobjective Optimization*. Kluwer Academic Publishers and Springer, Boston. ISBN 1-4020-7681-9

Brauers, W. K.; Lepkova, N. 2003. The application of the nominal group technique to the business outlook of the facilities sector of Lithuania over the period 2003−2012, *International Journal of Strategic Property Management* 7(1): 1–9. ISSN 1648-715x

Brauers, W. K. 2002. The multiplicative representation for multiple objective optimization with an Application for arms procurement, *Naval Research Logistics* 49: 327–340. doi:10.1002/nav.10014

Brauers, W. K. 1999. *Het Bruto Regionale Product van Vlaanderen, Wallonië en Brussel (the GRP of Flanders, Wallonia and Brussels)*. Working Paper 99/2, University of Antwerp (RUCA), Antwerpen.

Brauers, W. K. 1987. *Nominal Methods in Group Multiple Decision Making.* Research Paper N°3, Institute for Developing Countries, University of Antwerp, RUCA, Antwerpen.

Casella, G.; Berger, R. L. 2002. *Statistical Inference.* Second Edition. Pacific Grove, Cal., US, Duxbury, Thomson Learning.

Churchman, C. W.; Ackoff, R. L.; Arnoff, E. L. 1957. *Introduction to Operations Research*. New York, US, Wiley.

Churchman, C. W.; Ackoff, R. L. 1954. An Approximate Measure of Value, *Operations Research* 2: 172–180. doi:10.1287/opre.2.2.172

Commission of the European Communities 2008. *Proposal for a decision of the European Parliament and the Council on the effort of the Member States to reduce their greenhouse gas emissions*. Brussels, COM(2008) SEC (2008).

Commission of the European Communities 2008. *Proposal for a Directive of the European Parliament and the Council on the promotion of energy from renewable sources*. Brussels, COM (2008) version 15.4

Condorcet, Marquis de. 1785. *Essai sur l'application de l'analyse à la probabilité des décisions rendues à l a pluralité des voix (Proposal on the application of the probability analysis of the decisions taken by majority vote).* Paris, l'Imprimerie royale..

Dalkey, N.; Helmer, O. 1963. An experimental application of the delphi method to the use of experts, *Management Science*: 458–487. doi:10.1287/mnsc.9.3.458

Ginevicius, R.; Podvezko, V.; Mikelis, D. 2004. Quantitative evaluation of economic and social development of Lithuanian regions, *Ekonomika* 65: 1–13.

Ginevicius, R.; Podvezko, V. 2004. Quantitative assessment of regional development, *Environmental Research, Engineering and Management* 1(27): 10–14.

Gossen, H. H. 1853. *Entwicklung der Gesetze des menschlichen Verkehrs und der daraus Flieszenden Regeln für menschliches Handeln* (Development of the law of human relations and the therefrom derived rules of human behavior). 3 Auflage, Prager, Berlin (1927).

Huber, P. J. 1981. *Robust Statistics*. New York, US, Wiley. doi:10.1002/0471725250

Huber, P. J. 1969. *Theorie de l'Inference Statistique Robuste* (Theory of Robust Statistical Inference). Montreal, Canada, Les Presses de l'Université de Montreal.

Hwang, C-L.; Yoon, K. 1981. *Multiple Attribute Decision Making, Methods and Applications.* Lecture Notes in Economics and Mathematical Systems. Springer, Berlin.

Jantsch, E. 1967. *Technological Forecasting in Perspective*. Paris, OECD.

Karlin, S.; Studden, W. J. 1966. *Tchebycheff Systems: with Applications in Analysis and Statistics*, Interscience Publishers, New York, 278–280.

Keeney, R. L.; Raiffa, H. 1993. *Decisions with Multiple Objectives, Preferences and Value Tradeoffs*. Cambridge U.S., University Press.

Kendall, M. G.; Gibbons, J. D. 1990. *Rank Correlation Methods*. Edward Arnold, London.

Kendall, M. G. 1948. *Rank Correlation Methods*. Griffin London.

"Mažeikių nafta". Available from Internet: <www.nafta.lt/en/content.php?pid=34>.

Miller, D. W; Starr, M. K. 1969. *Executive Decisions and Operations Research*. 2nd Edition. Prentice-Hall Inc. Englewood Cliffs (N.J.).

Minkowsky, H. 1896. *Geometrie der Zahlen (Geometry of Numbers)*. Teubner, Leipzig.

Minkowsky, H. 1911. *Gesammelte Abhandlungen (Collected Papers)*. Teubner, Leipzig.

Pareto, V. 1906. *Manuale di Economia Politica (Handbook of Political Economy)*. Translation revised by Pareto himself: Manuel d'économie politique, Second Ed., Paris, 1927.

Pigou, A. C. 1920. (Ed.). *Economics of Welfare*. London.

Quade, E. S. 1970. *Cost-Effectiveness: Some Trends in Analysis*. Rand Corporation, P-3529-1, Santa Monica (CAL).

Quade, E. S.; Boucher, W. I. 1968. *Systems Analysis and Policy Planning: Applications in Defense*. Elsevier, New York.

Rieder, H. (Ed.). 1996. *Robust Statistics, Data Analysis and Computer Intensive Methods*. New York, Springer.

Roy, B.; Benayoun, R.; Sussman, B. 1966. *ELECTRE*, Société d'Economie et de Mathématique appliqués. Paris.

Ruggeri, F. 2008. Bayesian Robustness, *European Working Group, Multiple Criteria Decision Aiding, Series 3, N°17*: 6–10.

Saaty, T. L. 1987. What is the Analytic Hierarchy process?, in *Mathematical Models for Decision Support*. Nato Advanced Study Institute, Val d'Isere (F), July 26,1987, Mon 82.

Saaty, T. L. 1988. *The Analytic Hierarchy Process*. Mcgraw-Hill, New York.

Stigler, S. 1973. Simon Newcomb, Percy Daniell and the history of Robust estimation 1885–1920, *Journal of the American Statistical Association* 68: 872–9. doi:10.2307/2284515

The Journal of Economic Perspectives, Spring 2009, Symposium on Climate Change 23(2): 5–76.

Van De Ven, A. H.; Delbecq, A. L. 1971. Nominal Versus interacting group processes for committee decision making effectiveness, *Academy of Management Journal* 14(2): 203 and fol.

Zagorskas, J.; Burinskiene, M.; Zavadskas, E. K.; Turskis, Z. 2007.Urbanistic assessment of city compactness on the basis of GIS applying the COPRAS method, *Ekologija* 53: 55–63.

Zavadskas, E. K.; Viteikiene, M.; Saparauskas, J. 2007. Sustainable development assessment of cities and their residential districts, *Ekologija* 53: 49–54.

Zavadskas, E. K.; Kaklauskas, A.; Kaklauskiene, J. 2007. Modelling and forecasting of a rational and sustainable development of Vilnius: emphasis on pollution, *International Journal of Environment and Pollution* 30(3–4): 485–500. doi:10.1504/IJEP.2007.014824

Zavadskas, E. K.; Burinskiene, M. (Guest Editors). 2007. Internal and External Housing Environments, *International Journal of Environment and Pollution*, Inderscience Enterprises 30(3–4): 359–528.

Appendix A

The Ameliorated Nominal Group Technique as a source for objectives

A.1. The original Nominal Group Technique of Van de Ven and Delbecq (1971)

A group of especially knowledgeable individuals (experts), representing all stakeholders, is formed, which comes together in a closed meeting. A steering panel or a panel leader leads the group.

The nominal group technique consists of a sequence of steps, each of which has been designed to achieve a specific purpose.

1. The steering group or the panel leader carefully phrases as a question the problem to be researched. Much of the success of the technique hinges around a well-

phrased question. Otherwise the exercise can easily yield a collection of truisms and obvious statements. A successful question is quite specific and refers to real problems. The question has to have a singular meaning and a quantitative form as much as possible.

2. The steering group or the panel leader explains the technique to the audience. This group of participants is asked to generate and write down ideas about the problem under examination. These ideas too have to have a singular meaning and a quantitative form as much as possible. Participants do not discuss their ideas with each other at this stage. This stage lasts between five and twenty minutes.
3. Each person in round-robin fashion produces one idea from his own list and eventually gives further details. Other rounds are organized until all ideas are recorded.
4. The steering group or the panel leader will discuss with the participants the overlapping of the ideas and the final wording of the ideas.
5. The nominal voting consists of the selection of priorities, rating by each participant separately, while the outcome is the totality of the individual votes. A usual procedure consists of the choice by each participant of the *n* best ideas from his point of view, with the best idea receiving *n* points and the lowest one point. All the points of the group are added up. A ranking is the democratic result for the whole group.

A.2. The Ameliorated Nominal Group Technique of Brauers (1987)

6. Out of experience, one may say that there is still much wishful thinking, even between experts. Therefore the group was also questioned about the probability of occurrence of the event. In this way they became more critical even about their own ideas. The probability of the group is found as the median of the individual probabilities.
7. Finally, the group rating *(R)* is multiplied with the group probability *(P)* in order to obtain the effectiveness rate of the event *(E)*:

$$R \, x \, P = E. \tag{7}$$

Once again, the effectiveness rates of the group are ordered by ranking. Experience proves that the introduction of probabilities decreases significantly the total number of points.

A.3. An Application: Ameliorated Nominal Group Technique on the business outlook of the facilities sector of Lithuania over the period (2003–2012) (Brauers, Lepkova 2003)

The Facilities sector in Lithuania provides the following services:

- Acquisition, leasing and renting of existing buildings;
- Management of buildings, which is a multifunctional service. This means that all supervision, maintenance and repairing is included in the sector.

The Facilities Sector is only a very small sector in Lithuania, composed of a small number of small firms, which even perform other tasks outside facilities management, such as waste management. The largest firm in the sector counts only 179 employees.

A group of especially knowledgeable people was composed of delegates from the facilities sector, from the ministerial departments concerned and from the academic world (15 participants). Were all stakeholders interested in the issue represented? As neither representative consumer organization nor a representative trade union was present at that time it was assumed that the ministerial departments and the academic world were representative for these groups.

First a *Brainstorming Session* toke place. Jantsch gave the following basic rules for brainstorming sessions (1967: 136):

1. State the problem in basic terms, with only one focal point;
2. Do not find fault with, or stop to explore, any idea;
3. Reach for any kind of idea, even if its relevance may seem remote at the time;
4. Provide the support and encouragement which are so necessary to liberate participants from inhibiting attitudes".

In any case, an efficient reporting system is necessary to record the ideas presented (stenography or recording).

For the nominal group technique each participant has chosen the most important five events from his point of view, with the most important event receiving five points and the less important event one point Table A1 shows the results.

Table A1. Important Events influencing the Business Outlook of the Facilities Sector of Lithuania over the period 2003–2012

	Events 2003–2012	Given Points R	Rank	Median Probabilities P	E = RxP	Final rank
1	Member of European Union (a)	37	1	0.75	27.75	1
2	Large increase in foreign capital	20	2	0.75	15	2
3	More competition between facilities management companies	16	3	0.88	14.08	3 3
4	Large increase in GDP	16	3	0.75	12	4
5	New materials and technologies	12	6	0.75	9	5
6	Stability in international security	14	5	0.50	7	6
7	Higher quality in building construction	8	11	0.75	6	7
8	Application of new information technologies to facilities management	9	9	0.63	5.67	8
9	More relations with foreign companies having more experience in facilities management	9	9	0.63	5.67	8
10	Better legislation in supervision sector	11	7	0.5	5.5	10

end of Table A1

	Events 2003–2012	Given Points R	Rank	Median Probabilities P	E = RxP	Final rank
11	Optimal quality-price relation for services	7	13	0.75	5.25	11
12	Better public estimation for facilities management	8	11	0.63	5.04	12
	13 till 21					
22	Increase of individual property of housing	1	22	0.25	0.25	22
	Total Points	225			145.21	

(a) In 2003 Lithuania was not yet member of the European Union.

The introduction of probabilities of realization, introducing a sense of reality and presenting a guaranty against wishful thinking, produces quite some changes in the ranking.

The total 225 is a control figure for the group result. Indeed, each participant could distribute maximum: 5+4+3+2+1 = 15 points. With 15 participants, the total has to be not more than 225. It could be less, as each participant is not obliged to allot 15 points. The total of the given points, here namely 225, means that each participant used his rights completely. The reality check, however, diminishes the figure to 145.21.

Appendix B

The Delphi Technique to determine the importance of an objective

Delphi, so named after the Greek oracle, was first thought of as a tool for better forecasting. In this sense, it seems that the first experiments took place around 1948 (Quade, Boucher 1968: 334). Today Delphi is no longer limited to forecasting alone. Dalkey and Helmer at RAND Corporation first used Delphi in its present form around 1953 (Dalkey, Helmer 1963).

The Delphi Method is a method for obtaining and processing judgmental data. It consists of a sequenced program of interrogation (in session or by mail) interspersed with feedback of persons interested in the issue, while everything is conducted through a steering group.

The essential features of Delphi are the following:

1. the rather vague notion "persons interested in the issue" is interpreted by Quade as follows: "In practice, the group would consist of experts or especially knowledgeable individuals, possibly including responsible decision makers" (Quade 1970: 9–10);
2. the steering group treats anonymously the sources of each input;
3. inputs must as much as possible possess a single meaning and a quantitative form. The inputs with these characteristics are elicited with feedback in a series of rounds;
4. opinions about the inputs are evaluated with statistical indexes such as median and quartiles;
5. there is also a feedback of the statistical indexes with a request for re-estimation after consideration of reasons for extreme positions. The practice of Delphi reveals that after

several rounds convergence is shown between the various opinions (one of the main advantages of the Delphi method);

6. there are two developments of Delphi: one is based on a meeting, the other on the sending of questionnaires. The organization of a meeting produces quicker results; the meeting, however, has to be organized in such a way that communication between the panel members is impossible. In order to increase even further the speed of the outcome of a meeting, an on-line computer could be installed. Everybody involved in the Delphi teamwork would have a desk terminal linked to a computer and would be able to look at a television screen giving the results calculated by the computer.

Convergence in opinion between all stakeholders to give more importance to an objective results from a Delphi exercise, which could provide the given objective with a *Significance Coefficient*. For instance, giving a significance coefficient to pollution abatement, the stakeholders are asked to give the following importance to pollution abatement:

0, 1, 2 or 3

Suppose that after several rounds convergence is reached on 3 (for an example concerning voting by a jury, see Brauers 2008a).

LIETUVOS REGIONINĖS PLĖTROS DAUGIAASPEKTIS VERTINIMAS MOORA METODU

W. K. M. Brauers, R. Ginevičius, V. Podvezko

Santrauka. Nelygybė tarp skirtingų regionų pajamų išlyginama remiant skurdesnius regionus, t. y. dalį turtingesnių regionų pajamų pervedant skurdesniems. Tačiau tokia sistema nėra sėkmės garantas, be to, ji nepajėgi įvertinti regiono gyventojų gerovės. Plačiai žinoma tikslinės paramos sistema, kurią taiko tarptautinės organizacijos, tačiau jos galutiniai rezultatai ne visada būna akivaizdūs. Esant gerovės ekonomikai, kiekvienas individas turėtų būti patenkintas materialine gerove, sveikatos apsauga, švietimu, saugumu bei aplinkosauga. Kitaip tariant, turi būti išpildyti daugelis siekių. Tačiau šie skirtingi siekiai išreiškiami skirtingais mato vienetais. Be to, skirtingiems siekiams sulyginti pasitelkiami reikšmingumai, kurie suteikia subjektyvumo. Siekiant to išvengti, pirmenybė teikiama reitingavimo sistemą turinčiam MOORA metodui, paverčiančiam dimensinius skaičius bedimensiais. Be to, jis sukuria galimybę naudoti nesubjektyvią ekstreminio taško teoriją. Tikslai ir jų svarba yra objektyvūs, jei visos suinteresuotos pusės dėl jų sutaria. Ši teorija pritaikyta vertinant daugelį Lietuvos apskričių. Šiuo metu svarbu ne tik perskirstyti regionų pajamas, bet ir formuoti naujų statybų, turizmo vystymo, taršos mažinimo, atsinaujinančiosios energetikos nacionalinę politiką pagal Europos Komisijos programą „Vietinio užimtumo skatinimas“.

Reikšminiai žodžiai: MOORA, proporcinė sistema, ekstreminio taško teorija, regioninis vystymasis, pajamų perskirstymas, darbo jėgos nutekėjimas.

Willem K. M. BRAUERS was graduated as: Ph.D in economics (Un. of Leuven), Master of Arts (in economics) of Columbia Un. (New York), Master in Management and Financial Sciences, in Political and Diplomatic Sciences and Bachelor in Philosophy (Un. of Leuven). He is professor at the Faculty of Applied Economics and at the Institute for Development Policy and Management of the University of

Antwerp. Previously, he was professor at the University of Leuven, the Belgian War College, the School of Military Administrators, and the Antwerp Business School. He was a research fellow in several American institutions like Rand Corporation, the Pentagon, the Institute for the Future, the Futures Group and extraordinary advisor to the Center for Economic Studies of the University of Leuven. He was consultant in the public sector, such as the Belgian Department of National Defense, the Department of Industry in Thailand, the project for the construction of a new port in Algeria (the port of Arzew) and in the private sector such as the international seaport of Antwerp and in electrical works. He was Chairman of the Board of Directors of SORCA Ltd. Brussels, Management Consultants for Developing Countries, linked to the world-wide group of ARCADIS and Chairman of the Board of Directors of MARESCO Ltd. Antwerp, Marketing Consultants. At the moment he is General Manager of CONSULTING, Systems Engineering Consultants. Brauers is member of many international scientific organizations. His specialization covers: Optimizing Techniques with Several Objectives, Forecasting Techniques and Public Sector Economics such as for National Defense and for Regional Sub-optimization and Input-Output Techniques. His scientific publications consist of twelve books and hundreds of articles and reports.

Romualdas GINEVIČIUS. Professor, Dr Habil, Head of the Department of Enterprise Economics and Management, Vilnius Gediminas Technical University construction engineer and economist. The author of more than 350 research papers and over 20 scientific books; editor-in-chief of the 'Journal of Business Economics and Management' (located in ISI database 'Web of Science') and the journal 'Business: Theory and Practice'. Research interests: organization theory, complex quantitative evaluation of social processes and phenomena.

Valentinas PODVEZKO. Professor, Doctor, Department of Mathematical Statistics. Vilnius Gediminas Technical University. MSc Dept. of Mechanics and Mathematics (now Dept. of Applied Mathematics and Cybernetics) Lomonosov Moscow University (1966), Doctor (1984) (Scientific Institute for System Research of the Academy of Sciences of the USSR, Moscow), procedure of Habilitation, professor (2006). Author of over 150 publications. Research interests: decision–making theory, expert systems, sampling models in economics and technology.