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Assessing the performance of the construction sectors in the Baltic states and Poland

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Summary: The paper describes the evaluation of the construction market performance in three Baltic states, including Estonia, Latvia, Lithuania and Poland, based on using structural statistical criteria. The evaluation covers various periods of time, embracing the time before the economic crisis, in 2007, during the economic crisis, in 2009, and after the economic crisis, in 2013. For assessing the efficiency of their construction sectors' performance, the investigated countries are arranged in the order of preference according to this indicator by using three multiple-criteria decision making methods (MCDM), such as SAW, TOPSIS and COPRAS. These evaluation methods are based on determining the weights of the structural criteria used. For this purpose, three various methods, including the entropy, the method of the criteria impact loss (CILOS) and a new method of determining the objective criteria weights (IDOCRIW) suggested by the authors. The results obtained allowed the researchers to assess the construction market performance in the considered states in various periods of time, to compare them with other countries and to rank them based on this parameter. Therefore, the suggested method of market performance evaluation may be used as an effective supplementary aid for determining the priorities in the future business development, as well as for studying the competitive markets or directing the cash flows of an enterprise to the appropriate areas.

Keywords: construction sector, market indicators, assessing MCDM, entropy method, CILOS method, IDOCRIW method.

JEL: C51 , C44, N60.

In recent years, the construction industry has been the focus of research because the economic development of any country strongly depends on its effective performance. The processes of globalization and internationalization bring changes in the construction sector development of a country and pose a great number of new problems, challenges and questions. The criteria, which are critical for the construction industry development, are usually described as the integral whole of political, economic, cultural, technical and social factors, acting simultaneously and determining the performance of a particular business organisation and its effectiveness. Favourable conditions are required for effective development and planning of the future operations in the construction industry. Therefore, new methods and techniques for evaluating the environmental factors, which determine the performance of construction enterprises, are being sought. The investigations centered on determining and evaluating favourable market conditions are plenty. The authors offer case studies, surveys, statistical analysis, regression, interviews, predictive methods, etc., for this purpose (Fernando A. de Oliveira Tavares, Elisabeth T. Pereira and António Carrizo Moreira 2014; Jun Sang, Nam-Hyuk Ham, Ju-Hyung Kim and Jae-Jun Kim 2014; Óscar Arce, José M. Campa and Ángel Gavilán 2013; Hong Long Chen 2010; de Azevedo, Rogerio Cabral, Rogerio Tadeu de Olivera Lacerda, Leonardo Ensslin, Antonio Edesio Jungles and Sandra Rolim Ensslin 2013;). One of the basic aspects investigated in determining favourable conditions for the construction sector development is associated with the availability of data and information to the interested business organisations and individuals. This information and its analysis can help decision makers to answer the arising questions and to make proper strategic decisions, stimulating business development and decision making. The differentiation of the criteria used for evaluating the construction sector is aimed at determining the most important of them for this sector and their limiting values. The complex criteria and their limiting values specified in the EU standards helped the authors to objectively select the criteria for evaluating the performance of the construction sector and the conditions for its successful development. The performance of the construction market is considered to be effective, when the aims and needs of all interested parties are satisfied in the best possible way.

To assess the construction sector performance, the authors of the paper decided to analyse the problem associated with the changes, taking place on this market in the investigated countries in various periods of its development (in 2007, before the economic crisis, in 2009, during the crisis, and in 2013, in the post-crisis period). The analysis was based on four structural Eurostat criteria. In the present paper, multiple criteria decision-making methods (MCDM) are suggested for solving the problem of evaluating market conditions for the construction sector. The validity of the applied scientifically grounded and popular methods, as well as the obtained data, was also checked by the synthesis of the results. Any solution can be suitable or appropriate if it is most rational and takes into account major evaluation criteria. The significances (weights) of the criteria are determined by calculating their relative significances, which show how more important one criterion is with respect to another. In general, multicriteria problems are solved by employing one of the most commonly used methods for determining the significance of the criteria. However, the authors of the present paper suggest using the new CILOS and IDOCRIW methods developed by Edmundas Kazimieras Zavadskas and Valentinas Podvezko (2016) for assessing the criteria describing the construction sector.

To demonstrate the practical use of the suggested methodology, a case study, presenting the solution of the problem of evaluating the construction sectors of various countries (before the economic crisis, in 2007, during the economic crisis, in 2009, and after the economic crisis, in 2013), which is based on four selected Eurostat structural criteria, is given. As mentioned above, the four investigated countries included Estonia, Latvia, Lithuania and Poland. At the same time, MCDM methods, such as COPRAS (Edmundas Kazimieras Zavadskas, Artūras Kaklauskas and Vaidotas Šarka 1994), SAW (Kenneth R. MacCrimmon 1968) and TOPSIS (Ching-Lai Hwang and Kwangsun Yoon 1981), which are well-known and widely discussed in the literature, are used for determining the preference order of the states (or ranking them) from the above perspective. The unique character of the problem is demonstrated by the fact that the synthesis of the obtained data is performed using three different methods for calculating the criteria weights and three different methods for establishing the order of preference of the countries in this respect. In fact, it is the need for comparing the same evaluation criteria referring to different countries that encouraged the authors to consider the search for the above solution in terms of a multicriteria evaluation problem.

1. Literature Review

Most of researchers consider that the rate of the construction sector growth depends not only on the inner market development, but also on the macroeconomic environment associated with the situation in various countries in this sphere. The research into the world crisis development has shown that its effects on the construction sector performance were short-lived (Christopher Crowe, Giovanni Dell'Ariccia, Deniz Igan and Pau Rabanal 2013). However, the question still arises, why in some countries the unexpected crisis, which did not last long, was devastating for most of the construction enterprises, while it took a long time for other countries to recover from the crisis, though its aftereffects on this sector had not been so destructive in them. The crisis has changed the policy of construction enterprises so that most of them directed the provision of some of their services to more profitable foreign markets. The business people have already understood that, in the case of crisis, the state sector would cut the investments into construction and, therefore, some measures should be taken to reduce risks (Selim Sahin, Serdar Ulubeyli and Aynur Kazaza 2015). According to David Ingram (2015), construction is generally a cyclic industry. A strengthening economy has the general effect of raising individual incomes and encouraging entrepreneurship. Rising incomes stem from a self-reinforcing cycle of a rising demand. People spend more as they have more money to spend, which results in increased business revenue that can be shared with employees. Aspiring entrepreneurs take advantage of this trend by opening new businesses. This leads to the creation of construction opportunities in residential, commercial and industrial real-estate, boosting the demand throughout the industry. The general effects of a weakening economy are opposite to those caused by a strong economy. Lower incomes lead to more conservative spending and investing habits in families, and entrepreneurs are less encouraged to open new businesses. Even people and businesses less affected by economic downturns than others can be reluctant to invest in new construction projects in these times, preferring to delay capital investment until macroeconomic trends shift upwards. A great number of research works have been performed to analyse the state of the construction market in various countries in various periods of their economic development, based on particular quantitative and qualitative criteria (Yat-Hung Chiang, Li Tao and Francis K. W. Wong 2015; Rogério Cabral de Azevedo *et al.* 2013Arce *et al.* 2013). A number of various factors (criteria) determine the favourableness of the conditions for the construction sector development. Some of them have only a slight influence on the final result, however, their effect should be taken into consideration. In this case, the significances of the criteria should be determined. However, if the criteria, having a very weak influence on the described phenomenon, were included in the list of its evaluation criteria, the research would be too extended and the probability of making a more serious error would be higher. Therefore, a list of criteria influencing the development of favourable conditions for construction sector performance should not be too long and must include only the criteria more strongly influencing the investigated object than others. Researchers and construction specialists make efforts to determine the main criteria, influencing the construction market or the activities of construction enterprises on this market. For example, Che Maznah Mat Isa, Hamidah Mohd Saman and Siti Rashidah Mohd Nasira (2014) evaluated the main criteria, having an influence on the performance of the construction enterprises in Malaysia, which are striving to internationalize their activities. The survey of 109 enterprises allowed them to identify five criteria (factors), which were the highest in order of significance. These criteria described the 'intensity of competition', 'existence of strict quality requirements', 'proximity to competitors', 'proximity to the host country' and 'firm international competitiveness'. In 2006, the CIDB of Malaysia presented another research, where eight critical 'success factors' that were pertinent for successful business in the construction industry, were listed. They included 'productivity', 'quality', 'human resources', 'innovation', 'environmentally-friendly practices', 'knowledge', 'industry sustainability' and, of course, 'professionalism'. Abhijeet Gadekar and Sunil S. Pimplikar (2014) determined the success and failure factors, leading to the construction company's success or failure. The survey covered 30 Indian construction companies located in the Aurangabad district of the Maharashtra region of India. According to the results, cash flow management characteristic (with the rating of 9.1) was identified as the most important factor leading to the success of large-size firms. Insufficient capital (with the ratings of 9.0 and 8.6) was considered to be the most important factor for medium-size and small-size firms. Inadequate sales (with the rating of 9.3) were considered to be the most important factor for small-size firms. The factor of organizing and planning was perceived to be most important for contributing to the company's success with respect to the importance of the factors. Isabel M. Horta, Anna S. Camanho and Jorge Moreira da Costa (2012) examined the trends in the performance of the Portuguese construction industry and identified the factors promoting excellence and innovation in the sector. From a methodological perspective, this study helped to enhance the construction of composite indicators, using the principles of the "benefit of the doubt" weighting. This involves the use of Data Envelopment Analysis (DEA) to estimate weights for aggregating the key performance indicators of the construction companies. The paper also proposed a new DEA-based method to assess innovation within an industry by identifying the innovative companies and the extent of innovation. Most of researchers, involved in prediction and evaluation of the criteria influencing the performance of the construction sector, used the MCDM methods. The effectiveness of these methods in solving the problems associated with the analysis of the construction market is demonstrated in a great number of research works (Daniel Jato-Espino, Elena Castillo-Lopez, Jorge Rodriguez-Hernandez and Juan Carlos Canteras-Jordana 2014). Table 1 presents some cases, showing the use of MCDM methods for solving the problems associated with the analysis of the construction market.

Table 1 The MCDM methods used for assessing the construction market factors in 2012-2015

Reference	The aim of research	Applied MCDM method
Mehrbakhsh Nilashi *et al.* (2015)	Evaluation of the critical success factors in construction projects	ANP, DEMATEL, GRA
Seyed Ali Jozi, Mehrnoush Tabib Shoshtary and Ali Reza Khayat Zadeh (2015)	Assessment of the environmental risk of dams in the construction phase	TOPSIS; AHP
Gudienė, Neringa, Banaitis, Audrius, Podvezko, Valentinas and Banaitienė, Nerija (2014)	Identification and evaluation of the critical success factors for construction projects	AHP approach
Parviz Rezaei, Kamran Rezaie, Salman Nazari-Shirkouhi and Mohammad Reza Jamalizadeh Tajabadi (2013)	Selection and evaluation of the best location for underground dam construction	Fuzzy theory; AHP
Urban Pinter and Igor Psunder (2013)	Evaluation of construction project success	M-TOPSIS
Gokhan Arslan (2012)	Web-based contractor evaluation system for mass-housing projects	SAW
Simona Kildienė, Edmundas Kazimieras Zavadskas, Jolanta Tamošaitienė (2014)	Complex assessment for advanced technology development	AHP, permutation method

Analysing the Thomson Reuters Web of Knowledge, Web of Science database, we could observe that the popularity of the MCDM methods had been growing. New, hybrid versions of these methods, suitable for solving the considered problems, can be found. In particular, only in recent five years, the use of the MCDM methods for solving the construction industry problems has been described in 105 papers, while this number is even larger in the ScienceDirect database. The assessment of the competing markets based on using mathematical models can be a key factor determining successful business development.

2. Theoretical Background

Modelling is aimed at identifying the problem and getting prepared for making an optimal solution. The suggested model for problem solution is presented as a simplified and structured problem solution method. To obtain an effective and rational solution, the aim of the performed task should be clearly formulated, a set of criteria defined and the selected criteria analysed by scientifically grounded methods, allowing the researchers to choose the most effective and appropriate solution among the available alternatives. The model presenting the algorithm of the considered problem solution is given in Fig. 1.

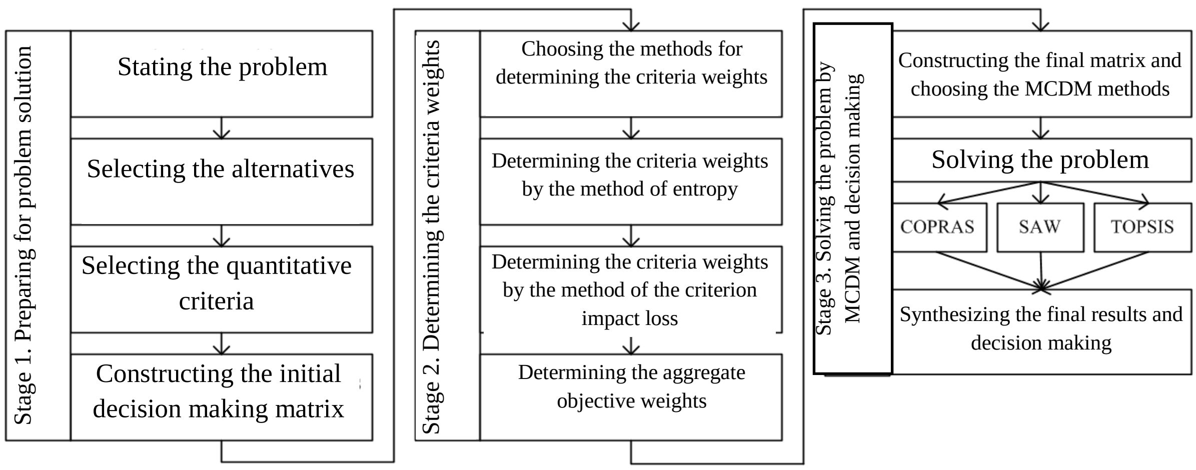

Figure 1 The model of problem solution

The model includes three stages: the preparation for problem solution, determination of the criteria weights and problem solution by using MCDM methods and decision making. Making a decision and its implementation form the final stage of the whole decision making process. When the problem is formulated, the information is analysed and a number of alternatives and the method of problem solution are chosen, a decision making process can proceed. The methodology used for solving the problem is described below.

2.1. The application of MCDM methods

In the present work, the MCDM methods, SAW, TOPSIS and COPRAS (Hwang and Yoon 1981; Romualdas Ginevicius, Valentinas Podvezko, Miroslav Novotny and Arūnas Komka 2012; Valentinas Podvezko 2011; Romualdas Ginevicius and Askoldas Podviezko 2013; Askoldas Podviezko and Valentinas Podvezko 2014) are used for comparing the construction industry in the Baltic states and Poland. The MCDM methods are based on the decision making matrix $R=\|r_{ij}\|$, the statistical data on the criteria used in the investigation (Table 2) and the vector of the criteria significances (weights) $\Omega=(\omega_i)$, where $i=1,2,..., n$; $j=1,2,..., m$; m denotes the number of criteria and n is the number of the compared countries (Willem Karel M. Brauers, Romualdas Ginevicius and Askoldas Podviezko 2014).

In practice, the weights of criteria subjectively determined by experts are commonly used (Thomas L. Saaty 1980; Hwang and Yoon 1981; Dragisa Stanujkic, Darjan Karabasevic, Edmundas Kazimieras Zavadskas 2015; Dovilė Lazauskaitė, Marija Burinskiene, Valentinas Podvezko 2015; Aleksandras Krylovas, Edmundas Kazimieras Zavadskas, Natalija Kosareva and Stanislavas Dadelo 2014; Gudienė et al. 2014).

The subjective weights reflect the opinions and judgements of experts, having long-term experience and profound knowledge in a particular area and, therefore, are widely used in practice. Recognizing the important role of this method in determining the criteria weights, we still would like to emphasize the significance of other methods of effective criteria weights' determination.

In evaluating the criteria weights, it is also possible to assess the structure of the data and to determine the real level of the criterion importance (significance), i.e. its objective weight. However, the objective weights are not so often used in practice as the subjective weights (Hwang and Yoon 1981; Qi Cheng 2010; Gang Kou, Yanqun Lu, Yi Peng and Yong Shi 2012; Zuosheng Han and Peide Liu 2011). Combination weighting is based on the integration of subjective and objective weighting (Leonas Ustinovichius, Edmundas Kazimieras Zavadskas and Valentinas Podvezko, 2007; Jian Ma, Zhi-ping Fan and Li-hua Huang 1999; Rasyida Saad, Muhammad Zaini Ahmad, Mohd Syafarudy Abu and Muhammad Sufian Jusoh 2014; Tien-Chin Wang and Hsien-Da Lee 2009).

In the present work, the methods based on entropy and the loss of the criterion impact (significance), as well as generalized objective methods are used for determining the criteria weights.

2.2. The method of entropy

The method of entropy was offered by Claude E. Shannon (1948). The weights of the criteria are determined by this method (Hwang and Yoon 1981) as follows:

1. The values of criteria are normalized by the equation:

$$\tilde{r}_{ij} = \frac{r_{ij}}{\sum_{i=1}^{n} r_{ij}} . \tag{1}$$

2. The entropy level of each criterion is calculated:

$$E_j = (-1/\ln n)\sum_{i=1}^{n} \tilde{r}_{ij} \cdot \ln \tilde{r}_{ij}; \qquad (j=1,2,..., m);\ 0 \le E_j \le 1. \tag{2}$$

3. The extent of variation of each criterion is determined:

$$d_j = 1 - E_j. \tag{3}$$

4. The normalized d_j values are taken for the weights obtained by the entropy method:

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} . \tag{4}$$

The method of entropy assesses the structure of the data array. The weights obtained by using this method reflect the structure of the data (i.e. the elements of the decision making matrix) and their inhomogeneity. The weight of homogeneous data (with the values of the criteria differing considerably), which is obtained by the entropy method (4), is about zero and does not have a strong influence on evaluation.

The weights of the criteria obtained by applying the entropy method do not depend on the criterion measuring units because normalized units are used in the evaluation. In this case, the criterion weight is associated with the dominance (significance) degree of a single criterion value. The largest weight of the criterion obtained by using the entropy method corresponds to the criterion with the highest weight ratio.

2.3. The method of the criterion impact loss (CILOS)

Another promising method of determining the objective weights (by the group work) based on the criterion impact loss (CILOS) is offered in (Boris G. Mirkin 1974; Edmundas Kazimieras Zavadskas and Valentinas Podvezko 2016). In this work, the impact loss of each criterion, when one of the considered criteria obtains an optimal, the largest or the smallest value, is evaluated. The logic and basic ideas behind this method, as well as its stages and the calculation algorithm, are described below.

First, the minimized criterion values are maximized so that the largest criterion value is optimal (the best), when, for example, the following expression is used:

$$\bar{r}_{ij} = \frac{\min_i r_{ij}}{r_{ij}}. \tag{5}$$

Maximized values of the criteria are not changed. Let a new matrix be $\mathbf{X} = \|x_{ij}\|$. The largest values of each criterion in the matrix, i.e. the largest values of each column, are calculated:

$x_j = \max_i x_{ij} = x_{k_j j}$, where k_j is the number of the row with the largest element for the j-th column.

The square matrix $\mathbf{A} = \|a_{ij}\|$ is constructed of the k_j-th rows' values, $x_{k_j j}$, of the matrix **X**, corresponding to the maximum of the j-th criterion: $a_{jj} = x_j$, $a_{ij} = x_{k_j j}$ (i,j = 1,2,...,m; m denotes the number of criteria), which means that the largest values of all the criteria can be found in the main diagonal of the matrix. The i-th row of the matrix **A** represents the elements of the row k_i of the matrix **X**. It should be noted that the matrix **A** can have the same rows as the matrix **X** because, when the largest values of various criteria are found in the same row, they belong to one alternative.

The matrix $\mathbf{P} = \|p_{ij}\|$ of the relative loss of the criterion significance is formed as follows:

$$p_{ij} = \frac{x_j - a_{ij}}{x_j} \quad (p_{ii} = 0) \ (i,j = 1,2,...,m). \tag{6}$$

The above matrix shows how much of the significance should be lost by each criterion of the alternative for it to be evaluated the best based on all the criteria (the optimum according to the Pareto principle). The elements p_{ij} of matrix **P** show how much the significance of the j-th criterion of the alternative decreased, when the i-th criterion was chosen to be the best.

The weights $q = (q_1, q_2, \ldots, q_m)$ can be found from the system of equations:

$$\mathbf{Fq} = 0, \tag{7}$$

where the matrix **F** is as follows:

$$\mathbf{F} = \begin{pmatrix} -\sum_{i=1}^{m} p_{i1} & p_{12} & \cdots & p_{1m} \\ p_{21} & -\sum_{i=1}^{m} p_{i2} & \cdots & p_{2m} \\ & \cdots & & \\ p_{m1} & p_{m2} & \cdots & -\sum_{i=1}^{m} p_{im} \end{pmatrix}. \quad (8)$$

The method based on the criterion impact loss (CILOS) offsets the drawbacks of the entropy method. Thus, when the values of a criterion do not considerably differ, the elements p_{ij} of the matrix **P** of the relative loss of the criterion significance (6) approach zero, while the respective criterion weight increases and has a strong influence on the evaluation. In the case of homogeneity, when the values of one of the criteria are the same in all the alternatives, all relative losses of the criterion, as well as its total loss, are equal to zero. Therefore, the linear system of equations (7) has no sense because one column of the elements in the matrix **P** is equal to zero.

2.4 The method of integrated Determination of Objective Criteria Weights (IDOCRIW)

The idea of integrating various weights into a general weight (Hwang and Yoon 1981; Ustinovichius *et al*. 2007; Ma *et al*. 1999; Saad *et al*. 2014) allows us to combine the weights W_j obtained by the method of entropy with the subjective weights. Edmundas Kazimieras Zavadskas and Valentinas Podvezko 2016 combined the best features of the entropy method and the CILOS (q_j) weights approach to obtain a new method – the Integrated Determination of Objective Criteria Weights (IDOCRIW):

$$\omega_j = \frac{q_j Wj}{\sum_{j=1}^{m} q_j Wj} \quad . \quad (9)$$

These weights emphasize the entropy of the values of particular criteria, however, the significance (influence) of these criteria decreases due to their higher losses compared to those of other criteria.

The next step is to combine the weights calculated by the entropy method with those calculated by the criterion impact loss approach (aimed at obtaining the integrated weights) and to use them for multiple criteria evaluation, as well as ranking of the alternatives and determining the best of them.

3. Empirical Results and Analysis

3.1 Data Description

The quantitative evaluation of the construction sectors in the Baltic states and Poland is based on the criteria describing the state of the construction industry in each particular country and the use of multicriteria evaluation methods. A set of criteria should include those, which describe the most important dimensions of the sectorial progress (Table 2).

Table 2 The criteria describing the construction industry in the Baltic States and Poland, (Eurostat data 2007, 2009, 2013)

	X_1	X_2	X_3	X_4
	Labour input in construction – annual data (2010=100)	Construction cost, new residential buildings – annual data (2010=100)	Production in construction – annual data (2010=100)	Building permits – annual data (2010=100)
Optimization	*max*	*min*	*max*	*max*
2007				
Estonia	144,97	108.37	179.77	344.94
Latvia	196.97	107.87	207.66	503.57
Lithuania	143.15	112.18	201.29	231.36
Poland	91.06	93.37	84.19	143.54
2009				
Estonia	122.31	102.68	109.50	80.75
Latvia	123.06	108.01	130.95	117.43
Lithuania	121.53	105.0	108.37	90.78
Poland	98.71	100.01	96.07	102.02
2013				
Estonia	112.66	113.31	149.76	118.23
Latvia	132.54	110.02	138.51	151.11
Lithuania	105.20	111.78	127.73	143.48
Poland	101.79	99.90	98.65	79.68

Table 2 introduces the statistical indicators for describing the construction sectors of countries, which show the decrease/increase in particular dimensions in the years 2007, 2009 and 2013.

In the considered case, the major selected dimensions were as follows:

- Labour input indicators: the number of persons employed, the hours worked, gross wages and salaries;
- Construction costs or prices: construction costs, material costs, labour costs (if not available, they may be approximated by the output price variable);
- Production (volume): the total of the construction sector, building construction, civil engineering;
- Building permits indicators: the number of dwellings, square meters of useful floor (or the alternative measure).

3.2. Calculation of the objective weights and their use for comparing the Baltic states and Poland

The described theoretical and methodological principles were implemented in the comparative analysis of the considered indicators of the Baltic states and Poland in 2007, 2009 and 2013. The objective weights were calculated by three various methods. In Table 2, the statistical data on the market conditions for the construction sector in 2007, 2009 and 2013 are presented. To determine the criteria weights by the entropy method, the criteria values were normalized, i.e. transformed into non-dimensional quantities (Table 3, 2007). The values for 2009 and 2013 were also normalized in a similar way.

Table 3 The normalized values of the criteria (the data for 2007)

Alternatives	X_1	X_2	X_3	X_4
Estonia	0.2516	0.2569	0.2672	0.2819
Latvia	0.3419	0.2557	0.3086	0.4116
Lithuania	0.2485	0.2660	0.2991	0.1891
Poland	0.1580	0.2214	0.1251	0.1173

It could be predicted that the criterion X_4 would get the largest weight (if the weights were determined by the entropy method) because the ratio of its largest value to its smallest value was the highest (reaching 3.5). The second largest weight would be that of the criterion X_3 (with the ratio of 2.5), etc.

The method of the criterion impact loss does not require data normalization.

The matrix of the criterion impact loss values calculated by equations (5)-(8) is as follows:

$$\mathbf{F} = \begin{pmatrix} -0.5377 & 0.1344 & 0.0000 & 0.0000 \\ 0.5337 & -0.4033 & 0.5946 & 0.7150 \\ 0.0000 & 0.1334 & -0.5946 & 0.0000 \\ 0.0000 & 0.1334 & 0.0000 & -0.7150 \end{pmatrix}.$$

The values of the criteria weights obtained by using the method of the criterion impact loss depend on the total loss of the criterion dominance (the elements in the main diagonal with the minus). The losses of the significance of individual criteria also have some particular influence on the values of the criteria weights.

It could be predicted that the criterion X_2 would get the largest weight if the weights were determined by this method because the total loss of the criterion significance was the lowest (0.4033), while the losses of the significance of individual criteria were also small (0.1334). It could be expected that the second largest weight would be that of the first criterion X_1, etc.

The weights of the criteria obtained by using the entropy method and the method based on the criterion impact loss, as well as the aggregate weights of the criteria, are given in Table 4.

Table 4 The weights of the criteria determined by the entropy and CILOS and IDOCRIW methods for 2007

Criterion	X_1	X_2	X_3	X_4
Weights obtained by the entropy method				
Weights	0.1877	0.0128	0.2700	0.5294
Rank	3	4	2	1
Weights obtained by CILOS method				
Weights	0.1502	0.6009	0.1359	0.1130
Rank	2	1	3	4
Aggregate IDOCRIW weights				
Weights	0.2129	0.0582	0.2771	0.4517
Rank	3	4	2	1

The calculations show that the criteria weights calculated by the method of the criterion impact loss compensate for the criteria weights obtained by the entropy method. The aggregate weights are the weights obtained by using two methods, which are integrated into the objective weight for evaluating the data array. In this case, a drawback of one method is offset by the advantages of another method.

In a similar way, the methods of entropy and criterion impact loss were used for calculating the criteria weights and their aggregate weights for the year 2009 (Table 5).

The matrix of the criterion significance loss calculated for 2009 by Eqs. (5)-(8) is as follows:

$$\mathbf{F} = \begin{pmatrix} -0.1979 & 0.0741 & 0.0000 & 0.0000 \\ 0.1979 & -0.2222 & 0.2664 & 0.1312 \\ 0.0000 & 0.0741 & -0.2664 & 0.0000 \\ 0.0000 & 0.0741 & 0.0000 & -1.1312 \end{pmatrix}.$$

Table 5 The weights of the criteria determined by the entropy, CILOS and IDOCRIW methods for 2009

Criterion	X_1	X_2	X_3	X_4
Weights obtained by the entropy method				
Weights	0.1969	0.0197	0.3081	0.4753
Rank	3	4	2	1
Weights obtained by CILOS method				
Weights	0.1689	0.4511	0.1254	0.2546
Rank	3	1	4	2
Aggregate IDOCRIW weights				
Weights	0.1648	0.0441	0.1914	0.5996
Rank	3	4	2	1

The matrix of the criterion significance loss calculated for 2013 by Eqs. (5)-(8) is as follows:

$$\mathbf{F} = \begin{pmatrix} -0.3820 & 0.0920 & 0.0751 & 0.0000 \\ 0.2320 & -0.3023 & 0.3413 & 0.4727 \\ 0.1500 & 0.1183 & -0.4915 & 0.2176 \\ 0.0000 & 0.0920 & 0.0751 & -0.6903 \end{pmatrix}.$$

Similar results can be observed for the criteria weights calculated for 2013 (Table 6).

Table 6 The weights of the criteria determined by the methods of entropy, CILOS and IDOCRIW methods for 2013

Criterion	X_1	X_2	X_3	X_4
Weights obtained by the entropy method				
Weights	0.1200	0.0261	0.2504	0.6035
Rank	3	4	2	1
Weights obtained by CILOS method				
Weights	0.1682	0.5207	0.2179	0.0931
Rank	3	1	2	4
Aggregate IDOCRIW weights				
Weights	0.1396	0.0942	0.3775	0.3887
Rank	3	4	2	1

Summing up, it can be stated that the criteria weights obtained by using the method of the criteria impact loss differ from those determined by the entropy method. However, these methods supplement each other. The aggregate weights demonstrated the advantages of both methods and were later used in the work for ranking the considered countries, which were arranged in the following preference order for the period of three years: X_4, building permits, X_3, production in construction, X_1, labour input in construction, X_2, construction cost of new residential buildings.

3.3 The evaluation of construction market effectiveness

The problem of evaluating market conditions for the development of the construction industries in four neighbouring countries, including Estonia, Latvia, Lithuania and Poland, has been solved, using the model offered by the authors. The solution of the considered problem is required to perform the analysis of the construction market and compare various countries based on its effectiveness. The dynamic information of the formulated problem allows the researchers, analysing the market trends, to compare various states in various periods of time.

The analysis of the obtained data (Table 7) allowed us to observe that the calculation results yielded by COPRAS and SAW methods were, actually, the same. The matching of the results can be accounted for by the sensitivity of COPRAS and SAW methods to optimization in the presence of a single minimized criterion.

Table 7 The ranking of the states based on the theory of aggregating weights and on using various MCDM methods

Method	**Estonia**	**Latvia**	**Lithuania**	**Poland**
	2007			
TOPSIS	0.5810	0.9856	0.3816	0.0186
Rank	2	1	3	4
COPRAS- SAW	0.2690	0.3584	0.2348	0.1377
Rank	2	1	3	4
Total rank	2	1	3	4
2009				
TOPSIS	0.1521	0.9857	0.3021	0.5266
Rank	4	1	3	2
COPRAS- SAW	0.2454	0.2906	0.2398	0.2442
Rank	2	1	4	3
Total rank	3	1	4	2
2013				
TOPSIS	0.6451	0.8815	0.7362	0.0415
Rank	3	1	2	4
COPRAS- SAW	0.2605	0.2850	0.2623	0.1922
Rank	3	1	2	4
Total rank	3	1	2	4

The analysis of the ranks determined based on the selected criteria has shown that, in 2007, when the threat of the economic crisis became real, the best market conditions for construction were found in Latvia and Estonia, while Poland demonstrated the worst situation in this area and Lithuania was the third in the rating (Table 7). This may be explained by the fact that housing construction began to increase in Lithuania and Estonia in 2002, while, in Latvia, this could be observed only two years later. However, the growth of housing construction in that country was more rapid than that in the neighbouring states (for example, the rate of construction there had been increasing by about 44% each year in the period until 2008). In 2007, in all the states except Poland, a boom in housing construction was recorded, while Latvia became an absolute leader (with 1188 m^2 of floor area put into service in that period) and the rate of construction in this country exceeded that of Lithuania by 25%. Thus, in 2007, 0,52 m^2 of floor area (per 1000 inhabitants) was put into service in Latvia, 0,42 m^2 – in Estonia and 0,28 m^2 – in Lithuania. The differences observed could be accounted for by different starting positions and economic levels of these countries, as well as by their different crediting policies. Estonia was the first Baltic state, where the crisis could be observed, and, as early as 2008, the rate of construction in this country decreased by 19%. Then, the crisis approached Latvia, though people in the construction industry could not believe it until the end of 2007. They stubbornly kept the prices high and even started new housing construction projects. Therefore, the rate of construction in this country in 2008 remained the same as the construction rate registered there in 2007. Lithuania was the last of the Baltic states to face the crisis, while Poland was the only country of the European Union (EU), where a slight economic growth was recorded in this period.

In 2009, during the economic crisis, when the construction market in the Baltic states was out of balance, these countries were ranked in the following way according to the situation on this market: Latvia was the first, Poland – the second, Estonia – the third and Lithuania – the fourth (Table 7). In the real estate sector, Lithuania suffered most of the Baltic states. The economic activity both in the construction and real estate sectors declined, and their total weight in the economy of the country, which reached 18% in 2008, decreased to 12% in 2012. In Latvia, the construction sector suffered most severely (its productivity dropped from 10% to 6%), however, more operations with real estate were recorded in this period. This allowed Latvia to gain a higher position in the area of the construction sector activities. The economy of Poland retained its stability at that time because this country, in general, is less open than other considered states. Therefore, the construction market in Poland also remained stable.

In 2013, when negative effects of the crisis weakened and the construction market began to expand in the Baltic states, Latvia still preserved the first place according to the obtained results. Lithuania was ranked the second, Estonia – the third and Poland – the fourth (Table 7). A higher position of Lithuania can be related to better conditions for doing business. According to the data provided in the World Bank report, 'Doing Business 2014', Lithuania jumped 10 positions to the 17th place (from the 27th place) and, in terms of the competitiveness index, outperformed more than half of its competitors, including not only its well-known rivals (Estonia and Latvia), but many other EU member-states as well. In the period of 2012-2014, the investments' market became more active in Lithuania, while the number of commercial real estate investment operations increased considerably and left behind the neighbouring states (Estonia and Latvia) in this area. As the comparative analysis shows, all the criteria used for evaluating the performance of the construction sector in four investigated states in 2013 had the lowest values in Poland. This can be accounted for by the growing insolvency of Polish construction firms, which, in 2011, increased by about 20%, then, by 46%, and, finally, reached 52% in 2012. The years 2011-2013 were very hard times for the construction industry in Poland. The main factors, determining ineffective performance of the construction sector in this country may be briefly described as decreasing investments to the infrastructure by the Polish government, as well as severe competition and decreasing profit margins due to the increased cost of raw materials.

4. Conclusions

The methods offered for determining the criteria, which can be used for evaluating the performance of the construction market allowed us to compare the construction markets of various countries, to analyse their potential for expanding business and to effectively manage the cash flows of an enterprise. The suggested solution model and a number of other methods used in the research yielded the reliable results because their validity has been proved by simultaneous application of three methods to criteria weights' determination. They included the Chands entropy method, the criterion impact loss (CILOS) method and the approach based on integrated determination of objective criteria weights (IDOCRIW). To arrange the investigated countries in the order of preference (i.e. to perform their ranking) from the perspective of the construction market performance, the well-known MCDM methods (SAW, TOPSIS, COPRAS), which are widely discussed in the literature on the problem, were used.

The analysis of indicators of the construction sector performance in the considered countries allowed us to assess its effectiveness with respect to that of other countries. The investigation results demonstrated negative effects of the crisis, which took place in 2009-2010 and caused the decrease in construction sectors' production, as well as the demand for their products. As a result, the productivity of construction enterprises had also decreased considerably. These harmful effects were stronger in the real estate sectors in Lithuania and Estonia. Estonia was the first Baltic state, which experienced the crisis. Then, the crisis came to Latvia. The specific geographical position, as well as a poorly developed market and the lack of experience in international marketing, did not allow the Baltic states to attract the investments from other countries. Therefore, new crediting lines that appeared at that time became the only source of increasing their economic growth. A different rate of the construction efficiency growth in these countries determined different initial conditions for their economic development, as well as the achieved economic level and the pursued crediting policies. Based on the results obtained in the analysis of the construction market, it can be concluded that, compared to the previous years, more favourable conditions for construction development in all Baltic states, and, particularly, in Latvia and Lithuania, were creased in 2013. It can be attributed to the fact that though their construction sectors were strongly affected by the crisis, these countries managed to achieve the pre-crisis level of construction development in a relatively short time. At the same time, the situation in Poland in the considered area is much worse. This is shown by the analysis of the Polish construction sector's performance indicators for 2007 (before the crisis) and for 2013 (after the crisis), which appeared to be the worst among those, showing the construction sector's efficiency in all investigated countries.

The case study presented in the paper has shown that the model suggested for evaluating the available alternatives can be effectively used for planning the work of construction enterprises in stages according to the suggested algorithm and following a methodology for determining the criteria weights (significances) and selecting multiple criteria evaluation methods. The main result of the research is the ranking of the considered countries (the Baltic states and Poland), which was performed based on the analysis of the effectiveness of their construction industry performance, and using the suggested model.

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