COMPARATIVE ANALYSIS OF CALCULATION ALGORITHMS USED IN THE PUBLIC PROCUREMENT PROCEDURES

PhD Student **Ionel PREDA**
The Bucharest University of Economic Studies, Romania
predaionel4@gmail.com

Abstract:

In public procurement, knowing the types of calculation algorithms and choosing the right algorithm to establish the scores of the submitted tenders have a very important role. The wrong choice of the calculation algorithm may lead to deficiencies such as obtaining identical scores for different tenders received, or ignoring the actual benefits of a tender due to the inappropriate way of calculating the scores.

The calculation algorithm must be set so as to objectively quantify the advantages which the contracting authority seeks to achieve by carrying out the procurement procedure.

The article describes the main types of calculation algorithms used in public procurement procedures, a comparative analysis of the results of algorithms applied in case of a real bid and the advantages / disadvantages of using each type of algorithm analysed.

Key words: public procurement, procurement procedure, award criterion, weighting factor, calculation algorithm, score

JEL classification: C00, D44, H57, H83

1. INTRODUCTION

The activity of establishing the award criterion means choosing the "most economically advantageous tender", so that a contracting authority can select a tender according to what it believes to be the best solution.

The forms of award criteria, according to Romanian Law no. 98/2016 on public procurement, are:

- the best quality - cost ratio;
- the best quality-price ratio;
- the lowest cost;
- the lowest price.

Thai et al., (2009) considers that the development of evaluation criteria should consider many factors, including the skill of the user agency to define the demand in a concise and clear manner, meaningful evaluation criteria, the nature of the specific demand and the organizational environment or culture of the user agency. The evaluation team should develop an evaluation plan. The reason of this plan is to identify the following:

- evaluation criteria;
- the weighting factors;
- scoring method;
- contractor selection methodology that will be utilised to determine which tender best satisfy the demand (Thai et al., 2009).

For the vast majority of public authorities price is not sufficient to determine the best offer. In fact, there are other important aspects to be considered, usually features of the item or additional related services that enhance the general quality of the supply. If the suply is more complex, the more non-price characteristics become very important in the offer evaluation procedure. In contrast, the lowest-price procedure is adequate for procurement of goods where price is the only important factor (energy procurement, office equipment and food) (Dimitri et al., 2006).

Thai et al., (2009) enumerated some examples of rated criteria such as: after sales service or warranty, firm's experience with comparable projects, past performance record, demonstration of expertise, quality assurance approach, qualifications of management team, understanding of the

project objectives and scope, proposed risk management approach, reporting arrangements (Thai et al., 2009).

Dimitri et al., (2006) finds that the assessment factors and the way in which scores are set differ from one country to another. The authors consider that two of the most representative formulas adopted are the following:

- formula usually utilised by CONSIP - Italy (Concessionaria Servizi Informativi Pubblici):

$$T = PE + PT \quad (1)$$

$$\text{and } PE = n\frac{(Pb-Po)}{(Pb-Ps)} \quad (2)$$

where PT = technical points, PE = economic points (obtained in relation to the offered price), n = maximum economic points available, Pb = reserve price, Po = price offered, Ps = threshold price (price that confers the maximum number of points);

- formula usually utilised by PPD - Cyprus (Public Procurement Directorate):

$$\text{Total score} = \frac{\text{TPx}}{\text{TPmax}} + \frac{\text{Minimum price}}{\text{Px}} \quad (3)$$

where TPmax = technical points of the best technical offer, TPx = technical points of bidder x, Px = price offered by bidder x, Minimum price = lowest price offered (Dimitri et al, 2006).

The article presents in Chapter 2 the main formulas for calculating scores and the graphical representation of the most important of these formulas and in Chapter 3 is carried out a comparative analysis of the results of the ratios in the formulas used to establish economic scores utilizing offered prices obtained in a real open tender in order to identify the main elements which characterize every calculation formula. The conclusions from Chapter 4 present the advantages of examined scores and the key differences that were found between the results of analysed ratios.

2. THE MAIN CALCULATION FORMULAS OF THE SCORES

According to Dimitri et al. (2006), the main formulas for calculating scores are of five types:

- linear scoring (Ls);
- parabolic scoring (Ps);
- lowest bid scoring (Lo);
- highest bid scoring (Hs);
- average scoring (As).

Depending on predictability and simplicity the same authors classify the scoring rules in two categories.

- simple scoring rules, when the score of every bidder depends only on his price bid. At this type of rules the relationship between the price and the score, the MVP are known a priori. This property makes scoring rules simple and predictable. Still, implementation is a possibility only if certain parameters can be pre-defined (such as a reserve price is used). The MVP is the money discount required for a bidder to get one additional point. To this group belong parabolic scoring and linear scoring.

- alternative scoring rules, when the score of every bidder is dependent on other bidder's price offers. In this category, the relationship between the price, the MVP and the score is not known ex-ante. Average bid, highest bid and lowest bid scoring belong to this category. These scoring rules are sensible to the bid distribution. Within this category, the decision to accept or to reject abnormally low tenders will influence the score obtained by all bidders and certainly will change the ranking (Dimitri et al., 2006).

Linear Scoring (Ls) is a very simple way to convert price bids into a score, according to the following expression:

$$\text{Price score} = nn\left[\frac{\text{Reserve price} - \text{Price bid}}{\text{Reserve price} - \text{Price threshold}}\right] \quad (4)$$

where 'nn' is the highest number of points (usually out of 100) available to bidders for price offers. The remaining (100 - 'nn') points can be obtain according to the technical aspects. The bidder will get no points if the price offered is above the reserve price. The price threshold is a lower limit: the bidder cannot increase his score with additional price reductions. If there is no price threshold, the public authority awards the maximum score 'nn' only if the product is given for free (Dimitri et al., 2006).

The monetary value of a point (MVP) is obtained directly from the following formula:

$$MVP = \frac{[\text{Reserve price} - \text{Price threshold}]}{nn} \quad (5)$$

Figure no. 1 presents the shape of two linear scoring rules, one with price threshold equal to 50 percent of the reserve price and another one without price threshold. In this illustration, the reserve price is 1,000 euro, with 70 points are attached to price and 30 points are attached to technical aspects. The inclusion of a threshold lowers the MVP and increases the slope of scoring rule. The slope measures how the score improves as price decreases. The slope shows the incentive for tenderers to bid on price. A lower MVP, means a higher incentive for the participants to bid on price (Dimitri et al., 2006).

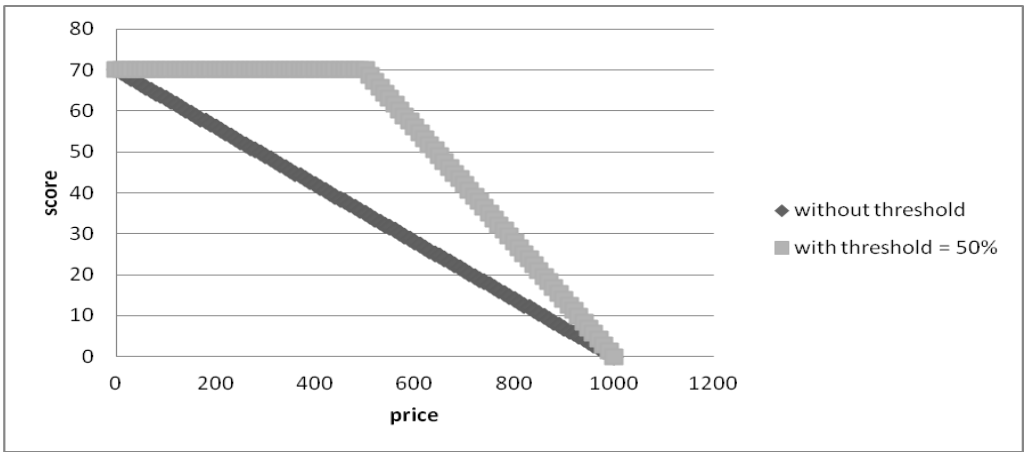

Figure no. 1. Linear scoring: the role of the price threshold

Source: Dimitri, N. et al., (2006)

Dimitri et al., (2006) considered that the **parabolic scoring (Ps)** is as an extension of linear scoring. The authors have noticed that with further price reductions, the score increases but at decreasing rates. When the price threshold is equal to zero, parabolic scoring takes the next expression:

$$\text{Price score} = nn\left[1 - \left(\frac{\text{Price bid}}{\text{Reserve price}}\right)^2\right] \quad (6)$$

An example of parabolic scoring is shown in Figure no. 2. The price threshold is equal to 70% of the reserve price. The figure shows that there are no stimulants to reduce bids below 30 euro, as under linear scoring with the similar threshold. Nevertheless, stimulants are already low for bids below 50 euro, therefore making additional discounts less likely to occur (Dimitri et al., 2006).

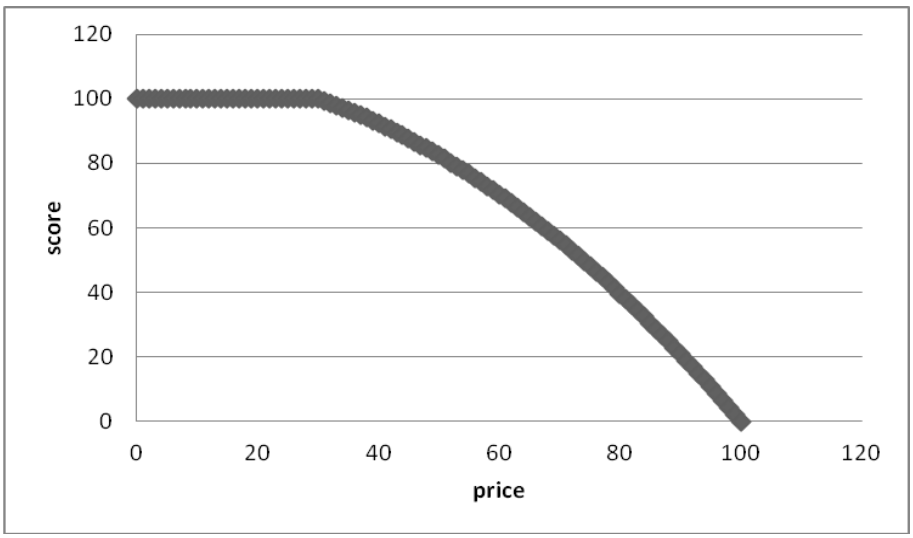

Figure no. 2. Parabolic scoring
Source: Dimitri, N. et al., (2006)

According to Dimitri et al., (2006), **lowest bid scoring (Lo)** has the following formula:

$$\text{Price score} = nn\left(\frac{\text{Lowest bid}}{\text{Price bid}}\right) \quad (7)$$

Another formula for the lowest bid scoring was established by Pauw and Wolvaardt, (2009):

$$\text{Ps} = 90\left[1 - \frac{Pt - Pmin}{Pmin}\right] \quad (8)$$

where

Ps = points obtained for price of tender under evaluation;
Pmin = lowest price;
Pt = price of tender under evaluation;
90 = highest number of points available to bidders for price offers.

A similar formula for the lowest bid scoring was used by Vidal and Sanchez-Pantoja, (2019) in the case of green public procurement:

$$\text{P} = 100 - \left(\frac{Pt - Pmin}{Pmin}\right) \cdot 100 \quad (9)$$

where

P = points obtained for price of tender under evaluation;
Pt = price of tender under evaluation;
Pmin = lowest price.

According to Dimitri et al., (2006), **highest bid scoring (Hs)** has the following formula:

$$\text{Price score} = nn\frac{(\text{Highest bid} - \text{Price bid})}{(\text{Highest bid} - \text{Lowest bid})} \quad (10)$$

Lunander and Andersson, (2004) studied public procurement from Sweden, mostly from the early 2000s, and they identified the following formula of the highest bid scoring:

$$\text{Si} = \text{S}_{\max} - \text{S}_{\max}\frac{(\text{P}_i - \text{P}_{\text{lowest}})}{(\text{P}_{\text{highest}} - \text{P}_{\text{lowest}})} \quad (11)$$

where

P_i = price of the bid under evaluation;
$P_{highest}$ = price of the maximum submitted bid;
P_{lowest} = price of the lowest submitted bid;

S_{max} = highest number of points available.

According to Dimitri et al., (2006), **average scoring (As)** has the following formula:

If bid < Average bid, then Price score = n

otherwise:

$$\text{Price score} = nn\frac{(\text{Highest bid} - \text{Price bid})}{(\text{Highest bid} - \text{Average bid})} \quad (12)$$

3. COMPARATIVE ANALYSIS OF THE CALCULATION ALGORITHMS USED IN A REAL BID

Following the presentation of the above calculation formulas, it is necessary to identify the main elements that characterize each formula option using the data obtained in a real bid.

For the comparative analysis of the results of the ratios in the formulas, we will use the data obtained in the open tender with the final stage of the electronic bid having as object the delivery of 28 pieces of interurban buses (award notice published in the Electronic System for Public Procurement (SEAP) under no. 169498 of 25.05.2016), to which 5 tenderers submitted the tender and where the award criterion used was the lowest price criterion (Table no. 1).

Table no. 1. The data on the open bid with the final stage of electronic bid having as object the provision of interurban buses

Award notice no. 169498 of 25.05.2016: open tender having as object the provision of 28 interurban buses						
Estimated unit price: 191,035.20.00 Euro without VAT/piece						
No.	**Name of economic operator tenderer**	**Make and type of tendered product**	**Tendered price before electronic bid (euro, excluding VAT / piece)**	**Position in the ranking before the electronic bid**	**Tendered price after the electronic bid (euro, excluding VAT / piece)**	**Position in the ranking after the electronic bid**
1	Briaris Ind	Iveco Bus Crossway	180,000.00	1	133,500.00	1
2	Iveco Truck Sevices	Iveco Crossway Pro	191,000.00	3	150,000.00	2
3	Mercedes-Benz Romania	Mercedes-Benz Intouro	191,029.60	4	174,752.00	3
4	Solaris Bus & Coach	Solaris Interubino	190,500.00	2	175,000.00	4
5	MHS Truck & Bus	Man Lions Regio	191,000.00	3	191,000.00	5

Source: Electronic Public Procurement System (SEAP) in Romania

A. Lowest bid ratio (1) (Dimitri et al., 2006):

$$\frac{\text{Lowest bid}}{\text{Price bid}} \quad (13)$$

The results of the application of the lowest bid ratio (1) are presented in Table no. 2.

Table no. 2. The results of the application of the lowest bid ratio (1)

No.	Name of economic operator tenderer	Tendered price before electronic bid (euro, excluding VAT / piece)	Ratio before the electronic bid	Position in the ranking before the electronic bid	Tendered price after the electronic bid (euro, excluding VAT / piece)	Ratio after the electronic bid	Position in the ranking after the electronic bid
1	Briaris Ind	180,000.00	1.0000	1	133,500.00	1.0000	1
2	Iveco Truck Sevices	191,000.00	0.9424	3	150,000.00	0.8900	2
3	Mercedes-Benz Romania	191,029.60	0.9423	4	174,752.00	0.7639	3
4	Solaris Bus & Coach	190,500.00	0.9449	2	175,000.00	0.7629	4
5	MHS Truck & Bus	191,000.00	0.9424	3	191,000.00	0.6990	5

B. Lowest bid ratio (2) (Pauw and Wolvaardt, 2009) and (Vidal and Sanchez-Pantoja, 2019):

$$1 - \frac{\text{Price bid} - \text{Lowest bid}}{\text{Lowest bid}} \quad (14)$$

The results of the application of the lowest bid ratio (2) are presented in Table no. 3.

Table no. 3. The results of the application of the lowest bid ratio (2)

No.	Name of economic operator tenderer	Tendered price before electronic bid (euro, excluding VAT / piece)	Ratio before the electronic bid	Position in the ranking before the electronic bid	Tendered price after the electronic bid (euro, excluding VAT / piece)	Ratio after the electronic bid	Position in the ranking after the electronic bid
1	Briaris Ind	180,000.00	1.0000	1	133,500.00	1.0000	1
2	Iveco Truck Sevices	191,000.00	0.9389	3	150,000.00	0.8764	2
3	Mercedes-Benz Romania	191,029.60	0.9387	4	174,752.00	0.6910	3
4	Solaris Bus & Coach	190,500.00	0.9417	2	175,000.00	0.6891	4
5	MHS Truck & Bus	191,000.00	0.9389	3	191,000.00	0.5693	5

C. Linear ratio (Dimitri et al., 2006):

$$\frac{\text{Reserve price} - \text{Price bid}}{\text{Reserve price} - \text{Price threshold}} \quad (15)$$

The results of the application of the linear ratio are presented in Table no. 4.
The price threshold is 100,000 euro, and the reserve price is 200,000 euro.

Table no. 4. The results of the application of the linear ratio

No.	Name of economic operator tenderer	Tendered price before electronic bid (euro, excluding VAT / piece)	Ratio before the electronic bid	Position in the ranking before the electronic bid	Tendered price after the electronic bid (euro, excluding VAT / piece)	Ratio after the electronic bid	Position in the ranking after the electronic bid
1	Briaris Ind	180,000.00	0.2000	1	133,500.00	0.6650	1
2	Iveco Truck Sevices	191,000.00	0.0900	3	150,000.00	0.5000	2
3	Mercedes-Benz Romania	191,029.60	0.0897	4	174,752.00	0.2525	3
4	Solaris Bus & Coach	190,500.00	0.0950	2	175,000.00	0.2500	4
5	MHS Truck & Bus	191,000.00	0.0900	3	191,000.00	0.0900	5

D. Parabolic ratio (Dimitri et al., 2006):

$$1-\left(\frac{\text{Price bid}}{\text{Reserve price}}\right)^2 \quad (16)$$

The results of the application of the parabolic ratio are presented in Table no. 5.
The reserve price is 200,000 euro.

Table no. 5. The results of the application of the parabolic ratio

No.	Name of economic operator tenderer	Tendered price before electronic bid (euro, excluding VAT / piece)	Ratio before the electronic bid	Position in the ranking before the electronic bid	Tendered price after the electronic bid (euro, excluding VAT / piece)	Ratio after the electronic bid	Position in the ranking after the electronic bid
1	Briaris Ind	180,000.00	0.1900	1	133,500.00	0.5544	1
2	Iveco Truck Sevices	191,000.00	0.0880	3	150,000.00	0.4375	2
3	Mercedes-Benz Romania	191,029.60	0.0877	4	174,752.00	0.2365	3
4	Solaris Bus & Coach	190,500.00	0.0927	2	175,000.00	0.2344	4
5	MHS Truck & Bus	191,000.00	0.0880	3	191,000.00	0.0880	5

E. Highest bid ratio (Dimitri et al., 2006):

$$\frac{(\text{Highest bid}-\text{Price bid})}{(\text{Highest bid}-\text{Lowest bid})} \quad (17)$$

which is identical with the ratio utilised by Lunander and Andersson, (2004):

$$1-\frac{(\text{Price bid}-\text{Lowest bid})}{(\text{Highest bid}-\text{Lowest bid})} \quad (18)$$

The results of the application of the highest bid ratio are presented in Table no. 6.

Table no. 6. The results of the application of the highest bid ratio

No.	Name of economic operator tenderer	Tendered price before electronic bid (euro, excluding VAT / piece)	Ratio before the electronic bid	Position in the ranking before the electronic bid	Tendered price after the electronic bid (euro, excluding VAT / piece)	Ratio after the electronic bid	Position in the ranking after the electronic bid
1	Briaris Ind	180,000.00	1.0000	1	133,500.00	1.0000	1
2	Iveco Truck Sevices	191,000.00	0.0027	3	150,000.00	0.7130	2
3	Mercedes-Benz Romania	191,029.60	0.0000	4	174,752.00	0.2826	3
4	Solaris Bus & Coach	190,500.00	0.0480	2	175,000.00	0.2783	4
5	MHS Truck & Bus	191,000.00	0.0027	3	191,000.00	0.0000	5

F. Average ratio (Dimitri et al., 2006):

$$\frac{(\text{Highest bid} - \text{Price bid})}{(\text{Highest bid} - \text{Average bid})} \quad (19)$$

The results of the application of the average ratio are presented in Table no. 7.

Table no. 7. The results of the application of the average ratio

No.	Name of economic operator tenderer	Tendered price before electronic bid (euro, excluding VAT / piece)	Ratio before the electronic bid	Position in the ranking before the electronic bid	Tendered price after the electronic bid (euro, excluding VAT / piece)	Ratio after the electronic bid	Position in the ranking after the electronic bid
1	Briaris Ind	180,000.00	4.7466	1	133,500.00	2.1989	1
2	Iveco Truck Sevices	191,000.00	0.0127	3	150,000.00	1.5679	2
3	Mercedes-Benz Romania	191,029.60	0.0000	4	174,752.00	0.6213	3
4	Solaris Bus & Coach	190,500.00	0.2279	2	175,000.00	0.6119	4
5	MHS Truck & Bus	191,000.00	0.0127	3	191,000.00	0.0000	5
-	average price	188,705.92	-	average price	164,850.40	-	-

The comparative situation of the results of the ratios obtained with the formulas presented above before the electronic bid is presented in Table no. 8.

Table no. 8. The comparative situation of the results of the ratios obtained with the formulas presented above before the electronic bid

No.	Name of economic operator tenderer	A. Lowest bid ratio (1) (formula 13)	B. Lowest bid ratio (2) (formula 14)	C. Linear ratio (formula 15)	D. Parabolic ratio (formula 16)	E. Highest bid ratio (formulas 17 and 18)	F. Average ratio (formula 19)
1	Briaris Ind	1.0000	1.0000	0.2000	0.1900	1.0000	4.7466
2	Iveco Truck Sevices	0.9424	0.9389	0.0900	0.0880	0.0027	0.0127
3	Mercedes-Benz Romania	0.9423	0.9387	0.0897	0.0877	0.0000	0.0000
4	Solaris Bus & Coach	0.9449	0.9417	0.0950	0.0927	0.0480	0.2279
5	MHS Truck & Bus	0.9424	0.9389	0.0900	0.0880	0.0027	0.0127

Sources: Based on the data in Tables no. 2, 3, 4, 5, 6 and 7

The graphical representation of the results of the ratios before the electronic bid is presented in Figure no. 3.

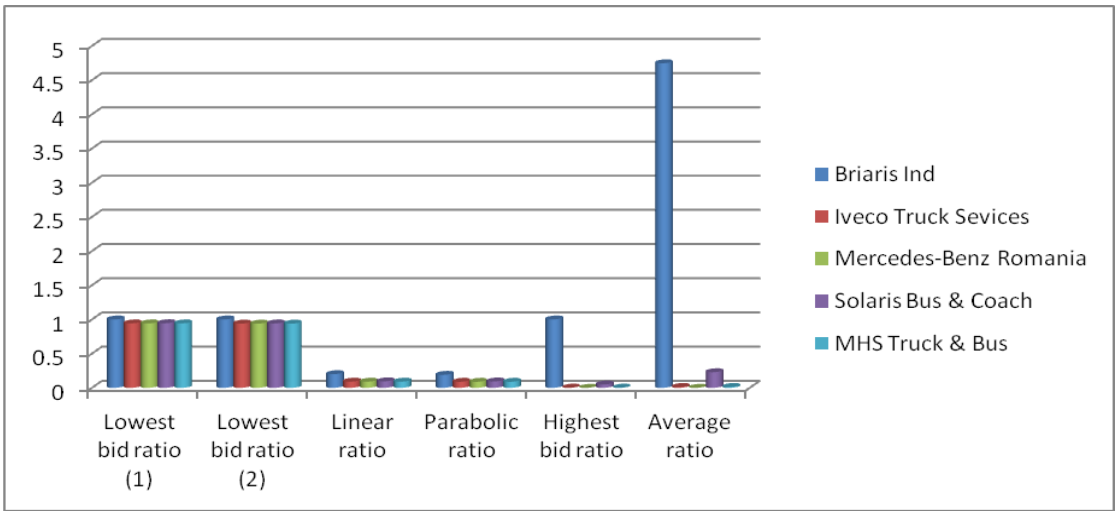

Figure no. 3. The graphical representation of the results of the ratios before the electronic bid

Source: Based on the data in Table no. 8

The comparative situation of the results of the ratios obtained with the formulas presented above after the electronic bid is presented in Table no. 9.

Table no. 9. The comparative situation of the results of the ratios obtained with the formulas presented above after the electronic bid

No.	Name of economic operator tenderer	A. Lowest bid ratio (1) (formula 13)	B. Lowest bid ratio (2) (formula 14)	C. Linear ratio (formula 15)	D. Parabolic ratio (formula 16)	E. Highest bid ratio (formulas 17 and 18)	F. Average ratio (formula 19)
1	Briaris Ind	1.0000	1.0000	0.6650	0.5544	1.0000	2.1989
2	Iveco Truck Sevices	0.8900	0.8764	0.5000	0.4375	0.7130	1.5679
3	Mercedes-Benz Romania	0.7639	0.6910	0.2525	0.2365	0.2826	0.6213
4	Solaris Bus & Coach	0.7629	0.6891	0.2500	0.2344	0.2783	0.6119
5	MHS Truck & Bus	0.6990	0.5693	0.0900	0.0880	0.0000	0.0000

Sources: Based on the data in Tables no. 2, 3, 4, 5, 6 and 7

The graphical representation of the results of the ratios after the electronic bid is shown in Figure no. 4.

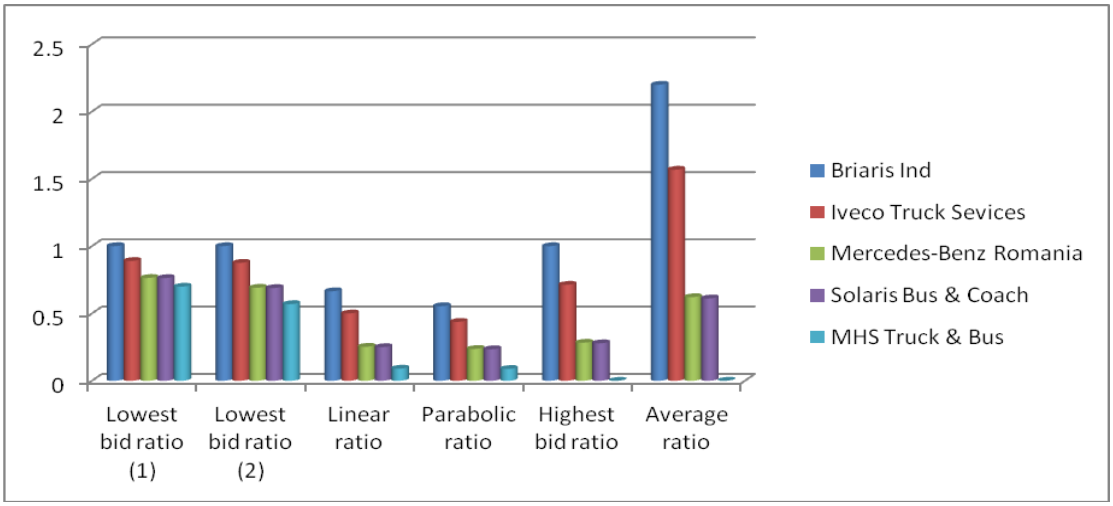

Figure no. 4. The graphical representation of the results of the ratios after the electronic bid

Source: Based on the data in Table no. 9

From the analysis of Figures 3 and 4 it can be noticed that the differences between the values of the 6 ratios after the electronic bid are much higher than the values of the ratios before the electronic bid. This is due to the fact that before the electronic bid, economic operators have offered prices very close or even identical to the estimated price of the procedure (and therefore the estimated value of procurement) because they hoped to be the only tenderers in the procedure and thus not having to reduce the price at the electronic bid, obtaining a maximum profit.

4. CONCLUSIONS

From the analysis of the two comparative situations, the following conclusions can be drawn:

- the tenderers' position in the ranking did not change, namely it was maintained in the same order before and after the electronic bid (in both comparative situations). This conclusion is a factor encouraging the use of the six ratios by the contracting authorities (in award proceedings using the "lowest price" award criterion) because calculation formulas do not distort competition results (performance of tenderers), being declared as winner the lowest price tender;
- for ratios A, B and E (based on the smallest tender, respectively the highest tender) their values are sub-unitary, the winning tenders having the value of 1, which means that by using these ratios the winning tender will get the maximum score and the other tenders will have lower scores than it;
- for ratios C and D (linear and parabolic), the values are strictly sub-unitary, the winning tenders having the highest values, meaning that all tenders, including the winning ones, will obtain scores lower than the maximum score;
- for ratios E and F (based on the highest tender and the average tender) the value of the ratio for the lowest tender is zero, which means that the score obtained by the tenderer with the lowest price tender will be zero;
- for ratio F (based on the average tender), the ratios for certain tenders are higher-unit, with the winning tender showing the higher-unit ratio. This means that these tenders will get scores that will exceed the maximum score that can be granted. For example, if the maximum score you can get is 90 points, then the winning tender after the electronic bid for ratio no. 6 (based on average tender) will score 90 points x 2.1989 = 197.90 points.

Also, from the analysis of the results obtained, it is necessary to use more than two decimals (preferably four) for ratios, since in the case of purchase of products with small unit prices and in which the contracting authority receives tenders with very close values, the ratios with only two decimals will not differentiate tenders exactly.

The Linear Score (L_S) has the advantage of being a score easy to calculate, allowing tenderers to set their own strategies especially for procurement procedures that have a final electronic bid stage. The score obtained by a tenderer does not depend on the tenders received from other economic operators, especially if these tenders are very low.

The parabolic score (Ps) encourages price reductions by tenderers, the score obtained being higher as the price decreases. Thus, the contracting authority can grant a higher weight for the technical score than for the economic score, thus encouraging tenderers to improve the characteristics of the technical tender.

The score based on the lowest tender (Lo) that is calculated for each tender received depends on the lowest price tendered. To get a maximum score, tenderers can choose an aggressive price reduction strategy, increasing their score and lowering the scores of the other tenderers at the same time.

The score based on the highest tender (Hs) depends both on the highest price received and on the lowest price, the maximum score being obtained in the situation of the lowest price tendering and the zero score being obtained at the highest price tendering.

By using the average score (As), the score obtained by a tenderer depends on all the tendered prices, reducing the prices below the average price, which is not reflected in receiving a higher score, as the maximum score is obtained for all tenders that have prices below the average price.

The further research could approach the identification of new calculation formulas and analysis of the correlations between the economic scores and the technical scores which can be offered in calculation algorithms within the same procurement procedure, emphasising the advantages, disadvantages, risks and vulnerabilities which may arise on the use of these algorithms for both contracting authorities and potential bidders.

REFERENCES

1. Bergman, M A., Lunberg, S. (2011), *Tender evaluation and award methodologies in public procurement*, pp. 2 – 32, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.453.9976&rep=rep1&type=pdf, Accesed 29 october 2018
2. Dimitri, N., Piga, G., Spagnolo, G. (2006), *Handbook of procurement*, pp. 28 - 304, Cambridge University Press
3. Lunander, A., Andersson, A. (2004), *Metoder vid utvärdering av pris och kvalitet i offentlig upphandling. En inventering och analys av utvärderingsmodeller inom offentlig upphandling. The Swedish Competiton Authority, Commission Report: 2004:1* (In Swedish) cited in Bergman, M, A. şi Lunberg, S. (2011), *Tender evaluation and award methodologies in public procurement*, pp. 2 – 32, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.453.9976&rep=rep1&type=pdf, Accesed 29 october 2018
4. Parikka-Alhola, K. (2008), *Promoting environmentally sound furniture by greenpublic procurement* cited în Witjes, S., Lozano, R. (2016), *Towards a more circular economy: proposing a framework linking sustainable public procurement and sustainable business models*, p. 3, Elsevier
5. Pauw, J., C., Wolvaardt, J., S. (2009), *Multi-criteria decision analysis in public procurement – a plan from de South*, pp. 16-20, https://core.ac.uk/download/pdf/43166215.pdf, Accesed 29 october 2018

6. Preuss, L. (2009), *Addressing sustainable development through publicprocurement: the case of local government* cited in Witjes, S., Lozano, R. (2016), *Towards a more circular economy: proposing a framework linking sustainable public procurement and sustainable business models*, Elsevier
7. Thai, K. V. (2007), *Introduction to Public Procurement. 2nd edn., Herndon, VA: National Institute of Governmental Purchasing, Inc.* cited in Thai, K. V. et al (2009), *International Handbook of Public Procurement*, p. 13, Taylor & Francis Group
8. Thai, K. V. et al (2009), *International Handbook of Public Procurement,* p.16, Ed. Taylor & Francis Group
9. Vidal, R., Sanchez-Pantoja, N., (2019), *Method based on life cycle assessment and TOPSIS to integrate environmental award criteria into green public procurement*, Sustainable Cities and Society 44 (2019) pp. 465–474, Elsevier