

Modelling the contractor's price offer

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Abstract: The preparation of the offer is a demanding part of the extensive activity of the contract process, which usually begins with the discovery of a job opportunity and ends with closing the contract for the construction of a building or on the contrary, not getting it. To prepare a good offer means, on the one hand, to count in own costs required by the execution of the contract as precisely as possible, on the other hand to correctly estimate the good bid price with the necessary profit and risk amounts included. The key for creating "good" bid prices is an individual approach to calculation of the contractor's own costs and determining the rate of profit according to the contractor's specific needs. For this purpose, the contractor should have its own database of company prices, the creation of which requires a long-term and intensive collection of price information that is often absent. How it is then possible to bid if the contractor does not have a complete company database of prices and needs to accelerate the preparation of the bid "reliably"? The paper is focused on the analysis, presentation and application of selected mathematical-statistical methods in the preparation of price offer by the contractor.

Keywords: Offer price, cost, investment process, Pareto analysis.

Abstrakt: Príprava ponuky je náročnou súčasťou zákazkového procesu, ktorý sa spravidla začína zistením zákazkovej príležitosti a končí uzavretím zmluvy o realizácii alebo aj nezískaním zákazky. Pripraviť dobrú ponuku znamená, čo najpresnejšie započítať vlastné náklady na realizáciu zákazky a tiež správne odhadnúť ponukovú cenu so započítaním primeranej (potrebnej) miery zisku a rizika. Za týmto účelom by mal zhotoviteľ disponovať vlastnou databázou firemných cien. Zostavenie tejto databázy si vyžaduje dlhodobý a intenzívny zber cenových informácií, ktoré často u zhotoviteľa absentujú.

Článok opisuje inováciu procesu prípravy ponukovej ceny v prípade, že zhotoviteľ nedisponuje kompletnou firemnou databázou cien a potrebuje prípravu cenovej ponuky "spoľahlivo" urýchliť.

1. Introduction

The contractor generally enters the procurement process in the project preparation stage. His aim is to obtain a contract, whether in the private sector, on the basis of references from its previous investors, or in the public sector through a tender in the public procurement process. In both cases, he submits a price offer which has to compete in tender ("generally" the lowest one wins), but it also has to ensure the contractor with a reasonable profit.

The aim of the paper is to present the use of existing pricing tools, calculation methods and bidding techniques with the possibility of using existing simple statistical methods such as Pareto

analysis, interpolation, Grubbs' Test, standard deviation, and basic descriptive characteristics of the location such as minimum, maximum, and weighted arithmetic mean. These basic statistical methods will contribute to the accuracy of cost and price modelling at the bidding stage but also at the stage of the construction itself, especially in relation to the analysis of any deviations of the achieved result from the planned situation.

2. Selected mathematical-statistical methods applicable to the preparation of the price offer

The selected statistical methods, such as Pareto analysis, interpolation, Grubbs' test, standard deviation, and basic descriptive characteristics of the location as minimum, maximum, modus, median, and weighted arithmetic mean, can be applied in costing and building pricing phases.

At the stage of preparation of the offer, the contractor pays special attention to its creation methodology. It was in this process that Pareto analysis was utilized and moreover published as a statistical method for the quality management process, based on the analysis of one variable (one character) [1], [4], [5], [8].

When applying Pareto analysis at the stage of preparing price offer, we follow the principle that the increased attention should be paid to units (items) with relatively frequent occurrences or items whose impact on cost is greater. Typically, these are units (items) corresponding, for example, to three quarters or 80% of the total weighted frequency. Based on this knowledge, in our next process we put 20% of the items (which however accounts for 80% of the contractor's bid price) under a more detailed analysis.

Price series method – methods of extrapolation or interpolation are used in the calculation of the valuation of project and activities such as coordination and project assistance with the help of rate tables with recommended price ranges or percentages. This method is used in the sixth chapter to evaluate the work of the designer.

The parametric *Grubbs' test* of extreme values is used to analyse the suitability of data in the selected set of characteristics (unit price, total price, range – measurement) of the project samples being considered.

Mathematical relationships are specifically chosen for the value of the test criterion, the calculated value is then compared to the critical value for the chosen probability or significance level. Prognostic methods are used by many experts in the exact sciences. They are addressed in different levels of knowledge and at different levels of use in practice. The goal in building industry is not to analyse them, this is an issue to be solved by statistical experts, but only to find a suitable application to determine the price trend prediction, for example, in the price model of the contractor in terms of construction time and possible larger price fluctuations.

In general, the contractor can choose one of three main groups of prognostic methods:

- subjective methods
- heuristic methods
- exact methods

The exact methods represent modern mathematical-statistical approaches (methods of trends extrapolation based on regression analysis of time series) based on statistical analysis of data. The essence of this method is in the retrospective analysis of the time series of the surveyed price index, the search for its trend and the extension of the observed trend to the next period. After compiling the mathematical model, in our case the development of price indices, it will be necessary to find a numerical solution of the given task for the practical use of the model [2], [3].

The choice of the appropriate prognostic method depends on a number of factors: the form of the prognosis, the prediction horizon, the nature of the data (eg. whether the data show the presence of the trend or the seasonal term), the costs associated with the construction of the prognosis, the required accuracy of the prognosis, the data availability, the clarity of the method. The choice of time series analysis method depends on:

- the purpose of the analysis
- type of time series
- experience of statistician

From the experience in economics, time series can be broken down into several components:

- *the trend* reflects long-term changes in the average behaviour of time series
- *the seasonal component* describes periodic changes in the time series
- *the cyclical component* describes fluctuations around the trend
- *the residual component* is generated by random movements during the time series

For more information about time series and breakdowns of individual components, see the literature [1], [4].

Mathematical description of the trend:

Equations of trend lines can be divided into the following basic groups [6], [7], [15]:

- constant trend: $y(t) = a$
- linear trend: $y(t) = a + b \cdot t$ for $t \geq 0$
- quadratic trend: $y(t) = a + b \cdot t + c \cdot t^2$ for $t \geq 0$
- exponential trend: $y(t) = a \cdot b^t$ for $t \geq 0, b > 0$
- logarithmic trend: $y(t) = c / (1 + a \cdot b^t)$ for $t \geq 1, b > 0, c > 0$
- Gompertz curve: $\log(y(t)) = c + a \cdot b^t$ for $t \geq 0, b > 0$

Regression equations can also be detected using MS Excel.

For the practical application of the above-mentioned methods and considering the extent of the problem under examination, the authors selected the model of preparation of the price offer of the construction contract using the Pareto analysis.

3. Contractors' methods/methodology of calculation

For calculating prices and costs, the contractor uses the traditional calculation methods listed in the following figure [10], [11]:

<i>Building's life cycle phase</i>	PHASE OF PROCUREMENT			
<i>Stage of Procurement</i>	Stage of project preparation		Stage of realization - execution of the construction	
<i>Type of documentation</i>	<i>Project documentation for building construction Tender documentation Tender documents Selection of the contractor + the works contract</i>		<i>Project for building permit Tender documentation and project documentation for building construction</i>	
<i>Calculation method</i>	Offer budget	Contract budget	Production calculation	Production invoice + analytic object card
	<i>Offer price</i>	<i>Agreed contract price</i>	<i>Limit of own costs</i>	<i>Updated + actual own costs</i>

Figure 1. Overview of applied calculation methods in the phase of procurement by contractor.

The offer calculation should be made by the contractor by evaluating the investor's bill of quantities by his company's prices, which means that he has his own unit price database. The creation of an individually calculated company prices database requires a long-term and intensive

collection of price information and its processing into a form that is most usable for the company in case of interest in the contract. In other words, a company should maintain and update its price database in the sorting order in which it has the most contracts. This is the only way to quickly prepare price offers from given bill of quantities. It should be emphasized that the type of classification system used does not change the amount of the bid price, only the offer structure and the composition of the bill of quantities change.

Contractors often argue with a lack of time to prepare their offers by individually calculating unit prices. The individuality of the calculation does not lie in the fact that for each contract we calculate new prices in the whole structure. It would certainly be the most accurate way, but to handle many calculated items within the limited offer time would simply not be possible. Therefore, the company must maintain a regularly updated construction price database or to look for options to manage this process "reliably".

3.1. Pareto analysis and its use in preparation of offer budget, methodology of processing

In preparing the offer budget, specifically in the valuation of items in the bill of quantities, it is possible to apply the Pareto analysis methodology.

Pareto analysis assumes that we have a set of statistical units that we want to divide according to a certain criterion (in our case, depending on the cost) of the 80/20 Pareto rule.

The contractor shall on the basis of the obtained bill of quantities create the budget using informative prices. The resulting price of the object from this informative valuation will be adjusted and calculated according to its individual conditions by adjusting part of the budget items to individual prices. For this purpose, as the Pareto analysis states, he selects the items that account for 80% of the total price of the building, which moreover according to this rule should represent about 20% of the total number of items in the bill of quantities. The remaining 80% of the items (with a 20% share of the price) remain unchanged, without modifying unit prices.

The applied Pareto analysis procedure is as follows [1], [9]:

1. The set of statistical units is given by the items in the bill of quantities (contains several work units of measure).
2. Value the quantity of units of measure by informative unit prices.
3. Arrange individual items by total price in descending trend.
4. Calculate the corresponding cumulative price sums in order and determine the 80% of the total informative price.
5. Specify the number of items in the total number of items that will be preferentially analysed (individual company price calculations).
6. Re-calculate the specified items (their unit prices) by company's overhead and profit rates.

This procedure will also provide us with information about the share of individual items on the price of the entire offer. For example, the budget item "HELUZ load-bearing brick masonry" with a cost of 13 392.952 represents 7.4% of the total offer price. The item foundation concrete represents 9 809.355 €, it is 5.4 %, but item XY with a price of € 2.323 represents only a negligible share of the total offer price. Then it is clear that we only re-calculate the "essential items" of the budget. The task will be to identify those essential items in terms of the calculated costs but also in terms of the frequency.

4. Results

There are currently a number of cost-calculation software programs that allow users to simulate cost developments in individual calculations when creating corporate pricing. We also used one of this software when designing the application method for this statistical method. Pareto analysis was done in the CENKROS Plus software by KROS Žilina.

4.1. Inputs for the Pareto rule application

The primary input function in applying the Pareto rule are the essential items and the definition of the percentage of the total cost they are supposed to represent. In the essential items selected according to the Pareto rule, an individual calculation of overheads and profit is applied. Rates for production costs, general expenses and profit are published according to the pricing policy of the contractor who constructed the house:

Production costs – 15 % of the wage base total,

General expenses – 9 % of the wage base total,

Profit rate – 10% of the base, which is the sum of wages, machines, production costs and general expenses.

4.2. Application outputs

The output of the Pareto analysis for the contractor is information that the items under a particular order number (processed by CENKROS plus) are objectively considered to be the essential items whose costs together account for 80% of the total offer price, in this case study it is 145 089,047 €. These essential items account for 24% of the total number of valued items in the meaning of frequency. As a preview, three essential construction works are included in the paper (table 1).

Table 1. Demonstration of unit prices of three essential items before and after an individual calculation by the contractor (without 15% material discount)

	<i>TSKP No.</i>	<i>Short description</i>	<i>Unit price from the database</i>	<i>Unit price after contractor's individual calculation</i>
Item 1	311231465	Load-bearing brick masonry HELUZ 44	124.45	115.23
Item 2	274321312	Reinforced concrete foundation	121.87	120.26
Item 3	764172016	Roof cladding Ruukki Elite	26.94	26.35

The effect of applying the Pareto rule when preparing an offer will be more obvious in complex comparison made on the basis of an analysis not only of the total price but also of the price of input items costs (materials, wages, machines, overhead) and profit.

Table 2. Comparison of contractor's budget prices with the analysis of complex inputs into the price

	Recapitulation of production calculation by SOC (informative prices) [€]	Recapitulation of production calculation - essential items [€]	Recapitulation of production - essential items + 15 % discount on the specified material [€]
1.	2.	3.	4.
Total price	180 867	171 434	164 368
Material total	125 620	125 620	118 554
% of total price	69.5	73.3	72.1
Wages total (direct + additional + taxes)	24 450	24 450	24 450
% of total price	13.5	14.3	14.9
Machines total	4 698	4 698	4 698
% of total price	2.6	2.7	2.9

Overhead total	15 415	8 379	8 379
% of total price	8.5	4.9	5.1
Profit total	6 684	4 286	4 286
% of total price	3.7	2.5	2.6
Constructions *	4 000	4 001	4 001
% of total price	2.2	2.3	2.4
Total %	100.0	100.0	100.0
% the share of the adjusted price from the total SOC price		94.8	90.9
the difference of the total SOC price and the adjusted price in €		9 434	16 499

*Constructions are items that are included in the total cost of the contract, but as subcontracts to which the production calculation is not created because their price analysis is unknown, they are only taken into account by their total price.

The first column of Table 2 presents all analysed variables at three levels of comparison:

- at the calculation level using the informative unit prices (column 2)
- at the calculation level made by individually calculated essential items according to the company's overhead rates and the necessary profit of the contractor (column 3)
- at the calculation level made by individually calculated essential items according to the company's overhead rates and the necessary profit of the contractor a and with a 15% discount on the specified material (column 4)

The difference between the total price of the budget with the informative prices (column 2) and the contractor's individually calculated offer price (column 4, first row of the table) amounting to 16 499 € (column 4, last row of the table) was generated by the re-calculation of the essential items by company's overhead and profit rates. This means that the contractor applied the strategy based on the on the pricing of essential units (individual unit pricing method according to corporate rates from intra-company accounting), thereby enabling to offer the developer his services at a lower price (16 499 €) than would be the offer based solely on the informative prices, i.e. by the valuation of the items in the bill of quantities with the informative unit prices of the existing database. The amount of 16 499 € represents a 9.1% difference in bids.

The application of Pareto analysis in practice, using the "essential units" function of the economic software, allowed the contractor to process the offer with less labour content and more precisely in terms of the planned economic efficiency of the contract (profitability of costs, sales and profits) provided that the company properly updates in-house accounting,

The bid price of the contractor was 164 368 € without the cost of electro montage (supplied as a subcontract from another contractor).

5. Discussion

The case study is oriented to the preparation of the bid price with the possibility of applying mathematical - statistical methods in the process of individual calculation by the contractor.

The system of individual calculation is perfectly processed in Germany and similarly in Austria, with the majority of the elements (items) of construction and assembly works being calculated individually by the construction company from the past. The calculator has statistical data from the accounting records that capture costs and expenses in the required sorting with immense consistency using software assistance. The feedback between the calculated costs and the actual expenses contributes to improving the individualized price database in each construction company.

Calculation formulas used in the United Kingdom, Canada and the United States, as in our country, are not regulated. The unit price calculations are based on existing company databases, so individual calculations taking into account regional impacts of the construction can also be applied to their maximum.

The calculation formula for calculating the unit cost of construction work, similar in ours and German practice, is again based on cost items as a unit costing elements.

The calculation formula used in the UK consists only of items that we call direct costs:

- *labour*
- *material and goods*
- *machinery and equipment.*

This way calculated unit prices only contain direct costs without overhead and profit and are referred to as the "Net Unit Price" in the British calculation practice.

Indirect costs (overhead) and *profit* (Mark-up) are negotiated individually for each contract.

The calculated unit rates of direct costs, their form and distribution into two basic parts, allow the calculator to adjust them according to real competitive conditions in a given segment of the region's market (overhead, profit).

The set of construction works prices in Canada and the US is based on *basic prices* and *aggregated prices*. *Basic prices* form the starting point for price offer creation and consist of a set of *sample prices* (published in price guide) and *company* price sets. Basic prices are created for individual technologies and are differentiated according to the concept and type of machinery.

The calculation formula is predominantly used in following segmentation:

- a) *materials* - the prices of materials and products shall be calculated according to the supplier's offer, including the transport to the site costs
- b) *labour* - hour wages of individual professions including holiday wages, sickness and pension insurance, dietary,
- c) *machinery and equipment* - rates per hour of machine application including its operation
- d) *overheads,*
- e) *profit.*

The unit prices constructed this way cover all charges for construction costs and profit for the execution of construction works, to the extent defined by item description and state standards.

From the analogy of the observed facts of the calculation formulas results, that although the individual calculation elements entering the cost of the construction work are almost the same (material, wage costs, machines, overhead), different and sometimes even fundamentally different is the method of calculating of individual calculation elements of unit price. The usual content of the calculated unit costs of construction works (UK practice) can also vary and also the bases used for the calculation of overheads and profit margins differ.

In the German calculation practice, the basis for calculation of indirect costs is the *cost of wages*, to which also the overheads of the site apply, calculated directly to partial performance or as the tariffs according to the chosen key for wage, material and other costs. Only the Switzerland is an exception, where the calculation formula and the guideline price processing system are similar to ours, which has a simple explanation. The whole system of building production valuation used in our country was exported from the Czechoslovak Republic and applied in Switzerland in the 1960s by Czech emigrants.

The English-speaking countries are characterized by the fact that all guide prices are published in price lists and price publications only at the level of *direct costs*, and the decision on the amount of indirect costs and size of the profit leaves the market to the competence of each company. This fact forces the company to choose any arbitrary, but reliable system of tracking the level of its own costs and to use this knowledge empirically in the individual calculation of new orders.

6. Conclusion

A summary of the approaches leading to the preparation of the bid price by the contractors in the foreign and even in our calculation practice is increasingly based on the application of individual calculations. It is possible to apply this calculation method given that the company has a price base that the contractor must build gradually and update regularly. If the contractor is not fully familiar with this process or lacks enough time, existing informative pricing databases with application of mathematical - statistical methods may be used when preparing the offer, for example to the extent that the case study presents in this paper.

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