THE APPLICATION OF SIMPLE STATISTICAL METHODS WITHIN THE DESIGN OF THE TENDER PRICE OF THE CONSTRUCTION CONTRACT [1]

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Abstract

Based on the needs of the construction practice, certain statistical methods are used more frequently. Their aim is to analyze several problems within the investment process during the preparation and the realization phase of the construction contract. For the contractor, the design of the tender price is one of the most difficult problems. This price represents the price, for which is he willing to perform the contract. The tender price must take into account all the specifics of the construction contract, which result from the individuality and the character of the particular construction; such as the layout, the design, the architectural solution, as well as the operational and ecological solution of a structure [5]. The tender price is often affected by the location of the construction, which is usually determined by the investor, and it has the impact on the traffic in the particular location. The individual time of supply, and the method of the realization represents an important role as well. They both are determined by the investor along with the designer of the particular construction. The contractors often complain about the lack of time needed for the preparation of their tender prices. Therefore, it is necessary to look for the possibilities how to reliably speed up this process; taking into account all the specific features of a structure. This article deals with the application of two simple statistical methods. The Pareto analysis, which can be used during the design of the tender price, and the extrapolation method, which can be used for the estimation of the price development, based on the regression analysis of the time series.
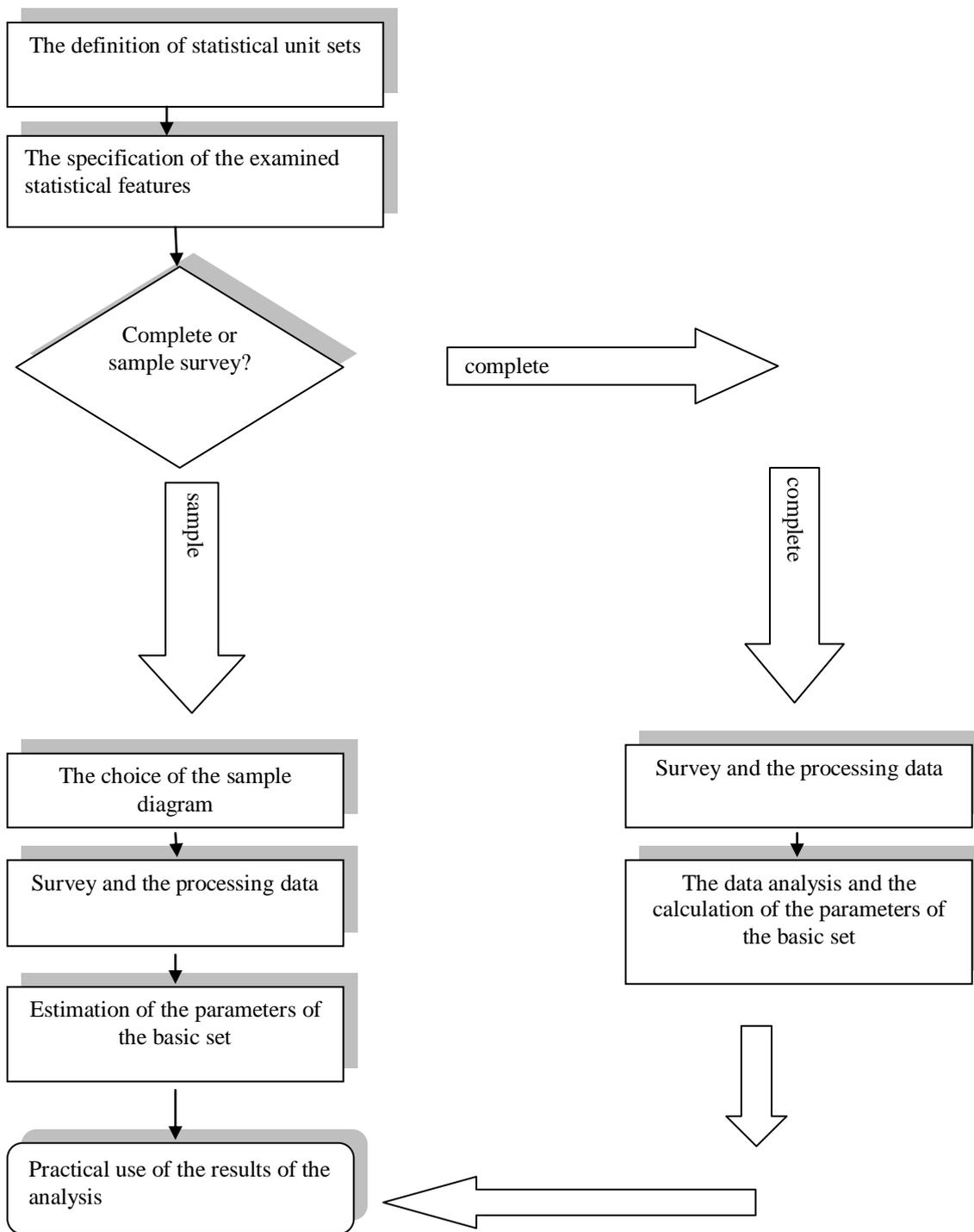
Keywords

Costs management, investment process, life cycle of a building, cost estimate, economic efficiency, price, cost, statistical methods.

Introduction

The main role of a statistical method is typically to examine the mass phenomena and the variability of their expression. The essential element is the design of a database by collecting all the necessary information, define the set of statistical parameters and finally to analyze all the examined phenomena [7]. Methods of statistical analysis provide a particular set of techniques for quantification of the basic statistical set of regularities or the sample of files for the purpose of their use in the next practical activities. [2]

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Diagram no. 1: The general procedure for solving the statistical tasks

In the construction practice, those statistical methods may also have a practical use, especially during the design of the tender price from the contractor′s point of view, in his company's pricing policy.

1. **The specifics of the researched phenomena within the price policy of the contractor**
    The pricing policy is considered to be developed as the weakest, but it is also an applied tool for the marketing mix in the construction industry even though, the price is an important factor of every construction company's success in the business.

Instead of the individual price policy, which responds to a specific part of a construction production, Slovak construction companies still use for the preparation of the construction contract the tender prices, which only indicate the approximate prices of all the construction works. These are annually published by several companies, which deal with the price settings within the construction industry. The explanation for this can be the fact, that the Slovak market is still not a well-functioning competitive market. At first it may seem that the amount of the construction companies, which are fighting for contracts, must be accompanied by a competitive battle, uncompromisingly forcing into the individual calculation of the tender price. However, the commonly irresponsible approach of many public works authorities, as well as many smaller developers, to an agreement on the construction's price is negated by the amount of competition.

The construction production commitment to the location of a structure partially lowers down the competition pressure of the companies from farther locations. This can be seen especially, when they try to compete with the individual construction works. This kind of market does not motivate the construction companies to watch their own actual costs and neither to the creation of their own pricing database, which could take into account the specific needs of each and every construction company, and not only in the cost, but also in the profitable area.

This situation illustrates the common reaction of the construction companies to the question why they do not own their own pricing database. They claim that they do not need one, since those indicative approximate prices include sufficiently high percentage charges of the overheads and profits, which cover their cost, and they provide the necessary prosperity as well.

However, this situation changes due to the entry of foreign investors, as well as foreign construction companies. The foreign investors are used to the professionally performed offer control, and also to the supply activities of companies and their invoices themselves. The foreign construction competition enters to distant markets only with their own management and technical capacity, hiring domestic subcontractors for the majority of the construction works. Whereupon will they have to comply with the conditions of the general contractors.

Therefore, the problematic dealing with the pricing policy of construction companies is extremely current, and it does require the application of all available comprehensive approaches within the pricing itself, using all the existing mathematical-statistical methods in order to design the tender price, which will be capable of competition for the contractor, and also acceptable for the investor.

2. Pareto analysis

During the design phase of the tender, every construction company should put into effect mainly their own, individually calculated prices. The individuality of the calculation does not mean that there has to be designed a fully new calculation of the price for every contract. Even though, this would be definitely the most precise way, in terms of labor intensity it would be unrealistic to manage this enormous amount of items that would need to be calculated in certain time limit (of putting out the offer). Therefore, the company's own pricing database of construction works needs to be regularly updated. The other option would be to look for a way to speed up the designing process of the tender price by creating the tender budget. The Pareto analysis presents this kind of possibility.

The Pareto analysis is based upon the assumption, that we own a database of statistical units, which is divided in the ratio of 80/20, according to the particular criteria by the Pareto rule (upon the cost level, when dealing with the design of the tender price).

First, upon the specified report and assessment of the contracting authority, the contractor shall design a cost budget using only approximate prices. As a next step, the final price of a structure will be adjusted from the approximate valuation, and it will be recalculated according to the individual conditions by adjusting part of the budget items into individual prices. For this purpose, the Pareto analysis will be applied. Items form the report and assessments, which represent 80% of the total price of a structure, will be taken out. According to the rule mentioned earlier, this should represent approximately 20% of all the items of the report and

assessment. The remaining 80% of the total amount of items (with the share price of 20%) stays unchanged, without any changes of the unit price.

The procedure steps of the Pareto analysis are following: [2]
1. The set of statistical units must be specified by the report and assessment items (it consists of numerous measurement units of works).
2. The amount of measurement units has to be priced by the approximate unit prices.
3. All the individual items according to the total price must be sorted in a descending order.
4. Corresponding cumulated sums of prices have to be calculated according to the order and the 80% border line of the total approximate price, must be determined.
5. The limit of the amount of the items must be determined from the total amount of items which will be analyzed primarily (they will be individually calculated by company's rates)
6. Specific items and their unit prices have to be recalculated by the company's overhead and profit rates.

Thanks to this procedure, the numerical data dealing with the share of individual items on the total offer price will be available.

Currently, there are several pricing software in Slovakia, which allow the users to simulate the development of costs in the individual calculation within the price making process of a company. In the next example there is presented one of those software. The Pareto analysis is applied in the CENKROS plus software created by Kros Žilina using following steps.

The first input will be the function of the Pareto rule called "**nosné položky** (bearing items)" which are marked as a window called "**položky** (items)". In the tab called "bearing items" it is necessary to determine the percentage portion of bearing items within total costs.
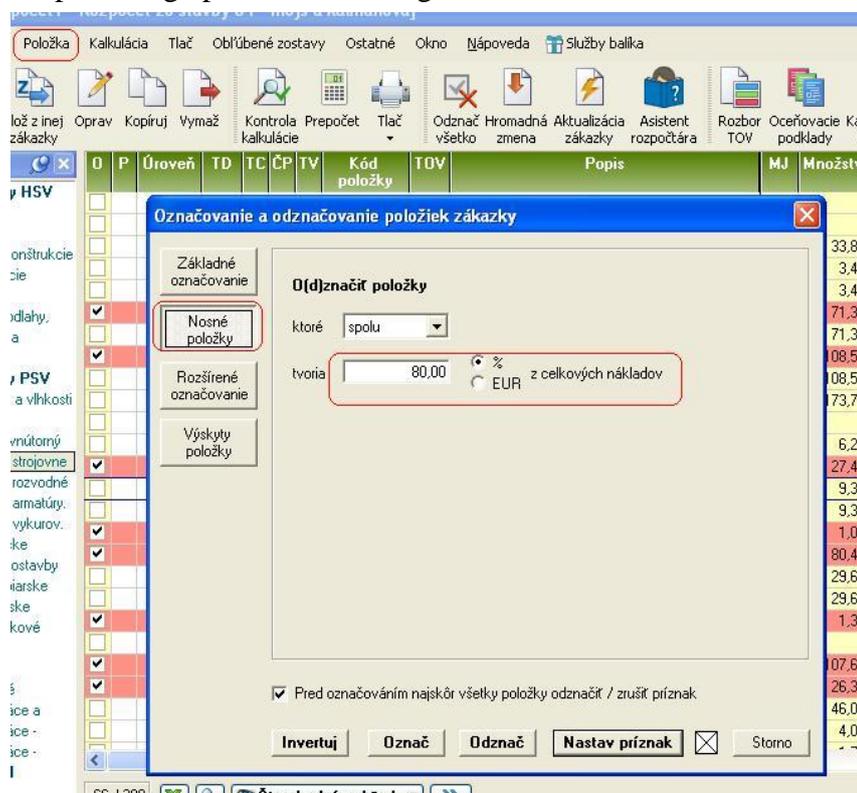
Scheme no. 2: The function called "bearing items" from the CENKROS plus software [10]

Next step, in the window rolled up, which is called "**ktoré** (which)", is the selection of the set of items, which are bearing within their sum called "**spolu** (sum)" or the items, which individually create a certain percentage or certain cost in euros (in this case we choose the option "**jednotlivo (individually**"). Into the box called "**tvoria (creating)**" is either written the percentage of the total costs or the sum in euros. This box is used for the specification of the items; whether they will be considered bearing within the budget, within the production calculation, within the drawing from the budget or within the production invoice. The **Enter** key is used for marking the bearing items; or the key **Označ** (select)/ **Odznač** (unselect) can be used as well. This represents the process of selecting all the bearing items. For a clear view, in the drop-down menu it is possible to use the selection of views of "**nosné položky** (bearing items)".

Scheme no. 3: The selection of views of "nosné položky (bearing items)" [10]

In the last step, the individual calculation of overheads and profit is applied for marked items using "kalkulačný vzorec (the calculation formula)" according to the Pareto rule (Scheme no. 4). The rates for the production and administrative overhead and profit are determined from the internal bookkeeping of the company, which is competing for the contract.

In the following example (Scheme no.4), the company`s production overhead of 15% of the basic salary + charges + additional salaries is calculated into the prices, along with the administrative overhead of 9% of the basics, and the rate of the profit of 10% of the basics, which consists of the sum of items of salary costs, machines, and other direct costs of the production and administrative overhead.

Scheme no. 4: The individual calculation of overheads and profit according to the company`s materials [10]

For the contractor, the Pareto analysis output represents the information about the kinds of items and their serial numbers within the budget that can be considered bearing, and whose overall costs represent 80% of the total tender price of the contract. Another output of the Pareto analysis is the information about the percentage of the mentioned bearing items, which are presents within the total amount of priced items in the budget.

However, the comprehensive comparison based on the analysis of total prices, profit, and individual cost items, which enter the price (such as material, salaries, machines, overheads, etc.), provides better information specified in the following levels:

- The calculation based on the indicative unit prices,
- The calculation based on the individually of calculated bearing items according to the company`s overhead rates and the required profit of the contractor,

- The calculation based on the individually of calculated bearing items according to the company`s overhead rates and the required profit of the contractor including the possibility of discount on specific type of material.

The recalculation of bearing items by the company`s overhead rates and profits will create a difference between the total price of the budget with the approximate prices and the individually calculated tender price of the contractor. This means, that the contractor has applied the strategy of company`s prices within the bearing items (individual calculation of unit prices according to the company`s rates from the inner bookkeeping). This way, he will be able to offer works along with the price taking into consideration the needs of the company; maybe even with lower prices than the presented offer, only based on the approximate prices, i.e., pricing the report and assessment by approximate unit prices of the existing database. Contractor`s application of the Pareto analysis in practice, using the "nosné položky (**bearing items)"** function of the existing pricing software, provides the creation of the tender price with less work involved. In case, the company is provided with the well-prepared inner bookkeeping, the price offer should be even more accurate in regard to the planned economical effectiveness of the contract (ratability of costs, sales and profits).

3. The method of the price development forecast based on the analysis of the time series with the seasonal component

During the design of the tender price, due to the competitiveness, the time factor is often neglected. However, this is not the right approach, because there is always some time passed from the beginning of the design of the tender price until the end of the realization of a contract. The prices of construction works and materials, as well as other commodities, change their values in time. This trend is followed up by the Statistical Office of the Slovak Republic, which processes the index of development of prices. They are published monthly and quarterly on their website.

During the design of the tender, it is very smart to take into consideration the development of prices, especially during the price fluctuations. Therefore, this risk of price change shall be calculated into the offer price using a reasonably acceptable amount [9]; especially, if the developer insists on the agreement on the tender price without any possibility of its adjustment (fixed price).

The expected trend in the construction price development for the period of the next three years or for the estimated time of the construction can be created using individual features of MS Excel program. In our study mentioned below, with the time horizon since 2011, we have used this trend estimation, using the exact methods of prediction, such as the extrapolation method, which is based on the regression analysis of the time series with the seasonal component.

In the forecast of the development of prices, the price index of the construction works, materials and products used within the construction, will be representing the input data during the time of the realization of a contract, and they will be quarterly published by the Statistical Office of the Slovak Republic. The overview of the past price development can be gained based on the mentioned statistical indexes. They form the ultimate information for their next forecasts.

If no significant changes are anticipated within the price levels of the construction and mounting works (currently, according to the continuous state of recession in Slovakia), the appropriate method to use would be the method of extrapolation of trends. The purpose of this method is to analyze the time series of the examined statistical indexes; to determine the trend line and to extend the trends into the future. By extending the trend, the estimated value of the index in the future quarters can be achieved.

The feature of the trend must be registered by a formalized relationship, i.e., by a particular mathematical formula, so that the calculation of predicted values will be ensured. To be able to find a particular trend line, it is necessary to know their individual types and regression equations. The trend lines, which are used the most during the design of the extrapolation forecasts (prognosis), contain two or three parameters. Based on the significance of the estimation of the parameters of the trend line, a second degree polynomial has been chosen. [8].

The time series of quarterly indices of prices in the construction industry since the first quarter of 2003 until the fourth quarter of 2011 for single-apartment buildings (family house type of buildings- according to ŠKS 1110 (section of JKSO 803 – residential buildings) will be analyzed and compared to the already known fact (first and second quarter of 2013), in the presented example (case study). [11]

| 1	2	3	4	5	6	7
i	Year	QUARTER				Sum
		I	II	III	IV	
1	2003	1,013	1,010	1,013	1,009	4,04500
2	2004	1,025	1,019	1,021	1,009	4,07400
3	2005	1,013	1,008	1,009	1,008	4,03800
4	2006	1,013	1,010	1,009	1,009	4,04100
5	2007	1,017	1,009	1,011	1,011	4,04800
6	2008	1,027	1,018	1,013	1,007	4,05900
7	2009	1,008	1,009	0,995	1,000	4,01200
8	2010	1,000	0,997	1,002	1,001	4,00000
9	2011	1,003	1,001	1,003	1,000	4,00700
Sum		9,113	9,081	9,076	9,054	36,324

Table no. 1: The time series of the indices for buildings KS no.111 (section no.803 – Residential buildings)

In Table no. 1 the term i = 1, 2, 3, ..., 9, where i = 1 corresponds to 2003.
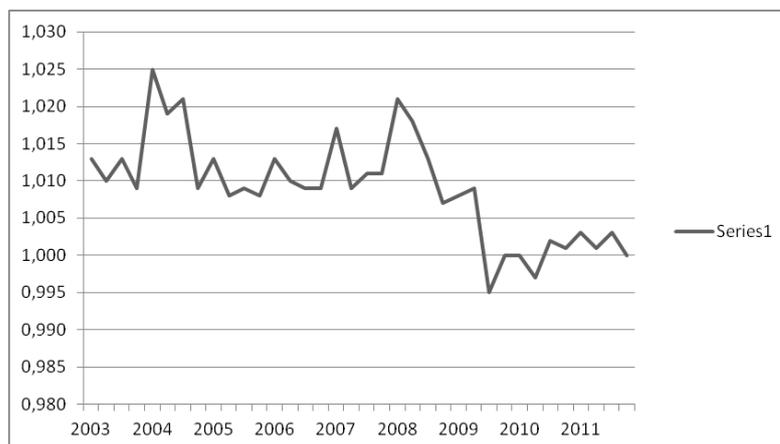
Figure no. 1: The quarterly index of the price development in the construction industry for the section no.803 – Residential buildings (KS no. 111)

Using the MS Excel program it is possible to create the trend line and its formula (regression equation), which helps to determine the estimated development of index prices for the next period.
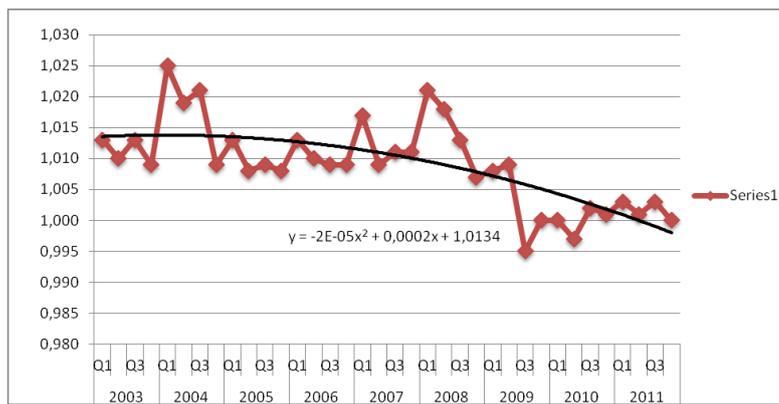
Figure no. 2: Quarterly index of the price development in the construction industry for the section no.803 – Residential buildings (KS no. 111) with the trend function of the 2nd degree polynomial

Proposed Design

In the example mentioned above (Figure no. 2), the trend line represents the second degree polynomial. The formula of the trend line is following:

$$y(x) = -0,00002x^2 + 0,0002x + 1,0134$$

where „x" represents the particular time term to determine the value of the index "y(x)".
The following Table no. 2 represents the forecast of the development of price indices for the next three years (the substitution of „x" in the equation of the trend line, for the value beginning with the value of 37, since the trend line, which is drawn according to the time series contains 36 input data).

Quarter	Year		
	2012	**2013**	**2014**
1st **quarter**	0,99342	0,98798	0,98190
2nd **quarter**	0,99212	0,98652	0,98028
3rd **quarter**	0,99078	0,98502	0,97862
4th **quarter**	0,98940	0,98348	0,97692

Table no. 2: The values of the quarterly indices for the section no. 803 – Residential buildings (KS no. 1110) for the next three years, using the trend without the seasonal component

This example only represents the general procedure of the trend setting. However, it is not recommended to use it in this form. It is necessary to make an analysis of the seasonal component, because the trend does not say anything about the seasonality.
In case of time series with a seasonal component, it is necessary to individually analyze the trend section, as well as to individually analyze the seasonal section of time series. It has to be done, because in terms of the repeating seasonality the time series has a developing trend [1].
The average values of quarterly indices for each year are used for the description of the trend section. The average values of quarterly indices for each quarter are used for the description of seasonal section.

Therefore, it is necessary to add data concerning average values to Table no.1. These values are calculated in Table no.3.

1	2	3	4	5	6	7	8	9
1	i	Year	QUARTERL				Sum	y_i	$i \cdot y_i$
			I	II	III	IV			
2	1	2003	1,013	1,010	1,013	1,009	4,04500	1,01125	1,01125
3	2	2004	1,025	1,019	1,021	1,009	4,07400	1,01850	2,03700
4	3	2005	1,013	1,008	1,009	1,008	4,03800	1,00950	3,02850
5	4	2006	1,013	1,010	1,009	1,009	4,04100	1,01025	4,04100
6	5	2007	1,017	1,009	1,011	1,011	4,04800	1,01200	5,06000
7	6	2008	1,027	1,018	1,013	1,007	4,05900	1,01475	6,08850
8	7	2009	1,008	1,009	0,995	1,000	4,01200	1,00300	7,02100
9	8	2010	1,000	0,997	1,002	1,001	4,00000	1,00000	8,00000
10	9	2011	1,003	1,001	1,003	1,000	4,00700	1,00175	9,01575
13	Sum		9,113	9,081	9,076	9,054	36,324	9,081	45,3030
14	y_j		1,013	1,009	1,008	1,006	4,036	1,009	
15	b_j		0,00251	0,000	0,000393	0,00212			

Table no. 3: Time series of price indices for residential buildings with the seasonal component
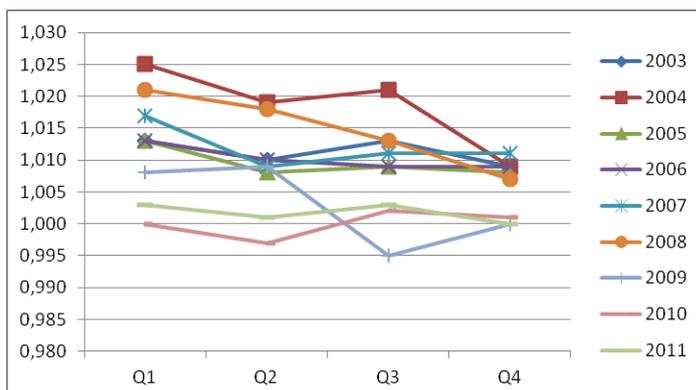
y_i, y_j - average values
„b_j"   - deviation

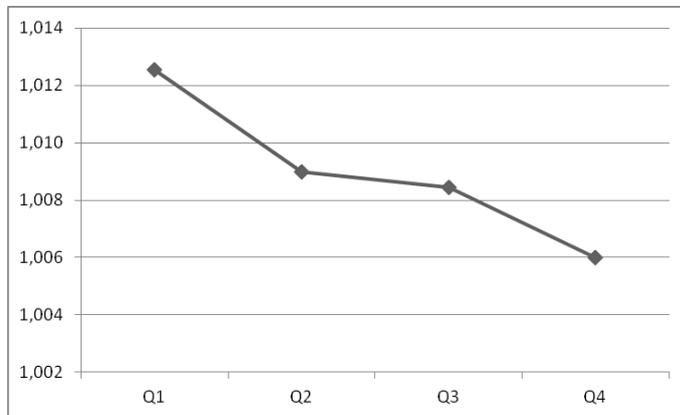The average values of the year indices for a particular year (Figure no. 3)

The determination of the seasonal component within the time series
Figure no. 3 represents the monitored indices of time series, which show asystematic fluctuations within the particular year. This means, that in the first quarter the value of the index is the highest. In the second and third quarter we can see a decline to approximately same values. Finally the lowest value is in the fourth quarter. Therefore, the analyzed series can be considered as a time series with a seasonal component. The overall trend of time series is decreasing.

Figure no. 3: The average quarterly indices of prices for a particular year.

Figure no. 4 also shows the seasonality for the particular years.

Figure no. 4: The average values of year indices of the development of prices within the construction industry for particular years for the section no.803 – Residential buildings (KS no.111)

It is necessary to know the average values of quarterly indices in order to describe the seasonal component for particular years. They can be found in Table no. 3. The average value is determined out of these four values (line no.14, column no.8). The seasonal deviations of the averages for particular quarters also have to be determined and compared to the overall average.

The determination of the trend component of the time series
Figure no.5 can be created based on the average values of quarterly indices for particular years.

$$y = -0{,}0003x^2 + 0{,}0012x + 1{,}0121$$
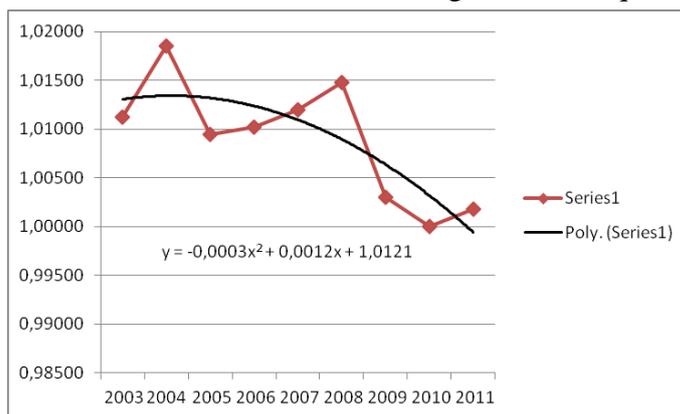
Figure no. 5: The average values of quarterly indices of price development within the construction industry for the section no.803 – Residential buildings (KS no. 111) during the monitored years

Based on the graph mentioned above, we can create the trend line along with a relevant trend equation using MS Excel program.
The created equation looks like this:

$$y(x) = -0,0003x^2 + 0,0012x + 1,0121$$

In the next step, it is necessary to adjust the equation of the trend by using the deviations of particular quarters from Table no.3 (line no. 15).

Following equations result from the mentioned sequence:

$y(x) = -0,0003x^2 + 0,0012x + 1,0121 + 0,00251$ pre 1st quarter
$y(x) = -0,0003x^2 + 0,0012x + 1,0121 + 0,000$ pre 2nd quarter
$y(x) = -0,0003x^2 + 0,0012x + 1,0121 + 0,000393$ pre 3rd quarter
$y(x) = -0,0003x^2 + 0,0012x + 1,0121 + 0,00212$ pre 4th quarter

where „x" represents the year, x = 1 for the year 2003, x = 2 for the year 2004, x = 3 for the year 2005, etc.,

Based on these relations, it is possible to determine the values of quarterly indices for the next period of quarters (Table no.4).

If the realization of a construction is supposed to take for example from 2-3 years, it is recommended to do the forecast for this period. However, the accuracy of the calculation for a longer period would be insufficient. The principle that should be applied when predicting for a period of a long time ahead is, that there must be available minimum of three times more past information (data) than is the number of forecasted data. [4]

quarter	Year		
	2012	2013	2014
1st quarter	0,99661	0,99151	0,98581
2nd quarter	0,99410	0,98900	0,98330
3rd quarter	0,99449	0,98939	0,98369
4th quarter	0,99622	0,99112	0,98542

Table no.4: The values of quarterly indices for the section no. 803 – Residential buildings (KS no. 111) for the next three years

Graphic representation:
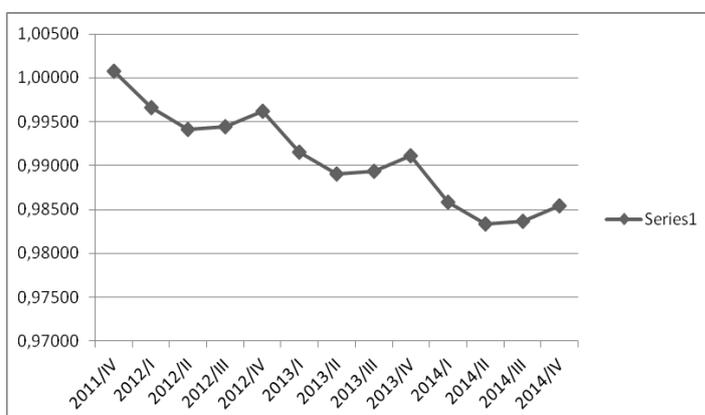
Figure no.6: Graph of quarterly indices of price development in construction industry for the section no.803 – Residential buildings (KS no.111) for the next three years (year 2012, 2013, 2014)

     The contractor can apply some of the other forecasting methods to determine the price development, as well as the increase of costs of the production. The contractor can also estimate this development for the required period of time (most often for the time of the realization of the construction) based on his experiences and professional knowledge. Anyway, every contractor should definitely take into account the risk of the price development, especially in the times of price fluctuations, and include it in the tender price. Table no. 5 presents the comparison between the forecast and the reality, which is so far known for the year of 2012 and for the 1st and 2nd quarter of 2013. Following table shows the quarterly indices of the price development based on the Statistical Office of the Slovak Republic [11] for the section no. 803 and for the classification of structures no. 111:

quarter	Section no.803 – Residential buildings (KS no. 111)		
	2012	**2013**	**2014**
1st quarter	0,998	0,999	-
2nd quarter	1,003	1,001	-
3rd quarter	1,002	-	-
4th quarter	0,998	-	-

Table no.5: The values for quarterly indices for the section no. 803 – Residential buildings (KS no. 111) – the reality

Results and Discussions

     The real development of the price indices in the same period of time (yet elapsed) is slightly more "optimistic" than the forecast of the trend line. Its equation of the regression is created by the MS Excel program, which determined the estimated development of the price indices for the next period of time (years 2012, 2013, 2014).

After multiplying the price indices for the year 2012, it can be stated, that compared to 2011 the price level basically remained unchanged. It reached the value of 1.0009, which represents the increase of 0.09 % compared to the previous year. After the 2012 the calculation of the price index (from the values forecasted) has the price level slightly decreased (about 1.9%), and the price index reached the value of 0,981 (compared to 2011).

The comparison to the year 2013 is so far possible only for the 1st and 2nd quarter. The final price index based on this forecast reached the value of 0.981, which represents a decrease of prices in the first half of the year. The price index of the same period of time, published by the Statistical Office of the Slovak Republic, reached the value of 0.999, which also represents only a small decrease of prices in the construction production.

Conclusion

     The application of presented statistical methods represents the modeling of the price and cost development, which takes place in the procurement phase of the construction. Its aim is to achieve the maximum efficiency of this procurement. This study points out the possibility of their use within the design phase of the tender price. This can be achieved by using the existing pricing data, the right methods of calculation and the customary techniques. Besides the methods mentioned above (the Pareto analysis and the forecasting method), it is necessary to note, that also other mathematical and statistical methods can be used in the process of the modeling of prices and costs within the entire investment process. It can be for example the interpolation, the Grubbs test, the standard deviation, as well as the basic characteristics of the

location such as the minimum, the maximum, the mode, the median, or the average. At the same time the application of the mentioned methods does not represent any higher requirements for the contractor in terms of the knowledge about the statistical and mathematical methods.

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