Development of prices in the construction industry

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Abstract:

Due to the development of the prices of construction works and materials at the moment, it is almost impossible for contractors to comply with agreed upon contracts. For this reason, there was a request from the contractors to adjust the contract price after signing the contract for works or later in the process of realization. Within this issue, forecasting the prices of construction materials and works could solve the problem of adjusting the contract price. The development forecast could be anchored in the contract conditions and at the start of construction, and an optimal reserve would be established. That would eliminate the risk for the investor changing the agreed contract price and also the possible occurrence of more work.

Keywords: prices of construction materials and works; statistical index; investor; adjustment of the contract price, price forecasting

Abstrakt:

Vzhľadom na vývoj cien stavebných prác a materiálov v súčasnosti, je pre dodávateľov takmer nemožné dodržať dohodnuté zmluvné ceny. Z tohto dôvodu vznikla požiadavka zo strany zhotoviteľov na úpravu zmluvnej ceny aj po podpise zmluvy o dielo alebo už aj v procese realizácie. V rámci tejto problematiky by prognózovanie cien stavebných materiálov a prác mohlo vyriešiť problém úpravy zmluvnej ceny. Prognóza vývoja by mohla byť zakotvená v zmluvných podmienkach a na začiatku výstavby by sa vytvorila optimálna rezerva, ktorá by eliminovala riziko zmeny dohodnutej zmluvnej ceny pre investora a tiež možný vznik ďalších naviac prác.

1. Introduction

The decisive tool for management of the entire construction and the starting point for the execution of the works is the contract for the work, which significantly affects the success of the final result. The contract for the works is often concluded, especially in the private sector, under pressure from the investor. In general, the terms of the contract, including the general contractual and commercial terms and conditions to the extent submitted by the investor cannot be commented on or changed by the supplier.

It can be concluded that in the process of procurement of construction contracts most often two types of contract prices are used in Slovakia and abroad:

- On the basis of unit prices, when the contractor is binded to fulfill all conditions, provided that the actual incurred own costs and a reasonable profit are paid by the investor. This type of contract is usually used when the amount of work is not exactly known, or changes in the amount of work actually performed are expected during construction (project documentation drawn up is in insufficient detail). [1]

- A contract with a fixed price (fix price), which bindes the contractor to carry out work and deliveries, regardless of his actual own costs incurred in connection with the delivery specified in the contract. [1]

Due to the development of the prices of construction works and materials at the moment, it is almost impossible for contractors to comply with concluded contracts, whether in the public or private sector. For this reason, there was a request from the contractors to adjust the contract price after signing the contract for the works or in the process of implementation. The development of the prices of building materials from 2021, which was difficult to predict, caused not only zero profitability for contractors, but also the unrealisable of construction orders in the implementation phase. This fact only leads to disputes between contractors and investors, because the contractors preferred to pay the contractual penalty and withdraw from such contracts before they were fulfilled.

2. Materials and Methods

On the basis of the data from statistical offices in EU countries, which monitor the development of prices and form indexes of construction works, materials and products consumed in the construction industry. It is possible to state an overall increase in prices in the monitored period from 2015 to the present day. The Slovak Statistical Office determines the prices of selected representatives, including all materials, complete costs for the construction (object) and profit. The Slovak Statistical Office publishes the prices of materials and construction works separately. Some foreign statistical offices publish a common price index, which includes the development of prices of construction works and the development of prices of construction materials and products together.

Table 1. Comparison of the development of the price index in our country and in nearby countries [7-11]

Year	Quarter	Construction work in Slovakia	Building materials in Slovakia	Austria	Germany	Czech Republic
2016	Q1	100,8	98,4	98,2	101,2	100,8
	Q2	101,6	99,4	102,8	101,9	101,1
	Q3	101,2	99,7	102,0	102,4	101,4
	Q4	101,6	99,6	103,4	102,7	101,8
2017	Q1	103,4	102,4	104,7	104,0	102,2
	Q2	104,5	102,6	105,0	104,9	102,7
	Q3	105,0	102,8	107,6	105,7	103,2
	Q4	105,3	104,4	108,7	106,4	103,9
2018	Q1	107,5	108,3	110,4	108,2	104,7
	Q2	107,1	109,0	112,0	109,2	105,9
	Q3	108,7	109,5	112,5	110,6	107,2
	Q4	109,2	109,6	111,7	111,5	108,1
2019	Q1	111,3	110,6	112,1	113,4	110,0
	Q2	111,7	110,4	112,6	114,3	110,4
	Q3	112,5	111,2	111,6	115,1	112,4
	Q4	113,3	111,1	110,6	115,7	112,8
2020	Q1	114,7	110,3	111,1	117,2	114,6
	Q2	115,1	109,6	110,8	117,7	114,9

	Q3	115,4	109,9	110,8	118,1	115,8
	Q4	116,4	109,9	112,4	118,6	115,9
2021	Q1	111,7	113,6	115,9	120,8	117,4
	Q2	119,2	119,6	124,0	125,2	120,5
	Q3	124,6	129,9	126,0	129,6	123,5
	Q4	124,3	134,9	125,3	132,3	125,4
2022	Q1	135,9	145,1	133,6	138,1	133,2

When comparing the development of the price index of construction materials and works, their similarity can be noticed. The Statistical Office here and offices abroad recorded the largest increase in prices in the construction industry in the first half of 2021 and the beginning of 2022. During this period, the price development index in the construction industry rose in the range of 15.8-31.5 percentage points. In the previous period (from 2016 to 2020), price development indexes in the construction industry expressed a "gradual growth" in the prices of construction works and materials in the range of 2 to 5 percentage points per year.

Data from the Slovak Statistical Office are used as a source for forecasting the time series of the development of the prices of construction materials and works. Individual data are represented by point values, which are expressed in percentage points, where the average of 2015=100 enters as the basis. Based on the data of the Slovak Statistical Office, which forms the indexes of construction works, materials and products consumed in the construction industry, it is possible to state an overall increase in prices. The monitored period begins with the first quarter of 2015 and ends with the fourth quarter of 2021, as newer data were not available at the time of creating this forecast.

3. Results

When deciding on the most suitable forecasting method, four types of forecasting methods are used. These were subsequently compared between each other on the forecasting errors they showed. In this case we used time series forecasting methods - decomposition by regression analysis, exponential smoothing, naive method and ARIMA model.

3.1 Decomposision by regresion analysis

Regression analysis is used as the first forecasting method of time series. Using this analysis relationships between individual variables- the values of the price index of building materials or the price index of construction works - were examined. The main purpose of regression analysis is to examine and characterize the inner relations between variables. Its task is to find a mathematical function called a regression function, or regression model, which should best describe the course of dependence between variables. Within the compared methods, a simple regression analysis is used for multi-criteria selection. A simple analysis is one where we deal with one independent variable, the dependent variable Y, will depend on the independent variable X. A useful aid in the investigation of dependence is the graphic method using a point graph formed by points $[x_i, y_i]$, for $i=1,\ldots,n$ in the plane, where x_i and y_i are the values of the examined variables X and Y. Based on the course of the point graph, we decide what type of dependence it is: linear, quadratic, hyperbolic, exponential, etc. [3]

3.2 Exponential smoothing

Exponential smoothing is a method that has a self-correcting mechanism. This mechanism is able to adjust forecasts in a way that is inconsistent with past errors. It is a weighted moving average of current and past values, where the weights decrease exponentially and therefore it can be used for smoothing and at the same time to make various predictions. [4]

Using this mechanism, this model can achieve more accurate forecast data and demand for the last period, except for the smoothing coefficient. The exponential smoothing method seeks to eliminate various historical irregularities elements in the current demand period and achieve optimal forecasting results.

This method is considered to be an evolution of the weighted moving average method, which calculates a time average that has a self-correcting mechanism. The weighted exponential average method aims to adjust the forecasts in a way that contradicts the previous deviations, through corrections that may affect the smoothing coefficient.

3.3 ARIMA model

ARIMA is a model of autoregressive integrated moving average, which serves mainly for better understanding and prediction of individual points in the future. ARIMA models are applied in cases where the data show evidence of non-stationarity in the sense of the mean, but not the variance, where the initial differencing step can be applied one or more times to eliminate the non-stationarity, of the mean function, the trend. When seasonality appears in a time series, seasonal differentiation could be used to remove the seasonal component. [5]

3.4 Naive method

For naive predictions, we simply set all predictions to the value of the last observation. Meaning

$$\hat{R}_{T+h|T} = R_T$$

Formula 1. Naive method [6]

where:

- R_t – observed value of the time series
- $|h|T$ – absolute value of the difference of the last observation

Naive predictions based on the random walk model are equal to the last observation because future movements are unpredictable and equally likely to be up or down.

4. Discussion

Multicriteria selection is created for the time series of indexes of building materials and the time series of indexes of construction works. For multicriteria decision-making, the minimization criterion is used in all of the aforementioned forecasting methods and errors.

- Decomposision by regresion analysis – reg

- ARIMA model – arima

- Exponential smoothing– ets

- Naïve method – naïve

Table 2.   Multicriteria selection of time series forecasts of construction materials

Time series	Model	Sigma	MAE	RMSE	MAPE	MASE	MSE	Overall	**Rank**
Material	reg	0,430	1,000	1,000	1,000	1,000	0,204	4,634	**4**
Material	ARIMA	1,000	0,949	0,930	0,954	0,949	3,518	8,300	**3**
Material	ets	0,813	1,00	1,000	1,000	1,000	5,000	9,813	**1**
Material	naive	1,000	0,947	0,944	0,949	0,949	3,518	8,307	**2**

	Weight	0,100	0,100	0,100	0,100	0,100	0,500		

Table 3. Multicriteria selection of time series forecasts of construction works

Time series	Model	Sigma	MAE	RMSE	MAPE	MASE	MSE	Overall	**Rank**
Works	reg	1,000	0,981	0,957	0,994	0,986	1,576	6,494	**4**
Works	ARIMA	0,429	0,841	0,925	0,829	0,842	4,567	8,433	**3**
Works	ets	0,447	0,926	0,925	0,938	0,927	5,000	9,162	**1**
Works	naive	0,395	1,000	1,000	1,000	1,000	4,444	8,839	**2**
	Weight	0,100	0,100	0,100	0,100	0,100	0,500		

- Sigma - standard deviation

- MAE – mean absolute error

- RMSE – root mean squared error

- MAPE – mean absolute percentage error

- MASE - mean scaled error

5. Conclusions

On the basis of multicriteria selection and the nature of time series, it was found that the most accurate forecasting time series of prices of construction works and materials is possible using exponential smoothing - ets model. Two forecast intervals are used in the graphs shown below; the dark blue part shows the 80% forecast interval, which are predicted with 80% probability. The light blue part represents the 95% prediction interval, which shows the predicted value of the price index of construction materials and works with a probability of 95%. The dark blue line shows the average of the predicted values of the price indexes of construction materials and works.
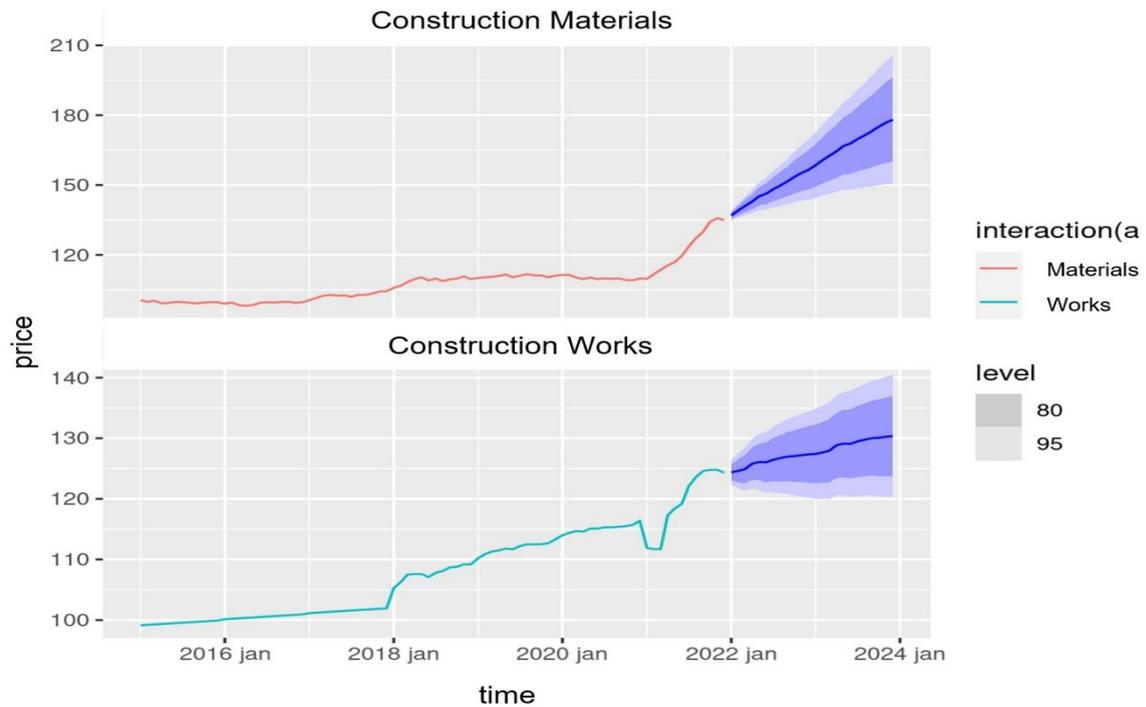
Figure 1. Forecast of the price development of construction materials and works

Table 4. Time series forecast of construction materials prices using the ETS model

Time	Forecast	Lower limit L80%	Upper limit H80%
03/2022	**140,97**	138,31	143,64
06/2022	**146,28**	141,79	150,76
09/2022	**151,55**	145,15	157,96
12/2022	**156,50**	148,04	164,96
03/2023	**162,54**	151,87	173,20
06/2023	**167,84**	154,83	180,85
09/2023	**173,11**	157,62	188,60
12/2023	**178,06**	159,95	196,17

Table 5. Time series forecast of construction works prices using the ETS model

Time	Forecast	Lower limit D80%	Upper limit H80%
03/2022	**124,91**	122,59	127,23
06/2022	**126,04**	122,76	129,33
09/2022	**126,97**	122,95	131,00
12/2022	**127,34**	122,67	131,99
03/2023	**127,94**	122,73	133,16
06/2023	**129,08**	123,36	134,79
09/2023	**130,01**	123,83	136,19
12/2023	**130,37**	123,76	136,98

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