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INFORMATION AND ANALYTICAL TOOLS FOR MONITORING THE PRICES OF MATERIAL AND TECHNICAL RESOURCES (MTR) OF CONSTRUCTION

Abstract: The article deals with features and principles of the price monitoring system for material and technical resources operating now in the road industry. To improve the process of information collection, processing, and analysis concerning the cost of building materials, products, and structures, as well as other types of resources, it is proposed to reinforce a centralized single database of material and technical resources on the basis of regional data. Minimization of costs for data collection, storage, processing and use is possible only with the maximum automation of electronic data collection and exchange, which is realized during the implementation of elements of the centralized monitoring system (CMS) in practice. The architecture, algorithm, and regulations for the formation of a CMS are proposed.

Keywords: material and technical resources, construction, market price monitoring systems, cost engineering, pricing, digitization, cost management, BIM, construction enterprise.

Introduction

The most important part of the input resources of construction production is material and technical resources. Thus, only the cost of materials in construction averages 60% of the cost of direct costs. Material and technical resources are external factors for all participants in the construction process, both for the construction customer and for contractors. The structure and

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quantity of another important resource, labor, directly depends on their features (amount). The cost of the object's life cycle depends on them. Therefore, every step to improve the management of input material and technical resources (MTR), including their cost, affects the economy of construction companies and the construction industry as a whole. When drawing up a BIM implementation plan for a construction project (BEP), modern companies include a section of 5D and 4D modeling. Up-to-date information on prices in construction is essential for the implementation and operation of 5D BIM at any stage of the life cycle. The efficiency of a whole arsenal of the latest methods of cost management, or Cost Engineering, Value Engineering, Project Management, Total Quality Management and others depends on timely, reliable information on resource cost and their current market price. The methodological basis for the formation of such data and their management needs further research.

These research and applied tasks determine the relevance of this dissertation, its purpose and content of further research.

Literature Review

It has been noted in the works of various researchers that it is necessary to use in the estimated calculations of current market (regional) prices for construction resources. With regard to pricing, setting and regulating the price of construction products [1, 2, 4], from the standpoint of efficiency (profitability) of investment activities [5, 22, 27, 29], from the perspective of planning and reducing customer costs, from the perspective of design and construction [23, 25]. It should be noted that the problem is complex. [1-4, 24, 25] formulated approaches to the formation of the structure of data banks of current market prices and some methods of indirect determination of the resource price.

In Ukraine, the first examples of creating databases on construction material costs for participants in the construction process are electronic database "Budtsina" developed by the team of research institute ASB under the leadership of Sudak V.S. and monthly periodical "Budprofi" [6] created for the regional construction market under the leadership of Rastagaeva S.A. in Kremenchuk, Poltava region. Since 2010, a lot of work in this direction is carried out by the state-owned enterprise "State Road Research Institute named after M.P. Shulgin [7].

It is advisable to consider the international experience for filling price directories for construction MTR, which are used to calculate the cost of construction. After all, in different countries this problem is solved differently.

In the Russian Federation and Belarus, there exist methods of collecting and processing statistical data to determine the weighted average current prices based on information on construction work by region [8, 9]. These techniques are based on contractors' information about past events – deliveries that have already taken place.

In Kazakhstan, the authorized state body quarterly calculates the weighted average or arithmetic mean of current prices by region based on department statistics from manufacturers of MTR and contractors [10].

Collecting statistics shows its objectiveness. However, the main set of data is the price reduction of manufacturers and information from contractors about the price of MTR used on construction sites, and not the data of real transactions for the sale of construction MTR.

In Turkey, the directory of market prices for construction materials, products and structures and the directory of market prices for construction works [11] are issued annually by a structural unit of the Ministry of Environment and Urban Planning of the Republic of Turkey. They are prepared on the basis of information provided voluntarily by participants in the construction MTR markets.

Most Spanish regions have their own price databases. They are usually mandatory for use by the state customer, but are developed and maintained by scientific and / or specialized orga-

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nizations at the expense of the budget. For example: The Andalusian Construction Cost Base (BCCA) [12] belongs to the Ministry of Development, Infrastructure and Land Management of Seville. It is updated, revised and expanded by the University of Seville through the Higher Technical School of Civil Engineering and the Official College of Land Surveyors and Technical Architects of Seville under a Special Agreement with the Ministry of Development and Housing of Seville (CFV).

In the USA, Canada, European countries this problem is solved completely by market mechanisms. The states provide conditions for setting up and operation of private specialized enterprises, which provide participants of the construction market, including the state customer, the information about the price of construction resources on a commercial basis [13, 14]. The quality and impartiality of their information is guaranteed by severe competition.

Aims

The purpose of the article is to present the results of practical implementation of the tools for monitoring the prices of material and technical resources of the road construction sector.

Results and methods

A system for monitoring market prices of the material and technical resources has been implemented and tested, which is based on determining the estimated market price of construction MTR, which is determined with a given accuracy on the basis of a sample formed to ensure this accuracy, including in terms of limited funding. Architecture is designed, work regulations, composition and structure of SSRC base are developed;

The system is implemented on the basis of the software package "Universal" (TOV "SoftPro", Kharkiv) and consists of two basic elements, namely:

- subsystem "monitoring" – tools for collecting information on the current price of construction MTR, an iterative system of observation, verification and data storage according to established rules
- subsystem "analysis" – which implements a set of rules and procedures for processing information collected by the monitoring subsystem; determination on the basis of a limited sample of the current range of market prices, the estimated current market price of MTR and the error of its calculation; formation of registers of market prices by regions in printed and electronic form, including for download in the estimated software packages and other compatible systems.

The price monitoring system must comply with the following principles:

- systematization;
- unity of methodology;
- transparency, openness;
- reliability;
- objectivity;
- independence;

The system must contain two interconnected technological parts:

a) monitoring of construction MTR markets, which means to conduct systematic collection, verification and storage of information on the current price in the MTR markets for construction;

b) processing and use of monitoring data, which means implementation of a set of rules, procedures, calculations regarding the information collected by monitoring and obtained as a result of its processing.

The distribution of functions between these parts should be established directly during the design and launch of the monitoring system and can be adjusted during its operation.

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The price monitoring system can be built as:

- part of the cost management system for the construction;
- corporate system of providing information in the customer's service, construction corporation;
- internal technological element of specialized enterprises for the provision of information and / or consulting services in the field of construction;
- part of the system of material and technical support of construction;

The main task of the price monitoring system is to determine the current market price of resources according to established rules with a given accuracy (error) within a limited time and / or financial framework. Therefore, the approaches and algorithms are universal and do not depend on the organizational structure and purpose of the economic activity of the system owner. This is confirmed by examples of successful application of the existing system for:

- regional price base;
- selection and control of the cost of MTR by the customer's service during construction;
- provision of services for the analysis of current market prices in the market of construction MTR by a specialized enterprise;
- determination of the current market price for MTR according to the information of resources for design organizations and customer services, for the preparation of tender proposals by construction companies,

This section considers the construction and sequence of implementation of a corporate dispersed system for monitoring market prices of material and technical resources by enterprises participating in the construction of facilities for the state customer on the example of a centralized system for monitoring prices for basic road construction materials.

Preliminary forecast of the results of full implementation of the corporate dispersed system of monitoring the market prices of material and technical resources by enterprises-participants in the construction of facilities for the state customer on the example of a centralized system for monitoring prices for basic road construction materials is given in Table 1.

Table 1. Preliminary forecast of the implementation results of the monitoring system for the market prices of material and technical resources in the construction

Scope	Result
Determination of the preliminary cost of construction, which is carried out with the involvement of budget funds or funds of enterprises, institutions, organizations of state and communal property.	Significant increase in the accuracy of calculations at the stage of investment planning
Creation of project documentation for new construction and repair and construction works involving budget funds or funds of enterprises, institutions, organizations of state and communal property.	Obtaining as part of the project real estimates for the implementation of construction and repair and construction works carried out involving budget funds.
Calculation of the cost of construction and renovation and construction works.	Control by the administrator of budget funds of the cost of resources in the acts of Design Center-2 on their compliance with regional prices. Reduction of budget expenditures for construction and renovation and construction works.
Transfer of data on the regional cost of construction materials to public authorities	Increasing the accuracy and expanding the list of data on regional prices for construction materials and equipment.

The introduction of such systems by other participants in the construction market or getting information on the current market price of MTR have a positive effect on the construction of facilities for the state customer (Table 2).

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Table 2. Preliminary forecast of results of introduction of supervision systems over the market prices of material and technical resources in construction

Use of data on the regional cost of construction materials by non-budget investors, construction customers, suppliers of construction resources, contractors.	Reducing the cost of construction and repair and construction works by stabilizing the cost of construction resources, reducing the cost of design work and the ability of the investor (customer) to control the cost of resources in the acts for their compliance with regional prices.
Publication of data on the regional cost of construction materials and the register in publicly available publications, including electronic.	Providing conditions for fair and transparent competition in the market for the supply of construction resources. Reducing the cost of construction and repair and construction works, due to the possibility of investor control of the cost of resources in the acts on their compliance with regional prices.

Architecture and regulations of the centralized system of monitoring prices for basic road construction materials

The mechanism of centralized monitoring of prices for basic road construction materials and the relevant information database are designed to:

- Collect prices from regional suppliers of materials
- Process them to determine the price range for each material
- Publish the regional directory of materials prices, as well as the register of suppliers that offer them
- Generate / transmit generalized price information in corporate format.
- Export the directory of materials and their prices in an agreed format for further use in similar systems, budget software, other compatible systems.

The general scheme of work is shown in Fig. 1. This is a two-tier system in which for the central departmental database the main data flow is formed due to the source information from the regional price databases for basic road construction materials. Similar interaction rules, algorithms and data structures apply at both levels.

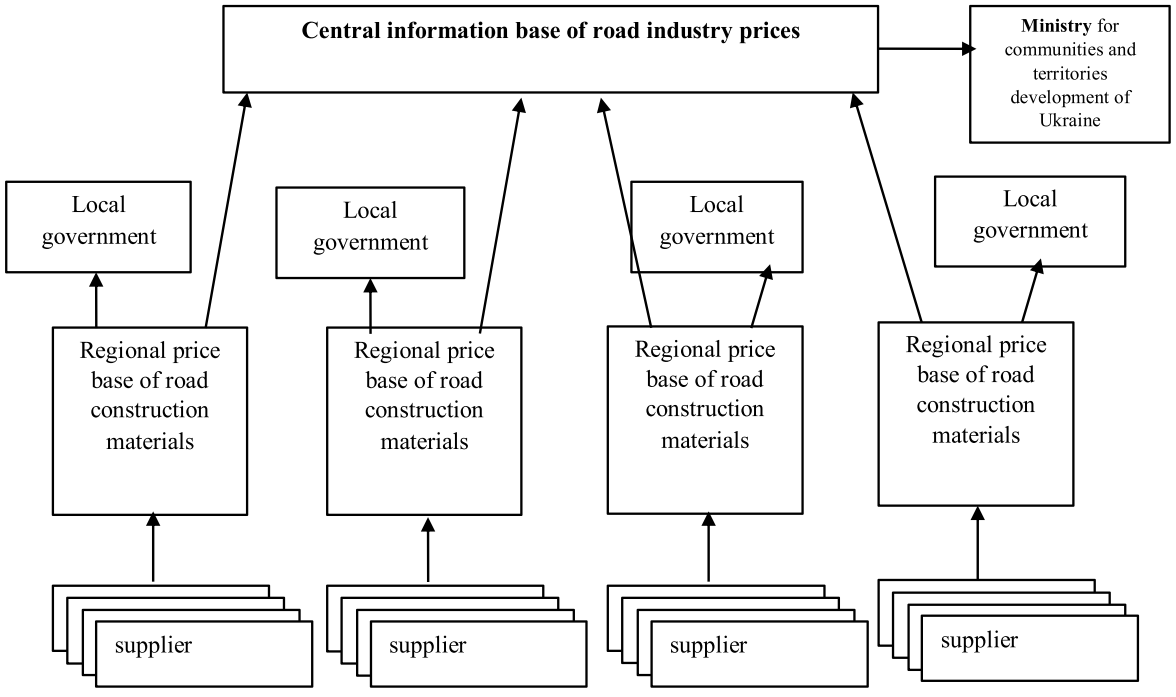

Fig. 1. The scheme of the mechanism of centralized monitoring of prices for basic road construction materials.

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The proposed scheme corresponds to the order of the State Agency of Motor Roads of Ukraine dated 10.07.2012 №270 "On current prices for material resources" (Order №270):

- Road services in each region monitor the prices of materials, taking into account their quality characteristics, timing and volume of supply;
- The results of monitoring by each regional Road Service are communicated to the central information database of road industry prices and local authorities.
- The registrar (the organization designated by Ukravtodor) creates, fills and services central information base. It generates in the automated mode and submits to the Department of Road Development Ukravtodor generalized information on the cost of road construction materials by region for further transfer to the Ministry of Regional Development.

Minimization of costs for collection, storage, processing and use of data is possible only with maximum automation of collection and exchange of information in electronic form [15, 16]. Modern hardware and software allow building a full-fledged centralized price monitoring system (CMS) [17].

The system should consist of a centralized database that will consolidate information from suppliers, as well as its management system (DBMS CMS) [18].

CMS operation algorithm.

1. Suppliers of materials provide information to regional Road Services using XLS files (technology currently in use).

2. Regional Services collect and process information using the PC Universal SBE [19].

3. Regional Services export the consolidated information on the area in the central information base, with the possibility to receive a sample on all data (information on the prices for the chosen material in other areas).

4. The exchange of information between the Services and the central information base shall be carried out in the off-line mode (data transportation) with a specified time period.

5. Import to PC Universal is carried out in a semi-automatic mode by the operator.

CMS DBMS can provide information on supplier prices in the following ways:

- In OFF-LINE mode – by exporting to the database of the system files of the agreed format (xls, xml, dbf) received from suppliers by e-mail or on electronic media.
- In ON-LINE mode – directly to the system database via the Internet.
- In OFF-LINE mode – via Universal 5 PC workstations and "Universal 7" [19].
- In OFF-LINE mode – through the export of data from similar regional, department CMS.
- The the following software is used for central information base:
- Advantage Database Server (Sybase, Inc) [19].
- Software package Universal 7 (server and client parts, as well as application server Universal-Communicator) [19].
- Apache Web server [19] or similar.
- To enter information, suppliers use (optional)
- Agreed format files (xls, xml, dbf) received by e-mail or on storage media.
- Internet browser (the list is agreed, an Internet channel is required).
- Universal 5 software package (local single-user program, which is distributed free of charge).

Additional system requirements:

- Strict authentication and logging of actions:
- Applicants (Regional Highway Services)
- Suppliers / manufacturers
- Registrar's staff.
- Base security
- Reliability of information storage

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- Continuous work cycle

Ability to store scanned copies of applicants' documents related to the system's electronic documents, as well as their quick search and filtering by criteria.

Monitoring subsystem. In Table 3 the Regulations of CMS work are given – the list of processes which are realized in system, frequency of their performance, people responsible for its performance, the content and sequence of operations included in each process.

Table 3. Regulations of work of CMS

Process	Description	Periodicity	Responsible
Entering directories	The procedure involves the automated import of registers of materials from the directories of the estimated value presented in the estimated programs, their consolidation, streamlining.	Once	
Customer registration	The Regional Road Services are registered in the database as Applicants at the stage of launching the CMS.	Once	Registrar
Supplier Registration	1. The Suppliers fill in an application for the Register of Suppliers. To do this, they fill in and send supporting documents in accordance with the regulations of the Registrar and "Price Information". A template in XLS file format, available on the Registrar's website, is used to complete the list of construction resources and generate a report. The Supplier's registration data and the list of materials offered by it are sent to the Registrar by e-mail or downloaded through the website. 2. The Registrar shall consider the application and, in case of a positive decision, temporarily (until the end of the accounting period or until all necessary documents are received), shall include the Supplier in the register. A personal section is created for the Supplier on the Registrar's website for further exchange of information with the Registrar. The following is sent to the supplier: a. Registration data for entering the personal section of the site. b. If necessary, a certificate of inclusion in the Register (paper copy).	Once	Registrar Supplier
Submission of information about the price of materials	1. The Customer and / or the Supplier, in accordance with the Application Rules, fills in the established application template in XLS-file format and sends it to the Registrar by e-mail or uploads it to its website. 2. Based on the application, the Customer and / or the Supplier generates a "Price Information" report. The report is printed by the Supplier, signed and sent to the Registrar.	At any time	Customer, Supplier
Confirmation of acceptance of information	1. Electronic applications (new prices) are temporarily stored in the database until the Registrar receives a printed version of the application from the Supplier. 2. After receiving the printed version, the Registrar considers (checks) the application and, in case of a positive decision, includes the new prices of the Supplier in the register. The following is sent to the supplier: a. Electronic confirmation of inclusion of prices in the Register. b. If necessary, a certificate of inclusion in the Register (paper copy).	As applications are received	Recorder
Application processing	Accepted applications are consolidated according to the following rules: – Unique keys for entry in the database are " resource code DBN" + "Manufacturer" Applications submitted one month before the end of the accounting period are valid for the next accounting period	As applications are received	Recorder

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Replenishment of the directory	If the Customer and / or the Supplier discovers the absence of the material offered to him, he may offer to add new items to the database. The Customer and / or the Supplier may propose to change the table of correspondence of the generalized names of materials on which the analysis is carried out and resources from the collections of the estimated cost.	As applications are received	Customer, Supplier
Approval of the directory	The registrar independently fills in the directory of materials of CMS The registrar agrees the table of compliance with the owner of the CMS by informing about the changes	1 time during the accounting period	Registrar

Subsystem "analysis"

The sample size is calculated at the design stage of the sample survey.

$$n = \frac{t^2 \sigma^2}{\Delta^2}, \quad (1)$$

where: Δ – permissible error, which is set by the researcher based on the required accuracy of the results of the designed sample;

t is a tabular value corresponding to a given confidence probability F (t), which will be guaranteed estimates of the general population according to the sample survey;

σ^2 – is the general variance.

The sampling error or, in other words, the representativeness error, is the difference between the value of the indicator obtained from the sample and the general parameter.

The average error of the sample mean is equal to:

$$S_{\bar{x}} = \sqrt{\frac{\sigma^2}{n}} = \frac{\sigma}{\sqrt{n}}, \quad (2)$$

Therefore, the average sampling error is greater the greater the variation in the general population, and the lower the larger the sample size.

The variance of the general population is determined by the formula:

$$\sigma^2 = S^2 \frac{n}{n-1}, \quad (3)$$

where: S^2 is the variance of the sample.

$$S_{\bar{u}}^2 = \frac{\sum_{i=1}^{n} \left(u_i - \bar{u}\right)^2}{n}, \quad (4)$$

where: u_i – the price of the resource (material) reported by the i-th supplier, UAH;

– $\bar{u}$ the average price of the resource (material) in the sample, UAH;

The deviation of the sample mean from the general average is equal to:

$$\Delta_u = tS_{\bar{u}}, \quad (5)$$

If the sample size is less than 30, it is necessary to use Student's distribution tables to determine t.

In practice, it is necessary to solve two problems: the first is to determine the sample size for a given calculation accuracy (formula 1); the second, inverse, – when the sample is and it is necessary to determine the possible accuracy of the calculation at a given probability (formulas 2-5).

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Using formulas 1-5, calculations are performed for one resource (material). But the number of resources (materials) that need to be monitored can be:

- in the estimate for cosmetic repair of the room from 10 to 100 positions of materials.
- in the estimate for the construction of facilities of average size from 100 to 1000 items of materials.
- the standard list of materials in the databases of estimated software packages (collection of estimated prices and price lists) contains more than 30,000 titles.

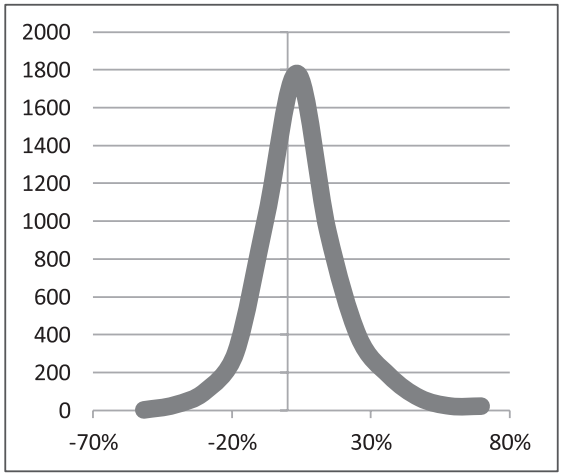
Each item of information resources of the design and estimate documentation has its own market price and individual supply network. Given a given, common to all resources, calculation accuracy and probability, the sample size and market price range for each resource will be its own and will be determined by formulas 1-5. Information can be collected simultaneously for the entire list and information about the price of several different resources can be received from one supplier.

To determine the sample size, it is necessary to know the general variance of the price of resources in the market and the allowable sampling error.

The general fluctuation of the price of resources (general variance) can be established from the data of researches of the market price of the previous periods, or from the publicly available information. For example, according to the cost of construction materials, which is published monthly by the Ministry of Regional Development. The main range of fluctuations in the price of materials is from -19% to + 48% (table 4).

Table 4. Price range for basic building materials according to the Ministry of Regional Development (compiled by the authors)

Deviation from the average price. Interval From to		Number of values	Percentage of total	
-52%	-41%	2	0%	
-41%	-30%	28	1%	
-30%	-19%	100	2%	
-19%	-8%	307	6%	
-7,6%	3%	1033	21%	
3,4%	14%	1782	36%	
14,5%	26%	948	19%	
25,5%	37%	391	8%	85%
37%	48%	184	4%	95%
48%	59%	65	1%	
59%	70%	22	0%	
70%	82%	22	0%	



The schedule of distribution of deviations of cost of construction materials from the average price, according to the Ministry of Regional Development.

Determine the standard deviation of the rule of "three sigma"

$$\sigma \approx \frac{1}{6}\left(x_{\max} - x_{\min}\right) = \frac{1}{6}(48+19) = 11{,}2\%$$

The allowable sampling error (Δ) can be established by experts or determined from a given accuracy of estimates. There are no such standards in Ukraine yet. In Western countries, at the stage of making a decision on construction, the accuracy of estimates is in the range from -25 to + 50%, at the stage of design decision the range is from -10 to + 15%, and at the stage of detailed design – from -5 to + 10% [32]. Based on the fact that for construction the share

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of materials in the total cost is 35%–65% the accuracy of determining their market value should be:

- at the stage of making a decision on construction in the range from -12 to + 25%;
- at the stage of the project decision from -5 to + 7%;
- at the stage of detailed design – from -2 to + 5%

The data on the price range and permissible errors allow us to calculate the minimum average sample size for different design stages (Table 5).

Therefore, to ensure a given accuracy of calculations at the decision-making stage, on average, it is sufficient to have a representative sample of four price proposals. The probability of the result is 0.95 (5 suppliers out of 100 will not fall into a certain price range). At the stage of design decision and detailed design for the given conditions it is necessary to collect 16 and 42 proposals for each material, respectively.

If the price variation is known for the resource (for example from previous periods) then to determine the sample size it is necessary to determine the standard deviation by the rule of "three sigma" and use formula 1 For example: for metal profiles (angle, channel, etc.) standard deviation can be from 5% to 12% then the sample size to determine the market price at the stage of detailed design:

$$n = \frac{t^2\sigma^2}{\Delta^2} = \frac{1{,}96^2 \times 8^2}{3{,}5^2} = 20$$

Table 5. Minimum average sample size for different design stages

	Parameter	Stage		
		Feasibility study	Project stage	Contract stage
1	Accuracy of determining the market value of materials	-12 до +25%	-5 до +7%;	-2 до +5%
2	Permissible sampling error (specified calculation accuracy), Δ	18%	6%	3,5%
3	The standard deviation of the general population, σ	11,2%	11,2%	11,2%
4	Tabular value of t, for a confidence level of 0.95 from the Student's distribution table	3,1825	2.1119	2,0211
5	**Minimum sample size**, $n = \frac{t^2\sigma^2}{\Delta^2}$	4	16	42

Taking into account and analysis of data on the impact of cyclical and seasonal fluctuations on the cost of construction material and technical resources or their groups is proposed to be carried out according to the method detailed in [30-31].

Seasonality indices are determined by the formula [30]:

$$I_{season} = \frac{\bar{y}_i}{\bar{y}_з} x100 \quad (6)$$

where $\bar{y}_i$ – is the average value of the indicator for the i-th period of the year;

$\bar{y}_з$ – the general average value for all years.

In addition to indices, seasonal fluctuations characterize the following indicators [30]:

seasonality:

$$R_{season} = I_{seasion.max} - I_{season\ min} \quad (7)$$

linear seasonality factor:

$$k_{season} = \frac{\sum|I_{season} - 100|}{4} \quad (8)$$

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quadratic seasonality factor:

$$k_{season\ quarter} = \sqrt{\frac{(\sum|I_{season}-100|)^2}{4}} \quad (9)$$

Taking into account and analysis of data on the impact of cyclical and seasonal fluctuations on the cost of construction material and technical resources or their groups is proposed to be carried out according to the method detailed in [4, 30, 31]. Thus, it is possible to carry out a visual assessment of seasonal fluctuations on the graphs (Fig. 2) and to make separate calculations (Table 6-7).

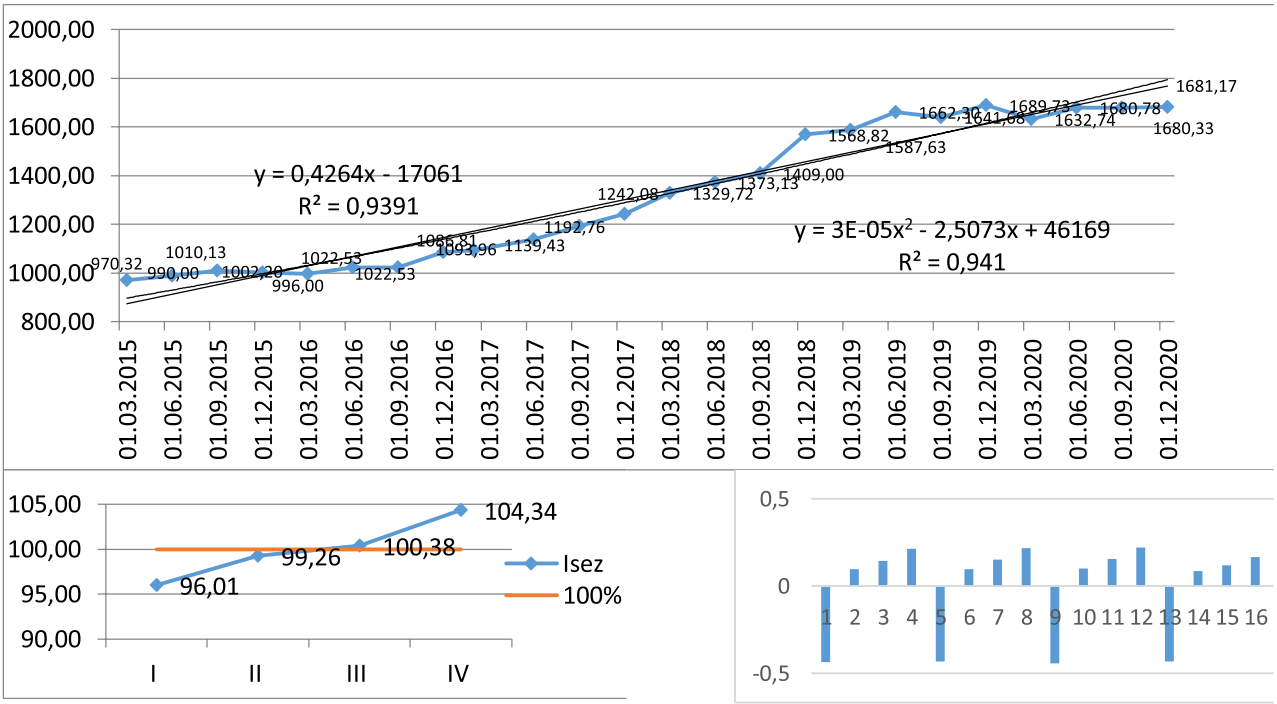

Fig. 2. Visual assessment of the impact of seasonality on the cost of MTP as part of centralized price monitoring

Table 6. Calculation of seasonality indicators

Quarter	Period						$\overline{y_i}$	Is (%)	$\lvert I_{seas} - 100\rvert$	$(I_{seas} - 100)^2$
	2015	2016	2017	2018	2019	2020				
I	970.3	996.0	1094.0	1329.7	1587.6	1632.7	1268.396	96.01	3.99	15.90
II	990.0	1022.5	1139.4	1373.1	1662.3	1680.8	1311.363	99.26	0.74	0.54
III	1010.1	1022.5	1192.8	1409.0	1641.7	1680.3	1326.072	100.38	0.38	0.14
IV	1002.2	1086.8	1242.1	1568.8	1689.7	1681.2	1378.47	104.34	4.34	18.87
General average $= (I_{av} + II_{av} + III_{av} + IV_{av})/4$							1321.075	100	9.45	35.46
Total							1321.075	100	9.45	35.46
$R_{season} = I_{season\ max} - I_{season\ min}$									3.25	
$k_{season} = \frac{\sum\lvert I_{season} - 100\rvert}{4}$									2.36	
$k_{season\ quarter} = \sqrt{\frac{(\sum\lvert I_{season} - 100\rvert)^2}{4}}$									2.98	

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Table 7. Calculation of the seasonal component [30]

Quarter	2011	2012	2013	2014	2015	2016	2017	2018	Average	Seasonal component
1	2	3	4	5	6	7	8	9	10	11
I	745.0	-78.2	579.1	-1285.6	5951.6	-182.0	6174.6	14735.4	3330.0	-303.9
II	-702.1	424.2	230.0	-724.1	2161.6	3413.1	7227.9	18125.0	3769.5	135.6
III	-604.6	834.3	-438.6	-211.3	1088.6	3075.8	10117.4	18741.3	4075.4	441.5
IV	-309.1	655.1	-1053.4	-882.7	-89.0	4881.7	11032.9	12649.0	3360.6	-273.3
Total	-870.8	1835.4	-682.8	-3103.8	9112.8	11188.7	34552.9	64250.8	3633.8	

Conclusion

The results of practical implementation of the price monitoring system and its elements in the formation and maintenance of a database of prices of construction resources by the Directorate for Construction of Facilities for EURO 2012 in Lviv during the construction of Lviv Stadium for Euro 2012, in developing and implementing a price analysis system and the formation of information on current prices for building materials, products and structures in a special format for download in software packages to calculate the cost of construction, for comparative analysis of changes in the volume and cost of the Beskid tunnel at the stage of working documentation compared to the stage of tender offer, development of consolidated indicators of the cost of construction of heat supply networks, in the development and implementation of TOV "AC "Construction-Modern Technologies" system for monitoring the prices of major construction MTR in the regions of Ukraine as an information resource for participants in the construction process proved that analytical tools functional and economic diagnostics of market prices of material and technical resources by enterprises-participants of construction at construction of objects for the state customer increase efficiency for participants of construction. Software for the formation of a centralized price monitoring system (CMS), which should consist of a centralized database that will consolidate information from suppliers, as well as its management system (CMS), provides management with tools for successful project administration at all stages of the life cycle. The implementation of research results confirmed their reliability, practical value and cost-effectiveness.

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