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FOURIER SERIES IN THE MODEL OF FORECASTING THE CONSTRUCTION PRODUCTS INDEX

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Abstract: *The article analyzes the monthly indices of construction products for 2011 - 2021 in Ukraine and identifies periodic fluctuations. The dynamics of production volumes and indices of construction products by types are considered. An approach to forecasting the index of construction products using the tools of harmonic analysis - the technique of constructing a Fourier series.*

Key words: *construction product index, periodic trend, forecast model, Fourier series.*

One of the important and promising sectors of the domestic economy is the construction industry. This industry allows you to create a large number of jobs and use the products of other sectors of the economy. Many modern scientific developments [1 - 5] contain the main provisions for determining the directions of development of the construction industry. However, the issues of determining forecasts for the further development of construction companies remain relevant. According to the author of [1], the domestic construction industry is in crisis. The success of the construction market as a whole depends on filling it with investment resources. The small flow of investment in the construction industry is primarily because today it is very cost-effective. The only way in which the construction industry survives and gradually develops is housing construction. This is of particular social importance as it determines the standard and quality of life of the population. The authors of [2] identified the importance of counteracting the impact of internal and external factors on the functioning of construction companies. Therefore, it is especially important to identify these factors and forecast the efficiency of construction companies, taking into account existing trends in the construction industry.

One of the important indicators of the development of the construction industry and its subsectors is the index of construction products (ICP). ICP, in accordance with international standards, characterizes the change in gross value added at factor value over time [3]. Based on the analysis conducted in [4], it founded that in 2020 the construction industry showed growth, despite the restrictive strict quarantine measures in a pandemic. The key investor in 2020 – 2021 was the state funding of "Large Construction" projects. That is why the positive contribution to the construction of engineering structures doubled the overall growth of construction, compensating for the decline in the construction of both residential and non-residential buildings. Fig. 1 shows diagrams of changes in the volume of construction output for 2011 - 2021, which can observed growth of all indicators.

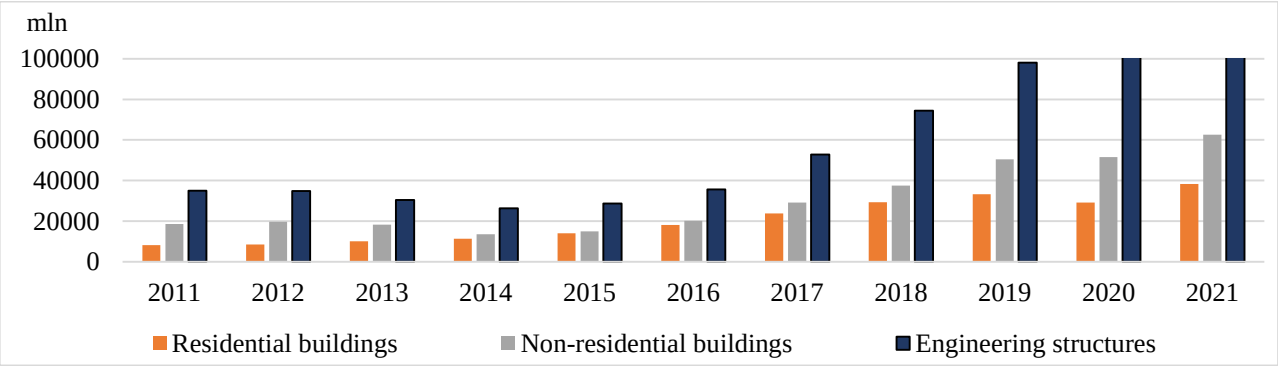

Fig. 1. **Changes in the volume of construction products by type**

However, the authors of [5] point out that this trend can explained not only by the growth in the number of products, but also by the gradual rise in prices. In the context of the problem of analysis of trends in the formation of the ICP indicator, it is important to study not only current data, but also to build a model for ICP

forecasting. The criterion for the adequacy of the ICP projected value should be the maximum proximity to the actual parameter. The initial data of the statistical analysis of the ICP is determined in the form of a discrete time series, which obtained according to the monthly information of the website of the State Statistics Service of Ukraine for 2011-2021 [6]. Fig. 2 shows the dynamics of changes in the values of the ICP, which becomes the basis for the assumption of periodic fluctuations (this can explained by the existing trend of ICP formation).

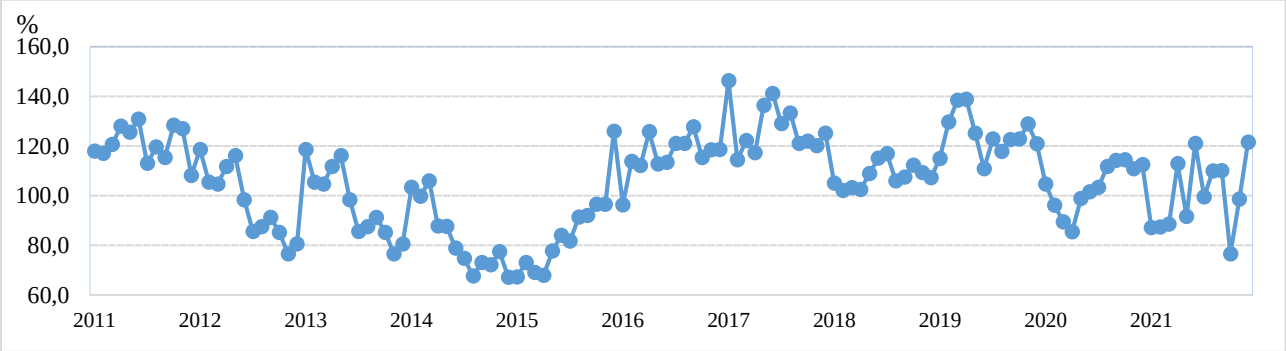

Fig. 2. **Changes of ICP (%)**

The graph in Fig. 2 allows us to determine the violation of the amplitude of periodicity in 2014, 2016, 2018 and 2020. Considering the dynamics of ICP changes, we can conclude that the ICP since 2016 is gradually increasing. In 2018, the growth rate slowed down somewhat, but in 2019 they almost reached the level of 2017. The analysis of indices of certain types of construction (Fig. 3) indicates that the trend of changes in indices of residential construction is completely different and shows a gradual decline , and only in 2019 there was a slight increase, then in 2020 a significant decrease and in 2021 a return to the level of 2017. Non-residential construction and civil engineering have the same dynamics as the general index: gradual growth with decline in 2018 and further fluctuations in 2019–2021.

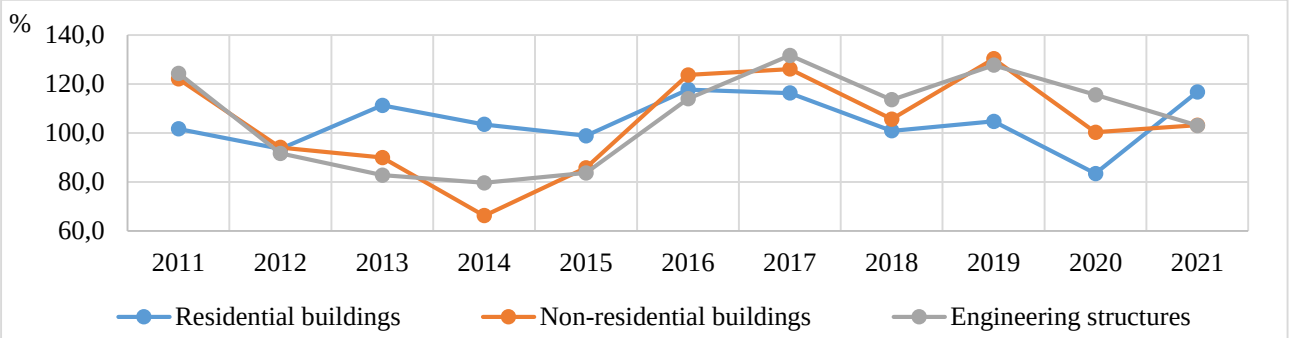

Fig. 3. **Dynamics of indexes of construction products by types (%)**

As a basis for building a forecast model, it is advisable to use the scheme of extrapolation, which based on the assumption of maintaining existing trends in time series. In general, functions with periodic character can represented as a linear combination of trigonometric functions. Therefore, since the changes in the studied ICP are periodic, it is advisable to use the periodic Fourier function. This extrapolation technique been used by the author of this work in studies of the industrial production index [7]. The Fourier approximation consists in the choice of such harmonic oscillations, the superposition of which on each other would reflect the periodic oscillations of the studied time series. As a development of the applied aspects of the application of Fourier series, it proposed to present the periodic component of the ICP. Forecast model presented in the form the trigonometric Fourier series: $I = A_0 + A_1 \cdot \sin\left(\frac{2\pi}{12}(t - C_{12})\right) + A_2 \cdot \cos\left(\frac{2\pi}{12}(t - F_{12})\right)$, where I – function of ICP with a fluctuation period of 12 months, A_0 – offset relative to the initial value, A_1 – amplitude of the sine

wave, C_{12} – the initial phase of sinusoidal oscillations, A_2 – amplitude of the cosine, F_{12} – the initial phase of cosine oscillations, index 12 shows the period of change of the ICP.

Using the functions of the MS Excel software environment, founded parameters of the ICP forecast model – $A_0 = 89{,}1$, $A_1 = 1{,}8$, $A_2 = 3{,}9$, $C_{12} = 5{,}4$, $F_{12} = 2{,}9$, coefficient of determination of the constructed model – $R^2 = 0{,}781$.

To assess the significance of the coefficient of determination, its minimum value calculated, according to which the correlation considered significant: $R^2_{\min} = \frac{t_\alpha^2 (n-1)}{n-2+t_\alpha^2 (n-1)} = 0{,}04$, where t_α – Student's coefficient for confidence probability 0.95 ($t_\alpha = 1{,}98$).

Thus, the significance of the correlation of the ICP output line with the constructed forecast line proved. High forecasting accuracy may not observed at all times, but in general, it is possible to perform a short-term forecast. The main task of extrapolation using the Fourier series is to take into account in the model a deterministic component that is present in the time series, and discard a random component that will determine not the predicted average value but its confidence interval. Assuming a normal law of distribution of the model deviations for a confidence probability of 0.95, the confidence interval of the ICP forecast value can calculated by the formula: $Y\left(1 \pm \frac{t_\alpha (n-1) \cdot \sigma}{\sqrt{n}}\right)$, where Y – the value of the ICP for forecast model equation, $t_\alpha (n-1)$ – Student's coefficient, n – number of observations, σ – the relative standard deviation of the model residues.

It established that the accuracy of the forecast does not exceed the permissible deviations. This indicates the possibility of using the built model in practice. This tool of harmonic analysis allows not only determined the correspondence of actual and forecast (planned) values, but also identified future trends in ICP formation and establish a scientifically sound value (or interval) with a high probability of achieving it. This process of forecasting modeling eliminates certain elements of uncertainty in management. Using the proposed methodological approach to determine the forecast values of ICP indicators will provide results of analysis that have practical value in addressing current issues of ICP forecasting in order to develop effective and timely measures to stabilize it. It can concluded that the proposed approach to forecasting is expedient and promising for solving urgent practical problems.

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