

Model of determination and forecasting of prices of forest products using the example of pulp

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Abstract. The paper presents the problems of the development of the Russian forest complex at the present stage, which are confirmed by a decrease in the volume of production and export of forest products. Fluctuations in global and domestic prices for forest products create real problems of sustainable and effective development of the forest complex. Many factors determine the dynamics of timber prices and affect various components of price dynamics. As the correlation analysis showed, the main influence on the trend component of pulp prices on the world market and the Chinese market is exerted by: the change in GDP per capita as a percentage, the inflation rate and the growth rate of investments. To determine the trend in pulp prices for the Chinese market, we used official data from GDP growth forecasts. Highlighting the determinants of development and forecasting, taking into account the main factor of gross product, the trend-cyclical model of pulp prices allows us to anticipate natural deviations in market development, plan the cost of forest products, the cost of exporting forest materials, which is important for the financial situation of forestry enterprises. In general, the developed methodological approach is applicable to other types of forest products, and the results of the study can be used by enterprises, organizations of the forest complex when studying market conditions and planning activities for various periods. At the level of state bodies, forecast models allow planning the cost of export-import turnover of forest materials, production of products by forestry enterprises.

1 Introduction

The forest complex of Russia has significant potential associated with the presence of a large-scale forest resource base, which is estimated for 2022 at 1185 million hectares (total forest area), which is a third of the world forest area. According to the materials of the state forest register (2021), the stock of wood in the forests of Russia is about 78 billion cubic meters. Currently, the annual estimated forest cutting is estimated at 730 million m³, but is used by less than 30% [1, 2]. A significant interest for the forest complex is the study of the price dynamics of the forest products market, which is difficult to study due to the unstable

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situation. The export of forest products to Russia remains significant, as more than 30% of the produced products are supplied to the world market [10, 13]. The development of the forest products market is associated largely with the prospects for the development of global consumption, which remain optimistic, and domestic consumption is developing inactive. The new UN report "Global Forest Sector Forecast 2050: Assessing Future Wood Demand and Sources for a Sustainable Economy," published in 2022, presented an optimistic forecast of the world's global consumption of timber products, which is associated with the accelerated development of the replacement of non-renewable materials. The projected consumption of wood products exceeds the projected 25% growth of the world population [2, 3]. Consumption of wood products will be driven by higher incomes in emerging economies, which will lead to catch-up effects on consumer goods (e.g. paper, packaging, clothing and furniture) and expansion in the construction sector [3]. In addition, like other sectors of the Russian economy, the forest complex is in a difficult situation today, therefore, in 2022, compared to 2021, there was a significant decrease in the rate of production and export of forest products. In 2022, there was a decrease in production volumes compared to almost all segments: lumber - by 11%, pellets - by 18.5%, plywood - by 27%, chipboard - by 6%, OSB - by 22%, MDF and fibreboard - by 11.1%, pulp - by 1%, paper and cardboard - by 2.5%. The negative results of the activities of the Russian forest complex are primarily associated with new factor changes in the global forest products market because of a large-scale sanctions trend. The reorientation of Russian trade flows of raw materials, semi-finished products and final products to Asia led to a restructuring of logistics, an increase in the cost of transportation, a break in projects with Western partners, and a fluctuation in the exchange rate. A number of industries owned by foreign owners (UPM, Stora Enso, and International Paper) have been suspended in Russia. There were problems with the supply of imported timber equipment, spare parts and equipment. The negative situation was intensified by fluctuations in prices for forest products in the global and domestic markets and on the eve of the expectation of a global economic recession in late 2022 and early 2023.

The closure of European forest markets to Russian producers has prompted increased trade with China as an important agent in global trade and cooperation in the trade of wood products, pulp, paper, cardboard and paper products, influencing international trade in paper and related products around the world. China is the world's main consumer of pulp (up to 70%). Over the past years, its needs have remained the main and defining indicator of the global market. The increase in pulp processing in China is associated with fundamental macroeconomic factors: growth in gross production, investment growth, a stable exchange rate of the national currency, low inflation, population growth, increased prosperity and culture of population consumption, etc. The dynamics of pulp consumption in China and other regions of the world is also influenced by new volatile factors due to the turbulent epidemiological and environmental situation. The increase in the export of Russian pulp to China is also associated with new trends arising from environmental protection. So, in China in 2017, a law was adopted banning the import of solid waste. In January 2021, a ban on the import of waste paper into China was introduced. These bans have contributed to the growing need for primary pulp. Another determinant of Russian pulp exports is the Chinese paper plastic packaging replacement program, which also provides an increase in the need for cellulose fiber for packaging materials. Therefore, by 2025, Russian pulp exports may amount to more than 3-3.5 million tons. Of course, Russian producers are geographically located closer to China.

Thus, the steady and stable growth of China's paper industry remains the main driver of the development of the global pulp and paper industry, and the current trend of reorienting Russian pulp exports will continue in the long term. In this regard, producers, traders are interested in forecasts of volumes and prices for forest products, projecting trade flows of forest products to China.

2 Relevance of the research

The relevance of the study is determined by the significance of forecasting forest complex indicators. The study of price dynamics for forest complex products, including pulp of various types, the development of price forecasting models will become tools for supporting management decisions for forest complex entities and government agencies, and will allow: to predict the volumes, structure, dynamics of forest complex production; plan the supply of forest products; plan tax revenues, customs tariffs to the state budget, government orders. Price forecasts help forest business entities make informed decisions when setting goals, when developing development policies and strategies, when drawing up a budget and developing a financial model, when developing an investment program and business plans, and other processes that determine the effectiveness of the company. The high volatility of world and domestic prices for forest products creates real problems of sustainable and effective development of the forest complex. Thus, for the period 2020-2022. Fluctuations in European pulp prices ranged from \$820 per ton at the beginning of 2020 to \$1,480 at the end of 2022. The fall in world pulp prices continues to this day. In April 2023 alone, North American pulp prices declined by \$50 -75/t. Price fluctuations also occur in the domestic forest products market. Thus, the price of pulp at the end of 2020 amounted to 43-45 thousand rubles. per ton, and by the end of 2021 already 65-67 thousand rubles/t with a subsequent decrease during 2022 to 58 thousand rubles/t. Currently, the price of pulp of all types is decreasing. In February 2023, the price of pulp decreased by 1.7%, in March 2023 by another 1% and amounted to an average of 55 thousand rubles per ton. In April 2023, the average prices of producers for pulp amounted to 52 thousand rubles/t. A significant change in prices occurs for other types of forest products, when sanctions on Russian forest products destroy world trade flows, thereby transforming the global forest market. For such types of products as lumber, wood boards, veneers and plywood, prices have decreased significantly over the period 2022-2023. Prices for forest raw materials and, in particular, round timber have dropped to values three and four years ago and are at a minimum level. In such conditions, the relevance and role of forecasting the dynamics of prices for forest products increases significantly. Finding trends and patterns, calculating multivariable forecasts, choosing optimal development options are one of the main tasks of macro and micro forecasting. The purpose of the study is to develop a multi-factor model for the isolation of determinants and forecasting, taking into account the main factor of gross product, a trend-cyclic model of prices for timber products using NBSK pulp for the Chinese market. In accordance with the set goal, the work solved the following scientific and practical problems:

- existing methods for forecasting prices for forest products have been updated and analyzed;
- calculations and analysis of the main characteristics and structure of price dynamics on pulp in the domestic and global markets were carried out, and principles of their adequate reflection were developed;
- identified the factors that determine the nature of the movement of pulp prices, assessed the impact of various factors on the development of pulp prices;
- forecast trend-cyclic model of pulp prices has been developed, and an adjusted model taking into account the GDP forecast.

Thus, the scientific novelty of the study is determined by the obtained results of a theoretical and practical nature related to a comprehensive assessment of the influence of various factors on the dynamics of pulp prices and the development of a price trend-cyclic model. The obtained results of the study of trends and patterns of price movement, the development of multivariable price forecasts will expand the theoretical and practical foundations of macro and micro forecasting.

3 Theoretical review of studies

Many accounting and research groups of industry specialists were engaged in research and assessment of development, forecasting of the forest complex. Some famous scientists can be cited: N. A. Burdin, I. N. Voevoda, A. S. Isaev, M. D. Kargopolov, N. P. Kozhemyako, V. A. Kondratyuk, N. A. Moiseev, A. P. Petrov, A. I. Pisarenko, A. V. Plastinin, A. Chernovol, V.A. Chuiko, E.A. Schwartz, A. Shvidenko, I.R. Shegelman, V.M. Shlykov, V.Yu. Schmidt, et al. Sheingauz A.S. and Antonova N.E. were engaged in the study of the forest complex of the Far Eastern region [3-6]. Scientists analyzed the ongoing changes in the natural resource sector of the region and established the dependence of the region's economy on the efficiency of the use of natural resources. Scientists investigated the forest complex of China, and found that its development began later than other industries, but in 15 years, the country became the largest producer of forest products and an important exporter of forest resources [1, 5, 6]. A.S. Sheingauz showed the dependence of the development of the forest complex of China on Russian timber imports, highlighted the main factors of the success of exports from Russia, among which logistic ties can be distinguished [5, 6].

The study of pricing and the relationship of prices with various factors is carried out constantly, since pricing largely determines the profitability and profitibility of the activities of economic entities. Among the earlier works can be noted the works of A. Ando [7], M. Blaug [8], R. Friedman [8, 9], etc. Theoretical models of prices of I. Fisher [10], S. Ross [11] and W. Sharp [11] remain relevant. Kendall M. J. and Stewart A. studies [12] provide a technique based on multivariate statistical analysis. In recent periods, more attention is paid not so much to theoretical aspects of pricing, but to practical modeling of relationships [13, 14]. N.D. Kondratyev founded the Russian School of Forecasting in the 20s of the XX century. Macro forecasting methodology, taking into account cyclicity and developed by A.I. Anchishkin, V.A. Bazarovm, A.N. Efimov, V.A. Kotelnikov, Yu.V. Yaremenko, Yu.V. Yakovets, etc. Research institutes and organizations analyze and on its basis predict the development of the forest complex: the Center for Macroeconomic Analysis and Short-Term Forecasting, the Institute for the Development of Science of the Russian Academy of Sciences, the Higher School of Economics, the European Commission, the International Institute for prikladnogo Systems Analysis, etc. Leading analytical and consulting companies specialized in this area are engaged in forecasting the performance indicators of the forest complex and the forest market. Large world corporations and LPK holdings also develop forecasts, but most forecasts represent the volume of production and consumption of forest products. As a rule, price forecasts are given for the near future. Most often, expert estimates of prices for the main types of forest products are given. This prudence is due to the high volatility of prices for forest products. Thus, for the period 2020-2022 price fluctuations ranged from \$820 per ton at the beginning of 2020 to \$1,480 at the end of 2022. A.Yu. Ermakova developed an annual forecast of prices for wood and lumber based on the construction of approximating functions [15]. Scientists of the Lesosibirsky branch of Siberian State University T.G. Ryabova, A.P. Mokhirev, S.O. Medvedev, A.S. Lyshko investigated the factors acting on the pricing of forestry enterprises [16]. Scientists have determined that the key factors for the forest market are demand, supply, consumer choice and government regulation, and studied individual and average prices. Scientists of the All-Russian Research Institute of Forestry and Forestry Mechanization L.V. Borisov, P.T. Voronkov, A.N. Belov investigated the dynamics of average regional prices from 2003 to 2012 for timber in six federal districts of the Russian Federation, and tried to assess the impact of structural shifts in production on price dynamics [17].

Thus, to date, researchers have developed a variety of forecasting methods and models from simple averaging techniques to complex hardware and software systems, but the changes that are taking place today predetermine the development of new forecasting

methods. Predictive models based on a combination of quantitative and qualitative methods are becoming more and more popular.

4 Research objectives and methods

NBSK softwood pulp (Europe, China and USA), BHKP hardwood pulp (Europe and China) prices were analyzed using the PIX index database of weekly market price measurements of different types of pulp. Price samples of pulp of different types are statically checked, verified and representative, therefore it can be considered that the results and conclusions reflect real processes [18, 19]. The study involves software products and software tools for data processing: MS Excel, SPSS. The algorithm for developing a multi-factor model [21, 22, 23] for highlighting and evaluating the determinants of forecasting the dynamics of prices for timber products using NBSK pulp for the Chinese market includes several stages (Table 1).

Table 1. NBSK China multi-factor price model methodology

Stage	Characterization
1st stage (staged)	Setting targets for modeling NBSK pulp price trends. Definition of macroeconomic variables of the model.
2nd stage (a priori)	Analysis of NBSK pulp price dynamics structure, formation of a priori information and assumptions to input statistics.
3rd stage (information)	Collection, processing of statistical information on price dynamics on NBSK pulp
Stage 4 (direct simulation)	Model view definition based on correlation matrix in regression: <ul style="list-style-type: none"> - analysis of indicators determining the development of the NBSK China price trend, - analysis of variables affecting the development of seasonality and cyclical price dynamics NBSK China
Stage 5 (model identification)	Define intercorrelation to exclude duplicate factors from the model.
Stage 6 (model adequacy check)	Final regression check for multicollinearity of factors.

4 The results of the analysis

The dynamics of the average monthly index prices NBSK and BHKP for Europe, the USA have positive trends over a long period. The dynamics of index prices NBSK and BHKP for the Chinese market have a similar structure with price dynamics for Europe, USA. The NBSK China price time series analyzed from 2011 to 2022 contains two different trends in focus and duration (Chart 1). There is a negative trend between Q3 2011 and Q3 2016 (Table 16). At the BOM stage, a linear trend was selected. Its parameters were evaluated, statistical significance was checked using the coefficient of determination and the Fisher test.

It was found that the trend parameters are statistically significant.

Downtrend equation: $y = -5.48 t + 743$.

The rest of the price trend shows an uptrend, which can also be represented by a linear trend (Fig. 1). The ascending trend equation is $y = 7 t + 658$.

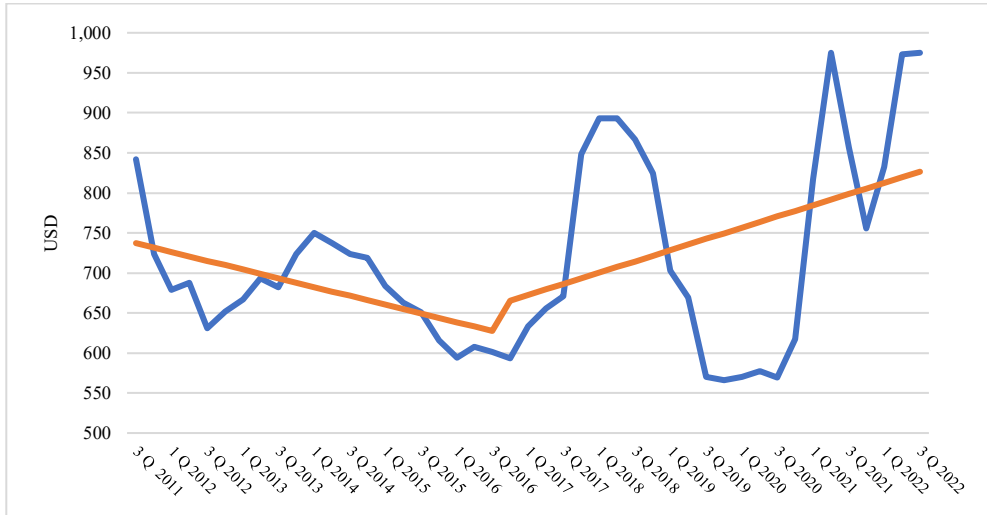


Fig. 1. Initial trends in pulp price dynamics NBSK China market

The studied time series of pulp prices in the global market and regional segments developed under the influence of many factors, that is, it takes into account the whole variety of conditions. Consequently, it can be assumed that the studied price dynamics reflect the natural process of price development. On the other hand, to improve the quality and reliability of forecasting, an analysis of the main factors is necessary. Initially, the results of analysis of macroeconomic indicators determining the development of the NBSK China price trend were obtained (Table 2). The obtained values of factor correlation coefficients are analysed by absolute values. The weakest link is established between the key rate and other factors, so this factor must be excluded. The strongest inverse link is between prices and imports.

Table 2. Correlation matrix of annual prices NBSR USD China from 2011 to 2022 with macro indicators in monetary and other dimensions

Indicators	Correlation coefficient with index value NBSK
GDP, trillion yuan	-0,15
GDP, billion USD	0,09
GDP per capita, USD	0,05
Direct investment, billion USD	0,28
Trade balance, billion USD	-0,29
Import, billion USD	-0,69
Exports, billion USD	-0,31
Number, billion people	-0,14
Inflation,%	0,22
Course Yuan / USD	-0,29

Source: Developed by the author

Correlation analysis of macroeconomic indicators shows that some of them have a close connection not only with the resulting indicator, but also with each other, which can distort the results. Other indicators have a weak impact, but they can be taken into account to increase the effectiveness of the analysis of factors. Given the weak correlation relationships of adding macroeconomic factors to China's development, NBSK index prices are not advisable to build a forecast model. Therefore, the rate of change in annual macro indicators

was calculated and the correlation with the rate of change in the average annual index prices of China was measured. This analysis showed that GDP growth rates in both national currency and USD, as well as % change in direct investment, can have a positive moderate impact. The most powerful positive influence is the % change in GDP per capita. The % change in inflation and the exchange rate of the national currency to USD have a negative impact on the change in NBSK prices (Fig. 2).

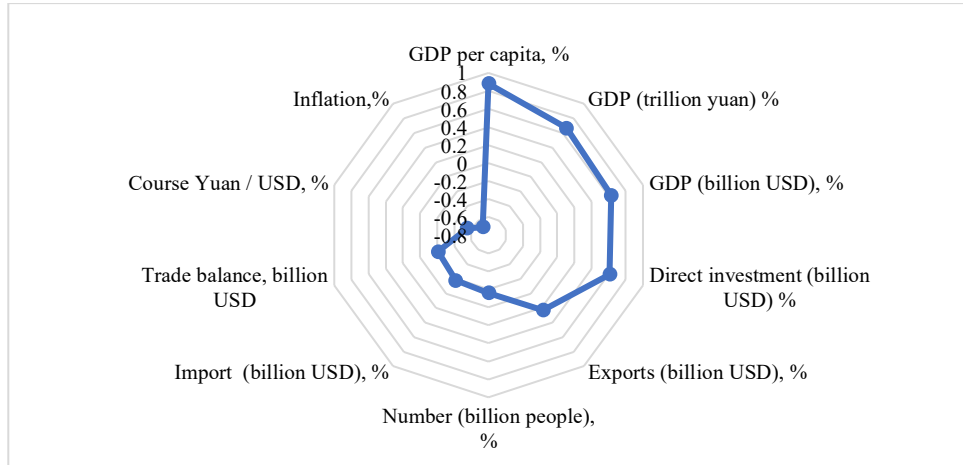


Fig. 2. Correlation of %-change in macro factors and %-change in annual prices NBSR China from 2011 to 2022

Source: Developed by the author

The inclusion of macro indicators in the model can be limited by inter-factor dependence and connectivity, which overestimates the close relationship between variables, therefore, the partial correlation coefficients are determined with subsequent testing and elimination of multicollinearity. Thus, GDP expressed in national currency and in USD, GDP per capita show strong multicollinearity and, therefore, one of the macro indicators should be left in the factor regression. In addition, the method of maximizing the variance of the initial dynamics of pulp prices was used to select the main determinants. For the identified factor regression equation, taking into account the correlation, it is optimal to include the %-change in GDP per capita. However, to include this macro-indicator in the regression model, it is necessary to have official confirmed predictive data for prediction. Now, there are confirmed data on GDP growth rate in USD, accordingly, when this macro indicator is included in the factor model to predict the trend of NBSK prices, a slightly large error in the forecast regression may be observed. Verification of the significance of the resulting factor regressions showed that inflation rates and private equity growth rates, which have a negative impact on NBSK's trend price growth, are also important factors. Nevertheless, the inclusion of macro data in the model is also problematic, due to the presence of official forecast statistics. As a result, a transition was made from 10 initial determinants to two generalizing characteristics (%-change in GDP per capita and %-change in inflation), which make it possible to explain about 70% of the variation in the initial dynamics of pulp prices.

Thus, the influence of a number of macroeconomic factors has a strong influence and can be used with great confidence to predict the price trend. It is advisable to include in the model of factor regression %-change in GDP per capita, the rate of inflation and the rate of investment growth. However, due to the lack of forecast data on the %-change in GDP per capita for China for the long term, it is recommended to determine the trend development of market conditions by the rate of GDP growth. According to international forecasts of

economic dynamics (UN (UN Conference on Trade), World Bank, IMF, OECD, etc.), China's growth is expected to recover in the blissful future. It should also be included in the factor model to predict the price trend NBSK China inflation rate and growth rate of direct investment.

Further, the results of the analysis of variables for the development of seasonality and cyclical price dynamics of China's NBSK were obtained. Cycling with a lag of 12-16 quarters in the time series of pulp prices in the Chinese market has been established since 2011 (Chart 2). The difference between the minimum and maximum price in cycles excluding the trend is from + 150 to - 200 dollars (Fig. 3).

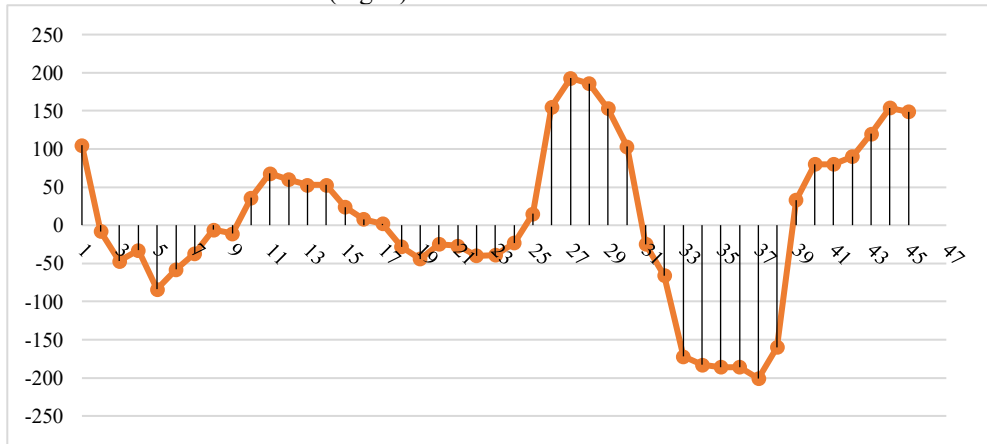


Fig. 3. Cyclical fluctuations of NBSK China price dynamics, USD

Source: *Developed by the author*

The imbalance in the pulp market is caused by price and non-price factors. The main non-price factors of supply and demand: inflation expectations, purchasing power, changes in the costs of factors of production (forest resources, raw materials, energy resources, etc.), improvement of technological processes, economic policy (taxes, subsidies). Thus, subsidies lead to a decrease in the cost of pulp production and/or processing, which certainly stimulates market expansion. Pulp supply is closely related to investments, which are hardly predictably responsive to market conditions, since they depend not only on private investment of entrepreneurs, but also on the investment policy of the state. Other government programs and industry regulation have a strong impact on the pulp price trajectory. Government policy on the regulation of pulp imports/exports and other types of forest products, an increase in the tax burden on producers can become a significant regression of pulp price dynamics. Inflationary expectations of producers and buyers can also have a mixed impact on pulp sales, usually with the observed decline in pulp prices, there are a large number of extended contracts (per annum or more). Gradually there is an increase in demand, which causes a revival in supply, in turn, pulp producers are starting to raise prices. Again, there is an excess of supply over demand, which moves prices to the bottom. Such fluctuations in pulp supply and demand lead to brief cyclical changes. Important indicators for pulp producers, independent agents, and traders are sales and pulp inventory levels [12, 13]. Thus, seasonal and cyclical changes in pulp prices are a function of many market variables that can affect pulp supply and demand.

When predicting the price dynamics of forest products, it is important to take into account and connect all the structural components of the time series. According to the developed adaptive trend-cyclic forecasting model, two versions of the price forecast for the period up to 2029 can be presented, with cycles of 13-15 quarters and a trend according to the actual previous increasing data, and an adjusted trend according to the growth rate of China's GDP

(Chart 4). The forecast was developed at the end of 2022 for the project to build a pulp mill with a capacity of 1 million tons of softwood pulp in the Krasnoyarsk Territory. Based on the results for the 1st - 2nd quarter of 2023, the forecast prices are confirmed by actual data.

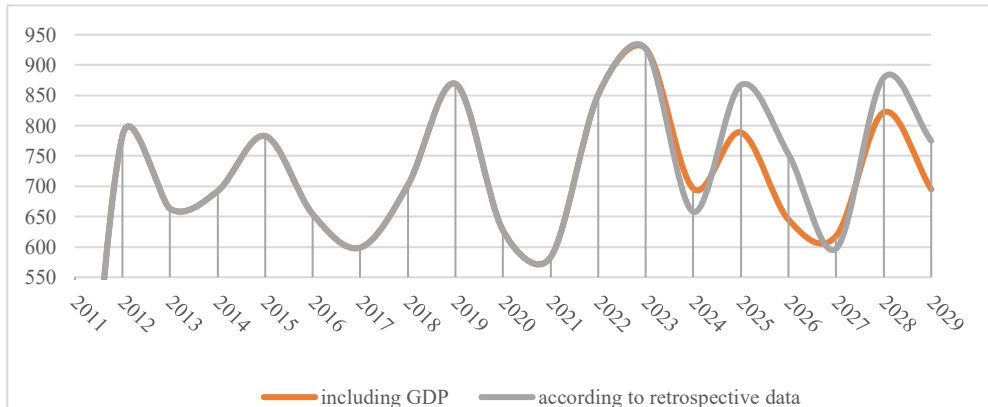


Fig. 4. NBSK China Price Dynamics Forecast 2023 to 2029

Source: Developed by the author

5 Conclusions

Highlight the highlights of NBSK's Pulp Price Forecasting Study for the China Market:

- The structure of pulp price dynamics was established, and a model was developed taking into account the trend, cyclic and seasonal components.
- An algorithm for predicting the dynamics of pulp prices has been developed and tested, which is based on samples of retrospective price data.
- Model for predicting the dynamics of pulp prices has been tested and verified.
- A forecast of the dynamics of pulp prices for the Chinese market until 2029 has been built.

The main impact on the trend component of pulp prices in the world market and the Chinese market is influenced by: %-change in GDP per capita, inflation rate and investment growth rate. In the absence of forecast data on these macro indicators for the long-term period, it is recommended to determine the trend development of market conditions by the rate of GDP growth. Short-term determinants form seasonal and cyclical fluctuations in pulp price dynamics. Among the short-term factors, it is necessary to highlight: pulp production and sales volumes in the world and in the analyzed region, logistic schemes of pulp commodity flows, pulp reserves, which are influenced by non-price supply and demand factors [18, 19, 20]. Here you have to analyze a wider range of variables related to industry indicators. So important seasonal and cyclical repressors are: volumes of harvesting and wood reserves, production capacities and volumes of pulp production, capacities and volumes of its processing, logistic schemes for the supply of pulp and many other factors. Factors may affect unidirectional or in different directions, with amplification or attenuation of their effects occurring.

In general, this methodological approach applies to other types of forest products, and the results of the study can be used by enterprises, organizations of the forest complex in studying market conditions and planning activities for different periods. At the level of state bodies, forecast models make it possible to plan the value export-import turnover of forest materials, the production of products by the forestry industries.

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