

Factor analysis of forest product price trends

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Abstract. The article considers some macroeconomic indicators that are potentially factors of price changes of forest industrial products using econometric methods. The study also determines the extent of influence of these factors on price values. The results of the analysis give an idea about trends in price changes of the forest industry complex, describing trends and market structure, and forecast price models of products of forest industry complex. In the construction of a forecast model for forest complex production, the multicollinearity of the macroeconomic factors considered, which presumably form the prices for products of the wood industry (plywood, hardwoods and softwood lumber) was taken into account. The price values of the Shanghai Stock Exchange were taken as a determining factor for the analysis of the dynamic series. The macroeconomic indicators of the North-West Federal District were considered as hypothetical effects on forest prices: currency exchange rate, GDP, population size, average per capita income, labour force size, inflation, reforestation. After correlation and regression analysis, four main factors were identified that shape the price of forest products selected for research (currency, population, per capita income, reforestation rate). This model can be used to determine the forecast values for forest products prices. Its availability is important for further development of proposals and measures aimed at regulating the values of the identified factors with a view to further manipulation of the prices of the forest industry complex, since their dynamics depend on them, including the country's budget revenues. In the current conditions related to overcoming external sanctions barriers, it is particularly important to find additional sources of income for the federal budget.

1 Introduction

The relevance of the topic of the study is due to the need to carry out an analysis of dynamic price series for forest complex products and factors influencing them, including for subsequent price forecasting. The study of the price change in forest products is important, as the forest complex plays an important role in the economy of forest-rich countries such as Russia, which has a quarter of the world's forest resources. The study of factors influencing forest product price dynamics allows to forecast market changes and make informed decisions on forest sector management and adjustment of tactical and strategic policies. Also, forest product price analysis can help to identify potential risks for producers and consumers of forest products. For example, the change in the dollar rate can have a significant impact

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on the value of forest products both domestically and internationally. It is therefore important to consider all factors that may influence the price of forest products in order to have a more accurate forecast. In addition, macroeconomic factors such as inflation, unemployment, income and other factors that may affect the supply and demand of forest products should be considered. The analysis of the price dynamics of forest products allows to identify trends and patterns that will help better understand the market situation and take effective management decisions.

In addition to sectoral indicators, such as supply (harvested wood) and many other macroeconomic factors influence the price of forest products: the dollar, inflation, average per capita income, world market situation, etc.

The volume of timber harvested in Russia has varied considerably over the past five years (Fig. 1), not only due to economic factors and sanctions, but also due to the tightening of the legal framework adopted for the conservation of forest resources. The tightening of legislation has a significant impact on the volume of timber harvested. The introduction of new regulations and rules creates difficulties in logging and increases in reforestation costs, which also cause fluctuations in wood prices. Increasing the cost of logging can reduce companies' profits and reduce interest in investing in this area. Therefore, the change in total harvested wood is a key indicator for assessing forest management in a country and measures need to be taken for sustainable use of forest resources and conservation of forest ecosystems.

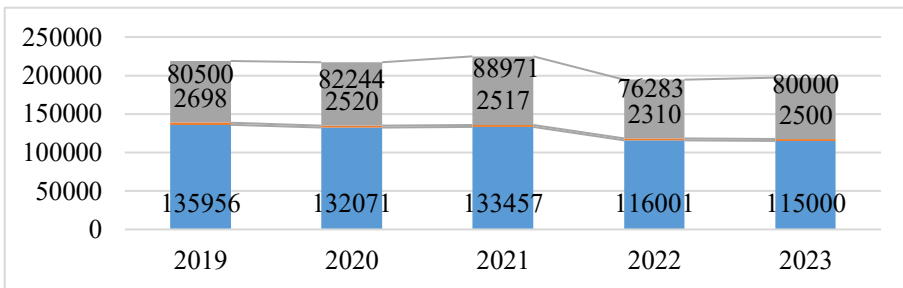


Fig. 1. Volume of wood production in Russia, thousand. m3.

2 Materials and methods

Considering the dynamics of total harvested wood from 2017 to 2022 (Fig. 2), it is necessary to note its overall decrease in the Russian Federation by 8.38%.

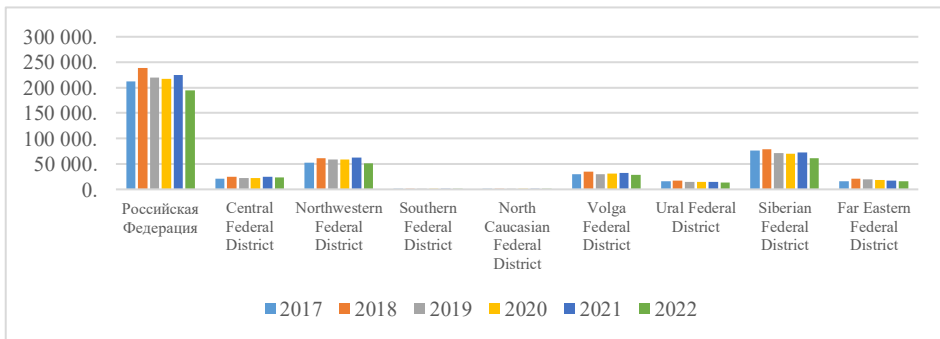


Fig. 2. Volume of harvested wood (thousand cubic metres) [1].

Analyzing chain indices, it is important to note the variation of harvested wood volumes during 6 years of time: in 2018 growth was +12.3%, in 2019 there was a decrease of 8%, in 2020 also a decrease of 1%, in 2021 growth of 4% and in 2022 a decline of 13%. This is due to the country's ban on exporting unprocessed wood. At the regional level, it should be noted that positive growth (+6.56%) was observed only in the Central Federal District. The most negative trends were noted in the North-Caucasus (-44.72%) and Southern (-31.08). It is important to note the strong negative trend of the indicator in question in the Siberian Federal District (-19.54%). The volumes of harvested wood in SFR in 2022 were 31% of the Russian value (fig. 2). It is important to note that in Siberia, the forest industry is one of the most important factors for economic growth, since 73.3% of the area is covered by forest vegetation and forest resources are characterized by high-quality species composition.

The analysis of forest products production in the period from 2017 to 2023. also shows the fluctuation and decrease in production in the last two years (table. 1).

Table 1. Production of forest products in Russia [2].

Products	Change 2023/2022, %	Change 2023/2017, %
Unprocessed timber, thousand m ³	109.2	144.7
Sawn timber, thous. m ³	110.5	138.5
Softwood lumber, thousand m ³	106.0	119.5
Fuel granules (pellets), thousand tons	72.0	109.4
Plywood, thousand m ³	107.1	93.2
Chipboards, million m ³	120.6	146.8
Cellulose, million tons	105.9	108.4
Paper and cardboard, million tons	99.4	117.0

Besides the importance of volume indicators of forest products production for the economy, price dynamics are also important. In order to understand the budget revenues from forest complex products and to have an opportunity to influence them, it is necessary to know about the price projections of the different types of forest complex products. To do this, it is important to understand the factors that contribute to changing prices of forest complex products.

The objective of this study is to identify factors that determine forest products price dynamics and price trends. The following scientific and practical objectives were identified to achieve this goal:

- Collect necessary information, create databases on prices and process them.
- To calculate and analyse the main characteristics and structure of the dynamics of forest products prices using economic-mathematical methods.
- Identify the main trends and patterns of changes in forest product prices.

The study focuses on forest products prices. The study is a forest complex with specific characteristics and features that are related to a multi-level structure, combining primary industries and processing industries that depend on the forest resource base. However, some structural determinants are difficult to analyse and often cannot be quantified as a price effect

on the forest products market. Furthermore, an important aspect of the national forest complex is its integration into the international division of labour and its connection with global market processes. Therefore, all global changes have a significant impact on the economic activities of the forest complex in Russia.

The scientific novelty of the study of the dynamics of forest products prices is to refine methodological approaches to factor pricing and to expand the practical tools for forecasting product prices.

Statistical analysis and economic-mathematical modelling of stochastic dynamics were applied to confirm the price trend for forest products. Regression and correlation analyses were performed during the study. Factor analysis with multiple regression is used as a tool to study complex relationships between variables. Multiple regression factor analysis is a statistical method of data analysis that allows studying the effect of several independent variables on a dependent variable. In this method each factor is presented as an independent variable that can influence the dependent variable.

Steps of factor analysis:

1. Performing correlation matrix calculation;
2. Performing the manipulation of the extraction of factors;
3. Selection and rotation of factors;
4. Interpretation of factors;
5. Calculate the factor values;
6. Assessment of the quality of the model and construction of predictive trends.

Forest products prices were studied using data from the Federal State Statistics Service, the Federal Customs Service and other sources.

3 Results

To construct a multifactor model of the price dynamics of forest products, it is necessary to study a number of regression factors in order to determine their individual influence on the constituent components of the price dynamics. The price dynamics of most types of forest products consists of components such as trend, seasonal and cyclic periodic components, random component. The trend component of price movements depends on macroeconomic factors. The multiple regression model allows to include a large number of factors, however, the more they are, the more difficult it is to calculate and interpret the results. Therefore, the main factors determining trends in forest product prices should be identified. (table 2).

Table 2. Dynamics of indicators potentially influencing prices of forestry products and dynamics of prices of various types of forestry products [4,5]

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
RUB/USD exchange rate (X1)	30.48	32.2	30.37	32.73	56.26	72.88	60.66	57.6	69.47	61.91	73.88	74.29	68.54

GRP of the Northwestern Federal District, in current prices; million rubles (X2)	3943054	4785459	5247508.5	5553389.2	5945311.3	7204795	8399737.4	8814881	9865793	10577620.1	10742733.5	16682107	18928860.6
Population of the North-West Federal District (X3)	13626	13660	13717	13801	13844	13854	13899	13917.5	13950.8	13966.789	13956.172	13924.24	13888.591
Per capita income North-West Federal District (X4)	19837	21184	23422	26167	28580	32329	33212	34299	36170	37920	39486	44632	50214
Labor force size North-West Federal District (X5)	7640.8	7671.5	7649.4	7580.4	7535.2	7604.2	7607.5	7557.4	7499.7	7460.2	7425.1	7473.2	7544
Inflation North-West Federal District (X6)	109.19	105.79	106.10	106.62	112.54	113.07	105.14	103.06	104.13	102.95	104.84	108.53	111.90
Reforestation North-West Federal District, hectare (X7)	163177	186468	185158.5	190529.3	195417.3	194106	201389	243339	236961	272201.2	336301.6	257640.3	260156.6
Price China BHKP (net from 2018) USD, cellulose (Y1)	777.34	699.4	635.29	672.55	609	640.62	517.07	647.48	759.92	565.63	458.82	652.41	767.64
Price Cardboard KLB 175gsm (ebpo) (Y2)	509.79	580.33	543.25	586.5	557.38	582.7	555.6	629.78	731.9	650.69	580.63	719.72	624.51
Price Cardboard WTKLB 135-140gsm (ebpo) (Y3)	676.94	771.66	763.09	767.1	752.43	757.74	743.66	761.53	820.97	796.62	734.58	790.44	650.37
Price Cardboard TL2 140-150gsm (ebpo) (Y4)	399.37	480.11	430.65	449.74	463.09	465.2	454.39	498.79	554.49	469.3	405.44	569.46	754.22
Price Cardboard TL3 140-150gsm (ebpo) (Y5)	382.25	460.68	407.88	425.7	439.31	443.78	431.58	476.17	534.12	436.09	378.5	547	734

Price Cardboard RB Fluting 100- 105gsm (евпо) (Y6)	368.92	448.58	394.35	413.79	431.94	438.74	424.3	467.1	523.62	430.22	365.15	533.08	727.39
Price Plywood, rub. (Y7)	172.85	178.64	189.55	178.24	197.97	277.09	337.05	283.82	309.89	323.95	369.79	366.69	289.43
Price Softwood lumber, rub. (Y8)	9403.33	8849.14	9843.42	10603.1	12834.18	19496.4	21813.78	17170.6	21617.9	22885.97	25102.81	26037.61	27466.7
Price Hard lumber, rub. (Y9)	25776.1	27588.5	27207.33	27163.5	34473.68	51141.8	49752.33	40934.1	45551	45002.61	50751.27	55241.25	46532.06

4 Discussions

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Based on the manipulation of the relationship between the factors studied, the following conclusions can be drawn:

- for Y4 and Y5 is X2;
- for Y7 and Y8 are the values X1, X2 (only for Y8), X3, X4 and X7;
- for Y9 are the values X1, X3, X4 and X7;

The significance of regression equations is assessed using some statistical tests. The most common way to estimate the significance of a regression equation is the F-test of Fischer.

It was used to test the zero hypothesis that all regression coefficients are equal to zero, that is, the regression equation has no predictive power. If the p-value obtained by F-test is less than the significance level (usually 0.05), then one can reject the null hypothesis and conclude that the regression equation is statistically significant. According to these criteria, the developed model of price forecast for softwood lumber and plywood is suitable.

The significance of individual regression coefficients can also be assessed by using t-tests. If the t-statistic for a coefficient is significantly different from zero and p-value is less than the significance level, then this coefficient can be considered statistically significant. In addition, to evaluate the significance of the regression equation, you can also use the determinism factor R², which shows what part of the variation of the dependent variable explains the regression model. The closer R² is to 1, the more important the model. According to this criterion, all three models of product forecasting are working.

To determine the shape of the trend, three options were analyzed: linear trend, polynomials of second and third degree.

The most accurately describes variables by the second-degree polynomial (achieves maximum R-square) for the resulting factor Y.

Summing up, it is necessary to note the strong degree of influence of factors ruble/US dollar, population size of CDF, average per capita income of CDF, reforestation of CDF on the change in prices of plywood, softwood lumber and solid sawn wood. Timber prices have been subject to high fluctuations in the past few years, both due to the movement of the dollar and ruble and the closing of European markets.

5 Conclusions

As a result of the calculations we will conclude that it is possible to build a predictive model on the basis of selected and justified factors: as a result, values taken for plywood prices, prices of solid lumber and prices of softwood lumber. These indicators are selected for the regression model, as they are influenced by the largest number of selected macroeconomic indicators.

It is important to consider the complexity of the relationship between economic factors and prices in order to properly analyse the current situation and predict its future development. Trends in forest products prices are driven by macroeconomic factors. Economic situation, inflation, taxes, exchange rates, political stability and other factors affect prices. Tax rates and exchange rates also play an important role in price formation. Changes in these parameters may affect the costs of producers, which will be reflected on the end-user. Political stability is also important, as instability can affect economic conditions and prices. Understanding these macroeconomic factors allows for forest product price trends to be predicted and sustainable decisions in the management and development of the forest complex.

Thus, macroeconomic factors are strongly influenced and can be used to forecast the trend of forest products prices. It is recommended to include in the factor regression model such regressions as currency exchange rate, population size, per capita income, reforestation index.

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