

ORIGINAL PAPER

The market of wood forest products in Serbia and analysis of its dynamic elements

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ABSTRACT

The most important product with a commodity character on the forest products market is wood, but also various wood assortments, which are the basic raw material in the wood industry. This paper analyzes the trends related to cutting, processing and sale of wood assortments (logs for cutting and logs for veneer peeling) from state forests in Serbia. In addition, these trends are analyzed separately for the commercially important species beech, oak and poplar. The methods used in the analysis are the Mann-Kendall trend test and the modified Mann-Kendall test with Hamed-Rao variance correction when the assumption of data independence is not met. The data were collected by the Statistical Office of the Republic of Serbia for the territory of Serbia (excluding AP Vojvodina and Kosovo and Metohija) and cover the periods 2002-2017 and 2003-2017. The research aims to determine the trends in the market of wood products (assortments) related to production (cutting), processing, as an intermediate phase, and sale of wood assortments as the final phase. The purpose of this research is to identify the trends in the mentioned categories, which provides a good basis for their prediction in the future. The subject of research is the volume of cutting, processing, and sales of wood assortments from state forests in Serbia. According to the results, a statistically significant growth trend in total cutting, processing and sales of wood assortments in the period 2002-2017 can be confirmed. The volume of processed wood assortments largely coincides with the realized volumes, which indicates that they were sold in the same year. A statistically significant trend was also observed in the production and sale of sawn timber (for beech, oak and poplar combined). The average annual growth rate for cutting was 2.5%, for processing 2.7% and for the sale of wood assortments 2.9%. As beech is the most widely represented wood species, the changes in supply and demand for this type of wood are mainly determined by the general market trends on the Serbian timber market. Production in forestry differs significantly from conventional production, so that the production possibilities in forestry are limited by the capacity of the forests and their resources. The timber market is therefore influenced and driven by this fact.

KEY WORDS

cutting, processing, sale of wood assortments, Serbia

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Received: 16 February 2024; Revised: 23 May 2024; Accepted: 27 May 2024; Available online: 5 July 2024

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Introduction

Global wood products markets are strongly influenced by changes in a wide range of regulatory and market factors (Latta *et al.*, 2016), in particular population, economic growth, demographic changes, technological changes, environment, *etc.* (de Fégely, 2005). In this context, it is expected that income and population growth will continue to lead to a slight increase in global demand for traditional forest products (Adamowicz *et al.*, 2008). In the case of the global market of wood products, it can be said to be the result of the interaction of many factors that affect changes and movements within the market (Sretenović *et al.*, 2008). When researching the market of wood products, it is essential to identify and explain the market flows, analyse the information obtained and predict future trends (Hetemäki and Hurmekoski, 2016). The dynamic nature of the market opens up different approaches for observing and studying its components, especially supply and demand (Debertin, 2012), as well as factors directly or indirectly related to the functioning of the market mechanism.

It is estimated that more than 4.5 million m³ of timber is harvested annually in the territory of Serbia, which corresponds to about 70% of the planned yield, *i.e.* 50% of the annual increment, with hardwood accounting for about 85%. Of the total volume of wood harvested, around 45% is firewood, 42% is technical wood and 13% is wood residue (Ministry, 2008). Accordingly, the aim of this research was to determine the trends in the market of wood products related to production (cutting), the processing of wood assortments and their sale, both at the overall level and for the commercially important wood species: beech *Fagus*, oak *Quercus* and poplar *Populus*. The aim of the study is to determine the trends of these categories, which is a good basis for their prediction in the future. The subject of this research is the volume of cutting, processing and sale of wood assortments. In the territorial sense, the territory of Serbia is included, excluding AP Vojvodina, and Kosovo and Metohija.

Methods

Official data from the Statistical Office of the Republic of Serbia on the volume of cutting, processing of wood assortments and sales of wood assortments were used for the study. Time series were formed and trends were derived for each of these categories. All wood species were recorded for cutting in the period 2002-2017 and separately for beech, oak, and poplar. Logs for cutting and logs for veneer peeling of beech, oak and poplar were included for the processing of wood assortments and sales in the period 2003-2017. In the second phase, the Mann-Kendall test was applied to test the significance of the trend (Mann, 1945; Kendall, 1975; Kulkarni and von Storch, 1995; Yue and Wang, 2004). Studies show that the most commonly used method for trend detection is the non-parametric Mann-Kendall test (Hamed and Rao, 1998; Guhathakurta *et al.*, 2010; Ghalharia *et al.*, 2012), which assumes independence of data in the time series (Yue and Wang, 2004; Pohlert, 2023). For this reason and because of the nature of the data, this method was also used in actual research. When the assumption of data independence is not met and there are significant autocorrelations in the data, the modified Mann-Kendall test with Hamed-Rao variance correction was applied (Hamed and Rao, 1998; Yue *et al.*, 2002; Rao *et al.*, 2003; Cunderlik and Burn, 2004; Mondal *et al.*, 2012; Blain, 2013). In the research, the variance of the Mann-Kendall statistic was modified in this way to compensate for the effects of serial autocorrelation on the data. R software was used in the paper, *i.e.* the approach using the p -value of the test. If the p -value of the test is less than the significance level α , the null hypothesis is rejected and the alternative hypothesis of the presence of a trend is accepted. In addition, the average annual growth

rate for cutting, processing and sales of wood assortments was determined on the basis of the ‘geomean’ function.

Results

Figure 1 shows the data on total cutting, processing and sales of wood from state-owned forests in Serbia in the period 2002-2017.

Figure 1 shows an increasing trend during the observed period for the cutting, processing and sales of wood assortments. The significance of the trend was tested below using the trend test (Table 1). When presenting the relationship between cutting, processing and sales of wood assortments in the period 2003-2017, it was found that in some years the realized volumes exceed the production of wood assortments in the current year. This is largely due to the sale of stocks of wood assortments from the previous year.

Figure 2 shows the autocorrelation coefficients of total cutting, processing and sales of wood assortments.

Based on the results obtained, a statistically significant growth trend in total cutting, processing and sales of wood assortments in the period 2002-2017 can be identified (Table 1). The growth trend indicates an increase in demand during the analyzed period, which is directly reflected in the sales volume and indirectly in the volume of cutting and processing of wood assortments.

The average annual growth rate for all three categories was approximately the same and ranged between 2.5% (cutting), 2.7% (processing) and 2.9% (sales) of wood assortments (Fig. 3). Based on the calculated growth rates, it can be seen that all three values are positive. Furthermore, a balance can be observed in the growth of the analyzed activities (cutting, processing and sales

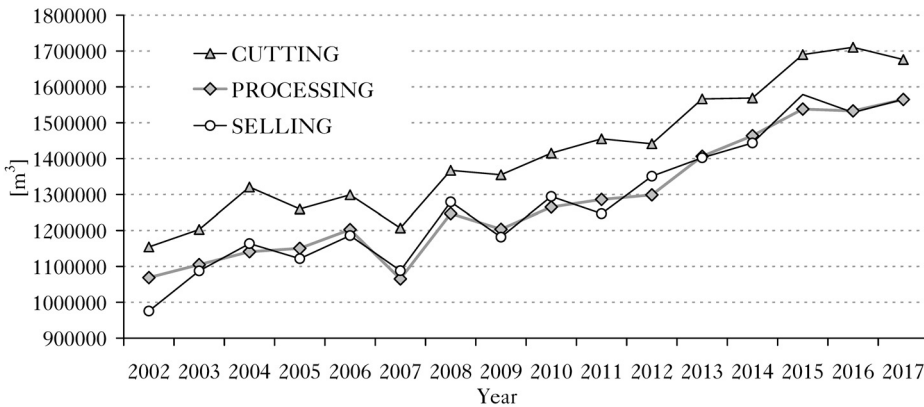


Fig. 1.

Cutting, processing and sales of wood assortments from state forests in Serbia in the period 2002-2017

Table 1.

Results of the trend test for cutting, processing and sales of wood assortments from state-owned forests in Serbia

Variable	Test	Statistic	p-value	Trend
Total cutting	Modif. Mann-Kendall	4.547	<0.001	Yes
Total processing	Modif. Mann-Kendall	3.499	<0.001	Yes
Total sales	Modif. Mann-Kendall	4.457	<0.001	Yes

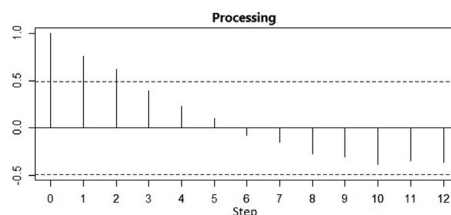
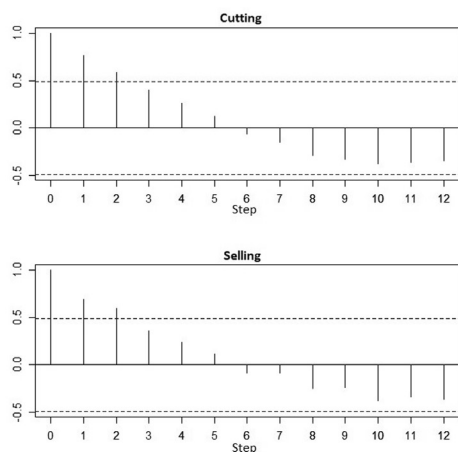


Fig. 2.

Autocorrelation coefficients of the total cutting, processing, and sales of wood assortments

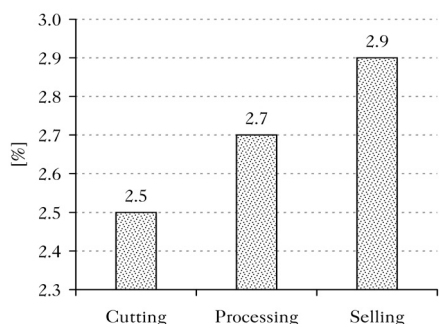


Fig. 3.

Growth rates for cutting, processing and sales of wood assortments from state-owned forests in Serbia for the period 2002-2017

of wood assortments), as the growth rates are in the range of 2.5-2.9%. This practically means that the volume of cutting, processing and sales of wood assortments follows a proportional growth, *i.e.* there are no extreme movements on the market that would lead to an imbalance between these three categories. The higher average annual growth rate in sales compared to the processing of wood assortments is explained by the sale of stocks from the previous year.

Figure 4 shows the data on the cutting of beech (in millions of cubic meters), oak and poplar (in thousands of cubic meters) in Serbia in the period 2002-2017. The figure shows an increasing temporal trend in beech cutting. The number of oak cutting does not show a trend, but only the fluctuation of values over the years. Poplar cutting decreased significantly in 2003, only to increase again in 2004. Since 2005, there has been a very slight upward trend, with declines in 2009 and 2011. The proportion of beech, oak and poplar cutting in the period 2003-2017 ranged approximately between 83-86% (beech), 2-6% (oak) and 11-12% (poplar).

The existence of a trend was checked with the corresponding trend test and showed that a statistically significant trend was confirmed for beech and poplar cutting, which was not the case for oak (Table 2). The planning of the production volume and the assortment structure are determined by the operational plan, which is coordinated with the forest management plan. All the movements mentioned are in line with the planning documents. Sporadic fluctuations are due to cutting carried out to repair the damage caused by drought, windbreaks, ice and snow breakage (random harvesting), *etc.*

Figure 5 shows the data of the total processing of beech, oak and poplar logs in Serbia (from state-owned forests) in the period 2003-2017.

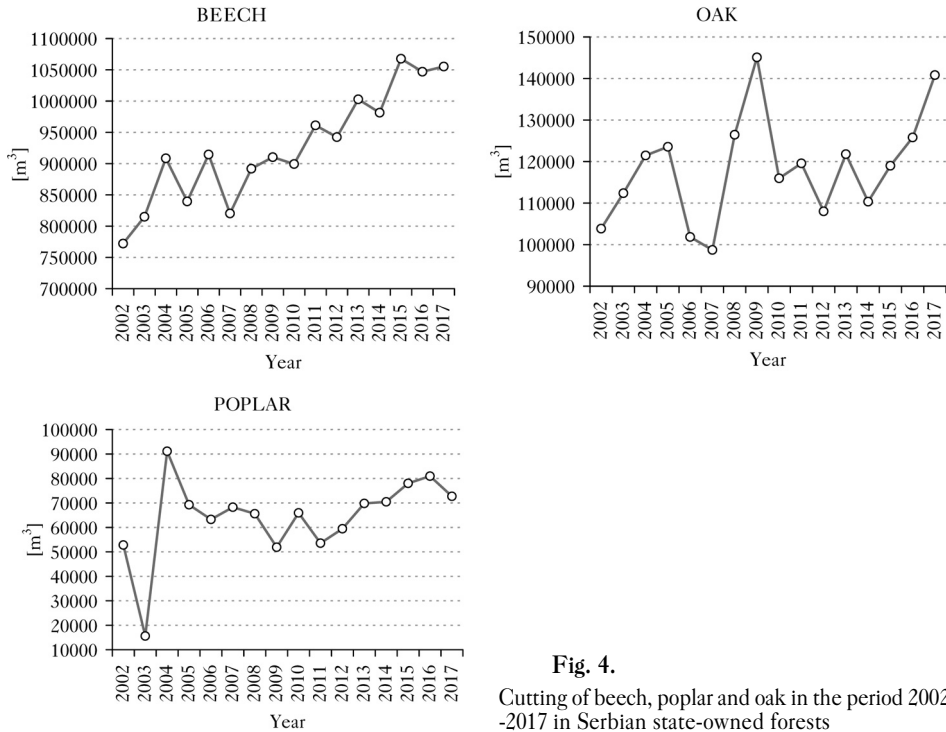


Fig. 4. Cutting of beech, poplar and oak in the period 2002-2017 in Serbian state-owned forests

Table 2.

Results of the trend test for cutting in the state-owned forests of Serbia

Variable	Test	Statistic	p-value	Trend
Beech	Modif. Mann-Kendall	4.097	<0.001	Yes
Oak	Mann-Kendall	1.396	0.163	No
Poplar	Mann-Kendall	2.026	<0.001	Yes

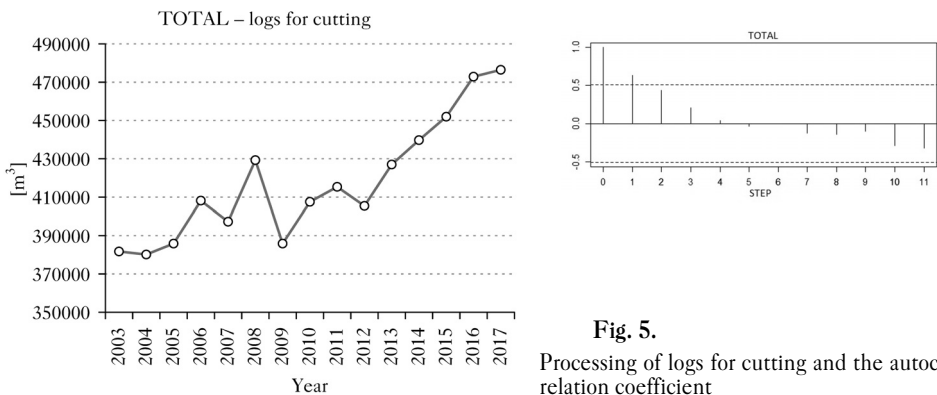


Fig. 5. Processing of logs for cutting and the autocorrelation coefficient

Figure 5 shows that an increasing time trend can be observed in the processing of logs for cutting at the overall level for beech, oak and poplar. The autocorrelation coefficient is significant at step 1, which is why the modified Mann-Kendall trend test was applied. This test confirmed the statistical significance of the trend (Table 3).

Figure 6 shows data on the processing of logs into veneer and peeled wood in total for beech, oak and poplar in Serbia (from state forests) in the period 2003-2017.

Figure 6 of the processing of logs for veneering and peeling overall for beech, oak and poplar shows a significant increase in the value in 2015, but the statistical significance of the trend was not confirmed (Table 3).

Figure 7 shows data on the sales of logs for the cutting of beech, oak and poplar in Serbia (from state-owned forests) in the period 2003-2017.

Figure 7 shows that the sales of beech, oak and poplar logs for cutting is increasing overall over time. The increasing trend in the sales of logs for cutting is a response to market demand for a specific product category, *i.e.* by assortment. The significance of the autocorrelation coefficient with step 1 is given, which is why the modified Mann-Kendall test was applied. This confirms the statistical significance of the trend (Table 4).

Figure 8 shows the data on the sales of beech, oak and poplar logs for veneering and peeling (total) in Serbia (from state forests) for the period 2003-2017.

Table 3.
Results of the trend test for the processing of logs for cutting and logs for veneering and peeling

Variable	Test	Statistic	ρ -value	Trend
Processing of logs for cutting				
Total (beech, oak, poplar)	Modif. Mann-Kendall	3.860	<0.001	Yes
Processing of logs for veneering and peeling				
Total (beech, oak, poplar)	Modif. Mann-Kendall	0.143	0.886	No

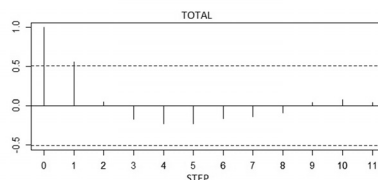
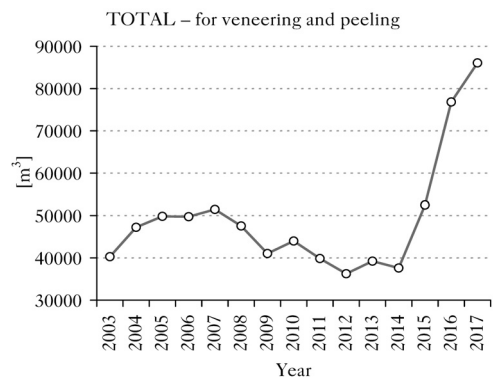


Fig. 6.
Processing of logs for veneering and peeling and autocorrelation coefficient

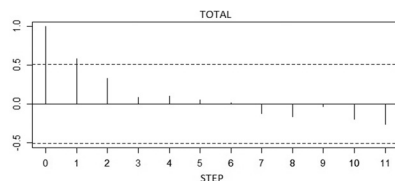
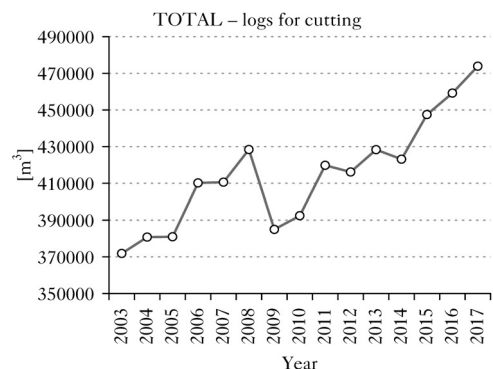


Fig. 7.
Sales of logs for cutting and autocorrelation coefficient

Table 4.

Results of the trend test for the processing of logs for cutting and logs for veneering and peeling

Variable	Test	Statistic	p-value	Trend
Sales of logs for cutting				
Total (beech, oak, poplar)	Modif. Mann-Kendall	3.959	<0.001	Yes
Sales of logs for veneering and peeling				
Total (beech, oak, poplar)	Mann-Kendall	0	1	No

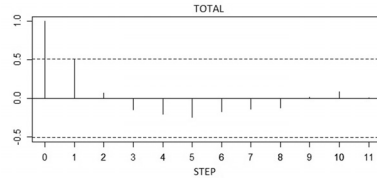
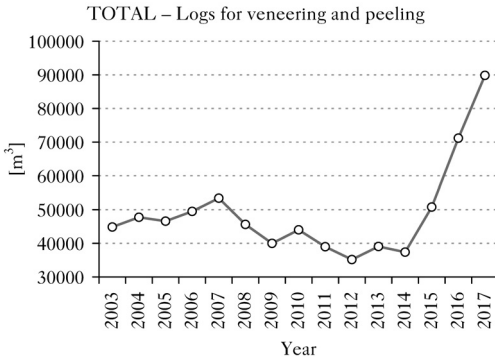


Fig. 8. Sales of logs for veneering and peeling and autocorrelation coefficient

Figure 8 of sales of logs for veneering and peeling at the overall level for beech, oak and poplar shows a significant increase in value in 2015. The fluctuations that occur in sales are largely determined by the supply movements in a given time interval.

The modified Mann-Kendall test was used to analyze the trend for the sale of logs for cutting, which showed that there is a statistically significant trend, while the statistical significance of the trend for the sale of veneer and peeled wood was not confirmed.

Discussion

Analyzing trends and changes in the market of wood raw materials is a complex task (Leskinen and Kangas, 2001; Banaš and Kožuch, 2019; Zastocki *et al.*, 2021). In contrast to products whose demand depends on the disposable income of consumers, in the case of wood it can be determined by the production volume of finished and semi-finished products of wood processing companies, whose demand depends on the needs of customers or further processing (Schwarzbauer, 2007; Brodrechtova *et al.*, 2014). In the territory of Serbia, in the period 2002-2017, statistically significant growth was achieved in the assortment categories of cutting, processing and sales of wood together for beech, oak and poplar. In addition, a statistically significant trend was also achieved in the processing and sales of logs for cutting (at the collective level for the three species mentioned). The average annual growth rate for cutting was 2.5%, for processing 2.7% and for the sale of timber assortments 2.9%. Taking into account these positive trends through the theory of derived demand, this indicates that the demand for wood in its raw form is dependent on the demand for wood end products, which simultaneously combines positive trends in the economy and economic growth with the strengthening of the wood market (Parobek *et al.*, 2014).

The demand for wood depends mainly on the lumber market, the construction industry, the import and export of wood products and the government’s natural resource management policies. Timber supply, on the other hand, depends on weather conditions, wood supply and substitution prices (Parajuli *et al.*, 2018). Based on the results of this research, it can be said that

movements in the wood market are largely determined by global movements, through various environmental, economic and distributional influences (Latta *et al.*, 2016). In this sense, the causes of the fluctuations and changes that occur, especially in the area of wood demand, should be sought in global movements related to changes in the economic, social and technological environment (Marčeta, 2023).

Conclusion

Based on the analyzed data, it was found that in Serbia in 2017 (the last year of the analyzed time interval) the share of cutting, processing and sales of beech, oak and poplar, in relation to all tree species, had the following values:

- 75.7% of total logging is the cutting of beech, oak and poplar;
- the processing of logs for cutting beech, oak and poplar accounts for 74.3%;
- the processing of logs into veneer and peeled beech, oak and poplar accounts for 96.7%;
- the sales of beech, oak and poplar logs for cutting accounts for 74.9%;
- the sales of beech, oak and poplar logs for veneering and peeling purposes amounts to 97.1%.

The demand for beech assortments is reflected in the fact that this is the most represented type of wood, which is why it has the largest share of the market portfolio. In this sense, changes in the supply and demand for this type of timber have the greatest impact on the dynamics of the entire wood market in Serbia. The demand for poplar logs is also considerable, and over the course of the year, demand exceeds the volume several times which can be compensated through planned cutting.

Based on the observation of the market of wood products in the context of this research, it can be stated that the fundamental determinant that determines the dynamics of market movements is the production potential of forests. In other words, the market is extremely limited by the possibilities that the forest as a raw resource can offer at a particular time, which largely distinguishes it from traditional forms of production.

Authors' contributions

M.M. – conception of the study, literature review, methodology, data collection, data analysis, drafting and preparing the manuscript; L.K. – drafting and preparing the manuscript, reviewing and editing the text; literature review, drafting and preparing the manuscript, reviewing and editing the text.

Conflicts of interests

The authors declare no conflict of interest.

Funding

The research was financed from the author's funds.

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Rynek drzewnych produktów leśnych w Serbii i analiza jego dynamicznych składowych

W artykule poddano analizie podstawowe składowe rynku produktów leśnych, tj. ścinę, przetwórstwo i sprzedaż sortymentów drzewnych. Celem było zbadanie trendów ilościowych w latach 2002-2017 lub 2003-2017 – w zależności od dostępności danych. Ponadto osobno przeanalizowano składowe z uwzględnieniem poszczególnych gatunków (buk, dąb i topola), a także ważnych z komercyjnego punktu widzenia sortymentów drewna (drewno tartaczne i okleinowe). Podstawową metodą była analiza trendów przy użyciu testu Manna-Kendalla lub – w przypadku niespełnienia założenia o niezależności danych – skorygowanego testu Manna-Kendalla. Do analizy wykorzystano oficjalne dane Urzędu Statystycznego Republiki Serbii.

Analiza wykazała wzrost ilości pozyskania, przerobu i sprzedaży wszystkich gatunków drewna, a także poszczególnych sortymentów (ryc. 1 i 2). Stwierdzono również, że rozmiar przetwórstwa sortymentów drewna w dużym stopniu odpowiada rozmiarowi sprzedaży, co wskazuje, że wszystkie wytworzone sortymenty drewna zostały zbyte w tym samym roku. Na podstawie uzyskanych wyników można zaobserwować statystycznie istotny trend wzrostowy całkowitego pozyskania, przerobu i sprzedaży drewna w latach 2002-2017 (tab. 1). Trend ten wskazuje na rosnący popyt w badanym okresie, co znajduje bezpośrednie odzwierciedlenie w wielkości sprzedaży i pośrednie w wielkości pozyskania i produkcji wyrobów z drewna. Średnia roczna stopa wzrostu dla wszystkich trzech kategorii była dodatnia i wahała się od 2,5 do 2,9% (ryc. 3). Równowaga w tych zależnościach wskazuje, że wielkość pozyskania, przerobu i sprzedaży sortymentów drewna wzrasta proporcjonalnie, tzn. na rynku nie występują ekstremalne ruchy, które prowadziłyby do braku równowagi między tymi kategoriami. Na obszarze środkowej Serbii w latach 2002-2017 wykazano statystycznie istotny trend wzrostowy w odniesieniu do pozyskania i przerobu wszystkich analizowanych gatunków drewna. Istniejący trend został poddany testowaniu statystycznemu i potwierdzony w odniesieniu do pozyskania drewna bukowego i topolowego, co jednak nie miało miejsca w przypadku drewna dębowego (ryc. 4; tab. 2). W odniesieniu do przerobu drewna tartaczno potwierdzono statystyczną istotność trendu dla buka, dębu i topoli (ryc. 5; tab. 3). Znaczący wzrost obserwowany był w 2015 r. w przypadku przerobu okleinowego drewna bukowego, dębowego i topolowego, co nie znalazło jednak potwierdzenia w teście statystycznym (ryc. 6; tab. 3). Uzyskane wyniki pozwoliły stwierdzić, że wystąpił statystycznie istotny trend wzrostowy w sprzedaży drewna tartaczno (ryc. 7; tab. 4), natomiast nie w przypadku sprzedaży drewna okleinowego (ryc. 8; tab. 4). Ogólnie rynek drewna w Serbii wykazuje tendencję wzrostową, zwłaszcza w segmencie związanym z popytem. Struktura podaży i popytu gatunków o znaczeniu komercyjnym wskazuje, że największy udział ma drewno bukowe. Praktycznie oznacza to, że wszelkie zmiany związane z podażą i popytem na ten gatunek mają największy wpływ na dynamikę całego rynku drzewnego w Serbii. Ponadto popyt na drewno dębowe często przewyższa podaż, podobnie jak na drewno topolowe, gdzie w ciągu roku popyt jest wielokrotnie wyższy niż ilość, którą można wystawić do sprzedaży w ramach planowanego pozyskania drewna.