ORIGINAL RESEARCH ARTICLE

The effect of natural disasters on the timber market

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Abstract. The aim of the study was to determine the impact an increased wood supply from the Beskid forests after natural disasters on the timber economy of the Węgierska Górka Forest District and its surroundings in the years 2004–2010. The analysis was based on the wood raw material sales recorded in the database of the State Forestry Information System (SILP). Information on the buyers'location and their main use for the raw material were obtained through the Central Statistical Office. Furthermore, wood material buyers were classified according to the Polish Classification of Activities (PCA) based on the year 2007, using only a subjective analysis designed for enterprises and other economic units in the national economy.

Changes in sales of wood material to the selected buyer groups were investigated using statistical analyses of linear trends. A Pearson's correlation analysis verified the relationships between the buyer groups and the supply of timber assortments by the Węgierska Górka Forest District. Other studies have also shown that an increased supply of raw material in the context of natural disasters affects the types of wood buyers and their location. In addition, they have shown an increase in interest towards the purchase of raw materials among buyers engaged in the wholesale trade of wood and other non-wood producers which in turn decrease the share purchased by sawmills.

Keywords: timber market, timber assortments, wood buyers, natural disasters

1. Introduction

Damage to a forest caused by natural disasters is usually characterized by the size of the affected area or the volume of damaged timber. Determining the full economic impact of natural disasters in forests is a complex issue, as it depends on the type of disaster and its extent, intensity, spatial distribution and duration, and many micro- and macro-economic factors affecting forest management.

Economic analyses of the effects of natural disasters are most frequently related to the increased costs of economic activities, losses due to the deteriorated quality of the wood raw material and price formation, as well as premature stand logging losses (e.g., Ratajczak, Spława-Neyman 1997, Baur et al. 2003, Kaliszewski 2009; Svensson et al. 2011; Szabla 2011). Thus far, research has paid little attention to the relationship between forest management in the context of natural disasters and its economic environment, especially of

entities involved in the distribution and processing of wood. Examples of this are a few studies (e.g., Patriquin et al. 2007, Chang et al. 2012) showing that in the short term, an increased supply of wood raw material positively affects a region's economy, but in the longer perspective, the effects are negative.

In the Beskid forests, unfavourable catastrophic events, mainly hurricane-force winds and gradations of the European spruce bark beetle, resulted in such an increase in forestry work that it far exceeded the management plans of the affected forest districts. Wood acquisition in the Węgierska Górka Forest District alone amounted to nearly 300,000 m³ in 2007, three times the average annual harvest (BULiGL 2009). Increased harvesting of wood raw material in the Beskid forests resulted in an unusual situation in the wood market, so the purpose of this study was to determine the impact of the increased supply of wood raw material due to a natural disaster on the economic relations of the Węgierska Górka Forest District and its environment − the buyers of

wood raw material − based on measuring its sales stream between 2004–2010.

2. Research methodology

2.1. Analysis of the variability of wood raw material buyers

The analysis of the variability of wood raw material buyers consisted of examining the economic relationships between suppliers and buyers, in a similar manner as for an input-output analysis (Leontief 1936). Analysing the complex relationships between different sectors or industries can make the matrix (or input-output tables) very large (e.g., Samuelson, Nordhaus 1995). However, in the case of the relationships between the forestry industry and its economic environment, the analysis is generally simplified and limited to one row and one column (e.g., Gołos et al. 1999, Płotkowski et al. 2004, Klocek 2005). Due to the subject of the study – exclusively the buyers of wood raw material – the classic input-output table will not be presented. However, the subject classification was maintained, as suggested by Czyżewski (2008).

The interrelationships between the Węgierska Górka Forest District and the buyers of wood raw material were presented materially, as the volume of sold wood (m³). Buyers were classified to the lowest level (subclass) of the Polish Classification of Activities (PCA) of 2007 (Regulation 2007) in accordance with the predominant type of their activity. The subclass is the fifth, lowest level of distinguishing Polish economic activities that is statistically monitored. The 2007 PCA also corresponds to the NACE Rev. 2 nomenclature of activities in the European Community (Regulation 2006), which makes it possible to reference it to the economies of other European Union Member States.

Mapping the economic links between the Węgierska Górka Forest District and buyers from its surroundings required measuring the flow of products resulting from trade. Qualifications were made on the basis of annual reports on the sale of wood, known as 'Reports on the sale of wood by customer and by assortment' for a given period (year). Based on the information gathered, among others, the name of the customer, REGON [business registration] number and volume of purchased wood raw material, the company's main activity was established. The analysis was performed using the search engine of national economy entities, available on the Central Statistical Office's website (http://www.stat.gov.pl/regon/), according to the 2007 PCA scheme. Only a subjective analysis was made, that is, of companies, institutions and other economic entities registered in the national economy. Due to the limited availability of information on the production profile of the surveyed companies, wood products were not analysed in the study by using the classification of the Polish Classification of Goods and Services (PKWiU).

2.2. Analysis of the variation of the locations of raw wood material buyers

A detailed analysis of the variation in the locations of wood material purchasing was conducted for all buyers connected economically with the Węgierska Górka Forest District for 2004–2010. Wood raw material buyers were classified by their geographical location, according to the information contained in the Central Statistical Office data base. The type and strength of economic links between the analysed forest district and wood buyers are presented by economic circles (regions) (Fig. 1), as suggested, among others, by Płotkowski (1994), Gołos et al. (1999) and Kuciński (2004):

• an internal circle, comprising economic entities located in the townships of Lipowa, Radziechowy-Wieprz, Milówka and Węgierska Górka; these are the communities located in the geographical area designated by the boundaries of Węgierska Górka Forest District,
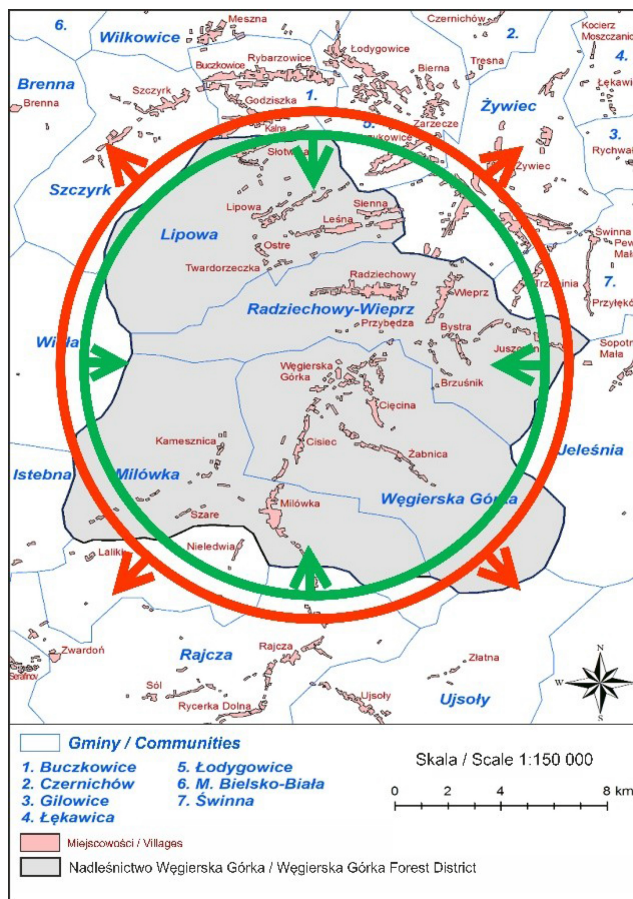

Figure 1. Economic relations of the Forest District of Węgierska Górka with the wood buyers from the inner circle (gray color) and the outer circle (black color). Source: own study based on Forest digital map (2010) and http://www.geoportal.gov.pl.

• an external circle, encompassing economic entities located outside the four townships mentioned above.

2.3. Statistical methods analysing the relationships of the economic entities

The dependencies between individual customer groups and the supply of specific timber assortments were analysed using the Pearson's correlation analysis. Correlation coefficients were established, and the following intervals were determined for the same, as suggested by Welfe (2009): $r < 0.2$ – no correlation; $0.2 \leq r < 0.4$ – poor; $0.4 \leq r < 0.7$ – moderate; $0.7 \leq r \leq 0.9$ – strong; $r > 0.9$ – very strong. In addition, the significance of linear trends in the analysed features was examined for the selected groups of wood buyers. The analyses were performed using the statistical package Statistica 10.0. (StatSoft Inc. 2011).

3. Results

3.1. Analysis of the variability of wood raw material buyers

The analysis showed a clear disproportion between the volume of purchased wood by the buyers from the 'inner circle' and the buyers from the 'outer circle' (Fig. 2). Despite the growing sales of the Węgierska Górka Forest District, from a level of 106,404.36 m³ in 2004 to 269,625.67 m³ in 2008 (an increase of 153.4%), there was a less significant increase in the purchase of wood by customers from the inner circle, that is, from 34,437.51 m³ to 49,471.76 m³ respectively (an increase of 43.7%) than those from the outer circle, that is, from 71,966.85 m³ to 220,153.91 m³ (by 205.9%). Similar trends were observed in the case of declining wood sales in 2009–2010.
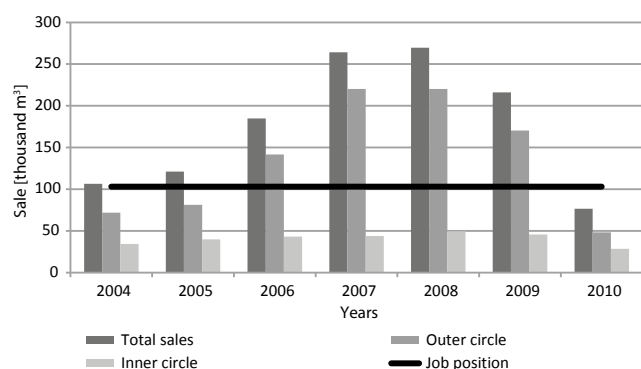
Among the main buyers of wood raw material, business entities from the sub-class of 'production of sawmill products' (in other words, 'sawmill industry/sector' or 'sawmilling') were most significant in relationship to the share of volume of wood sales (Fig. 3), and had a statistically significant ($p < 0.01$) linear downward trend. Next were the buyers from the 'wholesale, construction materials and sanitary equipment' (i.e., wholesale) sub-class, for whom a statistically significant ($p < 0.05$) increasing linear trend was observed. The third most important group was the 'wood packaging production' sub-class (in other words, 'wood packaging industry/sector'), for which a statistically significant increasing linear trend was recorded, albeit at the borderline level of statistical significance ($p = 0.06$).

A detailed analysis showed that in 2005, the share of buyers from the sawmill industry increased from 62.3 to 68.0% (by 5.7%) in relation to the previous year, thus achieving its maximum value for the whole period (Fig. 3). At the same time, however, the share of wholesale buyers decreased from 13.4 to 11.1% (2.3 percentage points). There was also a decrease in the share of wood packaging buyers from 9.9 to 6.6 (3.3%). However, in the following years, there was a downward trend in the sawmill industry to 35.8% in 2009 (a drop of 32.2%). But at the same time, the trend showed an increase of the wholesale buyers up to a maximum of 24.6% (an increase of 13.5%). At the same time – but only up to 2008 – the share of wood packaging industry buyers increased to a maximum level of 20.3% (up by 13.7%). In the last year analysed, a slight increase was noted in the share of sawmill industry buyers to 39.9% (4.1%). The opposite was observed among the wholesale buyers, that is, a decrease to the level of 18.4% (by 6.2%). A downward trend was also noted in the last two years among the wood packaging industry buyers of up to 18.4% (by 1.9%).
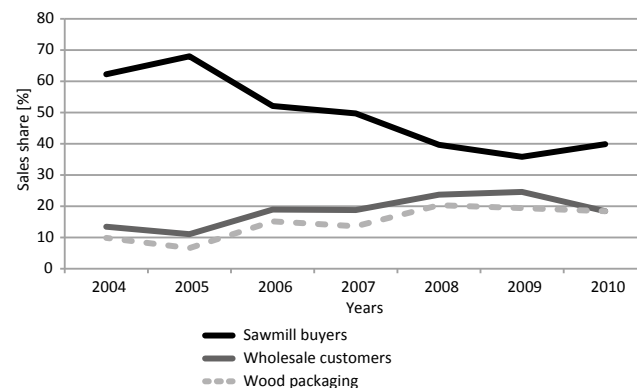

Figure 2. Sale of wood (m³) according to circles in the years 2004–2010. Source: own study based on reports from SILP database for the Forest District of Węgierska Górka.

Figure 3. The share of main wood buyers in the volume of sale of wood in 2004–2010. Source: own study based on reports from SILP database for the Forest District of Węgierska Górka.

3.2. Analysis of wood buyers from the inner circle

Among the wood buyers from the inner circle, the highest share of volume (Fig. 4) was found for buyers from the sawmill industry, which ranged from 49.3% (2009) to 79.0% (2005), showing a statistically significant ($p < 0.05$) downward linear trend. Buyers from the wood packaging industry comprised the second group, whose share ranged between 13.3% (2005) and 31.0% (2008), with no statistically significant ($p > 0.05$) linear trend. Another important group were retail customers, with a share between 5.9% (2005) and 17.6% (2010) and a statistically significant ($p < 0.01$) increasing linear trend.

Buyers from the inner circle of the sub-class 'production of other carpentry and building joinery' were less important, showing no statistically significant ($p > 0.05$) linear trend. Their share was practically constant and did not exceed a threshold of 1.7% (Fig. 4). The analysis of the share of 'other buyers' (a total of 64 PCA sub-classes) showed an increasing linear trend, albeit at the borderline of statistical significance ($p = 0.06$). Their share increased in only the last two analysed years, to 8.4% (2009) and 6.9% (2010) respectively. A detailed analysis of these customers did not reveal businesses from the wholesale sub-class.

3.3. Analysis of the wood buyers from the outer circle

Among the wood buyers from the outer circle, the highest share of volume (Fig. 5) was confirmed for the buyers from the sawmill industry. Their share was in the range of 32.2% (2009) and 62.6% (2005), showing a statistically significant ($p < 0.001$) downward linear trend. The share of wholesale customers was from 16.5% (2005) to 31.1% (2009), showing a statistically significant ($p < 0.01$) increasing linear trend. A statistically significant ($p < 0.01$) increasing linear trend was also observed for wood packaging industry buyers and their share in sales ranged from 3.3% (2005) to 17.9% (2008).

Of less significance were the agricultural production group of buyers, having a negligible but statistically significant ($p < 0.05$) downward linear trend and a share in the range of 3.6% (2010) to 7% (2005). No statistically significant ($p > 0.05$) linear trend was found for buyers from the building joinery group, whose share ranged from 4.1% (2008) to 8.1% (2010). For the last group of customers, that is, the remaining buyers (64 entities in total), the analysis showed a statistically significant ($p < 0.05$) increasing linear trend, and their share of sales grew from 3.9% to 9.9% (by 6.0%). The analysis also revealed that a portion of the wood was sold to foreign buyers. This share amounted to as much as 10% of the total volume of timber sold in 2005. In the remaining years, these values were at a much lower level.

3.4. Analysis of the economic relationships between the Węgierska Górka Forest District and the wood raw material buyers

A very strong positive correlation was observed between the quantity of wood purchased by the sawmill buyers and the sale of large-sized quality class C assortment of spruce offered by the Węgierska Górka Forest District ($r = 0.91$; $p < 0.01$); a strong correlation for quality class D ($r = 0.87$; $p < 0.05$) and quality class A ($r = 0.76$, $p < 0.05$), in addition to the S2a group assortment ($r = 0.81$; $p < 0.05$). Similar correlations among wood buyers were confirmed for the wholesale buyers, wood packaging buyers, agricultural producers (mixed activity) and the 'other recipients'. There were also strong positive correlations between the building joinery buyers and the sale of the S2b group assortment ($r = 0.91$; $p < 0.01$) and large-sized quality class C assortment ($r = 0.85$;
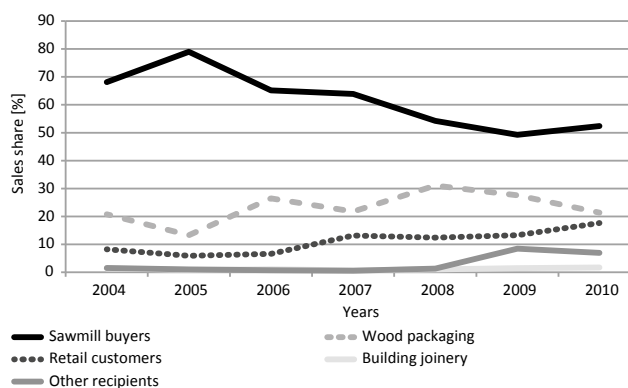

Figure 4. The share of wood buyers in the inner circle in the volume of sale of wood in 2004–2010. Source: own study based on reports from SILP database for the Forest District of Węgierska Górka.

Figure 5. The share of wood buyers in the outer circle in the volume of sale of wood in 2004–2010. Source: own study based on reports from SILP database for the Forest District of Węgierska Górka.
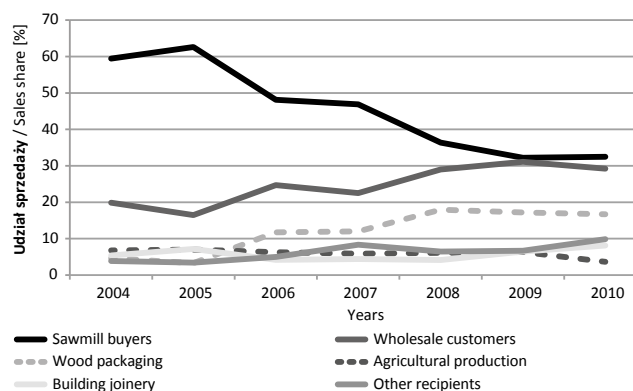
$p < 0.05$). In addition, strong positive correlations occurred between retail customers and the sales of the medium-sized S2b group assortment ($r = 0.79$, $p < 0.05$) and S4 group assortment ($r = 0.78$, $p < 0.05$).

4. Discussion and conclusions

The relationship between the Węgierska Górka Forest District and its economic environment – consumers of wood raw material – under conditions of natural disasters is limited only to wood raw material buyers. To this end, a subjective classification was used, that is, entities were grouped based on the criterion of their predominant economic activity. In this way, some elements of the input-output method were used, as suggested by Czyżewski (2008). Basically, this method was developed to analyse the complex economic relationships between different branches and even sectors of the national economy (Leontief 1936). In the field of forestry, the analysis is usually straightforward and limited to the relationships between selected forest districts and the immediate economic environment (e.g., Gołos et al. 1999; Płotkowski et al. 2004). An important element of the analysis, aimed at determining the impact of an increased supply of wood raw material on relationships in the timber market, was to obtain information on the amount of goods that could be used in the economy of the examined region. The forest district selected for the analysis is located centrally in relationship to all the forest districts affected by natural disasters in the Beskid Śląski and Żywieckie Mountains. This made it possible to categorize the buyers geographically, and to designate them in terms of their distance from the Węgierska Górka Forest District to an 'inner circle' or 'outer circle'. According to Czyżewski (2008), such a division is important in the context of analysing the service providers for a given geographical area. The division into these determined areas showed that there was significantly less wood distributed to the inner circle (from 28.4 to 49.4 thousand m³) than to the outer circle (from 48.1 to 220.2 thousand m³). This phenomenon can be largely explained by the limited possibilities of local business entities to process the raw wood material.

The results show that there was a clear change in the strength and diversity of economic relationships, mainly among the producers of sawmill products and timber wholesalers. Wholesalers were not even noted in the inner circle. The high share of producers of sawmill products, that is, at a similar level as in the Węgierska Górka Forest District in 2005, and the lack of timber wholesale customers were also noted by Gołos et al. (1999). These studies, however, were conducted for one year and on the example of Białowieża Forest Districts, that is, under different economic conditions.

Table 1. Pearson correlation coefficients (r) between observed variables: supply of selected assortments of timber spruce (m³) and quantity of wood purchased by the wood buyers (m³), determined according to their predominant activity (PKD 2007)

Specification	WA [1]	WB [2]	WC [3]	WD [4]	S2a [5]	S2b [6]	S3b [7]	S4 [8]
Sawmill buyers	**0.76**[*]	0.69	**0.91**[**]	**0.87**[*]	**0.81**[*]	0.60	-0.10	0.16
Wholesale customers	0.11	0.16	**0.85**[*]	**0.90**[**]	0.68	**0.98**[**]	0.22	**0.76**[*]
Wood packaging	0.00	0.02	**0.77**[*]	**0.86**[*]	0.63	**0.98**[**]	0.29	**0.78**[*]
Agricultural production	0.41	0.46	**0.96**[**]	**0.95**[**]	**0.83**[*]	**0.89**[**]	0.14	0.54
Building joinery	0.08	0.37	**0.85**[*]	0.75	0.60	**0.91**[**]	0.12	0.75
Retail customers	-0.35	-0.21	0.48	0.62	0.06	**0.79**[*]	0.12	**0.78**[*]
Other recipients	0.12	0.21	**0.83**[*]	**0.85**[*]	0.40	**0.88**[**]	-0.07	0.74

[*] correlation is significant at the 0.05 level
[**] correlation is significant at the 0.01 level
[1] large-sized assortment A including: logs and special timber
[2] large-sized assortment B including: logs and special timber
[3] large-sized assortment c including: logs and special timber
[4] large-sized assortment D
[5] medium-sized utilities assortment in various classes of length including pulp-wood
[6] medium-sized assortment independent of the buyer in various classes of length e.g. pallets, packaging
[7] medium-sized assortment in various classes of dimension including pulp-wood
[8] medium-sized assortment including large size of fire-wood

Source: own study based on SILP data

In the inner circle, clear increasing trends in sales were confirmed for retail customers, and in the outer circle, among recipients from other sectors, such as the road transport of goods. The analysis revealed that some of the wood was also sold to foreign buyers. Ślęzak (2012) reports that during this period, the share of exports was in the range of 1.1% (2007) to 4.9% (2010) of the total volume of timber sales in Poland. It should be noted, however, that all forest districts affected by natural disasters in the Beskid Mountains are located in the frontier zone or directly influenced by it, which makes it impossible to totally eliminate exports.

A large role in the distribution of timber acquired as the result of natural disasters was played by both buyers in the wood wholesale trade, as well as other entities not directly involved in processing wood raw material. According to Ratajczak (2011), the sawmill industry was in worse condition only in 2008, resulting from a decrease in production sales. This was also the case for the wood-based panel, joinery and wood packaging sectors. According to the Central Statistical Office, the amount of production from wood and its products decreased only in 2008–2009 (GUS 2012). On the other hand, a detailed analysis showed that as of 2006, the share of sawmill buyers in relation to timber wholesalers and wood packaging customers decreased. This was confirmed by the statistical analyses, which showed very strong positive correlations between the wholesale buyers and the supply of medium-sized S2b group assortment ($r = 0.98$; $p < 0.01$) and large-sized class D assortment ($r = 0.90$; $p < 0.01$); there were also strong positive correlations for large-sized quality class C assortment of spruce ($r = 0.85$; $p < 0.05$) and even the medium-sized S4 group assortment ($r = 0.76$; $p < 0.05$). Similar dependencies were observed for buyers from the wood packaging sector. The deterioration of the quality of raw wood material has undoubtedly resulted in the increased interest of economic entities other than sawmill buyers.

The increase in the sales of wood raw materials to consumers outside the local region (outer circle), including wholesale buyers of timber as well as foreign buyers, mitigated the negative effects of the overproduction of timber in the local wood market. As a consequence, it slowed down the sudden drop in the prices of wood raw material. This correlation is confirmed by previous studies (Prestemon et al. 2001). This was a favourable situation for the Węgierska Górka Forest District, because it preserved the continuity of the sale of timber affected by natural disasters, to which the efficient timber sales system of the State Forests Holding also contributed (Szabla 2009). However, the processing of wood raw material by local buyers within the inner circle could bring much greater economic benefits to the region, as Patriquin and others suggest (2007). The sale of wood raw material in an unprocessed state outside the area in which it was produced results in a loss of economic benefits associated with added value, mainly expressed in job positions and additional tax revenue. Zając (2011) makes the same argument, citing the example of the State of Thuringia in Germany. Adamowicz (2011) emphasizes that among the countries of Europe, greater benefits are achieved by those countries where imports of wood raw materials are higher than their exports.

The changes in wood buyers affect the increase in the value of the goods made in a specific production process or of the services created through the processing of wood. According to Gołosa et al. (1999), an increased processing of raw wood material increases its added value per cubic meter of wood. Płotkowski et al. (2004) also believe that the technological cycle of wood processing results in a two to fourfold increase in value between standing timber and wood industry products. Similarly, Ratajczak (2011) argues that the added value of producing furniture or paper is several times greater than that of firewood. Products with a high degree of processing have, therefore, more economic significance, as suggested by Lis (2012), Piszczek (2011) and Parzych (2008). This should be considered in the context of natural disaster areas, as both the distribution of wood raw material in the geographic area, as well as the unfavourable change in the share of wood buyers are important for the region's economy. Likewise, Płotkowski (1997) argues that goods and services produced in the area become a source of additional income for the local population. Their re-use within the region results in a multiplier effect. In this context, the new rules for wood sales, which came into force in 2017 (Regulation 2016), may be especially important, as they apply a 'geographic purchase criterion'. This mechanism can increase the profitability of wood processing plants by reducing the cost of transporting the purchased raw material to the nearest facility for the entrepreneur. Moreover, in the long run, this solution can bring tangible benefits to the region's local development. However, determining the benefits of implementing these sales guidelines would require an extended analysis of wood products and manufactured goods in the longer term, and take into account a number of micro- and macro-economic factors.

A number of factors affecting the wood sector, including social, economic, technical and environmental factors, complicate the analysis. The main reason for this is that the industry is very diversified, and each sector is characterized by different production processes, a different assortment of manufactured products, degree of modernization and other factors. (Ratajczak 2011). In addition, about 20,000 different wood products are distinguished (Ratajczak 2012). It is also difficult to determine the final products only on the basis of the wood buyers (PCA), especially since a significant share

were entrepreneurs in the wholesale timber business. The secondary processing of wood (e.g., furniture) will contribute to creating added value to a greater extent than primary products (e.g., sawn timber). Therefore, a full analysis of the economic impact for the region would require an expanded analysis of wood products and goods and their further distribution. However, a limiting factor is the large variety of wood products. The solution could be the application of model indices of the unit utilization of wood material in the final products and the usefulness of materials and wood products for various applications, as suggested by Ratajczak et al. (2006). This is beyond the scope of this study and requires separate research.

The results of the study justify the formulation of the following conclusions:

• The increased supply of wood raw materials resulting from natural disasters changed the flow of its sales, both in the case of timber buyers, as well as their location in the surrounding geographical area.

• The increased supply of raw wood material resulting from natural disasters led to an increase in the purchase of timber by wholesale buyers, as well as an increase in purchases by other entities not directly involved in the production of wood products, and thus, a decrease in the share of purchases by sawmill operators.

• Wood raw material buyers outside the region affected by natural disasters play an important role in mitigating the effects of the oversupply of timber, to the benefit of forest management.

• A detailed analysis of the distribution of wood raw material and its processing needs to be developed and further research should be conducted in this area.

Conflict of interest

The author declares that there are no potential conflicts of interest.

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