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HARVESTING CONDITIONS, MARKET PARTICULARITIES OR JUST ECONOMIC COMPETITION: A ROMANIAN CASE STUDY REGARDING THE EVOLUTION OF STANDING TIMBER CONTRACTING RATES

UVJETI PRIDOBIVANJA DRVA, OSOBITOSTI TRŽIŠTA ILI TRŽIŠNO NATJECANJE: RUMUNJSKA STUDIJA SLUČAJA O KRETANJU UGOVORNIH STOPA ZA DRVO NA PANJU

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ABSTRACT

A survey of timber harvesting operations and tendering prices was conducted in a representative forest region of Romania aiming to see to what extent the harvesting parameters of the sold harvesting stacks affect the tendering prices. Based on a sample of 1192 contracts, accounting for more than 20,000 harvested hectares and for more than 600,000 harvested cubic meters, descriptive statistics of harvesting conditions and tendering prices were computed and prediction models of tendering prices as a function of harvesting conditions were estimated. Harvesting factors such as the felling type, sold volume, removal intensity, tree size and pruning condition, slope and extraction distance had rather a low effect on the initial (adj. R^2 = 0.20) and final tendering prices (adj. R^2 = 0.17) showing that the remaining variability could be related to other factors. No obvious relations were found between the variation of harvesting factors and the variation of the difference in price paid by the contractors to buy the wood. As a consequence, a more detailed price analysis was conducted to see to what extent prices can be explained by the demand and supply evolution. Although the evolution of the prices and negotiated quantities may be considered confusing in the context of a normal market supply and demand, the analysis revealed that the stumpage market demand increase during analyzed years and there was a bigger demand for conifers species. The results of this study could be of help for both, the forest management and harvesting contractors in shaping and conducting their businesses. In addition, the study gives detailed statistics on the forest operations practices and conditions under the Romanian forestry, being of help for comparisons with other regions.

KEY WORDS: harvesting conditions, prediction model, auction price, selling price, supply, demand

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1. INTRODUCTION
UVOD

Romanian forests cover roughly 6.9 million hectares, predominating in the alpine landscapes (Florescu & Nicolescu 1996). They always played a key role in supporting the national economy and that is still true, the forest sector contribution to GDP being around 4% (WB, 2014). The Romanian forest functionality system divides the forests in two main groups (Parliament of Romania 2015) - protection and production forests - with the later predominantly managed under the continuous cover forestry practices as a compromise between production and protection functions.

The management of even-aged forests intended for the production of wood assortments is mostly based on regenerative felling that have predetermined rotation periods stipulated into management plans. Usually, this means repeated extractions in the form of thinning operations followed by several final fellings to extract the wood at the maturity of forest stands. In some cases, clear cuts are carried out to artificially regenerate poplar and spruce stands, by plantation. Only to a minor extent the production forests are managed under the uneven-aged systems.

Wood trading in the Romanian state-owned forests is strictly regulated, being characterized by standardized contracting procedures and rather an excessive bureaucracy (Rauch et al. 2015). The state-owned forest management company (National Forest Administration - Romsilva, NFA) is selling wood coming from state forests on public tenders or by direct negotiation with customers, according to some pre-established price list. Majority of the sold wood (80%) is object of public tenders and the wood is sold on the stump. The rest of it is harvested using NFA own harvesting facilities or by buying harvesting services from private companies that have wood harvesting permits issued by the central authority. This category is usually sold in roadside landings or, rarely, in central storages. The above described situation is due to the limited capacity of NFA to harvest the wood but also to the prescriptive legislation that is favoring the access of harvesting companies to the state wood resources (OM, 2016). Wood quantities to be harvested every year are at the level of the Annual Allowable Cut (AAC) established by the 10 years-based forest management plans. However, in many cases, due to the lack of accessibility, or for other different harvesting reasons, the annual wood quantity to be harvested is less than the AAC. Compared to other regions such as the Central European alpine forests (Spinelli et al. 2015), the standing wood is tendered, auction prices being established by the county branches of NFA using the reference prices that are established at national level based on market conditions, species, accessibility, estimated dimensional assortment and felling type (OM 2016). Decision on the amount of timber to be harvested, therefore sold, is based on forest management plans. Additionally, the county branches usually consider the average tree volume and provenience when establishing the auction price (OM 2016). The auction prices are established for every cut-block in RON/m^3 (RON - Romanian currency) that is applied for all the wood volume to be sold in that cut-block. The volumes are estimated at the level of compartment parts, compartments or groups of compartments and include all the trees that are to be harvested in those stands depending on the operations that are planned. These are done according to a forest management plan. Forest management plans are, in their essence, authorized regulatory documents prepared at forest management unit level (usually between 1000 and 5000 hectares) and having a 10-year validity (Abrudan 2012). They serve as a reference for planning, guarding and providing forest-based services and products including timber and non-timber forest products. For private forest owners, the forest management planning is done mainly by private companies and for state forests, by the National Forestry Research and Development Institute.

The tendering process is rather complicated including a preselection of potential harvesting companies, a proper transparency and publicity of volume estimation, prices and locations of cut-blocks as well as harvesting conditions and prescriptions (OM, 2016). All the standing wood is entering the tendering process. For some quantities, there are no offers, these quantities being labeled as untendered. In many cases, due to the tendering process, the selling prices are significantly higher than the auction price. Nevertheless, the untendered wood quantities can be negotiated in term of prices between the NFA county branches and the harvesting companies, but the negotiated price must not be lower than the auction price (OM, 2016). In case the negotiation fails the NFA county branch can harvest these wood quantities, using both their harvesting facilities and buying harvesting services.

The above described wood trading regulatory system is introducing certain distortions in the stumpage market, additional to those that are determined by the lack of homogeneity in harvesting conditions and the limitation in resource. Therefore, establishing a very clear connection between wood quality or harvesting conditions on one side and the market conditions, on the other side, is even more difficult. Although there are numerous attempts to elaborate models describing the factors influencing wood prices (Sohngen & Sedjo 1998), many of them quite successful, describing wood markets is still an issue due to high influence of the limited homogeneity of the harvesting conditions and stands characteristics (Wear & Parks 1994). Stumpage market description, however, is quite commonly done with remarkable results, using the transactions evidence (Niquidet & Kooten 2006). For Romania, the very prescribed regulation in terms of selling, harvesting and transporting the timber (Abrudan et al. 2015) as well as the relative immaturity of the market actors (the whole timber harvesting sector have recently been privatized) is making the market factors assessment even more difficult, although interesting attempts have been made, mainly about local conditions (Nichiforel & Turcu 2015). Moreover, small and medium-sized harvesting companies owning and operating partially mechanized equipment (Moskalik et al. 2017) are predominating the Romanian wood harvesting market environment (Sbera 2007) a fact that often results in a low financial capability and in the lack of appropriate technology to harvest the wood (Rauch et al. 2015). This is even worse in the steep-terrain alpine and hilly forests that are often characterized by a low access which limits the use of state-of-art cable yarding technology (Borz et al. 2014a, Visser and Harrill 2017), resulting in a poor time management and low productivities (Borz et al. 2013), unsafe harvesting procedures (Borz et al. 2014b, Leshchinsky et al. 2016, Potočnik and Poje 2017) and altered practices in terms of winching distance (Borz et al. 2014c) that generate increased work-related risks (Đuka et al. 2016) and production costs and sometimes affect the environment (Borz et al. 2015, Cosola et al. 2016). Small scale companies often lack the financial capability to purchase expensive mechanized equipment (Spinelli et al. 2012) and the ability to associate themselves for such attempts given the fact that they are competitors on the wood market. Also, the internal cost-control processes and mechanisms of the Romanian contractors are rather absent in the available literature, therefore difficult to understand and manage. While the environmental, cultural and social dimensions affect the sustainability of the wood procurement (Rauch 2013), and the type of mechanization degree of harvesting systems depends on economic condition (Moskalik et al. 2017), forest types, wood species, management methods, terrain and climatic conditions (Vusić et al. 2013) one of the important issues in the optimization of forest operations is the cost control (Mathews 1942, Oprea & Borz 2008) and economic sustainability (Rauch 2013). It refers not only to the operational costs but to the harvesting contract rates (Spinelli et al. 2015) and the general context between suppliers and contractors. Obviously, the Romanian harvesting conditions differ compared to those from other Western European or international countries with the main differences resting in the equipment (Moskalik et al. 2017, Sbera 2007) and practices used (Moskalik et al. 2017, Borz 2015), market context (Nichiforel & Turcu 2015) and the low access due to the poorly-developed transportation infrastructure (Iordache et al. 2012). The underdeveloped transportation infrastructure generates low access to wood resources by increased extraction distances that are just one of the well-known factors affecting the operational costs irrespective of the harvesting system used (Heinimann 1998). On the other hand, applied research should provide knowledge and tools to help and support the competitiveness of the industry (Brown et al. 2011) triggering this way innovation. This is particularly important in the forest-based industry where the innovation runs slow but in order to do that the industry's context should be known with the later referring both to the economic and technical environment. Often, a context is known by reliable statistics on the issues mentioned above and such statistics are usually gained by surveys.

The goal of this study was to analyze the harvesting conditions in relation to the wood selling prices for an area considered as being representative for the Romanian forest conditions. The working hypothesis of this study is that the variability of selling price of the timber could be explained by the variability of a set of technical factors characterizing the harvesting conditions. Therefore, the objectives of this study were set to: (1) developing descriptive statistics for harvesting conditions and timber selling prices, (2) attempting to model the wood selling prices as a function of operational harvesting conditions and (3) analyzing in detail the wood selling prices for the area taken into study.

2. MATERIAL AND METHODS
MATERIJAL I METODE

A survey has been conducted on the harvesting contracts with the data used in this study sourced by the Regional Forest Administration of Baia Mare (RFA Baia Mare), Maramureş (Fig. 1), accounting for 13 forest districts falling under its administration and for three management years (2012-2014). The authors believe that the data used in this study can be seen as being representative for the Romanian conditions for several reasons including the wide variability of the forests, tree species and harvesting conditions in the area (starting with the plain and ending with alpine forests) and the standard contracting procedures at national level.

Figure 1. Study area
Slika 1. Područje istraživanja

Descriptive data on the sold and harvested timber was refined from an initial database that accounted for more than 800,000 m^3, over bark (o.b.). Refinement was necessary due to the data inconsistency of some of the harvesting contracts. Specific parameters coming from the timber selling acts such as the felling type - FT, forecasted harvesting methods - HM, cut-block area - TA (ha), sold volume per cut-block - LS (m^3 over and under bark on main tree species), removal intensity - RI ($m^3 \times ha^{-1}$), tree size - TS ($m^3 \times tree^{-1}$) and pruning condition - PC (% of the tree height), terrain slope - S (°), extraction distance - ED (m), initial tendering price - ITP (RON × m^{-3}), final tendering price (selling price) - FTP (RON × m^{-3}) and the difference in price paid by the contractors PD (RON × m^{-3}) were coupled with data coming from the contractors side such as the effectively used harvesting systems (HS) for a number of 1192 harvesting contracts (644,055.00 m^3 o.b.) spanning the 2012-2014 period. Harvesting systems were described based on the equipment used and they were categorized in (1) motor manual tree felling and processing - tractor skidding (MMF-SKID), (2) motor manual tree felling and processing - cable yarding (MMF-CY) and (3) motor manual tree felling and processing - animal powered logging (MMF-AL). Such data was provided by the local contractors based on the request of the RFA Baia Mare and it was paired with the contract data into a Microsoft Excel sheet. The types of silvicultural systems under the analysis were clear felling (CF) which in the Romanian mountains is usually carried out in the case of spruce stands on areas less than 3 hectares, thinning (THI) which in Romania is less intensive in terms of removals, salvage felling (SAL) which is usually implemented to extract the wood affected by various factors such as drought, windthrow or mass infestations on relatively large areas, sanitary felling (SAN) which aims to remove locally affected wood and selective felling (SEL) which is the regular system to extract the wood under the continuous cover forestry practice in Romania assuming that such forests are old enough - reached their rotation - to carry on the main harvests. In such a case, a selective felling is done to remove 10 to 33% of the growing stock per decade, providing the needed space for natural regeneration. Given the fact that the forest managers categorize the wood extracted to create the space needed for skid roads or other harvesting and transportation infrastructure as salvage felling, in this study we used the same approach.

Data was analyzed statistically using the Microsoft Excel software. The authors chose this software package as it enables several functionalities of data refining, calculation and statistical analysis. The later was carried out sequentially in order to get the descriptive statistics of the studied conditions, to attempt to model the variation of tendering prices as a function of the harvesting conditions and to analyze in detail such prices. A first step was that of treating the outliers which was described above. Inconsistencies were found as all of the initial data was manually filled into the database. Then the descriptive statistics of the harvesting conditions and selling prices were developed, followed by an attempt to model the tendering prices as a function of harvesting conditions. To this end, a stepwise backward regression procedure using a confidence threshold set at $\alpha = 0.05$ was used to test the significance of predictor variables and of the developed models ($p \leq 0.05$) following a correlation analysis (not shown in this study) which assumed a threshold of $R = 0.75$ to treat the multicollinearity of the independent variables as described in Sabo & Poršinsky (2005). Exclusion of a given variable within a pair of highly correlated variables was made based on logical assumptions on which of them would be more suitable for the regression analysis. All of the procedures used were those specific to general statistics techniques as described, for instance in Zar (2010).

Finally, a detailed analysis of the difference in price was carried out assuming that stacks with the difference between auction price and selling price under the auction step were negotiated and negotiated stacks are less demanded by the harvesting companies. For simplicity reasons, when assessing the prices per species, stacks having more than 60% volume of one species were considered for that species or group of species. This was the reason for considering only two group of species or species: beech and conifers. The analysis was done in Romanian currency (RON). The average annual exchange rates for the three considered years were RON/EUR 4.4560 in 2012, 4.4190 in 2013 and 4.4446 in 2014 as published by the Romanian Central Bank.

3. RESEARCH RESULTS
REZULTATI ISTRAŽIVANJA

3.1. Descriptive statistics of the harvesting conditions and tendering prices – *Deskriptivna analiza uvjeta pridobivanja drva i natječajnih cijena*

Table 1 shows the summary statistics of operational variables and tendering prices. Cut-block area varied widely between 0.1 and 287 hectares as being specific to some Romanian wood selling practices. The minimum value is specific to those extractions aiming to create space within the forest for the skidding roads. Such extraction types were categorized in this study as salvage cuts (SAL). The maximum value was that specific to sanitary extractions (SAN) where the Romanian praxis is that of grouping several compartments or (and) compartment parts, possibly to cope with very low removal intensities. This study covered the harvesting data coming from more than 22,000 hectares. The mean cut-block area was of about 19 hectares. Accordingly, the volume sold per cut-block varied between 3 and 2,868 m^3 o.b., averaging 540.3 m^3 o.b. (513.4 m^3 under bark, hereafter - u.b.). According to the data shown, the bark volume for all of the harvested wood can be estimated at 32,053 m^3. Removal intensity is often related to the extraction types and the cut-block area. It varied largely between 0.2 and 962.4 m^3 o.b. × ha^{-1} (0.2 and 917.2 m^3 u.b. × ha^{-1}) as being specific to low extractions (SAN) or high intensity extractions (clear cuts - CF, selective cuts - SEL) and it averaged 97.3 m^3 o.b. × ha^{-1} (92.4 m^3 u.b. × ha^{-1}). Tree size varied also widely from less than 0.1 to more than 5.0 m^3 × tree^{-1}, as in the area exist some old-grown beech forests. Even if a wide range of forests were taken into account, including plain and hilly forests, the average terrain slope was of almost 24°. Notable was also the extraction distance which averaged more than 1,1 km, varying widely between 200 m and 3 km.

Clear fells (CF) accounted for less of 1% both in terms of sold (extracted) volume and harvested areas (Fig. 2). Predominant in the harvested volume were the selective removals (SEL) while the thinning operations (THI) accounted for near the same share in terms of harvested area and volume. As expected, the sanitary extractions (SAN) contributed more in the harvested area and less in the harvested volume.

The share of harvesting systems used to extract the wood was computed based on the number of contracts in which a given harvesting system was effectively used (not shown herein). Motor-manual tree felling and processing followed by skidding using winch skidders or adapted farm tractors (MMF-SKID) accounted for 89.18% of the cases being used

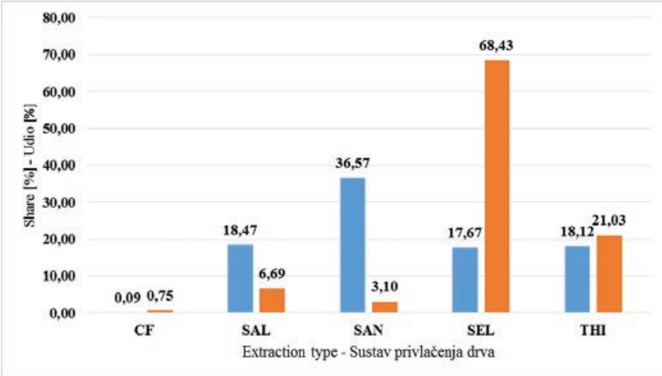

Figure 2. Share of extraction (felling) types on harvested areas (blue) and extracted volume (orange)
Slika 2. Udjeli vrste privlačenja (siječa) prema površini sječine (plavo) i obujmu privučenog drva (narančasto)

to harvest the wood corresponding to 1063 carried-on harvesting contracts. The next in line was the motor-manual tree felling and processing followed by animal powered logging (MMF-AL) with a share of 10.32% (123 cases). Cable yarding was used for less than 1% of the cases (6 cases).

3.2. Regression models of the tendering prices – *Regresijski model natječajnih cijena*

Regression analysis returned the models included in Equations 1 and 2. Following the correlation analysis both, the sold volume per cut-block (m^3 u.b.) and removal intensity

Table 1. Summary of operational conditions and tendering prices
Tablica 1. Sažeti prikaz uvjeta pridobivanja drva i natječajnih cijena

Parameters – *Parametri* Harvesting variables – *Parametri pridobivanja drva*	N	Descriptive statistics – *Deskriptivna statistika* Min.	Max.	Mean±St.dev.	Sum
Cut-block area [ha] – *Površina sječine [ha]*	1192	0.1	287.0	18.5±35.5	22,036.5
Volume sold per cut-block [m^3 o.b.] – *Prodani obujam po sječini [m^3 o.b.]*	1192	3.0	4868.0	540.3±675.4	644,055.0
Volume sold per cut-block [m^3 u.b.] – *Prodani obujam po sječini [m^3 u.b.]*	1192	3.0	4472.0	513.4±642.5	612,002.0
Removal intensity [m^3 o.b. ha^{-1}] *Sječna gustoća [m^3 brutto ha^{-1}]*	1192	0.2	962.4	97.3±128.6	–
Removal intensity [m^3 u.b. ha^{-1}] *Sječna gustoća [m^3 netto ha^{-1}]*	1192	0.2	917.2	92.4±122.7	–
Mean tree volume [m^3] – *Srednje kubno stablo [m^3]*	1192	<0.1	5.7	1.1±1.0	–
Pruning condition [% of tree height] *Čistoća od grana [% visine stabla]*	1192	<0.1	0.8	0.5±0.1	–
Terrain slope [°] – *Nagib terena [°]*	1192	0.0	50.0	23.5±10.0	–
Extraction distance [m] – *Udaljenost privlačenja [m]*	1192	200.0	3,000	1161.6±1078.4	–
Tendering price – ***Natječajna cijena***					
Initial tendering price [RON] *Početna natječajna cijena [RON]*	1192	15.0	288.0	79.3±41.6	94517.0
Final tendering price [RON] *Ostvarena natječajna cijena [RON]*	1192	16.0	350.0	98.1±54.7	116972.0
Difference [RON] – *Razlika [RON]*	1192	0.0	262.0	18.8±30.9	22455.0

(m³ u.b. × ha⁻¹) were excluded as they were strongly correlated, with their pairs expressed in over bark cubic meters. As shown in Eq. 1, in the case of prediction of initial tendering price (ITP) by the harvesting technical parameters, the common variability of all of the studied harvesting variables explained the variability of the former in a proportion of 20% (Adj. R^2 = 0,20). All of the variables taken into account, as well as the developed model were significant (α = 0.05, p < 0.01).

$$ITP = 39.604 + 13.823 \times FT + 14.087 \times HS + 0.148 \times TA - 0.007 \times LS + 0.028 \times RI + 5.637 \times TS + 35.351 \times PC - 0.443 \times S - 0.004 \times ED \quad \text{(Eq. 1)}$$

For the final tendering price (FTP) model (Eq. 2), however, the volume sold per cut-block and removal intensity failed to become significant. In the developed model, the common variability of the remaining variables explained the variability of the final tendering price in a proportion of 17% (adj. R^2 = 0.17). All of the variables taken into account, as well as the developed model were significant (α = 0.05, p < 0.01).

Regression analysis of the difference in tendering price (DP), did not returned an accurate model, as the adjusted coefficient of determination was very low (adj. R^2 = 0.03). However, the model was significant and included the felling type, harvesting system, cut-block area and terrain slope as relevant predictors.

$$FTP = 54.051 + 16.773 \times FT + 21.148 \times HS + 0.213 \times TA + 7.216 \times TS + 42.712 \times PC - 0.872 \times S - 0.003 \times ED \quad \text{(Eq. 2)}$$

3.3. Analysis of tendering prices – *Analiza natječajnih cijena*

We have made numerous attempts to describe the market and the factors influencing certain features of the supply and demand, but most them have not succeeded. Still, some interesting results were found when analyzing the transactions. Due to the described system for standing wood selling, the volumes that are tendered can give an indication regarding the timber demand: the smaller the negotiated volume the bigger the demand. Fig. 3 is presenting the ratio between the tendered and the untendered standing wood volumes for conifers and beech. Just looking at the tendered volumes for the three years (Fig. 3 and 4) one can see that the prices for conifers (89%) were bigger when compared with beech (67%), this probably indicating a bigger market demand for conifers species.

For the analyzed set of transactions, the auction price increased every year especially for both conifers and beech. Also, for both species the biggest increase in auction price was between 2013 and 2014: 39% for beech and 46% for conifers. Despite the auction price increase, the average price difference (average difference between selling price and auction price) did not decrease: it remained rather constant for conifers and even increased for beech, e.g. trend lines in Fig. 5 would confirm this statement. These numbers also indicate that the stumpage market demand increased during the analyzed years.

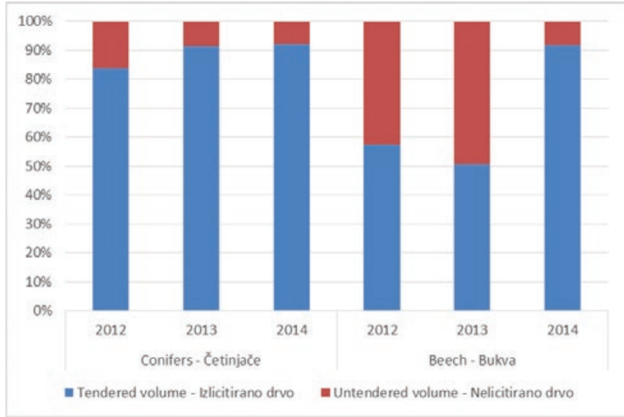

Figure 3. The ratio between tendered and untendered volume for conifers and beech
Slika 3. Udjeli izlicitiranog i nezlicitiranog drva za četinjače i za bukvu

Figure 4. The ratio between tendered and untendered volume per species (conifers on left and beech on right) and felling types (SAL - salvage, SAN - sanitary, SEL - selective, THI - thinning)
Slika 4. Odnos između izlicitiranog i nelicitiranog drva po vrstama drva (lijevi grafikon za četinjače, a desni za bukvu) i prema vrstama sječe (SAL - izvanredna sječa, SAN - sanitarna sječa, SEL - redovna sječa, THI - prorede)

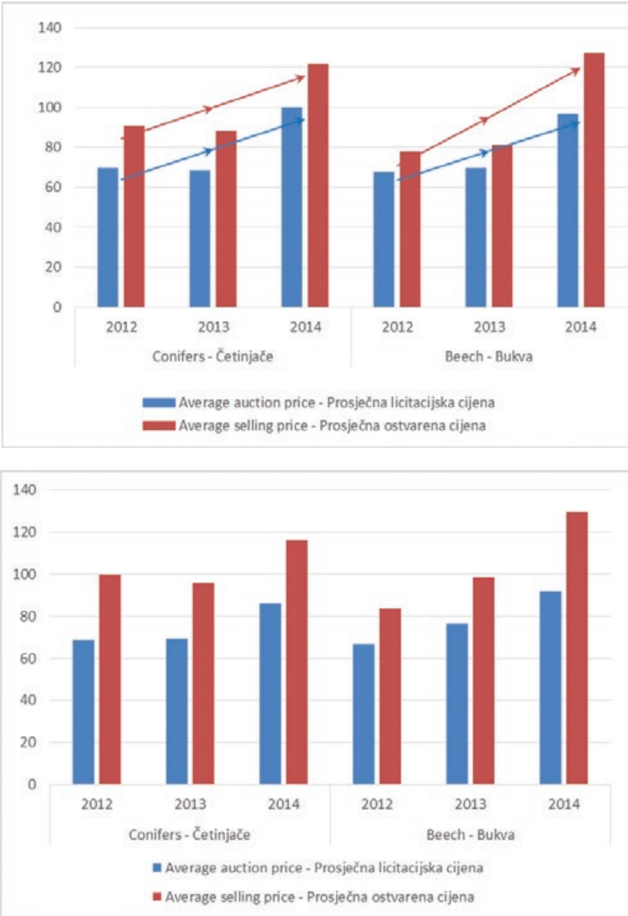

Figure 5. The price difference for beech and conifers (for all the recorded transactions on the left and only for the tendered stacks on right)

Slika 5. Razlika u licitacijskoj i ostvarenoj cijeni za četinjače i bukvu (utvrđena temeljem svih zabilježenih transakcija – lijevi grafikon, i samo za izlicitirane količine - desni grafikon)

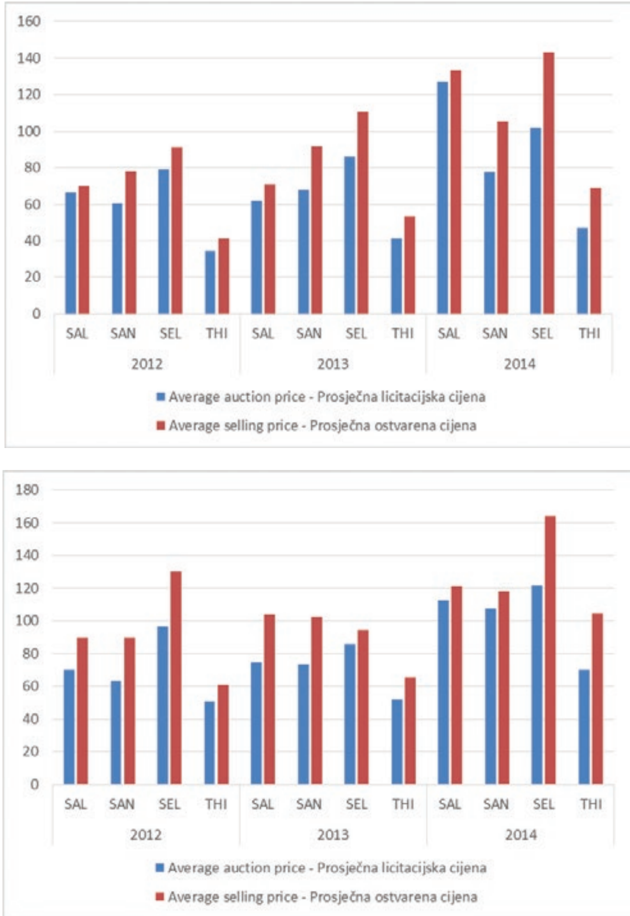

Figure 6. The price gain for conifers (left) and beech (right) per types of cuttings (SAL - salvage, SAN - sanitary, SEL - selective, THI - thinning) and years

Slika 6. Kretanje cijena na licitaciji za četinjače (lijevi grafikon) i za bukvu (desni grafikon) prema vrstama sječe (SAL - izvanredna sječa, SAN - sanitarna sječa, SEL - redovita sječa, THI - prorede) i navedenim godinama

Figure 5 is presenting the data of price differences for beech and conifers for all the recorded transactions (left graph) and those data by excluding the negotiated volume (right graph). Normally, the average price difference for this category of volume was bigger. It can be expected that harvesting companies tendered for volumes (cut-blocks) with lower prices. Despite this logical expectation, this is valid only for 2014, the year with the biggest auction prices.

Further analysis on the price difference focused on the type of silvicultural systems (Fig. 6). For the conifers dominated cut-blocks, we found out that in each of the analyzed years there were quite big differences in the average price difference between cut-blocks with different types of harvests, but no elements seem to be constant. Nevertheless, for beech dominated cut-blocks there are some features that were common in all three analyzed years: salvage volumes had the lowest price difference every year. Interestingly, in 2012, the highest price difference was recorded for the sanitary volumes.

4. Discussion and Conclusions – *Rasprava i zaključci*

The main goal of this study was to analyze the harvesting conditions and the wood selling prices in a forest area representative for the Romanian forestry and to produce reliable statistics on such conditions. Given the approach of this study, comparisons whit internationally available results are rather difficult to make. However, some points may be raised and discussed. First of all, the harvesting systems used in the analyzed region are in line with the practices reported by Borz (2015) for Romanian operations. Such practices refer mostly to the excessive extraction distances as being specific to the hilly and alpine forests of Romania. As a fact, extraction distance exceeded in average 1 km, therefore, increased harvesting costs, even if not evaluated in this study, are to be expected as previous studies shown also a poor management of the operational time and low productivities in such conditions (Borz et al. 2013). Coupled with the high timber purchasing costs, they may contribute to the reduction of profit margin of small size harvesting contractors, therefore, to even a greater reduction of their ability to access the wood. Then, the timber skidding predominates in such conditions as our results on the share of harvesting systems were similar to that reported by Sbera (2007), who indicated that, in Romania, more than 95% of the operational cases are handled using skidders and agricultural tractors fitted for forest operations. Cable yarding systems are less available, therefore used to a less extent in the region (less than 1% of the analyzed contracts in this study). To this end, improvement of operations should be undertaken by finding ways to switch the contractor's beliefs and technology to an environmentally-sound one. This would be in line with the very long extraction distances and with the slope within the area which reached, in average, 23.5° (43%). Nevertheless, technology switching to cable-yarding without any subsidies or incentives coming from the state is rather difficult to make by the contractors due to purchasing costs that are still too high for them while their investment capability is limited and further affected by the wood selling market and conditions in which they are required to operate.

Previous research has shown that the contract rates are only partially affected by the technical constraints in alpine harvesting operations (Spinelli et al. 2015). While this study did not include the harvesting costs for obvious reasons (*e.g.* most of the contractors are small companies that do not keep detailed records on their costs), it pointed out that most of the harvesting technical factors taken into study were significant in predicting the tendering prices, at least for the initial and final tendering price. However, the predictive capacity of the developed models was rather low (*e.g.* adj. $R^2 = 0.20$ for ITP and adj. $R^2 = 0.17$ for FTP), indicating that only a small part of the wood selling prices is explained by the technical factors characterizing harvesting operations. In addition, the price difference was difficult to accurately predict, probably due to other mechanisms underlying the contractors' willingness to pay more in the auction process. We acknowledge that such small determination coefficients as they were observed in this study, may result in a low predictive capacity of the models and therefore their reporting could be interpreted as inadequate. For instance, Lindroos and Cavalli (2016) pointed out that in time and motion studies such low predictive capacities should be treated carefully. However, the price-setting and wood selling mechanisms are more complex compared to the behavior of other harvesting systems, often including the effect of non-harvesting factors (Spinelli et al. 2015) and of the subjective perception of the contractors competing for resources. To this end, it is possible for contract negotiating approaches to increase the objectivism therefore to better relate the rates to harvesting conditions. But in order to do that a change in the wood selling process is required and this is rather difficult to achieve for the moment. Conversely, the harvesting contractors should keep detailed records on their costs and the applied science should support them in their attempt to objectively evaluate their costs.

This is even more important as the highly non-homogeneous harvesting conditions make the description of the wood market extremely difficult. The normal demand and supply curves cannot be drawn and described, influencing factors being either not known or impossible to assess based on the available data. Therefore, the graphs shown in Figs. 3 and 5 should be assessed in conjunction. The fact that the negotiated volume did not decrease despite of the increased volume on the market and increased auction price is rather confusing. Previous studies pointed out that there may be some explanations for this: increased demand for timber for both species, increased harvesting capacity in an unsatisfied market, increased accessed processing capacity, etc. (Nichiforel & Turcu 2015). Further studies are to clarify this aspect under specific conditions in Romania.

Of course, the demand is highly influenced by the auction price and we could not assess that influence in the absence of data regarding quantities of wood that were offered and not sold. The fact that there are prices that nobody can negotiate under is also an important distortion factor which makes stumpage market prices assessment based on transactions analysis almost impossible. The fact that the auction prices are rising constantly can be seen as a consequence of the stumpage market evolution in limited resources conditions but, under Romanian conditions, there is a hidden danger to have an incomplete market evolution image when the prices, based on the specific regulation, can only go up. This may have been the cause of important stumpage market boycott in winter 2016 when almost all the conifer quantities on the market were refused by allied harvesting companies in the most important region for these species. Therefore, the NFA auction prices calculation process should be more market based and less costs based, this facilitating the real and transparent competition in the stumpage market. For obvious reasons, one of the options for having proper stumpage market price estimation would be to allow the negotiation process to end also with lower prices than the auction prices.

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SAŽETAK

U radu se istražuje povezanost postupaka pridobivanja drva i kretanja natječajnih cijena drva na panju. Istraživanje je provedeno na uzorku koji obuhvaća jednu šumsku regiju u Rumunjskoj, a cilj je bio utvrditi u kojoj mjeri pokazatelji pridobivanja prodanog drva utječu na natječajne cijene. Korišteni podaci Regionalne uprave šuma Baia Mare (RFA Baia Mare), Maramureş (slika 1), koja se sastoji od 13 šumarija, čine ugovore o sječi kroz tri godine gospodarenja (2012–2014). Autori smatraju da se navedeni podaci mogu smatrati reprezentativnim za rumunjske uvjete te mogu poslužiti kao ogledni primjer za svrhu istraživanja u ovoj studiji. Na temelju uzorka od 1192 potpisana ugovora, koji su obuhvaćali više od 20.000 ha sječne površine i više od 600.000 m^3 užite drvne zalihe, na temelju deskriptivne statistike, dobiveni su modeli predviđanja budućih natječajnih cijena, ovisno o raznovrsnosti uvjeta pri pridobivanju drva. Značajke sustava pridobivanja drva kao što su: 1. vrsta sječe, 2. veličina sječine, 3. sječna gustoća, 4. dimenzije stabla, 5. nagib terena i 6. srednja udaljenost privlačenja drva, imali su prilično slab učinak na iznose natječajnih (početnih) (R^2 = 0,20) i prodajnih (ostvarenih) cijena (R^2 = 0,17), što pokazuje da se preostala varijabilnost cijena može odnositi i na druge čimbenike. Nije bilo jasno izraženih odnosa između odstupanja pokazatelja u sustavu pridobivanja drva i razlika u cijeni koju su ponuđači plaćali za kupnju drva na panju. Stoga je provedena detaljnija analiza cijena kako bi se vidjelo do koje se mjere cijene mogu objasniti promjenama u odnosu na ponudu i potražnju. Analiza je pokazala da je u razdoblju istraživanja došlo do povećanja potražnje drva na panju, istodobno i uz veću potražnju za vrstama četinjača. Rezultati ove studije mogli bi pomoći šumovlasnicima/šumoposjednicima pri gospodarenju šumama, ali i privatnim poduzetnicima u šumarstvu prilikom planiranja i vođenja njihovog poslovanja.

KLJUČNE RIJEČI: uvjeti pridobivanja drva, model predviđanja cijena, natječajna (početna) cijena, prodajna (ostvarena) cijena, ponuda, potražnja, četinjače, bukva.