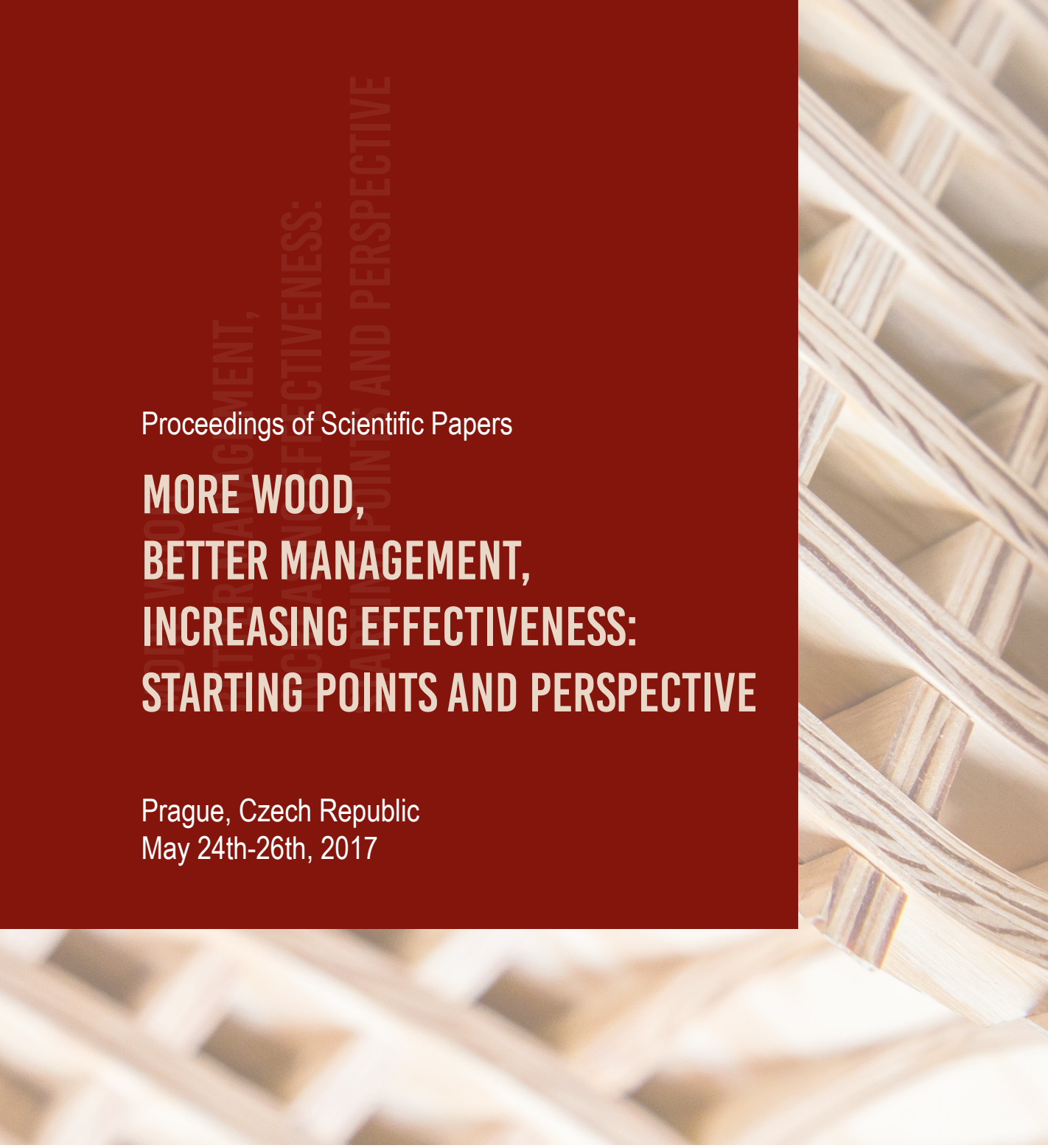

Proceedings of Scientific Papers

# MORE WOOD, BETTER MANAGEMENT, INCREASING EFFECTIVENESS: STARTING POINTS AND PERSPECTIVE

Prague, Czech Republic
May 24th-26th, 2017

Czech University of Life Sciences Prague
Faculty of Forestry and Wood Sciences

WoodEMA, i.a. – International Association for Economics and Management in Wood Processing and Furniture Manufacturing


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**Preface**

The Czech University of Life Sciences in Prague, the Faculty of Forestry and Wood Sciences is honoured to organise the 10th annual international scientific conference held in Prague, May 24th - 26th, 2017, under the auspices of WoodEMA, i.a. The aim of the conference is to transfer knowledge and experience from the field of economics and management of the wood-processing industry in the spirit of the conference title: More Wood, Better Management, Increasing Effectiveness: Starting Points and Perspective.

The conference proceedings fully support the above mentioned aim. Moreover, it includes 35 quality articles containing the results of the applications of the newest methods and approaches with an international dimension.

We believe that the outcomes of this conference including the proceedings will help to support and evolve the interest of published topics in the future.

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## CONTENTS

# AHP ANALYSIS OF WOOD PROCESSING PRODUCTION MANAGEMENT SYSTEM IN SOME SOUTH EAST EUROPEAN COUNTRIES

Dušak, M.; Jelačić, D.; Petrović, S.

## ABSTRACT

Small and medium enterprises (SMEs) make about 99 % of all enterprises within South East Europe wood processing and furniture manufacturing companies. The aim of this research was to establish the actual situation in production management systems of SMEs in wood processing companies in four South East European countries and to suggest some improvements according to the results of the analysis. Total of 10 experts dealing with management systems in wood processing in those four countries were surveyed, with the goal to propose the model to create better systems within SMEs in wood processing branch, to achieve better production and business results. Results were statistically processed by using AHP analysis. The AHP analysis of experts' opinions showed that the managers in small and medium enterprises in wood processing and furniture manufacturing should pay the most attention to conditions on the market, promotion and marketing, followed by products range and quality of products..
**Key words**: small and medium enterprises, AHP analysis, production management system

## 1. INTRODUCTION

Small and medium enterprises (SMEs) represent a significant part of the economy and industrial system of every country, and southeast European countries are no different in regards to the participaton of SMEs within their economy. Recently, research shows that the numbers for SMEs increase annually. Using Croatia as the average representative of southeast European countries, over 100,800 small and medium enterprises existed in 2014, representing 99.6% of all industrial subjects in Croatia. In 2015, the number of SME's increased to over 104,100 enterprises (99.7%). Out of those 99.7% of all industrial subjects in Croatia, 98.5% were micro and small enterprises, and 1.2% were medium enterprises.

In 2014, small and medium entrprises participated with 52% in the total Croation Gross Domestic Product (GDP) and over a 53% participation in 2015. In 2014, approximately 68% of Croatia's employees were employed by SMEs, and in 2015 that number was 50.9% in small enterprises and 17.5% in medium enterprises. In total, 48% of Croatian exports in 2014 were by small and medium businesses, and in 2015 that share of participation increased to 48.5%.

The Croatian case study is an accurate represetation for the average situation and percentages of small and medium enterprises in southeast European wood-processing and furniture manufacturing companies as a whole. Because most of the companies are situated in rural areas of southeast Europe, small and medium enterprises make up a large percentage of all wood industry companies. Wood-processing and furniture manufacturing companies are highly export oriented, thus the percentage of SMEs' exports exceeds the above numbers that represent total Croatian exports.

The aime of this research was to examine the current situation in production management systems in SMEs of wood-processing and furniture manufacturing companies in four southeast European countries (Croatia, Macedonia, Serbia, Slovenia), two of them members of European Union and two of them within negotiation process to become a member of EU. The study was aimed to establish parameters for company owners and managers in SMEs should consider to improve their business and production results in the future. The questionnaire aimed to establish the advantages and disadvantages associated with SMEs production management systems. Also, to suggest a model to create better production and management systems within SMEs in the wood processing and furniture manufacturing in southeast European countries.

## 2. MATERIAL AND METHOD

In the survey, the questionnaires for the purpose of an Analytical Hierarchy Process (AHP) analysis were used. The production management system parameters were grouped into seven categories and those categories were placed in relationships. The questionnaire was given to 10 experts from 4 previously mentioned South European Countries, who had to grade the relationships among the categories, according to their own opinion. To be able to help the managers in the decision-making processes, it was necessary to establish which of the seven groups of production management parameters to pay the most attention. Therefore, an AHP analysis method was performed.

The groups of production management parameters were as follows:

1. Leadership, Policy, and Organizational Structure of the Company,
2. Marketing and Market Activities of the Company,
3. Process Culture, Management Processes, and Production Deadlines,
4. Range of Products and Quality of Products,
5. Human Resources,
6. Information Technology and Modern Production Technology, and
7. Environmentally friendly production.

The AHP method is a multi-criterion decision making method that helps decide among suggested alternatives. Seven categories of parameters were established and placed to make $x \cdot (n-1)/2$ pairs. The questionnaire condition that should receive most consideration during the analysis was for the Consistency Ratio (CR) to be less than 10% ($CR \leq 0.10$), meaning that less than 10% of given answers (values) should be inconsistent.

## 3. RESEARCH RESULTS

The group of 10 experts from the four southeast European countries answered the AHP questionnaire to compare the importance of each group of production management parameters in grading each particular pair of the seven groups of parameters. Each expert's questionnaire was analyzed to calculate if the Consistency Ratio (CR) was less than 10%. Those questionnaires in which the CR was higher than 10% were considered inconsistent and were removed from the analysis. Therefore, 6 out of the 10 questionnaires were taken into consideration, thus why the overall analysis depicted the number of participants as N = 6.

The AHP analysis showed that CR = 1.2%, which designated that the analysis was valid. By the results of the analysis and by the ranking given according to the weight of each of the seven groups of parameters, the managers in SMEs in wood-processing and furniture manufacturing should pay the most attention to the conditions of the market activities and marketing (weight = 24.91%), followed by range of products, quality of products (weight= 19.59%), and information technology *versus* modern production technology (weight = 14.78%)..

**AHP Analytic Hierarchy Process (EVM multiple inputs)**

K. D. Goepel Version **04.05.2016** | Free web based AHP software on: http://bpmsg.com

**Only input data in the light green fields and worksheets!**

| | | | | | |
|---|---|---|---|---|---|
| n= | 7 | Number of criteria (2 to 10) | Scale: | 1 | AHP 1-9 |
| N= | 6 | Number of Participants (1 to 20) | $\alpha$: | 0,1 | Consensus: 67,1% |
| p= | 0 | selected Participant (0=consol.) | 2 | 7 | Consolidated |

Objective

Author: Marko Dušak

Date: 10-Nov-16 | Thresh: 1E-07 | Iterations: 4 | EVM check: 7,9E-09

| Table | Criterion | Comment | Weights |
|---|---|---|---|
| 1 | Leadership, policy and organizationa | | 11,1% |
| 2 | Process culture, management processes and production | | 11,6% |
| 3 | Product range and quality of | | 19,6% |
| 4 | Market, promotion and marketing | | 24,9% |
| 5 | Human resources | | 11,3% |
| 6 | Information technology, modern | | 14,8% |
| 7 | Environmentally friendly production | | 6,7% |
| 8 | | | 0,0% |
| 9 | | for 9&10 unprotect the input sheets and expand the | 0,0% |
| 10 | | question section ("+" in row 66) | 0,0% |

**Result**

Eigenvalue: lambda: 7,097

Consistency Ratio: 0,37 | GCI: 0,05 | CR: 1,2%

| Matrix | 1 Leadership, policy and organizational structure of the company | 2 Process culture, management processes and production deadlines and production | 3 Product range and quality of products products | 4 Market, promotion and marketing marketing | 5 Human resources | 6 Information technology, modern production technology | 7 Environmentally friendly production | 8 0 | 9 0 | 10 0 | normalized principal Eigenvector |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Leadership, policy and organizational structure of the company | - | 1 2/7 | 1/2 | 2/5 | 1 | 4/7 | 2 | - | - | - | 11,11% |
| 2 processes and production deadlines and production deadlines | 7/9 | - | 2/3 | 3/7 | 1 | 1 | 2 | - | - | - | 11,62% |
| 3 Product range and quality of products | 2 | 1 4/7 | - | 8/9 | 1 6/7 | 1 1/3 | 2 3/8 | - | - | - | 19,59% |
| 4 Market, promotion and marketing | 2 1/2 | 2 2/7 | 1 1/8 | - | 3 | 1 2/5 | 3 | - | - | - | 24,91% |
| 5 Human resources | 1 | 1 | 1/2 | 1/3 | - | 1 | 1 2/3 | - | - | - | 11,29% |
| 6 Information technology, modern production technology | 1 3/4 | 1 | 3/4 | 5/7 | 1 | - | 2 4/9 | - | - | - | 14,78% |
| 7 Environmentally friendly production | 1/2 | 1/2 | 3/7 | 1/3 | 3/5 | 2/5 | - | - | - | - | 6,71% |
| 8 0 | - | - | - | - | - | - | - | - | - | - | 0,00% |
| 9 0 | - | - | - | - | - | - | - | - | - | - | 0,00% |
| 10 0 | - | - | - | - | - | - | - | - | - | - | 0,00% |

*Figure 1. AHP Analysis on the seven groups of production management parameters*

## 4. CONCLUSION

The aim of this research was to establish the differences in opinions on different production management system parameters among experts dealing with production management issues within the four Southeast European countries. The AHP analysis was conducted to establish the ranking among the production management system parameters as a tool in the decision making process.

It was discovered by the AHP method that managers in wood-processing and furniture manufacturing SMEs in Southeast European countries should pay the most attention to conditions on the market activities and marketing knowing the needs and demands of the customers could help in improving production and business results of SMEs in this particular branch. A second group of production management system parameters that SMEs' company managers should pay attention to are the range of products available and quality of products. Customers welcome quality products, and even prefer quality over price.

This research and analysis can help managers in SMEs in wood-processing and furniture manufacturing improve their decision making process, improving their production and business results.

## REFERENCES

1. Bistričić, A.; Agatić, A.; Kuzman, Z. (2011): *The importance of small and medium-sized enterprises in the Croatian economy and in the European union states economies.* Scientific Journal of Maritime Research. University of Rijeka, pp. 145-158.
2. Dušak, M.; Jelačić, D. (2016). "Production management system of wood-processing SME's in Croatia," in: *Proceedings of International Conference WoodEMA- The path forward for wood products: A global perspective*, Baton Rouge, USA, pp. 9-14.
3. Espinoza, O.; Smith, R. (2015): *Business management practices for small to medium sized forest products firms.* Virginia Polytechnic Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating.
4. Jelačić, D., Homakova, R., Pirc, A., Meloska, Ž. (2009): *Seeking and implementation of innovation opportunities.* Wood research, vol 54. No.4/2009. SDVU Bratislava, Slovakia, pp. 129-142.
5. Krajnović, A.; Lordanić, S. (2012): *Strateški menadžment i korištenje instrumenata strateškog kontrolinga u malim i srednjim poduzećima.* Pregledni rad. Oeconomica Jadertina, Vol.2 No 1. UKD 65.012.4:334.7.
6. Nanić, A. (2013): *Small and medium enterprises as head of business of the European union. Profesional paper.* University of Bihać.
7. Neira, C. O.; Lindman, M.T.; Fernandez, M.J. (2009): *Innovation and performance in SME furniture industries.* An international comparative case study. Mark. Intell. Plan. 27(2): pp. 216–232.
8. Nowduri, S. (2014): *Management Information Systems Research for Small and Medium Enterprises: A Sustainability Perspective.* International Journal of Software Engineering and Its Applications Vol.8, No.8. pp. 201-208
9. Skorup, A.; Krstić, M.; Bojković, R. (2012): *Management information systems in small and medium enterprises*. International Scientific Conference MANAGEMENT 2012. Mladenovac, Srbija.
10. Thompson, A.A. (2001): *Strategic management: Concepts and cases*. J Strickland III, 12 ed, Boston [etc.], McGraw-Hill: Irwin, cop.

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# APPLICATION OF NEW TRENDS OF MARKETING COMMUNICATION AS A COMPETITIVENESS TOOL IN FURNITURE INDUSTRY

Olšiaková, M.; Loučanová, E.; Kalamárová, M.

## ABSTRACT

Nowadays there is an increasing importance of inbound marketing communication tools that support to achieve the marketing goals. Their importance relies in fulfillment of the objectives at low cost. The paper deals with the possibility to use new innovative forms of marketing communication in furniture industry. We focus on tools such as Guerilla Marketing, Viral Marketing, Content Marketing and many others that allow gaining a competitive advantage in the market with furniture
**Key words**: marketing, marketing communication, inbound marketing, furniture industry.

## 1. INTRODUCTION

Recently marketing communication has become more important, especially its innovative forms that support customer's attention, confidence to buy, creation a good relationship, but they also help to strengthen the market position or the customer's loyalty.

Companies use less traditional marketing communication tools, also called “outbound marketing”, which are primarily based on one-way companies communication with customers. Companies incline to apply inbound marketing communication tools that are characterized by active involvement of the customer into the communication that enables the instant feedback. Thus the customer feels to be the inseparable part of the sales process. Inbound marketing is also the way how to reduce the communication costs and to achieve better communication and marketing objectives.

From the perspective of the company its inclining to the new trends in marketing communication is also the possibility to address more customers.

Because many companies try to appeal to a wide range of customers they have to find the right tools combination of both types of marketing in order to encourage the synergic effect and to grab attention of different customer segments.

### 1.1. Innovative communication tools appliance in furniture industry

If the company uses the same old advertising practices, its business will remain invisible to many consumers who want to buy furniture. They could have problems to find the particular business or the offer. The fact is if internet, social media and "new media" are not the part of the marketing plan, the company will lose revenues on the market compared to the competition.

In the 80s and early 90s of the last century many traditional furniture stores advertised primarily in commercial newspapers, yellow pages, radio and television if they could afford it. Larger shops printed circulars and sent direct mails, but most marketing campaigns failed. They were used to address the most customers as possible, but they usually did not grab the attention of the right potential customer.

Another disadvantage of these campaings was the problem how to determine which of used tools brought the success. Perhaps they all were successful, maybe it was a coincidence.

Traditional communication media are designed to influence and gain the greatest number of people at once. Their probable benefit is that they are supposed to be faithful, because the customer connects the sellers' success on the market with frequency and repeatability of its advertising activity.
Their lack rests in determination of their efficiency (Root, 2011).

These weaknesses can be solved by innovative forms of marketing communication. The following tools belong among the most successful:

### *1.1.1. Content marketing*

Content marketing is the way of communication with customers, which allows the company building a long-term quality reputation and the respect of an expert in its field. This form of communication primarily educates customers about the problem that should be solved by the product using. For example, if the manufacturer of security doors educates his customers (through the blog, professional articles, TV shows) on burglary and advises, how not to give thieves a chance to rob customer´s house, it will mention handily its products and their benefits and thus creates demand for them.

Content marketing is based on the content. It is not completely a new tool, but it is becoming more important and it is placed on the top of trends in marketing strategies. This method presents the expertise of the company through the content they produce (articles on the website, ebooks ...). The value of content has recently increased significantly and the content marketing belongs among the best SEO strategies.

There are various ways how to create a valuable content:

- It is necessary to depersonalize from the company products and to focus on customer issues. (This is based on the assumption that nobody is interested in products. People are interested in themselves and how to solve their own problems. If they are inspired by something, they will share the knowledge in their surroundings.).
- The content creation should be based on business objectives (such as sales growth).
- The title is very important; it must grab the customers´ attention.
- The content must be created by "audience language", it should include examples.
- The product or service must be communicated peacefully and subliminally.

The company can obtain quality assurance and credibility through publishing articles or video blogs. At the same time, the company creates continuous advertising that is more effective than tradional advertising campaigns. It gives the customer information in time when they are necessary (Podnikajte.sk, 2012).

Importance of content marketing and its using in furniture enterprises is indisputable. The fact that almost all the furniture we buy is disassembled and not all of us are handmade carpenters or furniture manufacturers creates a space for creation of videos haw we can safely and seamlessly assemble the furniture purchased in this store.

### *1.1.2. Guerilla marketing*

Guerrilla marketing is an unconventional low budget marketing strategy that brings maximum results. This alternative advertising style relies on unconventional marketing policies, high customer involvement and imagination. The purpose of Guerrilla Marketing is to prepare a surprise to the final

consumer to gain an unforgettable impression and feeling. Guerrilla marketing is often ideal for small businesses that need to reach a wide audience, but it also has a significant application in large companies (Creativeguerrillamarketing, 2017).

Even Guerrilla marketing can be applied in the furniture industry as we present it in the Figure 1. This idea is realized by the IKEA Company and it is represented in the subway station. IKEA realizes a great number of brilliant ideas how to be noticed by as many people as possible.


*Figure 1. Example of guerrilla marketing realizing by IKEA*
Source: http://www.creativeguerrillamarketing.com/guerrilla-marketing/ikeas-parisian-guerilla-marketing-campaign-examples/, 2017


*Figure 2 Another IKEA´s idea of guerilla marketing*
*Source: https://www.merchandise.co.uk/blog/ikeas-guerrilla-marketing-staircase-drawers, 2017*

### *1.1.3. Viral marketing*

Viral marketing is a marketing technique that spreads via the Internet. This "bacillus" name is based on the principle, as the advertising message circulates.

The virus as well as the viral content spreads among people who came into contact with them. Its main objective is the product promotion and advertising as well as strengthening the brand awareness.
Viral marketing is supported by the social networks where people contribute content and share information. Chain e-mails, chat and SMS are other media for forwarding various messages.
Viral marketing is based on creative, funny videos or interesting pictures that are spread naturally among users.

Although furniture industry does not belong among top users of this tool (such as automotive, fashion, cosmetics, food or clothing industry), it is recommended to use it also in the furniture sector, as the good news that are spread in a circle of trusted people can overcome any well-designed campaign and it does require any special financial resources (Olšiaková, Loučanová, 2015).

### *1.1.4. E-newsletters*

Newsletter, emailing or email marketing is one of the most used and most effective online marketing tools (from a different point of view of direct marketing). It is the transmission of relevant information, promotional information via email on the basis of former agreement or of message requesting. The main advantages of this powerful tool mainly include:

- It is simple.
- Low cost of operation.
- Immediate and measurable results.
- Keeping in touch with customers.
- Increasing quotient of visitors return to the page.
- New sales channel = increasing turnover of ecommerce sites (TriadAdvertising, 2010).

Within the application of innovative marketing communication tools in the woodworking industry on its both processing stages, marketing communications should represent a complex of activities for customer acquisition with a regard to optimizing marketing strategy. In terms of innovative marketing tool within outbout marketing it is mainly a **Search Engine Marketing** strategy, which may include (besides optimization) paid site insertion to search engines or registers, PPC advertising or sponsored links in search engines and activities that lead to the websites visibility in search engines. From the perspective of classical forms of marketing communication it is also necessary to optimize individual tools of inbound marketing regarding to the products specifics of woodworking industry.

Complex optimization of inbound and outbout marketing tools should form a synergistic effect to increase sales of wood processing industry products through creativity, innovation, and innovativeness using in individual marketing communication tools, see Figure 3.

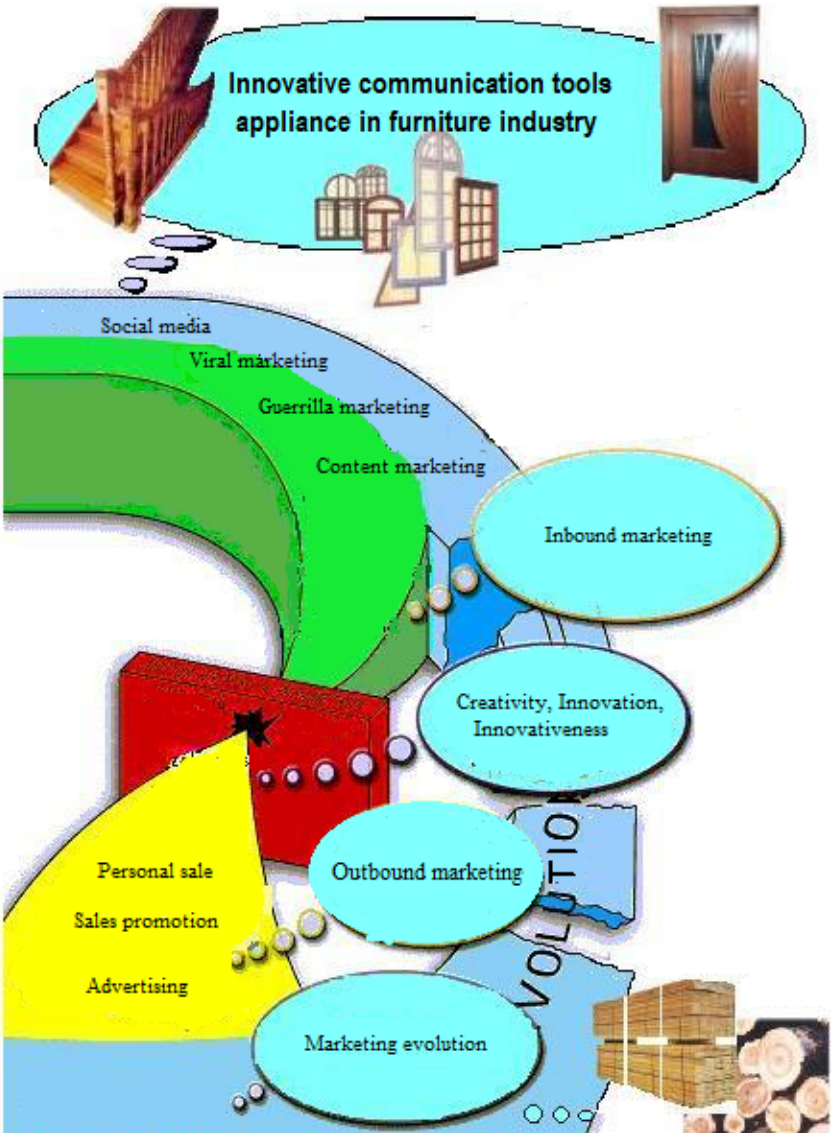


*Figure 3 Marketing communication evolution applied in the wood processing industry*
*Source: Loučanová, 2016 adjusted by Loučanová, 2005*

## CONCLUSION

Present forms of marketing communication rather use elements that provide customers with new knowledge, entertain them, or are in the form of experience. Customers tend to spend leisure time on the Internet, play online games, chat on social networks, watch videos on YouTube etc. So it is necessary to include new trends in leisure time and changes in customer preferences related to favorite forms of marketing communication into marketing plans. It is essential to create the right composition of communication mix, which will consist of an appropriate combination of the traditional and modern tools. This supports the successful appeal to target audience and allows minimizing of incorrectly spent money and failure in the market.

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## REFERENCES

1. Hrušovská, D. (2010): *Nové trendy v marketingovej komunikácii.* In Nové trendy v marketingovej komunikácii : Zborník medzinárodnej vedeckej konferencie. Trnava : Fakulta masmediálnej komunikácie UCM v Trnave, 2010. ISBN 978-80-8105-167-8. pp. 165-171.
2. Loučanová, E. (2005): *Inovácie ako podmienka konkurencieschopnosti drevospracujúceho priemyslu na globálnom trhu*. In: Inovace: jediná účinná cesta k úspěchu v globální ekonomice. Praha: Soukromá vysoká škola ekonomických studií, s.r.o., 2005, pp. 102--105. ISBN 80-86744-26-4
3. Olšiaková, M. - Loučanová, E. (2015): *Inbound marketing a jeho inovatívne formy marketingovej komunikácie.* In Trendy a inovatívne prístupy v podnikových procesoch : 18. medzinárodná vedecká konferencia [elektronický zdroj]. - Košice : Technická univerzita v Košiciach, 2015. ISBN 978-80-553-2488-3, [7] s. [online]. URL: http://www.sjf.tuke.sk/kpiam/taipvpp/2015/index.files/29_Olsiakova_Loucanova_InboundMarketing.pdf
4. Podnikanie.sk (2015): *Aký Je Rozdiel Medzi SEO a SEM a Čo To Vlastne Je?* [Online] Podnikanie.sk 26. 01. 2016] URL: http://www.epodnikanie.sk/online-marketing/rozdiel-medzi-seo-a-sem/
5. Root, M. (2011): *Successful Retail Furniture Store New Media Marketing* [Online] Furninfo.com [cit. 26. 01. 2016] URL: http://www.furninfo.com/furniture-world-archives/12528
6. TriadAdvertising (2010): *Čo je newsletter, emailing?* [Online] Triad Advertising [cit. 15. 10. 2015] URL: http://blog.triad.sk/marketingovy-slovnik/co-je-newsletter-emailing/

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# ANALYSIS OF A MARKET STRUCTURE IN PRIMARY WOOD PROCESSING SEGMENT IN SLOVAKIA

Sujová, A

## ABSTRACT

Oligopoly market structure is the predominant type of imperfect competition. The paper deals with description of the competitive environment in the segment of primary wood processing and its subjects in Slovakia. The distribution of the market share and the leaders of the segment have been determined by using the capacity data and economic indicators. By evaluation of the results achieved the type of oligopoly was identified. Based on the results, measures for improvement of the current situation in the segment of primary wood processing in Slovakia were suggested.
**Key words**: oligopoly, market power, primary wood processing

## 1. INTRODUCTION

Enterprises today work in conditions of hypercompetition where each competitive advantage brings only temporal extraordinary position. In imperfect competition the subjects try to influence or control the market. Concentration and centralization of a production cause, that a small number of manufacturers have control over a significant part of the commodity supply or demand. [3]

Oligopoly presents the most frequent market structure in economy´s sectors. It consists of a small number of firms disposing of economic power which particulary limits enter of other firms into market of the sector. That is why the firms can influence prices. Absolutely concentrated oligopoly is a structure of few large firms. If along 2-3 large firms also small and middle sized firms exist, the oligopoly is relatively concentrated. According to commodity production, the oligopoly can be homogeneous if products are the same and heterogeneous if products are differentiated.[5]

Within oligopoly structure several models were identified [7]:

- duopoly: in the branch only two firms producing the same product exist. They have the same cost curves and know a demand wich is linear (Cournot model, Stackelberg model, Bertrand model);
- model of kinked demand curve: in case of price increase by one firm, other firms don´t follow this step.
- models based on game theory: two or more firms affecting each other choose a strategy in aim of common influencing acticvities of each market participant,
- collusive oligopoly: the firms make an agreement in price and total profit maximization,
- dominant-firm oligopoly: the market onsists of one large, dominant firma and few smaller competitors.

There is a variety of methods using by evaluation of a level and effects of a concentration in conditions of imperfect competition. The substance of methods is quantification of indicators describing a position of individual producer on a relevant market of the certain commodity or characterizing a state of competitive environment in the monitored branch. The methods can be divided into two groups [6]:

- methods measuring concentration grade in the branch,
- methods measuring level of economic power of individual producer.

According to fact, whether indicators quantify concentration grade in regard to all subjects or to their subset wih certain feature, the indicators can be divided to two groups [2]:

- Indicators measuring absolute concentration:
  - *concentration rate in a branch quantified for defined number of subjects with the highest vaue of monitored indicator*,
  - *Herfindahl index* characterizing the concentration grade in the branch syntheticaly.

- Indicators measuring relative concentration:
  - *variance rate refering to concentration rate of particular groups of subjects with highest value of monitored indicator,*
  - *variational coefficient expressing rate of influence distribution of all subjects.*

The key indicator of concentration rate is a production share of individual firm on the production of a whole branch or defined group of firms.

The level of market concentration in an industry affects competitiveness and performance of the industry and subjects included in. The author of the paper has researched competitiveness of wood processing industry and possibilities of competitiveness increase in several scientific publications (Sujová 2005, 2007, 2008; Sujová et al. 2012, 2015a) as also factors influencing industry´s performance (Sujová et al. 2015b, 2017).

The aim o paper is to analyse a market structure of primary wood processing industry in SR, to identify an oligopoly type and concentration rate of the industry. The result is proposal of market structure improvement.

## 2. MATERIAL AND METHODS

First of all, theoretical and scientific knowledge concerning market structures of imperfect competition and branch concentration measuring were summarized. Input data needed for analysis of wood processing market were acquired from database Slovstat of Statistical Office SR [9], SK NACE 16100 Sawmilling and planing of wood according to statistical classification of economic acticities. The most important firms were selected for detailed analysis from more views: economic results and production capacity, sort of wood processed and assortment. The sources of required information for detailed analysis were websites of firms and webportal "Index of Enterpreneur".

To concentration measurement the next indicators were used:

Herfindahl, resp. Herfindahl – Hirschman index (H). Composition of the index is based on hypothesis that importance of a firm is a function of the square of its market share ($r^2$) [1]:

$$H = h(q_1, q_2, ..., q_n) = \sum_{k=1}^{n} \left(\frac{qk}{Q}\right)^2 = \sum_{k=1}^{n} r^2 \qquad (1)$$

Where *h* is a real function of *n* variables, $h : R^n \rightarrow R$,

Classification of concentration grade according to value of Herfindahl index is as follows:

- non-concentrated branch if $H < 1\,000$,
- slightly concentrated branch if $H \in \langle 1000,1800 \rangle$,
- concentrated branch if $H \geq 1800$.

Concentration rate ($CR_n$) is calculated for "n" the strongest firms and it expresses a relative share of the first "n" firms with the highest production volume on the production of whole branch. It is calculated as follows [6]:

$$CR_n = \frac{1}{Q}\sum_{k=1}^{n} qk \qquad (2)$$

where n was number 3 and 6 firms and for production volumes $q_k$ of firms inequality applies:

$$q_p > q_{p+1} \quad \text{pre } p = 1, 2, ..., n-1 \qquad (3)$$

Coefficients of concentration rate acquire values from the interval $0 \leq CR_\Psi \leq 100$.

Based on results achieved the oligopoly type was identified and possibilities for market structure improvement were suggested.

## 3. RESULTS

According to data of the Statistical Office SR, 324 subjects were registered in SK NACE 16100 in 2016. Hereof 69 firms had no revenues, small subjects were 234 and 21 firms were important. Small subjects were united to one group (other firms) and 21 firms were analysed in detail. The market structure of SK NACE 16100 is presented in table 1.

*Table 1. Firms in SK NACE16100 with the highest revenues in 2015*

| Name of the firm | Number of employees | Revenues in € | Equity in € |
|---|---|---|---|
| Rettenmeier Tatra Timber, s.r.o. | 150-199 | 70 538 042 | 19 683 509 |
| PRP s.r.o. | 150-199 | 21 833 075 | 8 692 |
| Amico Drevo | 100-149 | 8 079 505 | 7 887 000 |
| Beky, a.s. | 20-24 | 8 099 498 | 3 108 357 |
| LESOTRANS, spol. s r.o. | 0 | 7 863 702 | 323 962 |
| Drevomax s.r.o. | 100-149 | 7 850 351 | 757 452 |
| TOPHOLZ, s.r.o. | 50-99 | 7 568 259 | 1 905 546 |
| Gasparik,s.r.o. | 50-99 | 5 658 191 | 2 129 785 |
| DPC timber, s.r.o. | 10-19 | 5 345 481 | 68 540 |
| Píla Rosík, s.r.o. | 25-49 | 5 147 358 | 25 288 |
| KAMWOOD,s.r.o. | 50-99 | 4 652 792 | 445 152 |
| MMM WOOD, s.r.o. | 50-99 | 4 525 151 | 450 240 |
| UDAVA a.s. | 10-19 | 4 499 927 | 509 732 |
| JURTON, s.r.o. | 20-24 | 4 028 358 | 880 074 |
| Lesagro,s.r.o. | 25-49 | 3 693 986 | 499 585 |
| Herstek Milan spol. s r.o. | 3-4 | 3 263 807 | 1 594 |
| DREVICOM, s.r.o. | 20-24 | 3 139 642 | 1 551 481 |
| KROVY-SK s.r.o. | 10-19 | 3 060 662 | 417 984 |
| P.F.A. sro | 25-49 | 2 968 302 | 19 597 |
| Turzovská drevárska fabrika s.r.o. | 50-99 | 2 898 198 | 1 587 357 |
| SPEKTRUM s.r.o. | 25-49 | 2 563 411 | 444 555 |
| Other firms (234) | | 107 511 166 | |

Source: own processing according to webportal Index Podnikateľa

Data in table 1 shows that all firms in the Slovak primary wood processing industry are small and middle sized. The firm Rettenmeier Tatra Timber, s. r. o. has the highest revenues and number of employees and it presents 47 % market share. The second large firm is PRP with 24 % market share. Other firms have less than 5 % of the market share.

### 3.1. Analysis according to processed wood species

The most widespread wood species in Slovakia is beech with 33% representation. The most widespread conifrous species is spruce with 23,7 % representation. The most processed wood is spruce and coniferous wood species even in firms located in inconvenient position as for species composition of the forests and shipping costs can affect the input price negatively. Coniferous wood processing is in

69 % of firms and other 19 % process along coniferous also broadleaved wood. Only 12 % firms is oriented to broadleaved wood processing. The analysis of sawmill firms according to processed wood species in comparison with location of the firm plant is shown in table 2.

*Tab. 2 Sawmills according to wood species processing and location*

| | **Processing of wood species** | | | **Location** | | | |
|---|---|---|---|---|---|---|---|
| **Firm** | **coniferous** | **broadleaved** | **coniferous + broadleaved** | **Plant** | **Forest coverage** | **coniferous** | **broadleaved** |
| Amico Drevo | spruce | | | Oravský Podzámok | 40% | 87% | 13% |
| Beky | | beech, oak, nut | | Snina | 48% | 12% | 88% |
| DCP timber | spruce, fir | | | Martin | 55% | 60% | 40% |
| Drevomax | | | spruce, pine, oak | Konská | 55% | 60% | 40% |
| Krovy sk | spruce, fir, larch | | | Podrečany | 41% | 29% | *71%* |
| Lesargo | | | Beech, oak, maple, spruce, pine, fir | Pravenec | 55% | 60% | 40% |
| Lesotrans | n | | | Podvysoká | 59% | 87% | 13% |
| MMMWood | n | | | Michalová | 80% | 69% | 31% |
| P.F.A. | spruce | | | Lozorno | 22% | 10% | *90%* |
| Píla Rosík | spruce | | | Čierny Balog | 80% | 69% | 31% |
| PRP | spruce | | | Veľký Krtíš | 11% | 4% | *96%* |
| Rettenmeier | spruce, fir | | | Liptovský Hrádok | 62% | 80% | 20% |
| Spektrum | spruce, fir | | | Hliník nad Hronom | 60% | 24% | *76%* |
| Topholz | | | oak, beech, alder, lime, spruce, pine | Krnča | 15% | 7% | 93% |
| Turz.drev.fa | spruce, pine | | | Turzovka | 59% | 87% | 13% |
| Udava | | beech | | Udavské | 48% | 12% | 88% |

## 3.2. Analysis according to product portfolio

Portfolio analysis of companies included in market structure can show the direct and indirect competition in the analysed branch. Portfolio of the most important firms in primary wood processing in SR presents table 3.

For wood as an input raw material to wood processors applies, that same wood species from different sellers are not differentiated at all and a demand for each supplier is highly elastic [4]. If buyer doesn´t get product with different feature of services, he is oriented especially to price. Reactions of buyers to the change of price depends on price development expected in the future. Price elasticity relates to quantity of available material substitutes on the market.

The feature of the commodity market where primary wood processing belongs is a low product differentiation. All Slovak wood processing firms produce sawnwood as a main product and wooden products with higher added value such wood based panels are. A biomass production is a part of portfolio in 63 % of firms. Sawmill drying is provided by 37 % firms.

*Tab. 3 Portfolio of chosen wood processors*

| **Firm** | **Sawn wood** | **wood waste** | **Wood based panels and products** | | | | **Biomass** | **Wooden building** | **impregn** | **dryer** |
|---|---|---|---|---|---|---|---|---|---|---|
| | prisms, boards | bark, craps, sawdust | shalboards | KVH, BSH, europrism | floors, covers, veneer | palettes | pelets, chip, briquets, | Shelters, arbors | | |
| Amico Drevo | | | x | KVH, BSH | | | pelets | | | |
| Beky | x | | | KVH, BSH | | | briquets | | | |
| DCP timber | x | x | x | KVH, BSH | | | | | | |
| Drevomax | | | | europrism | | | pelets | | | |
| Krovy SK | x | | | | | x | | x | | |
| Lesargo | x | | | | veneer | | | | | |
| Lesotrans | | bark | | | | x | woodchip | | x | |
| MMM WOOD | x | | x | | | x | Pelets | | | |
| P.F.A. | | | | x | | | Pelets | | | |
| Píla Rosík | x | | | | Floors, covers | | | x | | x |
| PRP | x | sawdust | | KVH, BSH | Floors, covers | | woodchip | x | | x |
| Rettenmeier | x | | x | x | | | briquets | | x | x |
| Spektrum | x | x | | | | | | | | x |
| Topholz | x | craps | | | Floors, covers | x | X | | | x |
| Turzovská drev. Fabrika | x | | | | x | x | briquets | | | |
| Udava | x | | | | | | | | | x |

## 3.3. Analysis of a market power in the industry branch

Evaluation of market power or branch concentration was provided through Herfindahl index (HHI) and concentration rates of 3 firms (CR3) and 6 firms (CR6). Input data needed for calculation od indeces was processing capacity and market share after production capacity of firms.

Information about processing capacity and market share in the primary wood processing industry presented in table 4 showed, that Rettenmeier Tatra Timber, s. r. o. has 27 % market share and dominant position in the industry. Further investments to increasing processing capacities of this firm would be terminal because of limited supplies and insufficient warranties to supplies of sawmill roundwood. Investments in Rettenmeier are herefore oriented to secondary wood processing, a production of wood based products with higher added value [11].

Production capacity of wood processing firms may not be a decisive indicator of market share because it is impossible to determine capacity exploitation which is limited also by supplies of input raw wood material. By determination of market structure, indicators as revenues and profit were used too.

HHI index 2 128,9 presented in table 4 points to strong concentraton among subjects on the market. This result of the index indicates forming creation of market capture. Analysed branch is highly concentrated and there is a size inequability of firms in the branch.

*Tab. 4 Processing capacity, market shares of firms and Herfindahl index (HHI)*

| **Firm** | **Processing capacity in m³** | **Market share in %** | **HHI** |
|---|---|---|---|
| Rettenmeier | 800 000,00 | 27,22940776 | 741,440647 |
| PRP | 500 000,00 | 17,01837985 | 289,6252527 |
| Amico Drevo | 120 000,00 | 4,084411164 | 16,68241456 |
| Lesotrans | 80 000,00 | 2,722940776 | 7,41440647 |
| P.F.A. sro | 80 000,00 | 2,722940776 | 7,41440647 |
| MMM Wood | 60 000,00 | 2,042205582 | 4,170603639 |
| DCP timber | 50 000,00 | 1,701837985 | 2,896252527 |
| Píla Rosík | 50 000,00 | 1,701837985 | 2,896252527 |
| Spectrum | 45 000,00 | 1,531654187 | 2,345964547 |
| Krovy SK | 42 000,00 | 1,429543907 | 2,043595783 |
| Lesagro | 40 000,00 | 1,361470388 | 1,853601617 |
| Udava | 30 000,00 | 1,021102791 | 1,04265091 |
| Top holz | 30 000,00 | 1,021102791 | 1,04265091 |
| Beky | 22 000,00 | 0,748808713 | 0,560714489 |
| Drevomax s.r.o. | 20 000,00 | 0,680735194 | 0,463400404 |
| Turzovská drev.fa. | 18 500,00 | 0,629680054 | 0,396496971 |
| ostatné firmy | 950 500,00 | 32,3519401 | 1046,648028 |
| | 2 938 000,00 | 100 | 2128,937339 |

The second indicator measuring the concentration of the industry, a concentration rate was used. Results are presented in table 5.

*Tab. 5 Concentration rate*

| **Concentration rate** | | | |
|---|---|---|---|
| **CR3** | 1420000 | | |
| 1/2938000 | 0,00000034036*1420000 | 0,4833112*100 | 48,33112 |
| **CR6** | 1640000 | | |
| 1/293800 | 0,00000034036*1640000 | 0,5581904*100 | 55,81904 |

The processed data of primary wood processing industry follow, that industry concentration is high. Values of CR3 48,3 % and CR6 55,8 % indicate, that more than half of processing capacities is shared by six firms.

### 3.4. Identification of Oligopoly

Based on theoretical knowledge and results of analyses carried out, a type and model of oligopoly in a primary wood processing industry SR can be determined.

According to product character, it is differentiated oligopoly. Wood processors differs their production through following wood processing like impregnation, drying, wood waste processing. Product differentiation is in its further utilization.

From the view of market structure, it is relatively concentrated oligopoly. In analysed industry two large and a number of small firms exist. High concetration is proved also by indices measuring market power in the industry.

The firm Rettenmeier Tatra Timber has much higher market share than other firms, what indicates the model of dominant-firm oligopoly. This firm has reached not only the highest market share according to processing capacity and revenues, but also the highest profit presenting 75 % of profit in the industry.

Revenues of Rettenmeier Tatra Timber include except basic sawmill product also other products with higher added value. The firm produces also shalboards, regal and furniture boards and more than 90% of production is exported to markets of Western Europe. Production of energy based on biomass acquired from own wood waste makes energy costs much lower. The firm produces thermal and electrical power [13].

### 3.5. Suggestions for improvement

To extend the demand and also market space for wood processors could be possible by utilization of wood based products in a building industry. The most convenient on the Slovak market seems to be a construction wooden production providing supplies of wooden buildings. Wood processing firms oriented to this type of production are Píla Rosík and KROVY-SK. The other alternative a veneer production is. Utilization of veneer is possible in furniture manufacturing. This way of production extension can be opprtunity for competitiveness increase. The company Lesargo processing broadleaved wood and producing veneer has the best presumtions to increase its market power.

Wood processors should take into account very important factors influencing input raw material such assumed development of harvesting, age grades, forest categorie, structure of wood species and climatic changes. In accordance with prognosis, it is awaited a higher share of broadleaved wood species in region Kysuce and Orava, where representation of coniferous wood is 87 % in the present time. A partial increase of broadleaved wood representation is awaited in region of Small and Big Fatra with 60 % representation of coniferous wood in present. [10] After comparison of location of sawmilling firms and type of processed wood species the following firms should consider a change of processed wood: Turzovská drevárska fabrika, DCP timber and Lesotrans. Mentioned subjects processes only coniferous wood in locations with higher representation of broadleaved wood.

Primary wood processing industry is dependent on sufficient volumes of input raw wood supplies. Conditions for securing supplies of reguired wood volumes and quality should be created via long-term agreements between wood producers and wood processors. Afterward investments to modernization and extension of processing capacity can be provided.

## 4. CONCLUSION

Wood products market has often a character of commodity market. This market is characterized by big volumes of transactions, higher market concentration, low product differentiation with emphazise to prices. The Slovak primary wood processing industry consists of many small plants which don´t have enough finance for modernization of technologies and are not able to be competitive enough as large wood processors are. To be competitive on a market means to reach as high production efficiency as possible as also wood waste utilization. Higher finalization of wooden production make higher added value and profit. State support a stimuluses are in this industry needed, at least in securing a sufficient raw wood supplies which Slovakia disposes with.

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## REFERENCES

1. Fendek, M. (1999): Kvantitatívna mikroekonómia. Bratislava: IURA EDITION, 346 p
2. Fendek, M., Fendeková, E. (2008): Mikroekonomická analýza. Bratislava:IURA EDITION, 575 p.
3. Goga, M. (1996): Tajomstvá nedokonalého trhu. Bratislava: ELITA, 104 p.
4. Haluza, I. (2005): Biznis s drevom ovládli dlhodobé vzťahy. Trend [online]. [accessed: March 2016]. Available at: http://www.etrend.sk/firmy/biznis-s-drevom-ovladli-dlhodobe-vztahy.html
5. Lisý, J. et al. (2000): Economics. Bratislava: IURA EDITION, 2000. 507 p.

6. Schiller, B. R. (2004): Mikroekonomics, 1st eds. Brno: Computer Press, 432 p.
7. Sujová, A. (2005): Aspekty reštrukturalizácie drevárskych podnikov. Zvolen: TU Zvolen, 68.
8. Sujová, A. (2007): *Conditions of development and competitiveness increase of Slovak woodprocessing industry within European Union*. In: Proceedings of conference "Sustainable forestry – problems and challenges, Perspectives and challenges in wood technology" Vol. XLII. Skopje, Macedonia. September, 2007. 513 – 517.
9. Sujová, A. (2008): *Súčasný stav konkurencieschopnosti DSP SR, význam reštrukturalizácie pri zvyšovaní konkurenčnej schopnosti firiem.* In: Rajnoha R. et al: Zvyšovanie konkurenčnej schopnosti podnikov drevospracujúceho priemyslu SR s využitím efektívnych prístupov a nástrojov riadenia podnikov. Zvolen: TU Zvolen. 117.
10. SUJOVÁ, A., Hlaváčková, P., Marcineková, K. (2015a): *Evaluating the Competitiveness of Wood Processing Industry*. Drvna Industrija 66(4): 281-288. *doi:10.5552/drind.2015.1432 (*WoS)
11. Sujová, A., Hlaváčková, P., Marcineková, K. (2015b): *Measuring the Impact of Foreign Trade on Performance Growth of the Woodprocessing Industry*. Wood Research 60(3): 491 - 502.
12. Sujová, A., Michal, J., Kupčák, V., Dudík, R. (2017): The Impact of International Trade of Raw Wood to the economic Growth of Forest-Based Sectors in the Czech and Slovak Republics. BioResources, 12(1): 1102-1111. Doi: 10.14376/biores.12.1.1102-1111
13. Sujová, A., Rajnoha, R. (2012)**:** *Evaluation of competitive factors in Slovak woodprocessing enterprises as the base for business performance management*. In: Proceedings of the conference "Wood and Furniture Industry in times of change – new trends and challenges". Trnava, Slovakia. May 2012. 1-6.
14. Sujová, A., Šálka, J. (2016): Základy ekonómie, Zvolen: TU Zvolen, 199 s.
15. *** MPSR: *Green reports*. URL: http://www.mpsr.sk/index.php
16. ***Statistical Office SR: *Slovstat.* URL: http://www.statistics.sk
17. http://www.etrend.sk/firmy/drevospracovatelia-bojuju-o-surovinu-a-miesto-na-trhu.html [accessed:05.09.2016]
18. http://www.etrend.sk/trend-archiv/rok-/cislo-November/rettenmeier-vladne-piliarstvu.html [accessed: 05.09.2016]
19. https://www.indexpodnikatela.sk [accessed:12.11.2016]
20. http://www.priemyseldnes.sk/exkluzivne-rozhovory/rettenmeier-tatra-timber-sro-150317 [accessed: 08.01.2016]

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# THE POTENTIAL OF BEECH WOOD USE IN SELECTED COUNTRIES OF THE CENTRAL EUROPE FOR VALUABLE PROCESSING PURPOSES

Gejdoš, M., Potkány, M.

## ABSTRACT

The paper is focused on analysis of the potential for the Beech raw-wood in Slovakia, Austria, Germany and the Czech Republic. Evaluated are the supplies assortment structure of these tree species in selected countries over the past five years, with the forecast of its development in the future. For statistical evaluation of these data, the information available database sources in each country were used. Provided were the fundamental framework for the use of the available volume of beech wood in the segment of wooden houses. We focused also on the economic parameters of the partial use of this material in wooden constructions, which are dominated by coniferous tree species. Particularly in Slovakia will increase the abundance of beech and thus will need to look for other alternatives available using this raw material for more valuable processing purposes.
**Key words**: wooden constructions, beech sawlogs, wood supplies, wood prices

## 1. INTRODUCTION

The wood processing industry is in the area of wood products with added value mainly focused on coniferous valuable assortments and coniferous saw-logs in last ten years. In Slovakia almost 90 % of all processors processing only coniferous saw-logs. They argue with reasons as: fashion trends, physical and mechanical properties of wood, surface treatments, preferences of furniture giants and demand from big countries on coniferous wood products and valued hardwoods.

The potential use of other tree species also affects the tree species composition of forests in each countries. In Central Europe Slovakia it is currently the highest proportion of non-coniferous tree species and the most dominant tree species representation has just beech. Recently, the possibility of using higher quality beech wood is considerably limited and much of this volume ends as a raw material for less valuable processing purposes (pulp and paper industry, energy industry) [6].

The problem of beech saw logs using molest the producers of the raw-wood assortments almost everywhere in Europe. To support its use were even several ongoing promotion programs, some to levels of government (eg. Austria). Prospective option for the future seems to use this material in the wooden constructions. Based on the technology of processing and further processing of beech can get high-quality building components which have very good mechanical properties.

In the present paper, we will focus on the analysis of production possibilities for beech sawlogs in Slovakia, the Czech Republic, Austria and Germany in the period 2010 - 2015 and an analysis of the potential for valuable processing purposes, especially within a segment of wooden constructions.

## 2. MATERIAL AND METHODS

Information about supplies of beech saw-logs in Slovakia, Czech republic, Austria and Germany were assumed from Information bank of Forestry national center of Slovakia, Czech statistical office, Federal ministry of Food and Agriculture (Germany) and Federal Ministry of Agriculture, Forestry, Environment and Water Management (Austria) [1-2, 7, 9, 14].

Assessment of price developments was focused on sawlogs assortments from beech trees in selected provinces of Austria, Czech Republic and Slovakia. The analysed period represents the period from 2010 to March 2017. In the case of the Czech Republic the prices were calculated with using the exchange rate of the National Bank of the Czech Republic [13]. The assortments prices for Austria are in the trade parity on forest roads or forest warehouse. Prices in Slovakia and Czech Republic are placed on parity FCO (ex-warehouse vendor, respectively FCA (loaded truck purchaser). In order to

provide absolutely correct comparison, it is necessary to add the transport costs to the Austrian prices (eventually parity DAF or CIF). Information on price developments have been drawn from the magazine Holzkurier [8], the Czech Statistical Office [14] and the Forestry market information system [4].

## 3. POTENCIAL OF BEECH SAWLOGS

### 3.1. Development of beech sawlogs supplies

Good production qualities and relative environmental undemanding of spruce had in the past the effect on the growth of its popularity, especially in the wooden constructions sector. Often as a result of its economic significance were planted on sites that are not on the ecological optimum for this tree species. Now that due to global climate change is increasing pressure on the quality and stability of forest ecosystems, starting this solution encounters a problem. With gradual successive changes in forest vegetation zones, gradually again beginning the changing of species composition in Central Europe forests and "Carpathian Mountain Area" in favor of other tree species. It is thus clear, that the representation of spruce will continue to gradually reduce and strengthen will mainly the representation of beech wood. Consumption and use of saw logs from beech is now in Europe a significant problem. Table 1 shows the disposable potential assortment of beech wood for the period 2010-2015 from the evaluated supplies on the market (the year 2016 is not yet available in the statistics).

*Table 1. Beech sawlogs supplies [m³] in selected countries for years 2010-2015*

| Beech sawlogs supply | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Slovakia | 991520,9 | 1036487 | 1066571 | 1175744 | 1236589 | 1099516 |
| Czech republic | 64659 | 63197 | 58267 | 78410 | 56165 | 80666 |
| Germany | 1958000 | 2462000 | 2191000 | 2038000 | 2212000 | 2278000 |
| Austria | 141993 | 165696 | 140461 | 122853 | 127486 | 146049 |

The volume of supply for this assortment is in selected countries significantly affected by the tree species composition of forests. From selected countries of Central Europe had beech tree a dominant presence only in Slovak forests. Higher information value about the position of this tree species on different markets has its share from the total supply of all non-coniferous sawlogs listed in Table 2.

*Table 2. Percentage share of Beech sawlogs supplies [%] from non-coniferous sawlogs supplies in years 2010-2015*

| Country/Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Slovakia | 79,8 | 76,6 | 76,6 | 78,3 | 82,5 | 77,0 |
| Czech republic | 60,1 | 47,8 | 37,7 | 41,0 | 42,5 | 44,7 |
| Germany | 69,3 | 69,9 | 69,0 | 66,6 | 69,2 | 67,9 |
| Austria | 54,9 | 54,8 | 50,3 | 49,6 | 48,9 | 50,7 |

The table 2 shows that in all countries is the proportion of beech sawlogs from all non-coniferous assortments on market higher than 50% (the highest in Slovakia, long almost 80%). The use of this volume for valuable processing purposes is problematic. Part of saw-logs assortments ends in the pulp and paper industry and even as part of a renewable energy source. The aim of the producers and the processors of that raw material should be to increase the production of products with higher added value. Furniture producers often argue with fashion trends and the lack of market interest for beech furniture. One of the ways to increase the share of processing of valuable beech assortments is its application in the sector of wooden buildings.

### 3.2. Development of beech sawlogs prices

Figure 1 represents the development of prices for beech saw-logs in Slovakia, Czech Republic and Austria for the period 2010 to March 2017. Price developments (except Austria) over the past six years confirms the stagnation in the market with this assortment. Slovakia and the Czech Republic for the period 2011-2017 has increased the price of a grade IIIB (totally about € 7-8 .m$^{-3}$). For other quality classes in the same period of not more than € 2.7 m$^{-3}$. It should be noted that the price of inputs for timber harvesting and technologies in this period increased more dynamic of which may be stated, that price levels of these assortments were partly undervalued.

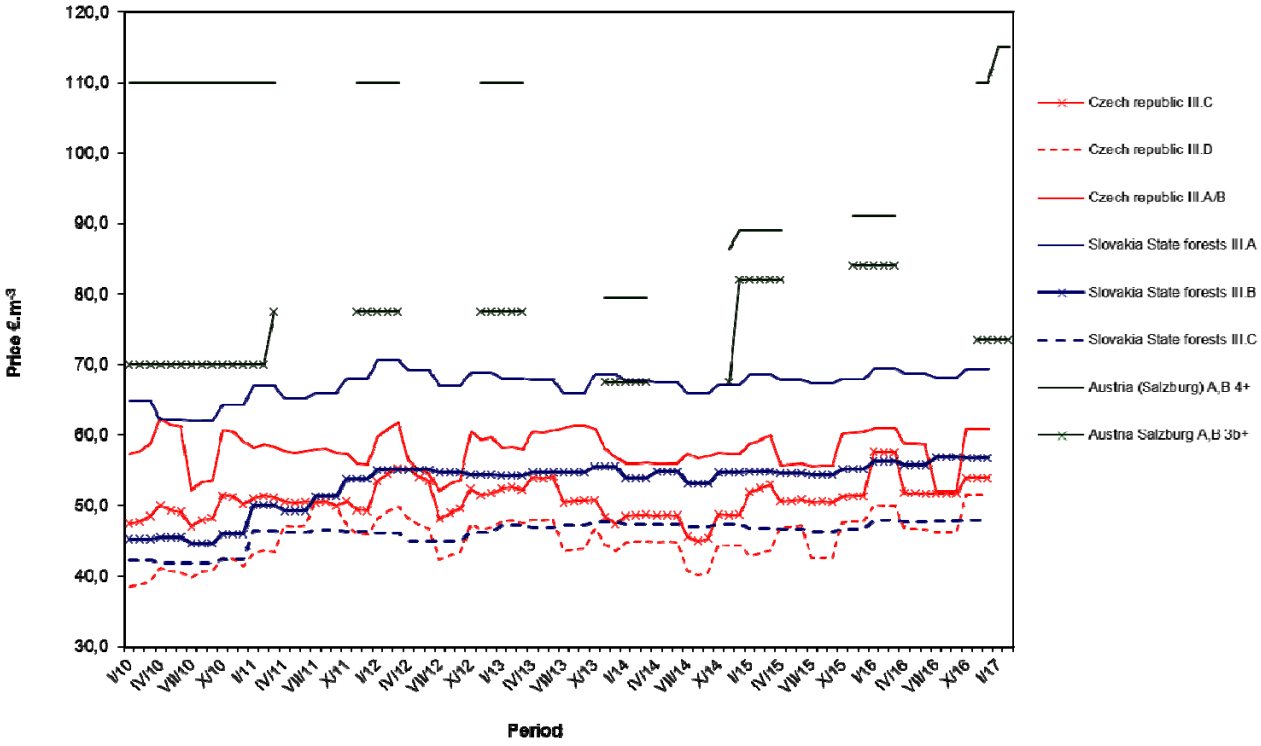


*Figure 1. Development of beech sawlogs prices (in €.m$^{-3}$) in selected countries of central Europe*

Specific position in this segment are Austrian provinces, where in addition to the mentioned support programs, providing different regional entities also a state support for renewable energy using. It has a major impact on the prices of all raw-wood assortments and therefore their price levels are significantly higher. The second fact is, that valuable non-coniferous assortments are principally traded only during the dormant period and therefore are price developments discontinuous. Price developments in Austria, but also see a certain stagnation. In principle, the price of these assortments for the past six years also did not change by more than € 5 m$^{-3}$.

Price developments in individual countries confirm, that the market for beech sawlogs would need a substantial recovery. Plants for the processing of higher quality beech assortments, while being increased, but their volume of processing compared to the total volume of production is still very low. For Market conditions would significantly help the common coordinated approach of the European Union in this area, or the introduction of support tools from the part of national governments.

## 4. VALUABLE PROCESSING PURPOSES

As the most promising application of valuable products from beech appears their use in wooden constructions. Beech wood has still enormous potential. Partial problems with non-coniferous tree species is particularly economically more exacting processing technology (compared with coniferous

tree species). By coniferous tree species predominate direct straight trunk which allows the use of more efficient techniques of cutting and higher material utilization. By non-coniferous tree species are rarely straight trunks and the large knots often. This requires a selective approach to cutting and cutting out the big knots, so production non-coniferous sawn-wood, which would be useful for prefabricated construction timber, is considerably reduced. It also affects the possibility deployment of automation and the subsequent drying process. Ultimately, then the final product is more expensive. The starting point is to produce structural components from veneer plywood slats, which allows the production deployment of an automated production process (Figure 2). These construction parts from beech are approx. thrice stronger than spruce. Basic comparison of mechanical properties on construction components made from beech and spruce are in Table 3.

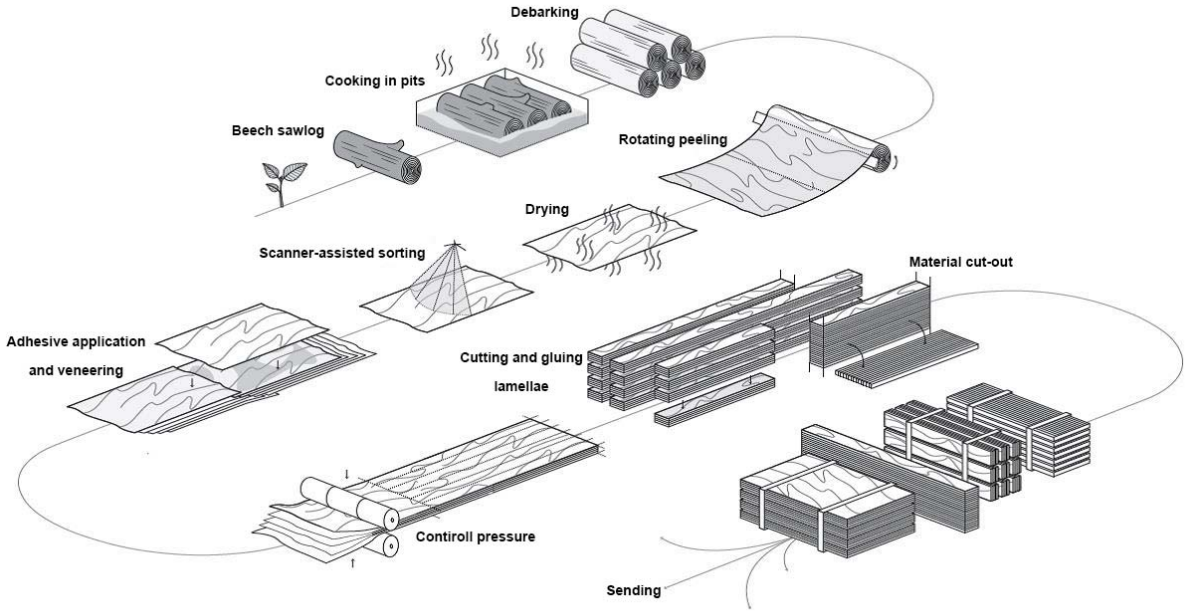


*Figure 2. The production process of laminated beech timber for the building purposes [source: 3]*

*Table 3. A sample of the table [source: 5]*

| Mechanical properties | Glued laminated wood [Beech] | Glued laminated wood [Spruce] |
|---|---|---|
| Tensile strength in the fiber direction / MPa | 70 | 24/28 |
| Compressive strength parallel to the fiber direction / MPa | 49,5 | 26,5 |
| The characteristic shear strength / MPa | 4,0 | 2,5 |
| The mean value of the Elasticity module in the fiber direction / MPa | 16 700 | 12 600 |
| Surface Density / kg/m$^2$ | 680 | 410 |

Based on the technical characteristics of laminated beech wood, compared with spruce, can be in applications for wooden constructions achieved a significant space savings. For these reasons, it can be assumed that much of the wooden constructions realized from these materials will be at the same price level as conventional wooden houses from spruce or steel structures. The advantage is also that the thus formed construction elements can be produced in virtually any size.

Thus obtained raw material is can be also, without beam construction elements in wooden constructions, used in the production of furniture and decoration in interior spaces.

Beech Saw-log has a relatively wide range of applications in the field of wooden constructions. A possibility is also the decorating of facade with wooden shingles cladding elements (Fig. 4), the production is carried out while only the coniferous tree species. Beech wood can in this respect also offer exciting addition to mechanical properties and good resistance and a variety of decorative options combined example with false core. Interesting applications in wooden constructions considering to the mechanical properties (table 3) also offer glued beech elements with finger jointed structure [11, 12].

*Figure 3. Beams and plates from beech laminated wood [5]*

*Figure 4. Facade, wooden shingles [source: 8]*

*Figure 5. Support structure construction from beech [source: 10]*

## 5. CONCLUSION

Wood consumption and sawn-wood production have in Europe slightly increasing trend. Sale of beech saw-logs and its use is problem in all Europe. With the gradual decline of intentional felling due to incidental felling in previous years and decades, while optimizing the tree species composition of forests to new environmental conditions, will decrease the representation of the most popular tree species - spruce. Processing industry should in future focus mainly on processing of raw beech and use of its potential. Using in the wooden constructions has extraordinary potential and the promising possibilities of optimization technology for producing this material. European market with beech wood could in the future to revive the particular using in the wooden constructions, which are gaining exceptional popularity and this segment also undergoing dynamic development. Compared to the indisputable

advantages, there are certainly risks in the form of economic investment and payback, as well as the development of new materials, especially biopolymers.

An indisputable fact remains the stable resource base (especially in Slovakia), which will ensure continuity of supplies for several decades and is expected the further strengthen in the representation of beech tree species for forests in Europe. In Slovakia, can also pose a potential risk the non-standard market with wood and the factors influencing it as: a one dominant state forestry enterprise, non-standard trade policy, political and lobbying influences and so on.

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## REFERENCES

1. Anonymous. (2015): *Informačná banka údajov (IBULH)*. Národné lesnícke centrum, Zvolen. URL: https://gis.nlcsk.org/ibulh
2. Anonymous. (2015): *Prodané množství surového dříví pro tuzemsko za ČR v roce 2016 (m³) od nejvýznamnějších společností obchodujících se dřevem*. Český statistický úřad. URL: https://www.czso.cz/csu/czso/indexy-cen-v-lesnictvi-surove-drivi-3-ctvrtleti-2016
3. Anonymous. (2016): *Buche ist der Ferrari im Holzbau*. In: WirHOLZBAUER 4/2016, pp. 42-43.
4. Brezinová, M. (2015): A*verage prices development of assortments and raw-wood supplies for the quarters* 2010 – 2017. In: Informačný list Národného lesníckeho centra, Zvolen 9 s.
5. Eckhart, M.; Matuzzi, F.; Radon, N. (2016). *Baubuche Buchen-Furnierschichtholz Produktvorstellung*. Pollmeier massivholz Gmbh. 8 pp.
6. Gejdoš, M.; Potkány, M. (2015): *Development of market with wood in Slovakia and Central Europe*. In: Wood processing and furniture manufacturing challenges on the world market and Wood-based energy goes global: proceedings of scientific papers. Dubrovnik, Croatia. 2015. pp. 1-6.
7. HOLZEINSCHLAGSMELDUNG FÜR JAHRE 2008 – 2014, Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna, Austria, 88 p.
8. HOLZKURIER, years 2010 – 2017
9. HOLZMARKTBERICHT 2008 – 2014, Federal Ministry of Food and Agriculture, Bonn, Germany, Ministerium für Ländlichen Raum, Ernährung, Landwirtschaft und Forsten, 25 s.
10. Klein, A. (2017): *Hochleistung mit Schweizer Buche*. In: Holzbau Austria - fachmagazin für holzbau und nachhaltige architektur. www.holzbauaustria.at.
11. Rohanová, A.; Bajza, O.; Ferenc, O. (2016): *Finger jointed in glued products – manufacture*. In: Chip and chipless woodworking processes 2016: the 10th international science conference, September 8-10, 2016, Technical University in Zvolen: proceedings of papers. ISSN 2453-904X. pp. 165-170.
12. Rohanová, A.; Krišśák, P.; Bajza, O. (2016): *Finger jointed of beech and poplar wood – properties*. In: Chip and chipless woodworking processes 2016: the 10th international science conference, September 8-10, 2016, Technical University in Zvolen: proceedings of papers. ISSN 2453-904X. pp. 159-163.
13. www.cnb.cz
14. www.czso.cz

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# WOOD BIOMASS AS A RENEWABLE RESOURCES MARKET DEVELOPMENT IN THE EU

Šupín, M; Kaputa, V; Parobek, J.

## ABSTRACT

The potential of bioenergy in EU depends to a large extent on the potential of available feedstocks from both domestic and imported resources. The European energy market has been designed to meet the needs of conventional generation technologies. The EU policy for markets regarding renewable energy sources (RES) is on the implementation of the RES Directive 2009/28/EC. National governments of the members states EU demonstrated strong commitment towards the targets set. Trade flows of solid biomass already contribute significantly to renewable energy production within the EU-28. It can be concluded from the planned overachievement and wood biomass market development of the 20% share by 2020. Therefore it is generally expected that these trade flows will increase in the future up to 2030 year also.
**Key words**: Renewable resources; Biofuels; Wood biomass; Market development;

## 1. INTRODUCTION

Renewable energy sources (RES) include the following:

- Non-combustible renewables
    - **Hydropower**: the electricity generated from the potential and kinetic energy of water in hydroelectric plants (the electricity generated in pumped storage plants is not included);
    - **Tide, wave, ocean energy**: mechanical energy derived from tidal movement, wave motion or ocean current and exploited for electricity generation
    - **Geothermal energy**: the energy available as heat from within the earth's crust, usually in the form of hot water or steam;
    - **Wind energy**: the kinetic energy of wind converted into electricity in wind turbines;
    - **Solar energy**: solar thermal energy (radiation exploited for solar heat) and solar photo-voltaic for electricity production.
- Combustible renewables
    - **Biofuels:** fuels from **biomass**
    - **Renewable municipal waste**

Wood biomass is a product consists of ligneous mass or part of ligneous vegetal mass come from forestry, agriculture, wood processing industry or other sources, e.g. municipal sphere. Public usually perceive the term wood biomass as something appointed for energy uses (heating and power) also due to loudly environmental policy. But there are other two significant industry consumers demanding wood biomass as an input for specific wood products production. Besides of energy utilization is wood biomass also chemically as well as mechanically processed in pulp and paper industry, respectively in agglomerate materials production. (Kaputa,V., Sucháň, R., 2012).

There are many specifics influencing production and consumption patterns in the market. On one hand, timber production is subject to available resources, which are the result of long-term forest management and long-term planning. Timber production has been recently influenced by the high proportion of accidental felling. On the other hand, timber production tries to adapt to rapidly changing market conditions and the requirements of wood processing sectors that vary over a relatively short period of time. (Parobek, J. et al. 2014).

Globalization as the process of international integration is affecting all industries, including forest based industry. As there are new products with lower prices available on the market, new strategies and

advantages are required to face international competitors. These, among other, include new business models, improvement of productivity, innovations and cooperation in terms of technology, outsourcing and supply chain. The process of globalization has led to the gradual reduction in trade barriers, and competitiveness has become a key issue in international markets since it can be considered as the major source of export development. The issues of competitiveness have also ascended high on the agenda of national governments and of the EU. In case of environmentally sensitive markets, the competitiveness of forest products can be influenced by factors related to the origin of wood material from sustainable and renewable sources. (Paluš, H., Parobek, J., Liker, B., 2015).

The energy sector is one of the pillars of growth, competitiveness and development for modern economies. Like most other regions across the world, Europe is going through a period of transformation. The last ten years of global financial and economic crisis has wiped out years of economic and social progress and exposed structural weaknesses in its economy. Meanwhile, various long-term challenges such as globalization, pressure on natural resources and an ageing population are intensifying. If we are to adapt to this changing reality, Europe cannot longer rely on business only as usually.

In order to tackle these issues, the European Union (EU) and its Member States launched in 2010 a new strategy for sustainable growth for the coming decade: the Europe 2020 strategy. The strategy deals both with short-term challenges linked to the crisis and the need for structural reforms through growth-enhancing measures needed to make Europe's economy fit for the future. (RES Directive 2009/28/EC)

One of the priorities of the EU is the creation of a resilient Energy Union with a forward-looking climate policy that is capable of delivering the adopted 2020 and 2030 climate and energy targets and the EU's longer-term climate objectives. To achieve this, EU has to decarbonize its energy supply, integrate the fragmented national energy markets into a smooth functioning and coherent European system, and set up a framework that allows the effective coordination of national states efforts. With fossil fuels accounting for roughly three-quarters of the EU's gross inland energy consumption in 2013, much remains to be done to achieve the envisaged transformation of the energy sector.

Renewable energy sources (RES) are important contributors to this transition, because they mitigate greenhouse gas (GHG) emissions, lower environmental pressures associated with conventional energy production and reduce the reliance of fossil fuels. Other benefits associated with the growth of RES include the reduction of fossil fuel imports, the diversification of energy supply and the creation of jobs, skills and innovation in local markets and in progressive sectors with significant growth potential. In a life-cycle perspective, the environmental pressures arising from renewable energy technologies are 3–10 times lower than from fossil fuel based systems.

Developing a strong renewable energy base in Europe has implications for Europe's competitiveness and export potential. To keep up with the ongoing transformation of the energy sector in Europe, we need data that is accurate and up-to-date.

To produce bioenergy, biomass has to be provided. This requires an analysis of existing and potential biomass resources. The resources for biomass use for energy come from a wide range of sources that can be divided into forest biomass, agriculture biomass and waste biomass and energy crops. However, in the present significant switch from a fossil fuel to a biofuel-based economy, forestry and agriculture are the leading sources of biomass for biofuels such as fuelwood, charcoal, wood pellets, bioethanol and biodiesel. Currently, biomass, mainly wood and wood energy products are the main from renewable sources for heat production. Forestry and wood-based industries produce wood, which is the largest resource of solid biomass. The sector covers a wide range of different resources with different characteristics - wood logs, bark, wood chips, sawdust and recently pellets. Pellets, due to their high energy density and standardised characteristics, offer great opportunities for developing the bioenergy market worldwide. As demand for wood increases from both wood processing industries and the energy sector, the question of whether there is enough wood is of great concern nowadays. In order to understand how much wood is available, it is essential to know how much wood is as a growing stock

in the forests and how much is removed. Wood for use as an energy source comes not only from tree felling, but also from selective thinning of managed forests and other forestry practices (direct sources). Wood for energy use may also be derived as a by-product from downstream processing in wood-based manufacturing, for example, as off-cuts, trimmings, sawdust, shavings, wood chips or black liquor (indirect sources). End-of-life wood and paper products may also be used as a source of energy (recovered wood). (Loučanová, E., Kalamárová, M., Parobek, J., 2015).

Demand for renewable wood resources is increasing worldwide. The assortments of pulpwood and fuelwood can be considered as a potential source of biomass and energy chips production. However, it should be taken into account that it is not possible to use the whole volume of these wood categories for energy purposes as hardwood pulpwood fibers are mainly used for pulp production in pulp and paper industry (Parobek, J. et al., 2016).

## 2. METODOLOGY

The analytic and synthetic methods were used to assess the market situation. Analysis of foreign market development was done based on the data from EUROSTAT, FAOSTAT, statistical offices and institutes of the international organizations selected countries regarding exports, imports, consumptions and the most significant countries with which renewable resources, mainly wood solid biomass are traded. Secondary sources of the data from reports of international organizations and associations referring to RES - wood biomass were also used in this paper.

## 3. SHARE OF RENEWABLES IN ENERGY CONSUMPTION IN THE EU

The share of renewables in gross final consumption of energy is one of the headline indicators of the Europe 2020 strategy. Renewable energy sources cover solar thermal and photovoltaic energy, hydro (including tide, wave and ocean energy), wind, geothermal energy and all forms of biomass (including biological waste and liquid biofuels). The contribution of renewable energy from heat pumps is also covered. The renewable energy delivered to final consumers (industry, transport, households and services including public services, agriculture, forestry and fisheries) is the numerator of this indicator. The denominator, the gross final energy consumption of all energy sources, covers total energy delivered for energy purposes to final consumers as well as the transmission and distribution losses for electricity and heat.

The target to be reached by 2020 for the EU is a share of 20% energy from renewable sources in gross final consumption of energy. Renewables will continue to play a key role in helping the EU meet its energy needs beyond 2020. For this reason, Member States have already agreed on a new EU renewable energy target of at least 27% by 2030. The primary production of renewable energy within the EU-28 in 2014 was 196 million tonnes of oil equivalent (toe) — a 25.4% share of total primary energy production from all sources. The quantity of renewable energy produced within the EU-28 increased overall by 73.1% between 2004 and 2014, equivalent to an average increase of 5.6% per year.

Among renewable energies, the most important source in the EU-28 was solid biofuels (43.8%) and renewable waste, accounting for just under two thirds (63.1%) of primary renewables production in 2014 (see Table 1). Hydropower was the second most important contributor to the renewable energy mix (16.5% of the total), followed by wind energy (11.1%). Although their levels of production remained relatively low, there was a particularly rapid expansion in the output of wind and solar energy, the latter accounting for a 6.1% share of the EU-28's renewable energy produced in 2014, while geothermal energy accounted for 3.2% of the total. There are currently very low levels of tide, wave and ocean energy production, with these technologies principally found in France and the United Kingdom.

The largest producer of renewable energy within the EU-28 in 2014 was Germany, with an 18.4% share of the total; Italy (12.1%) and France (10.7%) were the only other EU Member States to record

double-digit shares, followed by Spain (9.2%) and Sweden (8.5%). There were considerable differences in the renewable energy mix across the Member States, which reflect to a large degree natural endowments and climatic conditions. For example, more than four fifths of the renewable energy produced in Malta (80.3%) and around two thirds of that produced in Cyprus (66.7%) was from solar energy. By contrast, close to or more than a third of the renewable energy in the relatively mountainous countries of Sweden, Croatia, Austria and Slovenia was from hydropower. More than one fifth (22.1%) of the renewable energy production in Italy was from geothermal energy sources. Where active volcanic processes exist, their share that rose to 78.7% in Iceland. The share of wind power was particularly high in Ireland (51.8%) and also accounted for close to or more than one quarter of renewable energy production in Spain, the United Kingdom and Denmark.

The output of renewable energy in Malta grew at an average rate of 41.3% per year between 2004 and 2014, although the absolute level of output remained by far the lowest in the EU-28. Over this same period, annual increases averaging in excess of 10.0% were recorded for Belgium (14.2% per annum), the United Kingdom (12.7%) and Ireland (11.7%), while increases below 3.0% were recorded in France, Romania, Latvia, Denmark, Sweden, Croatia and Finland.

Renewable energy sources accounted for a 12.5% share of the EU-28's gross inland energy consumption in 2014. The importance of renewables in gross inland consumption was relatively high in Portugal (25.0%), Denmark (26.2%), Finland (29.4%) and Austria (30.0%) and exceeded one third of inland consumption in Sweden (35.8%) and Latvia (36.2%).

The EU seeks to have a 20% share of its gross final energy consumption from renewable sources by 2020; this target is distributed between the EU Member States with national action plans designed to plot a pathway for the development of renewable energies in each of the Member States. The share of renewables in gross final energy consumption stood at 16.0% in the EU-28 in 2014.

*Tab. 1. The EU primary production of RES energy in (Mtoe)*

| 2005 year | 2006 year | 2007 year | 2008 year | 2009 year | 2010 year | 2011 year | 2012 year | 2013 year | 2014 year | Primary Production |
|---|---|---|---|---|---|---|---|---|---|---|
| 67.0 | 68.6 | 72.3 | 76.3 | 78.4 | 85.2 | 80.9 | 87.1 | 88.5 | 85.8 | **Wood & other solid biofuels** |
| 4.0 | 4.4 | 5.8 | 6.6 | 7.4 | 8.5 | 10.4 | 12.2 | 14.0 | 14.9 | Biogas |
| 3.4 | 5.5 | 7.5 | 9.0 | 10.6 | 11.7 | 10.6 | 11.5 | 12.7 | 13.9 | Liquid biofuels |
| 26.9 | 27.2 | 27.1 | 28.6 | 28.9 | 32.4 | 26.9 | 28.9 | 32.0 | 32.3 | Hydro power |
| 6.1 | 7.1 | 9.0 | 10.3 | 11.4 | 12.8 | 15.4 | 17.7 | 20.4 | 21.8 | Wind power |
| 0.8 | 1.0 | 1.3 | 1.7 | 2.5 | 3.7 | 6.0 | 9.0 | 10.6 | 12.0 | Solar energy |
| 5.3 | 5.5 | 5.6 | 5.6 | 5.5 | 5.5 | 5.8 | 5.7 | 5.9 | 6.2 | Geothermal energy |
| 6.1 | 6.6 | 7.3 | 7.3 | 7.5 | 7.9 | 8.2 | 8.5 | 8.8 | 9.0 | Renewable wastes |

Among the EU Member States, the highest share of renewables in gross final energy consumption in 2014 was recorded in Sweden (52.6%), while Latvia, Finland and Austria each reported that more than 30.0% of their final energy consumption was derived from renewables. Compared with the most recent data available for 2014, the targets for France, the Netherlands and the United Kingdom require each of these Member States to increase their share of renewables in final energy consumption by at least 8.0 percentage points. By contrast, nine of the Member States had already surpassed their targets for 2020; this was particularly true in Croatia, Sweden and Bulgaria.

## 4. FOREST BIOMASS

Forests cover 41% of the EU land area. Currently, there are 182 million hectares of forest in the EU, which represent 5% of the world's forests. (FAOSTAT 2017). European forests are currently underutilized, as volume growth is significantly higher than utilization. In Europe, we are harvesting only 62% of annual forest growth. Every year, the wood stock in forest is increasing by almost 300 million m3.

One of the ecological aspects of forests is their role as an renewable energy resource. In many European countries, wood is being promoted as a renewable energy source in energy policies, resulting in significantly growing volumes of national and international markets for biomass (EUROSTAT 2017c). The primary production of renewable energies has been increasing in the long term; between 1990 and 2015, it increased by 170%. The primary production of renewable energy within the EU in 2013 was 192 million tonnes of oil equivalents (toe), which accounted for a share of 24.3% of total primary energy production from all sources. The most important source in the EU was biomass and renewable waste, accounting for 64.2% of primary renewable energy production in 2015 (EUROSTAT 2017a).

Production of wood biomass for the purposes of energy production is limited to certain wood assortments and other harvesting residues. For example, energy chips are made of harvesting residuals. The energy chips can be produced also from certain assortments (pulpwood and fuelwood) it can be assumed that there is a substitution in the production of these products. In this case the relationship would be negative or inverse. In 2015, 85% of all the biomass used for energy originated from forests or trees. Wood is by far the most important source for bioenergy. Wood for energy comprises different categories: wood fuel, charcoal, wood chips, pellets, bark, saw dust, recycled wood, black liquor and other residues of the forest harvest and the wood industry. Forest biomass supply chains cover a wide range of biomass sources, logistic systems, conversion technologies, end-products and stakeholders. Several supply chains have proven to be economically viable and are considered sustainable; others not. Bioenergy-related policies should be designed in a way that they enhance technological and economic efficiency and environmental sustainability. Objectives and policies for bioenergy and for renewable energy in general are often formulated and agreed upon at higher decision making levels. However, the design of objectives and policies can be better informed by knowledge and experience at the lower levels of decision making, where the implementation takes place, in order to integrate effectively renewable energy into the existing energy systems. Local strategies can assist in translating national plans to local level action, while allowing for local level prioritisation and ownership. Local planning can facilitate the identification of the most favourable sites and technologies, improve the understanding of the local environment and its actors and facilitate the integration of policies throughout various sectors to cater for regional ecological complexity.

The consumption of wood for energy in the EU has been increasing in recent times. The demand for wood in the EU is very likely to increase in the period to 2020 and potentially beyond, with most of this due to a significantly greater increase in the demand for wood for energy. In the EU and elsewhere, generally forests are managed for many purposes, one of which is to supply forest bioenergy. Production of forest bioenergy is thus most likely to occur as an integrated part of forest management and wood use for a range of objectives. A requirement to produce forest bioenergy seems unlikely to become the principal driver of forest management unless demand for forest bioenergy becomes very intense. In order to fill a gap between future demands for wood and potential supply, it will be necessary to intensify management of EU forests in order to increase removals of primary wood and import more wood into the EU and mobilize the availability of sources of other woody biomass. In the period to 2020, demand for forest bioenergy seems likely to be met through increased extraction of harvest residues including poor-quality stemwood and trees, the use of sawmill co-products and recovered waste wood. Some small roundwood may be used as a source of bioenergy. It is less likely that forest bioenergy will involve consumption of wood suitable for high value applications, such as sawlogs typically used for the manufacture of sawn timber. Meeting demands for forest bioenergy may involve some direct

competition with the wood-based panels and paper industries, or may involve 'picking up' existing supply in situations where demand for wood-based panels and paper is already declining.

In terms of changes to forest management, a rise in demand for forest bioenergy is already stimulating interest in the extraction of harvest residues and in the introduction of silvicultural thinnings in young stands. In some regions, it is possible that the additional revenue from forest bioenergy is giving incentives for harvesting operations in forests (thinning and/or felling) for co-production, where this would not otherwise occur. Demand for forest bioenergy would need to be very intense for harvesting to be introduced in otherwise unmanaged forest areas, or for forest management to be fundamentally restructured, solely to produce bioenergy.

The future potential of wood for energy will depend on three aspects:

(1) A better use and management of existing forests,

(2) The better use of the by-products or residues of trees in non-forest areas for bioenergy instead of dumping a huge share of this material as it is done in many parts of the world today, and

(3) The planting of new forests in order to compensate for the losses of forest in some regions, to increase the global forest area again and use part of this additional production for energy.

25-35 EJ (Exajoule = $10^{18}$J) of woody biomass can be supplied if these three conditions are fulfilled adding up to 75 – 85 EJ from woody biomass.

## 5. THE EU TRADE OF SOLID BIOMASS FOR ENERGY

The markets for biomass used for energy purposes are developing toward international commodity markets – wood pellets and fuel ethanol being two examples – and this development can be expected to continue. Already in some EU Member States the bioenergy use is largely based on imported biomass, and some countries have significant plans for a major increase in biomass import and processing for energy purposes. Earlier studies have shown that good statistics on the global trade of biomass for energy purposes are not available.

The importance of imported feedstock to the overall production of energy from solid biofuels in the EU28 continues to grow (Eurostat, 2016b). Imported solid biofuels generated 310.4 PJ of energy in the EU28 in 2014, which was 9% of all solid biofuels used for primary energy production in the subregion in that year. The EU28 imported an estimated 7.2 million tonnes of wood pellets in 2015; the US accounted for 60% of this, followed by Canada (21%) and the Russian Federation (11%).

Exports of wood energy from the western Balkans increased by 5.8% (by energy content) in 2015 compared with 2014, to 38 PJ. Firewood accounted for about 45% of the total, by energy content, followed by wood pellets (27%) and wood chips (18%); these values correspond to volumes of 1.88 million m3 of firewood, 679,000 tonnes of wood chips, and 583,000 tonnes of wood pellets. The export volume of firewood and wood pellets increased in 2015, but the volume of wood chips dropped slightly. The increase in wood pellet exports was due largely to an increase in pellet exports from Croatia (which accounted for 34% of all pellet exports from the subregion). Exports also increased from Montenegro and Slovenia, but they declined from Bosnia and Herzegovina and Serbia. An analysis of woodfuel trade flows among western Balkan countries showed that about 19% of the total trade occurred within the subregion in 2015, while 64% of total wood pellet production, 84% of total wood-briquette production, and 59% of total wood chip production were exported from the subregion. Italy remains the most important market for the export of all woodfuels from the western Balkans; about 71% of the total export of wood pellets went to the Italian market in 2015, which was 25% of Italy's total imports. About one-third of Italian firewood imports came from western Balkan countries. (Glavonič, B.,D., Kranjč, N., Paluš, H., 2015).

Argus Media (2016) reported that CIF spot prices for industrialwood pellets at Amsterdam, Rotterdam and Antwerp (ARA) declined steadily in 2015 through the first quarter of 2016. ARA CIF spot prices for industrial pellets declined significantly in 2015, with the largest fall (about 18%, year on year) reported in March 2016. This decline in prices can be associated with factors such as flat demand

(because buyers had ample supplies of pellets in storage) and an increase in supply from European suppliers and from North American and Russian exporters. The residential (premium) wood pellet market exhibited a slight downward price trend: according to Argus Media (2016), the price of delivered bulk premium (EN plus certified A1) pellets in northern Italy dropped by 2% in April 2016, to €145 per tonne. On the other hand, delivered bagged pellets showed almost no change, with an average price of €190 per tonne.

*Tab. 2. The EU-28 complete energy balances /imports, exports, consumption/ in Ktoe (Kilo tonnes of oil equivalent).*

| 2005 year | 2007 year | 2009 year | 2010 year | 2011 year | 2012 year | 2013 year | 2014 year | PRODUCT / Imports. Exports. Consumption/ |
|---|---|---|---|---|---|---|---|---|
| 2 388.1 | 2 985.6 | 3 783.2 | 4 934.7 | 5 100.5 | 5 106.1 | 6 148.8 | 7 414.5 | **Solid biofuels** (excl. charcoal) **Imports** |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 0.0 | 0.0 | Biogas **Imports** |
| 0.0 | 13.6 | 0.0 | 0.0 | 52.6 | 132.4 | 216.1 | 211.1 | Municipal waste (renewable) **Imports** |
| 127.9 | 347.1 | 1 055.7 | 1 386.3 | 1 628.2 | 1 417.2 | 1 083.5 | 1 289.4 | Biogasoline **Imports** |
| 424.6 | 1 862.5 | 3 071.7 | 4 191.4 | 5 412.4 | 5 783.4 | 4 996.4 | 5 851.5 | Biodiesels **Imports** |
| 275.6 | 38.5 | 252.8 | 574.2 | 516.4 | 559.4 | 633.0 | 756.2 | Other liquid biofuels **Imports** |
| 1 372.3 | 1 627.9 | 1 716.5 | 2 242.4 | 2 355.2 | 2 684.4 | 3 129.8 | 3 516.2 | **Solid biofuels** (excl. charcoal) **Exports** |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Biogas **Exports** |
| 0.0 | 0.0 | 0.0 | 0.0 | 30.0 | 35.1 | 34.5 | 33.9 | Municipal waste (renewable) **Exports** |
| 28.2 | 144.0 | 487.9 | 556.0 | 491.4 | 630.7 | 947.6 | 966.3 | Biogasoline **Exports** |
| 383.2 | 965.0 | 1 429.7 | 2 598.8 | 2 890.4 | 3 048.6 | 4 001.6 | 5 489.3 | Biodiesels **Exports** |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Other liquid biofuels **Exports** |
| 67957.1 | 73600.1 | 80330.8 | 87973.5 | 83379.8 | 89384.4 | 91632.9 | 89552.6 | **Solid biofuels** (excl. charcoal) **Consumption** |
| 4 000.0 | 5 783.0 | 7 397.3 | 8 530.0 | 10 437.5 | 12 214.8 | 13 953.0 | 14 933.0 | Biogas **Consumption** |
| 6 091.7 | 7 349.0 | 7 501.4 | 7 936.0 | 8 252.3 | 8 591.2 | 8 940.4 | 9 170.5 | Municipal waste (renewable) **Consumption** |
| 580.4 | 1 199.4 | 2 271.0 | 2 795.8 | 2 870.4 | 2 839.6 | 2 667.6 | 2 641.8 | Biogasoline **Consumption** |
| 2 527.0 | 6 171.7 | 9 636.5 | 10486.5 | 10900.0 | 11 897.3 | 10656.2 | 11491.3 | Biodiesels **Consumption** |
| 669.8 | 1 166.5 | 1 198.9 | 1 396.7 | 842.2 | 884.3 | 1 024.8 | 1 101.2 | Other liquid biofuels **Consumption** |

## 6. CONCLUSIONS

Results of the conducted research show that exists the number of factors influencing development of market with wood biomass as a RES. The current EU targets for the use of renewable energy is largely met through bioenergy use. Biomass has by far the largest land footprint of all renewable energy forms, and large-scale consumption will inevitably lead to increased emissions at a time when we need emission reductions. Forest bioenergy is produced as a complementary co-product of wood material / fibre products. Forest bioenergy consumption in the EU has increased and is likely to increase significantly in the period to 2020 and beyond. A requirement to produce forest bioenergy seems unlikely to become the principal driver of forest management unless demand for forest bioenergy becomes very intense. Already in some EU Member States the bioenergy use is largely based on imported biomass, and some countries have significant plans for a major increase in biomass import and its processing for energy purposes in future.

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## REFERENCES

1. Glavonjić, B., Krajnc, N., Paluš. H. (2015): Development of wood pellets market in South East Europe In. Thermal Science. - ISSN 0354-9836. - Vol. 19, no. 3, p. 781-792
2. Kaputa, V., Sucháň, R. (2012): Slovak wood biomass market. In Intercatherda 28/1, Poznań, ISSN 1640-3622, p. 24-30.
3. Loučanová, E., Kalamárová, M., Parobek, J. (2015): The competitiveness of wood products from the perspective of used materials. Acta Facultatis Xylologiae Zvolen, 57(2): 155−163, Zvolen, Technical University in Zvolen. DOI: 10.17423/afx.2015.57.2.16
4. Paluš, H., Parobek, J., Liker,B (2015):Trade performance and competitiveness of Slovak wood processing industry within the Visegrad group countries. DRVNA INDUSTRIJA 66 (3) 195-203
5. Parobek, J. *et al*. (2016): Energy Utilization of renewable Resources in the EU – Cluster Analysis Approach. BioResources 11(1), 984-995.
6. Parobek, J. et al. (2014): Analysis of wood flows in Slovakia. BioResources 9 (4) 6453-6462.
7. Šupín, M. (2013). Slovak and EU market with wood pellets. *Intercathedra* 29(2), 74-81.
8. ***: Argus Media. (2016). Biomass markets. Issue16014. Available at: www.argusmedia.com/~/media/files/pdfs/samples/argus-biomass.pdf/?la=en
9. ***: European Commission. Directive 2009/28/EC of the European Parliament and of the Council – on the promotion of the use of energy from renewable sources and amending and subsequently repealingDirectives 2001/77/EC and 2003/30/EC. Brussels, Belgium: European Commission; 2009. 62 p.
10. ***:. EUROSTAT (2017). "SHARES 2015 results" including detailed Member States' data and information on the indicative trajectories.
11. ***:. EUROSTAT (2017a). “Energy from renewable sources,” retrieved from: http://ec.europa.eu/eurostat/statistics-explained/index.php/.Energy_from_renewable_sources (accessed on March 22, 2017).
12. ***: EUROSTAT (2017 b). “Database–EUROSTAT,” retrieved from http://ec.europa.eu/eurostat/data/database (accessed on March 30, 2017).
13. ***: EUROSTAT (2017 c). Key figures on Europe 2016 edition. Publications Office of the European Union, ISBN 978-92-79-63347-8
14. ***: EUROSTAT (2017 d). Renewable energy in the EU Share of renewables in energy consumption in the EU still on the rise to almost 17% in 2015. Newsrelease 43/2017 - 14 March 2017
15. ***:European Biomass Association (AEBIOM), Statistical Report 2016 – European Bioenergy Outlook, Brussels,
16. ***: FAOSTAT (2017). Forestry statistics. Rome. Available at: http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626#ancor (accessed on March 28, 2017).
17. ***: Forest Products Annual Market Review (FPAMR) 2015-2016, ECE/TIM/SP/40, (2016), UN ECE Geneva
18. ***: IRENA (2014). A Renewable Energy Roadmap 2030. www.irena.org/remap
19. ***: REN21. (2016). *Renewables 2016 Global Status Report.* Paris. ISBN 978-3-9818107-0-7
20. ***: World Bioenergy Association (2014). Global Bioenergy Statistics 2014. Stockholm, Sweden

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# CZECH WOOD AND POTENTIAL OF ITS CONSUMPTION IN THE CZECH REPUBLIC

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## ABSTRACT

A high share of good-quality raw coniferous wood has been exported abroad (the export in coniferous roundwood and pulpwood reached 4.242 mil. cubic metres in 2015), although the Czech sawmilling capacities are sufficient. The capacities are rather increasing in terms of volume, but the number of sawmilling companies is declining. The Czech Republic´s consumption of wood and wooden products is low in the long term in comparison to other European countries. An increase in domestic wood consumption would be a proper impulse for further investment into Czech wood-processing industry. That could lead to a better situation on the market, e.g. sell the wooden products with higher added value. This article contains information about raw wood, wood-processing capacities in the Czech Republic, innovation possibilities and increase in consumption of wooden products.
**Key words**: Raw wood, consumption, capacities, support of consumption, innovation, added value

## 1. INTRODUCTION

Czech Republic has at its disposal a sufficient wood supply and ranks with the largest exporters of round wood in the world (FAO, 2016). Problems of domestic market include, however, the low domestic timber demand and the export of low added-value products. Activities of wood-processing companies including the promotion of wood-based products are inadequate (Sujová, Hlaváčková, 2015).

According to the International Standard Industrial Classification of All Economic Activities, Rev.4, the wood-working industry belongs under the Section C- Manufacturing; Division 16- Manufacture of wood and products of wood and cork, except furniture: manufacture of articles of straw and plaiting materials. This division is further divided into 161- Sawmilling and planing of wood and 162- Manufacture of products of wood, cork, straw and plaiting materials. It is also useful to mention the related divisions: 17- Manufacture of paper and paper products, 31- Manufacture of furniture and 32- Other manufacturing (United Nations, 2017).

## 2. SOME CHARACTERISTICS OF TIMBER INDUSTRY IN THE CZECH REPUBLIC

Timber harvesting data show relatively even values in the recent years, with the dominating coniferous raw material. The comparison of imports and exports indicates that the Czech Republic has been reaching the net export and the value of exports constantly increases. In 2015, the exported volume of coniferous round wood and fibre amounted to 4,242 thousand m³ while the imported volume reached 1,980 thousand m³ (Green Report, 2015).

*Table 1. Timber harvest in the Czech Republic (2010-2014)*

| Year/production | Production (1 000 m³) | | | | |
|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 |
| Coniferous | 15 066 | 13 340 | 13 056 | 13 229 | 13 472 |
| Non-coniferous | 1 670 | 2 041 | 2 005 | 2 102 | 2 004 |
| Total | 16 736 | 15 381 | 15 061 | 15 331 | 15 476 |

*Source: FAO Yearbook of Forest Products 2014*

*Table 2. Exports and imports of round wood and fibre in the Czech Republic (2010-2014)*

| Year/amount | Amount (1 000 m³) | | | | |
|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 |
| Export | 1 743 | 3 487 | 3 912 | 4 292 | 4 931 |
| Import | 979 | 1 784 | 1 875 | 2 442 | 2 439 |

*Source: FAO Yearbook of Forest Products 2014*

The territorial structure of exports is nearly constant, too: in 2015, timber was supplied to Germany (sawn wood, construction joinery products and pallets), Austria (round wood, sawn wood, veneers, agglomerated products, plywood sheets) and to Slovakia. More than 80 % of total timber production goes to EU countries (Ministry of Industry and Trade, 2015).

As mentioned by Sujová, Hlaváčková and Šafařík in their study published in 2015 (working with data for the period 2002-2011), "*timber industry in the Czech Republic exhibited in absolute performance indicators a gradual growth of added value by 28 % in the course of 10 years with the production value increasing by 43 % but with gradually decreasing revenues by 15 % and number of employees by 23 %.*" While the numbers of employees in CZ-NACE 17 and 31 are relatively stable, the sector of timber industry exhibits a gradually decreasing number of employees since 2008.

*Table 3. Number of enterprises and number of employees according to CZ-NACE (16, 17, 31)*

| Year | Number of units/Number of employees | | | | | |
|---|---|---|---|---|---|---|
| | CZ-NACE 16 | | CZ-NACE 17 | | CZ-NACE 31 | |
| | Units | Employees | Units | Employees | Units | Employees |
| 2008 | 26 832 | 43 332 | 707 | 20 851 | 5 538 | 27 293 |
| 2009 | 27 415 | 39 840 | 763 | 18 737 | 6 095 | 24 450 |
| 2010 | 28 848 | 37 015 | 928 | 18 318 | 7 292 | 22 569 |
| 2011 | 24 495 | 35 057 | 965 | 17 765 | 8 241 | 21 819 |
| 2012 | 29 405 | 34 473 | 929 | 18 080 | 8 116 | 20 954 |
| 2013 | 27 849 | 32 184 | 895 | 17 560 | 7 254 | 19 839 |
| 2014 | 27 553 | 30 859 | 928 | 17 585 | 6 783 | 19 991 |
| 2015 | 26 326 | 30 845 | 928 | 18 288 | 6 093 | 20 351 |

*Source: Ministry of Industry and Trade, 2016*

*Table 4. Number of employees, value-added labour productivity*

| Year | Value-added (CZ-NACE 16) in mil. Czech crowns | Work labour productivity in Czech crowns/month (CZ-NACE 16) |
|---|---|---|
| 2008 | 23 716 | 45 609 |
| 2009 | 21 378 | 44 716 |
| 2010 | 20 859 | 46 690 |
| 2011 | 20 848 | 49 557 |
| 2012 | 20 206 | 48 844 |
| 2013 | 20 702 | 53 605 |
| 2014 | 22 044 | 59 529 |
| 2015 | 22 812 | 61 632 |

*Source: Ministry of Industry and Trade, 2016*

## 3. CAPACITIES

Wood processing is one of traditional industries in the Czech Republic and sawmills can be found across the whole territory of the country. Most frequently occurring are micro- and small enterprises and

there are additional 5 large sawmills (breaking down over 200,000 m³ per year)[1]: Mayr Melnhof Holz Paskov, Stora Enso Wood Product Ždírec, Stora Enso Wood Product Planá, DDL Lukavec and Pila Javořice. Data taken over from the 2015 annual report published by the company Less & Timber indicate that the sawmill timber breakdown in Čáslav amounted to 230,541 m³. With respect to the above division, this operation should be included in the category of large sawmills too (Annual Report Less & Timber, 2016).

Linking up with the data publicized in Lesnická práce (Lesnická práce 2/2016 and Lesnická práce 6/2016), domestic wood-processing capacities can be valuated as sufficient. Although the number of sawmills has decreased, it would be possible to process up to 17,251,713 m³ of raw wood every year with the current machinery (at present, approximately 67 % of this volume is being converted). Even though the capacities are considered adequate, potential construction of a new sawmill operation in Štětí has been under discussion since 2012. The project proposal was presented by the company Labe Wood. Some available data (Drevmag, 2017) suggest that the sawmill operation should provide up to 200 jobs and a timber breakdown capacity of up to 1 mil. m³ of timber raw material per year. In spite of the fact that more detailed data are not known yet, the sawmill would definitely be one of the largest operations in the country. Another so far unrealized plan is the construction of a sawmill funded by the Austrian company Sweighofer in the locality of Vodňany, which was however declined by local citizens in a referendum. The surroundings of Tábor were chosen as a substitute locality but further steps in this intended project are not known so far (Silvarium, 2016).

*Table 5. Wood-processing capacities in the Czech Republic*

| | Number of units (2013) | Number of units (2015) | Processing volume (in cubic metres) in 2013 | Processing volume (in cubic metres) in 2015 | Change in the number of units 2015/2013 | Change in the processing volume 2015/2013 |
|---|---|---|---|---|---|---|
| Sawmills | 713 | 649 | 7 000 200 | 6 948 000 | -64 | -52 200 |
| Paper industry | 2 | 2 | 3 400 000 | 3 168 700 | No change | -231 300 |
| Sheet material | 3 | 3 | 1 643 900 | 1 433 300 | No change | -210 600 |
| Total | 718 | 654 | 12 044 100 | 11 550 000 | - 64 | -494 100 |

*Source: Lesnická práce 2/2016 a 6/2016*

## 4. CONSUMPTION

The domestic consumption of wood is gradually increasing but it is still low as compared with the advanced countries. For example, consumption per capita in the United States or in Japan is by 150 % higher than in the Czech Republic. Even though the country gets close to Germany (20 %) with its 13.5 % representation of wooden constructions, the neighbouring Austria reports a share of wooden constructions of about one third (Green Report, 2016). According to the Ministry of Industry and Trade of the Czech Republic, the timber consumption increase should be focused primarily on the following goals: "*to increase the construction of low-energy wooden family houses and to extend applications of wooden elements such as complex roof constructions, non-typical window frames, floors and internal wall tiles in order to reach higher competitiveness of wooden structures with structures built of classical building materials. Increased utilization of production waste in the form of e.g. pellets will be necessary as well (Ministry of Industry and Trade, 2016)".*

[1] Large sawmill is considered a sawmill operation with the breakdown capacity over 200 000m³/year; taken over from the methodology by Dětvaj in Pražan (2010)

## 5. INNOVATIONS

Traditional industries of which one is wood processing may be affected by technology changes more than other, better adapting branches of national economy (Paluš, Parobek, 2013). At the same time, small and medium-sized enterprises (which dominate the sawmill operations in the Czech Republic), have to withstand the pressure of international competition (Loučanová, 2005). The capacity of innovation is considered a necessary condition for competitiveness with no regard to the scope of activities of the enterprise. The innovation strategy should be based on the needs and requirements of customers to ensure the competitiveness at various conditions of competition (Loučanová, 2005*). "The phenomenon of the efficient development of wood processing industry in the coming years is ensuring sales of the timber production on the global market, in increasing the added value, in a more effective utilization of timber material and hence in a higher finalization of wood-based products, resp. invention and innovation in all areas relating to the higher degree of wood valorization (Loučanová, 2005)".* Sawmill production innovations lead to higher labour productivity. Innovated machinery allows to produce different assortments or to treat the "waste" wood material so that it is still usable in further conversion (Reisner, Bomba, 2011). Manufacturing time can be shortened, labour productivity can be improved and assortments demanded by customers can be supplied.

The European Union puts emphasis on the support of industries utilizing renewable raw materials. Of these, timber is a material of great future, its environmental impact being very low in the course of whole product life cycle, and new technologies enabling the use of timber even in areas formerly hardly imaginable.

## 6. CONCLUSIONS

Wood- processing represents one of traditional industries in the Czech Republic. The position of Czech exports point to active balance of trade; however, the volume of exports is adversely affected by low value added due to the low degree of processing in manufactured products. The supply of domestic raw timber is plentiful and the existing capacity of sawmills could absorb a timber volume by nearly 30 % higher. Thus, some capacities remain unused. In spite of the fact, construction of two other large sawmill operations has been discussed in recent years. Realistic appears the construction of sawmill in Štětí where a paper mill of the company Mondi has already been launched. Other large operations in the Czech territory with parent companies abroad could jeopardize the situation of small wood converters as to their access to raw timber and hence the competitiveness of their production. The still low level of the domestic consumption of wood-based products and the related low domestic demand only encourage the export of timber to foreign countries. This is why the promotion of a higher degree of timber produce finalization should be one of key areas in the concern of Czech timber industry.

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## REFERENCES

1. Drevmag, 2017. V Česku se schyluje k výstavbě dalšího pilařského gigantu. Dostupné na: http://www.drevmag.com/index.php/sk/aktuality/377-v-cesku-se-schyluje-k-vystavbr-dalsiho-pilarskeho-gigantu
2. FAO, 2016. FAO Yearbook of Forest Products 2014. Available at: http://www.fao.org/3/a-i5542m.pdf
3. Lesnická práce 2/2016. Písek: Čs. matice lesnická, 1922-. ISSN 0322-9254. Dostupné také z: http://www.silvarium.cz/lesprace

4. Lesnická práce 6/2016. Písek: Čs. matice lesnická, 1922-. ISSN 0322-9254. Dostupné také z: http://www.silvarium.cz/lesprace
5. Loučanová, E., 2005. Inovácie ako podmienka konkurencieschopnosti drevospracujúceho priemyslu na globálnom trhu. In Inovace: Jediná účinná cesta k úspěchu v globální ekonomice. Sborník z mezinárodní konference. Praha, 102-105. ISBN 80-86744-26-4
6. Annual report LESS & TIMBER, 2016. Dostupné na: https://or.justice.cz/ias/ui/vypis-sl-detail?dokument=43423001&subjektId=643374&spis=972528
7. Ministry of Industry and Trade, 2015. Panorama zpracovatelského průmyslu 2014. Dostupné na: http://www.mpo.cz/dokument154179.html
8. Green Report, 2015. Ministry of Agriculture of the Czech Republic, 2016. Praha: Ministerstvo zemědělství. 133 s.
9. Paluš, H., Parobek, J., 2013. Changing patterns of roundwood deliveries in Slovakia. In. Markets for wood and wooden products, Gdańsk, Poland, 77-94. ISBN 978-953-57822-0-9.
10. Pražan, Petr. *Analýza faktorů možností vývoje malých a středních pilařských provozů v ČR*. Polička, 2010. Disertační práce.
11. Reisner, J., Bomba, J., 2011. Technological and materiál innovations in woodworking industry in the Czech Republic. 4th International Scientific Conference - WOODWORKING TECHNIQUE, 239-243.
12. Sujová, A., Hlaváčková, P., 2015. Sectoral Analysis of Competitiveness of Wood Processing Industry in the Czech Republic. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 63(1), 293-302.
13. Sujová, A., Hlaváčková, P., Šafařík, D., 2015. Analýza výkonnosti drevospracujúceho priemyslu prostredníctvom pomerových ukazovatelov. Acta Facultatis Zvolen, 57(2), 165-178.
14. Silvarium, 2016. Stát pomůže Rakušanům se stavbou obří pily ve Štětí. Dostupné na: http://www.silvarium.cz/drevarstvi/stat-pomuze-rakusanum-se-stavbou-obri-pily-ve-steti
15. United Nations, 2017. ISIC Rev.4. Available at: https://unstats.un.org/unsd/cr/registry/isic-4.asp

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# COMPARISON OF GREEN GROWTH INDICATORS IN THE EU

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## ABSTRACT

The principles of wood raw material production are based on generally respected requirements of the society in order to meet its environmental, economic, cultural, social, and other needs. However, consumption is a key driver for the economy because the economic growth is linked to the increase in consumption. A lot of factors have a significant influence on this relationship. This paper deals with the analysis of the relationship among individual green growth indicators namely: greenhouse gas emissions per capita, the share of electricity produced from renewable sources, the share of energy from renewable sources in gross final energy consumption and energy intensity. Based on the available official databases of selected indicators this research analysed and compared the individual European countries level of development of these indicators and the achievement of results in relation to the European Union average. Furthermore, the research deals with the description of the current situation in the Slovak Republic and compares it with the selected countries of the EU.
**Key words**: green economy, green growth indicators, renewable resources, European Union

## 1. INTRODUCTION

Green economy is a "low carbon" economy aiming at the reduction of use of fossil fuels and the efficient use of renewable sources such as wood. For the first time, the term green economy was coined in a pioneering report for the Government of the United Kingdom by a group of leading environmental economists, entitled Blueprint for a Green Economy (Pearce, Markandya and Barbier, 1989). There is no internationally agreed definition of green economy. UNEP, for example, has defined the green economy as “one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient and socially inclusive” (UNEP, 2011).

Forestry and wood processing industry can significantly contribute to the objectives of green economy (FAO/UNECE, 2009). The principles of sustainability and some of the green economy principles, in this case, may worry because they tend to reduce consumption. This paradox led to the search for compromises not only in the context of national economies and regional associations but also at the global level (FAO/UNECE, 2005).

Green economy was evaluated by Jones (2008). He commented dependency of the economy on the unrenewable sources (fossil fuels) and their significant negative impact on the environment. In the future, the demand and price will increase and this development will make a lot of economic problems and climatic changes.

Sustainable development has long been on the political agenda of the European Union, with the creation of its Sustainable Development Strategy and the respective sustainable development indicators set (Eurostat, 2015). Progress towards the sustainable development strategy objectives is evaluated using a set of sustainable development indicators grouped into ten thematic areas. In order to positively implement green strategies, periodic assessments of the efficiency of implemented instruments are necessary. Results of monitoring help the politicians in making decisions about further strategies. The effective instrument of monitoring should create a set of relevant and internationally comparable indicators. OECD (2014) proposed 4 main areas of monitoring, which means 4 major indicator groups:

1. Indicators of environmental and resource productivity that represent interconnection between the effectiveness of natural resources exploitation, production, and consumption.
2. Indicators of the natural asset base that monitor the status and quality of natural resources in terms of their depletion and diminishing, which poses a risk of slowing down the growth.

3. Indicators of environmental quality of life that express either direct or indirect impact of the environment on human health and life.
4. Indicators of economic opportunities and policy response that serve the politicians to make the implemented political measures more effective.

The first part of the assessment is based on so-called "decoupling". It tries to describe whether the changes of the economic indicator have a significant impact on the environmental indicator. Decoupling describes if the development of growth of the environmental pressure indicator is lower than the level of economic growth. There is a possibility to describe "decoupling" as an absolute or relative value. The absolute decoupling explains the conditions when environmentally important variables are stable or even decreasing, while the economic growths. The relative decoupling occurs when the trend of environmentally variable's growth is positive but less than the tempo of the economic variable growth. Indicators which are impossible to connect with the economic variables are assessed on the basis of their trend (SEA, 2014).

## 2. METHODOLOGY

At the present time, more than 100 indicators structured around the ten themes are presented in the strategy of the EU. Each theme has a headline indicator that shows whether the EU has made overall progress. It is impossible to analyse all of them that is why only some of them have been selected based on a set of indicators proposed by the OECD (2014).

For the purposes of this research, we analysed data in the period from 2000 to 2012 using the official international databases (EUROSTAT, 2015). Development indicators have been consulted with experts from various institutions and specialized agencies as the concept of the green growth is not yet officially implemented in the Slovak Republic. Many times, the evaluation of development indicators is based on the assessment of the specific purposes.

For the evaluation of selected individual indicators of the green growth, we applied greenhouse gas (GHG) emissions per capita, the share of electricity generation from renewable energy sources, the share of renewable energy in gross final energy consumption and an indicator of energy productivity. For the comparison purposes, we provided all indicators in relative values in order to compare them with the EU 28 average.

The economic indicator and indicator of green growth were selected for the analysis of the dependence. This economic indicator was representing by the Gross Domestic Product (GDP) per capita. It describes the value of all final goods and services produced in the country accounted per capita. On the other side, the volume of GHG per capita represents green growth indicators. The hypothesis predicts their positive interconnection.

The relationship between above mentioned indicators is described by correlation (Gejdoš, 2016). It is one of the most common statistics where a single number that describes the degree of relationship between two variables. The correlation coefficient can be described as:

$$r = \frac{N\Sigma GDPxGE - \Sigma GDP\Sigma GE}{\sqrt{[N\Sigma GDP^2 - (\Sigma GDP)^2][N\Sigma GE^2 - (\Sigma GE)^2]}} \qquad (1)$$

N - number of countries,
GE - gas emissions per capita the percentages compare with EU 28 average,
GDP- an indicator of GDP per capita the percentages compare with EU 28 average.

The "*r*" value is called Pearson correlation coefficient and it is a measure of the linear correlation between the GDP per capita and the gas emissions per capita variables. It has a value between +1 and

−1, where 1 is a total positive linear correlation, 0 is no linear correlation, and −1 is a total negative linear correlation.

## 3. RESULTS

The results describe selected indicators and relationship between two selected indicators - GHG emissions per capita and GDP per capita. As indicated in Fig. 1 Luxemburg produces the highest GHG per capita among the EU 28 countries. The trend of the absolute value is decreasing every year, however, it is still greatest and in 2013 the value of GHG emissions per capita reached 20.75 $CO_2$ equivalents. In the percentage comparison, Luxembourg reached the value greater by 135% compared to the EU 28 average in 2013 (158% in 2009). Such high values are due to the fact that Luxemburg is a small country with the small population and has a very developed industry. On the other side, the lowest volume of GHG per capita during the analysed period was recorded in Latvia. The value ranges from 4.99 to 5.67 tons of $CO_2$ equivalent, representing only 54% of the EU 28 average. It could affect the less developed industry as well as some new investment in this country with progressive technology.
The Slovak Republic reaches values between 8.07 and 8.71 tons per capita with a decreasing trend. The situation in Slovakia can be evaluated positively because it is still lower than the average value of the EU 28 (8.84 tons per capita in 2013). In percentage, Slovakia achieved values between 90% and 93% compared to the average with a slightly upward trend. Based on Fig. 1, approximately half of the countries in this indicator reached values lower than the average of the EU 28.

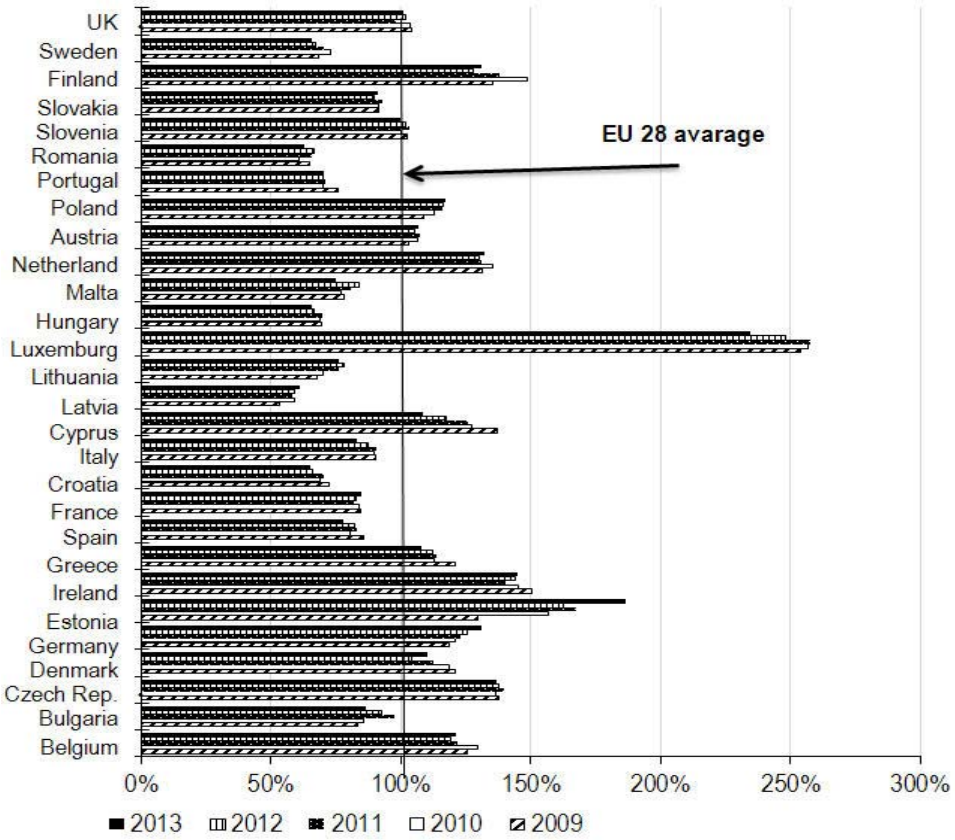


*Figure 1. The development of the percentage of greenhouse gas emissions compared to the EU28 average*

The share of electricity produced from renewable sources represents the ratio between the amount of electricity produced from renewable energy sources and total gross annual energy consumption of the country. The highest proportion of electricity produced from renewable energy sources in final annual energy consumption was recorded in Austria; almost 70.0% in 2014. During the last five years, this value has not changed significantly. The lowest share of electricity produced from renewable sources on the annual consumption of energy was in Malta. From zero values during the first two years, this indicator increased slightly to 3.3% in 2014. Regarding Slovakia, the value increased from 17.8% in 2009 to 23.0% in 2014. However, these values are still below the EU average (27.5 %).

An indicator of the share of energy from renewable sources in gross final consumption of energy reflects the share of energy from renewable non-fossil sources, namely, wind turbines, solar power and solid biofuels, hydropower, etc.). The highest share of energy produced from renewable sources in gross final annual consumption was in Sweden (Fig 2). The share increased from 47.2% in 2009 to 52.6% in 2014. In the percentage comparison, Sweden reached value 289% higher (2014) than was the EU 28 average. On the other side, the lowest share of electricity produced from renewable sources reached again Malta with the maximum 4.7% in 2014 and showed significant growth. Slovakia increased the value from 9.1% to 11.6% of the share of energy from renewable sources and it is still less than EU 28 average (16.0% in 2014). In other words, Slovakia achieved 79% compared to the EU average. According to data in Fig.2 14 European Union countries reached the share of energy from renewable sources in gross final consumption of energy less than the average of the EU 28.

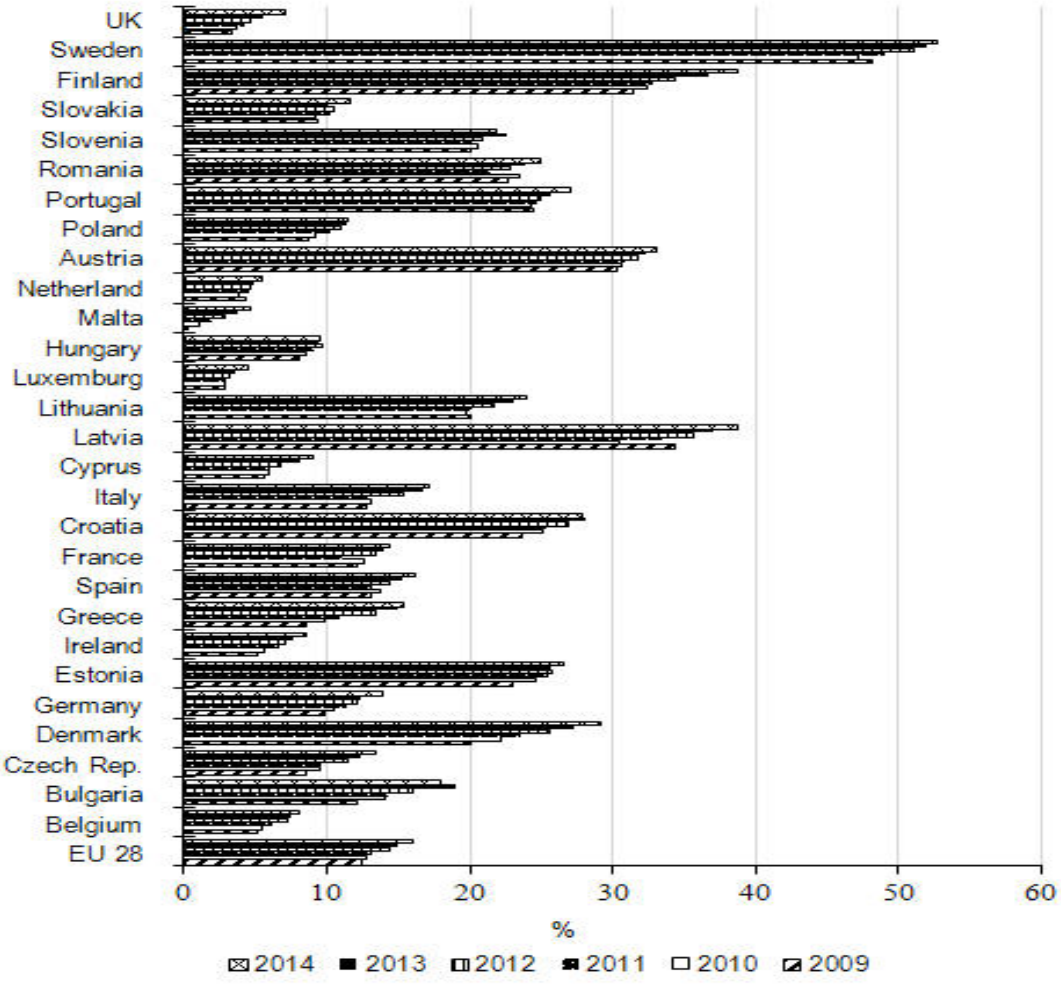


*Figure 2. The development of the share of energy from renewable sources in gross final energy consumption*

Energy intensity is the ratio between the gross inland consumption of energy and Gross Domestic Product (GDP) calculated for a calendar year. This indicator allows monitoring the growth of national income produced from the unit of energy used. Denmark had the highest energy productivity up 14.6 € per kilogram of oil equivalent. In 2009 Bulgaria reached the lowest value (2.0 € per kilogram of oil equivalent) and is still maintaining the same level. Compare to other countries Slovakia reached low value 4.5 € per kilogram of oil equivalent and achieved between 51% and 55% of the EU average, which recorded a slight upward trend. 17 European Union countries have the indicator value below the average of the EU.

The results also indicated the relationship between GHG per capita and GDP per capita as an economic indicator. Based on data from all EU 28 countries the correlation coefficient was calculated to express the intensity of dependence between the examined variables. The value of calculated correlation coefficient was 0.62. In case that value range from 0.5 to 0.7 it shows that there is a strong correlation with the direct dependence. The coefficient confirms that GDP per capita growth has a relatively strong impact on the growth of greenhouse gas emissions per capita. The same situation can be applied in the opposite case. From this relationship, it can be concluded that the value of all goods and services produced in the territory of the country fairly closely related to the amount of greenhouse gas that this country produces. It means that the current global trend of increasing consumption and consumer lifestyle while supporting economic growth and benefits has also a negative impact on the ecology and the environment.

## 4. CONCLUSION

Globalization is affecting all industries, including forest based industry. Therefore, new strategies and advantages focused on renewable are required (Parobek et al., 2016). In today's world of global climate change, constantly increasing consumption, leading to over-exploitation of natural resources and the high dependence of economies on fossil fuels and non-renewable resources green economy and the concept of sustainable development have a significant influence on all sectors of the society.

The aim of the research was to determine the level of the individual states of the European Union in the implementation of green economy concepts of sustainable development and green growth into their national policies and economies. The paper analysed various indicators of green growth, dismantled their nature and classification and described the current situation in the Slovak Republic in comparison with the EU countries. Based on available data on selected indicators, green growth was analysed. We tried to compare the level of individual European countries in the implementation of these indicators in relation to the average of the European Union as a whole. This comparison enabled us to identify a situation in the EU Member States.

The results also showed links and interdependence between the selected economic indicator and the indicator of green growth. There was a relatively strong dependence identified between these indicators that confirmed the general continuing global trend in increasing consumption. Consumerism, while good for economic growth, has a negative impact on the ecology and the environment. Therefore the future path of human society development should incorporate appropriate gentler alternatives that are in line with the context of green economy and sustainable development.

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## REFERENCES

1. Dzian, M.; Maťová, H.; Tríznová, M. (2015) *The test of the corporate character scale on two companies*. In: Wood processing and furniture manufacturing challenges on the world market and Wood-based energy goes global: proceedings of scientific papers. Zagreb 2015. 165--169.
2. EUROSTAT (2015) Sustainable development in the European Union 2015 monitoring report of the EU Sustainable Development Strategy. Luxembourg: Publications Office of the European Union, ISBN 978-92-79-49391-1. 356 p.
3. FAO/UNECE (2005) Forest Products Annual Market Review. ECE/TIM/SP/21. Geneva: UN. ISSN 1020-2269. 163 p.
4. FAO/UNECE (2009) Unece Geneva Timber and Forest discussion Paper 54 The forest sector in the green economy. Geneva: United Nations Economic Commission for Europe. ISSN 1020-7228. 54 p.
5. Gejdoš, P. (2016): *Analysis of Performance Improvement of Wood Processing Companies in Slovakia and the Czech republic through the Implementation of Quality Management System*. Acta Facultatis Xylologiae Zvolen. 58 (1): pp. 113-124.
6. Loučanová, E.; Kalamárová, M. (2014) *Postupy a nástroje na riadenie inovačných projektov.* In: Trendy a inovatívne prístupy v podnikových procesoch: 17. medzinárodná vedecká konferencia. - Košice: Technická univerzita v Košiciach. Slovakia. December, 2014. 1-8.
7. OECD (2014) Green Growth Indicators. Paris, OECD Publishing. ISBN 978-92-64-20202-3. 147 p.
8. Parobek, J.; Paluš, H.; Loučanová, E.; Kalamárová, M.; Glavonić, B. (2016): *Competitiveness of Central European Countries in the EU Forest Products Market with the Emphasis on Slovakia*. Acta Facultatis Xylologiae Zvolen. 58 (1): pp. 125-136.
9. Pearce, D.W.; Markandya, A.; Barbier, E. (1989) Blueprint for a Green Economy. London, Earthscan. ISBN 1 85383 066 6. 192 p.
10. SEA (2014) Selected Green Growth Indicators in the Slovak Republic. Banská Bystrica, Slovak Environment Agency. ISBN: 978-80-89503-35-3. 50 p.
11. UNEP (2011) Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication - A Synthesis for Policy Makers, URL: http://www.unep.org/greeneconomy

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# ANALYSIS OF THE PRICE CORRELATION OF RAW WOOD ASSORTMENTS IN THE CZECH REPUBLIC AND NEIGHBOURING COUNTRIES

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**ABSTRACT**

The price of wood is the main factor influencing profitability of both the forest owner and wood processing companies. The Czech Republic ranks among the major exporters of raw wood in the EU. For these reasons, the main objective of this paper is to analyse how the price of the wood in the Czech Republic is influenced by the prices in the neighbouring states (Austria, Germany, Poland and Slovakia). The chosen method for estimating the interactions between the prices is the advanced correlation analysis. The data for the analysis of the prices of the raw wood assortments was obtained by desk research based on obtaining information from publicly available scientific sources in the period 2012-2016. The results are given in well-arranged tables so relevant conclusions can be easily derived for market participants and related policies.
**Keywords**: wood prices, development of the prices, wood assortments, comparison of the wood prices

## 1. THE COUNTRIES NEIGHBOURING THE CZECH REPUBLIC

### 1.1. Slovakia

Until 2012, the average wood prices were published by the Statistical Office of the Slovak Republic. Since 2013, the information on wood prices are to be found on the official website of the Statistical Office (after entering the database “Slovstat”, one of the 3 databases used for publishing and storing the information) only in the form of indexes of the wood prices sorted by wood assortments. The indexes are divided into categories of coniferous and deciduous wood. Though, in the same category the average prices of the products of the agricultural production can be found.

The data regarding the average wood prices may be obtained from the newsletter of the National Forestry Center (Informačný list Spravodajca Národného lesnického centra). The newsletter offers tables containing information on the development of wood prices of various assortments every three months. The data is freely available on the Internet in PDF form, but unfortunately, this electronic form does not allow a user to further process and compile the data.

The assortments in the tables are divided according to quality and quantity categories; in addition, the data is sorted by purpose also in the newsletter. Unfortunately, the data is not usually complete and some of categories are wholly omitted. The prices (without value added tax) are related to the wood stored in expedition warehouses. Unfortunately, the number of statistical respondents is not published. This causes the fluctuation in the average prices in the categories of assortments where, very likely, not enough data was gathered.

The data used for comparison had to be transmitted from the newsletter. In order to eliminate any incomplete data (and the fluctuation caused by this), only the coinciding assortments and the assortments that were wholly filled were compared. As it can be seen from the chart below, the wood price is fluctuating. This happens because of the not very usual assortments in the category and only a small amount of information was obviously gathered.

### 1.2. Poland

In Poland, a comprehensive report (called Leśnictwo) on forestry is published annually by the Polish Statistical Office (Główny Urząd Statystyczny). In the report, all the data (which was reported) is published. The report has two language versions (it is written in both the English and Polish languages)

and is divided into several chapters. In the chapter devoted to the wood prices and the overall amount of the wood sold, the categories of assortments are thoroughly explained. Unfortunately, the report does not distinguish the categories of the trees (except from conifers and broadleaves), only the qualitative parameters are stated.

Nowadays, the only available data is from 2015 (a comprehensive report was published in December, 2016), no updated data has been published yet. The fact that the data is collated not only in PDF form (in which the report is published), but also in XLS form may be marked down as a significant advantage . This is useful when a user is aiming to further process and compile the data.

The quality category was adapted so the comparison with the prices in the Czech Republic would be possible. The titles of the quality categories of the wood were translated and assigned according to the specifications in the publication Leśnictwo to the quality categories coming from the publication "Recommendations for the rules for measuring and sorting the wood" (Doporučená pravidla pro měření a třídění dříví) from the Czech Republic.

### 1.3. Germany

The German Statistical Office (Statistische Bundesamt) only publishes the indexes of the prices instead of the average prices for the particular trees and assortments. In the publication "Price indexes for agriculture and forestry" (Preisindizes für die Land und Forstwirtschaft), the indexes for the given assortments are to be found. This is why, any comparison with prices in the Czech Republic is impossible. The indexes have been following the price movements since 2010. Though, the average prices for the given assortments are not published in the report.

The publication, Preisindizes für die Land und Forstwirtschaft, shows the price indexes for every month, for the previous month and also the comparison between the previous two months, and the comparison with 2010 as well (the 2010 index is valued 100 points).

Although the publication is aimed at being published on a monthly basis, in reality it is published with delays of 2 to 3 months. The unfortunate thing is that the prices cannot be calculated – the prices for the default year 2010 are not available, although the default index is set and stated.

These indexes are related to Germany as a whole country. In the publications, the price indexes for the particular federal states may be found also. As a difference from Slovakia, the tables are shown as a whole, as the indexes are placed there for every month in all the assortments. The data is published in PDF form, this does not allow a user to further process and compile the data.

### 1.4. Austria

The Austrian Statistical Office (Statistik Austria) publishes the price list for agricultural crops and woods. The price lists have been categorised by months since 2013, older price lists only provide one with information based on the annual price averages.

The Austrian system of categorising the assortments is similar to the system used in Germany and Switzerland (there are only small exceptions – the assortment Blochholz in Austria and the assortment Rundholz in Germany).

The wood prices valued in CZK (according to the exchange rate of the National Bank of the Czech Republic) are enclosed in the attachment (the comparison was completed by years). The indexes are assigned for each month in all the assortments (this is similar to Germany), so the data for the set period is not missing (as is the case in Slovakia).

The data is not only available in a large document in PDF format, but also in XLS form. This is why it is possible to easily obtain and process the data. In addition, the data is updated regularly, the latest publication is always only 1 or 2 months old.

## 2. COMPARISON WITH THE CZECH REPUBLIC

In the charts below, the development of the prices in the countries neighbouring the Czech Republic have been compared every quarter. The development of the prices has also compared between the countries.

Germany is represented in a form of modified price indexes only in order to show the development of the prices. Therefore, the values assigned to Germany do not represent the actual price, but only the price index. The Austrian prices are starting from the end of 2012, as the data for older quarters is not available. The prices from Poland are available annually for the period 2012-2015 only, the quarterly prices are missing.

In order to make the comparison effective and proper, the quality category was used as this category is the most important for trading. This is why only the medium sized spruce log wood, the medium sized beech log wood, pulpwood and fuel wood were used for comparison.

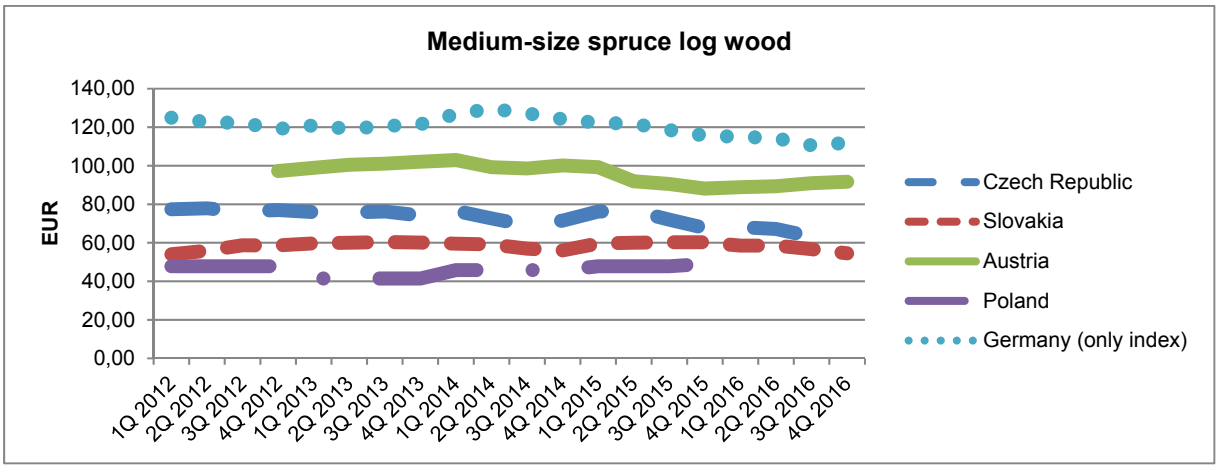


*Figure 1. Medium-size spruce log wood*

The chart above shows the comparison of the development of the medium sized spruce log wood. If comparing the development in the Czech Republic and Germany in the category of the medium sized spruce log wood, the trend is similar – increasing until 2015, then decreasing (the fluctuations are more significant in the Czech Republic). At the end of 2016, there is a small increase. The development of the price changes is similar to the development in Austria. The trend of the development of the spruce prices in Slovakia is de facto mimicking the development of the prices in other countries without significant deviations. Though, at the end of 2016, a mild decrease in the prices occurred.

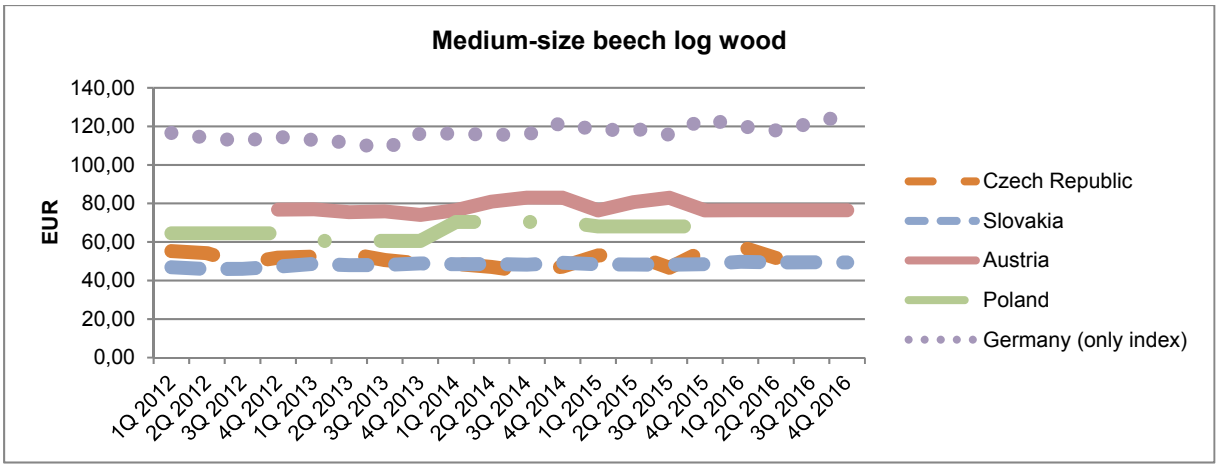


*Figure 2. Medium-size beech log wood*

In the category of the medium sized beech log wood, much greater fluctuations occur as there are larger differences in the prices. The second reason is that (when compared to the medium sized spruce log wood) the extent of the market is smaller. This allows dramatic changes even between quarters. The most stable development can be found in Germany where the price (according to the index) is slowly increasing. In the Czech Republic, dramatic decreases occur in the category of the medium sized beech log wood in the 3rd quarter. Then a significant increase follows during the 4th quarter of the same year. In Slovakia, the trend has been steady and stable since 2012.

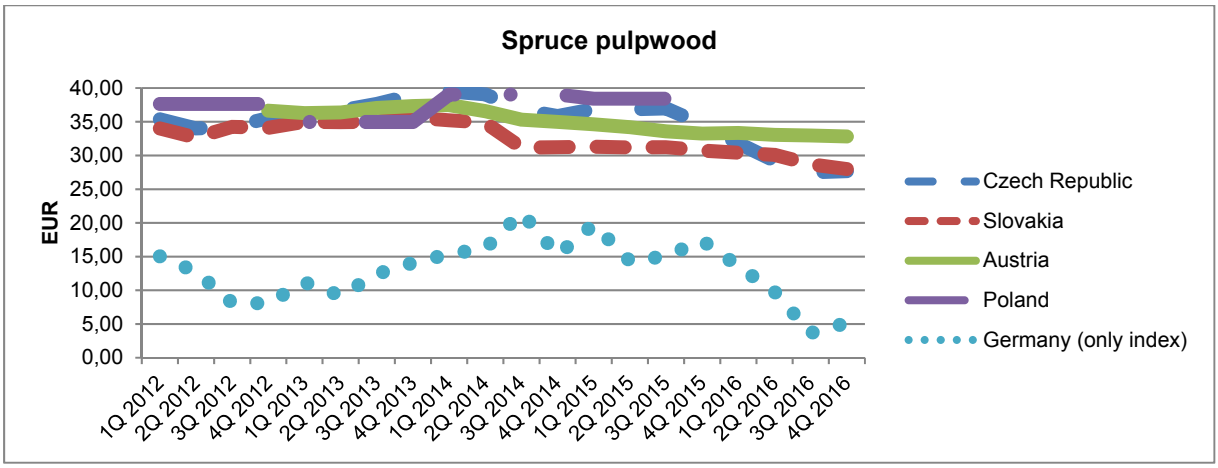


*Figure 3. Spruce pulpwood*

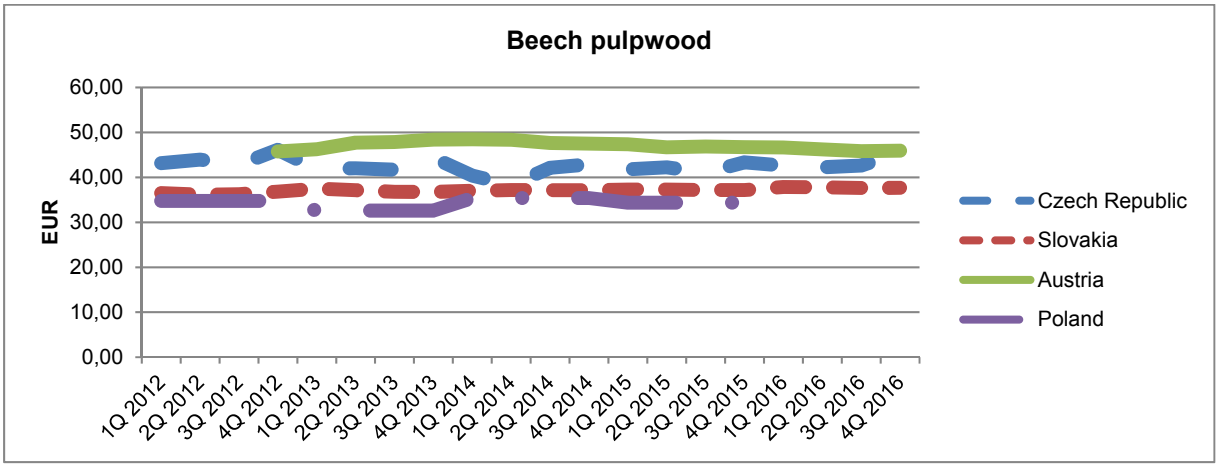

*Figure 4. Beech pulpwood*

The first chart above shows spruce pulpwood, the second one shows beech pulpwood. In Germany, only one category is available, this is why the price index is displayed in the spruce pulpwood chart only. When spruce wood is concerned, a decrease occurs from the 1st quarter of 2014 and, except from the 1st quarter of 2015, the decrease continues till the end of 2016 in the Czech Republic. This trend, even though milder, may be seen in Austria and in Slovakia as well. In 2016, a rapid decrease occurred in Germany. In the Czech Republic, beech pulpwood changed its price dramatically when compared to the price development in Slovakia, where the price is slowly increasing (without significant fallouts) in this quality category.

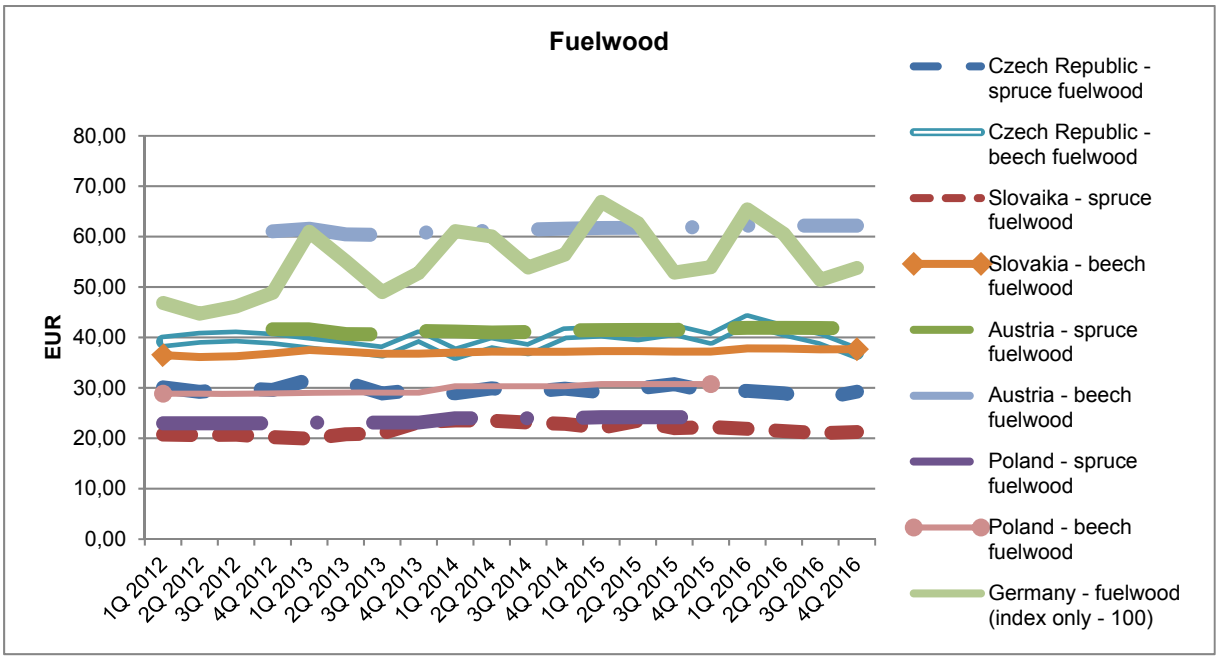


*Figure 5. Beech pulpwood*

Even though fuel wood is the lowest quality category, it plays an important role on the wood market. The price reacts (more than the cases of other wood categories) to energy prices and other (especially fossil) fuels. This factor is more significant for households than sawmill companies. In 2013, there was an increase in the category of spruce wood in Slovakia. Even though the trend was mildly decreasing from the time of the dramatic increase, the price was already stable in 2016. In Austria, the trend in the categories of the fuel wood is almost the same.

In Germany, the increase in the prices is to be seen very well during the winter period and, on the contrary, the decrease is visible during the summer period. In the Czech Republic, the development of the prices shows an increased demand which is why the price is increasing during the heating season.

## 3. CORRELATION ANALYSIS

The time series for each quarter of the period were analysed using R (R core team, 2014). To verify the hypothesis that prices in Austria and Germany could affect the prices in the Czech Republic with a certain delay, the correlation matrices were calculated in a phase shift by 1 quarter compared to the prices in Austria and Germany. These calculations did not correlate much more than the price comparison in the Czech Republic and abroad in the same period. It can only be assumed that if the prices in the neighbouring countries were available in a detailed breakdown for the individual months, a

shift by one month could be more significant in these calculations. However, due to the speed of the market reaction, a shift over the quarter is too big to produce more significant results.

The high level of significance (p-value) is indicated in Tables 1 and 2 by the following symbols.

| **symbol** | * | ** | *** |
|---|---|---|---|
| **p-value** | **0.01 – 0.05** | **0.001 – 0.01** | **< 0.001** |

The following tables show the results for two typical assortment: coniferous sawlog and pulp wood.

*Table 1 Quality saw logs - coniferous*

| | CZ_spruce | CZ_pine | SK_conif | D_spruce | D_pine | A_spruce |
|---|---|---|---|---|---|---|
| CZ_spruce | 1 | 0.800*** | 0.290 | 0.365 | 0.150 | 0.746** |
| CZ_pine | 0.800*** | 1 | 0.112 | 0.203 | 0.188 | 0.456 |
| SK_conif | 0.290 | 0.112 | 1 | 0.206 | -0.060 | 0.338 |
| D_spruce | 0.365 | 0.203 | 0.206 | 1 | 0.787*** | 0.655* |
| D_pine | 0.150 | 0.188 | -0.060 | 0.787*** | 1 | 0.395 |
| A_spruce | 0.746** | 0.456 | 0.338 | 0.655* | 0.395 | 1 |

As expected, large and statistically significant correlations between the prices of similar assortments within one country (CZ_spruce and CZ_pine, D_spruce and D_pine) can be observed. Among the states, we can see a high positive correlation between the prices of spruce in the Czech Republic and Austria, but surprisingly, not between the prices in the Czech Republic and Germany, or between the prices in the Czech Republic and Slovakia.

*Table 2 Correlation of pulpwood prices*

| | CZ_ spruce | CZ_ Beech | SK_conif | SK_ broadl | D_ Spruce | D_beech | A_spruce | A_beech |
|---|---|---|---|---|---|---|---|---|
| CZ_ spruce | 1 | -0.349 | 0.594** | -0.263 | 0.290 | -0.357 | 0.761** | 0.770** |
| CZ_beech | -0.349 | 1 | -0.079 | -0.330 | -0.361 | 0.018 | -0.257 | -0.295 |
| SK_conif | 0.594** | -0.079 | 1 | -0.481* | -0.568* | -0.561* | 0.941*** | 0.652* |
| SK_ broadl | -0.263 | -0.330 | -0.481* | 1 | 0.380 | -0.149 | -0.684** | -0.765** |
| D_spruce | 0.290 | -0.361 | -0.568* | 0.380 | 1 | 0.398 | -0.400 | 0.075 |
| D_beech | -0.357 | 0.018 | -0.561* | -0.149 | 0.398 | 1 | -0.659* | -0.322 |
| A_spruce | 0.76**1 | -0.257 | 0.941*** | -0.684** | -0.400 | -0.659* | 1 | 0.709* |
| A_beech | 0.770** | -0.295 | 0.652* | -0.765** | 0.075 | -0.322 | 0.709* | 1 |

Referring to pulp wood, we again see a strong positive correlation between the prices of spruce pulp wood in the Czech Republic and all pulp wood assortments in Austria. The same applies to the prices in the Czech Republic and Slovakia. However, the correlation with the prices in Germany is weak. Prices of coniferous pulp wood in Slovakia show a high positive correlation with the prices in Austria and the Czech Republic and a somewhat surprisingly negative correlation with the prices in Germany.

Referring to deciduous pulp wood, the prices in Slovakia correlate significantly only with Austria and, unlike the Czech Republic, negatively.

## 4. CONCLUSION

In the countries neighbouring the Czech Republic, it was determined which wood assortment data is gathered and how the data is being published. In Slovakia, the wood prices have been published from 2012 by the National Forestry Centre every 3 months in PDF form only. Therefore, compiling the data remains problematic. This is basically the same problem we have to face in Germany where the data is published by the Preisindizes für Land & Forstwirtschaft on a monthly basis. This data is delayed and published in form of indexes only.

In Poland, the data is published annually, the report called "Lesnictwo" is similar to the Czech "Green Report" (Zelená zpráva). Though, there are two significant differences – "Lesnictwo" only contains the average price from latest year (2015) and the data is available in XLS form. In Austria, the system is very similar to the Czech one, the prices are compared monthly (the summary is included). The data is published every month in Austria (with an approximate 2 month delay) in both PDF and XLS forms.

The development of the wood prices in the category of medium-size spruce log in the Czech Republic is similar when compared with the development in Germany and Austria (the only difference is that the fluctuations are greater in the Czech Republic). In the category of broadleaf, the Czech Republic has much larger fluctuations when compared to the neighbouring countries where the development is more stable. The price of spruce pulpwood is decreasing in the Czech Republic (the development in the neighbouring countries is similar, only the decrease is not so obvious). The prices of fuel wood are stable in the category of conifer when compared to Slovakia, where the fluctuation occurs quite often. The prices of the broadleaf category are slowly increasing, the same thing can be seen in Slovakia. The prices in Austria are very stable, in Germany only a small fluctuation in the prices takes place.

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## REFERENCES

1. Bundesanstalt Statistik Österreich. Land- und Forstwirtschaftliche Erzeugerpreise (2012 – 2017). Statistik Austria. URL: http://www.statistik.at/web_de/statistiken/wirtschaft/lanD_unD_forstwirtschaft/preise_bilanzen/preise/index.html
2. Český statistický úřad. *Indexy cen v lesnictví (surové dříví)* (2012-2016). ULR: https://www.czso.cz/csu/czso/katalog-produktu - Indexy cen v lesnictví
3. Główny Urząd Statystyczny. *Leśnictwo (2013 – 2016).* Statistical informationand Elaborates. URL: http://stat.gov.pl/obszary-tematyczne/rolnictwo-lesnictwo/lesnictwo/lesnictwo-2016,1,12.html
   Statistische Bundesamt. *Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung* (2012 – 2017) Fachserie 3 Reihe 3. URL: https://www.destatis.de/DE/Publikationen/Thematisch/LandForstwirtschaft/Bodennutzung/BodennutzungErzeugung.html
4. Národné lesnícké centrum vo Zvoleně. *Informačné listy Národného lesníckého centra vo Zvoleně* (2012 – 2016) ForestPortal. URL: http://www.forestportal.sk/lesne-hospodarstvo/informacie-o-lesoch/trhove-spravodajstvo/Pages/informacne-listy-ltis.aspx

5. Štatistický úrad Slovenskej republiky. *SlovStat* (2012 – 2016). Databáza ukazovateľov hospodárskeho a sociálno-ekonomického vývoja za Slovenskú republiku. URL: http://www.statistics.sk/pls/elisw/MetaInfo.explorer?obj=84&cmd=go&s=1003&sso=3&so=16
6. WOJNAR, Tomáš, ed. *Doporučená pravidla pro měření a třídění dříví v ČR 2008* (2007). 2. aktualiz. vyd. Praha. Lesnická práce, 2007. ISBN 978-80-87154-01-4.

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# BUSINESS MODEL FOR THE PROCESS EVALUATION

Marcineková, K.; Sujová, A.

## ABSTRACT

Aim of the paper is evaluation of the production processes in the wood-processing industry in the Slovak republic. Firstly, the key processes and business models for the furniture production process were described. Secondly, the paper deals with the methods of the measuring, modelling and optimization of the production processes. And finally indicators of the process measurement were presented. Research data for identification of key process and activity in the furniture manufacturing were collected via questionnaire. Based on theoretical knowledge and the research results the business model for improvement of key sub-process in furniture manufacturing was created.
**Key words**: Process Measurement, Furniture Manufacturing, Business Model

## 1. INTRODUCTION

Business models can be seen as representation of an enterprise and its strategy and management of processes. It could be conceptual, textual and graphical model of core business processes and activities. It is necessary to describe processes of furniture manufacturing as well as methods and indicators for the process optimization before the model is created.

### 1.1. Furniture manufacturing processes and Business Models

Manufacturing process could be divide into two groups: Processing Operations and Assembly Operations. There are three categories of the Processing Operations (Shaping processes, Property enhancing processes and Surface processing operations) and two categories of the Assembly Operations (Permanent joining processes and Mechanical fastening) [2]. Furthermore furniture manufacturing processes could be divided into the four groups Material Section, Linking (assembly processes), Formation (Shaping processes and Property enhancing processes) and Structural treatment (It is also shaping process at which obtained shape is used for linking components to each other). Sub-processes of the manufacturing processes are cutting, drilling, sawing, milling, turning, bending, pressing, thermo-mechanical processing, hydro-mechanical processing, grinding, surface finishing, adhesive bonding and jointing.

Kyung J. S., Cho W.G. and Yang S. J. [4] created business model for support program for small businesses by leveraging business process modelling techniques. Their study results into the creating the major two business models for SME support by analysing of input indicators, process indicators, performance indicators and action elements, the core success factors. Walsh P. [8] decomposed Key Performance Indicators (KPIs) into two groups such as Key Performance Outcomes (KPOs) and Key Performance Drivers (KPDs) with an emphasis placed on the KPDs.

### 1.2. Methods and indicators for the process measurement

Methods for the measurement of process performance or effectiveness are dived into three groups [7]:

- Methods relating to the overall business process
- Methods relating to the attribute of the process or activity
- Methods relating to the entire processing system

The most common methods and tools for the process modelling and optimization are Flow Charts, Petri Nets, Data Flow Diagrams, Role Activity Diagrams, Business Process Modelling Notation and Business Use Cases [5, 6].

In reference to Hossain M. M. and Prybutok V. R. [3] business performance management (BPM) model include 8 conceptual elements: Innovations, Competitive Advantage, Product and Service Outcomes, Customer-Focused Outcomes, Financial and Market Outcomes, Workforce-Focused Outcomes, Process Effectiveness Outcomes and Leadership Outcomes. Each of these constructs could be measured by set of indicators. Process effectiveness could be measured by different types of indicators as well as savings in costs, increasing productivity, cycle time, flexibility in manufacturing, lead times, setup times, results of Six Sigma and so on [7, 1].

## 2. MATERIAL AND METHODS

### 2.1. Sample determination

Primary research was focused on the furniture manufacturing companies. A database of enterprises was created consisting of 217 email addresses. The return ratio was 42.86%. Furthermore five of the enterprises were excluded because of their business focus (doors, windows and staircase manufacturing - 2 enterprises; upholstery - 1 enterprise; production of furniture not involving wood based materials - 2 enterprises). The questionnaire was divided into the two parts: the economic and the technological questions.

The Statistical office of the Slovak republic has published information about furniture manufacturing enterprises operating in the Slovak market. 1,404 furniture manufacturing companies employ 12,606 employees (9 in average). Therefore it could be stated that the largest group consists of micro-enterprises (0-9 employees). 70.45% of enterprises in the sample have less than 10 employees. The smallest group in the sample (3.41%) represents companies employing 50-249 employees. It is almost equivalent to the real market situation.

### 2.2. Methodology

Data were collected via questionnaire survey. Questionnaire was available in online form. In addition database was completed by data from structured interviews.

Based on questionnaire survey results the critical process and key sub-process were identified.

Furthermore based on theoretical knowledge study the input and output parameters were be identified and finally the business process model was designed as a data flow diagram.

## 3. RESEARCH RESULTS

### 3.1. Primary research results

The frequency of the answer to question “Which of the production processes are critical for your company?” is represented in figure 1. The most frequent answer was formation and it is affected by cutting conditions (feed rate, cutting speed, depth of cut) and so on. Therefore it is necessary to measure impact of the cutting condition to productivity, cost and effectiveness of this process.

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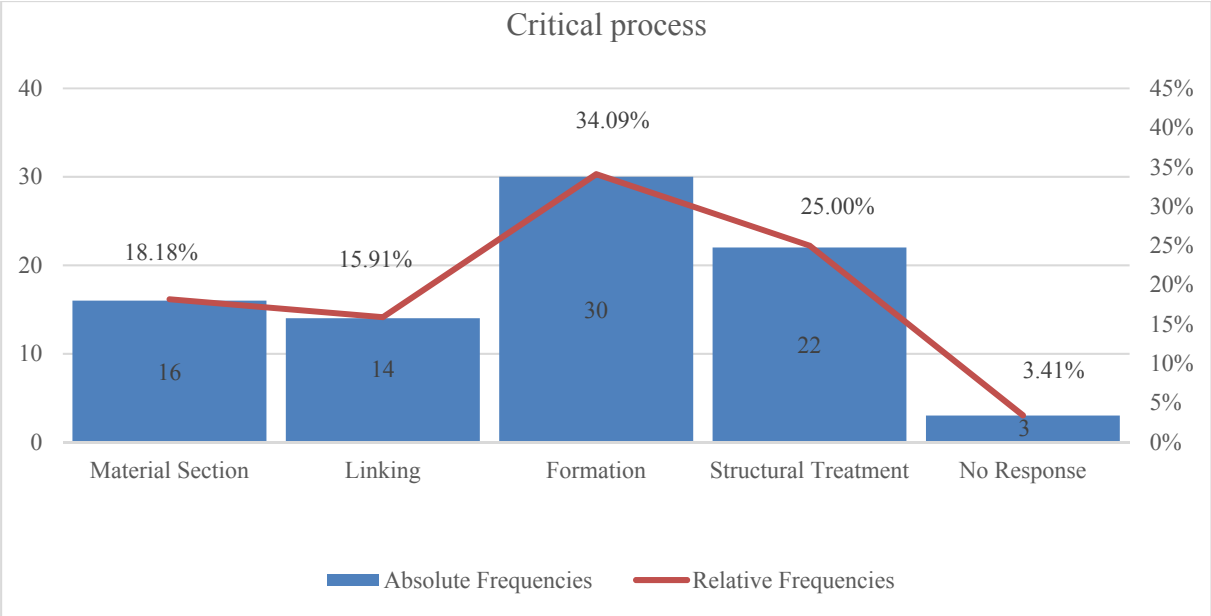
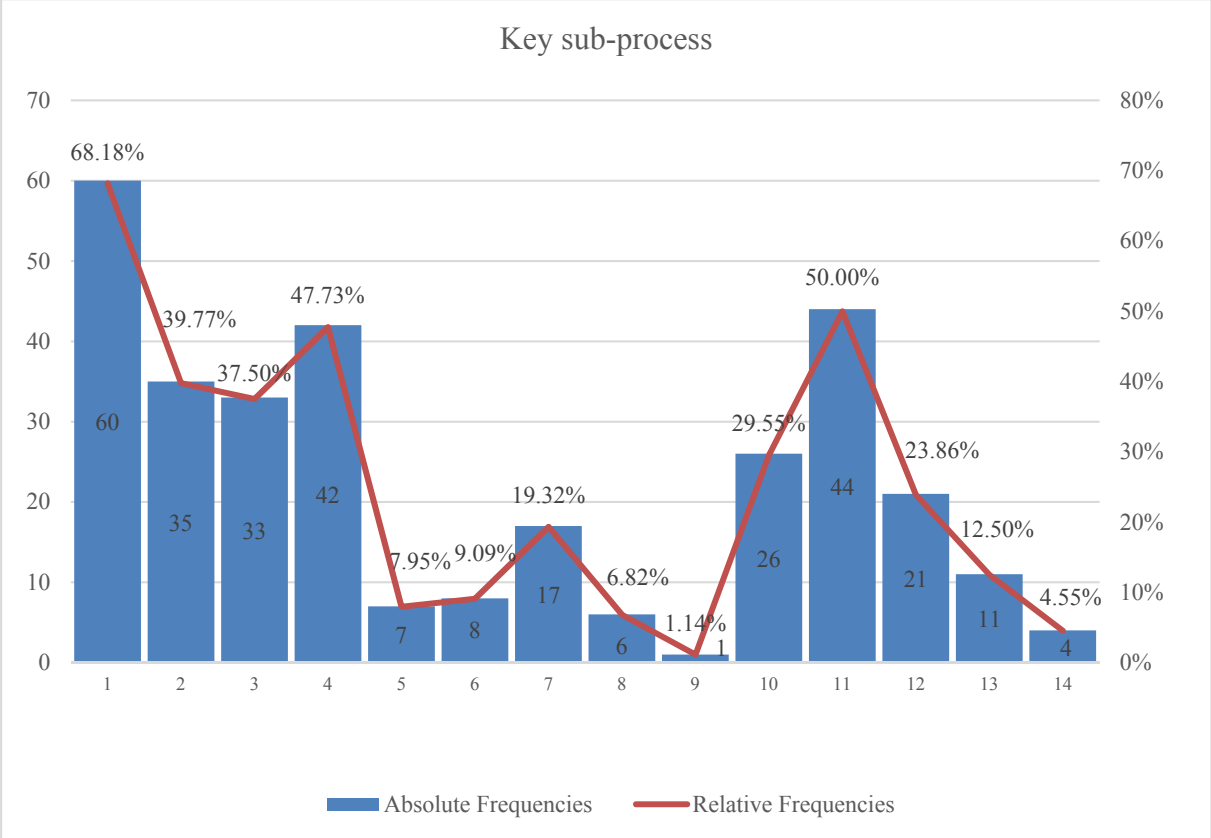



*Figure 1. Critical furniture manufacturing process*

*Source: Own processing.*




| | | | | |
|---|---|---|---|---|
| *Legend:* | *1 – cutting* | *5 – turning* | *9 – hydro-mechanical processing* | *13 – jointing* |
| | *2 – drilling* | *6 – bending* | *10 – grinding* | *14 - other* |
| | *3 – sawing* | *7 – pressing* | *11 – surface finishing* | |
| | *4 – milling* | *8 – thermo-mechanical processing* | *12 – adhesive bonding* | |

*Figure 2. Key furniture manufacturing sub-process*

*Source: Own processing*

The frequency of the answer to question "Which of production sub-processes are key for your company?" is represented in figure 2. The most frequent answers were cutting, surface finishing and milling.

### 3.2. Furniture Manufacturing Business Model

It is necessary to identify input and output parameters of the key sub-process for its optimization. This parameters are vary depending on physical character of furniture manufacturing process. Output parameters could be divided into three categories in term of overall effectiveness:

- maximization of the process quality,
- minimization of the process costs and
- maximization of the process productivity or minimization of the process time.

Based on the questionnaire research results it could be stated that cutting is the key sub-process of the furniture manufacturing. Therefore following input parameters have to be considered:

- Dimensions of raw material ($D_{In}$)
- Required dimensions of the output material ($D_{Out}$)
- Thickness of the saw blade ($T_b$)
- Cutting speed ($v_c$)
- Feed rate ($v_f$)
- Depth of cut ($a_p$)
- Electric power consumption (EPC)
- Material removal rate (Q)

These input parameters affect following output parameters:

- Yield of the raw material
- Surface roughness
- Kerf width
- Sub-process costs
- Sub-process productivity
- Sub-process time cycle

Model for the cutting process improvement was designed and so data flow diagram in figure 3 shows portioning of proposed process. Overall sub-process effectiveness is affected by the target values of output parameters. It is focused on saving in costs, increasing quality and productivity and reducing of time cycle. Costs could be calculated as summary of personal, energy and material costs. Time cycle represent period required to complete sub-process and it affect its productivity (how many outputs is produced per 1 minute). Quality is defined as surface roughness and it is measured by arithmetic average roughness of absolute values ($R_a$).

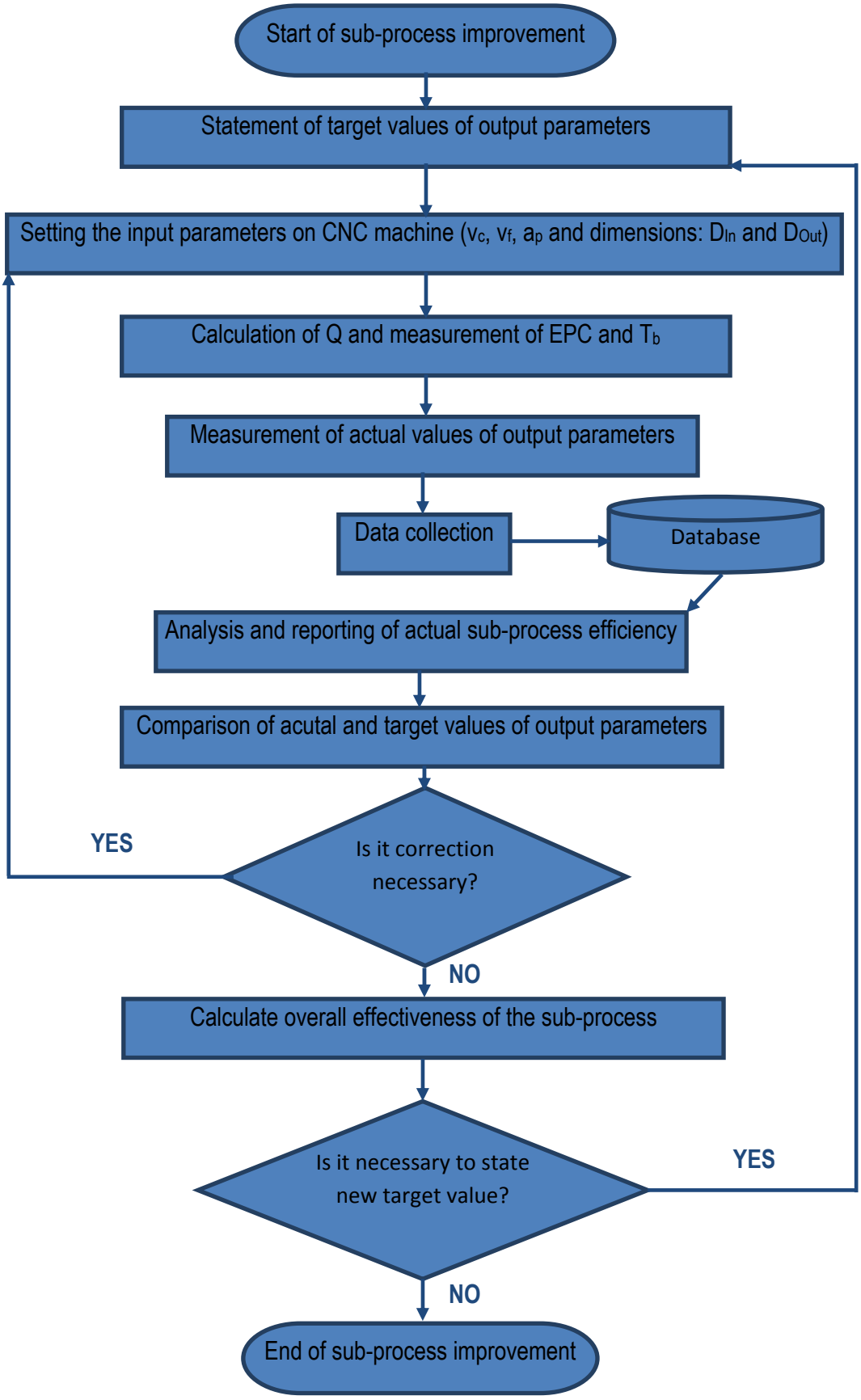



*Figure 3. Business model for process evaluation and improvement*

*Source: Own processing*

## 4. CONCLUSION

Primary research results indicate that most critical process in the furniture manufacturing is formation and key sub-process is cutting.

Table 1 represent most important sub-processes in furniture manufacturing from furniture producers' point of view.

*Table 3. A sample of the table*

| Sub-process | Absolute Frequency | Relative Frequency |
|---|---|---|
| Cutting | 60.00 | 68.18 |
| Surface finishing | 44.00 | 50.00 |
| Milling | 42.00 | 47.73 |

*Source: Own processing*

Overall effectiveness of cutting process depends on setting the input parameters on CNC machine and dimensions of raw and output material. This effectiveness is represented by calculation of the process costs (EUR), life cycle (min), productivity (pcs per min) and quality ($R_a$).

It is necessary to use big data analysis for the automatic functioning of Business Process Model. Currently many authors used Artificial Neural Nets with backpropagation as a data mining method.

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## REFERENCES

1. Gejdoš, P. (2010): *Increasing Performance of the Organization through Effective Implementation of Process Management.* In: International Conference on Business and Competitiveness of Companies: Aktuálne pohľady na konkurencieschopnosť a podnikanie, Bratislava: pp. 50-55.
2. Groover, M. P. (2010): *Fundamentals of modern manufacturing: Materials, processes, and systems*. 4th ed. New York: John Wiley & Sons.
3. Hossain, M. M.; Prybutok, V. R. (2009): *Theoretical Development of a Business Performance Management (BPM).* In: Proceedings of the Southwest Decision Sciences Institute, Oklahoma City: pp. 431-440.
4. Kyung J. S.; Cho W. G.; Yang S. J. (2013): *The study of business model development of support service program for small and medium enterprise using process modeling.* In: The e-Business Studies 14 (4): pp. 99-118.
5. Potkány, M.; Giertl, G. (2014): *Comparison of selected performance indicators of woodworking industry in the Czech Republic and Slovakia.* In: 7th International Scientific Conference on Position and Role of the Forest Based Sector in the Green Economy, Zvolen: pp. 131-138.
6. Potkány, M.; Krajčírová, L. (2015): *Quantification of the Volume of Products to Achieve the Break-Even Point and Desired Profit in Non-Homogeneous Production.* In: Procedia Economics and Finance, Ephesus 26, pp. 194-201.
7. Simanová, Ľ. (2015): *Specific Proposal of the Application and Implementation Six Sigma in Selected Processes of the Furniture Manufacturing*. In: Procedia Economics and Finance, International Scientific Conference: Business Economics and Management (BEM2015), Zvolen 34: pp. 268-275.
8. Walsh, P. (1996): *Finding key performance drivers: Some new tools*. In: Total Quality Management 7 (5): pp. 509-520.

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# APPLICATION OF MODERN METHODS OF QUALITY IMPROVEMENT IN SLOVAK FURNITURE INDUSTRY.

Simanová, Ľ.; Gejdoš, P.

## ABSTRACT

The article deals with the application of DMAIC improvement model in Slovak furniture industry. Six Sigma methodology and methods used in the different stages of the DMAIC improvement model are excellent tools for reducing undesirable variability in business processes that result in disagreement, rise of unproductive costs, losses and customer dissatisfaction. Evaluation of processes through DPMO, efficiency, level of sigma and capability of specific processes in furniture production provides relevant information for changes in processes, increasing their performance and secures the process of continuous quality improvement.
**Key words**: quality, changes in processes, quality improvement, Six Sigma, DMAIC

## 1. INTRODUCTION

The reason for the resulting changes in the quality and quality management is the overall development of the economic and political situation in developed countries. This trend is particularly marked change in producers' market to market buyers, quality assurance for the entire lifecycle of the product and the utilization factor of time to influence the market. At present, the companies aim to be able to enforce the domestic and foreign markets, while in the past focused primarily on increasing production volume and cost reduction. The success of any organization in the market depends on the quality of its manufactured products and services that are compared to the competition as well as the performance of the processes that take place within companies. An integral part of quality management in companies, not excluding furniture production are the using of modern techniques for securing and improving quality within process management, change management and performance improvement.

## 2. MATERIAL AND METHODS

In accordance with the recommendation of the authors Mateides et al. (2006), Töpfer (2008), Schroeder, 2006, Grasseová et al. (2008), Marcineková – Sujová (2015), (Pande et al., 2002), Čierna – Sujová (2016) and others amongst the most well-known and used methods and tools that are used in the process approach are Plan-Do-Check-Act (PDCA – Deming cycle), DMAIC, , Balance Scorecard, models EFQM (European Foundation for Quality Management), Systems of quality control, CAF (Common Assessment Framework), SIX SIGMA, norms ISO order 9000 and others.

Six Sigma has been applied not only in the industrial enterprises but also in the area of the services, health, and public administration, both in the private and public field, where there is a strong orientation on the customer, quality, time, and performance (Schroeder, 2006)

According to Töpfer et al. (2008), Six Sigma has two dimensions which are:

Six Sigma, as project management, with sound statistical foundations and effective quality management tools, which contain: systematic methodology DMAIC (Define-Measure-Analyse-Improve-Control) and DMADV (Define-Measure-Analyse-Design-Verify), project and process management, and a set of tools process analysis for resolving problems, statistics, philosophy and quality culture at a zero defect level.

Pande et al., 2002 Six Sigma, as a statistical concept for measurement, is based on the principle that there are no more than 3.4 errors in the process per million chances, whilst taking into account the complexity of products and processes.

The highly useful role of Six Sigma for small and medium enterprises was justified by Kaushik et al. (2012).

The term "Six Sigma" refers to the ability of highly-capable processes to produce output within specification. In particular, processes that operate with six sigma quality produce at defect levels below 3.4 defects per (one) million opportunities. According to Ev – Scaria (2010), Al – Agha et al., (2015), Kaushik et al. (2012) a Six Sigma is a statistical measure of process capability, which is equivalent to 99, 99966 % of good parts.

The DMAIC procedure will be describe in this section according to Pande et al., (2002), Mateides et al. (2006), Töpfer (2008) and amongst. This procedure for the implementation of improvement projects that requires management commitment and team work also involves the use of statistical methods, quality improvement techniques and the scientific method.

In the Define step, a team defines the problem objectives and goals, identifies the customers of the process and customers' requirements. In this step, the most used methods as a project charter, work plan, a measurement of the customer requirements and process map documentation.

In the Measure step includes the process performance measure selection, measurement system evaluation and analysis and determination of the process performance level and capability. In this step what to measure must be decided by the team.

The step of Analysis includes the analysis and determination of potential root causes of variation through the use of statistical tools and the basic quality tools such as Pareto charts, Ishikawa Diagrams, etc. The important input of this step is data generated by the measuring the important variables.

The goal of the Improve step is to find and implement solutions that will eliminate the causes of problems, reduce variation in a process or prevent a problem from recurring. The identification of potential solutions is often generated by brainstorming.

The Control step has the objective to continue measuring the performance of the process periodically and keeping it under control. The process management control and action plans are made by implementing control charts, control plans and mistake-proof devices. The first three steps are observational studies, that is, there is not intervention in the process. While in the last two steps are designed experiments.

**Capability indexes**

**Capability index $C_p$** as an indicator of potential process capability, characterizing process variation was calculated using the formula (1):

$$C_p = \frac{USL - LSL}{6\,\sigma} \qquad (1)$$

USL – upper tolerance limit
LSL – lower tolerance limit
σ - Standard deviation
6σ - 3σ on the left and 3σ on the right on the target value T

We compared the result of calculating $C_p$ and evaluated by the following values of $C_p$:

If: $C_p < 1$ - production process is not capable,
$C_p = 1$ - production process is close to capable,
$C_p > 1,33$ to $1,67$ - manufacturing process is capable to fulfil the tasks for which it was Designated

Value of **critical capability index $C_{pk}$** represents the actual, real process capability. To calculate critical index capability we used:

$$C_{pkUSL} = \frac{USL - \overline{\overline{X}}}{3\sigma} \qquad C_{pkLSL} = \frac{\overline{\overline{X}} - LSL}{3\sigma} \qquad (2)$$

USL – upper tolerance limit
LSL – lower tolerance limit
$\overline{\overline{X}}$ - Average mean value in subgroups, overall selective mean
σ - Standard deviation

Capability index always considers the lower value:

$$C_{pk} = \min\left(C_{pkUSL}, C_{pkLSL}\right) \qquad (3)$$

## 3. RESULTS - Analysis of the Current Situation in Slovak Enterprises of furniture

The implementation of process improvement in selected furniture company was conducted by following the steps DMAIC model.

**Step 1 - Define** - based on Pareto analysis was determined the significance of errors occurring in the process of production of furniture parts (Fig.1).

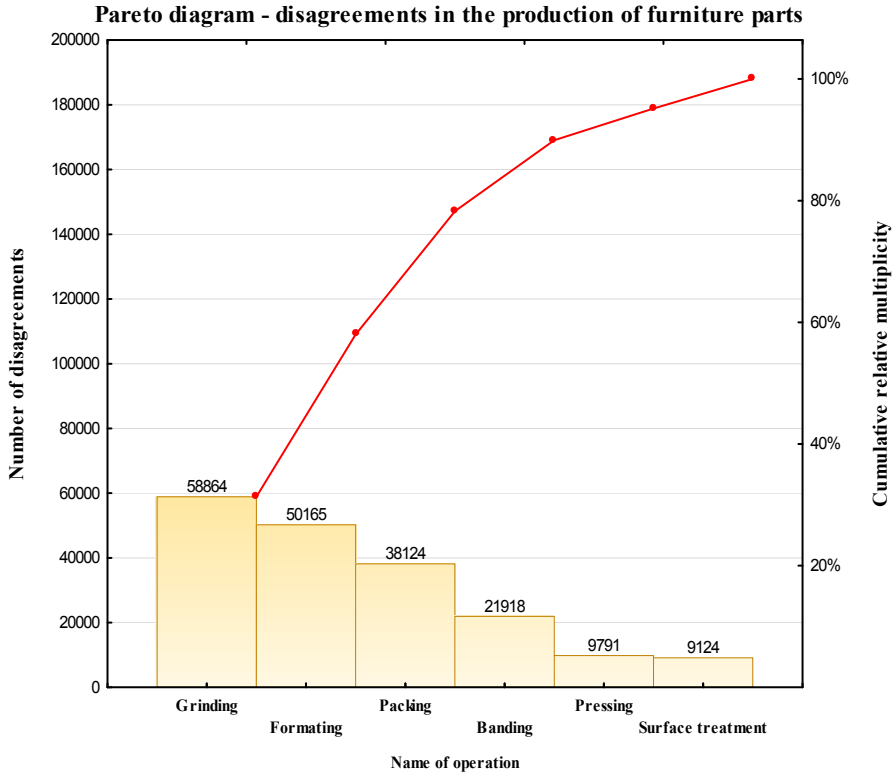


**Fig. 1.**
*Figure 1. Pareto diagram – disagreements in the production of furniture parts*
*Source: internal documents of firma and own processing*

Based on Pareto analysis they were analysed by various disagreements in the manufacturing process, where the most serious disagreement was classified in the process of grinding.

**Step 2 - Measurement** - in this phase were carried out 12 measurements, where it was determined the sample size 8 pieces. Based on hourly production was determined time interval 55 minutes. Check sheet of thicknesses parts presents the results of measurements in the process of grinding (Tab. 1). Histogram was designed to determine whether the process is under statistical control (Fig. 2).

*Table 1. The measured values of the selected feature of quality - the thickness of part (mm)*

| Measurement | Part 1 | Part 2 | Part 3 | Part 4 | Part 5 | Part 6 | Part 7 | Part 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 52,67 | 53,61 | 51,91 | 51,55 | 53,38 | 51,78 | 53,38 | 53,38 |
| 2 | 52,05 | 51,55 | 52,42 | 54,13 | 53,38 | 51,60 | 53,38 | 51,60 |
| 3 | 50,37 | 53,38 | 52,23 | 51,55 | 51,60 | 53,60 | 53,92 | 53,38 |
| 4 | 52,05 | 53,38 | 52,23 | 48,97 | 53,38 | 55,16 | 54,13 | 53,38 |
| 5 | 53,91 | 54,13 | 52,05 | 51,55 | 52,28 | 51,60 | 52,84 | 53,38 |
| 6 | 51,86 | 51,55 | 51,55 | 53,35 | 53,38 | 53,23 | 55,16 | 54,88 |
| 7 | 52,23 | 48,97 | 52,05 | 54,29 | 51,60 | 53,38 | 52,88 | 55,34 |
| 8 | 52,79 | 48,97 | 53,90 | 51,86 | 53,38 | 54,27 | 55,16 | 53,38 |
| 9 | 53,38 | 54,05 | 48,44 | 52,05 | 53,22 | 55,16 | 54,81 | 51,60 |
| 10 | 53,38 | 51,29 | 52,05 | 52,05 | 53,38 | 51,55 | 53,38 | 54,81 |
| 11 | 51,55 | 53,61 | 52,05 | 51,86 | 54,09 | 53,92 | 51,60 | 53,38 |
| 12 | 53,10 | 51,55 | 53,91 | 52,05 | 53,38 | 53,38 | 53,38 | 53,38 |

*Source: own processing*

Program STATISTICA CZ - Industrial statistics was used in this phase, which produces processed results of measured values that offer early information about critical process.

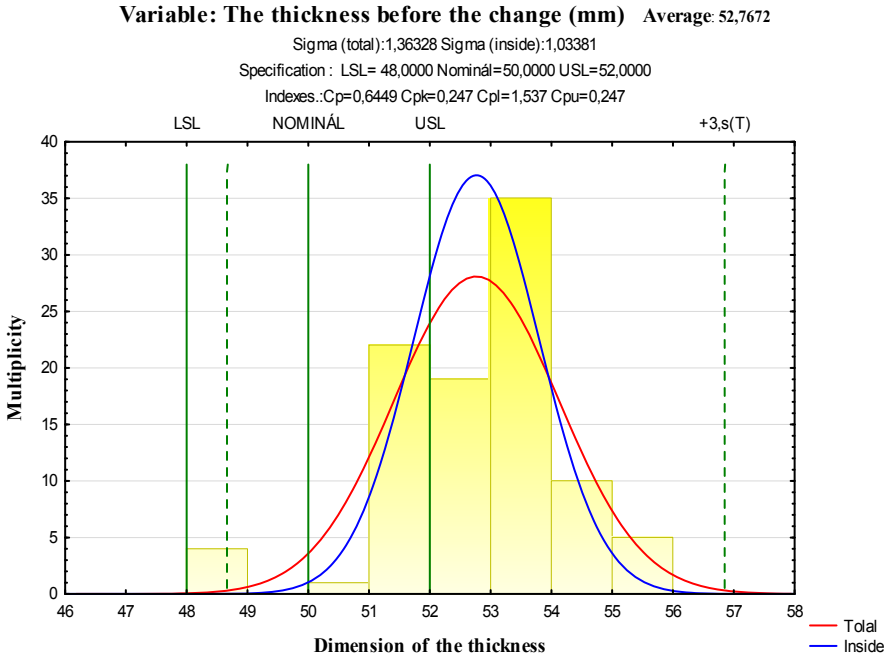


*Figure 2. Histogram of thicknesses furniture parts*
*Source: own processing*

Program STATISTICA CZ - Industrial statistics was used also in this phase, which produces processed results of measured values. The program has also provided graphic views of measured values in the form of diagrams Sigma, range, and capability, individual values that provide a detailed display of the qualitative character values within the tolerance limits and off.

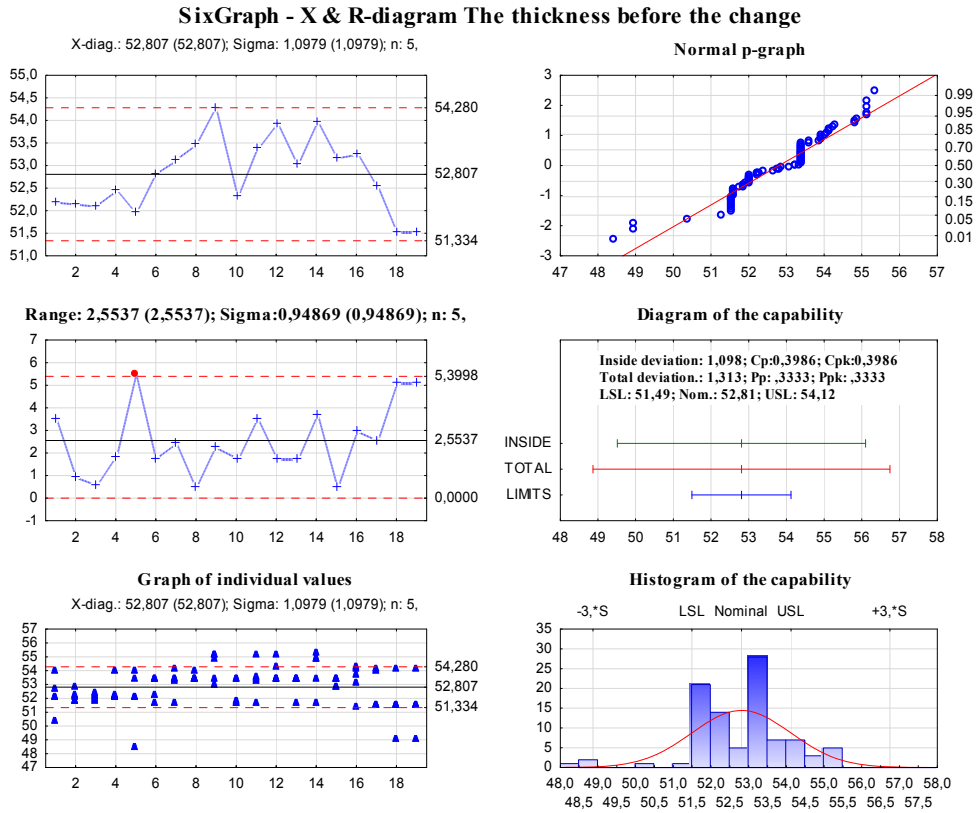


*Figure 3. Six Graphs of thicknesses furniture parts before the change*
*Source: own processing*

**Step 3 - Analysis** - in this phase was created through brainstorming Ishikawa diagram cause and effect in order to identify all potential causes of discrepancies in the manufacturing process. (Fig. 4).

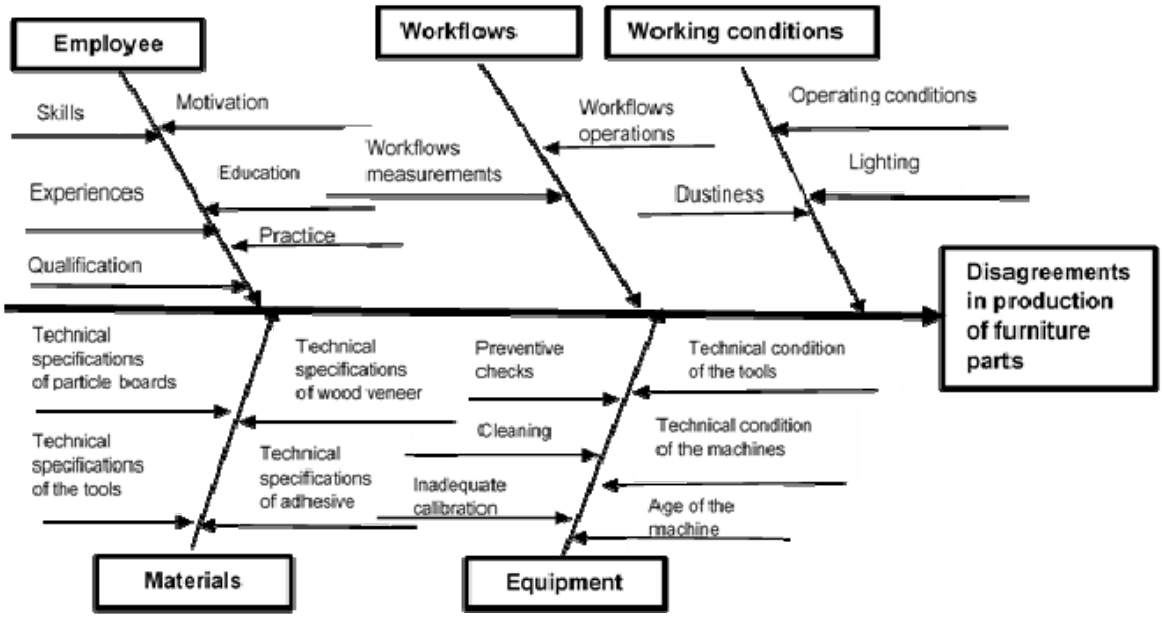


*Fig. 4. Ishikawa diagram – disagreements in the production of furniture parts*
*Source: own processing*

**Steps 4 – Improve -** in this phase through the Ishikawa diagram and based on the identified causes were implemented corrective measures such as a regular exchange of the grinding rollers,

precise adjustment of the machine, precise calibration of the grinding rollers, revision of workflows of the grinding furniture parts and calibration of the measuring instruments, increased the quality control of veneer, check of the pressure in the suction cup.

**Step 5 – Control** - repeated measurements of the reference character of quality and the subsequent graphical methods were carried out for management after implementing corrective measures (Tab. 2, Fig. 5).

*Table 2. The measured values of the selected feature of quality - the thickness of part (mm)*

| Measurement | Part 1 | Part 2 | Part 3 | Part 4 | Part 5 | Part 6 | Part 7 | Part 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 49,03 | 50,50 | 51,86 | 48,44 | 49,78 | 49,52 | 49,24 | 48,70 |
| 2 | 50,20 | 49,52 | 51,86 | 50,36 | 51,80 | 49,52 | 49,24 | 50,32 |
| 3 | 48,65 | 50,36 | 47,58 | 50,36 | 50,68 | 49,52 | 49,24 | 50,32 |
| 4 | 48,70 | 50,27 | 51,91 | 50,36 | 50,68 | 49,52 | 50,21 | 51,55 |
| 5 | 50,50 | 49,36 | 51,91 | 50,36 | 50,68 | 49,52 | 50,32 | 48,97 |
| 6 | 49,77 | 48,70 | 50,29 | 50,36 | 50,68 | 49,52 | 50,34 | *51,55* |
| 7 | 49,77 | 51,00 | 50,29 | 48,80 | 50,68 | 50,50 | 51,55 | 48,97 |
| 8 | 49,87 | 51,70 | 47,36 | 48,80 | 50,26 | 50,50 | 52,36 | 49,20 |
| 9 | 52,90 | 51,86 | 51,91 | 48,80 | 51,78 | 51,60 | 51,55 | 49,78 |
| 10 | 49,24 | 49,20 | 51,91 | 48,80 | 51,60 | 50,45 | 48,97 | 49,80 |
| 11 | 49,56 | 49,53 | 48,60 | 51,60 | 49,36 | 50,45 | 50,36 | 49,78 |
| 12 | 49,24 | 49,87 | 49,63 | 51,80 | 49,36 | 50,45 | 50,36 | 49,77 |

*Source: own processing*

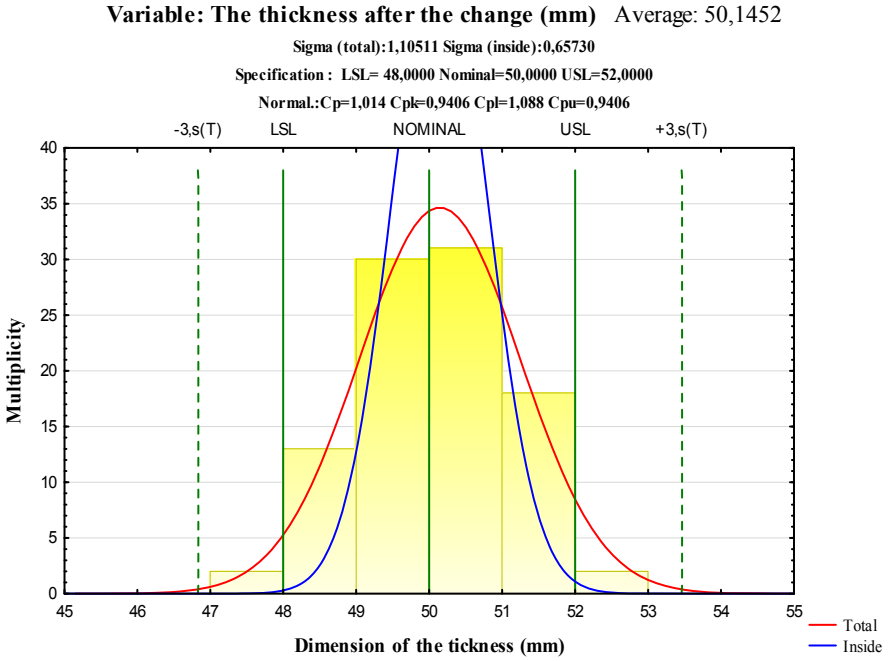


*Figure 5. Histogram of thicknesses furniture parts*
*Source: own processing*

A graphical presentation of the results of measured values from (the thickness of the furniture parts in the process of grinding) after the change - in the form of diagrams Sigma, range, and capability, individual values. Six Graphs present the process improvement after implemented changes (Fig. 6).

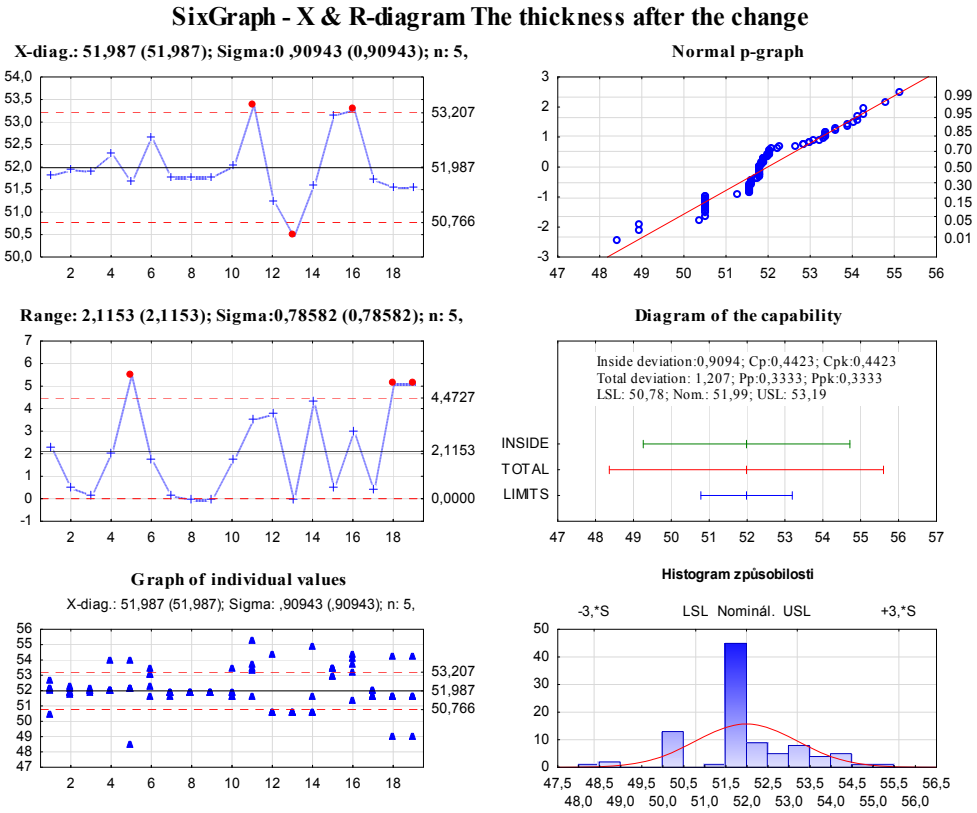


*Figure 6. Six Graphs of thicknesses furniture parts after the change*
*Source: own processing*

## 4. CONCLUSION

Observation of processes capability is a dynamic tool that allows making operational changes in the production process. Fluctuation of the quality mark values is a natural part of the process and it is impossible to achieve its absolute uniformity. At the same time, it is necessary to monitor this value because if there are systematic causes in the production process they will result in the process with the variability values so diversified that its performance is very low, with defects in output, increasing overall costs and unproductive losses, as it was in the process observed in this case.

Using modern tools of quality management as DMAIC model, histogram, and control chart can effectively monitor process capability, measure their performance and thus contribute to continuous improvement of quality, greater customer satisfaction, which have a positive impact on the economic results of the company and are the means to do as achieve excellence.

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## REFERENCES

1. Al-Agha, O.; Alzubaidi, A.J.; Al-Agha, M.I. Implementing Six Sigma Methodology in Industrial Control Systems. Int. J. Comput. Appl. Technol. 2015, 5, 2229–6093.
2. Čierna, H.; Sujová, E., 2016. Application of modern QMS - KAIZEN management system.
3. In MM science journal. - ISSN 1803-1269. - No. November (2016), p. 1456-1464.
4. Ev, G.; Scaria, J. Reducing rejection and rework by application of Six Sigma methodology in manufacturing process. Int. J. Six Sigma Compet. Advant. 2010, 1, 77–99.
5. Grasseová, M., Dubec, R., Horák, R., 2008. Procesní řízení ve veřejném sektoru. 1. publ. Brno: Computer Press, 2008. 266 s. ISBN 978-80-251-1987-7.
6. Kaushik, P.; Khanduja, D.; Mittal, K. A case study: Application of Six Sigma methodology in a small and medium-sized manufacturing enterprise. TQM J. 2012, 1, 4–16.
7. Marcineková, K., Sujová. A. (2015). The influence of the process control level on the enterprises' roe. Conference: 9th International Scientific Conference on Business Economics and Management (BEM), Book Series: Procedia Economics and Finance Číslo: 34. 290-295.
8. Mateides, A. et al.: Manažérstvo kvality. História, koncepty, metódy, EPOS Martin 2006, ISBN 80-805-7656-4.
9. Pande, P.S., Cavanagh, R.R., Neuman, R.P., 2002. Zavádíme Metodu Six Sigma: aneb jakým způsobem dosahují renomované světové společnosti špičkové výkonnosti. 1. vyd. Brno: TwinsCom, 2002. ISBN 80-238-9289-4.
10. Schroeder, R.A. Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations; Currency: Sydney, Australia, 2006.
11. Töpfer, A. 2008. Six Sigma. Koncepce a příklady pro řízení bez chyb. Praha: Computer Press, 2008. ISBN 978-80-251-1766-8.

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# CONTRIBUTION OF WOOD ENERGY TO REACHING THE SERBIAN NATIONAL RENEWABLE TARGET 2020

Glavonjić, B.; Lazarević, A.; Kalem, M.

## ABSTRACT

The paper shows research results for the woody biomass potentials for energy, their actual utilization, consumption of wood energy and its contribution to achieve the national target for Serbia 2020. Research results show that in 2015 total technical potentials of woody biomass for energy in Serbia amount to 7.97 million $m^3$ meeting the criteria of their sustainable use out of which 4.7 million $m^3$ or 59% is the estimated stemwood potential. Consumption side of woody biomass for energy shows its consumption in the amount of 7.5 million $m^3$, which gives positive difference of 469 thousand $m^3$ annually compared to possible potentials. Small difference between technically available potentials and their present utilization indicates the fact that the level of using the existing woody biomass potentials in Serbia is on the upper limit of its sustainable use. Therefore, further investments in the area of wood energy production should be planned carefully. Regarding the contribution of wood energy to final energy consumption (385,315 TJ) in Serbia in 2015, it was 61,042 TJ or 15.8 percent.
**Key words:** energy, wood, potentials, consumption, target.

## 1. INTRODUCTION

In order to contribute to the mitigation of climate changes globally, all European countries have set their national targets regarding the share of energy from renewable sources in the total final energy consumption by 2020. The targets are harmonized with available potentials of each country as well as their potentials to stimulate production and consumption of the so called green energy. In that sense, it is significant for each country to observe the situation regarding the level of using available potentials as well as the present share of energy from renewable sources in the total final consumption of energy so that adequate measures and activities for achieving the set targets could be taken in time. For such needs it was necessary to develop adequate methodology which would measure the intensity of using the existing potentials as well as to reach the level of the national targets 2020. In accordance with the stated needs, several large projects have been implemented in Europe under the auspices of the European Union and UNECE within which adequate methodologies for the stated needs were developed and implemented. This paper shows the results of the application of adequate methodologies for estimating the utilization level of the existing potentials as well as the share of wood energy in the total final consumption of energy using Serbia as example.

## 2. OBJECTIVES AND SCOPE

Potentials of woody biomass in Serbia are the main subject of the research in this paper. Purpose of the paper is to determine the present level of utilization of the existing potentials, possibilities for increasing the level of their utilization in the upcoming years as well as determination of wood energy contribution to the achievement of the national target regarding the share of energy from renewable sources in the total final consumption of energy in Serbia. The year of 2015, being the last year for which the needed data were available, was taken as the reference year for conducting the stated research and analyses.

## 3. METHODOLOGY

Analysis of total biomass potentials includes the analysis of potentials in forests (including the conversion of coppices), potentials outside forests and potentials in short rotation forestry for fast-growing wood species which can be grown on forest land or unused agricultural land. Taking into consideration comprehensive approach, as well as the fact that these are complex analyses, the methodology, principles, values of some parameters and data from recently finished projects within various national and international organizations have been used for these purposes. The methodology for analysis of the potentials in forests is more-or-less developed and known. However, the methodology for conducting the analysis of the potentials of biomass outside forests and of the potentials in short rotation forestry is still in the developing phase and, hence, it is still challenging for researchers dealing with this topic. In this paper is used the methodology for estimation of the biomass potentials whose high level of confidence has been proven by its successful implementation in numerous projects.

Analysis of the biomass potentials most often comprehends the following four phases: theoretical potential, technical potential, economic potential and implementation potential[2].

Forest biomass that could be used for bioenergy exploitation includes different types of raw materials derived from forests and from industrial processing of wood:

- Primary forest products: stemwood from annual thinnings and final fellings, which is not suitable for sawnwood production of other woody industrial products;
- Primary forestry residues: logging residues, stumps;
- Secondary forestry residues: wood processing industry by-products and residues, like sawdust & cutter chips, bark, slabs, lump wood residues, and black liquor;
- Trees outside of forests such as trees in settlement areas, along roads and on other infrastructural areas.

There is a difference between the total potential of wood available as energy source and additional potential of wood for energy. The difference is the volume of woody biomass that is already used as a fuel. This volume of wood cannot be considered as a resource for new bioenergy facilities being established.

The total potential of forest woody biomass is:

$$TP\_FWB_{x,y} = TP\_SW_{x,y} + TP\_PFR_{x,y} + TP\_SFR_{x,y} + TP\_BOF_{x,y}$$

$TP\_FWB_{x,y}$= total p-potential of forest woody biomass in country x in year y, ($m^3$/year)
$TP\_SW_{x,y}$= total potential of stemwood for energy in country x in year y, ($m^3$/year)
$TP\_PFR_{x,y}$= total potential of primary forestry residues (logging residues that is related to total timber harvest) in country x in year y, ($m^3$/year)
$TP\_SFR_{x,y}$= total potential of secondary forestry residues in country x in year y, ($m^3$/year)
$TP\_BOF_{x,y}$= total potential of biomass outside of forests.

Equations, calculation principles, values of certain parameters in equations and other elements used for calculating the potentials of woody biomass for Serbia are shown in details in the following literature [2] and [11].

## 4. RESEARCH RESULTS AND DISCUSION

### 4.1. Woody biomass potentials in Serbia

Using the above described methodology for the calculation of potential of biomass from forests and outside forest as well as numerous sources of the data woody biomass potential was estimated for Serbia.

[2] One may find the definitions of some categories of the potentials according to the BEE Best Practices and Methods Handbook, 2010

Total potential of woody biomass from forests, outside forest, from reconstruction of coppices and from wood energy plantation for energy purposes in Serbia is 7.57 million m$^3$ annually meeting the criteria of their sustainable use (table 1).

*Table 1. Sustainable potential of woody biomass for energy purposes from forests and outside forest in Serbia on annual level*

| Level | TP_SW (Technical potential stemwood for energy inluding bark) | TP_LG (Technical potential logging residue) | TP_SR (Technical potential secondary forestry residue) | Biomass outside forest available for wood supply | Biomass for energy from reconstruction of coppices and devastated forests | Green biomass from wood energy plantations | Total technical potentials |
|---|---|---|---|---|---|---|---|
| | m$^3$/y | m$^3$/y | m$^3$/y | m$^3$/y | m$^3$/y | m$^3$/y | m$^3$/y |
| Serbia | 4,783,593 | 483,176 | 460,184 | 1,441,427 | 186,852 | 217,337 | 7,572,569 |

Sources: 1. National Forest Inventory of Serbia, Ministry of agricultural, forestry and water management, Belgrade, 2010; 2. Forests in the ECE Region, ECE/TIM/SP/37, United Nations, 2015; 3. JWEQ, UNECE, Geneva, 2014; 4.FAO forestry data base, 2015; 5. University of Belgrade-Faculty of Forestry, Timber trade database, Belgrade; 6.WISDOM Serbia, FAO, 2015;

Forests are the most significant source of woody biomass with the participation of 4.78 million m$^3$ or 63.1% of the total potential. The remaining 36.9% is almost equally distributed among secondary forestry residue, logging residue and wood outside forest available for wood supply (Figure 1).

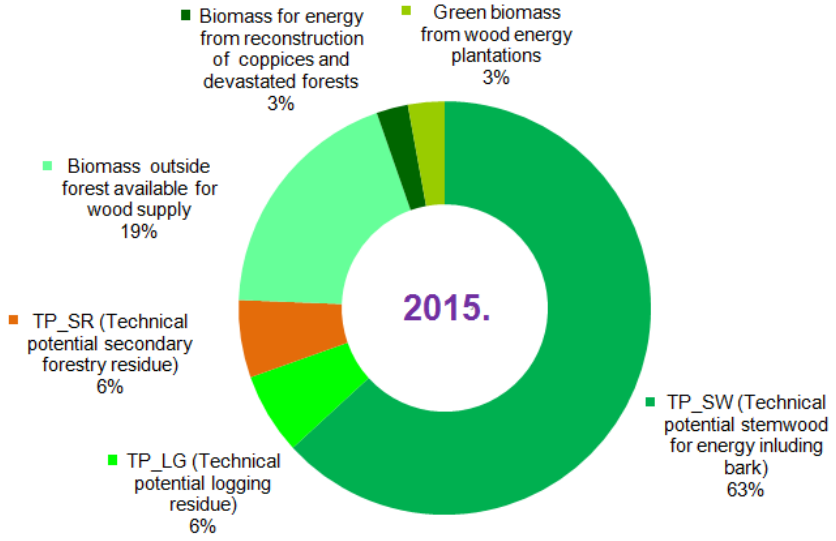


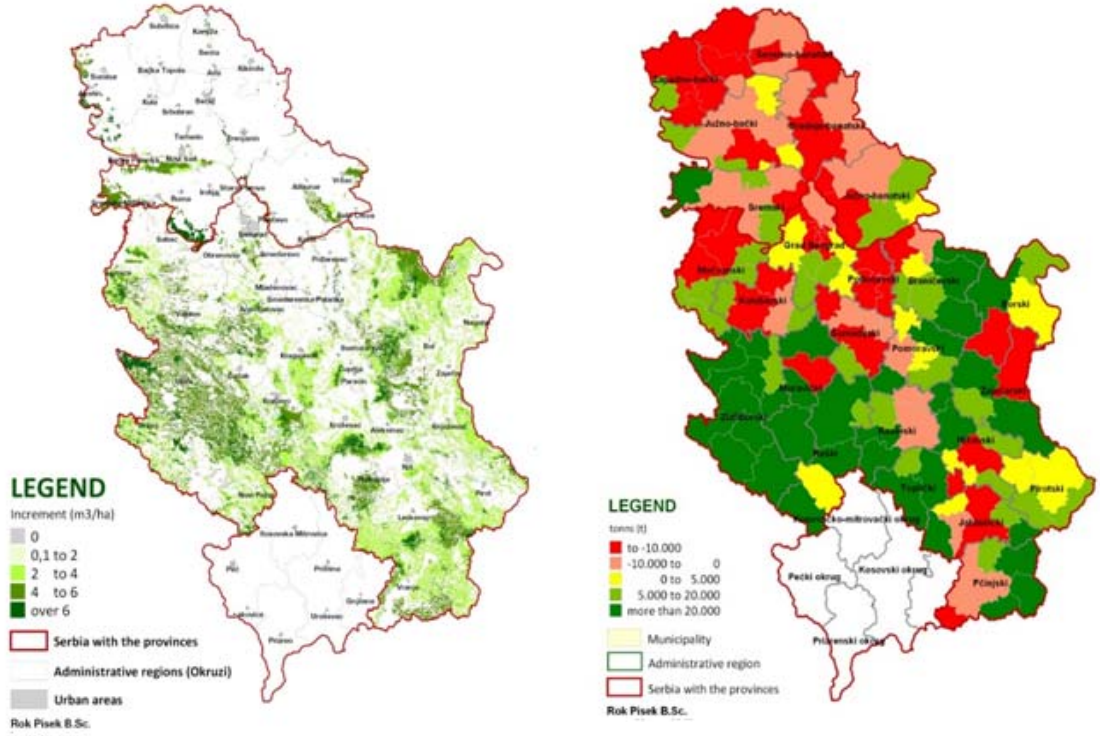

Figure 1. Participation of certain categories of potentials in total technical potentials in Serbia in 2015

More than ½ of the total woody biomass potentials are in the region Šumadija and west Serbia (55%) and 37% is in the region Southern and Eastern Serbia (figure 2).

Participation of Belgrade region is symbolic while the region of Vojvodina is suitable from the aspect of establishing energy plantations taking into consideration geographic characteristics of this region (lowland with moderate climate).

Regions of Belgrade and Vojvodina have relatively low share in the total woody biomass potentials. However, these two regions are very significant from the aspect of woody biomass consumption for energy purposes both in households and in public and commercial facilities. Figure 2 right shows the results of the supply/demand balance for all municipalities in Serbia, on which it can be seen that these

two regions in particular have extremely high consumption of firewood and other wood fuels. This practically means that the supply of these two regions, primarily with firewood, is done from other regions.




*Source : WISDOM Serbia, 2015*

Figure 2. Spatial distribution of annual volume increment in Serbian forests ($m^3$ per ha)(left) and supply/demand balance (tons) for all municipalities in Serbia (right)

Figure 2 shows the firewood balance scenario for current allowable cut. Less than half of municipalities (75) in Serbia have a negative balance in the sense that the actual consumption of wood fuels is higher than the allowable cut of their production in particular municipality. On this scenario the largest deficit is again in the municipalities in Central Serbia and Vojvodina and the largest surplus is in the municipalities in Southwestern and Western Serbia.

Such a situation results from two factors:

- large number of municipalities (especially in Vojvodina and central Serbia) which have modest forest resources and big wood consumption, and
- insufficiently reliable statistical records of wood fuels production which is several times higher than the officially recorded.

In practice, it means that large amounts of wood fuels from municipalities rich with forest resources and where firewood production is developed are placed in the municipalities with modest forest resources and big consumption of wood fuels.

## 4.2. Current woody biomass production and use

Analysis of woody biomass use on level of Serbia is conducted by using the balancing method according to the UNECE methodology based on the so called cascading use of biomass. Cascading

use of biomass implies "the same biogenic resources are used sequentially: first (and possibly repeatedly) for material applications and then for subsequent energy applications" [7].

**Wood resource balances** are based on available production and trade statistics which are in addition supplemented by a sector specific consumption analysis.

Analysis of current production and use of woody biomass in Serbia included analysis of actual consumption of woody biomass compared to total available technical potentials for energy. Objective of this approach was to observe the structure of production and consumption, share of certain exports in total production as well as the share of certain consumer categories in total consumption of woody biomass. Additional objective of this approach was to observe what extent the existing available potentials are already used for energy and what amount of woody biomass remains unused.

For the needs of this approach, adequate balance was made, whose structure and methodology is compliant with the structure and methodology produced by the UNECE (table 2).

Table 2. Balance of potentials and actual use of woody biomass in Serbia in 2013[3]

| **SERBIA 2015** | | 1,000 m³ | % | | % | 1,000 m³ | Material use: | |
|---|---|---|---|---|---|---|---|---|
| Supply from forest&woody biomass outside the forest | | | | | | | | |
| Industrial roundwood | (P+I-X) | 1,445 | 15.3 | | 10.4 | 927 | (C) | Sawmill industry |
| Technical potential stemwood for energy | (P) | **4,685** | 49.7 | | 4.7 | 423 | (C) | Panel industry |
| Bark | (P) | **99** | 1.1 | | 0 | 0 | (C) | Pulp industry |
| Technical potential of logging residue | (P) | **483** | 5.1 | | 7.1 | 628 | (C) | Processed wood fuel industry |
| Technical potential of woody biomass outside the forest | (P) | **1,441** | 15.3 | | 0.6 | 53 | (C) | Other physical utilization |
| Supply by-products | | | | | Energy use: | | | |
| Chips, particles&wood residues from industry | (P+I-X) | 460 | 4.9 | | | | | |
| Pulp production co-products | (P) | 0 | 0 | | | | | |
| Supply recovered wood: | | | | | | | | |
| Recovered wood for material&energy use | (P) | 12 | 0.1 | | | | | |
| Supply processed wood fuel: | | | | | 0.2 | 18 | (C) | Power and heat |
| Processed wood fuel | (P+I-X) | **390** | 4.1 | | 4.4 | 391 | (C) | Industrial internal |
| Supply from energy plantations | | | | | 70.6 | 6,291 | (C) | Households |

[3] Total potentials of woody biomass for energy include calculated technical potentials from certain sources (table 1) as well as the potentials which appear as a result of cascade use of woody biomass, export, import and from other sources (recovered wood for energy, etc.). Thus, differences in this balance can occur for certain biomass categories compared to the values given in table 1. This also refers to the secondary forestry residue.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Woody biomass from energy plantations | | **217** | 2.3 | | 2.0 | 177 | (C) | Undifferentiated energy use |
| Supply from reconstruction of coppices forests | | | | | | | | |
| Woody biomass from reconstruction of coppices forests | | **187** | 2.0 | | | | | |
| ∑ SUPPLY TOTAL FOR ENERGY | | **7,974** | **Difference for energy: +469** | | | **7,505** | ∑ TOTAL USE FOR ENERGY | |
| ∑ SUPPLY TOTAL | | **9,419** | **100** | | **100** | **8,908** | | ∑ TOTAL USE |
| | | | **Difference: +511** | | | | | |

(P)-Production&removals; I-import; X-export; (P+I-X)-apparent consumption; C-consumption, E-estimate

Sources: 1. Energy Balance of the Republic of Serbia for 2015, Statistical Office of the Republic of Serbia, Belgrade; 2. UNECE data base; 3.WISDOM Serbia, FAO, 2015; 4.Wood Logging in Serbia in 2015, Statistical Office of the Republic of Serbia, Belgrade; 5. Timber trade database, University of Belgrade-Faculty of Forestry, Belgrade; 6.Author's calculations based on conversion factors for various biomass forms

Analysis of the data on woody biomass potentials in Serbia shows that total available supply potentials for energy are on the level of 7.97 million $m^3$ annually. Stemwood for energy is the most significant potential of woody biomass with the participation of 4.68 million $m^3$. Biomass outside forest is the second most significant woody biomass potential for energy with the share of 1.44 million $m^3$, followed by logging residue with 0.48 million $m^3$, secondary forestry residue with 0.46 million $m^3$ and processed wood fuel with 0.39 million $m^3$.

Other categories of potentials which participate with 5.5% of the total supply potentials represent, from the aspect of required time for putting into function, potentials which could be available for operative use when the conditions for their use are created.

Consumption side of woody biomass for energy shows its consumption in the amount of 7.5 million $m^3$, which gives positive difference of 469 thousand $m^3$ annually compared to possible supply potentials. Households and wood fuel producers are the most significant categories of woody biomass consumers which participate with 92.2% of the total consumption of biomass for energy.

Small difference between available supply potentials and their present utilization indicates the fact that the level of using the existing woody biomass potentials in Serbia is on the upper limit of its sustainable use. Therefore, further investments in the area of wood energy production should be planned carefully. The reason for this is the fact that a lot of existing factories for wood pellets production operate with low level of utilization degree in particular because of the lack of wood raw material.

Taking into consideration the fact that most households in Serbia use firewood very inefficiently, if they were stimulated with adequate measures to obtain more efficient appliances and educated to use dry and air-dried wood, wood consumption in households could be significantly reduced. This way, additional amounts of woody biomass would be made available for other purposes (wood fuels industry, district heating systems, etc.). In particular, if consumption in households reduces by only 5% with the increase of efficiency of firewood use, it will make the amount of about 320 thousand $m^3$ of firewood available to be used for certain other purposes.

## 5. Contribution of wood energy to reaching the Serbian national renewable target 2020 and to climate change mitigation

According to [1] participation of renewable sources in total final energy consumption in Serbia in 2020 should be 27%. According to the official energy balance (Serbian Statistical Office 2015), total consumption of final energy for energy purposes in Serbia in 2015 was 341,689 TJ with the participation of wood energy with 43,237 TJ or 12.6%.

The amounts of wood fuels, especially firewood calculated with in official energy balance are several times smaller than the amounts of wood actually consumed for heating in Serbia. It also implies that total final energy consumption is higher than the officially registered in the energy balance, and consequently the participation of wood as energy generating product [8].

Results and performed calculations based on data in table 2 show that total amount of consumed energy from wood fuels in households and other consumers in the 2015 was 57,050 TJ or 1.36 million tonnes of oil equivalent (Mtoe). This amount is 32% higher than the value of energy from wood fuels which is contained in the energy balance of the Republic of Serbia for 2015.

According to WISDOM 2015 the main reason for such a large difference between the values in the energy balance and actual value of consumed energy from wood fuels in Serbia results from the lack of data on overall consumption of wood fuels. Namely, official statistics calculates energy value of firewood only from officially registered amounts out of which mostly in state forests. However, the majority of firewood produced in private forests and from outside forests are not recorded, thus they could not be included in Serbian energy balance.

Based on above presented results and calculations it can be concluded that final consumption of energy in Serbia in 2015 was 355,502 TJ with the participation of wood energy in the amount of 57,050 TJ or 16.1 percent (assuming that the values of other fuels are as presented in the official energy balance) (figure 3).

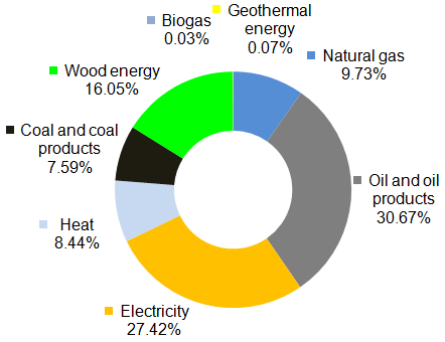



Figure 3. Participation of certain fuel types in total final energy consumption in Serbia in 2015[4]

This means that wood energy has a significant position and role in meeting energy needs in Serbia. On the other hand, taking into consideration the amount of woody biomass used for energy purposes in Serbia it can be concluded that that the consumption of firewood and long-length roundwood has reached its peak.

Concerning the share of energy from other renewable sources, it can be concluded that it is symbolic, amounting only to 358 TJ, 256 TJ of which is geothermal energy and 102 TJ is biogas. This is to confirm that wood energy has dominant share in renewable sources of energy thus giving the biggest contribution to the realization of the national target for 2020 Serbian renewable sources. This contribution could be even bigger if export of wood pellets from Serbia were discouraged and their production diverted to the consumption on the national market.

[4] *Sources: Total energy balance of the Republic of Serbia in 2015; University of Belgrade-Faculty of Forestry, Timber trade data base, 3.* Calculations Glavonjić 2016

According to [8] green energy export from Serbia through the export of wood pellets in the period 2006 – 2016 show that 534,166 tons of wood pellets were exported from Serbia in this period, or 2.51 billion kWh of green energy (figure 4).

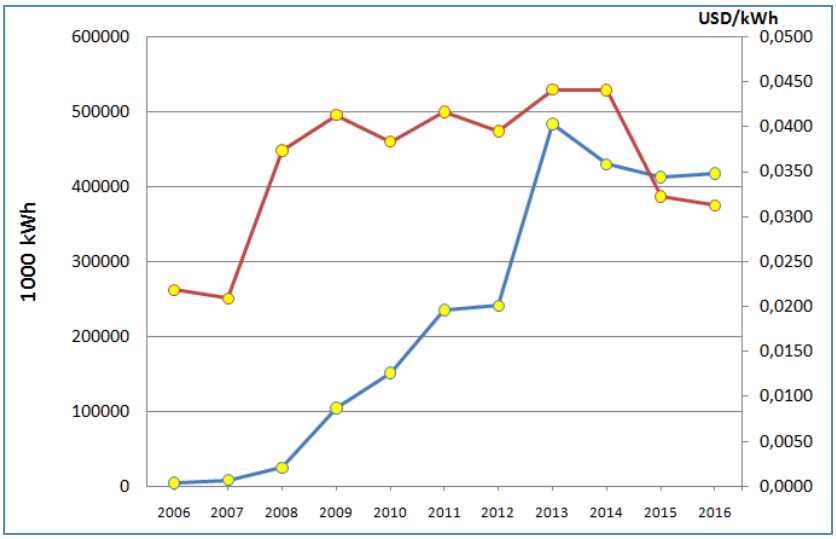



Figure 4. Export of green energy from Serbia through the export of wood pellets with average export price of 1 kWh *(Original)*

Average price of 1 kWh of energy from wood pellets exported from Serbia was in the range of USD 0.020-0.044, which is significantly less compared to the price of 1 kWh of energy from the natural gas which was imported in Serbia in the observed period. Prices of 1 kWh of energy from natural gas imported in Serbia in the period 2006-2015 were higher than the prices of 1 kWh of energy from wood pellets exported in this period from 2.1 times (2015) to as much as 3.2 times (2007).

Amount of exported green energy exported from Serbia in the form of export of wood pellets of 1.98 billion kWh was sufficient to replace 271.7 million $Sm^3$ of natural gas from import and make the savings effect of USD 23.1 million with which the imported gas was paid [8].

All this should be added with the unrealized effects in terms of the contribution of Serbia as a country to the mitigation of climate changes through the reduction of $CO_2$ emissions. With the export of wood pellets from Serbia, it is directly enabled for other countries to have higher own contribution to the mitigation of climate changes. In particular, had the amount of green energy from wood pellets substituted the same amount of energy consumed in Serbia through the consumption of imported natural gas, the amount of emitted $CO_2$ in Serbia would have been reduced by as much as 350 thousand tons of $CO_2e$ [8].

## CONCLUSIONS

Results of the conducted analyses clearly show that the existing potentials of woody biomass are on the upper limit of utilization observing from the aspect of sustainability. Increase of woody biomass consumption and consequently the increase of the share of wood energy in the total final energy consumption are possible through the following: stimulation of growing energy plantations, increase of efficiency of firewood use in households and reconstruction of coppices. Significant financial funds from the Government are necessary for all these activities through the system of incentives in order to increase the share of energy from renewable sources in the following three years and reach the set target of 27% in 2020. One of the measures expected to contribute to the increase of consumption of green energy from wood pellets in Serbia is the reduction of VAT rate from 20% to 10%, which is

applicable from 1st January 2017. Similar to this measure, it is necessary to adopt other stimulating measures as soon as possible.

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## REFERENCES

1. Biomass Consumption for Energy Purposes in the Energy Community, CRES, 2012
2. Biomass Energy Europe (BEE): Harmonization of biomass resource assessment, Volume I: Best Practices and Methods Handbook, 2010.
3. Energy Balance of the Republic of Serbia for 2015, Statistical Office of the Republic of Serbia, Belgrade, 2016.
4. FAO/UNECE data base;
5. Forests in the ECE Region, ECE/TIM/SP/37, United Nations, 2015;
6. Forestry in Serbia 2015, Statistical office of the Republic of Serbia, Belgrade, 2016
7. FPAMR: Forest Products Annual Market Review 2013-2014, UNECE, Geneva, 2014
8. Glavonjić et.al: Impact of wood pellets export on the development of their production in Serbia with the effects of substituting enegry from fossil fuels and reduction of carbon dioxide emission, Glasnik Šumarskog fakulteta br. 114, Belgrade, 2016. p.55-74
9. Mantau et al.: EUwood, Real potential for changes in growth and use of EU forests, Methodology report, June 2010
10. National Forest Inventory of Serbia, Ministry of agricultural, forestry and water management, Belgrade, 2010
11. Saal, U. 2010: Industrial wood residues. EUwood - Final report. Hamburg/Germany, 160 p.
12. Steierer F. NATIONAL AND REGIONAL WOOD RESOURCE BALANCES, UNECE, Geneva, 2010,
13. Timber trade database, University of Belgrade-Faculty of Forestry, Belgrade
14. Vasiljević A. 2015. The impact of wood market on socio-economic component of sustainable development of wood sector in Serbia, doctoral thesis, University of Belgrade-Faculty of Forestry, Belgrade
15. WISDOM Serbia, FAO, 2015;
16. World Bank: Sector Study on Biomass-based Heating in the Western Balkans, 2015

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# SUSTAINABLE DEVELOPMENT – INTERNATIONAL FRAMEWORK – OVERVIEW AND ANALYSIS IN THE CONTEXT OF FORESTS AND FOREST PRODUCTS – COMPETITIVE BUSINESS WITH QUALITY

Hyytiä, K. A.

## ABSTRACT

Business with forest products is more and more concerned with the sustainable development. International collaboration, agreements, standards, certification and governance have an important role. Sustainable markets are significant. International and national business and stakeholder collaboration has a wide importance taking into consideration competitiveness. Business and private sector has an important role in the sustainable development globally. There are many opportunities in the national and international policies, strategies and stakeholder collaboration in the sustainable development. Green international and national approaches represent collaboration in and towards sustainable development. This is a qualitative research based on literature.
**Key words**: Sustainable Development, Forests and forest products, Business, Competition, Quality

## 1. INTRODUCTION

The most important driver of a market-oriented firm is an endeavour to establish superior value for customers in the development of a sustainable competitive advantage. Quality including customer orientation can enhance market orientation. (Tokarczyk, J.; Hansen, E.; Green, M.; Down, J. 2007)

Quality management can enhance business performance and has a very positive impact on operational and business performance and customer satisfaction (Terziovski, M. and Samson, D. 1999). Forest certification guarantees the quality of forest management (Mirabella, N.; Castellani, V.; Sala, S. 2014).

## 2. GREEN BUSINESS IN MARKETS WITH STAKEHOLDERS

The business and private sector is expected to contribute to the sustainable development nationally and internationally (Transforming our world: the 2030 Agenda for Sustainable Development 2015).

According to an international comparative research in four countries, namely in Austria, Finland, Germany, and Slovenia, the most usually communicated area in the forest sector sustainability was the economic contribution of forests, namely in Finland and Austria. In Finland, the stakeholder framework has a significant role in sustainable development communication. (Korhonen, E.; Toppinen, A.; Lähtinen, K.; Ranacher, L.; Werner, A.; Stern, T.; Kutnar, A. 2016)

Drivers of the Corporate Responsibility can include both ethical and instrumental, namely economic and legal, aspects and they don’t have to be in conflict (Panwar, Rajat; Rinne, Tomi; Hansen, Eric; Juslin, Heikki 2006).

## 3. POLICY IN GREEN BUSINESS

It is possible to promote value reinforcement by green communication including forest certification schemes as the PEFC and the FSC. Strategies for obtaining added value are needed as well as effective communication and image for customers and end-consumers taking into consideration environmental communication. (Holopainen, J.; Toppinen, A.; Perttula, S. 2015).

Both forests and forest products with policy incentives can enhance sustainable development and climate change mitigation which can also enhance demand of wood products taking into account refining and energy production with wood compared to other materials (Lintunen, J.; Uusivuori, J.; Laturi, J.; Pohjola, J.; Rautiainen, A. 2016).

Climate change can be tackled with substituting other materials with wood. New wood-based-materials like nanomaterials have opportunities substituting materials like steel. (Seppälä, J.; Kanninen, M.; Vesala, T.; Uusivuori, J.; Kalliokoski, T.; Lintunen, J.; Saikku, L.; Korhonen, R.; Repo, A. 2015)

In the policy making, there exist opportunities for incentives in sustainable energy sources taking into consideration international sustainable development and international trade (Marcoux, J.; Ouellet, R. 2014).

We need mix of instrument synthesis or policy packages to create optimal policies (Ollikainen, M. 2016).

## 4. QUALITY WITH BUSINESS, COMPETITIVENESS AND POLICY

In the competitive markets of the forest industry, bioenergy and cellulosic biofuels provide examples in the competitiveness. Development of products with high value in an approach of a consistent biorefinery may be important for a national forest industry sector development. Economic growth can be attained with sustainable and environmental friendly practices. (Devappa, R. K.; Rakshit, S. K.; Dekker, R. F. H. 2015).

Competitiveness may be enhanced with higher value creation with better product quality and with sustainability (Korhonen, J. 2016).

It is important to have policies supporting sustainability. A company can have a responsible and a desired corporate image which may ameliorate the company's strategic position by internal and external aspects in differentiation taking into consideration the competitors. Corporate responsibility and strategy can be combined by the organization's image to have a competitive position. (Heikkurinen, P. 2013)

Corporate Responsibility is a context specific philosophy in business with strategic, proactive, and synergistic aspects (Panwar, R.; Rinne, T.; Hansen, E.; Juslin, H. 2006). There is an interaction between natural and business ecosystems which is essential in producing value in service supply (Matthies, B. D.; D'Amato, D.; Berghäll, S.; Ekholm, T.; Hoen, H. F.; Holopainen, J.; Korhonen, J. E.; Lähtinen, K.; Mattila, O.; Toppinen, A.; Valsta, L.; Wang, L.; Yousefpour, R. 2016).

Forest certification might be the best known tool of Corporate Social Responsibility in the global forestry and forest industry. The economics of forest certitication and the Corporate Social

Responsibility have similarities. They both constitute fundamental components in domestic and international companies in the forest sector. (Toppinen, A.; Cubbage, F., W.; Moore, S. E. 2014)

## 5. CONCLUSIONS

Sustainable business has an important role in the sustainable markets with stakeholders. Policy can enhance the sustainable development, sustainable markets and competitiveness. Sustainability is linked to stakeholders. In the sustainable development, resources and policies are interrelated with stakeholders. Stakeholders have an important role in the sustainable development. Stakeholder approach is linked to the Corporate Social Responsibility. Stakeholders have an important role in the markets and in the competitiveness.

## REFERENCES

1. Devappa, R. K.; Rakshit, S. K.; and Dekker, R. F. H. (2015): *Potential of Poplar Bark Phytochemicals as Value-Added Co-products from the Wood and Cellulosic Bioethanol Industry.* Bioenerg. Res. (2015) 8:1235–1251. DOI 10.1007/s12155-014-9572-z.
2. Fawzy, M. F.; Componation, P. J. (2015): *Biofuel Production: Utilizing Stakeholders' Perspectives*. Engineering Management Journal: EMJ; Huntsville27.2 (Jun 2015): 85-96.
3. Heikkurinen, P. (2013): *Reframing strategic corporate responsibility. From economic instrumentalism and stakeholder thinking to awareness and sustainable development.*
4. Holopainen, J.; Toppinen, A.; Perttula, S. (2015): *Impact of European Union Timber Regulation on Forest Certification Strategies in the Finnish Wood Industry Value Chain.* Forests 2015, 6(8), 2879-2896; doi:10.3390/f6082879.
5. Korhonen, E.; Toppinen, A.; Lähtinen, K.; Ranacher, L.; Werner, A.; Stern, T.; Kutnar, A. (2016): *Communicating Forest Sector Sustainability: Results from Four European Countries.* Forest Products Journal. September 1, (2016).
6. Korhonen, J. (2016): *On the high road to future forest sector competitiveness.* Dissertationes Forestales 217. 58 p.
7. Lintunen, J.; Uusivuori, J.; Laturi, J.; Pohjola, J.; Rautiainen, A. (2016): Metsät ja hiilivirtoja ohjaava ilmastopolitiikka. Metsätieteen aikakauskirja 3–4/2016: 157–164.
8. Marcoux, J.; Ouellet, R. (2014): *Waiting for Commercial Viability: Legal Incentives to Produce Cellulosic Biofuels and their Consistency with the WTO Regime.* International Journal of Sustainable Development Law and Policy; Montreal10.1 (2014): 79-110.
9. Matthies, B. D.; D'Amato, D.; Berghäll, S.; Ekholm, T.; Hoen, H. F.; Holopainen, J.; Korhonen, J. E.; Lähtinen, K.; Mattila, O.; Toppinen, A.; Valsta, L.; Wang, L.; Yousefpour, R. (2016): *An ecosystem service-dominant logic? - integrating the ecosystem service approach and the service-dominant logic*. Journal of Cleaner Production 124 (2016) 51e64.
10. Mirabella, N.; Castellani, V.; Sala, S. (2014): *Forestry operations in the alpine context. Life cycle assessment to support the integrated assessment of forest wood short supply chain*. The International Journal of Life Cycle Assessment; Dordrecht19.8 (Aug 2014): 1524-1535.
11. OECD (2016). Guidelines for multinational enterprises. http://mneguidelines.oecd.org/annualreportsontheguidelines.htm.
12. Ollikainen, M. (2016): *Forest Management, Public Goods, and Optimal Policies.* The Annual Review of Resource Economics. Annu. Rev. Resour. Econ. 2016. 8:207–26.
13. Panwar, R.; Rinne, T.; Hansen, E.; Juslin, H. (2006): *Corporate responsibility: balancing economic, environmental, and social issues in the forest products industry.*
14. Panwar, Rajat; Rinne, Tomi; Hansen, Eric; Juslin, Heikki (2006): Corporate Responsibility. Forest Products Journal; Madison56.2 (Feb 2006): 4-12.
15. Seppälä, J.; Kanninen, M.; Vesala, T.; Uusivuori, J.; Kalliokoski, T.; Lintunen, J.; Saikku, L.; Korhonen, R.; Repo, A. (2015): Ilmastopaneeli. METSIEN HYÖDYNTÄMISEN ILMASTOVAIKUTUKSET JA HIILINIELUJEN KEHITTYMINEN. Ilmastopaneelin raportti 3/2015.

16. Terziovski, M. and Samson, D. (1999): *The link between total quality management practice and organisational performance.* International Journal of Quality & Reliability Management, Vol. 16 Iss 3 pp. 226 – 237.
17. Tokarczyk, J., Hansen, E., Green, M., Down, J. (2007): *A Resource-Based View and Market Orientation Theory Examination of the Role of "Familiness" in Family Business Success.* FAMILY BUSINESS REVIEW, vol. XX, no. 1, March 2007 © Family Firm Institute, Inc.
18. Toppinen, A.; Cubbage, F., W.; Moore, S. E. (2014): *The Economics of Forest Certification and Corporate Social Responsibility*. Alavalapati, J. R. R.; Kant, S. (ed.). Handbook of forest resource economics. Routledge 2014.
19. Transforming our world: the 2030 Agenda for Sustainable Development (2015). United Nations: Department of Economic and Social Affairs. Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld.

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# ANALYSIS OF INVESTMENT EFFECTS IN WOOD PROCESSING INDUSTRY OF SLOVAKIA

Drábek, J.; Merková, M.

## ABSTRACT

The study investigates selected economic indicators in the sectors of wood processing industry in Slovakia in period 2008-2015, aim of the paper is focused on the analysis of volume and rate of investments in mentioned sectors. Based on the analysis and synthesis of knowledge of factors affecting investment level are summarized investment effects. The results are interested in factors with the main impact in efficiency of wood processing industry in the period. Based on the statistical results are formulated measures to increase the effectiveness and performance of wood processing industry in Slovakia.
**Key words**: Investments, Fixed capital, Performance Indicators, Wood Processing Industry, Slovakia

## INTRODUCTION

Investments as crucial factor for development and growth of each economy is the theme for our paper. Aim of the study was to investigate selected economic indicators in the sectors of wood processing industry in Slovakia, analysis was focused on volume (stocks, flows), share and return on investments. According results of statistical testing aim is to summarize investment effects and formulate measures for increasing of effectiveness and performance of wood processing industries in Slovakia.

## 1. LITERATURE REVIEW

Strategic and systemic measures such as more efficient use of wood as a domestic, sustainable renewable materials, support for building the processing capacities in Slovakia, programs to increase domestic consumption of timber in construction (the use of wood for public projects for new residential and nonresidential construction, reconstruction and modernization), support of domestic wood processors who manufacture products with higher added value, all these factors were underestimated in the past, and also because of this the wood sector in Slovakia found itself in a bad situation (Merková and Drábek, 2010). Successful economic development require besides the application of traditional methods also the application of new modern methods based on traditional systems of financial indicators and are completed by time and qualitative indicators (Sujová and Marcineková, 2015).

Potkány and Giertl (2014) investigated sales, profit, value added, number of employees and wages of wood processing industry in Slovakia and Czech Republic through correlation analysis during the period 2005-2012. Authors found differences between these 2 countries mainly in the stronger progress in the Czech economy in compare with the Slovak economy, which is evident even after accession of both countries to the EU. Hajdúchová *et al.* (2016) suggest that wood-processing industry should strive to increase its competitiveness by implementing modern management methods, using new technologies, or concentrating production in a larger scale. There is also a need for optimal solutions that reflect the principles of sustainable development. Sujová, Hlaváčková and Marcineková (2015) highlighted the fact that comparative advantage and competitive advantage based on lower prices the wood processing industry in Slovakia and Czech Republic over the past decade gradually loses. However, previous qualitative studies confirmed the competitive ability of the industry and potential to be successful on the international market, thus increase their performance and contribute to the sustainable growth.

More important than how much enterprises invested is income expected from those investments (Drábek, Jelačić and Merková, 2014). Insufficient development focused on competitiveness of wood-processing production and efficiency increasing, no solutions of the availability of financial resources for implementing of innovative plans could cause decreasing of competitiveness and long-term recession. The main reason for the negative status of the WPI is long-lasting unsolved problems.

## 2. MATERIAL AND METHODS

**Sectors analyzed** in the article are categorized according statistical classification of economic activities (NACE Rev.2). We select following industries of wood processing:

- NACE 16: Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials.
- NACE 17: Manufacture of paper and paper products.
- NACE 31: Manufacture of furniture.

Indicators of wood processing industries we compared with:

- Group C – Manufacturing.
- All NACE activities – Slovakia.

**Data analyzed** in the article are sourced from the statistical office of the European Union (Eurostat) in Database of National accounts. National accounts data are compiled according to European System of Accounts (ESA 2010) methodology. European System of National and Regional Accounts is the newest internationally compatible EU accounting framework for a systematic and detailed description of an economy, implemented since September 2014.

In investment area, based on *Statistical Explained Glossary* (Eurostat) or *Glossary of Statistical Terms* (OECD), we can define:

- **Gross fixed assets (stocks)** are the value of assets hold by producers before deducting of depreciation.
- **Net fixed assets** for national accounts purposes is derived from gross fixed assets by deducting of accumulated depreciation.
- **Gross fixed capital formation (flows)** statistically measures the value of acquisitions of new or existing fixed assets. It is a flow value measured by the total value of a producer's acquisitions, less disposals of fixed assets during the accounting period.
- **Consumption of fixed capital (depreciation of fixed assets)** represents depreciation – the value of fixed assets used up during the year as a result of production activity as well as service providing.

**Indicators analyzed** in the article are following:

- Gross fixed assets (stocks)
- Gross fixed capital formation (flows)
- Gross value added
- Operating surplus and mixed income (aggregate of value added)

**Indicators processed** in the article used the data describe above. We calculated:

$$Investment\ rate\ (\%) = \frac{Gross\ fixed\ capital\ formation}{Value\ added} \qquad (1)$$

$$Return\ on\ investment\ (\%) = \frac{Operating\ surplus\ and\ mixed\ income}{Gross\ fixed\ assets} \qquad (2)$$

We have used appropriate mathematical and statistical methods in the research of interdependencies between quantitative – numerical variables.

By one-dimensional descriptive statistics we analyzed selected sample characteristics for one variable – sample size, mean, median, confidence level ±95%, min., max., variance, coefficient of variance, standard deviation and standard error. Line plots as graphical statistical method were used.

In two-dimensional inductive statistics we applied analysis of variance (ANOVA) in the research. The purpose of ANOVA (Shapiro, Wilk, 1965, Iversen, Norpoth, 1976 and others) is to test differences in means (for groups or variables) for statistical significance. As graphical statistical method were used Box and Whisker plots. Assumptions of ANOVA are:

- Normality - the normal probability distribution with mean equal to zero.
- Homogeneity of variances - the variances are equal for all values.
- The individuals are independent - observations in groups are different objects.

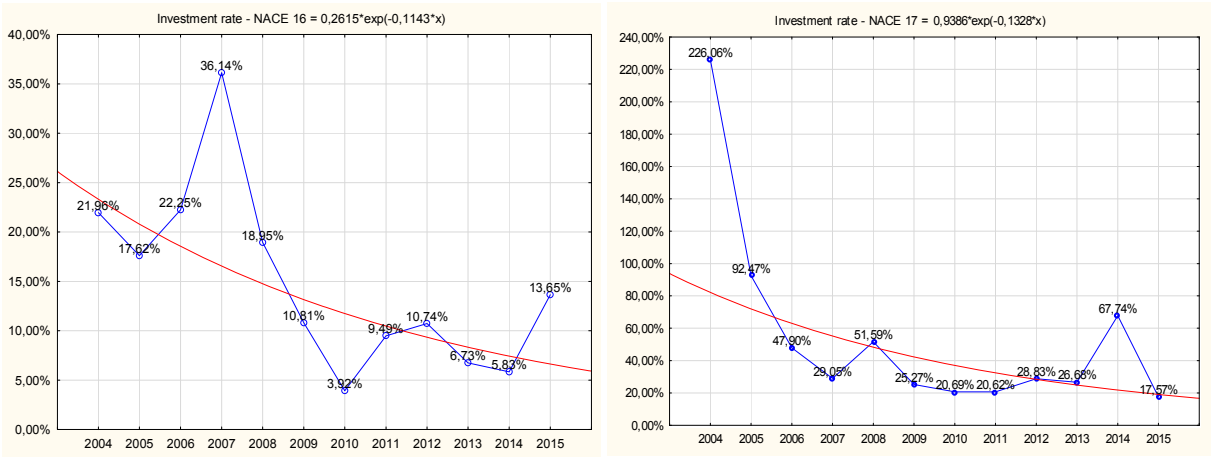
For testing of homogeneity of variances we used Levene test. Levene test is an inferential statistic used to assess the equality of variances for a variable calculated for two or more groups (Levene, 1960).

For statistical analysis, numeric and graphical presentation of the research results, we used the program MS Office Excel and software Statistica12 from StatSoft, Inc.

## 3. RESULTS AND DISCUSSION

The results are interested in factors with the main impact in efficiency of wood processing industries. Based on the statistical results are formulated measures to increase the effectiveness and performance of wood processing industry in Slovakia.

Level of expansion through investments we analyzed by indicator Investment rate (%), calculated according formula 1 as share of gross fixed capital formation in gross value added, so how much of the new value added in the economy is invested. Results of descriptive statistics of the indicator are presented in Table 1, specific values of the indicator for the period 2004-2015 presents Figure 1.



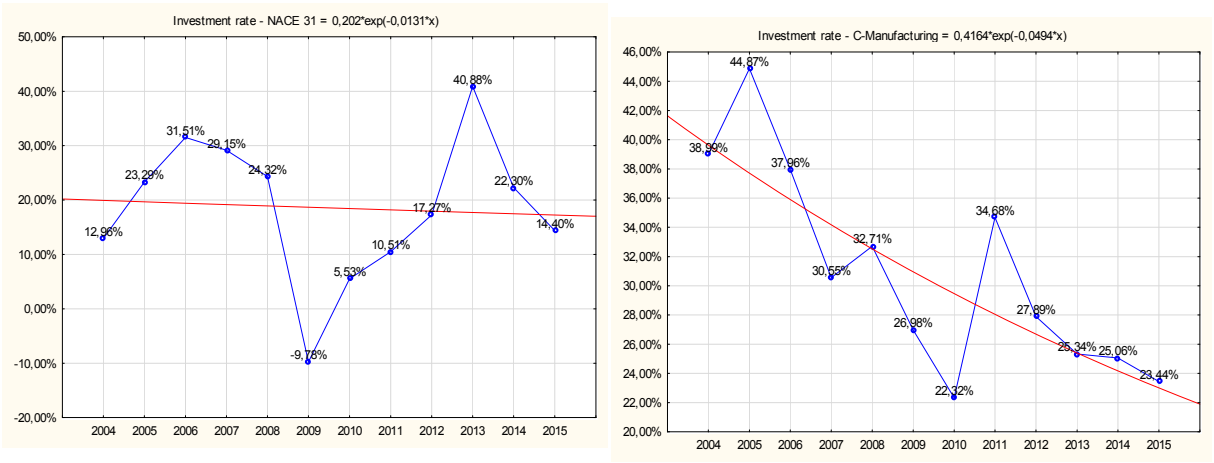



*Figure 1. Investment rate in wood processing industries in Slovakia (%). Source: own*

In relation to the Investment rate indicator, Eurostat publishes the "business investment rate". This ratio in business level is equal to investment rate defined by formula 1 in this article. It provides an indication of how much of the total income is reinvested in new fixed assets. Normally that ratio is about 20–23% of gross value-added. If business confidence is low, enterprises are less likely to tie up new earnings in additional fixed assets, which are usually held for a number of years. If, on the other hand, business confidence is buoyant, it is more likely that enterprises will spend more of their current earnings on longer-term investments in fixed assets. In turn, the rate at which enterprises invest earnings in longer-term assets is an indicator of business expansion – if the rate declines, then this typically lowers the rate of cumulative business expansion.

*Table 1. Descriptive statistics: Investment rate in wood-processing industries in Slovakia. Source: own*

| **Investment rate** | Valid N | Mean | Confidence -95,000% | Confidence 95,000% | Median | Minimum | Maximum | Variance | Std. Dev. | Coef. Var. | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slovakia | 12 | 26.31% | 26.00% | 22.53% | 30.81% | 0.09% | 3.01% | 2.13% | 5.11% | 11.4446 | 0.87% |
| C -Manufacturing | 12 | 30.90% | 29.22% | 22.32% | 44.87% | 0.50% | 7.05% | 5.00% | 11.97% | 22.8206 | 2.04% |
| NACE 16 | 12 | 14.84% | 12.23% | 3.92% | 36.14% | 0.83% | 9.11% | 6.45% | 15.47% | 61.3849 | 2.63% |
| NACE 17 | 12 | 54.54% | 28.94% | 17.57% | 226.06% | 34.26% | 58.54% | 41.47% | 99.39% | 107.3268 | 16.90% |
| NACE 31 | 12 | 18.53% | 19.79% | -9.78% | 40.88% | 1.76% | 13.27% | 9.40% | 22.53% | 71.6022 | 3.83% |

Investment effects we analyzed through ROI indicator (%), according formula 2 we calculated share of created operating surplus in gross fixed capital (stocks). Results of descriptive statistics of the indicator are presented in Table 2, specific values of the indicator for the period 2004-2015 presents Figure 2.

*Table 2. Descriptive statistics: Return on investment in wood-processing industries in Slovakia. Source: own*

| **Return on investment** | Valid N | Mean | Confidence -95,000% | Confidence 95,000% | Median | Minimum | Maximum | Variance | Std. Dev. | Coef. Var. | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slovakia | 12 | 7.25% | 6.82% | 7.68% | 7.30% | 6.16% | 8.44% | 0.00% | 0.68% | 9.38397 | 0.20% |
| C -Manufacturing | 12 | 9.18% | 7.91% | 10.45% | 9.40% | 4.29% | 12.44% | 0.04% | 2.00% | 21.80626 | 0.58% |
| NACE 16 | 12 | 0.81% | 0.72% | 0.90% | 0.84% | 0.58% | 1.06% | 0.00% | 0.14% | 17.49917 | 0.04% |
| NACE 17 | 12 | 4.28% | 3.20% | 5.36% | 3.56% | 2.84% | 7.37% | 0.03% | 1.69% | 39.61554 | 0.49% |
| NACE 31 | 12 | 6.14% | 5.22% | 7.06% | 6.04% | 4.00% | 8.65% | 0.02% | 1.45% | 23.57914 | 0.42% |

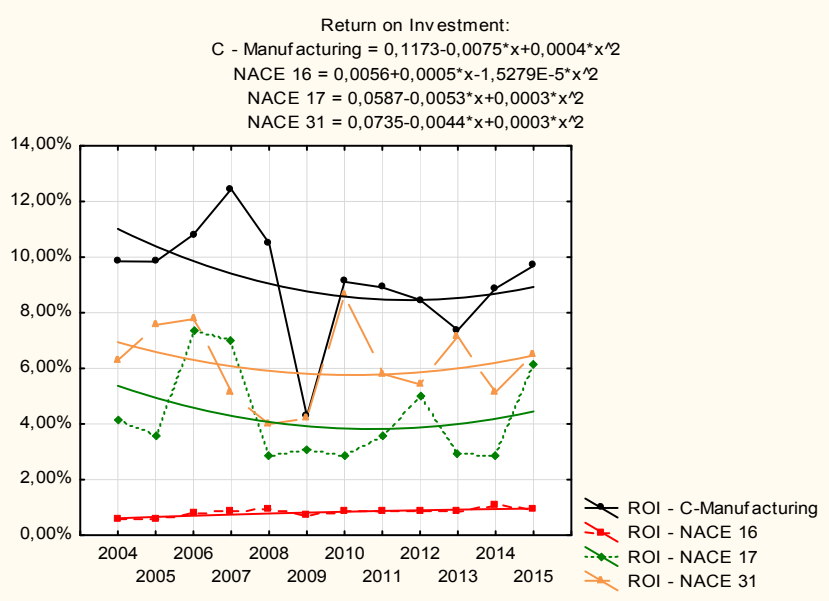



*Figure 2. Return on Investment in wood processing industries in Slovakia (%). Source: own*

Levene test we used for testing the Homogeneity of variances and results presented in Table 3 determined the p-value $p<0.05$ for each variable, whereby we reject null hypothesis of equal variances in favor of alternative hypothesis that variances are different. The assumption for ANOVA test was not fulfilled and therefore is no reason to continue in the analysis.

*Table 3. Levene Test for Homogeneity of Variances. Source: own*

| Levene Test for Homogeneity of Variances (NACE 16; NACE 17; NACE 31) | | | | | | |
|---|---|---|---|---|---|---|
| Variable | MS Effect | df Effect | MS Error | df Error | F | p |
| Investment rate | 0.328043 | 2 | 0.067260 | 33 | 4.877215 | 0.013941 |
| Return on investment | 0.000579 | 2 | 0.000043 | 33 | 13.39165 | 0.000055 |

Wood processing sector has comparative advantages, which make it possible to define potential effects of investments in analyzed industries. Performance improvement due to investment could be shown in a variety of benefits. Powerful company from a management perspective is considered if it has a stable market share, loyal customers, low cost, balanced cash flow and at a certain liquidity can achieves required profitability (Potkány et al., 2013). Thanks to competitive advantages the sectors of wood, furniture, pulp and paper could be interesting for foreign investors. Industrial distribution of FDI in 2014 (UNCTAD) presents the services sector accounted for almost two thirds of global FDI stock (64 %), followed by manufacturing (27 %) and the primary sector (7 %), with 2 % unspecified. At the global level in cross-border mergers and acquisitions, increases were particularly significant in pharmaceuticals, non-metallic mineral products, furniture and chemicals and chemical products. Differences exist between the developed and developing economies in manufacturing. Increase, driven by large acquisitions in a limited number of industries, such as furniture, food and beverages, and non-metallic mineral products, was in developing economies. Investment promotion agencies (IPAs) identified the most promising industries for attracting FDI to their country in 2016, for developing and transition regions, industries most commonly chosen are agriculture, food and beverages, and utilities. Developing-country multinational enterprises still lag farther behind in industries that are more traditional, mature or less internationalized – such as wood and wood products (WIR, 2016). FDI may become the basis for the modernization of production facilities, the transfer of new technologies, know-how, creating healthy competition and more efficient to integrate our economy into the international division of labour, decreasing unemployment, growth of GDP (Merková and Drábek, 2010). As described Sujová et al. (2015), current policies of national governments prefer to provide for a high level

of finalization of wood processing in the State of raw wood production. Just lack of investment is often the reason of low level of finalization and thus low added value creation in companies.

## CONCLUSION

Article focus directed to selected economic indicators and then to investment effects of certain sectors. We tried to find differences among investment activities of wood processing industries in Slovakia (NACE 16, 17 and 31) and we applied analysis of variance for variables Investment rate and ROI indicator. However, on the basis of statistical results, the assumption of homogeneity of variances was not fulfilled and therefore there was not appropriate to discuss the results of the analysis. Various levels of investment activities are visible and it follows differences in investment effects in wood processing industries in Slovakia.

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## REFERENCES

1. Drábek, J., Jelačić, D. and Merková, M. (2014): Substance of investment projects, in “Investments to forests and forest based production”. In: Jelačić, D. (Ed.). Zagreb: WoodEMA, 2014. p. 1-31.
2. Hajdúchová, I. et al. (2016): The Slovakian forest-based sector in the context of globalization. *BioResources 11(2),* 4808-4820. DOI: 10.15376/biores.11.2.4808-4820.
3. Iversen, G. R. and Norpoth, H. (1976): *Analysis of Variance*.
4. Levene, H. (1960): Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling. Stanford University Press. pp. 278–292.
5. Merková, M. and Drábek, J. (2010): *Effects and benefits of foreign direct investment for the development of wood-processing industry*. In: Proceedings of the 3rd WoodEMA International Scientific Conference “Wood processing and furniture manufacturing: present conditions, opportunities and new challenges”. Vyhne, Slovakia. 2010. pp. 125-133.
6. Potkány, M. and Giertl, G. (2014): Comparison of selected performance indicators of woodworking industry in the Czech Republic and Slovakia. In *7th International Scientific Conference on Position and Role of the Forest Based Sector in the Green Economy: Proceedings of Scientific papers,* Zvolen: Slovakia, pp. 131-138.
7. Potkány, M. Giertl, G. and Turkota, M. (2013): Statistical prognosis of value added level in the wood and furniture industry of the Slovak Republic In: *The Managers of Quality and Production Association*. Poland, 2013. pp. 92-100.
8. Shapiro, S. S. and Wilk, M. B. (1965): An analysis of variance test for normality (complete samples). *Biometrika* 52, 591-611.
9. Sujová, A. and Marcineková, K. (2015): Modern Methods of Process Management Used in Slovak Enterprises. *Procedia-Economics and Finance Journal* 23, 889 - 893. doi:10.1016/S2212-5671(15)00381-0
10. Sujová, A., Hlaváčková, P. and Marcineková, K. (2015): Measuring the impact of foreign trade on performance of the wood processing industry. *Wood Research 60(3)*, 491-501.
11. ***. European Commission: Eurostat: National accounts. Luxembourg. URL: http://ec.europa.eu/eurostat/web/national-accounts/data/database
12. ***. European Union (2013): European System of Accounts ESA 2010. Luxembourg: 2013. doi:10.2785/16644
13. ***. Eurostat: Statistical Explained Glossary.

URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Thematic_glossaries
14. ***. OECD: Glossary of Statistical Terms. URL: http://stats.oecd.org/glossary/index.htm
15. ***: United Nations Conference on Trade and Development - UNCTAD (2016): World Investment Report (WIR) 2016. Geneva, 2016.

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# INVESTMENT VALUATION AND PERFORMANCE OF WOOD PROCESSING COMPANIES IN SLOVAKIA

Merková, M.; Drábek, J.

## ABSTRACT

The study investigates investment measurement and management in wood processing companies in Slovakia. The aim of the paper was to test the using of certain methods and groups of indicators in investment effectiveness valuation and their possible impact in better business performance. We are mainly interested in indicators such as Net Present Value or Internal Rate of Return based on discounted cash flow valuation. We used in the research two-dimensional inductive statistics between categorical variables, the dependence we examined with contingency and we also applied analysis of variance. Results of the research emphasize that use of certain investment effectiveness valuation methods significantly affects better business performance in Slovakia.
**Key words**: Business performance, Manufacture enterprises, Wood processing industry, Investment, Investment valuation methods, Discounted cash flow indicators.

## INTRODUCTION

There is a number of approaches, concepts or methods how to valuate effectiveness of investment activity and company needs to apply tools that lead to sufficient business performance. The aim of the paper was to test the using of certain methods and groups of indicators in investment effectiveness valuation and their possible impact in better business performance. We expressed the assumption that use of discounted cash-flow indicators has a significant impact on business performance and these methods are applied in companies that achieve a moderate or higher ROE. Results of the verification we present in the paper.

## 1. THEORETICAL REVIEW

It can be concluded that the economic experience quite often realizes the financial management based on the accounting profit and common indicators such as profitability or activity ratios. These indicators are presently considered as insufficient, which is also one of the reasons for the significantly poor competitiveness of enterprises.

The most frequent method in business management is financial analysis and financial indicators (Sujová. Rajnoha and Merková, 2014). However, only complex evaluation can assure fulfillment of entrepreneurial goals – increase of production abilities, cost decrease, ennobling of invested capital, and increase of the enterprise market value. Investment basis must be evaluated equally well (Drábek, Jelačić and Merková, 2014). In evaluation of investment we evaluate their suitability, efficiency and feasibility of the particular project. Moreover we evaluate the impact of the project on total effectiveness, prosperity and financial stability of the company (Merková and Drábek, 2014). According Sujová and Marcineková (2015), successful economic development require besides the application of traditional methods also the application of new modern methods based on traditional systems of financial indicators and are completed by time and qualitative indicators.

Komplex model of investment valuation typical for foreign firms in Slovakia presented Rajnoha, Novák and Merková (2016). Use of investment controlling valuation with the statistically significant impact in business performance growth was proven in next study (Merková, 2015). At the same time, investment controlling is applied mostly in partly of fully foreign firms in Slovakia. Foreign

investment may become the basis for the modernization of production facilities, the transfer of new technologies, know-how, creating healthy competition and more efficient to integrate our economy into the international division of labor, decrease unemployment, growth of GDP as well as provide access to European and global market of products and services (Merková and Drábek, 2010). Positive impact of foreign direct invetment in Slovakia was demonstrated in study of Merková, Drábek and Jelačić (2012). Another research realized in Slovakia (Merková, Rajnoha and Dobrovič, 2015) has statistically confirmed that better business performance is significantly dependent on financing from foreign capital.

Testing of selected economic indicators of wood processing industry in Slovakia and Czech Republic through correlation analysis during the period 2005-2012 demonstrated differences between these 2 countries mainly in the stronger progress in the Czech economy in compare with the Slovak economy, which is evident even after accession of both countries to the EU (Potkány and Giertl, 2014). Wood-processing industry should strive to increase its competitiveness by implementing modern management methods, using new technologies, or concentrating production in a larger scale. There is also a need for optimal solutions that reflect the principles of sustainable development (Hajdúchová *et al.,* 2016). Just because current difficult situation in wood processing industry of Slovakia there is increasing potential for any effects.

## 2. MATERIAL AND METHODS

In analysis of investment effectiveness evaluation methods companies could choose any number of responses and identify one or more methods or group of methods. We focused on four groups of methods for investment evaluation. However, performance of companies can certainly not be associated with a number of methods or evaluation groups that are used in the evaluation. For example, an enterprise which uses two groups of methods - annual and additional methods may not be successful and powerful than company using only one group, for example. Discounted cash-flow methods, which take into account the time factor when considering a long-term capital are significant. In order to categorize businesses by relevance of using of certain combinations of methods, enterprises were divided into four categories:

- **Without evaluation**: Companies indicated that they are not engaged in evaluating of investment efficiency and do not use assessment methods.
- **Annual evaluation**: Enterprises are characterized by using only annual or complementary methods, but they do not use discounted methods appropriate for longer period than one year or controlling methods of assessing the effectiveness of investments.
- **Discounted cash-flow indicators**: Businesses are characterized by the fact that they use discounted cash-flow indicators or some other but in terms of importance for investments less important methods. Surely they do not use controlling methods.
- **Controlling evaluation**: Enterprises are characterized by exploiting the discounted and controlling methods of assessing the effectiveness of the investment.

To build data collection of companies in Slovakia there was created on-line questionnaire through internet application (more in Questionnaire Survey or Rajnoha et al. 2013). We maintain complete anonymity of participating firms. The size of research sample was 164 counts. In complex research we analyzed all companies, we created samples according certain industries (engineering, automotive, wood processing etc.). Part of research presented in this paper has mainly focused on manufacturing enterprises (core of business was production) and in realization to them especially analyses companies in wood processing industry. Statistical classification of Economic activities (NACE Rev. 2) in the Statistical Office of the Slovak Republic defines within the wood processing industry:

- NACE 16: Manufacture of wood
- NACE 17: Manufacture of paper and paper products

- NACE 31: Manufacture of furniture

The aim was also to analyze individual sectors included to wood processing complex, but just low number eg. in the pulp and paper industry (2 companies), in the furniture industry (11 companies) would cause the low relevance of the results for the two-dimensional statistics, because these sectors individually assessed only by means of univariate descriptive statistics. For two-dimensional statistics for qualitative (nominal) variables we put related sectors together. In this case, the sample created all sectors of the wood processing industry (WPI) covering 34 companies.

We used two-dimensional inductive statistics between categorical variables, the dependence we examined with contingency (Pearson 1904, Everitt 1977, Pánik 2005 and others). We applied chi-squared test, which is commonly used for testing the independence between two categorical variables. Results of chi-squared tests describe selected statistics: Pearson's chi-square and significance p-value „p", Pearson's contingency coefficient (CC), Adjusted contingency coefficient (Adj. CC) and degrees of freedom (df).

Pearson's Chi-square: $\chi^2 = \sum_{i=1}^{k} \left[ \left( f_{o_i} - f_{e_i} \right)^2 / f_{e_i} \right]$; while $\sum (f_o - f_e) = 0$ (1)

Pearson's contingency coefficient CC: $CC = \sqrt{\chi^2 / (\chi^2 + N)}$ (2)

Maximum contingency coefficient $CC_{max}$: $\mathrm{CCmax} = \sqrt{(q-1)/q}$ (3)

Adjusted contingency coeff. Adj. CC: $\mathrm{Adj.\,CC} = \mathrm{CC}/\mathrm{CCmax}$; while $\mathrm{CC} \leq \mathrm{CCmax}$ (4)

Where:
$f_{o_i}$ – observed frequency in an field of the table,
$f_{e_i}$ – expected (theoretical) frequency in an field of the table,
k – number of cells in the table
N – sample size
q – number of rows or columns (in square tables)

For statistical analysis, numeric and graphical presentation of the research results, we used the program MS Office Excel and software Statistica12 from StatSoft, Inc.

## 3. RESULTS AND DISCUSSION

Based on descriptive statistics of variable business performance (categorized according the ROE indicator into 6 groups) in the sample of all companies shows the mean 2.06, companies in average create positive, but relatively low Return on Equity in the range of 2-4 % in Slovakia. Median is at level 2. Modus, the maximum frequency is represented in the second group with a performance at the level of 0-2 % ROE, which includes 29 % of the total sample of enterprises.

By comparison, **in the sectors of the WPI** are larger frequencies of lower performance in groups 0, 1, 2 and 3, the median in comparison with the sample of all enterprises have been reduced to a negative one, which means that up to half of the WPI enterprises has a negative or very low positive ROE. The results of descriptive statistics thus represent **the lowest performance** of all surveyed industries. Obtained results in tested research samples are presented in Table 1 and 2.

*Table 1. Descriptive statistics: Business performance (Groups of ROE indicator). Source: own*

| Research sample | Counts | Mean | Median | Mode | Counts (mode) |
|---|---|---|---|---|---|
| All tested companies | 164 | 2.06 | 2 | 1 | 47 |
| Manufacture | 106 | 2.02 | 2 | 1 | 32 |
| Wood processing companies | 34 | 1.65 | 1 | 1 | 11 |
| Wood industry | 21 | 1.90 | 1 | 1 | 8 |
| Furniture industry | 11 | 1.27 | 1 | 2 | 4 |
| Pulp and paper industry | 2 | 1.00 | 1 | multiple | 1 |

*Table 2. Observed frequencies: Business performance (Groups of ROE indicator). Source: own*

| Group (ROE indicator) | Group 0 (negative ROE) | Group 1 (0-2 %) | Group 2 (2-4 %) | Group 3 (4-7 %) | Group 4 (7-10 %) | Group 5 (over 10 %) | Total |
|---|---|---|---|---|---|---|---|
| Sample of all companies | | | | | | | |
| counts | 25 | 47 | 35 | 26 | 12 | 19 | 164 |
| cumulative | 25 | 72 | 107 | 133 | 145 | 164 | - |
| relative counts | 15.24% | 28.66% | 21.34% | 15.85% | 7.32% | 11.59% | 100.00% |
| cumulative | 15.24% | 43.90% | 65.24% | 81.10% | 88.41% | 100.00% | - |
| Sample of Wood processing companies | | | | | | | |
| counts | 8 | 11 | 8 | 3 | 0 | 4 | 34 |
| cumulative | 8 | 19 | 27 | 30 | 30 | 34 | - |
| relative counts | 23.53% | 32.35% | 23.53% | 8.82% | 0.00% | 11.76% | 100.00% |
| cumulative | 23.53% | 55.88% | 79.41% | 88.24% | 88.24% | 100.00% | - |

When we analyzed each group of evaluation methods separately, the most common were annual indicators (108 companies). But when we specify what the basic focus and crucial evaluation is, presented in Table 3 and Figure 1, frequency and use of annual methods was reduced to 46 companies and the greatest number of enterprises (63 enterprises, 38.41%) has focused on discounted cash-flow assessment methods. **In wood processing industry**, the situation in the use of investments evaluation methods is worse compared with the research sample of manufacturing enterprises. As evidenced from the relative counts, in the WPI is higher proportion of businesses that do not benefit from any valuation (28% in manufacture compared with 35% in the WPI). And further, the use of whatever method is lower in WPI, controlling evaluation uses only one wood processing company. The current situation of the WPI can therefore be viewed as negative.

*Table 3. Observed frequencies: Investment effectiveness valuation methods. Source: own*

| Investment effectiveness evaluation – crucial methods | Without valuation | Annual indicators | Discounted cash-flow indicators | Controlling valuation | Total |
|---|---|---|---|---|---|
| Sample of all companies | | | | | |
| counts | 46 | 46 | 63 | 9 | 164 |
| cumulative | 46 | 92 | 155 | 164 | - |
| relative counts | 28.05% | 28.05% | 38.41% | 5.49% | 100.00% |
| cumulative | 28.05% | 56.10% | 94.51% | 100.00% | - |
| Sample of Wood processing companies | | | | | |
| counts | 12 | 9 | 12 | 1 | 34 |
| cumulative | 12 | 21 | 33 | 34 | - |
| relative counts | 35.29% | 26.47% | 35.29% | 2.94% | 100.00% |
| cumulative | 35.29% | 61.76% | 97.06% | 100.00% | - |

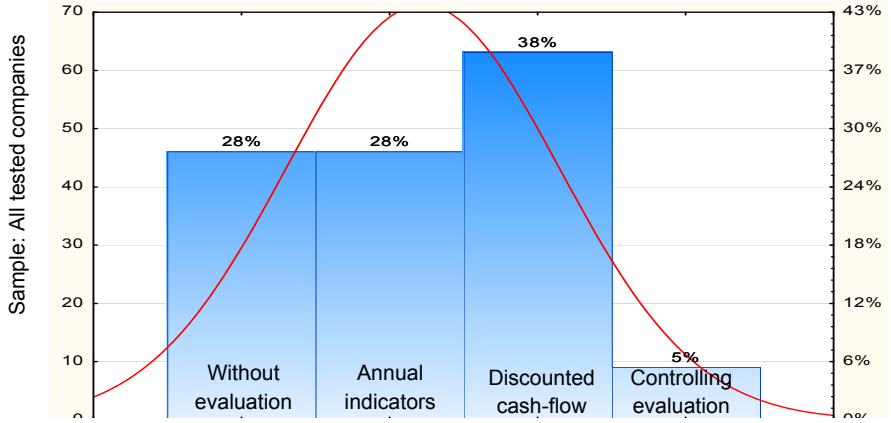


*Figure 1. Focusing on investment effectiveness evaluation – crucial methods Source: own*

In analysis of investment effectiveness evaluation methods companies could choose optional number of responses and identify one or more methods or group of methods for investment evaluation (defined in theoretical part of this paper). Each method were surveyed as a binary variable, but we also analyzed certain group of methods to determine if their use has an impact on performance. Business performance in this analysis was categorized into three groups. Table 4 presents obtained results.

*Table 4. Contingency: Use of investment valuation methods vs. Business Performance – Statistics. Source: own*

| Investment valuation methods x Business Performance | Counts | Pearson's chi-square | df | p | Contingency coefficient (CC) | Adjusted CC (Adj. CC) |
|---|---|---|---|---|---|---|
| Use of annual indicators: | 164 | 3.816 | 2 | 0.148 | 0.15 | 0.20 |
| - profit | 164 | 1.067 | 2 | 0.587 | 0.08 | 0.11 |
| - cost | 164 | 1.608 | 2 | 0.448 | 0.10 | 0.13 |
| - earnings | 164 | 1.323 | 2 | 0.516 | 0.09 | 0.12 |
| - payback period | 164 | 4.797 | 2 | 0.091 | 0.17 | 0.22 |
| - return on investment (ROI) | 164 | 0.480 | 2 | 0.786 | 0.05 | 0.07 |
| - approximation of earnings | 164 | 2.831 | 2 | 0.243 | 0.13 | 0.17 |
| Use of discounted cash flow evaluation: | 164 | 4.530 | 2 | 0.104 | 0.16 | 0.22 |
| - Net present value (NPV) | 164 | 1.323 | 2 | 0.516 | 0.09 | 0.12 |
| - Profitability index (PI) | 164 | 6.470 | 2 | 0.039 | 0.19 | 0.26 |
| - Internal rate of return (IRR) | 164 | 6.349 | 2 | 0.042 | 0.19 | 0.25 |
| - Payback period (PP) | 164 | 1.054 | 2 | 0.590 | 0.08 | 0.10 |
| Use of investment controlling evaluation | 164 | 4.244 | 2 | 0.120 | 0.16 | 0.21 |
| Use of additional methods: | 164 | 0.776 | 2 | 0.678 | 0.07 | 0.09 |
| - break-even analysis | 164 | 1.980 | 2 | 0.372 | 0.11 | 0.14 |
| - project commercial life cycle | 164 | 2.229 | 2 | 0.328 | 0.12 | 0.15 |

We demonstrated statistically significant relationships between performance and two indicators: Profitability Index and Internal Rate of Return. Both pursued relationships show moderate dependence with similar Adj. CC at 0.26 (and 0.25 respectively). The analysis of observed frequencies, but especially residuals show that if companies do not use specified evaluation method, they obtain poor performance with negative or very low positive ROE to 2%. When they use the mentioned methods, the differences between observed and expected frequencies are significant for the second and third group of performance (positive ROE above 2%), residuals are slightly higher for the second performance group (ROE 2-7%). So, we cannot say, that with application of these methods companies have extremely high performance; probability to result with the ROE indicator at the level of 2% or 10% is the same. But it is sure that without analyzed methods companies are very weak with the ROE under 2%.

## CONCLUSION

Results of the research based on statistical testing emphasize, that use of certain investment effectiveness valuation methods significantly affects better business performance in Slovakia. Use of discounted cash flow methods resulted in higher performance than without the use of methods, but does not guarantee placement in the highest categories of ROE, on which are likely to have significant impact controlling methods. However, it is possible to confirm our assumption set at the beginning of the study.

In wood processing industry of Slovakia is clear negative situation as reveals analysis of investment evaluation methods application. Up to 35% of WPI businesses does not use any method that could be applied in investment decision-making and we consider this is a problem with an impact in worse performance of wood processing industry in Slovakia.

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## REFERENCES

1. Drábek, J., Jelačić, D. and Merková, M. (2014): Substance of investment projects, in “Investments to forests and forest based production”. In: Jelačić, D. (Ed.). Zagreb: WoodEMA, 2014. p. 1-31.
2. Everitt, B. S. (1977): The analysis of contingency tables. London: Chapman, Hall.
3. Hajdúchová, I. et al. (2016): The Slovakian forest-based sector in the context of globalization. *BioResources 11(2),* 4808-4820. DOI: 10.15376/biores.11.2.4808-4820.
4. Merková, M. (2015): Use of Investment Controlling and its Impact into Business Performance. In Procedia Economics and Finance 34 (2015), p. 608-614. https://doi.org/10.1016/S2212-5671(15)01675-5
5. Merková, M. and Drábek, J. (2010): *Effects and benefits of foreign direct investment for the development of wood-processing industry*. In: Proceedings of the 3rd WoodEMA International Scientific Conference “Wood processing and furniture manufacturing: present conditions, opportunities and new challenges”. Vyhne, Slovakia. 2010. pp. 125-133.
6. Merková, M. and Drábek, J. (2014): Investment behavior and performance of wood processing companies in Slovakia, in “Investments to forests and forest based production”. In: Jelačić, D. (Ed.). Zagreb: WoodEMA, 2014. p. 123-142.
7. Merková, M., Drábek, J. and Jelacic, D. (2012): Determinants of Effects of Foreign Direct Investment in Terms of Slovak Republic and Wood-Processing Industry of Slovakia. *Drvna industrija* 63, 129-142. doi:10.5552/drind.2012.1136
8. Merková, M., Rajnoha, R. and Dobrovič, J. (2015): The influence of foreign capital in scope of business performance and investment management. In *Finance and the Performance of Firms in Science, Education and Practice*. International Scientific Conference. Zlín, 2015.
9. Pánik, M. J. (2005): Advanced Statistics from Elementary Point of View. London: Elsevier Academic Press.
10. Pearson, K. (1904): On the Theory of Contingency and Its Relation to Association and Normal Correlation. London: Dulau, Company.
11. Potkány, M. and Giertl, G. (2014): Comparison of selected performance indicators of woodworking industry in the Czech Republic and Slovakia. In *7th International Scientific Conference on Position and Role of the Forest Based Sector in the Green Economy: Proceedings of Scientific papers,* Zvolen: Slovakia, pp. 131-138.
12. Questionnaire Survey of the Grant Project of the Ministry of Education Nr. 1/0089/11 - Measurement and performance management of the wood industry companies in SR.
13. Rajnoha, R. et al. (2013): Measurement and Management of Business Performance. Zvolen: Technical University in Zvolen.

14. Rajnoha, R., Novák, P. and Merková, M. (2016): Relationships between Investment Effectiveness Controlling and Business Performance. In *Montenegrin Journal of Economics* 12 (2), p.29-44. DOI: 10.14254/1800-5845.2016/12-1/1
15. Sujová, A. and Marcineková, K. (2015): Modern Methods of Process Management Used in Slovak Enterprises. *Procedia-Economics and Finance Journal* 23, 889 - 893. doi:10.1016/S2212-5671(15)00381-0
16. Sujová, A., Rajnoha, R. and Merková, M. (2014): Business process performance management principles used in Slovak enterprises. *Procedia - social and behavioral sciences* 109, 276-280. doi:10.1016/j.sbspro.2013.12.457

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# IMPACT OF SELECTED PARAMETERS ON THE ENERGY PERFORMANCE OF BUILDINGS

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## ABSTRACT

In the context of the Paris Convention on Climate Change, by which the European Union will have been committed to the reduction of $CO_2$ by 40% by 2030 compared to 1990. Area of leading to the fulfillment of this commitment is to reduce the energy consumption of buildings. According to the legislation, the Slovak Republic committed to that after 2020, all new buildings will have close to zero energy consumption after deduction of energy from renewable sources. This commitment result in increasing investment costs. The aim is to present the impact of selected parts of family house (such as windows, insulation thickness) on calculation of energy use for space heating, meeting the requirements of the energy performance of buildings. The determination of the total lifecycle costs (investment costs, costs of space heating) for selected types of building elements and comparison of construction on silicate base and construction from wooden panels in the context of life-cycle costs is an important benefit.
**Key words**: life cycle costing, insulation thickness, wooden house, brick of house

## 1. INTRODUCTION

The European Union is committed to the reduction of $CO_2$. One area of leading to the fulfilment of this commitment is to reduce the energy consumption of buildings, because buildings consume more than 40% of total energy (60 % of energy use for space heating). This commitment to increasing investment costs. According to the legislation, the Slovak Republic committed to that after 2020, all new buildings will have close to zero energy consumption after deduction of energy from renewable sources. This aim can be achieved only by reducing our energy consumption and increasing the share of energy from renewable sources, but they are limited. In this paper, we focus on the impact of the selected elements of the house (windows, insulation) energy performance of the building. The aim is to present the impact of selected parts of family house (such as windows, insulation thickness) for specific heat, therefore the impact on heating costs for the investor. Many authors as (Dylewski, 2011; Monteiro, 2016; Neroutsou, 2016) assign to a key parameter for reducing the energy performance of buildings U-value (heat transfer coefficient for a wall with a thermal insulation layer [W/m2 K]). Monitored qualitative parameter in the peripheral wall for this paper is U - value. For windows we chose a qualitative parameter value Uw by author (Klesken,Majer,2012). Thermal insulation is one of the most effective ways of saving energy used for heating and cooling buildings.

Application of LCC analysis to assess the economic side with regard to the entire lifecycle in finding a cost-optimal level. The optimal level is expressed as the lowest life-cycle costs. Life cycle costs (LCC) provide a form of synopsis of the initial and consequential costs of building-related decisions. These cost figures may be implemented to justify higher investments, for example, in the quality or flexibility of building solutions through a long-term cost reduction. On the other hand, LCC can be used to avoid apparent cost savings in the phases of construction, maintenance or refurbishment which will in fact lead to substantial expenses in the phase of use. LCC is an instrument for optimising buildings with a long-term perspective and for exploiting the economic principles of sustainability(Pelzeter,2007). This paper shows that the methods of LCC calculation affect not only the absolute values of the calculation, but also the relative results, i.e. the ranking of compared alternatives which form the basis of building-optimisation decisions. The basic thesis is that if the calculation methods are changed, the result of a building optimisation with LCC varies.

## 2. METHODOLOGY OF LCC

Life cycle cost analysis is a method that uses many data into only one key economic figure. The data describe the structure of a building, its surroundings and use, the processes caused by building/use and the costs associated with those processes. The procedure of this data-consolidation can be divided into three steps. Initially, the building data (location, areas, construction, materials, technical equipment, etc.) and its use (kind, intensity, quantity of persons or machines, probability of changes, etc.) are structured for the input. The first step is therefore hat of structuring the data.

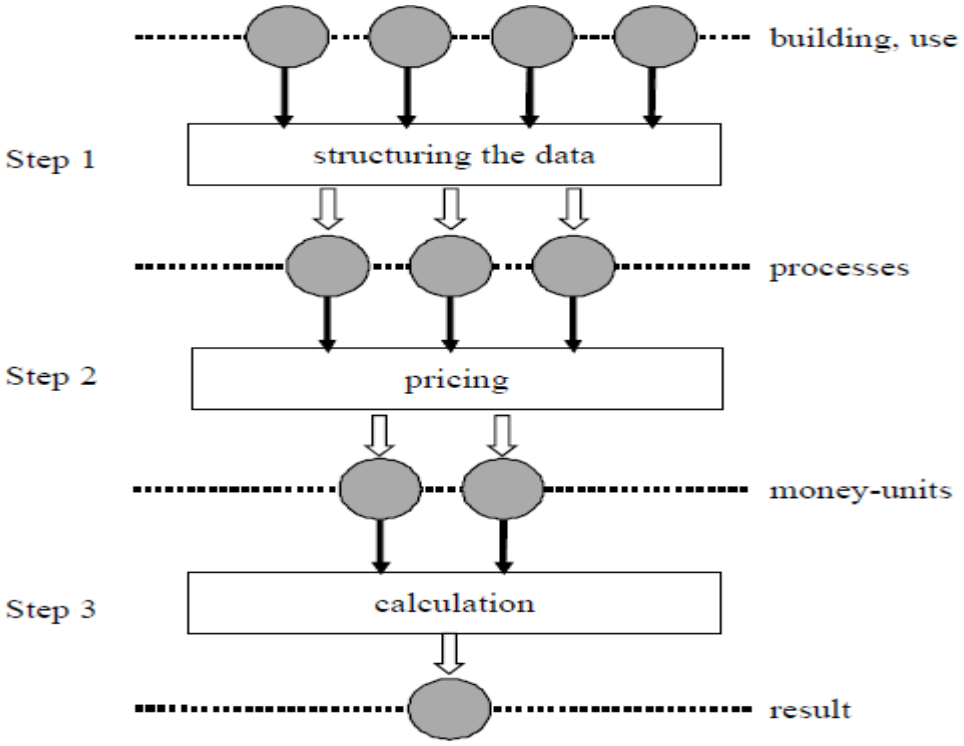


*Figure 1.* Life cycle costing *procedure* in three steps, source: (Pelzeter, 2007)

The second step is pricing. In relating prices to each process, all information is converted into money-units. In a third step, the method of calculation determines the form and unit of the result (Figure 1). The results may be transformed through a combination with non-monetary terms, e.g. LCC per m2 or per workplace. Data may be structured according to (Pelzeter, 2007):

- phase of life cycle;
- areas (according to part and type of construction, use, etc.);
- room number;
- functional elements;
- technical duration of life cycle;
- economic duration of life cycle;
- groups of costs;
- risk factors; and
- other.

Third step: calculation. The calculation of LCC can utilise all methods of investment appraisal:

- static;
- dynamic net present value (NPV);
- explicit yearly cash flow;
- incl. income;
- incl. taxes; and
- other.

First, we determine the structure necessary data. For this purpose was selected the project of a family house situated near Zvolen. Size of the useful area is 100 m2. Building elements that follow we chose external wall and windows. Qualitative parameter that affects the energy consumption for heating was selected U-value in the external wall and Uw value for windows. We designed several types of windows (W1, W2, W3, W4) and perimeter walls for wood and brick buildings (P1, P2, P3). We created combinations for comparison within the LCC and it will be more specific in the next part. Secondly, we contacted reputable manufacturers to calculate all combinations. All products used in the analysis are certified and their characteristics are guaranteed by manufacturers. For other elements of the house (roof, floor, and heat source), we choose a fixed value for all combinations.
Finally life cycle is set n = 30 years. This period is the period of the loan. The entire investment will be covered by a mortgage. Payment will consist of the fixed loan interest rate and principal, during the entire period of the loan. The average interest rate on the loan during 30 years is optimistic, set at 2%. Change in energy prices is set at 2% following the average development for the last 10 years. We designed Life cycle costs by the formula:

$$\mathrm{LCC} = \mathrm{P} + \mathrm{OC} \times e_f + \mathrm{I} \quad (1)$$

P - Loan principal = investment to external wall with thermal insulation and windows
OC – operating costs per year (costs for space heating only)
$e_f$ – Inflation factor (change in energy price)
I – interest.

After consultation with experts for the Statistics, we defined the following formula:

$$e_f = \sum_1^n (1+r)^n = \frac{(1+r)x[(1+r)^n - 1]}{r} \quad (2)$$

n – Years of lifecycle,
r – Change in energy price (prediction)

Operating costs (costs for space heating only) is determine using the methodology of the consumption calculator (Link: http://www.spp.sk/sk/domacnosti/spp-radi-a-pomaha/kalkulator-spotreby/ ) used by SPP. The methodology is based on the quantification of heat consumption for space heating for 1 year. This calculation can be considered as indicative for our purpose. Due to the selected type of heat source for LCC analysis for this paper, such as a gas condensing boiler. The input database for use of the consumption calculator methodology is made of thousands of SPP customers (family houses only) and their real gas consumption. Utilization of the SPP methodology for determining OC classifies family houses into 5 groups (A-E). For each type of house are defined parameter alternatives (roof, floor, windows, external wall and insulation), which are characterized by the U value. Groups A +, A * +, A, A *, A / B, A / B * are used in this paper. Table 2 shows what parameters belong to each class. Classes C, D, and E did not use in our analysis, because our parameters were better.

*Table 2. comparator between SPP terminology and terminology in LCC analysis*

| Type of house in SPP calculator | Type of windows and external wall in LCC analysis |
|---|---|
| A+ | U3 W2 and U3 W4 |
| A*+ | U3 W1 and U3 W3 |
| A | U2 W2 and U2 W4 |
| A* | U2 W1 and U2 W3 |
| A/B | U1 W2 and U1 W4 |
| A/B* | U1 W1 and U1 W3 |

A+ – propertie of passive house,
A*+ – propertie of passive house with window correction
A – very excelent properties of house,
A* – very excelent properties of house with window correction
A/B – very good properties of house,
A/B* – very good properties of house with window correction.

An important element of the analysis is OC, which values can be seen in Table 4. Values are based on the SPP calculator and the impact of the windows was determined using the study (Klesken, Majer, 2012).

*Table 3. cost for space heating per year (OC in LCC) (€), Source: SPP calculator*

| | **U1** | **U2** | **U3** |
|---|---|---|---|
| **W1** | 660 | 510 | 400 |
| **W2** | 620 | 465 | 360 |
| **W3** | 660 | 510 | 400 |
| **W4** | 620 | 465 | 360 |

## 3. DEFINITION OF WINDOWS AND THERMAL INSULATION OF BUILDNG EXTERNAL WALLS

For LCC analysis, we chose elements of the house windows and perimeter walls and their insulation. Other house elements are fixed for analysis. The roof and floor are determine U value = 0.15 [W/m2 K] (according to STN 73 0540-2/Z1: 2016.) for all variants. We chose a gas condensing boiler as a heat source. The relation between the heat transfer coefficient for a wall without thermal insulation and the heat transfer coefficient for a wall that has been insulated is illustrated by the formula:

$$U = \left(\frac{1}{U_0} + \frac{d}{\lambda}\right)^{-1} [W/m^2K], \quad (3)$$

$U$ – heat transfer coefficient for a wall with a thermal insulation layer [W/m2 K],
λ – Thermo insulating material thermal conductivity [W/mK],
$U_0$= 1/ $(R_0 + R_{si} + R_{se})$ – heat transfer coefficient of a wall without thermal insulation [W/m2 K],
$R_0$ – Thermal resistance of a homogenous layer of a building material [m2 K/W],
$R_{si}$ – Inside air film thermal resistance [m2 K/W],
$R_{se}$ – outside air film thermal resistance [m2 K/W],
d – thickness of the insulating layer [m].

Air film thermal resistances (Rsi, Rse), if there is no detailed information abort boundary conditions, is accepted according to STN-EN ISO 6946: 2008 (they accept the value of 0.14 and 0.04).

### 3.1. Properties of external wall and thermal insulation

According to the standards (STN 73 0540-2/Z1: 2016) we determine U-values of external walls for comparison. U1 – value according to the current regulations, U2- value according to regulations after 2020 and U3 value we determine more stringent to determine the effectiveness of increasing the U – value of external wall. We identified the combinations in Table 1.
U1 = 0, 22 [W/m2 K], combination of P1, P2 or P3 with I1, I2, I3 or I4
U2 = 0, 15 [W/m2 K], combination of P1, P2 or P3 with I1, I2, I3 or I4
U3 = 0, 11 [W/m2 K]. combination of P1, P2 or P3 with I1, I2, I3 or I4

The properties of external wall and insulations we determine in this part:
P1 – Ytong Lambda YQ, 375 mm, 375×249×599, R = 4,4 [m2 K/W] , U = 0, 22 [W/m2 K], Insulation I3, I2 or I3 (mm)
P2 – 1. External facade, 2. Wood Fibre Insulation by STEICO, λ = 0,038 [W/mK], I4 (mm), 3. Frame construction from KVH, 4. Wood Fibre Insulation in frame construction, λ = 0,038 [W/mK], 140 mm, 5. OSB 3 λ = 0,22 [W/mK], 120 mm, 6. pre-wall with natural insulation λ = 0,04 [W/mK], 40 mm, 7. SDK λ = 0,22 [W/mK], 125 mm
P3 – 1. External facade, 2. Insulation I3, I2 or I3 (mm) 3. OSB 3 λ = 0,22 [W/mK], 120 mm, 4. Frame construction from KVH with mineral wool λ = 0,034 [W/mK], 140 mm, 5. OSB 3 λ = 0,22 [W/mK], 120 mm, 6. vapour barrier, 7. pre-wall with insulation λ = 0,04 [W/mK], 40 mm, 8. SDK λ = 0,22 [W/mK], 125 mm

I1 – mineral wool, λ = 0,034 [W/mK] (density 90kg/m3)
I2 – polystyrene foam EPS, λ = 0,038 [W/mK]
I3 – polystyrene foam XPS, λ = 0,036 [W/mK]
I4 – wood Fibre Insulation by STEICO, λ = 0,038 [W/mK]

*Table 4. Insulation thickness (m)*

| **Brick of house** | | **I 1** | **I 2** | **I 3** |
|---|---|---|---|---|
| **P1** | **U1** | - | **-** | **-** |
| | **U2** | 0,08 | 0,08 | 0,08 |
| | **U3** | 0,2 | 0,2 | 0,2 |
| **Wooden house** | | **I 4** | **I 1** | **I 2** |
| **P2** | **U1** | - | - | - |
| | **U2** | 0,02 | - | - |
| | **U3** | 0,12 | - | - |
| **P3** | **U1** | - | - | - |
| | **U2** | - | - | - |
| | **U3** | - | 0,08 | 0,10 |

### 3.2 Properties of windows

For this paper we selected 4 types of windows (W1, W2, W3 and W4). Windows are characterized by Uw – value, glazing and type of window frame.

W1 – plastic window with double glass, Uw = 1,3 W/m2 K],

W2 – plastic window with triple glass, Uw = 0,8 W/m2 K],
W3 - wood window with double glass, Uw = 1,3 W/m2 K],
W4 - wood window with double glass, Uw = 0,78 W/m2 K].
According to STN EN ISO10077-1. The value of heat transfer coefficient of the window is determine by this formula:

$$Uw = \frac{Uf \text{ x } Af + Ug \text{ x } Ag + \Psi g \text{ x } Ig}{Ag + Af} \quad (4)$$

Uw - heat transfer coefficient for window
Af – area of frames (m2),
Ag – area of glass (m2),
Ψg– the glazing psi value W/(m.K),
Ig– perimeter of the glazing in the frame (m).

When we know all the parameters of windows in the building can calculate orientation loss of heat at specific types of windows in a specific location. This calculation differs from the position of the house. The heat gain is not considered for the simplification. Calculation of heat losses through windows can also be subsequently quantified in the OC using the study methodology (Klesken, Majer, 2012). The methodology of this calculation is illustrated by this formula (Klesken, Majer, 2012):

$$W \text{ real consumption} = Aw \text{ x } Uw \text{ x } Gt \quad (4)$$

W real consumption – Actual heat consumption through the window area,
Aw –The reference window area [kWh],
Uw – as already defined in the paper [W/m2 K],
Gt – The values are different in each month (deviating from the average daily temperature during the month and location [kKh],

$$\text{Transformation from [kWh] to } [m^3] = \frac{\text{W real consumption}}{10{,}555},$$

For each month we have to calculate W real conception and then make a calculation on all the used windows of the house. By the same methodology, we determine window correction for this paper.

## 4. RESULTS

From Table 5, which shows the results of all LCC analysis alternatives, we can state the following. The three best alternatives for a brick house are P1 W2 U3 I1, P1 W1 U3 I1 and P1 W2 U3 I3. Below 40 000 euros we only got the first alternative. The highest cost LCC had an alternative P1 W3 U1 I1 over 55 000 euros. The three best alternatives for a wooden house are P3 W2 U3 I3, P3 W1 U3 I1 and P2 W2 U3 I4. Below 44 000 euros we only got the first alternative.
Then we can see the difference between the best alternative for a brick house and a wooden house of about 4 000 euros. The difference between alternatives is not too big in 30 years horizon. We can say that the wooden windows (W3, W4) are too expensive and they have very similar parameters with plastic windows. Alternatives with plastic windows was better in LCC analysis. Quality of properties of windows and insulation have big impact on LCC. The lowest cost was with the highest U value for the external wall and windows, because they are lowering operating cost.

*Table 5. Results of LCC analysis (€)*

| **Brick of house** | | | **I 1** | **I 2** | **I 3** |
|---|---|---|---|---|---|
| **P1** | **W1** | **U1** | 49 948,6 | **-** | **-** |
| | | **U2** | 50 634,0 | 47 934,0 | 48 988,0 |
| | | **U3** | 45 720,3 | 40 313,3 | 42 333,3 |
| | **W2** | **U1** | 49 210,2 | - | - |
| | | **U2** | 48 858,1 | 46 164,1 | 47 217,1 |
| | | **U3** | 44 901,2 | 39 494,2 | 41 514,2 |
| | **W3** | **U1** | 54 733,6 | - | - |
| | | **U2** | 55 416,0 | 52 722,0 | 53 776,0 |
| | | **U3** | 50 507,3 | 45 101,3 | 47 120,3 |
| | **W4** | **U1** | 53 290,8 | - | - |
| | | **U2** | 53 146,6 | 50 355,6 | 51 505,6 |
| | | **U3** | 49 768,0 | 44 362,0 | 46 382,0 |
| **Wooden house** | | | **I 4** | **I 1** | **I 2** |
| **P2** | **W1** | **U1** | 55 515,4 | - | - |
| | | **U2** | 51 974,4 | - | - |
| | | **U3** | 44 973,6 | - | - |
| | **W2** | **U1** | 54 779,0 | - | - |
| | | **U2** | 50 202,0 | - | - |
| | | **U3** | 44 152,4 | - | - |
| | **W3** | **U1** | 60 303,4 | - | - |
| | | **U2** | 56 761,4 | - | - |
| | | **U3** | 49 755,6 | - | - |
| | **W4** | **U1** | 58 859,0 | - | - |
| | | **U2** | 54 490,0 | - | - |
| | | **U3** | 49 021,0 | - | - |
| **P3** | **W1** | **U1** | - | 53 692,4 | - |
| | | **U2** | - | 50 036,4 | - |
| | | **U3** | - | 47 115,6 | 44 692,6 |
| | **W2** | **U1** | - | 52 956,0 | - |
| | | **U2** | - | 48 265,0 | - |
| | | **U3** | - | 46 295,4 | 43 874,4 |
| | **W3** | **U1** | - | 58 480,4 | - |
| | | **U2** | - | 54 824,4 | - |
| | | **U3** | - | 51 903,6 | 49 481,6 |
| | **W4** | **U1** | - | 57 036,0 | - |
| | | **U2** | - | 52 552,0 | - |
| | | **U3** | - | 51 163,0 | 48 741,0 |

Source: Author's own research

P1, P2, P3 – as already defined in the paper,
W1, W2, W3, W4 – as already defined in the paper,
U1, U2, U3 – as already defined in the paper,
I1, I2, I3, I4 – as already defined in the paper.

## 5. DISCUSION AND CONCLUSION

LCC analyzes to enter many variables. They are the economic variables that are difficult to predict for 30 years. Determination of the amount of inflation, changes in prices enrgii and the interest rate the bank is a very difficult task. These parameters, of course, also affect the results of the analysis of LCC and need to choose very carefully. We chose an optimistic estimate of the economic parameters. Elements of building the roof, floor, exterior walls and windows. When comparing wooden house and

brick house, we ignored same elements of building. Therefore, we focused on the external walls and windows. Qualitative feature was U value for external wall and Uw for windows.

To analysis with a number of combinations we can say that the higher cost LCC had wooden house than brick house but the difference was not great. Many alternatives for wooden house was more positive than the brick house. We can say that you can not tell which type is more advantageous for the investor. It depends on many parameters that have to be precisely defined. The great advantage is the ecological construction site of wooden house. Use of renewable sources and various subsidies for the construction of wood can this difference be removed completely. We did not considered in the analysis of recuperation and other heat sources. Wooden windows and various alternatives have not had the lowest LCC costs. That does not mean they are not useful. In our analysis, we expected the same characteristics of windows throughout the life cycle and the same lifecycle. This should be considered in future analyzeses.

At the end of the paper we can say that LCC analysis gives us an objective view of the total cost of the family home during the whole life cycle. It takes into account the individual elements of the house and their impact on the LCC. The input economic or technical parameters of the LCC analysis can be changed and subsequently evaluated to find the optimal solution for the future customer. LCC is a suitable tool for selecting a family house based on wood or silicate.

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## REFERENCES

1. Pelzeter, A. (2007): "Building optimisation with life cycle costs – the influence of calculation methods", Journal of Facilities Management, Vol. 5 Issue: 2, pp.115-128,
2. Dylewski, R.; Adamczyk, J.; (2011): Economic and environmental benefits of thermal insulation of building external walls, Building and Environment 46 (2011) 2615e2623.
3. Kleskeň, P.; Majer, D. (2012): Prepočet spotreby plynu cez okno ?, časopis Dom a byt 2/2012, online on http:// www.makrowin.sk/spotreba-okno/ .
4. Monteiro, H.; Fernández, J., E.; Freire, F. (2016): Comparative life-cycle energy analysis of a new and an existinghouse: The significance of occupant's habits, building systems and embodied energy, Sustainable Cities and Society 26: 507–518.
5. Croxford, N., B. (2016): Lifecycle costing of low energy housing refurbishment: A case studyof a 7 year retrofit in Chester Road, London, Energy and Buildings 128 (2016) 178–189.
6. STN 73 0540-2/Z1: 2016. Tepelná ochrana budov. Tepelnotechnické vlastnosti stavebných konštrukcií a budov Časť 2 Funkčné požiadavky.
7. STN EN ISO 6946: 2008 (73 0559), Building components and building elements -- Thermal resistance and thermal transmittance -- Calculation method (ISO 6946: 2008).
8. STN EN ISO10077-1: 2006, Thermal performance of windows, doors and shutters -- Calculation of thermal transmittance

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# ANALYSIS OF CUSTOMER SATISFACTION IN THE RETAIL CHAIN STORES WITH FURNITURE

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## ABSTRACT

In our paper we present the results of the survey conducted in Slovakia. The main theme of the survey was: "customer satisfaction in the Slovak retail chain stores with furniture". The analysis was executed on the basis of the questionnaire survey evaluation among customers of the Slovak retail chain stores. The survey results were analyzed by univariate and multivariate statistical analysis. Within the contingency tables was conducted chi-square test of independence and were determined statistically significant dependencies between variables. Therefore, they were determined the factors that affect customer satisfaction in retail chain stores with furniture.
**Key words**: customer satisfaction, retail stores, contingency tables, chi-square test,

## 1. INTRODUCTION

The problematic and the importance of customer satisfaction is an ongoing issue, which should be given constant attention of every company management. Many managers still believe that customer satisfaction is reflected in the complaints. This argument is based on the assumption that if customers do not complain, they are satisfied. Research has shown that this assumption is wrong. Only few of dissatisfied customers decide to complain. However, this does not mean that these dissatisfied customers are not talking about their dissatisfaction to other potential customers. It was found that of the 100 dissatisfied customers will only four of them complain to company, but each of those dissatisfied will say that at least to ten people, so the company can lose up to thousands of potential customers. Therefore emphasis should be placed on the regular monitoring of customer satisfaction and application of new methods of examination and evaluation of customer satisfaction. Based on the received feedback companies can continually improve provided products and services and so meet customer requirements more effectively.

## 2. PROBLEMATIC

The issue of customer satisfaction was in marketing theory long neglected. Most businesses paid more attention to its market share than the customer satisfaction. However, this proved to be a mistake, because while the market share gives an indication of past performance of the company, customer satisfaction is a measure of future performance. If customer satisfaction begins to decline, it will be reflected by reducing of the market share (Kotler, 2003). Over time, the importance of studying customer satisfaction became undeniable, but so far there is no agreement about its definition. Rather there are a number of formulations and views on customer satisfaction and methods of evaluation.

Customer satisfaction can be characterized as the result of comprehensive, psychological and comparing process, when the customer compares his own experiences after using a product with the expectations, desires, individual standards or other benchmark. If the expected performance is confirmed or overcome, the customer satisfaction is creating (Mateides, Dado, 2000). Customer satisfaction can thus be defined as a subjective sensation associated with fulfillment of his needs and wishes, which are based on experience as well as expectations. In theory, customer satisfaction is based on the theory of conflict. This theory is based on determining the customer's ideas on certain parameters of the product and its benefits, which are then compared with the experience arising after the realization of the purchase. Regarding the experience that exceeded expectations, the customer has a feeling of satisfaction. Otherwise, if experience does not reach a specified customer's expectations, he

is not satisfied. It is necessary to take into account the degree of the market adaptation of the product, the impact of time and repeated satisfaction or dissatisfaction (Kozel, 2006).

There are several reasons why it is necessary to devote to monitoring customer satisfaction, not only for business but also at the macroeconomic level. The main reason on the company level is the impact of customer satisfaction on the financial results of the company. On the macroeconomic level, it is about creating measure for comparing enterprises (customer satisfaction index), which are then applied as a tool for forecasting the possible development trends of individual companies. These issues are based on the theory of conflict, which is based on the assumption that the customer has created some idea about the characteristics of the product. This idea confronts with the characteristics of the product, which received by purchase. In that moment there is a situation where the customer feels the consistency or inconsistency between experience and his expectations (Loučanová et al., 2014).

## 3. SURVEY METHODOLOGY

Collecting of data was realized by method of questioning by a questionnaire on the topic: Customer satisfaction in the retail chain stores with furniture. The questionnaires were collecting since February till the end of March 2016 in 24 retail stores of selected trade company in all regions of Slovakia.

The questionnaire consisted of questions that were aimed at obtaining of socio-demographic data of respondents (a) gender, b) age, c) location of residence, d) education, e) work status, e) income of consumers) and another 7 closed questions were related to exploring problematic of customer satisfaction with the retail chain stores of the company. Questions related to exploring problematic were aimed at:

- satisfaction with width of offered range
- satisfaction with quality of products
- satisfaction with employees' approach
- satisfaction with employees' knowledge
- satisfaction with shipping and payments conditions
- satisfaction with claim solution

For those questions were stated 4 grade scale of answer (very satisfied, somewhat satisfied, somewhat dissatisfied, very dissatisfied). Also there was one question if customers had an experience with claim (yes or no).

After collecting and separating of questionnaires were qualified 312 received questionnaires for final evaluation. For the questionnaires evaluation was used method of one-dimensional and two-dimensional descriptive statistics: frequency and contingency tables. Hypotheses were tested at significance level of $p\ (\alpha) = 0.05$. The test of null hypothesis was realized by the method of independence test – Pearson $\chi 2$ (chi-square) test. Statistical results were compared with the value table for the relevant degrees of freedom. For results evaluation we used a two-dimensional analysis by testing the null hypothesis H0, which assumes that there is no association between the two variables. Otherwise we set the hypothesis H1, which assumes that there is an association between the two variables (statistically significant). If H0 is rejected, then the hypothesis H1 is in validity (Rimarčík, 2007).

$$\chi^2 = \sum_{i=1}^{R} \sum_{j=1}^{C} \frac{(n_{ij} - E_{ij})^2}{E_{ij}} \text{ while } E_{ij} = \frac{n_i n_j}{n}, \quad (1)$$

R - number of rows (categories of row variable),
C - number of columns (categories of column variable)
$n_{ij}$ - observed value of two nominal variables,
$E_{ij}$ – expected value of two nominal variables,
$n_i$ – sum of the $i_{th}$ row,
$n_j$ – sum of the v $j_{th}$ column.

## 4 RESULTS OF SURVEY ABOUT CUSTOMER SATISFACTION IN THE RETAIL CHAIN STORES WITH FURNITURE

Within the socio-demographic characteristics of respondents we can state that in our survey were participating:

- 53 % of women and 47 % of men,
- the most respondents were in the age between 20 and 40 years (41 %) and in the age between 40 and 60 years (37 %). At least respondents were in the age up to 20 years,
- almost 30 % of respondents were from Žilina region and only 7 % were from region of Košice,
- within the education of respondents were almost half of them with high school degree (48 %), 13 % with Bachelor degree and 11 % with Master degree,
- almost 60 % of respondents were employed, 12 % were self-employed and 12 % of them were pensioners,
- the income of respondents was mostly up to 400 € (39 %) and up to 700 € (36 %).

In the question of width of offered range were almost 95 % of respondents satisfied with this factor (45 % very satisfied and 49 % somewhat satisfied). In the cases of gender, age, location of residence, education and income there were not any significant difference between answers of respondents and our hypotheses have not been statistically confirmed. Our hypothesis has been statistically confirmed only in case of work status of respondents. The most unsatisfied respondents were pensioners (14 % were somewhat dissatisfied and 3 % were very satisfied) and on the other hand the most satisfied were employed respondents (40 % were very satisfied and 56 % were somewhat satisfied).

In the question of quality of products almost 90 % of respondents were satisfied with quality of the products (29 % very satisfied and 59 % somewhat satisfied). In the cases of gender, age, location of residence and income of respondents there were not any significant difference between answers of respondents and our hypotheses have not been statistically confirmed. Our hypotheses have been statistically confirmed in case of education and work status of respondents. The most respondents who are very dissatisfied and somewhat dissatisfied with quality of the products have basic education (26 % of them). On the other hand, the most respondents who are very satisfied have university education (one half of them). Within the work status the most satisfied are employed respondents (64 % are somewhat satisfied and 30 % are very satisfied). The most unsatisfied satisfied respondents are pensioners (27 % of them).

In the question of employees' approach were 78 % of respondents very satisfied with an approach of employees and 21 % of respondents were somewhat satisfied. In the cases of gender, location of residence and income there were not any significant difference between answers of respondents and our hypotheses have not been statistically confirmed. Our hypotheses have been statistically confirmed in case of age, education and work status of respondents. Within the age of respondents were the most very satisfied respondents with employees' approach from the group 60 years and over (90 %) and the lowest level of satisfaction had respondents from the group up to 20 years (59 %). In the case of

education were the most very satisfied respondents with university education (94 %) and the lowest level of satisfaction had respondents with basic education. Within the work status the most very satisfied are employed respondents (86 %) against only 55 % satisfaction of students.

In the question of employees' knowledge were 73 % of respondents very satisfied with knowledge of employees and 26 % of respondents were somewhat satisfied. Within this question there were not any significant difference between answers of respondents depend on their socio-demographic characteristic and our hypotheses have not been statistically confirmed.

In the question of experience with claim of the products 26 % of respondents had an experience and 74 % of respondents don't have any experience. In the cases of gender, age, location of residence and income there were not any significant difference between answers of respondents and our hypotheses have not been statistically confirmed. Our hypothesis has been statistically confirmed in case of education and work status of respondents.

In the question of shipping and payments conditions almost 90 % of respondents were satisfied with this factor (58 % very satisfied and 32 % somewhat satisfied). Within this question there were not any significant difference between answers of respondents depend on their socio-demographic characteristic and our hypotheses have not been statistically confirmed.

In the question of claim solution were two thirds of respondents satisfied with the solution of their claim (24 % very satisfied and 42 % somewhat satisfied). In the cases of gender, age, location of residence and income there were not any significant difference between answers of respondents and our hypotheses have not been statistically confirmed. Our hypothesis has been statistically confirmed in case of education and work status of respondents.

## 5. CONCLUSION

Based on the survey results we can conclude that in the explored retail sales chain of furniture dominates high customer satisfaction in each of the explored areas. The highest overall level of customer satisfaction was achieved in width of offered range and absolutely most customers were very satisfied with the approach of the staff in the stores and the knowledge of staff. This result is perhaps a little bit surprising because in Slovakia is currently approach of the staff and their knowledge quite a common problem. The result can therefore be attributed to a long-term history of explored company on the market and also to effective management of sales staff. All companies have to pay attention on behavior of selling persons and their communication with customers, as well as on the professional level of their knowledge.

Within the statistically significant results were pensioners the most dissatisfied respondents by the employment status. They were most dissatisfied with the width of offered range, product quality and claims solution. It could follow from greater disposition of free time by pensioners, so they would welcome more offered products in store and therefore could spend more time in store. In the case of quality of products the results may indicate that pensioners perceived product quality differently than other groups of respondents and thus may also relate to dissatisfaction with claims solution. On the other side, older respondents expressed the highest satisfaction with the approach of employees. This may result from the tendency of elderly people to communicate more, and often times not only about purchased products. Expression of their highest satisfaction confirms the very good level of employee communications and customer care in retail chain stores.

In the case of respondents' education were the respondents with basic education relatively less satisfied with the quality products, employees' approach and claim solution. On the other side, respondents with university education were the most satisfied. In this case is visible a clear difference in the perception of quality parameters by respondents' education. This significant difference indicates that respondents with basic education probably cannot properly attribute the quality parameters to the products, because their opinion differs significantly from the opinion of other respondents. Likewise,

form this different perception may result a negative opinion to claim solution. This may be related to the ability of problem review and mutual acceptance of arguments. Within people with university education is expected greater knowledge of the issue, as well as understanding the arguments of the opposing party. From this abilities can result maximum satisfaction of these respondents. In contrast, by respondents with basic education may mentioned competencies and abilities absent.

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## REFERENCES

1. Kotler, Ph. (2003): *Marketing od A do Z. Osmdesátpojmů, ktoré by měl znát každý manažér.* Praha: Management Press, 205 p. ISBN 80-7261-082-1.
2. Kozel, R. (2006): *Moderní marketingový výskum*. Praha: Grada Publishing, 280 p. ISBN 80-247-0966-X.
3. Loučanová, E.; Parobek, J.; Paluš, H. (2014): *Identifikácia požiadaviek slovenských zákazníkov na úložný nábytok na základe modelu KANO*. In: Acta Facultatis Xylologiae Zvolen. ISSN 1336-3824. - Vol. 56, No. 1 (2014), pp. 109 – 117.
4. Mateides, A. – Ďaďo, J. (2000): *Spokojnosť zákazníka a metódy jej merania*. Bratislava: EPOS, 255 p. ISBN 80-8057-224-0.
5. Rimarčík, M. (2007): *Štatistika pre prax*. 200 p. ISBN 978-80-969813-1-1.

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# FURNITURE TESTING FOR HIGHER COMPETITIVENESS, BETTER QUALITY AND DESIGN

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## ABSTRACT

The furniture manufactured in new century can be characterized by joints manufactured on the computer numerical control (CNC) machine. This furniture is from the point of view of structure known as ready-to-assemble (RTA) or dismountable furniture. The current trend lies in the interdisciplinarity of the product development and testing of mechanical properties of furniture. The mechanical testing and manufacturing process of chair, table and joint manufactured on CNC machines are described. The Digital Image Correlation (DIC) analyzes displacement and deformation of critical construction. The numerical simulation predicts the most stressed joints and together with furniture mechanical tests allows us to work on its higher quality. The test results provide new information that can be used during developing process and enable the optimization of strength properties. This article presents the importance of furniture product development and application of new testing methodologies.
**Key words**: furniture, testing, technology, quality

## 1. FURNITURE TESTING: STATE OF THE ART

The mostly manufactured furniture today is dismountable furniture. This furniture is usually described as a type of construction with a use of knock-down fittings. This construction is commonly used by large volume producers as well as small carpenters because of its simplicity. The significant advantages are the through-feed lines, production cells or other technologies that can be used for drilling, sawing and routing. Dependence on the fittings and its influence on design, price and quality of final product are the major issues. The nesting technology had an influence on the manufacturing of joints on CNC machines. The ready-to-assemble (RTA) furniture is the result of such approach. The necessity to eliminate multiple positioning of the part on the machine table leads to new construction and joints development related to the CNC machines. Manufacturing cell is able to produce a complex furniture product which is simple for production as well as for assembly with high accuracy and without any additional material for joinery. Nevertheless, the process depends on manufacturing technology which influences the speed, flexibility and quality. The above mentioned principles excluding their disadvantages and traditional construction concepts can lead to new interesting designs. The nowadays furniture construction and technology development trends and modern methodologies of applied research and development of industrial products enable faster launch of competitive furniture products. The synergic effect of the above described fact is wide cooperation between research and development university departments and commercial sphere.

CNC machining technology has been developed in the 40`s and 50`s of the 20 century in the United States. Main advantages of a CNC technology are automation of the manufacturing process, high accuracy and speed of processing, high reliability and versatility with low maintenance and exclusion of technology breaks for new settings. On the other hand main disadvantages are higher purchasing and operating costs, higher knowledge demands on the operator and lower production speed compared to large series production of the various specialized machines (Higley, 2002). While RTA and/or flat pack furniture has been produced for more than twenty years, experience with constructing it and with its strength properties is still limited. Development of technologies, new materials and informatics not only in production and marketing, but also in furniture design brings many methods which allow engineers and designers to adopt new work approaches. Despite the fact that standardized furniture testing, is not compulsory for producers in most cases, it is commonly

implemented. Numerical simulations have been applied by furniture industry in a limited way so far, e.g. Mirra Chair (Larder and Wiersma, 2007). However they are supported by research quite significantly. From a large number of works we can mention research on behaviour of constructions of sitting furniture (Prekrat et al, 2012; Horman et al, 2010) or case furniture (Nicholls and Crisan, 2002; Tankut et al, 2012).The DIC method in relation to a shape/deformation measurement describes e.g.(Nestorović et al, 2011).

## 2. EXPERIMENTAL (LABORATORY) TESTING

The design of the chair was made by a CNC machine out of plywood (12mm), with integrated dovetail not-glued joints. Similar principles of furniture based on rapid manufacturing were described e.g. (Oh et al, 2006). The construction of the chair was assembled from six parts while no glue was used. It was designed as self-locking construction (Figure 1). The construction was mechanically loaded in an accredited furniture testing laboratory according to the Czech standard CSN EN 1728 (2013), article no. 6.4. Experimental optical measurement was carried out by the digital single lens reflex camera which was set perpendicularly to the examined surface. To achieve constant intensity of the recorded surface image, it was necessary to keep stable lighting conditions. For this purpose the examined surface of the chair construction was lightened by diffuse lights. The frequency of recording was set up to 1 fps. The open-source tethering software, connected to the camera, was used to transfer data to PC. Correlation computation of displacement and strain fields was carried out in DIC software.

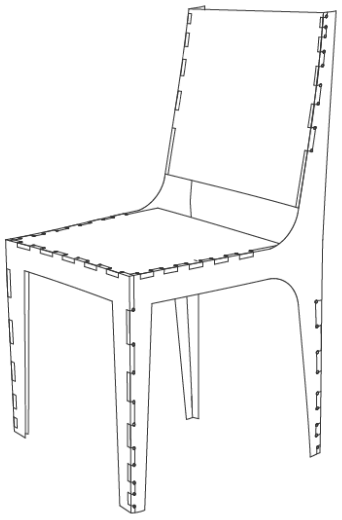

*Figure 1. RTA chair design, used for testing*

The goal of the work was to compute displacement fields on the chair side surface using the DIC method. The DIC computation brought reliable results which are based both on quantitative (standard deviation was lower than 0.05) and qualitative evaluation (displacement contours follow mechanical behavior assumptions resulting from a loading mode). The highest absolute value of horizontal displacement was experienced at the top of backrest (u = 3,9 mm) and the highest absolute value of vertical displacement was experienced at the front leg (v = 1,2 mm). The next step in the analyses was to look at the strain fields computed from displacements. The strain field in horizontal direction (εxx) is depicted in the Figure 2; the vertical strain component (εyy) is depicted in the Figure 3. The results show that vertical strain is highest in the dovetail connections on top of the chair seat.Its highest absolute strain did not exceed 0,3 % so we can affirm that all strains occurring there are elastic, below the proportional limit of all possible loading modes in wood and birch plywood (Wood Handbook, 2010). The horizontal strain is the highest in the backrest dovetail joints and its maximal absolute value is 1,56 %.

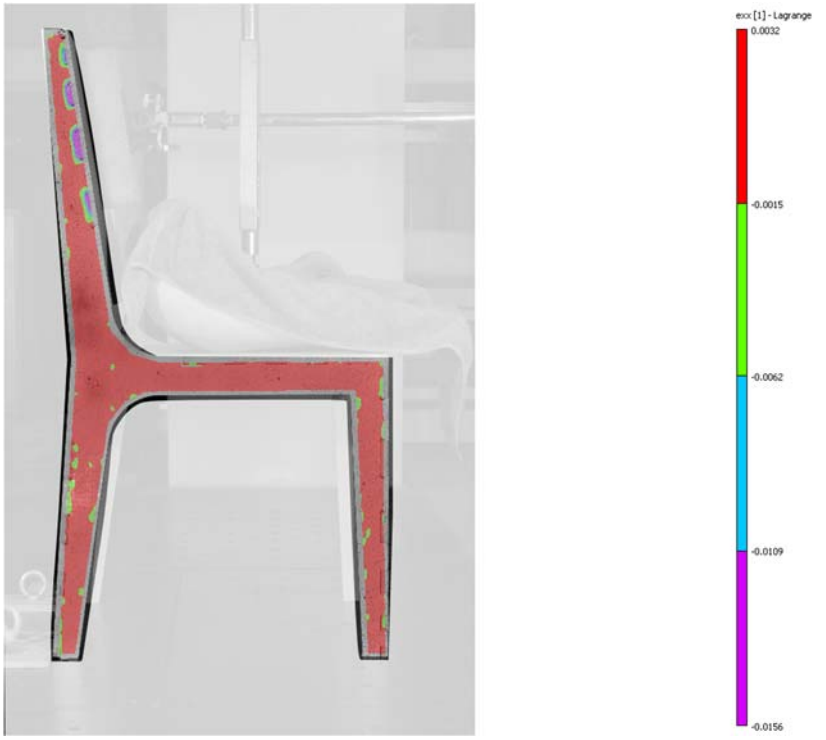


*Figure 2. Results: the strain field in horizontal direction* (εxx)

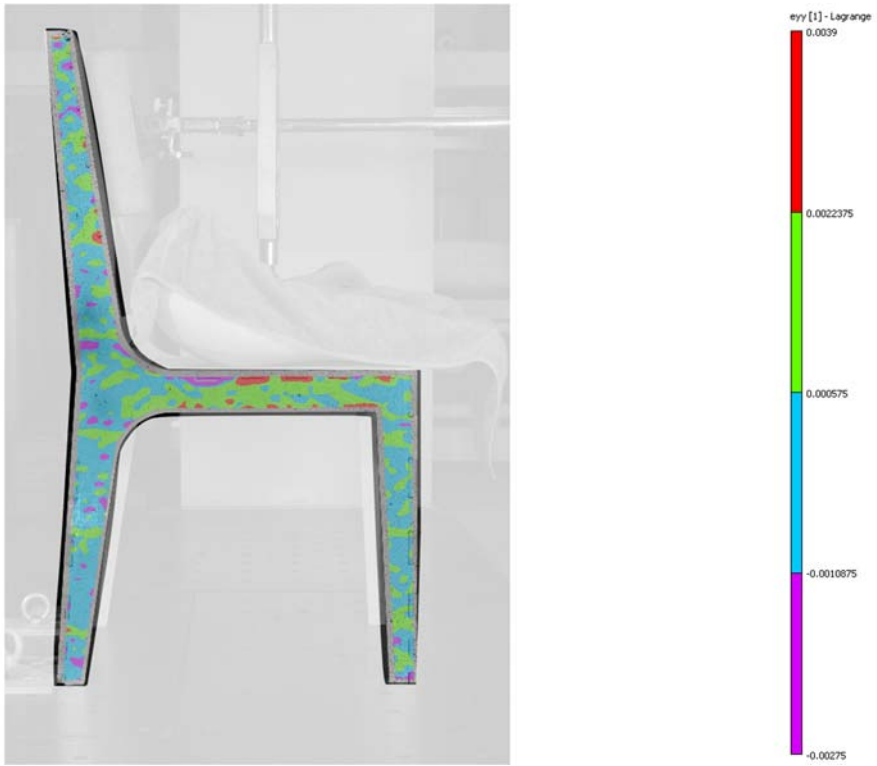


*Figure 3. Results: the strain field in vertical direction (εyy)*

## 3. NUMERICAL TESTING OF FURNITURE

The analysed desk construction was produced as a prototype using CNC laser cutting, precise CNC press banding (metal parts – base of the desk) and typical furniture production CNC processing (wooden composite materials – desk top).The aim of the study was to establish the probable mechanical behavior of the office desk, especially the base, in consequence of the defined static loading based on the standards. The study focuses on the analysis of the extreme response (maximum tension)

points and the probable breakage points by means of static numerical analysis. These points will be evaluated and based on that we will propose a solution for the achievement of the optimum results. The model of the analysed construction was created in the modelling environment of the CAD software (Autodesk Inventor). The three-dimensional model was parametric. The strength numerical analysis was carried out in the module Strength Analysis of the used CAD software application by means of the finite element method (FEM).

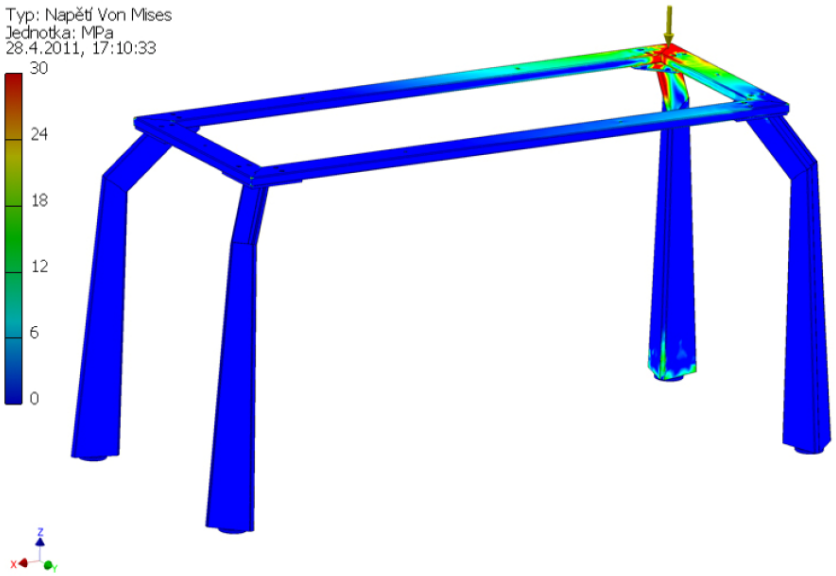


*Figure 4. Results: equivalent tension (von Mieses) when the apron is loaded in the corner*

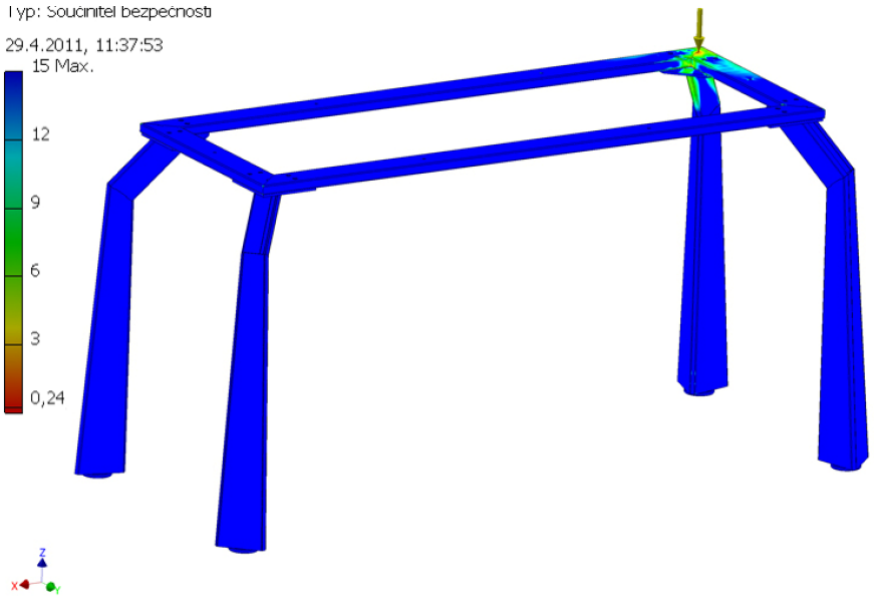


*Figure 5. Results: coefficinet of safety – apron loaded in the corner*

The model is nonlinear in its geometry and it is made of three different materials. All components were allotted with the appropriate material and the its properties: physical, mechanical and constants such as density, Young´s modulus of elasticity, Poisson constant, yield points and rupture points in tension were established based on literary sources and standards. The process of ascertaining the size of the affecting force was based on the Czech standard (EN 527-3, 2005) which deals with the methods for the construction stability and mechanical strength establishment. Based on paragraph 5.2 of the

standard – Vertical loading test - two points where a loading force of 1000 N was applied on the construction were selected. The first was the centre of a long apron; the second point was a corner of an apron. The construction of the desk stand was analysed with emphasis on the upper part of the leg. The leg is made of an open profile, therefore, we expected that it will be the most sensitive to loading.

The results of the numerical simulations are presented in a graphical form as pictures showing the progress of the measured quantity by means of color spectra. The resulting images represent von Mises stress (Figs. 4) and the coefficient of safety (Figs . 5 and 6). The desk top was excluded from the simulation as in the final prototype this is made of anisotropic – laminated chipboard, which would unnecessarily prolong the calculating time. With respect to the focus of the study on the analysis of the stand and the critical points in the upper part of the leg, an inclusion of a desk top would be inefficient. Therefore, when assessing the results of the analysis, we have to take into account that the loading force applied to the desk apron at the given point would be more homogeneously distributed over the entire construction – thanks to the desk top.

According to the analysis, the expected deformations and damage would occur at the points where the upper part of the desk leg is connected to the plate (which ensures the dismantling connection of the desk leg to the apron), specifically at the points of contact between the plate and the edges. Because of the symmetry in the leg geometry and the symmetrical progress of tension in this geometry, the leg was divided by a vertical plane in the axis of symmetry and further we will only concentrate on the results of one half of the model. In Fig. 8 we can see the lowest coefficient of safety of 0.41 in bending inside the open profile. This value says that the equivalent tension at this point is 504.88 MPa, which is approximately 2.5 times higher than the yield point of steel (Re 207 MPa). According to the numerical analysis, a permanent deformation of the material would appear at this point.

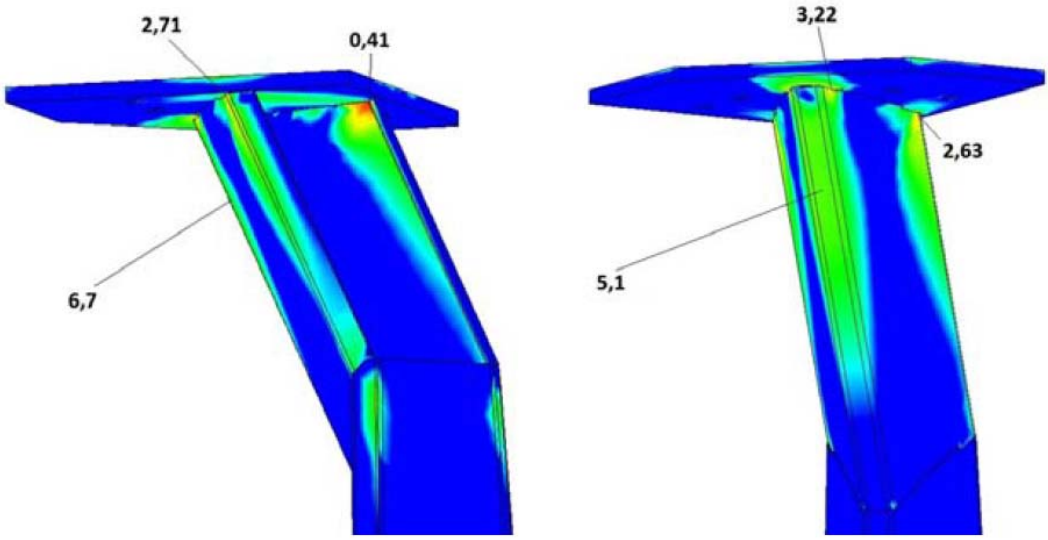


*Figure 6. Results: coefficient of safety – detailed view of the upper part of the leg*

## 5. NUMERICAL TESTING OF RTA JOINT

The example of RTA furniture joint and numerical simulations in Finite Element Method (FEM) is shown in Figures 7 and 8 or by (Šimek and Koňas, 2009). The design was prosessed in ANSYS software with the use of 18mm particleboard, cam fittings and beech dowel joints were employed in non-linear solution. The stress was applied in angular plane, in compression. This numerical model can further be used for example to design a piece of case furniture or to optimize some design variables.

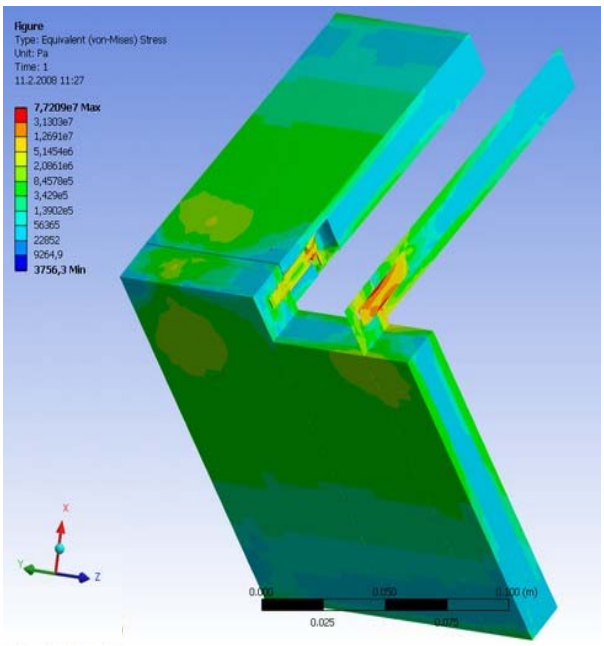


*Figure 7. Results: von Miesses equivalent of RTA joint loaded at angle plane in compressio*n

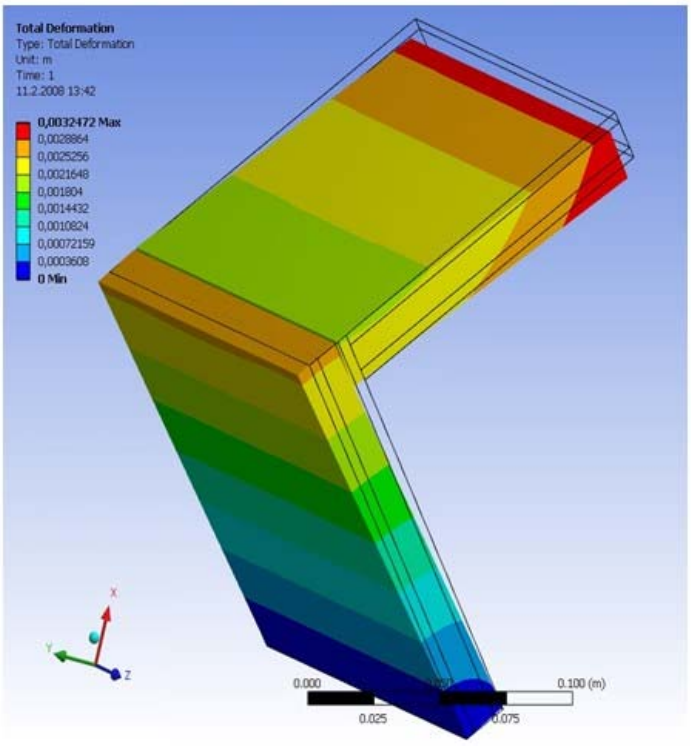


*Figure 8. Results: total deformation of RTA joint loaded at angle plane in compression with initial geometry*

## 5. DISCUSSION AND CONCLUSION

Standard testing of furniture mechanical properties is well known among bigger manufactures, even though the quality testing and certification is not obligatory in many countries. ISO, ASTM or other standards are applied together with new materials and technologies in the furniture industry. Furniture products are very accurate and quickly made thanks to new technologies. The use of hardware as a traditional approach in European furniture industry is one of the basic principles of furniture

constructions. The influence of computer technologies and processes bring new holistic perspective to furniture industry.

The focus of this article is to demostrate new concepts of furniture testing based on the connection with modern technologies, recent R&D advances in the field of wood products and parametric design. Such design currently represents what most industries are trying to achieve – not only does it save resources, but it also increases competitive strength and stimulates innovation (Song and Gazo, 2013). In the furniture industry and timber trade, this tendency may be observed largely in the field of education and innovation. This is due to the fact that one of the specific features of parametric designs is usually innovative design that is not always accepted by customers. Also due to the fact that furniture, unlike other industrial products, doesn't have such well-developed legislation dealing with the placement of new products on the market, new products struggle to break into the market. From the applied method point of view, it is possible that presented methods are applicable to furniture testing due to time saving, low requirements on employed devices, undemanding data procession and data assessment realized by accredited laboratories or research institutes. Research institutes of furniture companies can apply these methodologies to increase their competitiveness and innovation potential (by deeper analysis of data it is possible to detect poorly designed connections or to optimize the construction from the shape or used materials point of view. Presented methods are projected to be adopted in the future by large and mid-size furniture manufacturers.

**Acknowledgement:** We wish to thank to the Faculty of Forestry and Wood Technology, Mendel University in Brno for the support of this research.

## REFERENCES

1. Higley, J. B. (2002): *CNC applications.* Calumet., Purdue University, USA,
2. Horman, I., Hajdarević, S., Martinovaić, S., Vukas, N. (2010): *Numerical analysis of stress and strain in a wooden chair.* Drvna Industrija, 61 (3), pp. 151-158.
3. Larder, L., Wiersma, J. (2007): *CEA takes a front seat.* ANSYS Advantage, Vol. 1/1, 2 p.
4. Nestorović, B., Skakić, D., Grbac, I. (2011): *Determining the characteristics of composite structure laminae by optical 3D measuremtent of deformation with numerical analysis*. Drvna Industrija, 62 (3), pp. 193-200.
5. Nicholls, T., Crisan, R. (2002): *Study of the stress-strain state in corner joints and box-type furniture using Finite Element Analysis*. Holz als Roh- und Werkstoff , v. 60, pp. 66–71.
6. Oh, Y., Johnson, G., Gross, M.D., Do, E.Y.L. (2006): *The designosaur and the furniture factory.* International Conference on Design Computing and Cognition, Eindhoven, NL, pp. 123 – 140.
7. Prekrat, S., Smardzewski, J., Brezović, M., Pervan, S. (2012): *Quality of corner joints of beech chairs under load.* Drvna Industrija, 63 (3), pp. 205-210.
8. Song, M., Gazo, R. (2013): *Competitiveness of US Household and Office Furniture Industry*, International Journal of Economics and Management Engineering, Apr. 2013, Vol.3 (2), pp. 47-55.
9. Šimek, M., Koňas, P. (2009): *Modelování ohybového namáhání demontovatelných nábytkových spojů metodou konečných prvků. Acta Universitatis agriculturae et silviculturae Mendelianae Brunensis,* sv. LVII-1, pp. 137-146.
10. Tankut, A.N., Tankut, N., Karaman, A. (2012): *Creep performance of Ready-to-Assemble fasteners in bookcase construction.* Proceedings from XXIII. International Conference Ambienta, Zagreb, October 12, 2012, pp. 195-208
11. *** EN 1728 (2013): Furniture – Seating furniture – Testing methods for the determination of strength and Durability
12. *** ČSN EN 527-3 (911105) (2005): *Kancelářský nábytek – Pracovní stoly (Office Furniture – Working Tables)*, Český normalizační institut, Praha, 16 p.

13. *** USDA Forest Service (2010): *Wood handbook – Wood as an Engineering Material*, Centennial edition. FPL, Madison, p. 509.

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# WOMEN IN FORESTRY SECTOR IN BULGARIA

Chobanova, R.; Georgieva, D.

## ABSTRACT

This paper aims to characterize the employment rate, performance as well as economic and social work conditions for women in forestry sector in Bulgaria. It also aims to characterise the impact of factors affecting competitiveness and productivity corresponding to females employment, such as: formation of wages; education and training, insurable earnings for women in the sector, etc. At the end, some conclusions and policy recommendations are drown. The study is based on literature and legal framework survey, as well as on statistical analysis and individual interviews.
**Key words**: forestry, competitiveness, labour productivity, women, Bulgaria

## 1. INTRODUCTION

One of the main strategic objectives of the European Union (EU) is to achieve inclusive economic growth by increasing the level of female employment in the Member States of the Union. There are some specifics of employing women in forestry sector. On the one hand a major challenge to the forestry sector development in Bulgaria is the loss of competitiveness that results to negative consequences such as slowing the economic growth and ineffective utilization of forest resources in the country (Chobanova R., 2016, p.61). On the other hand, the different activities in forestry are not equally attractive for women and this has to be taken into account when identifying where increasing the employment is leading to better labour productivity and competitiveness of the sector. In this respect it is important to characterize the employment rate, performance as well as normative and real work conditions for women in Bulgarian forestry sector and factors affecting them.

## 2. EMPLOYMENT OF WOMEN IN THE FOREST SECTOR IN BULGARIA

Generally in Europe the employment rate is lower among women[5]. The EU strategy aims to achieve 75% employment rate of females and males at the age between 20 and 64 years, by 2020. On a national level, a priority objective of Bulgaria is to increase the employment rate of people at the age between 20 and 64 years, up to 76% by 2020 (Europe 2020: National reform programme, 2015, p. 49). The number of employed women is approximately 9 percentage points more than the number of employed men in 2015[6]. Such kind of data could be considered as positive when it comes to the participation of females in the labor market, which as noted, is almost equaled to that of males.

Employment of women in forestry sector differs from the general employment in the economy. For the period 2008 - 2015 the employment of women in forestry sector is lower, more specifically in "Forestry and logging"; "Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials"; "Manufacture of paper and paper products"; "Manufacture of furniture" (see figure 1)[7]. The highest number of employed females is reported in the "Manufacture of furniture" but their share, however, is only 1/5 of the total number of the employed in the industry. One of the most underdeveloped industries based on women employment's rate is

[5] Employment rate is 63% among women and 76% among men at the age between 20 and 64 years.

[6] The data is based on published information in National statistical institute for employed men and women in the Northwest, North Central, Northeast, Southeast, Southwest and South Central regions of Bulgaria.

[7] The data is from Eurostat for the period 2008-2015 on the basis of analysis of employed men and women only for the periods for which there is published data in these sectors.

"Forestry and logging". In addition, for the time period that is analyzed, all considered sectors reports an outflow of female labor force. The lowest employment rate of women is for the years 2014 and 2015. Therefore, although at national level there is overall improvement in employment rates, the data for the forestry sector indicates lower activity in the labor market.

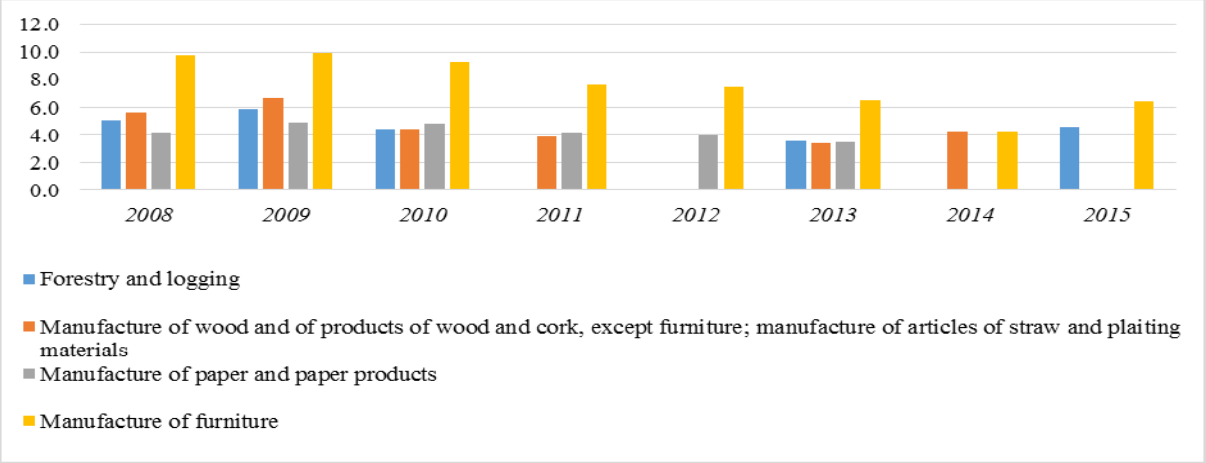


*Figure 1. Employed women in "Forestry and logging"; "Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials"; "Manufacture of paper and paper products"; "Manufacture of furniture", 2008-2015, thousands*

*Source: calculated using data from Eurostat, 2016, [online]: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=for_emp_lfs&lang=en, Last update on 21.12.16, Extracted on 27.01.17*

## 3. EDUCATION AND TRAINING OF WOMEN WORKING IN THE FORESTRY SECTOR

Among the main factors affecting productivity and competitiveness is education. For that purpose by 2020, 40% of women and men who are at the age between 30 and 34 years should acquire tertiary or equivalent education (Europe 2020 strategy for smart, sustainable and inclusive growth, p.13). The national contribution to achieve this objective concerns the target - by 2020 to increase the percentage of people, falling in the age group between 30 and 34 years old, who have tertiary education up to 36%. In 2016 this percentage is 33.4%, which marks a positive trend.

The impact of education in forestry sector to the growth differs from the national level. Taking into account the fact that women who are employed in the forestry sector in Bulgaria have low level of education and skills (see figure 2) the impact of this factor could not be defined as positive for improving competitiveness in the forestry sector. In addition, none of the considered forestry sectors reports data for employed women that have tertiary education.

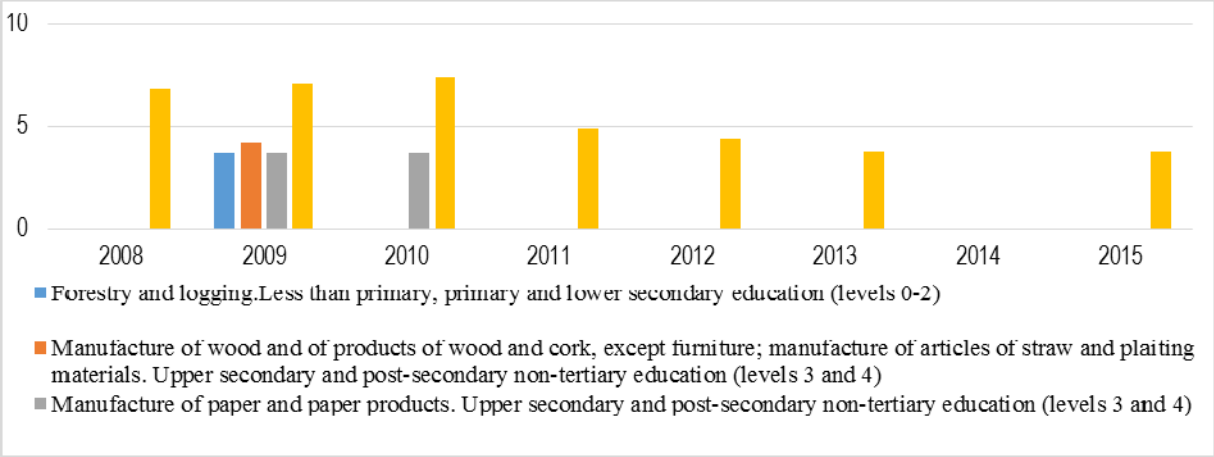


*Figure 2. Educational level of women in "Forestry and logging"; "Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials"; "Manufacture of paper and paper products"; "Manufacture of furniture", 2008-2015, thousands*

*Source: calculated using data from Eurostat, 2016, [online]: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=for_emp_lfs&lang=en, Last update on 21.12.16, Extracted on 27.01.17*

In order to identify the reasons for such lower level of female employment in forestry sector we will examine the impact of general for the sector development factors such as minimum wage, minimum monthly insurance income, as well as specific for female employment factors such as differences in salaries and maternity leave.

## 4. GROSS NATIONAL MINIMUM WAGE AND MINIMUM MONTHLY INSURANCE INCOME OF WOMEN EMPLOYED IN FORESTRY IN BULGARIA

There is a common understanding, supported by several arguments that the correlation between women's participation in the labor market and the payment they receive is positive (Cuberes D., M. Teignier, 2011, p. 9). On other hand, there is no significant deviations from the way of forming the wage of employees working in the forestry sector in Bulgaria compared to other economic sectors. Employees in the forestry sector that are receiving additional remunerations for working overtime and on Sundays are almost twice less than the country's total number of people receiving additional payments (Stefanova - Bogdanska D., 2014). In this context, women that are employed in the forestry sector relay mainly on the gross wages that are specified in their employment contracts.

For the purposes of forming the contracted gross wage significant influence have the minimum wage[8] for the country per year and the minimum monthly insurance income by professions and positions per year. The minimum wage regulates the minimum amount of salary, which women who are employed in the forestry sector must receive as remuneration. As a result of changes in economic, political and social level, the amount of the minimum wage (for all professions and positions in the country) increases annually and in 2017 it is 460 leva. It should be noted that Bulgaria is in the group of countries in Europe in which the monthly minimum wage is below 500 EUR[9]. This in turn is a factor that affects the income of employed women in the forestry sector. The annual changes of the minimum wage are essentially a

[8] The minimum wage is the lowest wage on an hourly, daily or monthly rate that employers may legally pay to their employees. It has gross nature, must be form based on market principles and is annually determined by the state.

[9] In the scope of the group of countries in Europe where the monthly minimum wages are below EUR 500 except our country falls further Romania, Lithuania, Hungary, the Czech Republic, Latvia, Slovakia, Croatia, Estonia, Poland and Albania, Montenegro, FYR Macedonia/ Republic of Macedonia and Serbia. From all the countries that are included in this group only Albania and FYR Macedonia/ Republic of Macedonia have less monthly minimum wages than Bulgaria.

prerequisite for changes of the average annual salary which employed females in "agriculture, forestry and fishing"[10] receive. From 2010 to 2015 there is insegnificant increase of the average annual salary of women who are employed in the sector (see figure 3).

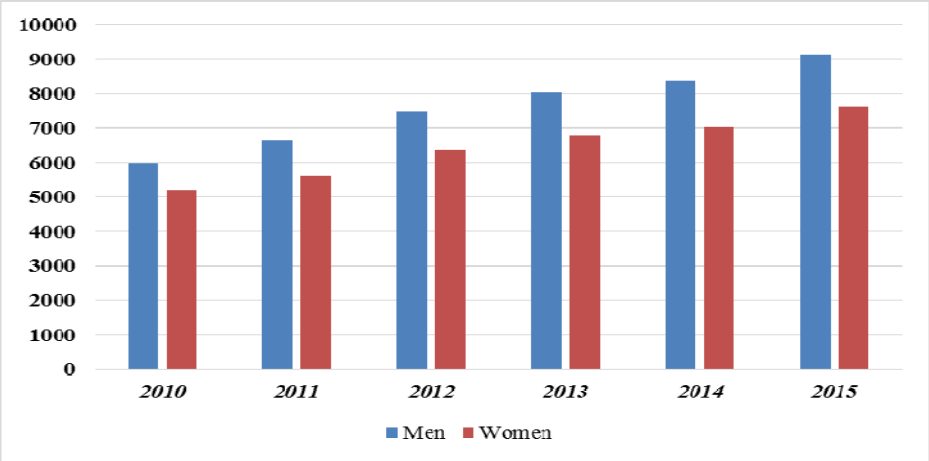


*Figure 3. Average annual wages of men and women employed in sector "Agriculture, forestry and fishing", 2010-2015, in leva*

Source: calculated using data from National Statistical Institute, 2016; [online]: http://www.nsi.bg/bg/content/3958/%D0%BD%D0%B0%D1%86%D0%B8%D0%BE%D0%BD%D0%B0%D0%BB%D0%BD%D0%BE-%D0%BD%D0%B8%D0%B2%D0%BE-%D0%B8%D0%BA%D0%BE%D0%BD%D0%BE%D0%BC%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8-%D0%B4%D0%B5%D0%B9%D0%BD%D0%BE%D1%81%D1%82%D0%B8-%D1%84%D0%BE%D1%80%D0%BC%D0%B0-%D0%BD%D0%B0-%D1%81%D0%BE%D0%B1%D1%81%D1%82%D0%B2%D0%B5%D0%BD%D0%BE%D1%81%D1%82-%D0%BF%D0%BE%D0%BB, last open on 15.04.2017

TThe gender equality can enhance competitiveness and economic productivity, which is a prerequisite for achieving higher economic growth (Cuberes D., M. Teignier, 2015, p.1; Revenga A., S. Shetty, 2012, p. 40-43). In the forestry sector in Bulgaria there is a pay gap between men and women which is increasing through the years (see figure 3). As main reasons for the existence of such gap the following factors can be mentioned - the presence of discrimination in the workplace; different working tasks that are given to men and women; various practices that employers provide to men and women regarding their career development and skill training; underestimation of the kind work and skills women can develop or already have, and the opportunities to reconcile work and family responsibilities (Tracking the gender pay gap in the European Union, 2014, p. 5-7).

The minimum monthly insurance income is introduced in Bulgarian legal framework in 2003. It serves as a basis for calculating the compulsory and voluntary contributions that are made for and by the insured person. For the representatives of female sex social security contributions have an important role in determining the amount of compensations that must be paid by the National Insurance Institute in terms of general sickness and maternity. For the period 2010 - 2017 an increase of the minimum insurance income is noted among all qualifying groups of professions employed in forestry sector (see table 1). This increase is largely due to changes in the minimum wage during the years. For forestry jobs that do not require special qualification from 2010 to 2013 (inclusive) the amount of minimum monthly insurance income is higher than the amount of minimum monthly wages for the same period. From 2013 to 2017 (inclusive) both indicators are aligned. For the period 2016 - 2017 the

[10] In terms of national statistics it should be noted that the statistical data published in the NSI includes the information for the entire sector "agriculture, forestry and fishing." There is no published detailed data concerning only the forestry. Therefore, the following data and conclusions are made for the whole sector "agriculture, forestry and fisheries" in which forestry is included.

amount of the minimum monthly insurance income for skilled workers in forestry is similar to that of the minimum wage for the country. In this basis, the legislature introduces equal insurance relations to the qualified and unqualified staff. In terms of minimum monthly insurance income, fishing and agriculture (covered by sector - "agriculture, forestry and fishing") offers better opportunities than those of forestry for women – managers, specialists and workforce, who does not occupy managerial positions. This conclusion is based on the fact that for the period 2012 - 2017 the amount of the minimum monthly insurance income for qualified and unqualified staff in fishing and agriculture is higher than in forestry (Social Security Fund Budget Act, Appendix № 1 to Art. 9, para. 1, p. 1, by years).

*Table 1. Minimum monthly insurance income in forestry, 2010 – 2017, in leva*

| Years | Managers | Specialists | Technicians and associate professionals | Administrative support | Employed in public services, trade and security | Skilled workers in agriculture, forestry, hunting and fishing | Qualified workers and craftsmen | Machinery operators and assemblers | Professions requiring special qualifications |
|---|---|---|---|---|---|---|---|---|---|
| 2010 | 621 | 444 | 392 | 380 | 320 | 352 | 392 | 397 | 270 |
| 2011 | 655 | 466 | 412 | 400 | 336 | 370 | 411 | 457 | 283 |
| 2012 | 684 | 487 | 431 | 418 | 351 | 387 | 429 | 478 | 296 |
| 2013 | 700 | 500 | 450 | 430 | 390 | 400 | 440 | 490 | 320 |
| 2014 | 750 | 525 | 472 | 451 | 400 | 400 | 450 | 490 | 340 |
| 2015 | 780 | 546 | 491 | 469 | 416 | 416 | 468 | 510 | 360 |
| 2016 | 900 | 620 | 530 | 480 | 450 | 420 | 520 | 500 | 420 |
| 2017 | 900 | 620 | 530 | 480 | 460 | 460 | 520 | 500 | 460 |

*Source Collected from Social Security Fund Budget Act, Appendix № 1 to Art. 9, para. 1, p. 1, per years*

The low rates of the minimum insurance income have negative effects to maternity leave and the opportunities for raising a child. In order to increase female participation in the labor market in the forestry sector, it is appropriate and helpful to increase the minimum insurance income and to bind it to the wages and qualifications of employees. This could help women towards reconciling work, private life and motherhood.

## 5. MATERNITY LEAVE AS FACTOR FOR INCREASING WOMEN'S EMPLOYMENT

In 2014 employed women in Bulgaria between 20 and 49 years old who have children under the age of 6 are approximately 13.5 percentage points less than employed women without children. This data is above the EU average for the same period (13.2%) (Labor force participation of women, 2015, p.4). It is believed that parenting has a significant impact on female employment (Country report Bulgaria, 2016, p.38), which is a factor that has strong impact on the productivity and competitiveness of the forestry enterprises. Main factors that affects the participation of women with children under the age of 6 in the labor market are: legal rights of women, regarding their rightful maternity leave and compensations for it; access to services related to child care; working hours and the opportunity for part-time work; and working conditions in the workplace.

In accordance to the European legal framework (Council Directive 2010/18/EU), Bulgarian legislation defines the pregnant women and mothers as a risk group, providing them specific legal protection. In this regard female employees in forestry sector have the right to leave for 410 days due to pregnancy and childbirth for each child (Labor code, article 163). During maternity leave, women are paid compensation, which is 90 % of the average gross wage or the average daily insurance income, on which the social security contributions for a period of 24 calendar months before the month of the

maternity leave are calculated. However, the amount of financial support provided by the state and calculated on this basis, is below the necessary parental resources that are needed for raising a child. It is so, because of the fact that the compensations are directly related to the social security income which minimum rates (see table 1) are equivalent or close to the gross national minimum wage. The legislature allows the maternity leave of 410 days to be transferred from the mother to the father who should take care of the child. This provision does not encourage fathers to take maternity leave, despite the fact that the leave is paid and recognized as working experience. Such circumstances can be seen as main reasons women to refuse to terminate their maternity leave and to return to work, despite the low amount of compensation provided by the state for raising up a child[11].

In Bulgaria for the period 2007-2014 the percentage of women who do not work due to maternity leave or to take care of elderly has increased by 5 percentage points (Labour force participation of women, 2015, p.15.). It should be noted that there is a risk of loss of skills and competencies related to protracted maternity leave (European Commission 2013 Employment and Social Developments in Europe; OECD (2012) Closing the Gender Gap). Because of that childcare services could help mothers to raise their children while working and by that to reduce the percentage mentioned above. However, childcare services in our country are underdeveloped and only 11% of children under the age of 3 attend kindergartens for more than 30 hours per week (Country report Bulgaria, 2016, p.38). This is 23 percentage points below the target of the European Council in this area. Fees of childcare services are identified as the main reason for the underdevelopment in this area. In this regard, fees in Bulgaria for childcare for all-day service for one child in 2012 are approximately 5% more than the net income of a family with two members (Labour force participation of women, 2015, p.18). The lack of childcare facilities is the second most important reason pointed out as a factor negatively affecting the use of such kind of services.

When the maternity leave is over and the mother must return to work she has the rights to offer her employer, for a certain period of time, to change the employment relation in connection to the duration and distribution of working hours (Labor code, article 167, p. b). This legislative rights helps mothers through the adaptation process from maternity leave to perform well on their job. However, part-time work is not a common practice in Bulgaria and less than 5% of employees do not work full-time jobs (Labour force participation of women, 2015, p.5). It should be noted that till now, the awareness of women regarding their legislative rights on issues concerning maternity leave was not an object of reproductive population attitudes study. Because of that, there are no data on women who benefited from the legislature rights for mothers, imposed by the law.

Economic literature claims that a factor indirectly affects competition on the labor market is the reproductive behavior of women (Gencheva, M., J. Marinova, p.70). This behaviour is mainly connected to concerns over the negative impact of workflow and working conditions on the embryo (fetus). In this regard, some possible reasons for miscarriage among women are hard physical labor tasks, presence of harmful working conditions and workplace stress. For the period 2006 - 2010 accidents in forestry sector are mostly associated with loss of control over the machine, vehicle or forklift trucks; loss of control over hand tools or objects; movement of the body during physical load (normally leading to an internal injury); movement of the body that can lead to fracture, cleavage, sliding, falling, collapsing; slipping or tripping to fall; falling. However, only small share of employees in forestry sector feels that their health is at risk during work and that their job has a negative impact on their health. In this regard, although there are work accidents reported in forestry sector, there are relatively low rates of absences because of health reasons ("Prevention Safety and Health at Work" job security, life, p.7). In addition, the legislature imposes the requirement enterprises to have rooms for personal hygiene of females and for rest of pregnant women. There is a legislative prohibition women to participate in difficult and hazardous work tasks. Because of that, enterprises must transfer females to suitable jobs or must alleviate the working conditions for all pregnant women or nursing mothers that are employed in the

[11] The conclusions are based on conducted individual interviews with women, working in forestry sector, who are currently on maternity leave, pending their pregnancy and birth, or parents of children up to 6 years old.

organization. Therefore, forestry sector in Bulgaria is a sector with a low risk in terms of safety and security for women.

## 6. CONCLUSIONS AND RECOMMENDATIONS

As a main conclusion it could be notted that participation of females in the forestry labor market is lower than of males.This state of the art is resulting from the influence of several factors such as economic, legal and social.

In order to stimulate employment rate among femaes in forestry sector it should be eliminated the pay gap between genders. The foregoing can be accomplished through increase of the wage and the monthly insurance income. This should not be done lightly, but the rise must correspond to the specifics of the tasks performed by woman as well as her education, skills and competences. It is appropriate to introduce requirements in the job description for each position, regarding not only the level of education but obligation for yearly increase the level of knowledge and skills of workers (skilled and unskilled). The obligation should not be interrupted during maternity leave. Because of that, development and implementation of virtual educational platforms (VEP) could be seen as a form of a long distance learning that could benefit all workers that must be absent from work for a long period of time.

The main social factors that are having an impact on women's employment rates may be linked to the possibility females to combine work tasks with their personal lives. This has strong impact mainly to future and current mothers and mothers of children under the age of 6. By providing childcare services, creating work environment conducive to the maintenance and development of the social status and introducing flexible full-time working hours for mothers, employers can support the balance between women's work and their family obligations. It is appropriate during safety briefing on labor safety, some of the lessons to have focuses on women and maternity rights legislation. In particular, females' rights for diferent working conditions and prevention of risk factors that can lead to miscarriage. Such social policies must be disclosed in the non-financial statements and anual forestry enterprises's reports, which would promote and enhance the image of organizations that have adopted them.

From the legislative point of view it should be noted that despite the process of harmonization between national and European legislation, no substantial progress in women employment in forestry sector, was achieved.

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## REFERENCES

1. Chobanova R. (2016). Intensifying SMES business networks in forestry, 9th International Scientific Conference WoodEMA 2016, The path forward for wood products: a global perspective, p.61-66.
2. Council Directive 2010/18/EU of 8 March 2010 implementing the revised Framework Agreement on parental leave concluded by BUSINESSEUROPE, UEAPME, CEEP and ETUC and repealing Directive 96/34/EC
3. Country report Bulgaria (2016), A thorough review on the prevention and correction of macroeconomic imbalances, Brussels, 26/02/2016, the SWD (2016) 72 final
4. Cuberes D., M. Teignier (2011). World Development Report 2012: Gender Equality and Development, World Bank
5. European Commission (2013). Employment and Social Developments in Europe
6. Europe 2020: National reform programme (2015). Republic of Bulgaria, Ministry of Finance
7. Europe 2020 strategy for smart, sustainable and inclusive growth, Brussels, 3.3.2010 COM (2010) 2020 final

8. Labour force participation of women (2015). European Commission, 2015
9. Labor Code, promulgated. SG. br.26 from 1986., last amended and supplemented. SG. 105 from 30 December 2016
10. Revenga A., S. Shetty (2012). Empowering Women Is Smart Economics, Finance & Development, Vol.49, №1
11. Stefanova - Bogdanska, D. (2014). Specifications management salaries in the furniture industry
12. Tracking the gender pay gap in the European Union (2014). Luxembourg: Publications Office of the European Union
13. ***: Emplayment rate, age group 20-64, European countries.

URL: http://ec.europa.eu/eurostat/web/europe-2020-indicators

14. ***: Statistics on minimum wage

URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Minimum_wage_statistics/bg

15. ***: Presidency conclusions (2002).*Barcelona European council*

URL: http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/71025.pdf

16. ***: Sectoral characteristics of working conditions

URL:http://bilsp.org/documents/551_5_%D0%90%D0%BD%D0%B5%D0%BA%D1%81%20C%20-%20%D0%A1%D0%B5%D0%BA%D1%82%D0%BE%D1%80%D0%B8.pdf

17. ***:Gencheva, M., J. Marinova The status of Mothers in Bulgarian legislation: developments and trends or how legislation imposes discriminatory norms and attitudes towards women

URL: http://www.cwsp.bg/upload/docs/63.pdf

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# IMPROVING FORESTRY SECTOR MANAGEMENT IN THE REGION OF BLAGOEVGRAD AND KYUSTRNDIL IN BULGARIA

Chobanova, R.; Popova, R.

## ABSTRACT

The paper attepts to characterise the performace and problems before forestry sector in Bulgaria and its cross border region with Macedonia (FYROM). The methods applied include statistical analyses of demographic trends, GDP, unemployment, R&D, ICT potential, cluster activities as well as generalisation survey's results from a focus group of with managers of forest industry SMEs, provided in Octber, 2016. Also analysis of the main policy documents for forestry development of the coutry are provided. Some recommendations are drown concerning management of supply chain based business network development applying contemporary ICT.
**Key words**: Bulgaria, challenges, innovationbusiness network, supply chain, forestry

## 1. FOREST SECTOR IN BULGARIA

### 1.1 General characteristics of forestry[12]

Forest areas of Bulgaria occupy 4,148,114 ha or 37.4% of the territory. Of these, 3,774,778 million ha (91.0%) are forests. Prevaling is the state ownership of forest areas - 74.5 % of the total area. For the period 2005 - 2010 the average annual logging growth rate increased from 14.1 million m3 to 14.4 million m3 of wood and is 178 m3 / ha. The use of non-timber forest resources as a business - source of revenue is inadequate. To a considerable extent, especially in forest areas - state property, the potential remains untapped. This is due to lack of inventory as well as of realistic assessment of these resources and opportunities they provide for revenue diversification in the forestry sector. (National strategy for development of the forestry sector in Bulgaria, 2013)

The registered around 3,000 enterprises in forestry, including logging activities, predominantly work according to weather conditions, only about 400 of them work permanently. The logging enterprises are characterized by low productivity, non-innovative equipment for logging, haulage and transport of wood, low level of education and skills of workers. (National strategy for development of the forestry sector in Bulgaria, 2013).

The forest road network in the country is relatively underdeveloped. According to data from expert assessment of the World Bank, in forest areas there are about 28 000 km of roads. Of these, about 10,000 km are paved with gravel or asphalt coating and about 18,000 km are unpaved. Those, owned by State Forestry Company and State Hunting Company are about 18,000 kilometers, and of the Republic and others - about 10 000 km. (National strategy for development of the forestry sector in B th, 2013)

[12] Forestry is a sector of the economy addressing natural resources management. It encompasses certain activities such as logging, primary processing site, hauling and loading timber (logs and logs) in a vehicle and transportaction. The forestry provides raw materials for the Forest Industry.
According to the Classification of Economic Activities (NCEA-2008 in Bulgaria) economic activities are separated into sections. Each sector consists of several sections. Forestry falls under Sector A "Agriculture, forestry and fishing", Section 02. This section includes farming activities, forestry trees and gathering of wild forest materials and products. Besides the extraction of wood (logs) in forestry some partially processed products are extracted - firewood, charcoal produced in a conventional manner and sets for industrial purposes (mine props, industrial wood for the production of chemical pulp, etc.). Activities in Forestry are presented in two groups - 02.1 Reproduction of forests and 02.2 Logging. The processes in Forest sector include: Logging, Woodworking, furniture manufacturing, Production of briquettes / pellets.

Over the past 10 years, mainly due to financial constraints, no new roads are built, maintenance or reconstruction of existing ones is insufficient. 75% of the total forest roads are not convenient for of modern means of transporting timber. In addition, as a result of the depreciation of the forest road network increases the share of unusable or with difficult access during certain periods ones. This fact results in increasing activities and costs in supply chain, and in such a way in reducing the competitiveness of the forest sector. Forest underdeveloped infrastructure and poor condition of forest roads create prerequisites for excessive use of wood in certain forest areas. In addition, traditional practices on construction of forest roads are lagging behind in comparison to other European countries that aim to mitigate the potential environmental violations resulting from the design and construction of forest roads. (National strategy for development of the forestry sector in Bulgaria, 2013)

The main problems of Forestry in Bulgaria according to the National strategy for development of the forestry sector in Bulgaria, 2013, are low labor productivity; difficult access to financing; lack of opportunities for using funds from the EU structural funds to invest in the renewal of equipment, machinery, technology and transport of forest products; insufficient participation (support) by banks in investment projects; low level of certified forest areas and certified forestry contractors.

### 1.2. General characteristics of forest Industry

**Forest Industry** includes woodworking and furniture manufacturing. According to the Bulgarian Chamber of Forest Industry (BCWFI), for the period 2008-2015, the number of enterprises in both subsectors of 4226 declined to 4074. Employment decreased from 47 663 in 2008 to 36 682 in 2015. (BCWFI, NSI 2015**)**

The forest industry is part of sectors of C "Manufacturing" and includes section 16 – “Manufacture of wood and products of timber and cork, except furniture”, Section 17 – “Manufacture of paper and paperboard and products of paper and cardboard” and Section 31 – “Furniture manufacturing”. The most specific characteristic of these sections of sector C is that they include activities of enterprises which make chemical or mechanical transformation of materials, substances or components in new products.

Technical and economic characteristics of the Forest Industry could be assumed as follow: (Grigorov, 2008)

• the main raw material used in woodworking is wood;
• final products of timber processing are wood panels, plywood and others products;
• low transportability of raw materials and production base wood;
• high level of wood waste accompanying the different phases of the treatment of wood;
• economic value is increasing with multiple usage of wood at different stages of technological processes.

The main problems of the Forest Industry in Bulgaria are identified as follow (BCWFI, 2016):

• low export readiness;
• problems with delivery of raw material;
• lack of qualified staff.

**Woodworking** includes activities for the processing of wood raw material by cutting and planning, manufacture of products of wood, cork, veneer and plywood, parquet floors, woodwork and timber products for construction, wooden containers, etc. The production of woodworking enterprises is a key material in the furniture manufacturing and this puts into focus the furniture as a final product and result of the manufacturing in Forest Industry.

As an economic resource the wood has several characteristics, among which are:

- Wood is an organic material of plant origin and is reproduced in nature with or without human intervention. For most tree species reproduction process lasts from 80 to 120 years, and for fast growing species from 15 to 40 years.
- The timber use is universal for many sectors of the national economy – in industry, in agriculture, in construction, in the manufacture of musical instruments, etc.

- The timber could be defined as scarce raw material, because of its wide use and long periods of reproduction.
- The timber has a large heterogeneity in the species, size (length, diameter, volume), shape (curvature) and particularly in physical and mechanical properties that are different even in a separate carcass in the longitudinal, transverse and radial direction. Depending on these differences is determined technology and organization of processing and its storage mode for the machines, quantity and quality and use.
- Woodworking and furniture manufacturing are not fully utilized. This is due, on the one hand, unevenness and, on the other hand - the characteristics of technological processes in mechanical and processing. There are underusing , wasting as well as transport problems. The amount of waste in this production is around 25-40%, in plywood is about 55-60% of the raw material, while the veneer - over 60%.

Securing the raw materials is very important for enterprises. It determines achievement of their economic goals for both sectors Forestry and Forest Industry. The timber is simultaneously exercised product of Forestry and the main raw material in the Forest Industry. On the one hand, production and sale of wood determine the financial results of companies whose business is the manufacture of wood. On the other hand, wood is the raw material of quality and quantity of which depend on economic performance of enterprises, who transform it. For business influenced by many other factors - the price of raw materials, seasonality and timing of deliveries, average transportation distances, etc.

Raw material price is the main factor of competitiveness of enterprises in the Forest Industry. This cost typically varies between 40 and 65% of the total cost, depending on the category and quality of the wood and the cost of the other components of the manufacturing process, for example chemicals, energy and labor.

## 2. FOREST SECTOR IN BLAGOEVGRAD AND KYUSTENDIL REGIONS

### 2.1. General characteristics

Districts of Blagoevgrad and Kyustendil are part of the South Planning Region of Bulgaria and are on the crossborder with Macedonia (FYROM). They include 462 municipalities, 452 973 villages and cities and a population of 452 973 people. The prevailing share of enterprise belongs to manufacture of furniture for offices and shops. The smallest share among them belongs to the production of mattresses.

### 2.2. Problems

The problems in the region identified by the INTERREG IPA CBC Programme 2014-2020 concern demographic development, unemployment, poverty, GDP, cooperation and ICT, competitiveness and innovation. These problems affect the Forestry development in the cross-border region.

The *demographic development* of the two regions is characterized by low population density, reduced fertility and an aging population. In the period 2007-2012 the population decreased in Kyustendil (-10.98%) and noted extreme reduction in municipalities Treklyano (-43.74%) Nevestino (-26.80%), Rila (-24.17% ) Kocherinovo (-21.10%) and several others.

*Unemployment* is 10.4% in Blagoevgrad. But significantly higher are the levels of unemployment in rural areas. It is due to low economic activity, low share of educated workforce and high youth unemployment. This is a problem of big importance for both cross-border countries. Unemployment among young people, especially those with higher education is worrying because of the emigration phenomenon having two main consequences. The first one concerns emigration, taking place mostly in higher educated population. Motivating young and qualified professionals and scientists to stay / move in the region is a problem given the lack of opportunities for career development. The second one concerns worsening the already unfavorable demographic situation in the region.

The *poverty rate* has negative trends of increasing. Blagoevgrad is on the first place in the country with the lowest proportion of people living below the poverty line (12.4% in 2011 compared to 21.2% for Bulgaria).

*GDP* over the period 2007-2011 increased in Kyustendil - 5%, but remained below the national average. Foreign investments in the region are quite limited and this is a barrier for the efficient and sustainable development of local enterprises. (NSI, 2012).

The main areas of *industrial activity* are the production of clothing and footwear, food, pharmaceutical and machinery, electronics, power generation and mining. The problems of the industry are related to the loss of competitiveness due to ongoing restructuring, loss of traditional markets, lack of modern technology, low resource efficiency, lack of management skills and technical personnel and weak investment and research and development.

*R&D* is not among the main strengths of the two regions. Overall, capacity for innovation and R&D remains at the national level is too low from EU-27. There are limited opportunities (financial, human, managerial) and very low potential for innovation of existing enterprises to implement new technologies into account prevailing international character of applied research. The majority of existing enterprises have a low level of technological development and limited potential for applied research. They lack the know-how and qualified personnel in order to achieve innovative growth. Nevertheless there are still enough internal dynamic engines for research and development that can accelerate innovation potential in the region (University of Blagoevgrad, American university in Blagoevgrad, etc.

### 2.3. Good practices potential

There are several examples of good practices with potential for solving the above problems. They respect cluster development some examples of which in the cross border. *Clusters* can be seen as a starting point for coordination of networking activities at the institutional level. According to expert opinions potential for cluster development in the forestry sector of the region exists in the processes of *logging - woodworking- furniture production*. Among the leading companies in these operations in the region are:

*Table1: Leading companies in logging, woodworking and furniture*

| *Logging* | *Woodworking* | *Furniture* |
|---|---|---|
| Semkovo 99 - Belitsa | Technowood - Razlog | Pirinska mura – Bansko |
| State Forestry enterprise - Yakoruda | Yakorudski bor - Yakorouda | Belar furniture - Razlog |
| Perivol - Razlog | Georgi Penchev - Belica | Meni - Bansko |
| KI VO KO - Bansko | Ariana M 91 - Razlog | Mebelprom – Razlog |
| | PK Belica - Belitsa | Polezhanov - Razlog |

The end product of such clusters in the region could be: Furniture for offices and shops; Kitchen furniture; Joinery and timber products; Packaging of wood; Other.

There is lack of use of information as contemporary resource of competitiveness. The use of ICT in mountainous and remote areas is quite limited.

*Competitiveness* of regions is generated by low cost factors (of labor and of natural resources), but not on innovation, education and training, technology transfer, research and development. In addition recent years the economies of the regions of Kyustendil and Blagoevgrad maintain their specialization in sectors and activities that require relatively low skills and technologies. Such policy determines the nature of regional exports, which is mainly of products with low added value.

*Low productivity and resource efficiency* of local SMEs is a problem that interferes with their ability to withstand the competition from neighboring countries and the EU. Difficult access to financial resources prevents SMEs to successfully development and competing with their European counterparts. The insufficient SMEs' access to international markets is another factor affecting such stAte of the art.

*Logging* is typical for places closely located to forests. This forest activity has significant potential for the region because of existing natural resources. However, its share is modest and far from possible income generation. The results can be improved through measures and cooperation for the efficient and sustainable use of forests in the region.

Concentration of management of forest areas ownership is presented by the Southwestern state enterprise in Blagoevgrad. It manages state forest areas in seven districts - Blagoevgrad, Kyustendil, Sofia City, Sofia region, Pazardzhik, Pernik and Lovech. It is composed of 38 regional offices and 35 state forestry and 5 - State hunting ones. The total area of forest areas managed by Southwest state enterprise is 934 968 ha, of which 686,310 ha are state forest areas (73.4%). This is a rich natural resource that determines the large volume of activities in the forests. (http://www.uzdp.bg)

In the *Forest industry* dominates the production of joinery, wood panels and other products. The smallest share of the production belongs to the packaging. The largest woodworking companies are: Technowood - Razlog, Furnirplast Ltd. – Blagoevgrad. Among the largest furniture companies is Pirinska mura - Bansko. The wood raw material is often purchased from other regions. The materials for the manufacture of furniture are basically different types of wood panels. Bulgarian furniture companies buy it from Kastamonu - Kazanlak and Kronospan - Burgas, the two great woodworking enterprises in the country, situated also in other geographical areas and from foreign manufacturers.

A discussion with representatives of the Furniture Industry in 2016 shows that the main problems of the enterprises are:

- Inadequate management skills in the sector;
- Insufficient information about business opportunities in the branches;
- Loss of traditional markets;
- • Insufficient cooperation with research institutions, as well as of links to European networks;
- Lack of information about registration of patents and other forms of protection of industrial property;
- Lack of information about standards;
- Difficulties in career development of women working in the sector;
- Unattractive work and working conditions in the sector;
- Low level of pay in the sector.

The recommendations of the business to BCWFI and institutions summarized on the base of the focus group discussion in October, 2016 are as follow:

- raise awareness and reduce problems with communications, particularly for those enterprises that are in remote areas of the country;
- creation of a digital platform for the needs of enterprises in the Forestry sector to raise awareness of developments in the sector, opportunities for participation in various European associations and networks, programs and projects of the EU and others;
- cooperation between enterprises and application of patent for production in the regions.

## 3. CONCLUSIONS AND RECOMMENDATIONS

The analyzes of the state of the art of regions of Blagoevgrad and Kyustendil in terms of demographic trends, GDP, unemployment, R&D, ICT, forest potential, cluster initiatives allow highlighting factors negatively affecting forest business development. Among them are:

- low density of population, falling birth rate and aging population;
- high youth unemployment;
- limited investment;
- slow process of increasing GDP;
- low productivity and resource efficiency;
- low level of technological development and limited potential for applied research;

- unused forest potential, creating conditions for the development of clusters in the chain - *logging – woodworking - furniture*.

Overcoming such barriers requires:
- improving forest management (e.g., forest planning effective zoning based on a landscape approach, improving the sustainability of forest plantations, the introduction of responsible purchasing policies);
- improvement of technologies (e.g., more efficient use of raw materials and recycling efficiency);
- improvement in management (e.g., strengthening social safety nets, more effective implementation of policies and practices);
- improvement of policies (for example, the creation of incentives for reducing the rate of unsustainable forest management by implementing public policies that support responsible forest management);
- improvement of scientific information database;
- sustainable consumption;
-improvement of the roads.

Possible management solutions include also implementation of the universal reference model for Supply Chain including Planning, Procurement, Manufacturing, Order Management, Logistics, Returns, and Retail; Product and Service Design including Design Planning, Research, Prototyping, Integration, Launch and Revision, and Sales including CRM, Service Support, Sales, and Contract Management which are congruent to the Porter framework.

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## REFERENCES

1. Christova, D.,2011, State of clusters in Bulgaria, Association of Business Clusters in Bulgaria
2. Communication from the Commission: An Integrated Industrial Policy for the Globalisation Era. Putting Competitiveness and Sustainability at Centre Stage, COM(2010)614, 28.10.2010
3. Communication from the Commission: A Stronger European Industry for Growth and Economic Recovery. Industrial Policy Communication Update, COM(2012)582, 10.10.2012
4. Communication from the Commission: Industrial Renaissance COM(2014) 3 NACE Rev. 2 Division 16 (“Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials”)
5. Grigorov N.,2010, Improving the organization of woodworking and furniture companies in Bulgaria in terms of the transition to a post-industrial society, S.
6. Grigorov N., 2008, Network organizational structures and their applications in enterprises of wood and furniture sector, S..
7. National strategy for development of the forest sector in the republic of Bulgaria for the period 2013 - 2020, May, 2013
8. Program CBC IPA Bulgaria - FYROM 2014 to 2020.
9. ***: http://www2.eshipglobal.com
10. ***:www.timberchamber.bg
11. ***:https://www.mi.government.bg/bg
12. ***:www.nsi.bg
13. ***:http://www.apics.org/
14. ***:http://mebeli.info/
15. ***http://www.uzdp.bg
16. ***:http://www.uzdp.bg

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# USING OF QUALITY CONTROLLING AND BALANCED SCORECARD IN THE QUALITY MANAGEMNT

Šatanová, A.; Gaffová, Z.; Nedeliaková, E.

## ABSTRACT

Controlling is a tool that should bring greater transparency to the factory economy of companies and contribute to its effective management. The basis for using controlling in quality management is process-oriented approach and economic concept of quality. Contents of costs on quality can be concretised through the several models. This article deals with issue of using Controlling and Balanced Scorecard in the quality management of chosen company. The paper presents that the benefits of solved issue lies in the detection and in the identification of costs on quality, in definition of possibilities of its tracking as a basis for the introduction of quality controlling in company and its linking to the determination of company strategy with using Balanced Scorecard method.
**Key words**: quality, controlling, quality management, quality economy, Balanced Scorecard, strategy.

## 1. Introduction

Quality requirements for products and services are touching equally of big, medium and small companies. The reason is fact that the quality is the guarantee of customer satisfaction and success of the company and in the oncoming conditions of turbulence development is the quality reliable business tool of the viability of the company, it means - guarantee of its future (Zgodavová, 2002).

Prerequisite for success is becoming controlling as a tool for integrating processes of information processing, analysis, creation of business plans and controls (Baran, 2001) and the draft of company´s strategy. Therefore, this article deals with the application of controlling and Balanced Scorecard in quality management in chosen company.

## 2. THEORETICAL BACKGROUND OF RESEARCH PROBLEMS

The term "controlling" is of English origin and is derived from the verb "to control", respectively noun "control", whose translation has more than 50 content meanings. The verb meaning to that term is to (1) maintain, manage, regulate, to (2) govern, to (3) use, control. (Eschenbach, 2000).

That concept also explains the expression "to have airplane under control", which means "an aircraft under control." (Foltínová, Kalafutová, 1997). Horváth (Horváthová, Gallo, 2003) considers controlling as a "management tool whose function is to coordinate the planning, control and secure information base, to improve business results and achieve their objectives."

Mann / Mayer (Mann, Mayer, 1992) define controlling as a "system of rules that facilitate the achievement of business objectives in a timely manner to prevent surprises and turns red when it appears in the management of risk requiring appropriate measures". Another definition states Bauer (Bauer, 2003): "As a controlling concept aims to support decisions of the management, creating a streamlined information system and provide the necessary information to the goals of economic forms."

Freiberg (Freiberger, 1996) defines controlling as a "specific policy of corporate governance based on comprehensive information and organizational links of the planning and control process." Macík (Macík, 1999) called for controlling as an "integration tool to combine several control and information subsystems." According Chodasová (Chodasová, 2000) controlling is "one of the most effective methods for enabling search key issues in corporate governance. The core of the controlling is

a comparison is of planned state with the real facts, in measurable terms, and in the evaluable expression (Brabec, Kymlička, 1996).

Quality has to be oriented to meet customer requirements. TQM concept has certain principles of quality management, we have based on the materials of the European Foundation for Quality Management (EFQM) visualized in Figure 1 (Noskievičová, 1996).

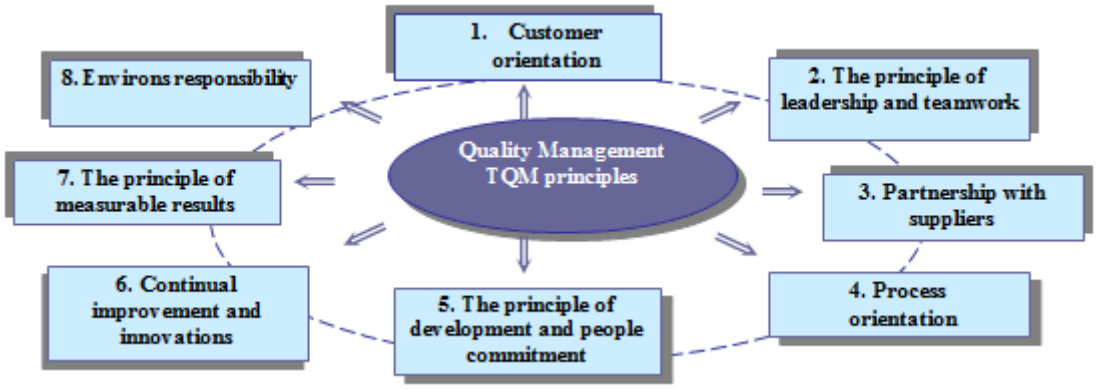


*Figure 1. The principles of quality management according to TQM concept*

Process management also in the field of quality management (see principle 4 in Figure 1) is not applied in the organization as a set of functions, but as a set of processes. It establishes responsibilities for individual processes and seeks to effectively manage the processes to achieve the greatest added value to customers "(Booth, 2003). To identify and determine the relationship between the processes it usually used process map that graphically illustrates the distribution of all processes in the company. How to define such chart is shown in Figure 2.

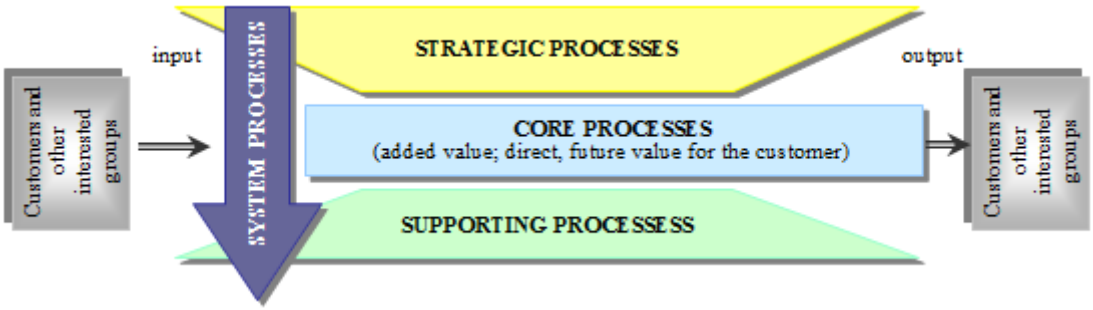


*Figure 2. Example of compilation process map for any company*

The following proposal brings together two concepts, i.e. controlling and quality management, which together produce a new concept of controlling the quality that is still not in Slovak companies in a wide application, but in practice, in German companies, has been known for several years.

Balanced Scorecard as a tool for improving the efficiency of processes enables to convert the vision and strategy of the organization into a comprehensive set of performance measures of processes.

The basic requirements for effective performance measurement of processes include: the validity of measurements, completeness of measurements, sufficient frequency of measurements, the accuracy required, the possibility of detecting bottlenecks performance, timing measurements, stability data obtained at the time, clarity of information, accountability for the measurement results. Before we fulfill this strategy, you need to ask the fundamental question: What is the quality of my products and processes? In the answer to this question is the hidden secret of the success of the organization.

## 3. PROPOSAL FOR THE APPLICATION OF CONTROLLING AND BALANCED SCORECARD IN QUALITY MANAGEMENT

Procedure for the application of the concept of controlling quality in the company can be divided into several parts. The methodology of this process is shown schematically in Figure 3.

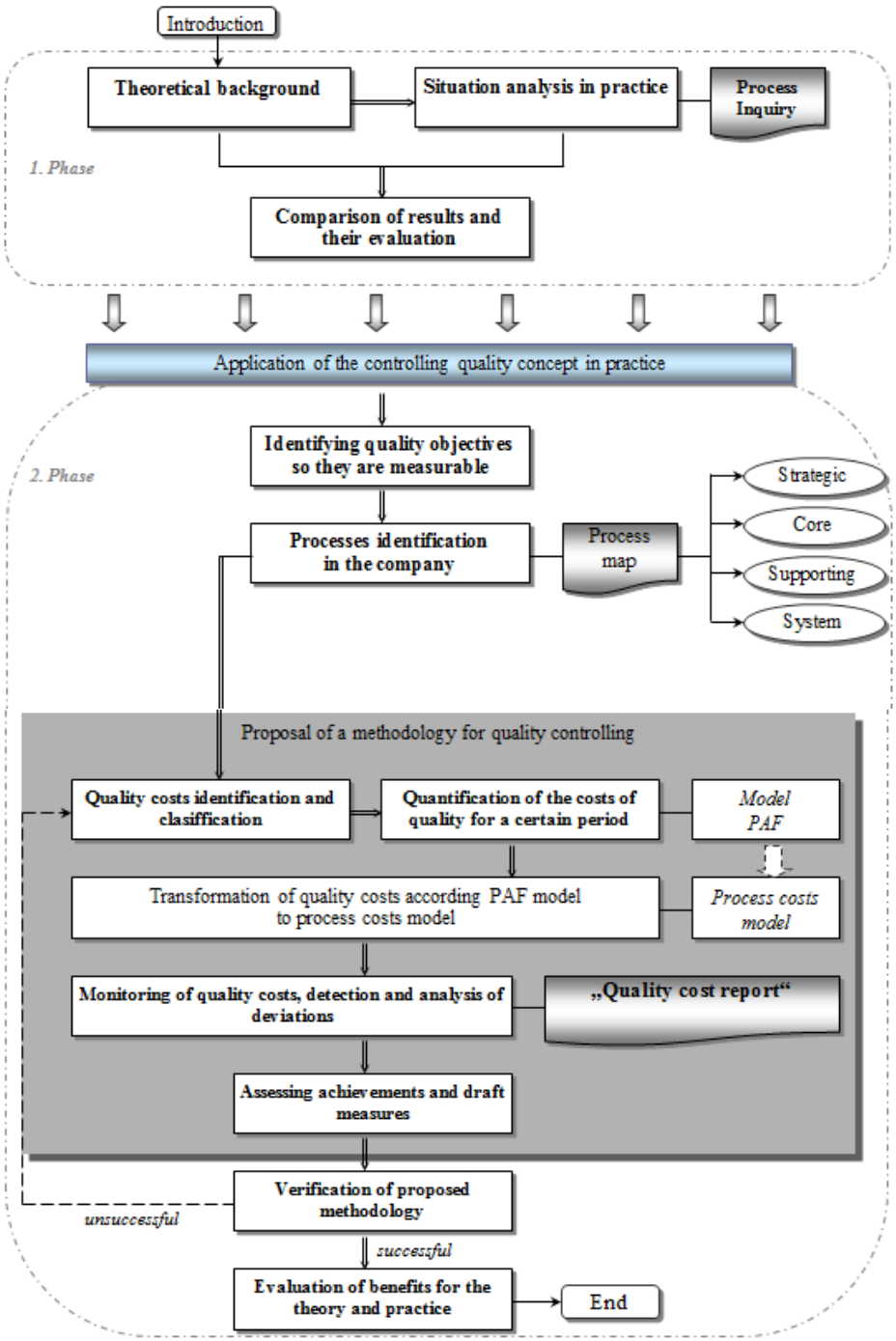


Figure 3. Methodology of applying the concept of controlling quality

### 3.1. Strategic and fundamental objectives of the business and quality cost report

Monitored furniture company has defined strategic objectives, the achievement of which has set some basic goals at the company level, over a one year and further specifics at lower organizational levels - units and subsequently workplaces. Followed by classification and identification quality costs and producing a quality cost report.

Quality costs are monitored under the program MS EXCEL through partial quality cost reports per month. Quarterly or semi-annually and annually the company compiles "Quality Cost Summary Report". The proposal of the report is shown in Table 1. Its structure consists of horizontal columns of planned values, values of recalculated plan, facts and deviations compiled over time by month and follow cumulative totals. At the end of each quarter and semi-annually cumulative column is clearly highlighted. Vertical structure consists of individual cost items for quality, which, by their content, are divided into material, labor and other costs, resp. expenses.

*Table 1.* Quality cost report

| QUALITY COST REPORT | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Cost item | Monitored period (month) | | | | | | | Cumulative | | | | | | |
| | | *Plan* | | Recalcul. plan | | Facts | | Devia-tions | Plan | | Recalcul. plan | | *Fact* | | *Devia-tion* |
| | | € | % | € | % | € | % | | € | % | € | % | € | % | |
| **N 1** | **Costs for prevention** | | | | | | | | | | | | | | |
| N 1.1 | Selection, approval, supplier evaluation | | | | | | | | | | | | | | |
| N 1.2 | Internal audits | | | | | | | | | | | | | | |
| N 1.3 | External audits | | | | | | | | | | | | | | |
| N 1.4 | Internal Training and Education of employees | | | | | | | | | | | | | | |
| N 1.5 | External Training and Education of employees | | | | | | | | | | | | | | |
| N 1.6 | Calibration services | | | | | | | | | | | | | | |
| | **Overall** | | | | | | | | | | | | | | |
| **N 2** | **Costs for evaluation** | | | | | | | | | | | | | | |
| N 2.1 | Entry control | | | | | | | | | | | | | | |
| N 2.2 | Produce control | | | | | | | | | | | | | | |
| N 2.3 | Checkout | | | | | | | | | | | | | | |
| N 2.4 | Internal laboratory exams | | | | | | | | | | | | | | |
| N 2.5 | External laboratory exams | | | | | | | | | | | | | | |
| N 2.6 | Purchase and maintenance measuring technique | | | | | | | | | | | | | | |
| | **Overall** | | | | | | | | | | | | | | |
| **N 3** | **Internal loses** | | | | | | | | | | | | | | |
| N 3.1 | Bulk errors | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N 3.2 | Extra work at repairing renewable nonconforming products | | | | | | | | | | | | | | |
| N 3.3 | Irreparable loss of nonconforming products | | | | | | | | | | | | | | |
| N 3.4 | Loss of supply errors | | | | | | | | | | | | | | |
| | **Overall** | | | | | | | | | | | | | | |
| **N 4** | **External loses** | | | | | | | | | | | | | | |
| N 4.1 | Mismatched irreparable products (complaints) | | | | | | | | | | | | | | |
| N 4.2 | Discounts on the prices of products of substandard quality | | | | | | | | | | | | | | |
| N 4.3 | Transport induced non-conforming products | | | | | | | | | | | | | | |
| N 4.4 | Travel induced non-conforming products | | | | | | | | | | | | | | |
| | **Overall** | | | | | | | | | | | | | | |
| | **Quality costs** | | | | | | | | | | | | | | |

Mentioned analyses of quality costs must have predictive value, therefore they will be compared with the selected variables such as sales, total costs. Based on the results obtained from the reports and the results of indicators, it will be possible to detect benefits from the applied methodology, the concept of quality controlling, then inform senior management about achieving results in terms of quality and also in the future to formulate the necessary measures in the area of quality assurance and improvement.

### 3.2. Possibilities of BSC application

First, a draft of the strategic map it should be based on strategic business objectives, leading to the realization of the vision and mission (see 2.). Strategic targets should be differentiated according to the principle of the four BSC perspectives (financial, customer, process and learning and growth perspective), concerning to pay attention to the principles of the strategy, the implementation of which BSC requires.

Another important step is tied vision and strategy of the organization with the processes in the company which should ensure implementation of the strategy, based on the maps of interaction processes (identified interrelated processes). All processes of interaction maps processes must be assessed in relation to the objectives assigned to them.

After this step, it is necessary to prepare relevant analysis of the processes current state in relation to the implementation of the BSC. For each process from the map of interactions on the basis of process maps and information sheets the objectives for each process are defined, the current status of monitoring and measuring their performance. It is also necessary to describe each process in relation to setting strategic goals.

Very often, companies do not set targets for process performance. In determining the target values of performance processes it needs to maintain an algorithm of action based on the principle QPD (Quality Policy Deployment). This process is shown in Figure 4.

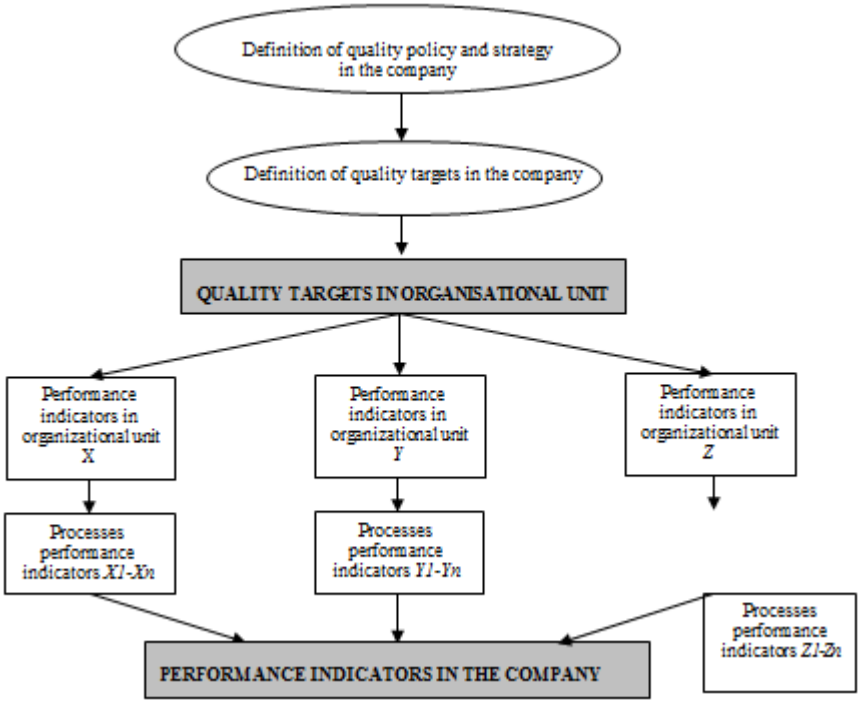


Figure 4. The algorithm of defining processes performance indicators

## 4. CONCLUSION

Quality is currently seen also as an economic category, which can be measured, and here occurs a tool that helps to make a quality measurable, transparent and predictable. It is a controlling in the area of quality management, in the literature known as the quality controlling.

In the article, we have designed a methodology of application the concept of quality controlling in the monitored furniture company, where it is necessary to identify quality targets so they are measurable, identify processes within the structure and thereby create a process map.

Principles of quality controlling are closely linked with the principles of Total Quality Management. Its basic is created by quality costs. We have, in conditions of monitored furniture company, classified and identified unit costs by PAF model, and we proposed to follow them through MS Excel and evaluate through partial cost reports monthly, quarterly or semi-annually.

Annually a summary quality cost report is prepared. In the conclusion we introduced a way of linking quality controlling (targets, processes, quality costs monitoring and quality indicators derived from them) to establish company´s strategy using the Balanced Scorecard.

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## REFERENCES

1. Albert, S. (2003): *Process management as base of quality, enviroment and risk management*. Kvalita, 3/2003, 4-8, Jorunal of the Slovak Society of Quality Management, ISSN 1335-9231.
2. Baran, D. (2001): *Podnikový controlling*. Bratislava: Vydavateľstvo STU. ISBN 80-227-1558-1.

3. Bauer, M. (2003): *Was controller in Deutschland zum Unternehmenserfolg beintragen*. In: Zeitschrift Controlling&Management, ZfCM 47.Jg. 2003, p.118.
4. Bradec, D.; Kymlička, P. (1996): *Controlling: nástroj efektívneho řízení podniku*. Moderní řízení, 96, n.5, p. 36-38.
5. BS 6143 *GUIDE TO THE ECONOMICS OF QUALITY*. 1992. Part 1: Process Cost Model. London, BSI.
6. Campanella, J. (1990): *Principles of Quality Costs*. Wisconsin: ASQC Quality Press. ISBN 0-87389-019-1.
7. Eschenbach, R. et. al. (2000): *Controlling*. Praha: Aspi Publishing. ISBN 80-85963-86-8.
8. Foltínová, A. (2009): *Nákladový controlling*. Bratislava: IURA EDITION, spol. s. r. o. ISBN 978-80-8078-286-03.
9. Freiberg, F. (1996): *Finančný controlling*. Praha, Management Press 1996.
10. Hansen, W.; kamiske, G., F. (2003): *Qualitätsmanagement. Digitale Fachbibliothek*. Düsseldorf: Symposion Publishing GmbH. ISBN 3-936608-48-2.
11. Hardt, F. (2000): *SAP-gestütztes prozessorientiertes Qualitätscontrolling*. In: Zeitschrift Kostenrechnungspraxis Qualitätscontrolling, p. 65-71.
12. Holíková, M. (2010): *Možnosti uplatnenia controllingu kvality v podmienkach drevárskeho a nábytkárskeho priemysl,* p. 127.
13. Horváthová, J.; Gallo, P. (2003). *Controlling*. Prešov: Dominanta, p. 237.
14. Horváth & Partner (1997): *Qualitätscontrolling*. Stuttgart: Schäffer-Poeschel Verlag für Wirtschaft Steuern Recht GmbH. ISBN 3-7910-1148-0.
15. Chodasová, Z. (2000): *Kontrola v riadení stavebného podniku*. Slovenská technická univerzita Bratislava, 1.vydanie, 2000, p. 69.
16. Juran, J. M. (1962): *Quality planning and analysis*. New York: McGraw Hill.
17. Linczényi, A.; nováková, R. (2001): *Manažérstvo kvality*. Bratislava: Vydavateľstvo STU v Bratislave. ISBN 80-227-1586-7.
18. Macík, K. (1999). Kalkulace nákladu - základ podnikového controllingu. Ostrava: Montanex, 1999. 241s.
19. Mann, R., mayer, E. (1992): *Controlling*. Průmysl a obchod, Praha: Profit, a.s. 1992.
20. Mateides, A.: Strašík, A. (2004): *Manažérstvo kvality*. Banská Bystrica: EF UMB. ISBN 80-8055-906-6.
21. Nenadál, J. (1995): *Ekonomika jakosti v praxi*. Žilina: MASM. ISBN 80-85348-26-8.
22. Nenadál, J. (2001): *Meření v systémech managementu jakosti*. Praha: Management Press. ISBN 80-7261-054-6.
23. Noskievičová, D. (1996): *Statistické metody v řízení jakosti*. Ostrava: VŠB TU, p. 99.
24. Paulová, I.; Hekelová, E.; Šatanová, A.; Šalgovičová, J. (2008*): Metódy zlepšovania efektívnosti a účinnosti komplexného manažérstva kvality*. 1. vyd., 304 strán, Vydavateľstvo STU, ISBN 978-80-227-2857-7.
25. Sasse, A. (2001): *Kosten- und nutzenorientiertes Qualitätscontrolling*. Zeitschrift Kostenrechnungspraxis, Sonderheft n. 3, p. 76-79.
26. Sasse, A. (2000): *Systematisierung der Qualitätskosten und der Abweichungskosten für das Qualitätskostenmanagemen*t. Zeitschrift Kostenrechnungspraxis Qualitätscontrolling, p.43-55.
27. Sedliačiková, M.; Šatanová, A.; Foltíniová, A. (2012): *Finančný kontroling v teórii a praxi malých a stredných podnikov*. Ekonomický časopis/Journal of Economics, 52, n. 9, p. 148 – 159.
28. Staňek, V. (2003): *Zvyšování výkonnosti procesním řízením nákladů*. Praha: Grada Publishing. ISBN 80-247-0456-0.
29. STN EN ISO 9001: 2008. *Systémy manažérstva kvality. Požiadavky*. Bratislava: Slovenský ústav technickej normalizácie, november 2008.
30. Šatanová, A. (2002): *Manažment kvality*. Zvolen: LSDV TU vo Zvolene. ISBN 80-89029-60-4.
31. Šatanová, A.: Potkány, M. (2004): *Controlling – moderný nástroj riadenia podniku*. Ekonomický časopis/Journal of Economics, 52, n. 2, p. 148 – 165.
32. Šatanová, A. et al. (2008): *Manažérstvo kvality.* Zvolen: Vydavateľstvo TU, ISBN 978-80-228-1928-2.
33. Šesták, M. (2002): *Náklady na kvalitu známe i neznáme*. KVALITA, 2, s. 40.
34. Wildemann, H. (2000): *Qualitätscontrolling in Industrieunternehmen*. Zeitschrift Kostenrechnungspraxis, Sonderheft n. 1, p.11-17.
35. Zgodavová, K. (2002): *Zmluvné zabezpečovanie verejných služieb*: teoretické východiská a prax v Slovenskej republike. Ekonomický časopis/Journal of Economics, 50, n. 6, p. 1005 – 1021.
36. http://www.mkonetzny.de

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# HUMAN RESOURCE MANAGEMENT AND QUALITY MANAGEMENT IN WOODWORKING INDUSTRY COMPANIES IN SLOVAKIA

Gaffová, Z.; Šatanová, A.

## ABSTRACT

A dynamic and changing economic environment makes it hard for companies to ensure long-term competitiveness. The decisive factors are the quality and price of products, delivery terms, warranty conditions, etc., and the system and quality of company management in the internal environment. It is therefore necessary to introduce new methods of management and changes in approaches. The quality management system brings changes related to people and their work, where corporate culture plays an important role. One of the most important factors that affects the success of an employee's work is motivation. The success or failure of incentives strongly influences the quantity and quality of work. Work productivity and performance increases in direct proportion to the increase in positive motivation. After a thorough analysis of motivational needs, it is necessary for companies to deal with their employees' motivational process**.** The aim of the presented article is to analyze the factors affecting the motivation of employees in woodworking industry companies in Slovakia. The starting point is the questionnaire method, with which we will gain a view of the work motivation of employees in various surveyed companies.
**Key words**: company, woodworking industry, employee, quality, quality management, motivation, questionnaire method

## 1. Introduction

Competitiveness and a stable position in the market is the primary business objective. The condition for achieving this goal is quality, while its decisive factor is customer satisfaction. Ensuring high quality is not a one-time process, it is a process of continuous improvement of products, services, organization, manufacturing processes, and the continuous improvement of employee education. The success of mastering the difficult task of ensuring the required quality of outputs lies primarily in the people. It is up to the managers of the organization to develop and promote a vision, strategy and quality policy, and it depends on how they approach the motivation of individuals to achieve the objectives of the organization. The primary task of management is to improve the effectiveness and efficiency of the organization, including the quality management system through the engagement, development and motivation of its employees.

## 2. THEORETICAL BACKGROUND OF RESEARCH PROBLEMS

Human resources represent the "motor" of a company that sets other resources into motion and determines their use. At the same time, human resources are the most valuable and often most expensive resource that decides the prosperity and competitiveness of a company (Galajdová, 2001).

Human resources in a company are the full human potential. It consists of the number and structure of employees, as well as aspects such as education and culture, interpersonal relationships and the ability to cooperate. In a dynamic sense, human potential can be defined as a large range of motivation, knowledge, skills, abilities, predictable and unpredictable reactions and ways of perception, survival and behavior. In this sense, human potential represents the only and unique, living and life-giving, dynamic and dynamizing force of an organizaion (Blašková, 2006).

Authors (Fisher, Schoenfeld, Shaw 1993) perceive human resource management as an activity that includes all management decisions and practices that directly affect people or human resources working in an organization.

Authors (Carell, Kuzmits, Norbert, 1992) define human resource management as a "summary of programs, functions and activities that are designed to maximize the objectives of employees and the organization".

The definition of quality by J.M. Juran "The quality of a product represents the ability to use the product. The degree to which the summary of a product's characteristics is decisive for the performance of its function under the expected conditions".

Crosby defines the quality of products „as the correspondence of the product's properties with the customer's requirements“ (Šatanová, 2004).

According to STN EN ISO 9000:2000 Quality management systems, Fundamentals and vocabulary, the term quality means the degree to which a set of inherent characteristics of a product, system or process meets the requirements of customers and other stakeholders.

Quality management is a coordinated set of activities directed at controlling and managing an organization with regard to quality (according to STN EN ISO 9000:2001 Quality management systems. Fundamentals and vocabulary).

Quality motivation and stimulation is an important component of quality management, whose task is to reconcile interests in the quantity and quality relationship. Motivation is a purposeful action on the use of existing themes and the formation of new themes for the purpose of the orientation of employee activity to improve the quality of products. (Šatanová a kol., 2012).

A quality management system is an organizational structure, procedures, processes and resources necessary for the application of quality management (Mateides, Stašík, 2004; Šatanová, 2004).

The first task of top management is to create two basic documents: the organization's quality policy and the organization's quality objectives. The above documents differ in both the time horizon and the form of processing and responsibility for the fulfillment of the tasks set out in these documents. While the quality policy document typically has a time horizon of 3-5 years, quality objectives are complied for each calendar year. The quality policy is a document where all tasks are expressed verbally, while quality objectives must be measurable and quantifiable. While the quality policy reflects an approach that the company's leadership will provide in relation to customers or within the company, quality objectives are tasks that employees in specific job positions are responsible for (Kupčák 2006)

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## 3. THE CURRENT STATE OF THE WOODWORKING AND FURNITURE INDUSTRY IN SLOVAKIA AND THE CZECH REPUBLIC

In the past, Czechoslovakia was at the top of the woodworking industry among countries around the world. Developed cooperative relationships and amenities were at a very high level until 1989. The regime change and the abandonment of central control caused a decline in the development of the woodworking industry in both the Czech Republic and Slovakia. Today, the woodworking industry in Slovakia represents a 2.6% share of the added value of the total production in Slovakia, placing Slovakia in the 6th place among EU countries. The Czech Republic has a 2.1% share of added value, placing it on the respectable 8th place among all EU countries.

The question is what caused this decline from the top of the woodworking industry to the respective 6th and 8th place, and what are the options for returning our countries to the place where they belong. As is further apparent from the analysis, the majority of timber in Europe is intended for further industrial processing, and only about a quarter is used as fuel. Industrial wood also dominates logging in Slovakia (91%) and the Czech Republic (86%). On the contrary, the majority of timber is used as fuel in Greece (72%), Italy (70%) and Cyprus (60%).

Logging is sustainable in most EU countries. It is annually generally around 1.5% to 2.5% of wood in European forests. This means that if forests weren't renewed, they would be completely logged in about 50 years.

According to statistics, the share of export in the total production of logs in the Czech Republic stands at 29%, and as much as 39% in Slovakia.

The Slovak timber industry could achieve even better results. More than a third of the logged trees in our country are exported abroad, and we therefore loose a large part of the added value used by other producers abroad. It would surely also help the unemployment in Slovakia.

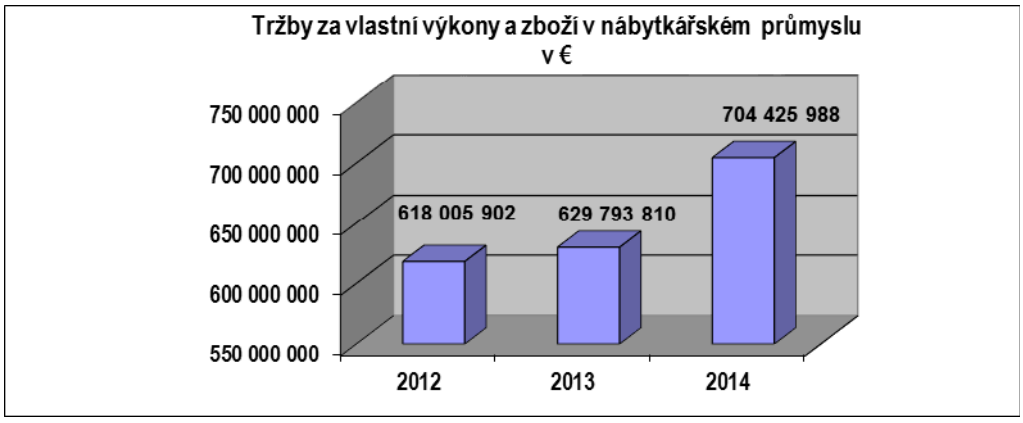
If Slovakia or the Czech Republic managed to process the logged timber in their own country as effectively, the share of the woodworking industry in the value added could increase even more. Scandinavian countries - Sweden and Finland, but also Italy, Romania and Austria initially treat the logs in their domestic production capacities, and less than 5 percent of their timber is exported.

The importance of the woodworking industry in Slovakia's economy is given by its specific function and role in the whole national ecomomic complex. In the structure of industrial production, it represents an important source of economic assets in the national economy, which, unlike the most significant industrial sectors in Slovakia, is dependent solely on the processing of renewable domestic raw materials.

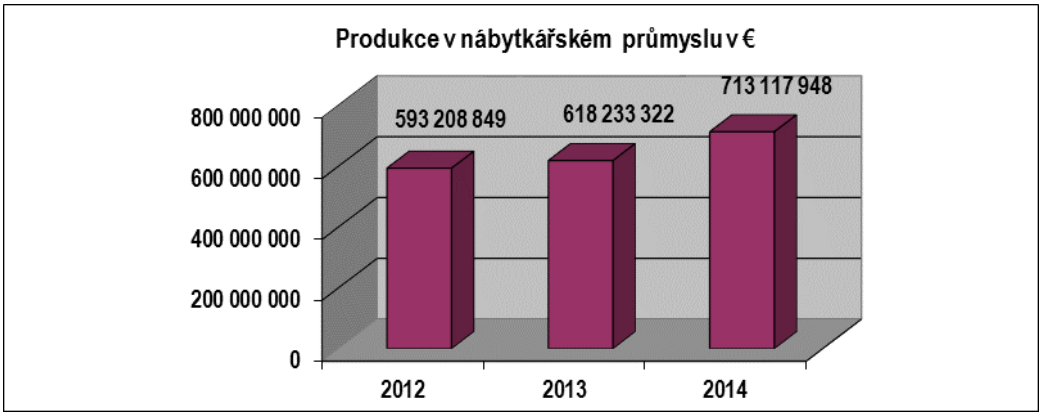
The woodiness of Slovakia and promising opportunities in logging create conditions for sufficient material potential and for the development of the woodworking industry. In Slovakia's economy, the woodworking industry has a specific position resulting from its comparative advantages. It is not largely dependent on the import of raw material inputs, and it is consistently capable of generating a surplus in foreign trade. Due to the distribution of raw material sources, it is significant from the perspective of regional development of small and medium business, because it has good possibilities for using changes in production technology and innovative process results, it can support the development of employment with a relatively low capital entry and it quickly adapts to market demands.

The development in the woodworking industry, in SK NACE classification, statistical classification of economic activities according to selected indicators is as follows: SK NACE 33 – furniture industry, SK NACE 16 woodworking industry

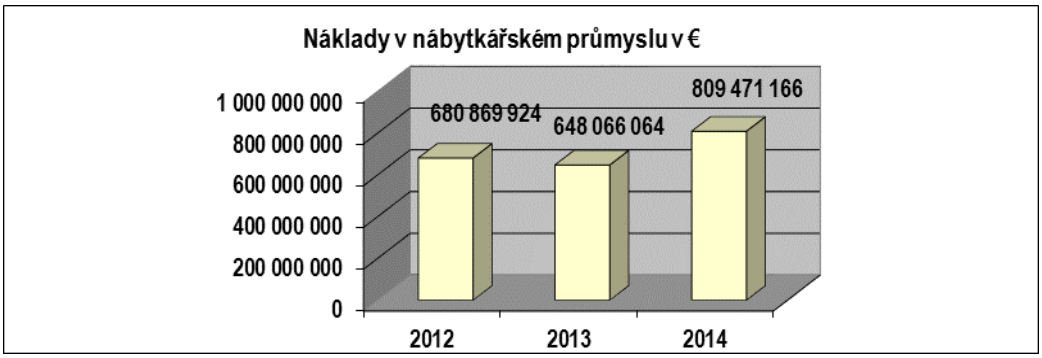
We projected the development of selected economic indicators into graphical from. I present the following graphical overview of the furniture and woodworking industry in Slovakia in Euros. The data are drawn from the Statistical Office and the Industry Yearbook of Slovakia.



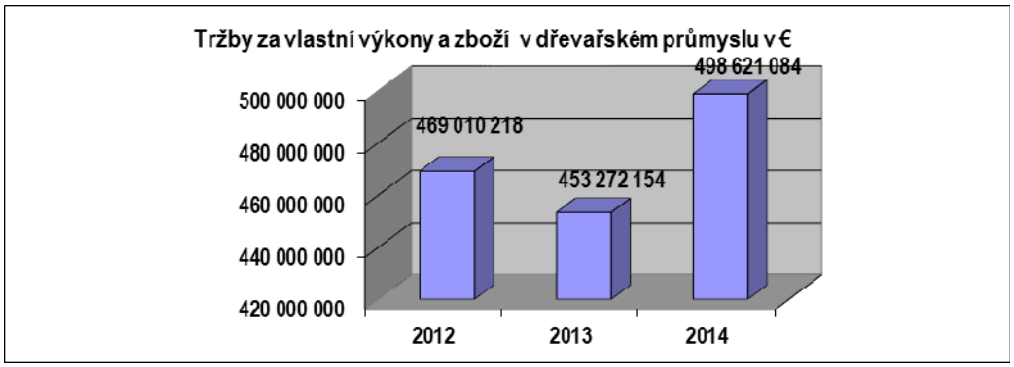

Graph 1. Sales of own work and goods in the furniture industry



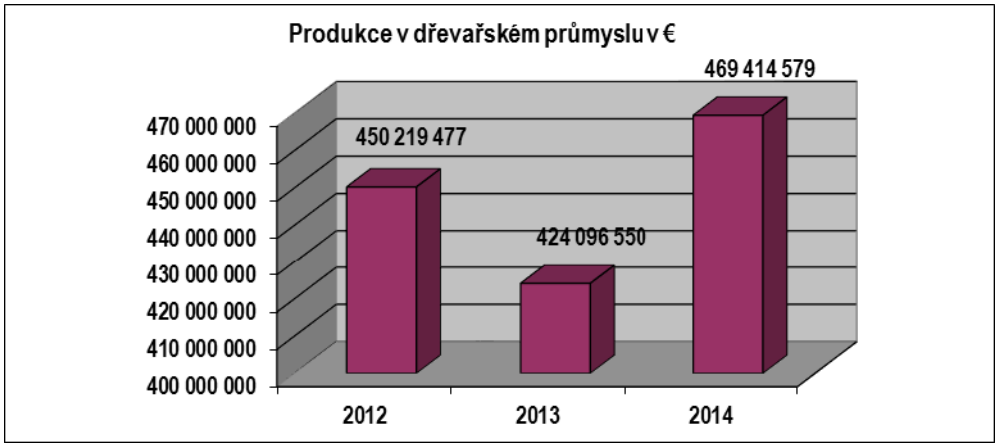

Graph 2. Production in the furniture industry in €



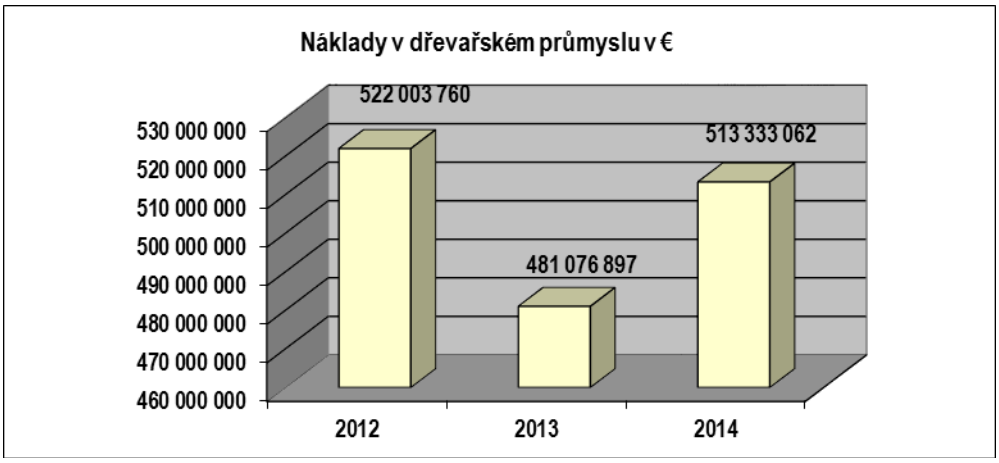

Graph 3. Costs in the furniture industry in €




Graph 4. Sale of own work and goods in the woodworking industry in €

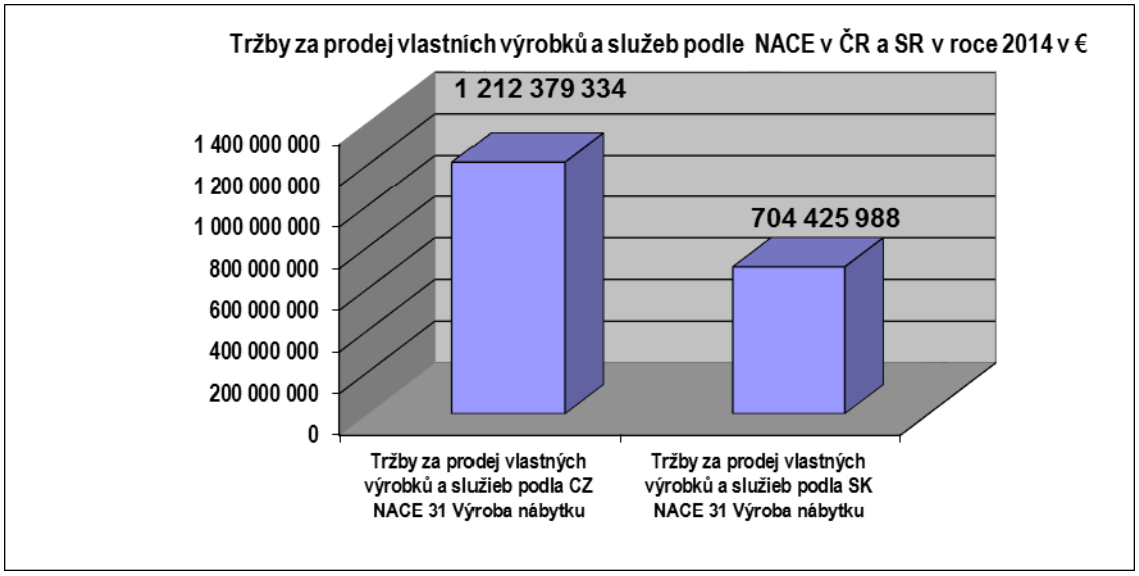



Graph 5. Production in the woodworking industry in €




Graph 6. Costs in the woodworking industry in €

The development of economic indicators according to NACE classification in the Czech Republic and Slovakia is presented in the following graphs. The calculations in EUR were reviewed by the National Bank of Slovakia with the exchange rate as of September 14, 2015




Graph 7. Sales of own products and services according to NACE in the Czech Republic and Slovakia in 2014 in €

When comparing the economic indicator, i.e. According to NACE, the Czech Republic is stronger than Slovakia in the sale of its own products and services.

## 4. PROPOSAL OF A HUMAN RESOURCE MANAGEMENT SYSTEM AND QUALITY MANAGEMENT SYSTEM IN COMPANIES IN THE WOODWORKING INDUSTRY IN SLOVAKIA AND THE CZECH REPUBLIC

The primary objective is to analyze the current state of the woodworking industry in Slovakia; we will try to propose measures that would help us achieve development in the woodworking industry using the acquired knowledge. A proposal of measures and stimuli will be processed using models that will allow us to express the anticipated production increase and its impact on the development of the woodworking industry in percentages.

The issue we will address in the project is the analysis of stimuli for the development of the woodworking industry in Slovakia.

The aim is to define stimuli affecting the development of the woodworking industry in Slovakia and the Czech Republic, evaluate them and use their influence for the development of the woodworking industry. To successfully meet this formulated objective, it is necessary to determine the following sub-objectives:

- Analysis of the woodworking industry up to 1989
- Analysis of impacts caused by the change of regime
- Proposal of measures leading to an improvement in the current state of human resource management
- Creating models with which we can precisely assess the impact of the proposed measures
- Evaluation of the benefits and their practical testing

Every employee has a different hierarchy of needs that affect his behavior at work. Therefore, if we want to change people's attitudes to work, we need to know their individual needs and analyze them. The goal is to analyze factors that are effective in motivating employees with regard to quality assurance and its systematic management in companies in the woodworking industry, based on theoretical approaches and practical conditions. The starting point is information obtained in companies in the form of a questionnaire, where specific questions are established to get an overall picture of the work motivation of employees in each surveyed company.

The main objective is to design a methodology for top management in companies in the woodworking industry to improve the efficiency and effectiveness of the organization through involvement, development and the motivation of its employees. The task of management is to methodically work with people so that they believe that customer satisfaction as well as the satisfaction of the employees can be achieved with proper leadership, the use of all available resources and continuous changes for the better, which leads to the most efficient results

The methodology will be designed based on the results of the survey. There are several kinds of research methods for the purposes of the survey. For the considerable amount of benefits, we chose the interrogation method using a questionnaire. The questionnaire will be distributed electronically. After the data is collected, we will proceed to process and evaluate the obtained data, where we will utilize appropriate research methods such as analysis, synthesis, deduction and mathematical-statistical methods. The research is focused on the motivation process in companies in the woodworking industry. The results of the research will provide an insight into what motivation factor is considered most important by employees in the woodworking industry, in what areas and how it affects their work performance and what further measures and approaches we propose to improve employee motivation.

The goal that the company will achieve through proper motivation is an increase in engagement, loyalty, stability and ultimately employee performance. Employee motivation affects the company's image and contributes to increasing its attractiveness, which is why it should be given adequate attention in companies in the woodworking industry. The motivation process is created based on a survey conducted in companies in the woodworking industry, and it will be a competitive advantage over companies in the woodworking industry that are not engaged in the motivation process, did not introduce it and therefore do not use it.

In order to fulfill the main objective of our research, we set the following sub-objectives:

- Analysis of theoretical and practical approaches to solving the given issue.
- Characterization of the theory of motivation.
- Analysis of the need for motivation.

- Identification of motivational needs. Every employee has a different hierarchy of needs that affects his behavior at work. Therefore, if we want to change people's attitudes to work, we need to know their individual needs.
- Examination of whether small and medium enterprises have an introduced systematic approach to employee motivation.
- Determination of whether properly designed motivation increases the performance of employees.
- Verification of whether proper motivation is a competitive advantage in terms of maintaining the current high-quality employees.
- Compare companies or the approach of their top management in companies that have an implemented quality management system (QMS) to employees in the area of work motivation with companies that do not have a QMS.
- Propose options for improving the current state of work motivation in the sector of small and medium-sized enterprises in the woodworking industry in the Czech Republic and Slovakia

## 5. THE PROCESS OF APPLYING A HUMAN RESOURCE MANAGEMENT SYSTEM AND QUALITY MANAGEMENT SYSTEM IN COMPANIES IN THE WOODWORKING INDUSTRY IN SLOVAKIA AND THE CZECH REPUBLIC

### 1. Evaluation of the woodworking industry up until 1989 lumber industry, furniture industry

- Collection of data from available sources, sales of own products and goods, revenues, costs, profit before tax, average number of employees, average monthly wage, added value.
- Export and import of raw timber in individual assortments in thousands of $m^3$ – coniferous logs of quality grade I to III, coniferous wood of quality grade IV to V, deciduous logs of quality grade I to III, deciduous wood of quality grade IV to V, firewood
- Sources of wood raw material in regions of Slovakia and the Czech Republic
- Investment development in the woodworking industry: acquired investments in the woodworking industry in industrial production, the inflow of direct foreign investments, the rate of investments, investment per worker
- Performance measurement indicators in the woodworking industry: labor productivity from sales, labor productivity from added value, rate of added value.
- Data analysis: Pareto analysis, correlation and regression analysis, analysis of time series and trends, cluster analysis, econometric models
- Evaluation with emphasis on the economic indicators of the country, systematic measures for the development of the woodworking industry

### 2. Evaluation of the effects of the regime change

- Data collection in the period after 1989, lumber industry, furniture industry
- Data analysis
- Evaluation with emphasis on the economic indicators of the country, systematic measures for the development of the woodworking industry, measures by the Ministry of Economy of Slovakia and the Czech Republic, measures for enterprises in the woodworking industry sector, measures for a higher volume of investments and technological development of the woodworking industry.

### 3. Proposal of measures aimed at improving the current state

- Based on a comparison of data from previous analyses, we will try to propse measures to improve the current situation.

- We will calculate the expected impact of the measures on the development of the woodworking industry in the given countries.

**4. Creation of models with which we can precisely assess the impact of the proposed measures.**

- We will create models in the propsed measures through which we will be able to assess their impact and precisely estimate the consequences of their introduction into the current market economy.
- The models will include a proposal of a series of measures inevitably necessary to achieve the desired state.

**5. Evaluation of the benefits and their practical testing**

- We will try to apply the results of the model benefits in practice and assess their impact on the development and economy of the woodworking industry.

## 6. CONCLUSION

The main business objective of companies in the woodworking industry in Slovakia and the Czech Republic is competitiveness and maintaining a market position, whereas human potential is one of the capitals of business success. The human factor determines the level of the quality the company's products to a significant extent. A fundamental prerequisite for achieving the desired level of quality is a responsible approach to the assigned tasks and corresponding personality traits of the employee.

For this reason, we present a proposal for a human resource management system and quality management system in companies in the woodworking industry in Slovakia and the Czech Republic, and the process of its application: assessment of the woodworking industry up until 1989 and the impacts caused by the change of regime, a proposal of measures to improve the current situation, creating models with which we can precisely assess the impact of the proposed measures and evaluate their benefits, as well as possibly test them in companies in the woodworking industry in Slovakia and the Czech Republic.

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## REFERENCES

1. Blašková, M. a kol. 2006. Riadenie a rozvoj vysokokvalifikovaného ľudského potenciálu. Zvolen: Vydavateľstvo Technickej univerzity vo Zvolene, 2006, ISBN 80-228-1701-5.
2. Carell, M. R., Kuzmits, F. E., Norbert, N. F. 1992. Personel Resource Management. New York: Macmiillan Publishing Company, 1992.
3. Drábek, J. − Volčko, I. 1998. Investície a rozvoj DSP. In: Výkonnosť transformačných ekonomík a investičné procesy. Bratislava: Vydavateľstvo EU v Bratislave, 1998, s. 94-99.
4. Drábek, J., Merková, M. 2010. Efektívnosť priamych zahraničních investícií v odvetví spracovania dreva, Vydavateľstvo TU Zvolen, 2010, 103 s. ISBN 978-80-228-2196-4
5. Fisher, C. D., Schoenfeldt, L. F.,Shaw, J. B. 1993. Human Resource Managgement.
Boston: Gougton Miffin Company, 1993.
6. Galajdová, V. 2001. Personálne riadenie. Zvolen: LSDV Zvolen, 2001,
ISBN 80-89029-20-5.

7. Hrubec T., 2002 – Vývoj dřevozpracujícího průmyslu po roce 1989. Lesnicko-dřevařský sektor ČR a zemí EU, Sborník referátů z konference Brno, str. 31, 23.5.2002
8. Informácia o ťažbe dreva, jeho spracovaní a vývoze do zahraničia. Vypracovalo MP SR. Uznesenie vlády SR č. UV – 18818/2009
9. Informácie o stave realizácie programu Drevo – surovina 21. storočia, vrátane Programu na podporu rozvoja spracovania a využívania drevnej suroviny. Vypracovalo MH SR. Uznesenie vlády č. UV – 10455/2006
10. Kovalčík, M., Moravčík, M., a kol. 2009. Analýza a kvantifikácia dopadov svetovej finančnej a ekonomickej krízy v lesníctve SR a návrh opatrení na jej riešenie. NCL-LVU Zvolen 2009, 59 s. ISBN 978-80-8093-082-0.
11. Kupčák, V. 2006. Ekonomika lesního hospodářství. ISBN80-7157-998
12. Kupkovič, M. a kol. 2003. Podnikové hospodárstvo, SPRINT, Bratislava, 2003
13. Lesáková, Ľ. 2004. Metódy hodnotenia výkonnosti malých a stredných podnikov. Banská Bystrica : Univerzita Mateja Bela, Ekonomická fakulta. 2004. 121 s. ISBN 80-8055-914-7
14. Mateides, A., Straśík, A. 2004. Manažérstvo kvality. Banská Bystrica: EF UMB, 2004, ISBN 80-8055-906-6.
15. Moravčík, M. 2007. Vypracovanie lesníckej časti prognózy a vízie vývoja slovenského poľnohospodárstva, potravinárstva, lesníctva a vidieka správy za úlohy riešené v roku 2007 v rámci kontraktu,ktorý bol uzavretý medzi MO SR a NCL, december 2007. Dostupné na : http://www.nelsk.sk/files/1231 pdf
16. Mrník, A: Zmierňovanie následkov krízy v odvedtví spracovania dreva. In. Stolársky magazín, 5/2009, str. 40-41. ISSN 1335-7018. Dostupné na internete: http//www.lesy.sk/showdoc.do?docid= 3764
17. Prazan P. 2010.:Analýza faktorů možností vývoje malých a středních pilařských provozů v ČR. Dizertační práce 2010
18. Sedlák, M. 2009. Manažment. Bratislava: Iura Edition, 2009. 434 s. ISBN 978-80-8078-283-2
19. Správa o stave podnikatelského prostredia v Slovenskej republike s návrhmi na jeho zlepšovanie. Prodkladateľ MH SR. Uznesenie vlády č. UV – 15097/2010
20. Suchomel, J., Gejdoš, M., Šulek, R.2010. Marketingová analýza obchodu s drevom na TU vo Zvolene, VŠLP. Vedecká monografia. Zvolen: Vydavateľstvo TU vo Zvolene 2010. 113 s. ISBN 978-80-228-2128-5.
21. Synek, M. a kol. 1999. Podniková ekonomika, C.H. Beck Praha, 1999
22. Šatanová, A. 2004. Controlling v podnikoch drevárskeho priemyslu. Vedecké štúdie, Zvolen, Vydavateľstvo TU Zvolen, 2/2004/B. 81 s. ISBN 80-228-1310-9
23. Šatanová, A. 2012: Controlling kvality v drevospracujúcom podniku. Zvolen: Technická univerzita vo Zvolene, 2012. 95 s. ISBN 978-80-228-2445-3
24. Šatanová, A. 2012: Teória a prax kontrolingu kvality v drevospracujúcom podniku In: Acta Facultatis Xylologiae. Zvolen Res Publica Slovaca: Vedecký časopis Drevárskej fakulty TU vo Zvolene. Vydavateľstvo TU vo Zvolene, 2012, str. 115-125, ISSN 1336-3824
25. Šatanová, A. a kol. (2011): Ekonomika a manažment podnikov dřevozpracujícího průmyslu.. vysokoškolská učebnica Zvolen: TU Zvolen, 2011. 567 s. ISBN 978-80-228-2319-7.
26. Šatanová, A., Sedliačiková, M. Volčko, I. 2013. Stanovenie hodnoty nábytkárskeho podniku na báze metódy ekonomickej pridanej hodnoty = Determination of furniture company value based on economic value added method . VEGA 1/0089/11 ; 1/0581/12. In Acta facultatis xylologiae Zvolen : vedecký časopis Drevárskej fakulty. - ISSN 1336-3824. - Roč. 55, č. 1 2013. s. 129-143.
27. Vysušil., J., Fotr, J. 1993. Ekonomika a finance podniku pro manažery, Eurovia, Praha, 1993.

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# DEVELOPMENT AND PRODUCTION OF UPHOLSTERED SOFA

Tauber, J.; Svoboda, J.; Kozák, M.

## ABSTRACT

This article shows new trend in the field of upholstered seating furniture. The trend is comissioned production and continuous development of a new upholstered component. Our aim was to develop a product meeting needs of an end user while considering ergonomics, comfort, appearance and also meeting standards related to this type of furniture. This article shows the development of an upholstered sofa. The result propotype of an upholstered sofa is unique because of its specific shape solution, modern design and elegance of the final product.
**Key words**: sofa, design, ergonomics, supporting frame for upholstering

## 1. SOFA DESIGN

Design of this upholstered sofa links historically proven facts with the current trend. Visually, there is a link in permeation of matter and subtile look, which has been created by stylish thin wooden legs. Design of the sofa comes from classical construction and craft processing while following basic rules concerning ergonomics and typology that are being laid upon upholstered furniture. This article shows the whole process starting with the original thought up to testing in furniture testing room. During the process, author of this design was developing the final shape using visualizations. First visualizations were followed by creation of a reduction model. Shape proving of an upholstered sofa led to more exact construction solutions and realization of the final prototype and testing in furniture testing room.

Final appearance of the new sofa is shown in the first figure. There are three shape variations of appearance of this upholstered sofa. The first option shows fully upholstered variation of the seat. The second and third option uses decorative wooden component placed to the front side of the seat.

*Figure 1. Three basic variations of SOFA design*

### 1.1. Model production

A sofa model in reduction 1:10 was created to check the outer relations and proportions. The model itself was made by 3D printing machine. Sofa model draft intended for printing was made based on visual documentation in 3D MAX studio. When it was done, the model was exported as STL. Before printing, the model was opened in a programme called Slic3r Prusa Edition 1.33.8 for making final corrections (settings of material, printing quality, thickness of printed layer). The printing itself was meda on PRUSA 3D i3MK2 printer using PLA material with applying temeperature of 215 °C. Printed 3D model is shown in the following picture.


*Figure 2. SOFA model printed by 3D printing machine.*

The final appearance of designed Sofa is shown in Figure 3. We used the variation of fully upholstered seating. Visualisation was created in 3D MAX studio 2016.

*Figure 3. Sofa final look visualisation*

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## 2. TECHNICAL DESCRIPTION OF THE CONSTRUCTION

Supporting frame construction is determined by its shape which brings a certain way of covering the sofa by textile material. The supporting frame is composed out of four assembling units (2 armrests [A], 1 backrest [B] and one seat frame [C]). These parts are put together using screws and T-nuts M8 after being uphostered. See the following pictures (Figure 4. – 6.).

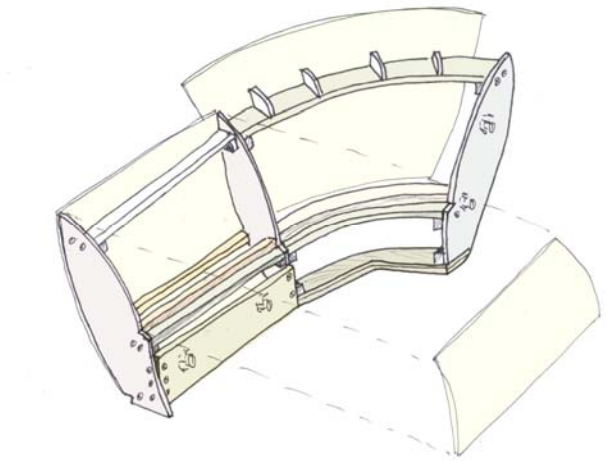

*Figure 4. Supporting frame, assembling unit [A]: Armrest*

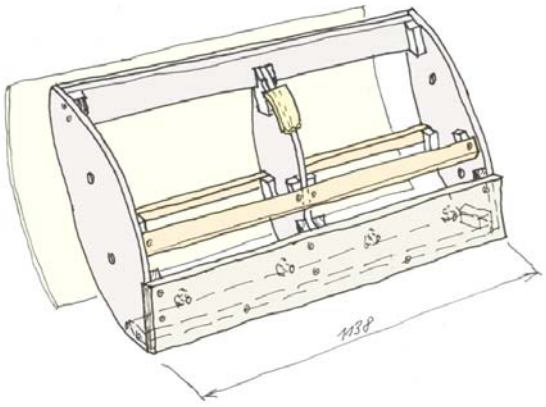


*Figure 5. Supporting frame, assembling unit [B]: Backrest*

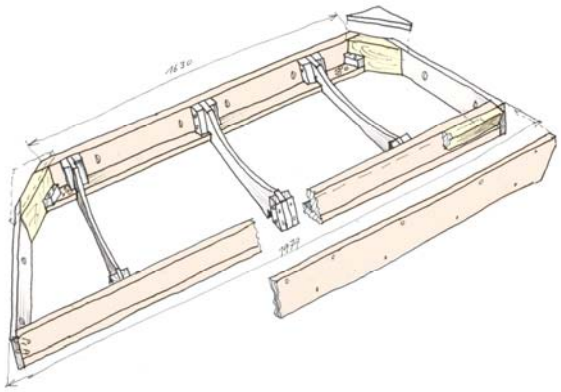

*Figure 6. Supporting frame, assembling unit [C]: Seat frame*

## 2.1. Supporting frame material

Rails and support blocks are made of hard solid wood (beech), other rails are made of hard coniferous wood (spruce). Vertical and shape units which are not suitable for solid wood because of size

are made of 15 mm wide birch plywood , strained parts are doubled and have 30 mm width. Fillings are made of hard 3mm thick fibreboard and of 2,2 mm thick cardboard.

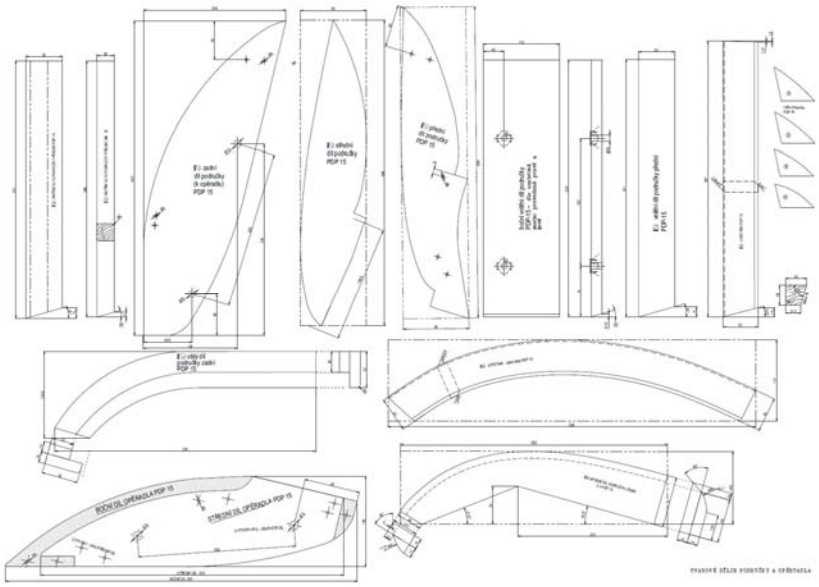

*Figure 7. Most of the supporting frame construction parts were made from plywood by CNC machine.*

## 2.2. Construction of assembling units

Supporting frame of the armrests [A].

Connecting of parts is made by screws ø 4,5 mm or staples and supporting blocks, all connections are glued by PVAc on the whole surface. The fillings are glued and fastened on the peripheries by staples. Supporting frame of the armrests is devided into two parts depending on the shape, front linear and back, which is round and spreads out behind the seat up to the backrest part. Uphostery is made from foam and fibre wadding.

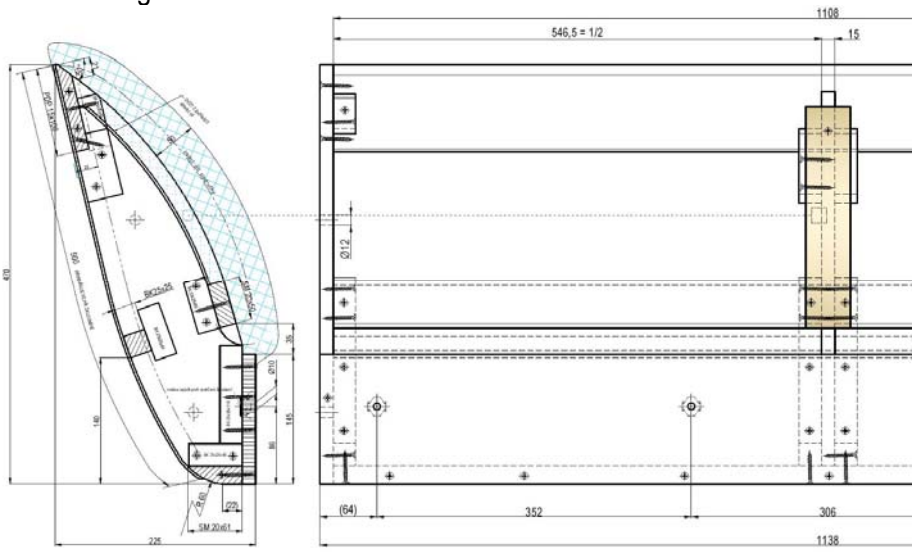


*Figure 8. Technical drawing of the supporting frame of the backrest [B]*

Supporting frame of the backrest [B].

Similary to armrests, connecting of components is made by screws ø 4,5 mm or staples and support blocks, all connetion parts are glued with PVAc on the whole surface. The middle part is smaller on the front side than the side parts, to make it softer by inserting foam. Springing of the backrest surface is made by horizontal springing straps and 2 layers of foam with fibre wadding under covering, the back filling of backrest is firmed after being firmed to uphostered armrests. Covering is stiched invisibely.

Seat frame [C].

Seat frame is in shape of irregular hexagon, horrizontal rails and support blocks are made of hard wood (beech), back scew part is made of coniferous wood on the peripheries (spruce), side parts, crossbars and front seating skew part is made of 15 mm thick birch plywood. Connection of front rails and side parts is made thanks to wooden dowels ø 10 mm, which go through the whole hickness of the side parts where is screw in between, other connections are made by screws and support blocks. There are wooden scew legs fastened to lower rails by allen screws screwed to stop nuts and wooden pegs ø 10 mm glued to the leg. There are holes ø 12 mm made on the side and back part for screws, for connection with armrests and back rest. Springing of the seat is made by zig-zag sprigs, where is sandwich from polyuretan foam and fibre wadding under the covering.

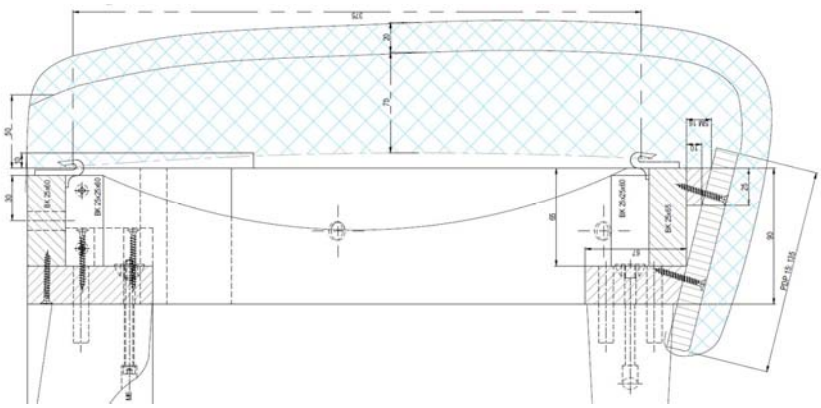

*Figure 9. Technical drawing of the seat frame [C]*

## 3. PROTOTYPE MANUFACTURING

While working on the solution, we managed to create two propotypes of the Sofa. The contruction is described in paragraph named Supporting frame material. The Sofa contruction was made in practical workrooms of Mendel University. The supporting frame for upholstery can be seen in Figure 10. Upholstered parts were made in cooperation with upholstery Karel Malý. We used classical upholstery modern materials. There is 3 mm thick fiberboard and 2,2 mm thick cardboard used for the filling. Covering textile was used in two colourful variations. When creating the propotype, we used following type of covering textile which has high resistance to scuff marks. The covering material has commercial name BORA TERRA 25 and 28, Damask, made from 100% PES (polyester), weight: 330 g/m2, resistance 100.000 ot.MD (EN ISO 12947), permanence on light: 5 (EN ISO 105-B02), endurance against humidity/dryness: 5/5 (EN ISO 105-X12), width 140 cm, hard to egnite: BS 5852.

*Figure 10. Supporting frame propotype*

## 4. PROTOTYPE MANUFACTURING

The designed sofa meets the upholstered furniture requirements stated in european standards EN 16139 Furniture- Strenght, durability and safety – requirements for non- domestic seating.

If the requirements of these standards are met, it is probable that it will meet also requirements of domestic usage, EN12520 Furniture- Strength, durability and safety-Requirements for domestic seating, because the requirements of EN 16139 are generally higher than EN 12520.

### 4.1. Stability

The stardard above states in general that the seating furniture must not be overturned in these situations:

- while there is loading on the front edge of the seat surface in median plane;
- while loading the seat surface led over the front corner;
- while tilting to the side;
- while leaning on the backrest;
- while sitting on the front side of the seat.

Requirements for stability are met if the furniture is not overturned during tests demanded by the standards EN 16139. The tests are being carried out due to EN 1728 Furniture-Seating-Test methods for the determination of strength and durability while using loadings stated in EN1613, level of test severity is in relation to applications and it determines 2 levels of usage and extreme usage.

*Figure 11. Prototype of yellow variation of the Sofa, legs: American walnut*

*Figure 12. Prototype of green variation of the Sofa, legs: American walnut*

## 5. CONCLUSION

Usage of solution results of this project can be found in various levels. In theoretical level: the product represents nowadays trend in the field of upholstery furniture which is based on functionality and comfort.

We managed to create final desing of new seating component. There has been detailed drawing documentation made for the designed seating part containing visual processing. Before actual manufacturing a reduced 3D model has been printed to certify outer relations. The actual manufacturing was divided into two phases. In the first phase, supporting frame and all wooden legs were made. The final look of the sofa was made in the second phase in which the whole supporting frame was upholstered. This propotype had been tested plentifully so that all strenght and safety demands linked to this type of furniture were certified. The product described was designed in a way to meet all demands of public areas in general use and to meet all european standards for this type of furniture. Two experimanetal prototypes were made.

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## **REFERENCES** (alphabetical order)

1. EN 12520 (2016): Furniture - Strength, durability and safety - Requirements for domestic seating.
2. EN 16139 (2013): Furniture - Strength, durability and safety - Requirements for non-domestic seating.
3. EN 1728 (2013): Furniture - Seating - Test methods for the determination of strength and durability.
4. TAUBER, J.; ŠIMEK, M.; HOLOUŠ, Z.; SVOBODA, J. (2016) New Trends in Upholstered Furniture. In The Path Forward for Wood Products: A Global Perspective: Proceedings of Scientific Papers. Zagreb: WoodEMA, i. a., pp. 35--41. ISBN 978-0-692-76612-5.

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# THE CONCEPTION INDUSTRY 4.0 IN THE ENVIRONMENT OF WOOD PROCESSING COMPANIES IN SLOVAKIA

Remeň, O.; Sujová, A.

## ABSTRACT

The paper is focused on the issues of the current phenomenon which bears the name Industry 4.0 and its application in terms of wood processing industry (hereinafter WPI) in Slovakia. Many authors argue that under the term industry 4.0 we are talking about the further, in this case the fourth, industrial revolution. However a more appropriate definition would be industrial evolution. WPI development potential in Slovakia is enormous, which is also supported by a strategic asset of the country in the availability of wood raw material. It is therefore appropriate to question whether the German Industry 4.0 concept is applicable in the Slovak economy. The current period of fast pace of technology development, and constantly rising demand are pushing companies into investment decisions in the field of innovation. The principles are simple, reduce costs and increase the volume and efficiency of production. Therefore is the WPI environment for the implementation of the Industry 4.0 concept ideal. This paper discusses the Industry 4.0 concept implementation in the WPI environment in Slovakia, ideas that are already used in companies and ideas remaining only theoretical.
**Key words**: industry 4.0, production efficiency, wood processing company.

## 1. INTRODUCTION

Industry and production itself exists along with the mankind for many years during which they have undergone several changes and stages of development. The outcome of this evolution is the form in which we know them today. Evolution as a part of the existence of the industry is a process, that has been and still is conditioned by a variety of factors. These factors have changed over time along with the requirements of the society and the market itself. Currently, it is innovation that stands behind this evolutionary process as the main driving force. With other words we can say that survivability and competitiveness of an enterprise are maintainable only if the inovation itself becomes a routine process, in the everyday activities of the company, with the properties of an continually repeated cycle. In the last 60 years, the evolution of information technology has opened possibilities for companies to obtain data and exchange relevant informations in real time without significant restrictions. This resulted into reduction of the complexity of the research and product development, testing, implementation and product production. This progress alowed reducing costs and increasing process efficiency (McKenney, 1995). This period in history can be bookmarked as the beginning of the industrial digitizing process.

Currently, business data are emerging in each phase (manufacturing or non-manufacturing) of the business process. The overall amount of data generated in 2011, is several times larger than the cumulated data from the beginning of mankind to the year 2003 (Chen, 2014). Many enterprises, (with their existing analytical tools) can only with difficulty handle such amounts of data and efficiently process them and thus obtain the necessary information.

Enterprise research activities should look for the best ways to innovate with the goal to gain advantage over the competitive companies through the linking of the cyber and physical world. This issue requires the help of technologies and solutions like cloud computing, big data, internet of things, digital twin, and more. This improvement in the field of business intelligence and enterprise automatization will provide a new set of tools, which will improve the enterprise-skills to capitalize on new business and optimization opportunities (Chen, 2014).

The solution for effective linking of the cyber and physical world, is the German concept of the Industry 4.0. Many authors argue that under the term industry 4.0 we are talking about the further, in this case the fourth, industrial revolution. However, a more appropriate definition would be industrial evolution. The wood processing industry (hereinafter referred to as WPI) development potential in

Slovakia is large, which is also supported by a strategic asset of the country in the availability of wood raw material. It is therefore appropriate to question whether the German Industry 4.0 concept is applicable in the Slovak economy.

## 2. MATERIALS AND METHODS

The current period of fast pace of technology development, and constantly rising demand are pushing companies into investment decisions in the field of innovation. Merková et al. (2015) published the results of a complex research focused on the investment potential of WPI in comparison with other industries (automotive, engineering etc.) in Slovakia. The research confirms that the development potential of WPI in Slovakia is large, which is supported by the strategic asset of the country in the availability of wood raw material. The author but sees the main issues in the form of investments, where intangible investments, which are crucial for better performance, are not a typical investment activity for WPI and in the process of inveswsssatment project preparation and realization in companies of WPI.

Industry 4.0 represents a necessary step for the WPI enterprises in Slovakia. The rising demand pushes the production on a theoretical border where enterprises must consider the fact, that time is today the most valuable parameter and only due time saving activities, which will eventuate into performace increase and cost saving in all aspects of production is it possible to gain advantage over other competitive enterprises. Therefore is it necessary to link the cyber and physical space with the purpouse to eliminate deth-time activities an use the full potential of the enterprise transformation process. To ensure the right implementation of the industry 4.0 idea to the WPI, a step-by-step tactic model has to be developed.

Enterprise performance is closely associated with the performance and effectiveness of the transformation processes itself. According to the interview with Ing. Michal Dic which is an employee of the SOVA digital, the base for the industry 4.0 theory is fact, that the fundamental elements of the enterprise transformation process are formed by the triangle of the three basic aspects which are illustrated in figure 1.

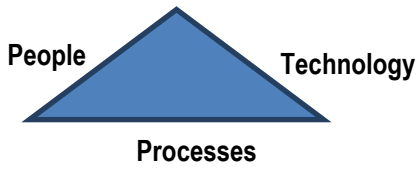


*Figure 1 The triangle of the three basic transformation process aspects*

The encompassment of these three basic aspects is for the enterprise effectiveness necessary, because the optimization of the transformation process in the current state, in which it is today, should represent the first step on the road to the industry 4.0 idea. This is also the starting point for the implementation of the industry 4.0 concept in the WPI in Slovakia. In order to prepare the WPI enterprises for the industry 4.0 it is necessary that all of these three aspects are mastered in the context of understanding the main issues connected to their respective narow places.

### 2.1. People optimization

The term optimization of people involves the methodology of employee education, motivation, remuneration and team building also the establishment of required information channels. In addition these information channels are necessary for efective work performance without downtimes and actions that does not add or does not create value according to the end product.

Social aspects of the people optimization issues in WPI in Slovakia are discussed in many pappers. Authors points out that nowadays successful enterprises appreciate not only knowledge and experience of their employees but also their willingness to cope with all difficult tasks. This enables the

employees to cope with all problems more easily. Therefore, well managed enterprises use their corporate culture as an efficient tool of managing or directing their coworkers. System of values, standards and habits influences the behaviour and performance of all employees (Hitka, 2015). In the term of pepole optimization are comunication and iformation flow equally important to the mentioned social aspects.

### 2.2. Technology optimization

Technology development increase has caused an increase of production possibilities (machines) which will produce faster and with high quality. However not every enterprise is able to inovate in such fast pace in which is the technology development today. The fact that modern technology solution often become obsolete before their amortization time even expires is considered today as the main issue for the most WPI enterprises. Enterprise should consider the structure of their technology park in consideration to the capacity-need, people disposition, energy intensity, capital intensity and environmental impact.

The main goal lies in the optimization of the existing technology park or in other words retrieve the maximum continual performance now. Energy saving means cost saving and lesser enviromental impact. It is necessary to mention that under the term technology we understand not only manufacturing machines but also buildings, IT, tools etc. Many authors have alredy worked with this issue such as Ju (2009), Hrastel (2007), Zhang (2009) and Xu (2016).

### 2.3. Process optimization

The research in the field of process management is experiencing increasing attention among the researchers in the recent years. Theoretical knowledge concerning process management conceptions and methods was compiled from several kinds of sources. Information resources are formed mostly from the scientific publications of foreign authors. The most important authors that have contributed to the development of the theory and practice of process management are:: G. R. Lee and G. B. Dale, H. Fayol, A. Sloan, M. Zairi and D. Sinclair, M. Weske and his business process management system, D. P. Norton and Kaplan and their system Balanced Scorecard, M. Hammer and J. Champy with methodology of business process reengineering. To the group of domestic authors that are dealing with the process management issue belong: Gejdos, P. (Process Quality Management), Potkany, M. (Process Outsourcing), Sujová, A. (Business process management), Svozilová, A. (Business process Improvement), Zauskova, A. (Innovation performance) and Zavadsky, J. (Business process performance management).

In the research paper of Sujová (2015), based on the results of the research, the author came to the conclusion that most of the investigated WPI enterprises are small sized (76, 5 %) and the dominative type of production is job-work and small-lot (74, 1 %). However, 23, 5 % of the WPI enterprises in Slovakia do not manage processes at all.

Meaning of the process improving lies in carrying out positive changes which increase the performance of a process. The basis for improving a process is stating the target values of key performance indicators of a process and their comparison with actually achieved values ascertained when measuring and analysing a process (Sujová, 2015).

### 2.4. Digitalization, tools and methods

According to the fact, that the main aim in industry 4.0 is the idea to link cyber and physical space it is necessary to prepare these two part and optimize them in the enterprise just before the linking. For the preparation of the physical space we recommend to use the triangle of the three basic aspects of the transformation process (mentioned above). After performing the optimization in the field of the three basic aspects of the transformation process it is possible to aim the effort on the preparation of the cyber space of the enterprise. Today most of the enterprises have alredy started the proces of

digitalization and use IT solutions like ERP, BIS and more that help them to manage the production process. However accumulated data are often not correctly proceeded, evaluated and targeted for the key indicators needed to be monitored. Figure 2 ilustrates the data obtaining, evaluating and distribution process in enterprise.

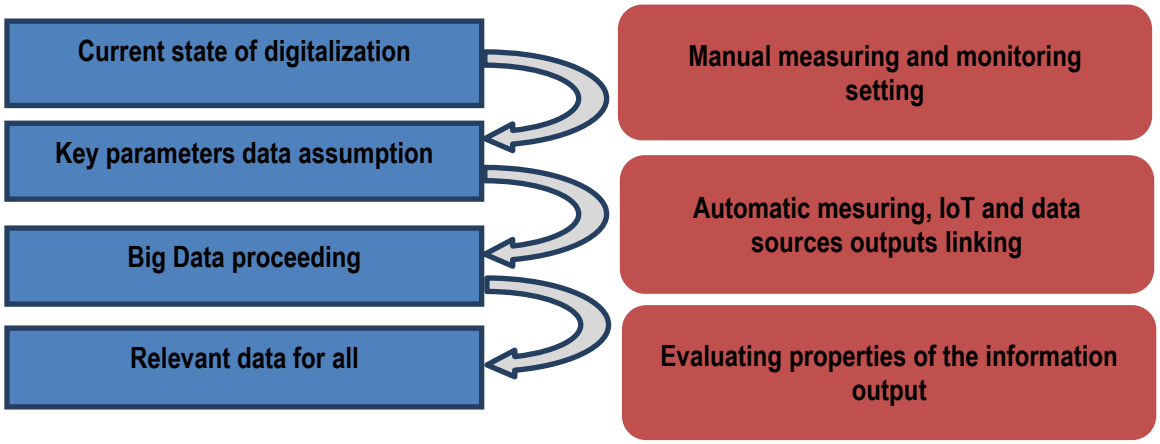


*Figure 2The process of obtaining and evaluating of enterprise data*

The digitalization of processes revealed in the past ten years several issues according to the amount of data produced in enterprises world wide. However most of them are unable to efficiently process these data for their own favour. This isue is solved due the implementation of the basic tools of the industry 4.0 as the Big Data, Internet of things (IoT) and the Digital Twin.

### *2.4.1. Big Data*

At present, although the importance of big data has been generally recognized, people still have different opinions on its definiton. In general, big data refers to the datasets that could not be perceived, acquired, managed, and processed by traditional IT and software/hardware tools within a tolerable time. McKinsey & Company observed how big data created values after in-depth research on the U.S. healthcare, the EU public sector administration, the U.S. retail, the global manufacturing, and the global personal location data. Through research on the five core industries that represent the global economy, the McKinsey report pointed out that big data may give a full play to the economic function, improve the productivity and competitiveness of en terprises and public sectors, and create huge benefits for consumers. Traditional data management and analytics systems are based on the relational database management system (RDBMS). However, such RDBMSs only apply to structured data, other than semi-structured or unstructured data. It is apparently that the traditional RDBMSs cannot handle the huge volume and heterogeneity of big data. (Chen, 2014).

### *2.4.2. Internet of things (IoT)*

The basic idea of IoT is to connect different objects in the real world, such as RFID, bar code readers, sensors, and mobile phones, etc., to realize information exchange and to make them cooperate with each other to complete a common task. The big data generated by IoT has different characteristics compared with general big data because of the different types of data collected, of which the most classical characteristics include heterogeneity, variety, unstructured feature, noise, and rapid growth (Chen, 2014).

### *2.4.2. Digital Twin (IoT)*

Digital Twin - twin Digital is a digital copy of a physical object (product and / or production), which can be used for multiple purposes. Digital twin processes data from sensors installed in physical objects that usually used to optimize the operation of these physical objects. Digital twin contains three main parts:

- Physical products in real space
- Virtual product in virtual space
- Connection data and information that ties the virtual and real products together

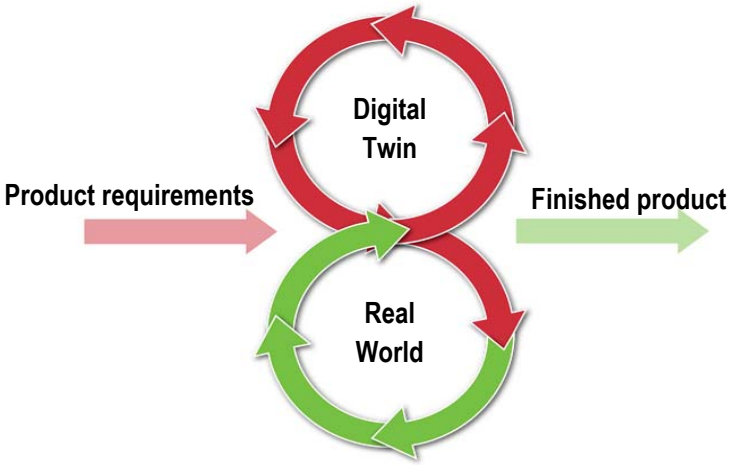


*Figure 3 Digital Twin process*

The mission of the twin digital is to create, test and produce products in a virtual environment. Only after the product is digital ready the physical production will start (Figure 3). Subsequently, more complex physical products are tied through sensors back to the digital twin, so the digital twin contain all the information serving for the further optimization of the production process. (Dic, 2017).

Digital twin is also used to control production processes. PLM tools and DM will create a digital model of the production and then a detail simulation and optimization of all processes and activities is carried out. Only after this virtual production the physical production will start. After the production starts, data from the manufacturing processes are recorded. These data should be constantly evaluated, optimized, and gradually in iterative manner become more effective. Digital twin is an essential tool for Industry 4.0 that increases operational efficiency of the enterprise (Dic, 2017).

## 3. RESULTS

After the analysis of the investment potential of the WPI development according to the research of Merková (2015) and the interview with Ing. Michal Dic it is possible to assume that the WPI in Slovakia has development potential for the implementation of the Industry 4.0 idea. According to the materials it is possible to assemble a theoretical model of steps necessary for the WPI "evolution" in Slovakia. Due the analysis of theoretical materials and interwiev results is it possible to create a theoretical model of indutry 4.0 preparation and implementation steps for enterprises, which is illustrated in the Figure 4.

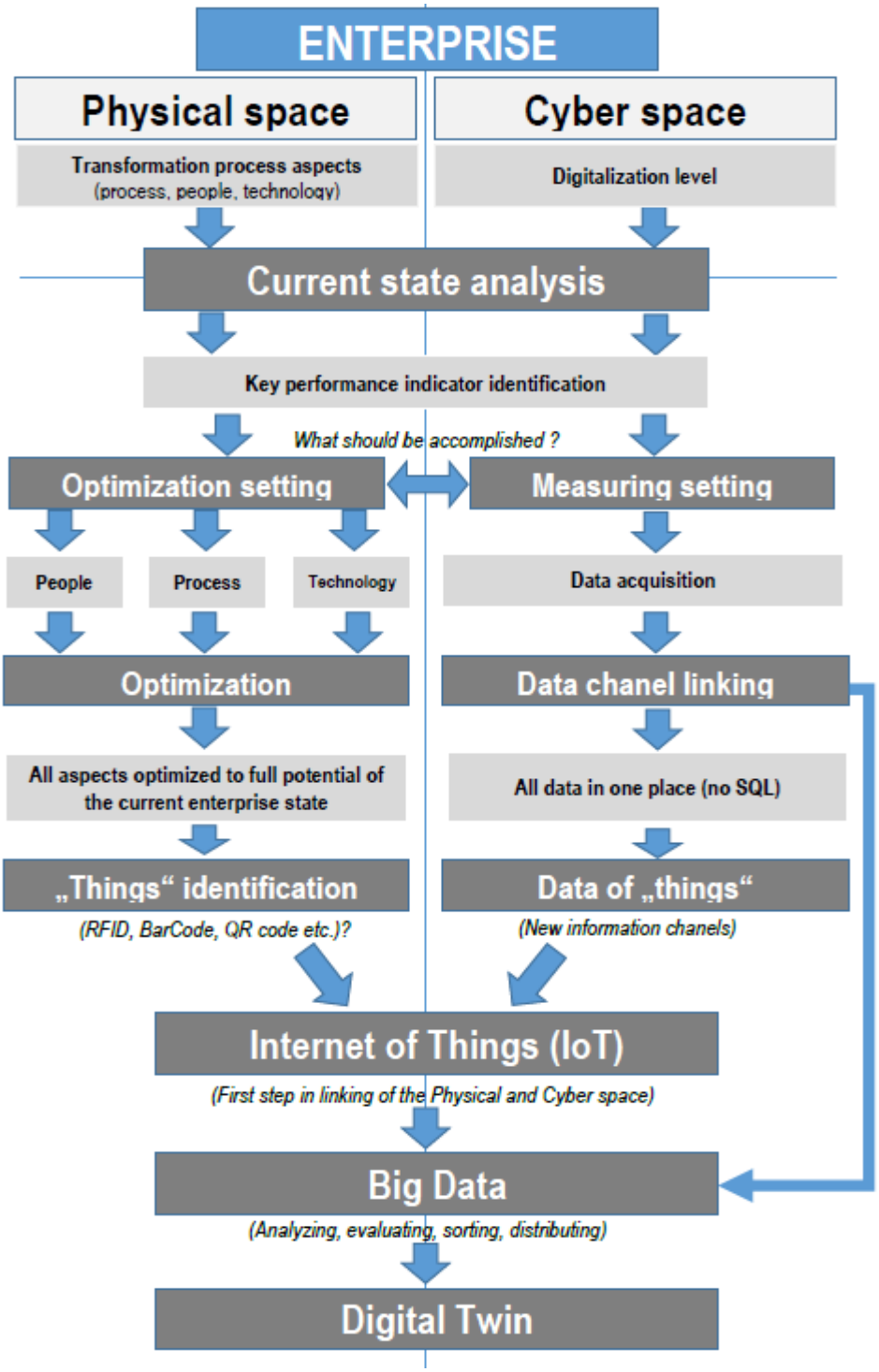


*Figure 4 Steps for Industry 4.0 implementation*

## 4. CONCLUSIONS

Like the revolution that preceded it, the fourth industrial revolution has the potential to increase the level of incomes and improving quality of life worldwide. New technologies and progress has resulted

into fundamental changes in many countries. Inovation activities are necessary for enterprises to sustain competitiveness an the markt. In this papere we have focused on the development potenitial of the WPI in Slovakia according to the idea of Industry 4.0.

Industry 4.0 in the enviroment of WPI has space for futhure development. However the WPI in Slovakia should be more involved in the investment and innovation, particularly in the field of intangible assets, because today software solutions are necessary for the functionality of the transformation process in the enterprise.

The WPI enterprises should take necessary steps before implementation the idea of Industry 4.0 into their everyday existence. In this paper we have developed a methodology of steps that are necessary for the enterprise to accomplish just before the implementation of the Industry 4.0. This model should help WPI enterprises to sustain competetive advantage against other European competitors on the global market.

This step-by-step model is only in the phase of development and therefore not definite. We recommend to focus the future research on the issue of the digitalization, its state and progress in connection on the Industry 4.0 idea in the WPI in Slovakia and the search for the key indicators that would represent a standardized view on the performance, flexibility and efectivity of the WPI enterprises.

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## REFERENCES

1. Anderson, M. C., Banker R. D., Ravindran, S. (2003): *The New Productivity Paradox*. Communications of the Acm, 46(3): 91-94.
2. Audretsch, David B. (1995): Innovation and industry evolution. Cambridge, Mass: MIT Press Print.
3. Chen, Min. (2014): Big data: related technologies, challenges and future prospects. SpringerBriefs in Computer Science. Cham: Springer, 2014. Accessed April 15, 2017.
4. Dic, M. interwiev
5. Hitka, M., Stipalova, L. (2011): *Comparing of Employees Motivation Level in Enterprises of Wood Working Industry with Other Manufacturing Enterprises in Slovak Republic*. Drvna Industrija, 62(3): 185-192.
6. Hitka, M., Vetrakova, M., Balazova, Z., Danihelova, Z. (2015): *Corporate Culture as a Tool for Competitiveness Improvement*. Procedia Economics and Finance. Vol. 34, pp. 27-34.
7. Hrastel, I., Gerbec, M., Stergargek, A. (2007): Technology Optimization of the Wet Flue Gas Desulphurization Process, Supported with Technical, Economy and Reliability Based Analysis.
8. Ju, J., Shi, Z. W. (2009): Research on Technology Optimization of Energy-Saving for Rural Residential Buildings in Harbin.
9. Mantyneva, M., Salminen, V., Ruohomaa, H. (2016): *Digitalization and Big Data Supporting Responsible Service Business Co-Evolution*. What's Ahead in Service Research?: New Perspectives for Business and Society, pp. 292-302.
10. McKenney, James L., Copeland, D., G., Mason, R., O. (1995): Waves of change: business evolution through information technology. Boston, Mass: Harvard Business School Press, Print.
11. Merkova, M., Drabek, J., Jelacic, D. (2015): *Evaluation of Investment Management and Business Performance in Wood Processing Industry in Slovakia.* Drvna Industrija, 66(3): 241-249.
12. Rasner, J. Sujova, A. (2001): *Radical Change of Woodprocessing Firm through Production Restructuralisation*. In: Proceedings of conference "Ways for Improving Woodworking Industry for Transitional Economics", pp. 205-210.
13. Salminen, V., Ruohomaa, H., Kantola, J. (2017): *Digitalization and Big Data Supporting Responsible Business Co-Evolution.* In J. I. Kantola, T. Barath, S. Nazir and T. Andre (Eds.), Advances in Human Factors, Business Management, Training and Education.
14. Shang, K. H., Zhou, S. X., van Houtum, G. J. (2010): *Improving Supply Chain Performance: Real-Time Demand Information and Flexible Deliveries*. M&Som-Manufacturing & Service Operations Management, 12(3): 430-448.

15. Sujova, A. (2015): *Influence of the Economic Crisis in 2008 on the Performance of Companies in Wood-Processing Industry*. Procedia Economics and Finance. Vol. 34.
16. Sujova, A., Marcinekova, K. (2015): Improvement of Business Processes - a Research Study in Wood-Processing Companies of Slovakia. Procedia Economics and Finance. Vol. 34., pp. 296-302.
17. Xu, X. H., Tian, W. H., Li, Q., Wang, L. (2016): *Application of Resolution Principle in Search Agent's Semantic Query Optimizing Model*. Design, Manufacturing and Mechatronics (Icdmm 2015), pp. 1474-1481.
18. Zhang, J. G., Song, X. W., Chen, H. Y., Shi, R. X. (2016): *Determination of Critical Chain Project Buffer Based on Information Flow Interactions*. Journal of the Operational Research Society, 67( 9): 1146-1157.

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# JUSTIFICATION OF CAPITAL INVESTMENT IN SMALL-SCALE UNEVEN-AGED FOREST ESTATES

Posavec, S.; Beljan, K.; Koren, F.

## ABSTRACT

This paper addresses the issue of justification of capital investment in small-scale uneven-aged forests (silver fir-common beech) in the Republic of Croatia. Investment is considered a purchase of a forest and its pertaining land. A case study was conducted on a real-life case of a forest estate that is currently for sale (area of 2.5 ha). Property purchase was hypothetical, while all incoming parameters such as property price, forest characteristics, increment, assortment structure and selling prices of wood assortments were real. Forest Management plans for private forest owners were used to estimate the cash flow. Cash flow and investment analysis were calculated using capital budgeting tools. Although the expected return on investment in forestry is in about 20 years, local currency inflation was taken into consideration. The results of the case study analyses would show whether the decision making was economically justified and if so, under what conditions to invest into a purchase of a small-scale forest property.
**Key words**: small-scale forestry, management plan, investment analysis, Croatia

## 1. Introduction

Capital budgeting is a decision-making process concerning long-term investment in real estate. It is a decision-making process on the so-called long-term projects that include forestry. The purpose of investment in forestry is in holding and generating specific yields (Klemperer 2003). In Croatia, the potential real estate market includes privately-owned forests, since in case when forests are owned by the state they are sold under special conditions. Consequently, this research was focused on the justification of capital investment into privately-owned forests (investor's forest purchase and forest management in the future). According to National Forest Inventory, privately-owned forests in the Republic of Croatia account for around 23 % of the total forest area which is 546,350 ha (Čavlović 2010). It is not possible to accurately establish the area covered by privately-owned forests due to incomplete land registration, as well as incomplete Management Plans for privately-owned forests (Berta et al. 2017). According to their characteristics, privately-owned forests located in Gorski Kotar region (Čavlović 2010) have the potential for production of high quality logs, although their owners do not recognise that (Posavec and Beljan 2012) and neither do the potential investors. Irrespective of the fact that Management Plans do not include business analysis elements (Posavec 2003), the fact that financial value of forests and investment potential has not been recognised is not surprising. A large number of authors has addressed the issue of characteristics of privately-owned forests in the Republic of Croatia (Kovačić 1987; Paladinić et al. 2008; Posavec et al. 2011; Posavec and Beljan 2012; Krajter et al. 2015; Berta et al. 2017), yet the authors have not tackled the issue of justification of capital investment or economic assessment of privately-owned forests. Consequently and also due to limited forest management potential, as well as due to the fact that individual forests are normally small-scale, privately-owned forests require a special approach.

One of the fundamental characteristics of the forest in terms of capital is long payback period (Posavec 2003; Beljan 2015). This investment characteristics is unacceptable when considered from private capital stance, since its objective is to achieve short payback period. Nevertheless, there certainly are investors for whom 20 years payback period is justified. Internal rate of return (IRR) for state-owned forests in Croatia ranges between 2% and 3 % (Figurić 1996), according to Partaš (1896) it stands at 3 %, whilst according to Nenadić (1930) at least 1 % to 2 %, according to Plavšić (1940) up to

2.5 %, according to Zelić (2006) it stands at 1.19%, according to Beuk (2012) 1.9 %, whereas according to Beljan (2015) it stands at 2.17%. It is obvious that the expected return on investment ranges between 1 % and 3 % which exceeds the interest rates currently offered by commercial banks. This capital is considered a low-risk investment that results in low internal rate of return (IRR), as well as low discount rates (Beljan 2015). Its minimum acceptable rate of return (MAR) that needs to be met by the investment is highly important for investors (Klemperer 2003). Each investor has an individual MAR according to which they make their investment decisions. The results presented in this text include internal rates of return for different investment scenarios in small-scale uneven-aged forest estates in Croatia according to which it is possible to define their relation with the investor's MAR. It can be assumed that investment that covers the inflation rate will be identified by investors as propitious.

The specific objective of this research is to determine the economic justification of purchase concerning a small-scale uneven-aged forest estate in Gorski Kotar region (Croatia). A hypothesis has been put forward that upon low discount rates the investment has a solid economic footing, since the expected discounted payback period exceeds 20 years.

## 2. material and methods

### 2.1 Research area

The research area includes privately-owned forests in the region of Gorski Kotar in the Republic of Croatia. The region is specific due to uneven-aged forests of common beech (*Fagus sylvatica* L.) and silver fir (*Abis alba* Mill.) covering an area of around 127,300 ha of which privately-owned forests account for 23.79 % (Čavlović 2010). The average area covered by forest land parcel stands at 0.34 ha, as opposed to forest estates covering an area of 1.28 ha (Berta et al. 2017). The region is included in the zone of continental karst, whilst the dominant forest communities are *Omphalodo-Fagetum* (Marinček et al. 1992). The altitude ranges between 350 m and 1,534 m a.s.l., whilst the average annual temperature stands at 7.3°C with annual precipitation of 2,275 mm (meteorological station of the city of Delnice). Privately-owned forests that can potentially be found on the market differ from state-owned forests. Wood volume is three times lower in privately-owned forests compared with state-owned forests (Čavlović 2010), whereas forest regeneration is more difficult in all the forests throughout Gorski Kotar, irrespective of ownership (Čavlović et al. 2006; Teslak et al. 2016). The selected case study is a privately-owned forest that covers an area of 2.5 ha, which is for sale and is located in the immediate vicinity of the town of Čabar (45°35'40"N 14°38'50"E). The forest comprises of a coherent land surface divided into three cadastral plots. The privately-owned forest is surrounded on all sides with other forests owned by private forest owners, and an asphalt road passes through it. Due to the ice break dating back to spring 2014 (Šimić-Milas et al. 2015; Delač 2016) and bark beetle (*Ips typographus* L.) attack, the previous forest management was marked by a large-scale salvage felling.

### 2.2 Data collection and forest management simulation

The basic characteristics of the forest in question were established in December 2016 through field measurement on 4 circular plots of a radius of 12.62 m (500 $m^2$ surface). The location of the plots (their position in the area) were selected in advance using the method of simple random sampling. All the trees were measured - silver fir (*Abis alba* Mill.), common beech (*Fagus sylvatica* L.), norway spruce (*Picea abies* Karst.) and scots pine (*Pinus sylvestris* L.) whose diameter breast height (DBH) exceeds 10 cm. Each tree species was determined, their DBH was measured and their height was estimated

according to Čavlović and Božić (2008). Height curves were constructed using Mihajlov function (Mihajlov 1966) based on the heights measured and the diameter of the trees. Moreover, wood volume was determined based on standing timber prices according to Schumacher and Hall (1933). The current financial value of the total wood mass was estimated using assortment tables and the corresponding price list of Main forest products (HŠ 2012).

A virtual forest stand was constructed based on the data provided through field measurement according to the methodology described in Beljan et al. (2016). The virtual forest stand represents digital version of the stand measured on the field and it is used to access forest stand growth simulators in order to analyse future forest management.

The future forest management was simulated using MOSES ver. 3.0. programme, a programme package for forest stand growth and increment simulation, which is based on statistical modelling in mixed and uneven-aged stands (Hasenauer et al. 2006). Virtual forest stand was entered into MOSES programme and hence a simulation of forest management was performed for the forthcoming 30 years. For that purpose the privately-owned forest covering an area of 2.5 ha was divided into 5 smaller forest stands each of which covered an area of 0.5 ha, so that the revenue generated from timber assortment would be duly distributed in time. Consequently, the simulation was performed separately for each of the 5 forest stands with the starting time difference of 1 year. The 5-year cutting-cycle was used during the simulation, whilst the harvested volume was determined according to Klepac (1953). The harvested volume and its assortment structure can be followed at any point of the simulation.

### 2.3 Cash flow and economic analysis

Cash flow is a financial category that reflects the flow of cash: revenues and costs (Damodaran 2002). The forecast of cash flow for a specific project is the most difficult aspect of the process of economic analysis due to the fact that cash flow is the basis for the assessment of all the financial elements of the project (Damodaran 2002; Orsag and Dedi 2011). The option of purchase price of the forest in the local currency standing at HRK 1 to HRK 4 $m^{-2}$ (Eur 1=HRK 7.42 on the date 30/03/2017) was considered. The costs concerning the purchase of forest estate were present on a one-time basis only nor did they at the commencement of the investment period. On the other hand and besides the costs, there were the revenues resulting from a 30-year period of forest management concerning the sales of standing timber (the investor sold standing timber assortment and did not own mechanisation, nor did they hire workers). The revenue generated through harvesting was presented for each year using the price list provided by Croatian Forests Ltd. for standing timber sales (standing timber) in combination with assortment tables.

Investment analysis was performed based on cash flow using the discounted payback period (Orsag and Dedi 2011), (NPV) nett present value (Klemperer 2003) and IRR-internal rate of return (Damodaran 2002). All the elements of analysis were observed within a 30-year period. Referential constant discount rate was used throughout the analysis, which in forestry of the Republic of Croatia according to Beljan (2015) stands at 2 %, yet the possibility to apply the rates ranging from 1 % to 6 % was also analysed.

## 3. RESULTS

The initial assortment structure of the privately-owned forest was determined following field measurement and data analysis (Table 1). The share of beech was the largest (133.43 $m^3$ $ha^{-1}$) and it was followed by silver fir, norway spruce and scots pine. It is important to highlight that standing dead timber accounts for almost one quarter of wood volume. The initial characteristics determined the future planning in relation to the forest in question which primarily concerns the harvesting of standing dead timber whose assortment structure, as well as its financial value, are not favourable for the investor. It was visible from the assortment structure (Table 1) that most wood volume was concentrated in one-

meter firewood and sawlog of 1st and sawlog of 2nd class, which was a direct consequence of a relatively small diameter. The share of the most valuable assortments - veneer and peeled veener – which account for only 5 $m^3$ $ha^{-1}$, cannot be considered as sufficient profit for the investor within a short period of time.

The excessive share of standing dead timber (Table 1), resulting exclusively from natural processes, determines the future planning. The forest needs to be channelled through forest management towards a higher wood volume that will in the future have the potential to lead towards higher quantities of uneven-aged forest harvesting and hence also towards production of assortment of higher financial value. From the initial assortment structure it was clear that all the timber assortments were present, yet their mutual ratio was unsatisfactory.

*Table 1. Initial assortment structure of small-scale uneven-aged forest estate in year 2016*

| Timber assortments | Silver fir | Common beech | Norway spruce | Scots pine | Standing dead trees | TOTAL |
|---|---|---|---|---|---|---|
| | [$m^3$ $ha^{-1}$] | [$m^3$ $ha^{-1}$] | [$m^3$ $ha^{-1}$] | [$m^3$ $ha^{-1}$] | [$m^3$ $ha^{-1}$] | [$m^3$ $ha^{-1}$] |
| Veneer | 0.11 | 1.65 | 0.11 | 0.55 | - | 2.42 |
| Peeled veneer | - | 2.74 | - | 0.28 | - | 3.02 |
| Sawlog 1st | 10.66 | 10.30 | 5.64 | 3.11 | - | 29.70 |
| Sawlog 2nd | 8.66 | 10.84 | 3.70 | 1.86 | - | 25.06 |
| Sawlog 3rd | 4.50 | 8.08 | 2.27 | 2.91 | - | 17.75 |
| Thin roundwood | 10.41 | 4.49 | 3.51 | 0.00 | - | 18.40 |
| Long-meter firewood | 0.00 | 17.45 | 0.00 | 0.82 | - | 18.27 |
| One-meter firewood | 27.43 | 62.33 | 9.06 | 2.53 | - | 101.36 |
| Timber waste | 13.68 | 15.56 | 5.27 | 2.47 | 95.60 | 132.58 |
| TOTAL | 75.45 | 133.43 | 29.56 | 14.52 | 95.60 | 348.56 |

### 3.1 Forest management simulation and cash flow

Simulation of the future management of a small-scale forest estate focuses on the increase of wood volume in the immediate future aiming to increase the production of more valuable assortments. Figure 5 provides the opportunity to observe the simulation on stand level and forest level (which actually shows the average for all the stands). During the first five years the focus was on the required harvesting of standing dead trees which resulted in wood volume decrease (Figure 5a). Subsequently and until the end of the observed period the wood volume increased (Figure 5a) and it can be assumed that its optimum will be achieved only in 60 years (starting from 2016). Uneven-aged forest harvesting that was simulated every 5 years (Figure 5a) resulted in revenues that can be observed through cash flow (Figure 5b).

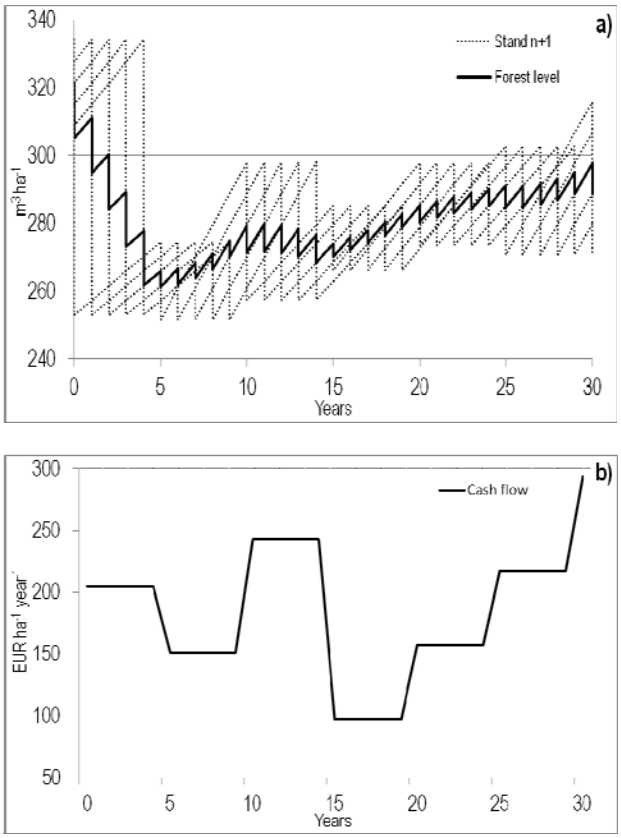


*Figure 5. Management simulation on stand and forest level (a), cash flow (b)*

Cash flow is the direct consequence of forest management simulation. It has been shown through average values per hectare (Figure 5b). Uneven-aged forest harvesting resulted in revenues every five years, yet, when observed at the level of the forest, the revenue was generated annually, albeit in another stand (in another part of the forest). Wood volume values (Figure 5a) and cash flow (Figure 5b) cannot fully match due to the quality of the harvested wood assortments, since during some years smaller volumes of wood were harvested and yet cash flow was high due to high unit price of wood assortments. At the commencement of the observed simulation period the revenue generated was relatively low, yet upon passage of time it showed an upwards trend (Figure 5b). The previously mentioned low revenue during the first years was necessary so that substantially higher revenue would be generated in the future.

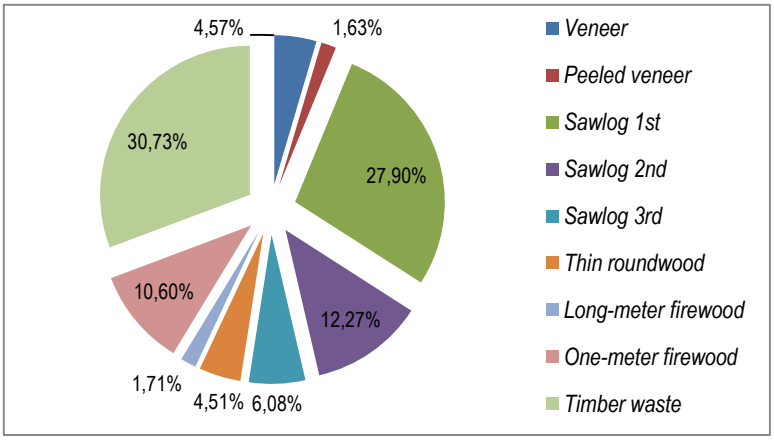


*Figure 6. The share of produced wood assortments during 30-year simulation period*

The expected production of wood assortments has been shown in Figure 6. Timber waste had the highest share, accounting for 1/3 of all produced wood assortments. Timber waste, i.e. wood produced through standing dead tree harvesting is the direct consequence of the existing state initially found on site (Table 1). Hence highly-valuable assortments both of veneer and peeled veneer jointly account for only 6 %. The revenue during the simulation period was primarily generated through sawlog of 1st and sawlog of 2nd class which jointly account for 40.17 %. The simulation of forest management (Figure 5) was intended to achieve optimum results, whilst the criteria for forest harvesting were primarily biological, rather than financial. Consequently, it is obvious that the most valuable assortments will be harvested during the period after 30 years.

### 3.2 Investment analysis

The analysis of capital investment justification was performed based on cash flow and the initial investment (Table 2, Table 3). Discounted payback period and NPV were analysed with various scenarios concerning the purchase price of the forest and discount rates ranging between 1 % and 6 %. The investment costs showed in the subsequent tables were expressed in HRK and Euro. Forest prices on the local Croatian market are linked with the domestic currency and they are most frequently round numbers (e.g. HRK 2, HRK 3, or HRK 4 per $m^2$), whilst in rare cases the price is expressed in Euro. Hence, the prices expressed in Euro are not round numbers. Table 2 and Table 3 were both designed as crossword puzzles from which discounted payback period can be deducted and NPV if two entries, investment cost and discount rate, are given.

*Table 2. Discounted payback period with different purchase prices of the forest and applying various discount rates*

| Investment cost [HRK $ha^{-2}$] / [Eur $ha^{-2}$] | Discount rate | | | | | |
|---|---|---|---|---|---|---|
| | 1 % | 2 % | 3 % | 4 % | 5 % | 6 % |
| 10 000 / 1 347.70 | 4 yrs | 7 yrs | 8 yrs | 8 yrs | 8 yrs | 9 yrs |
| 20 000 / 2 695.41 | 14 yrs | 16 yrs | 19 yrs | 22 yrs | 26 yrs | 30 yrs |
| 30 000 / 4 043.12 | 26 yrs | 29 yrs | >30 yrs | >30 yrs | >30 yrs | >30 yrs |
| 40 000 / 5 390.83 | >30 yrs | >30 yrs | >30 yrs | >30 yrs | >30 yrs | >30 yrs |

Discounted payback period changed along with the changes of investment costs and the applied discount rate (Table 2). As expected, upon higher discount rate the payback period was always longer and vice versa. Table 2 presented cases in which return on investment was expected also after 30 years.

Nett present value was also influenced by discount rate and investment costs and according to the identical principle as discounted payback period (Table 3). Upon investment cost of EUR 0.13 $m^{-2}$ and EUR 0.27 $m^{-2}$ NPV was positive at all discount rates. The second extreme was investment cost of EUR 0.53 $m^{-2}$ where NPV was always negative. In Table 3 it is important to point out that high investment costs do not always suggest negative NPV. Combinations of investment cost and discount rate for which NPV is negative (Table 3) also have discounted payback period that exceeds 30 years (Table 2).

*Table 3. NPV of a 30-year investment with different purchase prices of forest and applying various discount rates*

| Investment cost [HRK $ha^{-2}$] / [Eur $ha^{-2}$] | Discount rate | | | | | |
|---|---|---|---|---|---|---|
| | 1 % | 2 % | 3 % | 4 % | 5 % | 6 % |
| | NPV [Eur $ha^{-2}$] | | | | | |
| 10 000 / 1 347.70 | 3 530.49 | 2 908.48 | 2 401.74 | 1 985.61 | 1 641.16 | 1 353.80 |
| 20 000 / 2 695.41 | 2 182.78 | 1 560.77 | 1 054.03 | 637.90 | 293.45 | 6.09 |
| 30 000 / 4 043.12 | 835.07 | 213.06 | -293.67 | -709.81 | -1 054.26 | -1 341.62 |
| 40 000 / 5 390.83 | -512.64 | -1.134.65 | -1 641.38 | -2 057.52 | -2 401.97 | -2 689.33 |

Internal rate of return showed the percentage of invested compound interest on the invested capital during a particular period of time (30 years). The period of time analysed upon investment of EUR 1 347.70 $ha^{-2}$ showed internal rate of return of 16.1 %, for investment of EUR 2 695.41 $ha^{-2}$ it was 6.025 %, the invested EUR 4 043.12 resulted in 2.39 %, whereas the highest investment of EUR 539.08 $ha^{-2}$ showed IRR of 0.31 %.

## 4. Discussion and conclusion

The research findings show that capital investment in small-scale uneven-aged forest estates has economic justification. NPV is the principal criterion for acceptance or refusal of investment (Klemperer 2003; Orsag and Dedi 2011) and hence in Table 3 all the possible combinations of NPV can be determined. Consequently, investment cost or discount rate must not be observed separately, since e.g. a high investment cost at a low discount rate results in positive NPV. It is important to highlight the fact that in some cases the return on investment can be expected also after 30 years (Table 2). Upon the highest purchase price of the forest and application of the highest discount rate it is even possible that there will never be any return on investment. In other words, quantity and quality of wood assortments that can be produced from the forest would not be sufficient to settle the excessive investment costs. A conclusion can be reached that an investment is propitious only upon specific investment costs and discount rates, which was shown both in Table 2 and Table 3.

All the IRR opportunities presented are feasible in real investment upon purchase of small-scale uneven-aged forest estates, yet there is the issue of possible purchase price of the forest. It is highly unlikely that a potential investor will be provided the opportunity to invest in (in the purchase of) a forest at low prices that result in IRR of 16 %. In this specific case the investor would have to invest a maximum of EUR 4 043.12 $ha^{-2}$ at the highest discount rate ranging between 2% and 3% (2.39%, to be more specific) so that NPV would be equal to zero, that is, each purchase price and discount rate lower than those previously mentioned would ensure a positive NPV (Table 3). Upon comparing IRR with average inflation rate of the local HRK currency during the period ranging between 2000-2016 that stood at 2.28 % (CBS 2017), a conclusion was reached that the purchase of the forest at the price of EUR 4 103.87 $ha^{-2}$ covered the rate of inflation. In other words, the purchase of the forest at a lower price would ensure the increase of the invested capital for the investor, irrespective of inflation.

Concerning the MAR of the investor, a conclusion can be made that investment in this type of forests is unsatisfactory for those who expect high rates of return within a shorter period of time. Nevertheless, forestry needs to be considered from the aspect of investment in real estate which is extremely low risk (Klemperer et al. 1994) and one needs to strive towards the notion of unlimited annuity (of a normal forest) that will continuously produce both monetary and non-monetary values both for the common good and to the benefit of the investor. Forest management requires planning and management of large-scale areas and it is more acceptable for public capital where short payback period is not imperative (Beljan 2015). Natural forests, which have the largest share in the Republic of Croatia, are extremely low risk due to their stability, natural regeneration and stable wood assortment prices.

This research presented a scenario of optimal small-scale forest management. There certainly are more and less intensive forest management scenarios, yet the one presented in this paper is the one to provide the greatest long-term benefits both for the environment and for a "patient" investor. From the economic aspect, certainly the best option is to harvest the entire wood volume already during the first year and generate profit, yet this should not be considered as a desirable option by any investor.

Besides the presented cash flow (Figure 5b) which is the result of standing timber sales, revenue generated through hunting and harvesting of non-wood forest products, which can only exert a positive impact on the financial aspect of the investment, can also be considered. Moreover, a potential investor needs to consider the fact that the Republic of Croatia is currently preparing for the implementation of

Sub-Measures 8.5. (Subsidies for Investment in Increasing the Resilience and Environmental Value of Forest Ecosystems (NN 30/2015)) through which works in privately-owned forest estates can be financed by year 2020. Furthermore, it is important to point out the fact that the results of this research are based on one sample and it is possible that specific privately-owned forests in Gorski Kotar region can have favorable or untoward characteristics compared with the analysed sample.

Consequently, concerning all the previously presented information, the hypothesis that had been put forward was partially accepted. In fact, only the investors who deem the presented values of the economic analysis sufficiently satisfactory, are the ones who can certainly increase their capital levels through investment in privately-owned forests of Gorski Kotar region.

## REFERENCES

1. Beljan, K. (2015): *Economic analysis of even-aged silver fir (Abies alba Mill.) forest management (in Croatian with English abstract).* PhD thesis, University of Zagreb, Croatia, Zagreb. 166 p.
2. Beljan, K.; Vedriš, M.; Mikac, S.; Teslak, K. (2016): *Generating Virtual Even-Aged Silver Fir Stand Structure Based on the Measured Sample Plots*. South-east European forestry, 7 (2): pp. 119-127.
3. Berta, A.; Kušan, V.; Križan, J.; Stojesavljević, D.; Hatić, D. (2017): *Estate characteristics of private-owned forests in Croatia according to regions (in Croatian with English abstract)*. Šumarski list, 141 (1-2): pp. 57-65.
4. Beuk, D. (2012): *Hunting in the integrated management of Spačva forests (in Croatian with English abstract).* PhD thesis, University of Zagreb-Faculty of Forestry, Zagreb. 216 p.
5. ***:CBS (2017): *Croatain bureau of statistics*. URL: http://www.dzs.hr/default_e.htm
6. Čavlović, J. (2010): *First National Forest Inventory in Republic of Croatia (in Croatian)*. Zagreb: Ministry of regional development and forestry & Faculty of Forestry. 300 p.
7. Čavlović, J.; Božić, M. (2008): *National Forest Inventory in Croatia - Methods of Field Assesment (in Croatian)*. Zagreb: University of Zagreb-Faculty of Forestry. 146 p.
8. Čavlović, J.; Božić, M.; Boncina, A. (2006): *Stand structure of an uneven-aged fir–beech forest with an irregular diameter structure: modeling the development of the Belevine forest, Croatia*. European Journal of Forest Research, 125 (4): pp. 325-333.
9. Damodaran, A. (2002): *Investment valuation - Tools and Techniques for Determining the Value of Any Asset* (2nd edition ed.). New York: John Wiley & Sons, Inc. 992 p.
10. Delač, D. (2016): *Catastrophic consequences of ice break in February 2014 on the forests of Gorski Kotar region (in Croatian)*. Šumarski list, 140 (7-8): pp. 389-413.
11. Figurić, M. (1996): *Introduction to economics of forest resources (in Croatian)*. Zagreb: Šumarski fakultet Sveučilišta u Zagrebu. 343 p.
12. Hasenauer, H.; Kindermann, G.; Steinmetz, P. (2006): *The tree growth model MOSES 3.0.* In: Sustainable forest managemet growth models for Europe. Hasenauer, Hubert. Berlin: Springer, 64-70
13. ***:HŠ (2012): *Price list of major forest products*. URL: www.hrsume.hr
14. Klemperer, D. W. (2003): *Forest Resource Economics and Finance*: McGraw-Hill. 551 p.
15. Klemperer, D. W.; Cathcart, J. F.; Haring, T.; Alig, R. J. (1994): *Risk and the Discount Rate in Forestry*. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere, 24 (2): pp. 390-397.
16. Klepac, D. (1953): *Several formulas for the intensity of logging (in Croatian)*. Šumarski list, 77 (9-10): pp. 373-385.
17. Kovačić, Đ. (1987): *The problems of forest management in privately owned forests in Croatia*. Šumarski list, 111 (5-6): pp. 249-257.

18. Krajter, S.; Posavec, S.; Paladinić, E.; Županić, M.; Beljan, K.; Curman, M.; Ćaleta, M. (2015): *Forest land ownership change in Croatia. COST Action FP1201 FACESMAP Country Reports, Joint Volume*. In: Forest land ownership change in Europe. Živojinović, I, et al. Vienna: University of Natural Resources and Life Sciences (BOKU), 1-40
19. Marinček, L.; Mucina, L.; Zupančić, M.; Poldini, L.; Dakskobler, I.; Accetto, M. (1992): *Nomenklarorische revision der Illyrischen buchenwälder (verband Aremonio-Fagion)*. Studia Geobotanica (12): pp. 121-135.
20. Mihajlov, I. (1966): *Dendrometrija*. Skoplje: Univerzitet u Skoplju. 428 p.
21. Nenadić, Đ. (1930): *A productive factors and profitability of forest economy (in Croatian)*. Šumarski list, 54 (5): pp. 209-225.
22. NN. (30/2015): *Subsidies for investment in improving the resilience and environmental value of forest ecosystems (in Croatian)*. Official Gazette 30/2015.
23. Orsag, S.; Dedi, L. (2011): *Budgeting Capital-Investment Projects Evaluation (in Croatian)*. Zagreb: Masmedia. 416 p.
24. Paladinić, E.; Vuletić, D.; Posavec, S. (2008): *Review of the state of private forest ownership in the Republic of Croatia*. Radovi (Croatian Forest Research Institute), 43 (1): pp. 45-58.
25. Partaš, I. (1896): *The internal rate of return of invested capital in the woods (in Croatian)*. Šumarski list, 20 (6): pp. 205-210.
26. Plavšić, M. (1940): *Accounting and profitability of forest economy (in Croatian)*. Glasnik za šumske pokuse (7): pp. 313-434.
27. Posavec, S. (2003): *Bussiness analysis characteristic in management of renewable natural resource-forest (in Croatian).* Master thesis, University of Zagreb, Faculty of Economics and Business, Zagreb. 132 p.
28. Posavec, S.; Beljan, K. (2012): *Information analysis of management goals of private forest owners in Croatia* Informatologija, 45 (3): pp. 238-245.
29. Posavec, S.; Šašek, M.; Beljan, K. (2011): *The structure and potential of small scale forests in the north-west of Croatia.* In: IUFRO Small-scale forestry conference synergies and conflicts in social, ecological and economic interactions, Freiburg.107-112.
30. Schumacher, F. X.; Hall, F. D. S. (1933): *Logarithmic expression of timber-tree volume*. Journal of Agricultural Research, 47 (9): pp. 719-734.
31. Šimić-Milas, A.; Rupasinghe, P.; Balenović, I.; Grosevski, P. (2015): *Assessment of Forest Damage in Croatia using Landsat-8 OLI Images*. South-east European forestry, 6 (2): pp. 159-169.
32. Teslak, K.; Vedriš, M.; Gašparović, M.; Žunić, M., Jura. (2016): *Stand Regeneration Characteristics of Beech and Fir Forests in Gorski Kotar Region*. South-east European forestry, 7 (2): pp. 99-108.
33. Zelić, J. (2006): *Calculating the value of standing timber (forest tax) in regular stands of Sessile oak (in Croatian with English abstract)*. Šumarski list, 130 (3-4): pp. 113-124.

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# RISK MANAGEMENT AS A PART OF A QUALITY MANAGEMENT SYSTEM IN WOODWORKING COMPANIES

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**ABSTRACT**

In March 2016 was approved revised standard ISO 9001:2015. Part of this standard is to part 6. Planning and 6.1. Actions to address risks and opportunities. Organizations working in wood industry with established quality management system will need to demonstrate how this measure complied in practice. Content of the paper shall be highlight the key issues of Risk management in the woodworking companies in the context of the requirements the amended ISO standard.
**Key words**: quality management system, risk management, FMEA

## 1. Introduction

The ISO 9000 standards originated in 1987 with a bulletin from the International Organization for standardization (ISO) [11]. The original ISO 9000 series consisted of five standards: ISO 9000, 9001, 9002, 9003 and 9004, plus ISO 8402 (which was published in 1986 and it focused on terminology).

All ISO standards are evaluated on a five-year schedule to determinate whether they remain suitable for their application or if they need to be revised or withdrawn. At the annual meeting of ISOs Technical Committee 176 in 1990 it was agreed that the series of ISO 9000:1987 should be revised and that the revision should be done in two phases. [28] This approach was adopted because a great numerous of organizations were familiar with the 1987 standards and would likely be resistant to major structural changes. The results of these processes were a small revision of the ISO 9000 family in 1994 and a greater and more important revision with major changes to structure and content of the standards in the year 2000. After the 2000 revision ISO 9000 family consisted of the following three standards: ISO 9000:2000, ISO 9001:2000 and ISO 9004:2000. ISO 9000:2000 was the general standard that serves as an overall guide to the other standards. Its purpose was to provide definitions of terms and a basic explanation of the ISO 9000 standards. ISO 9001:2000 consolidates the former ISO 9001/9002/9003 standards into a single document and was the only standard to which certification was assessed. The 2000 version of ISO 9001 was written to be more user-friendly to small businesses and service organizations.

ISO 9004:2000 provided further guidance for continuous improvement of internal quality management systems. ISO 9001:2008 in essence re-narrates ISO 9001:2000. The 2008 version only introduced clarifications to the existing requirements of ISO 9001:2000. There were no new requirements. ISO 9001 was supplemented directly by two other standards of the family: ISO 9000:2005 and ISO 9004:2009. In 2012, ISO TC 176 - responsible for ISO 9001 development concluded that it is necessary to create a new QMS model for the next 25 years. The revised standard ISO 9001:2015 was published by ISO on 23 September 2015. September 2015 is start of 3 years transition period to September 2018. Certifications to ISO 9001:2008 will no longer be valid after September 2018.

ISO does not decide when to develop a new standard, but responds to a request from industry or other stakeholders such as consumer groups. Typically, an industry sector or group communicates the need for a standard to its national member who then contacts ISO. ISO standards are developed by groups of experts from all over the world that are part of larger groups called technical committees. These experts negotiate all aspects of the standard, including its scope, key definitions and content. The technical committees are made up of experts from the relevant industry, but also from consumer associations, academia, NGOs and government.

The standards are to be applied to any type of organizations; independent to the size of the organizations or the kind of products manufactured or services provided, in private and public organizations, including government services.

The aim of the presented article is to analyse the requirements of the revised ISO 9001: 2015 with a focus on the ones concerning the management of risks and opportunities. An integral part of the article there is also a case study aimed at reducing nonconformities emergent in the process of production and assembly on the brushing line by means of FMEA.

## 2. Literature review

Quality management (QM) is business practice that may benefit companies. As several empirical studies have shown, implementing QM [12, 17]may effectively have a positive influence on firm performance, improvement of productivity, operational efficiency, product quality, employee motivation or on external nature such as market-share, customer satisfaction, delivery and organizational image-related factors [18, 26]. This positive effect may result from their impact on firm costs and differentiation levels. Firms that implement QM focus on providing superior value to the customer and on improving the efficiency of the processes. Continuous improvement of processes and product quality lead to increased revenues (through product reliability) and reduced costs (through process efficiency) [4]. Also, research has been done on how far this type of standard has a significant impact and positive influence on business performance.[13, 21] As the literature shows, many scholars have analysed the benefits derived from the ISO 9001 on several performance dimensions. In order to analyse the benefits arising from the ISO 9001 standard, some authors have used lists of benefits to examine its effects, whereas others have used or even proposed classifications of benefits, such as (1) internal benefits and external benefits [10], (2) benefits related to operational performance and financial performance [7, 22], (3) benefits related to operational, customer, people, and financial results [9, 16], (4) other classifications.[23] Furthermore, the difficulties frequently associated with ISO 9001 standard adoption include the following: lack of top management involvement during the implementation process [26], employee and middle-management resistance, lack of financial and human resources, insufficient knowledge about quality programs [2,19]and involvement of a long and bureaucratic documentation [5, 19, 29]

The ISO 9000 series was the fastest growing standards in history and was very popular from the start. The implementation of this type of standards is voluntary, although in some sectors it has de facto become an obligatory measure, given the coercive influence of customers.[6, 20]

A total of 1,519,952 certificates were issued worldwide in 2015, compared to 1,476,504 the previous year, an increase of 3 %. Since 1987, were the ISO 9000 family was issued, it is unlikely that any other standards had more impact on international trade, on the relationship between suppliers and their customers and on the management of quality. [1]

## 3. New requirement ISO 9001:2015 standard – risk management

Most discussed is an explicit requirement for risk-based thinking. The concept of risk has always been implicit in ISO 9001 such as „Prevention actions“– this edition makes it more explicit and builds it into the whole management system.

Risk-based thinking is inherent in all clause of a quality management system:

- Introduction - the concept of risk-based thinking is explained
- Clause 4 - organization is required to determine its QMS processes and address its risks and opportunities

- Clause 5 – top management is required to (promote awareness of risk-based thinking, determine and address risks and opportunities that can affect product /service conformity)
- Clause 6 - organization is required to identify risks and opportunities related to QMS performance and take appropriate actions to address them
- Clause 7 – organization is required to determine and provide necessary resources
- Clause 8 - organization is required to manage its operational processes
- Clause 9 - organization is required to monitor, measure, analyse and evaluate the effectiveness of actions taken to address risks and opportunities
- Clause 10 - organization is required to correct, prevent or reduce undesired effects and improve the QMS and update risks and opportunities
- Note, risk is implicit whenever suitable or appropriate is mentioned (clause 7 and 8) [15]

All activities of an organization involve risk. Risk is effect of uncertainty on objectives. An effect is a deviation from the expected – positive or negative. Objectives can have different aspects (such as financial, health and safety, environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process). [14] ISO 9001 standard combines words risk and opportunities. The risk can be either negative or positive. Opportunity is not the positive side of risk. An opportunity is a set of circumstances which makes it possible to do something.

Organization shall use risk-based thinking to prioritize the way you manage of processes. It means organization shall identify of risk, analyse of risk, evaluating of risk, plan actions to address these risks and evaluate the effectiveness of these actions. Risk-based thinking is part of the process approach. Not all the processes of a quality management system represent the same level of risk in terms of the organization's ability to meet its objectives. Some need more careful and formal planning and controls than others [8].

Principles and guidelines on risk management are described in ISO 31000:2009 standard. This International Standard can be used by any public, private or community enterprise, association, group or individual. This standard is not specific to any industry or sector. ISO 31000 standard can be applied throughout the life of an organization, and to a wide range of activities, including strategies and decisions, operations, processes, functions, projects, products, services and assets. This standard is not intended for the purpose of certification.

The tools used for risk assessment are described in ISO 31010:2010 standard. This standard describes the process of risk assessment through risk identification, risk analysis, risk evaluation, and risk treatment.

Risk management reduces the probability of negative results. The standard ISO 31010 described the tools which can be used for risk assessment. One of the tools is also FMEA, the most widespread tool in practice.

FMEAs have been defined by Pahl and Beitz as "a formalized analytical method for the systematic identification of possible failures and the estimation of the related risks (effects)". [24] FMEAs can be divided into two categories based on their use: Design FMEA, and Process FMEA.[3, 27]The focus of design FMEAs is to analyse the product (at a system and sub-system level) to gain an understanding of potential quality concerns arising from product design and functionality. Process FMEAs are performed to investigate manufacturing and assembly procedures to identify, and analyse, potential failures due to improper process design. [25] While conducting FMEAs (both, design and process), the component being analysed needs to be identified first. Next, the type of failure (failure mode) must be determined and recorded. Once this is completed, the consequence of the component failing through the specified failure mode must be investigated and recorded. Based on these assessments, the scenario of the particular component failing through the specified failure mode is assigned a probability of occurrence (O), a score for severity of consequence (S), and a score for detectability of failure during design (D). The values for O, S and D typically range from 1 to 10. A Risk Priority Number (RPN) is calculated by multiplying O, S and D, and is used as a metric to quantify the importance of component failures.

## 4. Methodology FMEA- case study

The analysed wood-working industrial company has been on the market since 2013 and present they have got 5 branches in the Slovak Republic. The company has implemented an integrated management system (ISO 9001, ISO 14001, OHSAS 18001). Production activity is production of veneered furniture based chipboard as well as production of solid timber furniture. Production is focused on the production of cabinet doors, office furniture, chiffoniers, bookcases and tables. wood-working industrial company has identified and documentation-supported individual processes. Processes are divided into core, support and management ones. The process, analysed in this article, is manufacturing and packaging process. It belongs to the core processes of the company.

In the process of production and packaging there are the following activities: formatting, pressing, formatting and edge banding, formatting and curved edges banding, surface finishing of the edges, brushing, surface finishing and packaging.

In Table 1 there are shown the monitored quality characteristics, which are checked at individual stages of this process.

*Table 1. Quality characteristics*

| Operation | Monitored Quality Characteristics |
|---|---|
| Formatting | Thickness according to incise plan, tolerance: thickness ± 0.1 mm |
| | Dimensions of component according to incise plan, tolerance: dimension ± 2 mm |
| | Rectangularity according to values for difference of a diagonal, tolerance: rectangularity ± 3 mm |
| Pressing | Glue spread according to the process scheme: 52g/m$^2$± 4g/m$^2$ |
| | Application temperature of glue: 190-210°C |
| Formatting and edge banding | Dimensions and rectangularity of component according to design documentation |
| | Accuracy of drilling according to design documentation |
| | Application temperature of glue: 190-210°C |
| Formatting and curved edge banding | Dimensions and rectangularity of component according to design documentation |
| | Accuracy of drilling according to design documentation |
| | Colour shade according to reference samples |
| Edge surface finishing | Surface roughness according to reference samples |
| | Gloss according to reference samples |
| Brushing | Depth of brushing according to reference samples |
| Surface finishing | Gloss according to technology technique |
| | Colour shade according internal colour sample |
| Packaging | Visual checking of component according to IKEA Handbook (Quality Manual) |
| | Checking assembly – Checking of drilling |

The company performed the analysis of spoilage during time period of three months in 2016. In the Table 2 there are summarised the results.

*Table 2. Number of spoil works*

| Month | Operation | | | | | |
|---|---|---|---|---|---|---|
| | Formatting | Pressing | Formatting and edge banding | Surface finishing | Packaging | Brushing |
| **October** | 18,338 | 3,889 | 8,456 | 2,961 | 14,517 | 20,848 |
| **November** | 18,708 | 3,223 | 7,171 | 3,716 | 14,434 | 20,699 |
| **December** | 13,035 | 2,679 | 6,288 | 2,306 | 10,802 | 16,317 |
| **Sum Total** | **50,081** | **9,791** | **21,918** | **8,983** | **39,753** | **57,864** |

The maximum amount of spoil works is produced in brushing activity. After a more detailed analysis it was found that the most frequent nonconformities have come into existence due to

overbrushing or vice-versa underbrushing of wooden components. To minimize these nonconformities the company's management performed an analysis of possible failures and their effects (FMEA).

### 4.1. Methodology FMEA

**The aim of FMEA:** Minimisation of spoil works emergent in the process of manufacturing and assembly with the intention of activities related to a brushing.
**Team Creation:** team leader and members
**Methodology Procedure of Brushing:**

A process of brushing ensures natural wood look on the base of surface structure-texturing. Summer (soft) wood is pulled out by means of grinding discs and only winter (hard) wood leaves. A result of application of brushing technology on a component is not clearly visible but it is possible to feel touch. A bushed component is at the touch rougher than a moulded melamine component.

Components come into a line on the roll-way, wherein they are moved with sectorial feeder on the conveyor belt of brushing line (seeFig.1a). They continued on the belt toward the brushing booths, wherein the process of brushing is performed (see. Fig.1b). After finishing of the process, the brushed components continue to the end of the belt, wherein they are moved with sectorial feeder on the roll-ways, of which they continue to the paint line (see. Fig.1c).

*a)* *b)* *c)*

*Figure 1. The brushing line a) input to the brushing line b) brushing booths, c) output from the brushing line*

**Requirement imposed on the brushing process:**

- mounting of abrasive papers - transverse and longitudinal paper;
- mounting of 5 dead rolls, the first and second roll is used to generate brushed surface (reverse rotation rolls provide removal of the raised fibres). The third roll is used for abrasion of component surface, the fourth roll is a carousel with 19 brushes, which chamfers created groove edges on the component surface and the final, the fifth roll is used for final surface abrasion;
- adjusting of the component thickness;
- adjusting of the conveyor speed;
- setting of the parameters of the longitudinal and transverse brushing;
- setting of the parameters for individual rolls;

**Observed quality marks:** depth of brushing procedure

The measurement must be performed at least 3 times per a shift as well as when the range of goods is changed. The measurement is performed at 5 points at the direction of a diagonal of a sample. An arithmetic average is calculated from measured values and then it is recorded in the checklist. Tolerance is T = 0.20 ± 0.05 mm.

**Failure Mode and Effect Analysis**

The team recorded the results of analysis into Tab. 3 and Tab. 4. At the assessment of occurrence, significance and detectability we acted upon the tables which are defined in the standard ISO 60812.

*Table 3.Assessment table of FMEA –actual state*

| № | Subject of analysis | Possible failure | Possible cause | Possible effects of failure | Occurrence | Significance | Detectability | RPN |
|---|---|---|---|---|---|---|---|---|
| 1 | Brushing procedure | Incorrect adjusted input parameters of brushing line | Incorrect adjusted thickness of component | Underbrushing component | 5 | 7 | 4 | 140 |
| 2 | | | Incorrect adjusted line speed | Underbrushing component | 4 | 7 | 4 | 112 |
| 3 | | Low quality of brushing disks | dust-glazed brushing disk | Underbrushing component | 4 | 7 | 2 | 56 |
| 4 | | Incorrect performed measurements | Breach of measurement frequency | Nonconformity occurrence | 5 | 7 | 5 | 175 |
| 5 | | | Breach of measurement position | Nonconformity occurrence | 5 | 7 | 4 | 140 |
| 6 | | | Forgotten calibration of depth gauge | Nonconformity occurrence | 4 | 7 | 4 | 112 |
| 7 | | Failures of receiver | Incorrect inserted (jammed) component | Overbrushing | 3 | 8 | 3 | 72 |
| 8 | | Insufficient pressure in sucking discs of an arm of receiver | Worn sucking discs | Incorrect inserted component into the line | 3 | 5 | 6 | 90 |

*Table 4. Assessment table of FMEA – after the implementation of corrective action*

| № | Corrective actions | Responsible | Deadline (2017) | Occurrence | Significance | Detectability | RPN |
|---|---|---|---|---|---|---|---|
| 1 | Development of a work instruction<br>Development of a check list<br>Training<br>Retraining once a year<br>Check of record development in a check list for a period of three months | Quality engineer | March 2017 | 3 | 7 | 3 | 63 |
| 2 | Development of a work instruction<br>Development of a check list<br>Training<br>Retraining once a year<br>Check of record development in a check list for a period of three months | Quality engineer | March 2017 | 3 | 7 | 3 | 63 |
| 3 | Specification of store place for unused disks<br>Covering of brushed disks on the line | Store-keeper | January 2017 | 1 | 7 | 1 | 7 |
| 4 | Development of a work instruction<br>Development of a check list<br>Training<br>Retraining once a year<br>Check of record development in a check list for a period of three months | Quality engineer | March 2017 | 2 | 7 | 2 | 28 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | Development of a work instruction<br>Development of a check list<br>Training<br>Retraining once a year<br>Check of record development in a check list for a period of three months | Quality engineer | March 2017 | 2 | 7 | 2 | 28 |
| 6 | Development of a work instruction<br>Development of a check list<br>Training<br>Retraining once a year<br>Check of record development in a check list for a period of three months | Quality engineer | March 2017 | 2 | 7 | 3 | 42 |
| 7 | Reprogramming of brushing booth (for a period of stopping of conveyer belt simultaneously stopping of brushing disks) | IT technician | April 2017 | 1 | 8 | 3 | 24 |
| 8 | Exchanging of sucking discs once a half-year | Foreman | JuneDecember 2017 | 1 | 5 | 3 | 15 |

## 5. Discussion and conclusion

In the FMEA form there is presented that one of the corrective actions was to develop a check sheet for recording of the parameter machine settings. Observing directly the operation it was revealed that workers had not always set the machine parameters correctly, respectively had not checked the correctness of the entered parameters during the exchange of a shift or at the change of the range of good. Employees' retraining is related to this action. The retraining is oriented at machine setting which is necessary to perform before the actual brushing process. Then there are subsequent recording of the parameters, were adjusted in the machine, in the check list. A shift leader should randomly check the correctness of entered data.

Another proposed corrective action, which is related to up-to four causes, was the redeveloping of work instructions for performing depth measurement of brushing. Therefore there were causes, which are together interrelated it was useless to develop a work instruction for each individual cause. For the reason it was suitable to develop one work instruction, which contains detailed steps of technique in the implementation of the measurement (from the actual calibration of the depth gauge up to the recording measured values). It was also elaborated the record for production supervision of brushing. This record was complemented by a cell with measured values of brushing in diagonally individual points. As well as it was complemented by a cell with an arithmetic mean therefore the company can continue to work with measured values and to assess the brushing process.

Another proposed action is the transfer of abrasive papers to the store with grinding material and abrasive papers. Or it is possible to cover these papers with at least a polythene foil what preventing of dust glazed of abrasive paper, thereby increasing the quality of the abrasive paper.

Among the latest proposed action belongs reprogramming cycle of brushing booths, so that in the case of hang-up of the conveyor belt, they were stopped and did not produce over brushed components. Further, it is necessary to ensure the functionality of sucking discs for a feeder and a receiver by the exchange in a cycle of half-year. By these actions there should be avoided respectively eliminated the causes of the spoil good occurrence in the brushing line.

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## REFERENCES

1. Aggelogiannopoulos, D. (2007): Implementation of a quality managemnt systems (QMS) according to the ISO 9000 family in a Greek small-sized winery: A case study. *Food control*. 18 (2007), 1077-1085.
2. Al-Najjar, S.M. (2011): ISO 9001 implementation barriers and misconceptions: an empirical study. Int. J. Bus. Adm. 2. 1923-4007.
3. Ambekar, S.; Edlabadkar, A.; Shrouty V. A. (2013): Review: Implementation of Failure Mode and Effect Analysis. Int J Eng Innov Technol. 37–41.
4. Bernardo, M.; Simon, A.; Tarí, J. J.; Molina-Azorín, J. F. (2015): Benefit of managemnt systems integration: a literature review. Int. Journal of Cleaner Prosuction. 94. 260-267.
5. Boiral, O. (2011): Managing with ISO systems: lessons from practice. Long. Range Plan. 44 (3). 197-220.
6. Braun, B. (2005): Building global institutions: the diffusion of management standards in the world economy e an institutional perspective. In: Alvstam, C.G., Schamp, E.W. (Eds.), Linking Industries across the World. Ashgate, London. 3-27.
7. Briscoe, J.A.; Fawcett, S.E.; Todd, R.H. (2005): The implementation and impact of ISO 9000 among small manufacturing enterprises. Int. J. Small Bus. Manag. 43 (3). 309-330.
8. BSI. (2015): Risk-based thinking. International Organization for Standardization. Geneva, Switzerland. www.iso.org
9. Casadesús, M.; Gimenez, G. (2000): The benefits of the implementation of the ISO 9000 standard: empirical research in 288 Spanish companies. TQM Mag. 12 (6). 432-441.
10. Casadesús, M.; Gimenez, G.; Heras, I. (2001): Benefits of ISO 9000 implementation in Spanish industry. Eur. Bus. Rev. 13 (6). 327-335.
11. Ferguson, W. (1996): Impact of the ISO 9000 series standards on industrial marketing. Industrial Marketing Magazine, 25,305-310.
12. Huarng, F.; Chen, Y. T. (2002): Relationships of TQM philosophy, methods and performance: a survey in Taiwan. Ind. Manag. Data syst. 102.226-234.
13. Chow-Chua, C.; Goh, M.; Wan, T.B. (2003): Does ISO 9000 certification improve business performance? Int. J. Qual. Reliab. Manag. 20 (8). 936-953.
14. ISO 31000, 2009: Risk management.
15. ISO 9001, 2015: Quality management systems.
16. Karapetrovic, S.; Casadesús, M.; Heras, I. (2010): What happened to the ISO 9000 lustre? an eight-year study. Total Qual. Manag. 21 (3). 245-267.
17. Kaynak, H. (2003): The relationship between total quality managemnt practices and their effects on firm performance. J. Oper. Manag. 21. 405-435.
18. Kim, D. Y.; Kumar, V.; Kumar, U. (2011): A performance realization framework for implementing ISO 9000. Int. J. Qual. Reliab. Manag. 28 (4), 383-404.
19. Magd, D.; Nabulsi, F. (2012). The effectiveness of ISO 9000 in an emerging market as a business process management tool: the case of the UAE. Procedia Econ. Finance. 3. 158-165.
20. Mendel, P.J. (2006): The Making and Expansion of International Management Standards: the Global Diffusion of ISO 9000 Quality Management Certificates. Oxford University Press, New York
21. Mokhtar, M.Z.; Muda, M.S. (2012): Comparative study on performance measure and attributes between ISO and non - ISO certification companies. Int. J. Bus. Manag. 7. 185-193.
22. Naveh, E.; Marcus, A.A. (2004): When does the ISO 9000 quality assurance standard lead to performance improvement? Assimilation and going beyond. IEEE Trans. Eng. Manag. 51. 352-363.
23. Nield, K.; Kozak, M. (1999): Quality certification in the hospitality industry: analyzing the benefits of ISO 9000. Cornell Hotel Restaur. Adm. Q. 40. 40-45.
24. Pahl, G.; Beitz, W.; Feldhuesen, J.;, Grote, K.H. (2007): Engineering design: a systematic approach. 34. London: Springer-verlag; DOI:10.1007/978-1-84628-319-2.
25. Renu, R.; Visotsky, D.; Knackstedt, S.; Mocko, G.; Summers, J.D.; Schulte, J. (2016): A Knowledge Based FMEA to Support Identification and Management of Vehicle Flexible Component Issues. Procedia CIRP 44. 157 – 162.
26. Sampaio, P.; Saraiva, P.; Rodrigues, A.G. (2009): ISO 9001 certification research: questions, answers and approaches. Int. J. Qual. Reliab. Manag. 26 (1). 38-58.

27. Stamatis, D. H. (2003): Failure mode and effect analysis: FMEA from theory to execution. Asq Press.
28. Tsiakals, J. J. (2002): The need for change and the two-phase revision process. In. C.A. Cianfrani, J. J. Tsiakals & J. E. West (Eds.). The ASQ ISO 9000:2000 handbook. 63-72. Milwaukee: ASQ Quality Press.
29. Zeng, S.X.; Shi, J.J.; Lou, G.X. (2007): A synergetic model for implementing an integrated management system: an empirical study in China. *J. Clean. Prod.* 15. 1760-1767.

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# WOOD FURNITURE ASSORTMENT MARKET ANALYSIS: PROBLEMS & PERSPECTIVES IN CROATIA

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## ABSTRACT

Market research process involves actions to be carried in order to get as much information as possible necessary for competitive business plan of the company. Therefore, assortment market analysis of target market groups eliminates the risk in making company's business decision. On the other hand, a customer's always have an opportunity to choose what to buy. In that context the aim of this paper was to analyze current situation at wood furniture market regarding different product assortments, problems of that market and its future perspectives in Croatia.
**Key words**: market analysis, wood furniture, furniture market

## 1. INTRODUCTION

In the current economic context, future consumers' choice of whether to save money or to spend depends on their overall perception and expectations, which can be assert by the Eurostat consumer confidence indicator who showed a negative balance when spending money on major purchases, which include furniture. Furthermore, during the economic recession, the furniture retail industry was negatively impacted as consumers cut back on non-essential spending, but now there is an uptick in demand.

Today, a big furniture stores are becoming more popular than before (Dong and Zhao, 2012) and furniture retail sale is a very competitive area. The availability of information offers the consumers the possibility of choice, while the purchase has become unbelievably easy and fast, which has made the selling place a very important point in the final choice of the product. Furniture is a type of product that consumers select with a great deal of consideration and spend a lot of time before they finally decide to buy it (Oblak, 2012). According to Market Research (2016) the number of single- and two-person households has been increasing, resulting in the demand for small and portable furniture. Consumers have also been looking for furniture that is multi-purpose, foldable, and technology-driven, especially when it comes to living in smaller spaces. More consumers are willing to buy luxury items for their living and work environments and in terms of location, Europe has the largest market for luxury furniture, but developing countries such as China and India are not far behind. Oblak et al. (2017) found that consumers in Croatia and Slovenia were mostly stimulated to buy furniture due to low prices; slightly less due to the company's marketing activities and least of all due to the sales staff. The Internet was, normally, found to be the first source of information but consumers would often also seek information in the furniture shops. Pirc Barčić et al. (2016) established that in Croatia higher level of correlation between selling place attributes (number of suppliers, size of warehouse area, and number of sellers) than in Slovakia and Slovenia were established. One of possible reasons of higher correlations between sales area and other selling places attributes could be that Croatian market is still traditional oriented, the process of transition from the traditional sales functions are still dominating, customers are more oriented to face–to–face contact with seller and less to contemporary technology, like internet selling platforms, than in Slovakia and Slovenia. Additionally, index of furniture consumption per capita is below EU average (Centre for European Policy Studies 2014), so need to probe further into furniture attributes information play an important role in customer decision process when buying a wood furniture. In that context, the aim of this paper was to analyze current situation at wood furniture market regarding different product assortments, problems of that market and its future perspectives in Croatia.

## 2. MATERIALS AND METHODS

The sample frame were random samples of 593 different wood furniture pieces categorized into four product categories: a) storage furniture b) kitchen furniture c) tables), and d) furniture for sitting, lying and resting. The samples from a twenty-three furniture selling places (small furniture shops and retails stores) in four Croatian counties (Zagreb City, Karlovačka County, Krapinsko-zagorska County, and Zagrebačka County) were selected and analyzed. The storage furniture category include: closets, wardrobes, chest of drawers, and office bookcases were included. The kitchen furniture category include kitchen sets (dressers, sideboards and cupboards) while the table category include: kitchen/dining tables, club tables, and office tables. The fourth product category, furniture for sitting, lying and resting, include: dining chairs, office chairs, beds, and upholstered furniture.

Additionally, of all 593 samples, 15 were exclude from further analysis. The excluded samples were those that were selected outside of previously mentioned four counties.

Data were collected with quantitative and qualitative data collection methods. The reason was that the integration of these two methods, wherever feasible, makes it possible to supplement the collected data with new ones and to make more extensive conclusions on the basis of previous analyses (Lobe, 2006). Quantitative data were collected by three questioners (one per each product category) whereas qualitative data were collected through informal conversations of questioner to selling persons in the furniture selling places. Questioners were students of the final year of the undergraduate study of wood technology. Data entry was closely supervised to ensure accuracy. Descriptive and frequency statistics were generated for the quantitative data while qualitative information from open-ended questions was analyzed.

Data collection was carried out during the winter and spring in 2017 and were analyzed in MS Excel.

## 3. RESULTS AND DISCUSSION

### 3.1. Product category profiles

*Table 1. Frequencies of analyzed furniture product categories*

| Product category | Products | Number of samples (n) | The share (%) | Average price per category (in EUR) | Min. price per category (in EUR) | Max.price per category (in EUR) |
|---|---|---|---|---|---|---|
| Storage furniture | closets, wardrobes, chest of drawers, and office bookcases were included | 241 | 41,7 | 345 | 28 | 3.745 |
| Kitchen furniture | kitchen sets - dressers, sideboards and cupboards | 65 | 11,2 | 951 | 296 | **7.351** |
| Tables | kitchen/dining tables, club tables, and office tables | 176 | 30,4 | 967 | 30 | 3.560 |
| Furniture for sitting, lying and resting | dining chairs, office chairs, beds, and upholstered furniture | 96 | 16,6 | 457 | **27** | 6.912 |
| Total | | **578** | 100 | **634** | | |

As shown in table 1, the maxim price (7.351 EUR) of analyzed furniture products was noted within storage furniture – it was a set of well know designed kitchen. The minimum price of 28 EUR was noted

within the furniture for sitting, lying and resting – it was a dining room chair. Additionally, the same minimum price (27EUR) in the category of storage furniture (chest of drawers) was also noted. An average price of all analyzed furniture products was 634 EUR, but when looking to the product category level the highest average price of 967 EUR was found within tables.

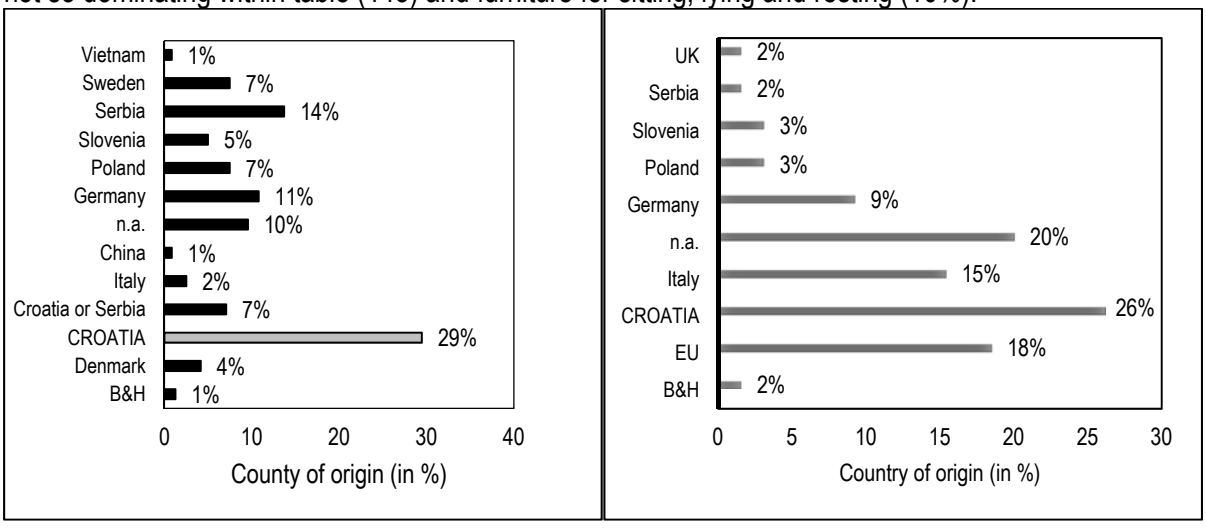
### 3.2. Are wood furniture products in Croatian furniture selling places made in Croatia?

Croatia was the most usual county of origin when observing the structure of analyzed wood furniture, noting a 21,6% of total analyzed products. Poland was in the second place with the share of 10,7%, followed by Italy (9,5%), and Serbia (7,3%). In 7,8% of analyzed furniture pieces, European Union was noted as a country of origin, but no additional information about manufacturing county was presented. It worth to point out is that almost 10% of analyses products declaration didn't imply the information about the manufacturing country (table 2).

*Table 2. Structure of wood furniture according to a country of origin for all product categories (n=578)*

| Country of origin | The share (in %) | Country of origin | The share (in %) |
|---|---|---|---|
| CROATIA | 21,6 | Bosnia & Herzegovina | 4,0 |
| Poland | 10,7 | Sweden | 3,8 |
| Italy | 9,5 | Denmark | 3,5 |
| EU | 7,8 | China | 2,9 |
| Serbia | 7,3 | Hungary | 1,4 |
| Germany | 5,7 | Czech Republic, Latvia Macedonia, Malaysia, Austria, Brazil, Bulgaria, Estonia, France, UK, and Spain | < 1 |
| Slovenia | 5,2 | Croatia or Serbia (not clear) | 2,9 |
| n.a. | 9,9 | TORAL | 100,00 |

When analyzing the structure of countries for certain product categories, as seen in figures 1, 2, and 3, Croatia is dominating county of origin for storage furniture (29%) and kitchen furniture (26%), but not so dominating within table (145) and furniture for sitting, lying and resting (10%).




*(a)* (b)

*Figure 1. Country of origin structure for: (a) Storage furniture (n=241), and (b) Kitchen furniture (n=65)*

*(*B&H – Bosnia and Herzegovina)*

Poland was found as dominated county of origin within tables taking a share of almost ¼ of total analyzed products category. Within furniture for sitting, lying, and resting European Union was noted as the preferred area of origin (no specific EU countries were noted), followed by Bosnia and Herzegovina. Additionally, twenty percent of all analyzed kitchen furniture documents, 12 % of furniture for sitting,

lying and resting declarations, and 10% of storage furniture documents didn't imply information about country of origin.

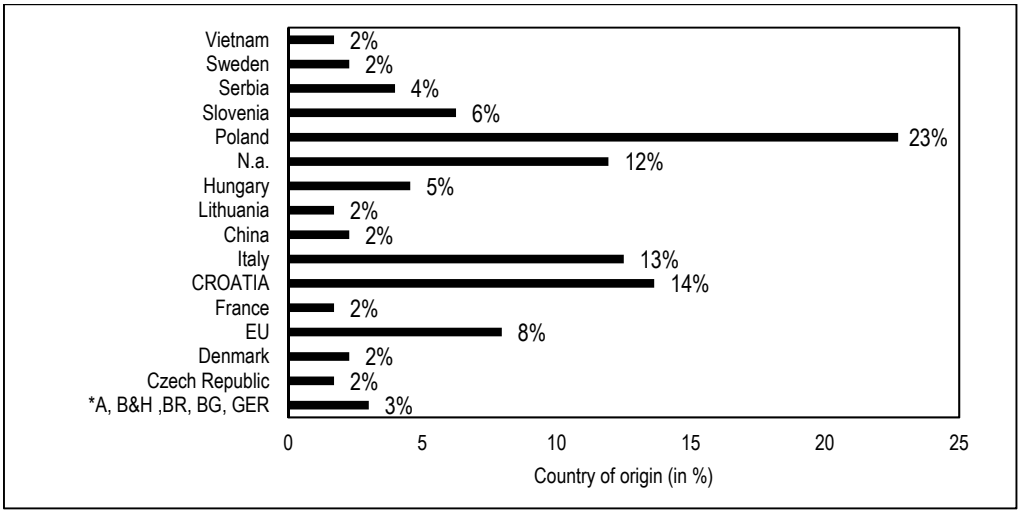



*Figure 2. Country of origin structure for tables (n=176)*

**For Austria (A), Bosnia-Herzegovina (B&H), Brazil (BR), Bulgaria (BG), and Germany (GER) the share was 0,6%/ country*

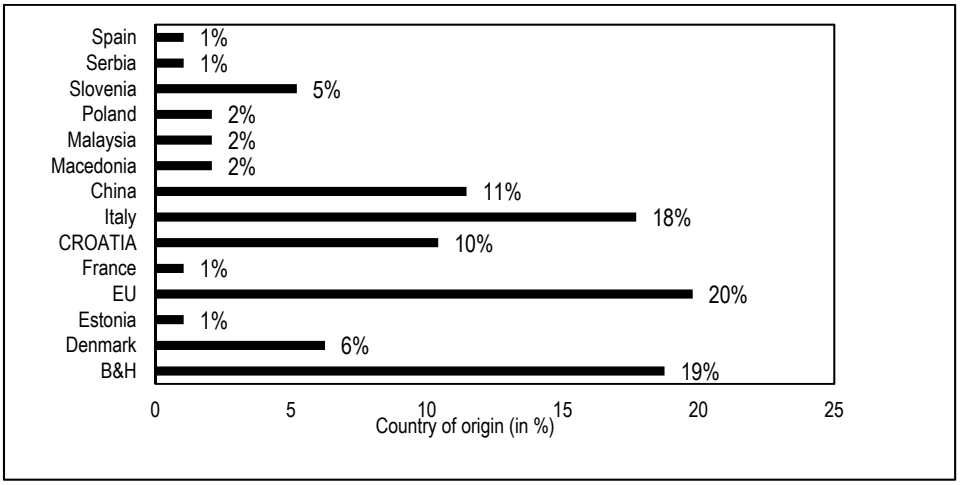
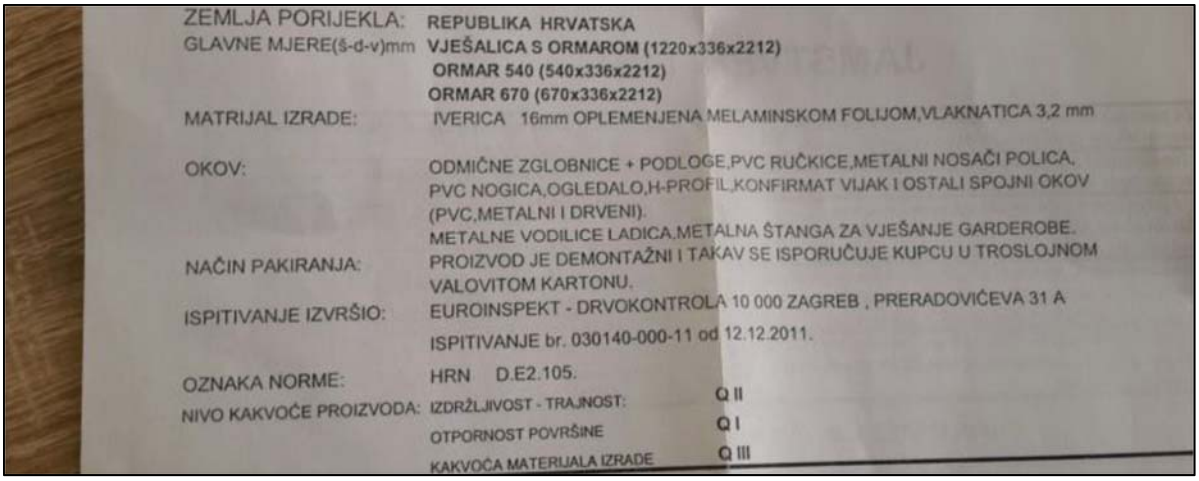



*Figure 3. Country of origin structure for furniture for sitting, lying and resting (n=96)*

### 3.3. Information about Products (declarations)

According to a Consumer Protection Act (NN 41/14, NN 110/15), in part related to marking of the products (Part II – Business operation with consumers), products on the territory of the Republic of Croatia offered to the consumers shall bear, at least, on the packaging, imprint, label or on the product itself: 1) the basic features of the product to the extent that the consumer has made a purchase decision such as the name of the product, the type and model of the product, the name under which the product is sold, the composition of the product, its properties and the technical characteristics of the product; and 2) the name and address of the manufacturer or importer established in the territory of the European Union. Furthermore, all previously mentioned information must be clear, visible and legible, and written in Croatian and Latin, which does not exclude the possibility of simultaneous use of other languages and may include signs and pictograms that are easily understandable to the consumer, but this regulations do not apply to products whose labeling is regulated by a special regulation.

When analyzing the present declaration of the product (Figure 4) it can be noted that the document contain all relevant information regarding the product which can give an acceptable amount of information to the potential buyer of the product.



| | |
|---|---|
| ZEMLJA PORIJEKLA: | REPUBLIKA HRVATSKA |
| GLAVNE MJERE(š-d-v)mm | VJEŠALICA S ORMAROM (1220x336x2212)<br>ORMAR 540 (540x336x2212)<br>ORMAR 670 (670x336x2212) |
| MATRIJAL IZRADE: | IVERICA 16mm OPLEMENJENA MELAMINSKOM FOLIJOM,VLAKNATICA 3,2 mm |
| OKOV: | ODMIČNE ZGLOBNICE + PODLOGE,PVC RUČKICE,METALNI NOSAČI POLICA, PVC NOGICA,OGLEDALO,H-PROFIL,KONFIRMAT VIJAK I OSTALI SPOJNI OKOV (PVC,METALNI I DRVENI).<br>METALNE VODILICE LADICA,METALNA ŠTANGA ZA VJEŠANJE GARDEROBE. |
| NAČIN PAKIRANJA: | PROIZVOD JE DEMONTAŽNI I TAKAV SE ISPORUČUJE KUPCU U TROSLOJNOM VALOVITOM KARTONU. |
| ISPITIVANJE IZVRŠIO: | EUROINSPEKT - DRVOKONTROLA 10 000 ZAGREB , PRERADOVIĆEVA 31 A<br>ISPITIVANJE br. 030140-000-11 od 12.12.2011. |
| OZNAKA NORME: | HRN D.E2.105. |
| NIVO KAKVOĆE PROIZVODA: | IZDRŽLJIVOST - TRAJNOST: Q II<br>OTPORNOST POVRŠINE Q I<br>KAKVOĆA MATERIJALA IZRADE Q III |

*Figure 4. An example of the declaration document - information about product from Croatian furniture manufacturer*

### 3.4. Regulations and documents regarding product information – Problems & Perspectives

The General Product Safety Act (NN 30/09, NN 139/10 and NN 14/14) implements the European Commission Directive on General Product Safety (EC / 2001/95) in the national legislation of the Republic of Croatia with the ultimate aim of safe products being set to the market and ensuring consumers access to all relevant information regarding the safety of products at the same time.

The compulsory furniture test prescribed by the Protocol on compulsory examination of furniture and furniture parts and the conditions to be met by legal persons authorized to examine these products is no longer effective by the announcement of the unavailability of the Official Gazette (NN. 71 from June 14th, 2013). With this announcement, the majority of furniture categories therefore falls under the regulations of the General Product Safety Act, as a part of the General Product Safety Requirements in Art. 5 prescribe that the obligation of the manufacturer is to set/provide to the market only safe products. According to the Law, the product is considered to be safe when it is in compliance to specific regulations which are in accordance to European Community Treaty, in particular this concerns the articles that determine the health and safety requirements that the product must fulfill to be marketed. The product is considered to be safe, also when it complies with the Croatian standards trough which European standards are accepted and whose list was published in the Official Gazette. For more information, by the term 'safe product', the Law understands any product that, under normal or reasonably foreseeable conditions of use, including the duration and, where applicable, put into service, presents no risk or only the lowest risk associated with product use and which is considered acceptable and consistent with high level of safety and health protection. The characteristics of the product, its composition, packaging, assembly instructions and installation and maintenance, the effect of the product on other products where it can reasonably be expected to be used with other products, the presentation of the product, its marking, warnings and instructions for its use and removal and any other markings or notices relating to that product of that category of consumers exposed to the risk of using the product concerned with particular emphasis on children and the elderly.

However, there are a special groups of products for which a mandatory testing still remains regarding the area of general product safety. A list of products for which a mandatory testing is required and list of Croatian standards in the area of general products safety regarding this products was published in Official Gazette (NN 109/2014 is in force form September 2nd, 2014. The list, among other products, includes some product categories relevant for wood furniture industry, for example garden

furniture, children furniture (cribs and beddings for household use), and gymnastic equipment. It could be note that this new approach and new European rules will be of use to furniture manufacturers (ex. those manufacturers producing wood products and furniture for which a mandatory testing is required) in the context of lowering the operational costs. In such a manner, the full responsibility of placing the safe product to the market is fully borne by the manufacturer/producer of the product. Also, in a case that the manufacturer place in safe product to the market the law imposes a fine of 1.500 to 4.500EUR. Inspection supervision over the implementation of the Act is carried out by market inspectors of the Ministry of Economy and in accordance with the powers provided for by the Law.

## 4. SUMMARY

In this research different wood furniture pieces categorized into storage furniture kitchen furniture, tables and furniture for sitting, lying and resting in a twenty-three furniture selling places regarding information about products (declaration of products) and prices were analyzed.

The maxim price of analyzed furniture products was 7.351 EUR, while the minimum price of 27 EUR was noted. An average price of all analyzed furniture products was 634 EUR, which presents a rather high price level given that the average month salary in Croatia is around 750 EUR. In that context it can be noted that the wood furniture in Croatian market is rather expensive, but the range of prices for different furniture categories is rather wide (from very cheap furniture pieces to a luxury high price and design products).

All furniture manufacturers, distributors, and furniture shops fall under the regulations of the General Product Safety Act whose ultimate aim of safe products being set to the market and ensuring consumer's access to all relevant information regarding the safety of products at the same time. However, there are a special groups of products for which a mandatory testing still remains regarding the area of general product safety which include some of wood furniture groups.

## REFERENCES

1. Dong, H.; Zhao, L., 2012: A study of teh Evacuation of Large Furniture Stores, Journal of Chinese People's Armed Police Force Academy. http://en.cnki.com.cn/Article_en/CJFDTOTAL-WUJI201210019.
2. Lobe, B. (2006): Združivanje kvalitativnih in kvantitativnih metod –stara praksa v novi preobleki? Družboslovne razprave, 20 (53):55-73.
3. Oblak, L., 2012: Trženje lesnih izdelkov in storitev. Univesity of Ljubljana, Biotehnical Faculty, Slovenia
4. Oblak, L.; Pirc Barčić, A.; Klarić, K; Kitek Kuzman, M.; Grošelj, P. (2017): Evaluation of Factors in Buying Decision Process of Furniture Consumers by Applying AHP Method. Drvna industrija, 68 (1): 37-43.
5. Pirc Barčić, A.; Motik, D.; Paluš, H.; Klarić, K.; Liker, K.; Oblak, L. (2016): Analysis of Furniture Selling Places in Croatia, Slovenia and Slovakia. Drvna industrija, 67 (3) 257-262.
6. *2016: House and Homes - 27 Top trends and predictions. Market Research. http://blog.marketresearch.com/5-top-trends-in-the-furniture-industry European consumer
7. *** 2014: The EU Furniture market solution and a possible furniture products initiative, Centre for European Policy Studies, Final report, Brussels, 2014. https://www.ceps.eu/system/files/Final%20report_en.pdf
8. ***: Consumer Protection Act (NN 41/14, NN 110/15). http://narodne-novine.nn.hr/clanci/sluzbeni/2014_03_41_723.html
9. ***: General Product Safety Act (NN 30/09, NN 139/10 and NN 14/14). https://www.zakon.hr/z/119/Zakon-o-op%C4%87oj-sigurnosti-proizvoda

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# FURNITURE DEVELOPMENT BASED ON INTERNET OF THINGS (IoT)

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## ABSTRACT

The Internet of Things (IoT) is a system of interrelated digital devices that are provided with the ability to transfer data over a network automatically. Smart furniture, like any other smart devices, is the one that comes with the capability of being connected to the Internet through the latest technology. In our case study, we discuss about "walk-in wardrobes", an intimate component to our daily domestic lives. We interact with these objects in a smart way – these "smart" objects will be able to gather data on our use of them, cross-reference this with relevant online-data sources and then "react" to our moods, behaviours and states of mind. Research provides the data on producers' points of view about the importance of selected features while developing "walk-in wardrobes", where quality, design, services, and smart functions are evaluated and discussed.
**Key words**: IoT, smart furniture, wood industry, Slovenia

## 1. INTRODUCTION

The concept of Internet of Things (IoT) is not new, but is developing very fast and has a big influence in our everyday life. The IoT is the ubiquitous presence of devices (such as sensors, actuators, RFID tags, etc.) around us, integrated in a variety of everyday things which have interaction capabilities to common objects (Bleda et all, 2012). Hansen and Leavengood (2015) describe IoT as a connectivity of physical objects with the Internet. The IoT is transforming everyday physical objects that surround us into an ecosystem of information that will enrich our lives. The objects like furniture, mirror, door and table can now be connected to each other so that they impact our life in a positive way.

The IoT and the digital world give endless options of virtual connections which can impact multiple areas of our life. There are possibly five billion connected objects today and this is expected to grow to around 25 billion by 2020 with the market worth an amazing $300 billion. This development opens up many opportunities for the forest and wood sector.

Hansen and Leavengood (2015) emphasize several uses of the IoT in the forest sector: smart forest for monitoring, interconnected scanners in sawmilling, closely connected whole supply chain and distribution and of coarse smart doors and windows, furniture and packaging.

*What exactly are smart home and smart furniture? Many authors (Soo-hyung, 2014; Ito et all, 2003;* Hansen and Leavengood, 2015; Papadopoulos et all, 2016; Bohn et all, 2004; Gaul and Ziefle, 2009; Tokuda et all, 2004; Dean and Donovan, 2007) understand the concept of smart home as a home where all the things which can be connected will be connected to the internet. Within that we can find smart appliances like smart refrigerators, smart lights and also smart furniture. Smart furniture, like any other smart devices, is the one which comes with the capability of being connected to the Internet through the latest technology. Smart furniture will offer many other benefits along with the basic function they are intended to perform (SMRG, 2017).

Smart furniture is an important evolution and tendency in the furniture industry (Tokuda et all, 2004). It has a capability to alter conventional things and space into an intelligent spot that includes computing systems (Ito et all, 2003). Some authors (*Di Lello and Saffiotti, 2011; Zizka, 2013)* also emphasize robotic furniture, like robotic table and robotic chair, which are guided by an overhead vision system and controlled over a wireless network by an external computer.

In the furniture production manufacturers are teaming up with mobile telecom companies to combine smart home tech with network-connected household goods. In Korea, SK Telecom has partnered with furniture maker Hyundai Livart, to produce a range of so-called 'smart furniture' which adds touch screens and other gadgets to mundane items such as tables and cabinet doors. The

furniture has network connectivity and touch screens built-in, and uses a new service by SK Telecom – users can browse the Internet, listen to the radio and use all manner of applications (as well as the ability to make and receive calls from their furniture), besides linking to door bells, doors and room temperature controls. It might seem rather outlandish, but it's just one example of the type of practical applications that are starting to make their way to market. (Banks, 2014)

Ikea, as a global furniture producer and retailer, has also a very clear vision of smart furniture. It has already introduced wireless smartphone charging in some of its furniture (nightstands, kitchen desks, etc.). IKEA's future kitchen ideas include networked devices, shelves that act as refrigerators, tabletops that cook, and instant food delivery by drone. (Nelson, 2015)

In our case study we discuss about "walk-in wardrobes", an intimate component to our daily domestic lives. We interact with these objects in a smart way – these "smart" objects will be able to gather data on our use of them, cross-reference this with relevant online-data sources and then "react" to our moods, behaviours and states of mind.

Research will provide the data about producers' points of view about the importance of selected features while developing "walk-in wardrobes", where different functions will be evaluated and discussed.

## 2. METHOD

### 2.1. Analytic hierarchy process

Analytic hierarchy process (AHP) (Saaty, 1980) is a management approach to support multi-criteria decision making in complex real world problems. It has been used in numerous applications in various areas connected to wood, furniture, sale and customers. Scholz and Decker (2007) measured the impact of wood species on consumer preferences for wooden furniture. Ojurović et all (2013) performed analysis of the key factors of competitiveness in wood processing and furniture production. Motik et all (2010) compared product lines in furniture industry regarding financial efficiency, risk and competition. Esmaili and Fazeli (2015) analyzed criteria that influence the purchasing decision of a green product as well as compared indicators of green products and green promotions activities.

AHP supports rational decision making based on hierarchical structured problems. Pairwise comparisons represent the key phase in AHP. They enable decision maker to express his opinion and preferences about qualitative and quantitative factors. The relative importance of one factor over the other is measured on Saaty's 1-9 scale (Saaty, 2006) (Table 1).

AHP is also suitable for group decision making. The properly chosen decision makers with supplement knowledge, competences and experiences enable success of the decision making process. There exist different suitable ways to form a group decision from individual decisions (Alonso et all, 2010; Altuzarra et all, 2007; Forman and Peniwati, 1998; Grošelj et all, 2015; Srdjevic and Srdjevic, 2013). In this paper, the geometric mean method is used to aggregate individual judgments into a group vector of weights.

*Table 1. The fundamental scale of AHP (Saaty, 2006)*

| Value $a_{ij}$ | Description |
|---|---|
| 1 | Elements *i* and *j* are equally important |
| 3 | Element *i* is slightly more important than element *j* |
| 5 | Element *i* is much more important than element *j* |
| 7 | Element *i* is proved to be more important than element *j* |
| 9 | Element *i* is absolutely more important than element *j* |
| 2, 4, 6, 8 | Middle values |

Individual pairwise comparisons of *m* decision makers and their reciprocal values for the inverse comparisons are presented in the pairwise comparison matrices $A_k = \left(a_{ij}^{(k)}\right)_{n\times n}$, $k=1,\ldots,m$ .

$$A = (a_{ij})_{n\times n} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix},$$

The consistency of judgments is measured by the consistency ratio $CR_A = CI_A / RI_n$, where consistency index $CI_A = \dfrac{\lambda_{A,\max} - n}{n-1}$ depends on the principal eigenvalue of matrix $A$, $\lambda_{A,\max}$ , and the random index $RI_n$ (Saaty, 1980), which depends on the size of the matrix $A$. $CR_A < 0.1$ is considered acceptably consistent.

When we have multiple decision makers we have to group their individual pairwise comparisons. The group value is calculated by geometric mean of indivudual pairwise comaprions:

$$a_{ij}^{\text{group}} = \sqrt[m]{a_{ij}^1 \cdot a_{ij}^2 \cdot \ldots \cdot a_{ij}^k}$$

The weights for individual criteria is calclulated by Additive Normalization Method:

$$w_i = \frac{1}{n}\sum_{j=1}^{n}\left(\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}\right), \quad i = 1,\ldots,n$$

## 3. RESULTS

### 3.1. Preparation and application of the AHP method

The first model was used to determine the most important features of smart functions in a walk-in wardrobe. For the survey, a questionnaire with all pairwise comparisons of the individual criteria at the same level has been prepared (Figure 1).

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USER FRIENDLY | | | | | | | | | | | | | | | | FLEXIBILITY IN USE |
| 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| USER FRIENDLY | | | | | | | | | | | | | | | | NUMBER OF SMART FUNCTIONS |
| 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| FLEXIBILITY IN USE | | | | | | | | | | | | | | | | NUMBER OF SMART FUNCTIONS |
| 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

*Figure 1. Quastionare with pairwise comparison for fist model*

The respondents were selected from experienced workers in the furniture companies or those who are responsible for sales and development in the company. Therefore, we have obtained information from people who know what criteria (features) are most important for customers when deciding to buy a walk-in wardrobe. We collected 15 filled AHP poll, which is a satisfactory pattern to use this method.

### 3.2. Results of the AHP method

We come up with weights to individual criteria by processing the data obtained. Figure 2 shows the weight value as the criteria of important features of smart functions in a walk-in wardrobe.

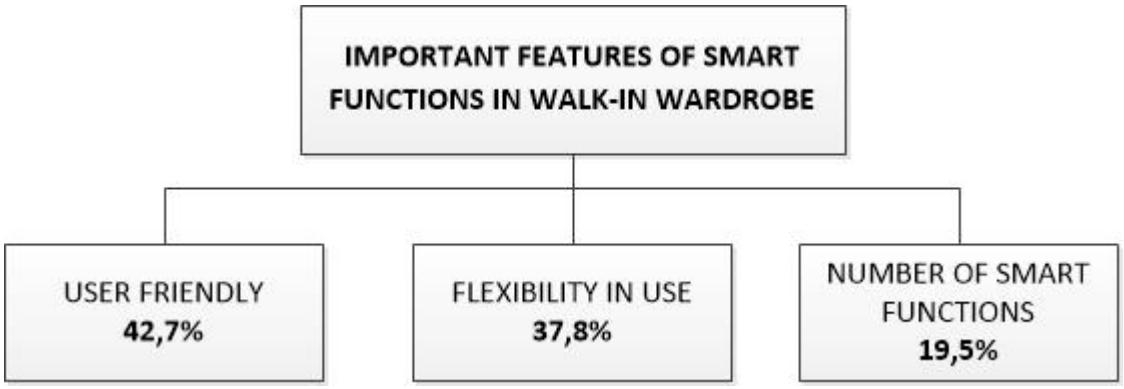


*Figure 2. Important features of smart functions in walk-in wardrobe*

According to experts the most important criteria (when deciding to buy a walk-in wardrobe with these functions) are user friendly smart functions (42.7%), followed by flexibility in use (37.8%) and number of smart functions (19.5%).


*Figure 3. Importance of each smart functions in a walk-in wardrobe*

With second part of the survey we wanted to find out which smart functions are the most important (Figure 3). The majority of respondents opted for illumination or smart lighting (37.7%) and information about the availability of clothes in the wardrobe (28.8%) when they have to choose what smart tool customers want to have in their "walk-in wardrobe". Much less would have chosen news (19.5%), a smart mirror (13.1%), the weather forecast (11.6%), and fashion advice (5,6%).

## 4. CONCLUSIONS

New smart and intelligent furniture is of great value for making our lives easier and that is why it is very important for elderly people with the reduction of stamina, wearing down of bones and muscles atrophy, slowing down of senses and spiritual capabilities, loss of balance and slowing down of person's activity and mobility.

But its greatest value comes from IoT basics: physical assets equipped with sensors can give an information system the ability to capture, communicate, and process data - and even, in a sense to collaborate - they create game-changing opportunities: production efficiency, distribution and innovation, all stand to benefit immensely. IoT systems can also take the guesswork out of product development by gathering data about how products (including capital goods) function, as well as how they are actually used. Using data from equipment rather than information from customer focus groups or surveys, manufacturers will be able to modify designs so that new models perform better and to learn what features and functionality aren't used and should therefore be eliminated or redesigned. IoT can also spur new business models that would shift competitive dynamics within industries. As with any major technological shift, realizing IoT's potential will require significant management attention not just to new technical imperatives but also to organizational issues.

The IoT in the furniture industry is a relatively new and promising thing. Currently, there are only such a few wooden products available in the Slovenian market, therefore the development, promotion and production of such products can be an advantage for the company. In our case study about smart walk-in wardrobe we found that it should have user friendly interface and should be flexible in use. Costumers want to customize smart functions to their needs and expectations. For costumers the most important function is illumination, followed by information about clothes in their wardrobe. They will also use it to follow the news and weather forecast.

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## REFERENCES

1. *Alonso, S.; Herrera-Viedma, E.; Chiclana, F.; Herrera, F., 2010: A web based consensus support system for group decision making problems and incomplete preferences. Information Sciences, 180(23), 4477-4495.* doi: *http://dx.doi.org/10.1016/j.ins.2010.08.005*
2. *Altuzarra, A.; Moreno-Jiménez, J. M.; Salvador, M. (2007): A Bayesian priorization procedure for AHP-group decision making. European Journal of Operational Research, 182(1), 367–382.* doi: *http://dx.doi.org/10.1016/j.ejor.2006.07.025*
3. Banks, R. (2014): *Internet of Things will change everything.* URL: http://www.mobileindustryreview.com/2014/11/internet-of-things.html
4. Bleda, L. A.; Maestre, R.; Santa, G.; Jara, J. A.; Skarmeta, G. A. (2012): *Web of Things as a Product Improvement tool: Furniture as Case Study.* In: *Sixth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing,* Palermo, pp. 846-851, doi: https://doi.org/10.1109/IMIS.2012.111
5. Bohn, J.; Coroamă, V.; Langheinrich, M.; Mattern, F.; Rohs, M. (2004): *Living in a World of Smart Everyday Objects—Social, Economic, and Ethical Implications.* Human and Ecological Risk Assessment: An International Journal, Vol. 10, Issue. 5, pp. 763-785, doi: https://doi.org/10.1080/10807030490513793
6. Dean, M.; Donovan, M. (2007): *Robotic chair.* URL: http://raffaello.name/projects/robotic-chair/
7. *Di Lello, E.; Saffiotti, A. (2011): The PEIS Table: An Autonomous Robotic Table for Domestic Environments. Automatika 52, 3, pp. 244–255.*
8. *Esmaili, M.; Fazeli, S. F. (2015): Surveying of Importance of Green Marketing Compared Purchase Budget and Preferred Brand when Buying by AHP Method (Vol. 6).*
9. *Forman, E.; Peniwati, K. (1998): Aggregating individual judgments and priorities with the analytic hierarchy process. European Journal of Operational Research, 108(1), 165–169. doi: http://dx.doi.org/10.1016/s0377-2217(97)00244-0*
10. Gaul, S.; Ziefle, M. (2009): *Smart Home Technologies: Insights into Generation-Specific Acceptance Motives.* In: Holzinger, A.; Miesenberger, K. (eds.) HCI and Usability for e-Inclusion. USAB 2009. Lecture Notes in Computer Science, vol. 5889. Springer, Berlin, Heidelberg.
11. *Grošelj, P.; Pezdevšek Malovrh, Š.; Zadnik Stirn, L. (2011): Methods based on data envelopment analysis for deriving group priorities in analytic hierarchy process. Central European Journal of Operations Research, 19(3), 267–284. doi: http://dx.doi.org/ 10.1007/s10100-011-0191-x*
12. Hansen, E.; Leavengood, S. (2015): *The Internet of Things: Opportunity for the Forest Sector?* OWIC Executive Innovation Brief, Volume 4, Issue 1 (a summary of the paper: Spotlight on the Internet of Things. PricewaterhouseCoopers (PWC). URL: http://www.pwc.com/gx/en/research-insights/spotlight/internet-of-things.html)
13. Ito, M.; Iwaya, A.; Saito, M.; Nakanishi, K.; Matsumiya, K.; Nakazawa, J.; Nishio, N.; Takashio, K.; Tokuda, H. (2003): *Smart furniture: improvising ubiquitous hot-spot environment.* In: International Conference on Distributed Computing Systems, Providence, RI, pp. 248-253.
14. *Motik, D.; Šegotić, K.; Jazbec, A. (2010): Application of AHP Model and Survey Results in Deciding on a Product Line in Furniture Industry. Drvna industrija, 61(2), 83-87.*
15. Nelson, P. (2015): *IKEA's Internet of Things plans imagine the networked kitchen.* Network World, May 4, 2015. URL: http://www.networkworld.com/article/2917281/internet-of-things/ikea-has-plans-for-iot-first-up-networked-kitchen.html

16. *Ojurović, R.; Moro, M.; Šegotić, K.; Grladinović, T.; Oblak, L. (2013): Analysis of the Investment in Wood Processing and Furniture Manufacturing Entities by Key Factors of Competitiveness. Drvna industrija, 64(2), 131-137. doi: http://dx.doi.org/10.5552/drind.2013.1235*
17. *Olšiakova, M; Loučanova, E; Paluš, H. (2016): Monitoring changes in consumer requirements for wood products in terms of consumer behavior. Acta Facultatis Xylologiae, 58(1), 137-147.*
18. Papadopoulos, I.; Trigkas, M.; Karagouni, G.; Papadopoulou, A.; Moraiti, V.; Tripolitsioti, A.; Platogianni, E. (2016): *Market potential and determinants for eco-smart furniture attending consumers of the third age.* Competitiveness Review, Vol. 26, Issue 5, pp. 559-574, doi: https://doi.org/10.1108/CR-06-2015-0058
19. *Saaty, T. L. (1980): The Analytic Hierarchy Process. New York: McGraw-Hill.*
20. *Saaty, T. L. (2006): Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process. Pittsburgh: RWS Publications.*
21. *Scholz, S. W.; Decker, R. (2007): Measuring the impact of wood species on consumer preferences for wooden furniture by means of the Analytic Hierarchy Process. Forest Products Journal, 57(3), 23-28.*
22. *Smart Home Research Group - SMRG (2017): What exactly are smart home and smart furniture? URL:* http://cuddlyhomeadvisors.com/smart-home-smart-furniture/iot-based-smart-furniture-for-your-smart-home/
23. Soo-hyung, P. (2014): *Internet of Things smart furniture unveiled by SK Telecom, Hyundai.* URL: https://www.cnet.com/news/internet-of-things-smart-furniture-unveiled-by-sk-telecom-hyundai/
24. *Srdjevic, B.; Srdjevic, Z. (2013): Synthesis of individual best local priority vectors in AHP-group decision making. Applied Soft Computing, 13(4), 2045-2056. doi: http://dx.doi.org/10.1016/j.asoc.2012.11.010*
25. Tokuda, H.; Takashio, K.; Nakazawa, J.; Matsumiya, K.; Ito, M.; Saito, M. (2004): *SF2: Smart Furniture for Creating Ubiquitous Applications.* In: *Proceedings of the 2004 Symposium on Applications and the Internet-Workshops (SAINT 2004 Workshops)* (SAINT-W '04). IEEE Computer Society, Washington, DC, USA, p. 423
26. Zizka, T. (2013): *Research: Interactive Furniture.* URL: http://zizka.weebly.com/blog/research-interactive-furniture

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# THE IMPERFECTLY COMPETITIVE RAW WOOD MARKET AND STABILITY OF THE FOREST AND WOOD PROCESSING SECTOR IN THE CZECH REPUBLIC

Šafařík, D.

## ABSTRACT

Considering the conditions in the Czech Republic, the state enterprise Forests of the Czech Republic (FCR) is often used as an example of a market structure which is called an oligopoly with a dominant company and competitive fringe. The aim of the paper is to describe the market structure existing in the forestry and wood processing sector. The process of church property restitutions having been almost completed and the change in the structure of the ownership of forests in the Czech Republic having been made, it is possible to hypothesize that there is no risk of monopolisation of the sector; the competitive fringe is strong enough even in case of change in selling techniques – in the sales channels of the dominant company and a significance of the impact of the FCR on the low competitiveness of the wood industry in the Czech Republic can be excluded.
**Key words:** forestry, economics, market structure, state enterprise, oligopoly, wood industry

## INTRODUCTION

The accession of the Czech Republic (CR) to the European Union in 2004 triggered a gradual transformation of the monopolistic market into an oligopolistic market due to strengthened influence of small and middle-sized companies (for more see Kraft, 2007). When researching the oligopolistic behaviour of companies, most mainstream economists assume the basic theoretical model of oligopolistic competitive behaviour in the conditions of post-industrial society as created by Samuelson and Nordhaus (2004). This theory of oligopoly was further elaborated for the conditions of market industries by Varian (1992).

Oligopoly can be defined as a market model of the imperfect competition type, assuming the existence of only a few companies in a sector or industry, from which at least some have a significant market share and can therefore affect the production prices in the market (Severová et al., 2011). The oligopoly theory usually refers to the partial equilibrium study of markets in which demand side is compatitive, while the suply side is neither monopolized nor competitive (Friedman, 1982).

Neoclassical and Neo-Keynesian schools of economics provide models of olygopolistic competition defined in various ways (see Schiller, 2013). Šrédl and Svoboda (2011) argue that, above all, these oligopoly models differ in the character of the behaviour of the competing companies; this is confirmed by Severová et al. (2011). However, Samuelson and Nordhaus (2004), as well as Soukupová (2006), have found some correspondences in the assumptions of those varying models.

Currently, an industry often consists of one big and dominant company accompanied with several smaller ones. In the economic theory, such an imperfect market structure is called an oligopoly with a dominant company and a competitive fringe (see e.g. Samuelson and Nordhaus, 2004; Severová et al., 2011; OECD, 2002; Tasnádi, 2010). Hořejší et al. (2008) describe a modified oligopoly model, in which the dominant company is accompanied by several mid-size companies and a bigger number of small companies representing the competitive fringe. The companies in the competitive fringe behave as perfectly competitive companies: they can sell any volume of their outputs for the price set by the dominant company. The Organisation for Economic Co-operation and Development (OECD) defines a dominant firm in the glossary of statistical terms. A dominant firm is one which accounts for a significant share of a given market and has a significantly larger market share than its next largest rival. Dominant firms are typically considered to have market shares of 40 per cent and more. (OECD, 2002) Providing that the dominant company controls 60-80% of the market, it can choose from various possible

strategies including monopolising the sector and crushing the competitive fringe using suitably selected selling techniques (Samuelson, Nordhaus, 2004).

Considering the conditions in the Czech Republic, the state enterprise Forests of the Czech Republic, state enterprise (FCR) is often used as an example of such a market structure, the FCR being a dominant company which raises fears that the industry might be monopolised; consequently, it is criticized for the low competitiveness of the wood processing industry and for instability of the sector.

The aim of the paper is to describe the market stucture existing in the forestry and wood processing sector through the positive approach and using the main market atrubuts. It will be find out what market share the FCR has and how strong the competitive fringe is. Since the process of Church restitutions is almost completed and the ownership structure of the forests in the Czech Republic has been changed, and with regard to the extension of the spectrum of selling techniques–the trading channels of the FCR – since 2011, it is possible to hypothesize that there is no threat of monopolization of the industry; the competitive fringe is strong enough even if a change in selling techniques occurred–the trading channels of the dominant company. It is also possible to rule out a significant influence of the FCR on the low competitiveness in the Czech timber industry. Yet, there may be barriers blocking the entry into the industry, such as economies of scale or product differentiation costs. Nevertheless, those issues are not addressed in the model described in this article due to the extent of the article.

## MATERIAL AND METHODS

Both primary and secondary research methods have been employed during the elaboration of this article. Concerning the secondary research, it mainly included the method of bibliographic research, which created the theoretical foundation for the results of the primary research and for the method of describing the market division among the individual subjects. As for the primary research, the mathematic method (percentages) has been used together with an analysis and a consequent synthesis of the identified data and with the comparative method.

The main surveyed entity was the state enterprise of Forests of the Czech Republic, which was founded by the Deed of Incorporation of the Ministry of Agriculture of the Czech Republic in 1991 pursuant to Act No. 111/1990 Coll. on State Enterprises. Information about this enterprise was obtained from its websites and its annual reports.

The organization of the FRC is divided into the Directorate and organizational units, which are represented by 4 forest enterprises, a seed enterprise, 6 flow administrations, and 12 regional directorates. The directorates manage 74 forest administrations. The main activity of the organization is to manage more than 1.3 million hectares of forest assets owned by the state (almost 86% of the area of all state forests). The annual logging rates fluctuate around 7 milion $m^3$ on average. In 2015, the total revenue of the enterprise was ca CZK 13 billion, its total costs accounted for CZK 7.7 billion, the profit or loss after tax was CZK 5.4 billion, the added value was CZK 7.8 billion, and the total value of its assets was CZK 70.3 billion. (FCR, 2015)

Concerning the primary research, the Economic Accounts for Forestry and Logging (EAFL) published by the Czech Statistical Office (CSO) were the most important source of information. The materials and data sources for the creation of the EAFL comprised CSO publications and reports and documents from the FCR, the Ministry of Finance of the Czech Republic, the Ministry of Agriculture of the CR, the Ministry of Environment of the CR, the Support and Guarantee Agricultural and Forestry Fund, the Forest Management Institute in Brandýs nad Labem, the Forestry and Game Management Research Institute, private companies, and from others.

The EAFL follow the Summarizing Account for Forestry published earlier; however, there are certain differences in the methodology (such as in the case of standing timber). The EAFL are a part of the Integrated Environmental and Economic Accounting for Forests, which is the basic methodological tool for measuring the economic size and the performance of the sector, or for forestry primary

production within the national economy. The main purpose of the accounts is to analyse the production process and the primary income achieved by it. The elaboration of the EAFL is governed by the rules of the European System of Accounts (ESA); thanks to it, their data are comparable with other European countries (EU). (CSO, 2017)

The following indicators were used to determine the dominant position of the FCR on the market and to describe the position of the FCR in the oligopoly model:

- forestry branch output – includes the sales of products and services,
- total output of forestry – expressed as a value, it represents the total final production of the forestry sector which leaves this sector. It is the production of timber. The production is assessed with a basic price, i.e. the amount which the producer obtains from the buyer for a unit of the products and services produced by them plus the subsidies obtained for the product and minus the tax levied for the product (CSO, 2017). Namely, it means the incomes from realising the possessions and services of forestry, mainly from realising timber; financial and exceptional earnings are not included.
- gross value added forestry branch – represents the final effect of the forestry sector measured by the difference in the final production of intermediate consumption by the forestry sector (CSO, 2017),
- factor income – represents the reward from all the production factors and the total value which the units produce by their productive activity (CSO, 2017); in other words, it is the gross operating result.

If there is a competitive fringe which is strong enough, then there is no risk of monopolisation of the forestry sector. The companies in the competitive fringe can maximize their profits at the level of the adopted output prices (*P*) and of their individual marginal costs (*MC*):

$$P = MC_i\,(q_i)$$

*i = 2,..., n.* *(Hořejší et al., 2008)*

The years 2009 – 2014 were chosen as the reference period for the article because of the availability of the data. The data were processed using Microsoft Office Excel.

## RESULTS AND DISCUSSION

In the Czech Republic, forests cover approximately 2.7 million hectares. Almost 60% of the forests are owned by the state. In 2015, 16.16 million m3 of raw timber was logged in total in the Czech forests; the total timber reserve accounted for 692.6 million m3 (MoA, 2016). Compared with the preceding years, there was a slight increase in logging. The development of logging in the Czech Republic in the reference period of 2009 – 2014 is shown in Table 1.

*Tab. 1 Roundwood logging in the Czech Republic in million m³*

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| The total logging by the forestry sector | 15.5 | 16.74 | 15.38 | 15.06 | 15.33 | 15.48 |
| The logging by the FCR | 7.72 | 8.05 | 8.02 | 7.84 | 8.04 | 7.98 |
| Proportion of logging by the FCR in the total logging by the forestry sector | 49.80% | 48.10% | 52.10% | 52.10% | 52.40% | 51.60% |

*Sources: FCR, 2009 – 2014*

The Table 1 clearly shows that the share of the FCR in logging is more than 50%. In 2015, 91% of the total volume of timber sold by the FCR was in the form of whole trees. The technological timber product range for further industrial processing is created by business entities in the position of contractual partners of the FCR under complex contracts. These contractual partners buy whole trees on the legal basis of complex contracts and subsequently launch timber onto the market. The contractual obligations of the FCR and their contractual partners arise from public tenders pursuant to the provisions of Act No. 134/2016 Coll. on Public Procurement. Together with non-public owners of forests in the Czech Republic, these business entities create the competitive fringe of the raw timber market as well as of the whole forestry sector in the Czech Republic.

Table 2 demonstrates the structure of timber realisation by the FCR according to the individual trading channels. It follows from Table 2 that more than three-quarters of the timber volume is sold under long-term public contracts for complex activities concluded for the periods of 5 years. The second most important trading channel is auctions of standing timber, either in the form of attendance auctions or in the form of electronic auctions. The year 2010 was important with regard to the evaluation of timber sales by the FCR in the P area – stem (whole trees) and the OM area – log landing (technological product ranges). Since 2011, the portion of the FCR's sales of finished technological product ranges from the OM area has been decreasing while its portion of tree sales from the P area has been increasing. The portion of sales via other sales techniques – trading channels – has been increasing since 2011, too.

*Tab. 2 The structure of timber realisation in thousand m3*

| Years | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Comprehensive contracts | 3,080 | 3,291 | 7,154 | 6,054 | 6,119 | 6,142 |
| Electronic auctions | 0 | 0 | 0 | 956 | 1 151 | 1 011 |
| Auctions in person | 0 | 0 | 0 | 0 | 0 | 55 |
| Commodity exchange (FMU) | 127 | 0 | 302 | 332 | 291 | 249 |
| Electronic auctions (FMU) | 4,236 | 4,939 | 154 | 152 | 110 | 101 |
| Regional sales (FMU) | 1,030 | 1,007 | 0 | 0 | 0 | 81 |
| Own production | 0 | 0 | 79 | 89 | 76 | 283 |

*Sources: FCR, 2009 – 2014; Note: FMU – forest management units*

The Czech timber market is apportioned among the entities owning forest capital – forest plots with forest covers – and business entities trading in timber. The share of the FCR in forest plot ownerships in the CR was 1.313 million ha (i.e. 50.65%) in 2009, 1.305 million ha (i.e. 50.16%) in 2014, and 1.283 million ha (i.e. 49.25%) in 2015 (MoA, 2010, 2015, 2016). The decrease in the share of ownership results from the ending process of the property settlement between the state and Churches and religious societies, known as "Church Restitutions", pursuant to Act No. 428/2012 Coll. The ownership relations concerning the forests in the CR in 2009 and 2014 are stated in Figure 1.

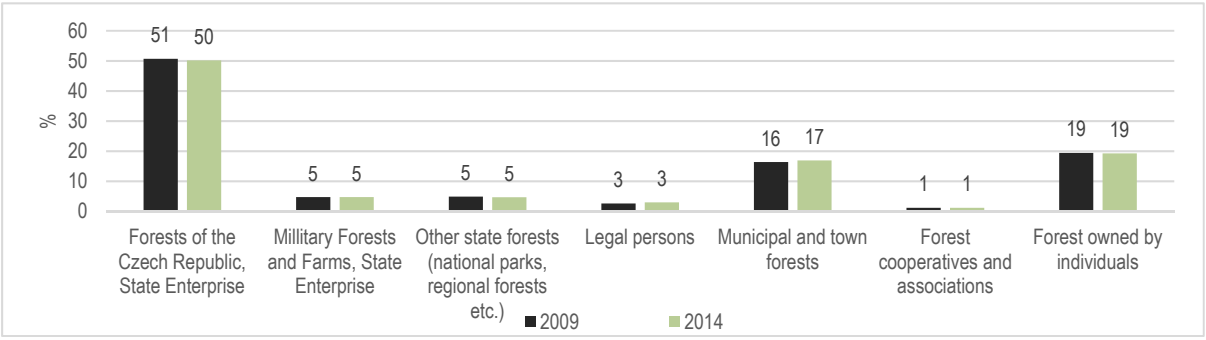


*Fig. 1 The ownership relation concerning the forests in the CR in 2009 and 2014*
Source: MoA, 2010, 2015

Furthermore, the indicators of the market share of the FCR were determined. They were the indicators of forestry production, total production, gross value added, and income from production factors. The values identified in the FCR were compared with the data from the Economic Accounts for Forestry and Logging. The results of the comparison are in Table 3. The share of the FCR in the total production of the Czech forestry industry is crucial for the description of the model of oligopoly with a dominant company and for the verification of the formulated hypothesis. The size of the competition fringe is demonstrated in Figure 2.

Tab. 3 Comparison selected economic accounts for forestry and logging, years 2009 – 2014

| Indicator | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| | *current prices, in million CZK* | | | | | |
| Forestry branch output | 36,440.6 | 43,878.0 | 49,570.8 | 51,020.4 | 52,891.7 | 55,242.3 |
| State-owned enterprise FCR forestry output | 7,760.2 | 9,774.5 | 11,756.7 | 11,611.8 | 11,537.1 | 12,101.3 |
| Share of FCR on forestry branch output | 21.3% | 22.3% | 23.7% | 22.8% | 21.8% | 21.9% |
| Total output of forestry | 43,955.2 | 52,785.2 | 57,275.1 | 58,448.5 | 60,252.8 | 62,598.7 |
| State-owned enterprise FCR total output | 8,437.0 | 10,818.0 | 12,832.0 | 12,281.0 | 12,144.0 | 12,513.0 |
| Share of FCR on total output of forestry | 19.2% | 20.5% | 22.4% | 21.0% | 20.2% | 20.0% |
| Gross value added forestry branch | 14,354.1 | 16,622.3 | 17,861.5 | 20,338.6 | 21,922.2 | 24,501.3 |
| Gross value added State-owned enterprise FCR | 2,359.0 | 4,267.6 | 7,069.6 | 7,356.3 | 6,842.1 | 7,876.8 |
| Share of FCR on gross value added forestry branch | 16.4% | 25.7% | 39.6% | 36.2% | 31.2% | 32.1% |
| Factor income | 12,457.3 | 14,744.0 | 15,900.9 | 18,198.9 | 19,505.5 | 22,066.5 |
| State-owned enterprise FCR factor income | 783.9 | 3,159.7 | 5,275.2 | 5,478.3 | 4,956.7 | 7,963.2 |
| Share of FCR on factor income | 6.3% | 21.4% | 33.2% | 30.1% | 25.4% | 36.1% |

Sources: CSO, 2017; FCR, 2009 – 2014; managerial accounting of FCR

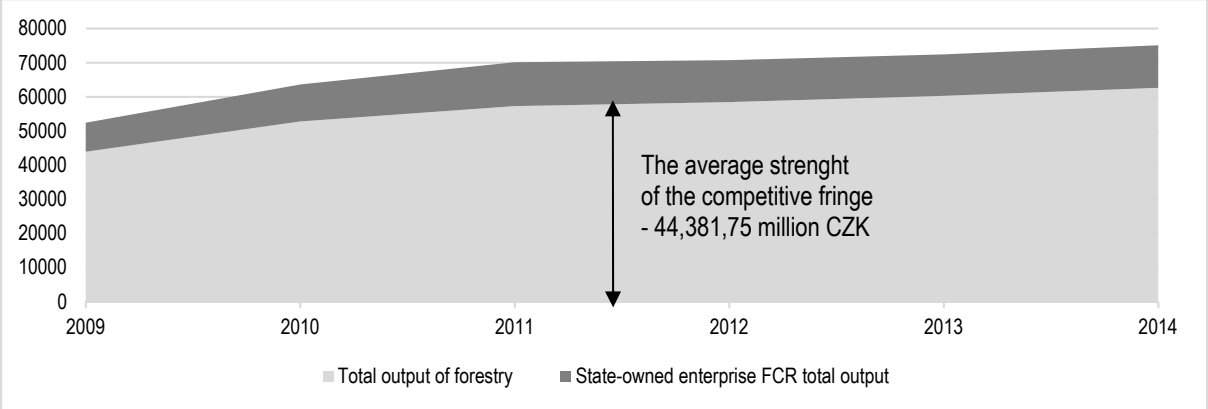


Fig. 1 Share of the FCR on the total output of forestry sector in CR (in million CZK)

The second indicator of Table 3 shows the total share of the FCR, specifically the portion of the FCR in the production of the forestry industry in the CR. It is obvious from the Table 3 that their total market share fluctuated around 20% in 2009 – 2014, being the highest in 2011 when it accounted for 22.4%. If the values are averaged, it is possible to say that the average market share of the FCR over last six years was 20.6%. When this value is compared with bibliography, it turns out that the FCR does not have big enough a share in the market so as to endanger the market with monopolisation; to endanger it; their share would have to be 60–80% (according e.g. Samuelson and Nordhaus, 2004).

Nevertheless, the FCR are not even a dominant company of an oligopoly in the real meaning of it, since the share of a dominant company in an oligopoly should be approximately 40% (see OECD, 2002).

## CONCLUSION

The aim of this paper was to describe the market structures of the forestry and wood processing sector. For the purpose of this article, a hypothesis was formulated stating that there is no risk of monopolisation of the forestry industry since the state enterprise FCR does not have such a significant share of the market and the competitive fringe is strong enough, even if the FCR extends their selling techniques–their trading channels. Financially expressed, the strength of the competitive fringe over the surveyed reference period is CZK 44,381.75 million on average. The parameters of the identified actual state of the market structure of the Czech forestry does not correspond with the oligopoly with a dominant company as described by Hořejší et al. (2008). Thus, the formulated hypothesis is not rejected. The protection of the market and the market competition, as well as the elimination of some barriers blocking the entry into the industry, are guaranteed by the state by means of legal instruments.

## REFERENCES

1. Act no. 111/1990 Coll., on state enterprise, as amended.
2. Act no. 136/2016 Coll., on public procurement, as amended.
3. Act no. 428/2012 Coll., on property settlement with churches and religious societies and on the amendment of certain acts, as amended.
4. CSO. 2017. Economic accounts for forestry and logging. Czech Statistical Office. [online] [cit. 2017-02-15]. Available at: <http://www.czso.cz>.
5. FCR. 2009 – 2014. Annual Reports 2009 – 2014. Forest of the Czech Republic, state enterprise. [online] [cit. 2017-03-10]. Available at: <http://www.lesycr.cz>.
6. FCR. 2015. Annual Report 2015. Forest of the Czech Republic, state enterprise. [online] [cit. 2017-04-10]. Available at: <http://www.lesycr.cz>.
7. FRIEDMAN, J. 1982. Oligopoly theory. In Arrow, K.J., Intriligator, M.D. (eds.): Handbook of Mathematical Economics, 2. Elsevier Science and Technology: 491-534.
8. HOŘEJŠÍ, B., SOUKUPOVÁ, J., MACÁKOVÁ, L., SOUKUP, J. 2008. Mikroekonomie. Praha: Management Press.
9. KRAFT, J. 2007. Perspektivy firem oligopolního lemu v podmínkách ekonomicky se sjednocující Evropy a jejich vliv na makroekonomické veličiny. Trendy ekonomiky a managementu [online] [cit. 2017-02-20]. Vysoké učení technické v Brně, I(1): 33-38. Available at: <http://hdl.handle.net/11012/19973>.
10. MoA. 2010, 2015, 2016. Information on Forests and Forestry in the Czech Republic by 2009, 2014, 2015. Prague: Ministry of Agriculture of the Czech Republic. [online]. Available at: <http://eagri.cz>.
11. OECD. 2002. Glossary of Statistical Terms. Organisation for Economic Co-operation and Development. [online] [cit. 2017-02-28]. Available at: <https://stat.oecd.org/glossary/detail.asp?ID=3199>.
12. SAMUELSON, P.A., NORDHAUS, W.D. (2004). Economics. McGraw Hill Higher Education, Columbus.
13. SCHILLER, B.R. 2013. The Micro Economy Today. 13th edition. Business and Economics.
14. SEVEROVÁ, L., KOPECKÁ, L., SVOBODA, R., BRČÁK, J. 2011. Oligopoly competition in the market with food products. Agricultural Economics – Czech, 57(12): 580-588.
15. SOUKOPOVÁ, J. et al. 2006. Mikroekonomie. 4. vyd. Praha: Management Press.

16. ŠRÉDL, K., SVOBODA, R. 2011. Oligopolní konkurence s dominantní firmou a obchodní řetězce. Trendy ekonomiky a managementu [online] [cit. 2017-02-21]. Vysoké učení technické v Brně, V(9): 99-105. Available at: <http://hdl.handle.net/11012/19606>.
17. TASNÁDI, A. 2010. Quantity-setting games with a dominant firm. Journal of Economics, 99(1): 251-266.
18. VARIAN, H.R. 1992. Microeconomic analysis. 3rd edition. London: W. W. Norton & Company, Ltd.

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# DIFFERENT PROFILES OF BRAND PERSONALITY – THE RESULT OF THREE INDEPENDENT MEASUREMENTS

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## ABSTRACT

The aim of this paper is to show results of the three independent measurements. A research compares customers perceptions on two furniture sellers – IKEA and Möbelix, during three years in Slovak republic. The result is "brand personality profile" for each company during three years. To identify profiles Geunes, Weijters and De Wulf (2009) method has been used. The first research study was carried out in 2015, the second research study was carried out in 2016 and the last one was carried out in 2017 on three independent samples of respondents. It resulted in six different profiles of brands.
**Key words: brand personality, corporate personality profile, furniture sellers**

## 1. INTRODUCTION

Every company wants to successfully establish itself on the market, but it is up to the company how to reach the aim (Loučanová, Parobek, Kalamarova, 2016). A company can influence the customers with e.g. the products, marketing communication to reach a positive image among them. Customers with positive attitude towards the company, loyal customers and satisfied customers are the way how to measure the real success of the company on the market in general. These facts were mentioned in some studies e.g. Loučanová et al. (2014), Parobek et al. (2015), Loučanová, Kalmárová, Parobek (2015) etc. Kaputa, Paluš, Vlosky (2015 p. 121) see the opportunity for Slovak wood processing companies in non-price factors as competitive advantage in foreign markets.

By the revealing the brand personalities of IKEA and Möbelix (foreign furniture retailers) in Slovak market we can help Slovakian furniture retailers to compete with them, to distinguish them, to imitate them, to reveal their weaknesses etc. Slovakian furniture retailers can use this knowledge to gain the unique competitive advantages.

The main aim of this paper is to reveal the brand personality profiles of IKEA and Möbelix (furniture sellers on the Slovak market) using the measure of the brand personality (MBP) which was developed by Geuenes, Weijters and De Wulf (2009) and to compare them to results of our two previous studies. The first study was carried out in 2015 and the second study was carried out in 2016 on two independent samples of respondents. The last one research was conducted in 2017.

This method can help to reveal brand personality profile which we want to use to reveal the attitudes of the consumer towards the selected companies.

Alpatova and Dall'Olmo Riley (2011) compare the two brand personality scales in their study Aaker's (1997) and Geuens et al.'s (2009) scales. And they support Geuens et al.'s (2009) scale. Alpatova and Dall'Olmo Riley (2011) said that Geuens et al.'s (2009) scale "*is an effective practical instrument for branding research, which could be used for any product category and for analyses on an industry, individual brand and respondent level".*

## 2. MATERIAL AND METHODS

In our two studies carried out in 2015 and 2016 on two different samples we tested a measure for brand personality developed by Geuens, Weijters, de Wulf (2009) on IKEA and Möbelix. This measure consists of twelve items and five factors – Activity, Responsibility, Aggressiveness, Simplicity and Emotionality (see table 1). The authors of this method used a 7-point Likert scale to rate brand on 12 brand personality items.

We translated all items from this scale to Slovak language and constructed a questionnaire. Respondents were asked to rate brand personality traits on a Likert-type scale. The respondents rated 12 items on the scale from 1 – strongly agree, 3 – neither agree nor disagree (neutral answer, the midpoint of the scale) to 5 – strongly disagree.

There are other authors dealing with the issue of brand personality measure e.g. Jenifer Aaker (1997) who constructs a valid scale to measure brand personality in US (Whelan and Davies. 2007). The Corporate Character Scale method developed and tested by Davies et al. (2001, 2004) is used to measure the image and the identity of the companies. Gorbaniuk et al. (2017) developed four universal personality dimensions: Innovativeness/Enterprise, Openness to others, Stability and Machiavellianism. Haji et al. (2012 p. 449) identified four antecedent constructs for Negative Brand Personality: Corporate Social Irresponsibility, Self-Incongruence, Brand Confusion, and Price Unfairness. Sung et al. (2015) identified six dimensions for luxury brands: Excitement, Sincerity, Sophistication, Professionalism, Attractiveness, and Materialism. Milas and Mlačić (2007) created Croatian scale and Bosnjak et al. (2007) German scale, Ahmad and Thyagaraj (2017, p. 86) created scale for India. They mentioned that their scale is a suitable alternative to Aaker's brand personality scale in Indian context.

*Table 1. The new brand personality measure (Geuens, Weijters, de Wulf 2009 p. 103).*

| Dimension | Items |
|---|---|
| Responsibility | Down to earth<br>Stable<br>Responsible |
| Activity | Active<br>Dynamic<br>Innovative |
| Aggressiveness | Aggressive<br>Bold |
| Simplicity | Ordinary<br>Simple |
| Emotionality | Romantic<br>Sentimental |

The sample I consisted of 409 respondents (consumers). We gathered data during November and December 2015. The sample II consisted of 467 respondents and data were collected during March and April 2016. The sample III consisted of 216 respondents. This research was conducted during spring 2017 (March and April). The snowball sampling technique was used (non-probability sampling technique) because we needed respondents that had knowledge and experience with both IKEA and Möbelix companies. Face to face interviews were carried out in every researches. As for selected time periods for research studies, Christmas time period and spring were selected because of increasing demand for furnishing items in Slovak republic.

For data analysis we used the weighted mean score on the 5-pointing rating scale for both companies as for scale dimensions (see Table 3). We used mode and weighted mean as well (see Table 2) for items of the dimensions of the scale.

## 3. RESULTS

*Table 2. The results from our three studies (2015 - I, 2016 - II, 2017- III) - items.*

| Dimension | Items | Mode IKEA I | Mode IKEA II | Mode IKEA III | Mode Möbelix I | Mode Möbelix II | Mode Möbelix III | Mean IKEA I | Mean IKEA II | Mean IKEA III | Mean Möbelix I | Mean Möbelix II | Mean Möbelix III |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Responsibility | Down to earth | 2 | 2 | 2 | 2 | 2 | 2 | 2,09 | 2,00 | 2,13 | 2,28 | 2,21 | 2,35 |
| | Stable | 1 | 1 | 1 | 2 | 2 | 2 | 1,72 | 1,65 | 1,92 | 2,1 | 2,22 | 2,14 |
| | Responsible | 1 | 1 | 1 | 2 | 2 | 2 | 1,8 | 1,94 | 1,89 | 2,3 | 2,36 | 2,34 |
| Emotionality | Romantic | 4 | 4 | 5 | 4 | 4 | 4 | 3,13 | 3,12 | 3,31 | 3,63 | 3,47 | 3,50 |
| | Sentimental | 2 | 4 | 2 | 4 | 4 | 4 | 3,12 | 3,10 | 3,22 | 3,58 | 3,43 | 3,42 |
| Activity | Active | 1 | 1 | 1 | 2 | 2 | 2 | 1,69 | 1,76 | 1,89 | 2,12 | 2,18 | 2,23 |
| | Dynamic | 1 | 1 | 2 | 2 | 2 | 2 | 1,95 | 1,93 | 2,16 | 2,27 | 2,43 | 2,53 |
| | Innovative | 1 | 1 | 1 | 2 | 2 | 2 | 1,72 | 1,76 | 1,86 | 2,37 | 2,46 | 2,49 |
| Aggressiveness | Aggressive | 5 | 5 | 5 | 5 | 5 | 5 | 3,74 | 3,85 | 3,80 | 3,56 | 3,64 | 3,75 |
| | Bold | 2 | 2 | 2 | 2 | 2 | 2 | 2,34 | 2,30 | 2,46 | 2,58 | 2,77 | 2,70 |
| Simplicity | Ordinary | 4 | 4 | 2 | 2 | 2 | 1 | 3,17 | 3,16 | 3,02 | 2,47 | 2,43 | 2,46 |
| | Simple | 2 | 2 | 2 | 2 | 2 | 2 | 2,21 | 2,15 | 2,24 | 2,29 | 2,32 | 2,45 |

Table 2 shows the results of our three research studies. The basic results of first survey (conducted in 2015) are: approximately 55.3% of the respondents were female and 44.7% were male. All respondents were over the age of 18 years old. More than 65% of the respondents were under the age of 51. As for the economic status, more than 50% were employees, more than 15% were students and more than 11% represented entrepreneurs. Approximately 60% of respondents lived in the cities.

As for results of the second survey (2016): approximately 60% of the respondents were female and 40% were male. All respondents were over the age of 18 years old. More than 82% of the respondents were under the age of 51. As for the economic status, more than 58% were employees, approximately 20% were students. More than 67% of respondents lived in the cities.

For more details of these two studies see our publication Maťová, Triznová, Dzian (2016) Different profiles of brand personality–the result of two independent measurements.

The third survey (2017) and the basic results of this study are: approximately 56% of the respondents were female and 44% were male. All respondents were over the age of 18 years old. More than 79% of the respondents were under the age of 51. As for the economic status, more than 51% were employees, 25% were students. More than 60% of respondents lived in the cities

Table 3 illustrates the profiles of the brand personalities – dimensions of the IKEA and Möbelix during three years.

*Table 3. The resuts from our three studies (2015 - I, 2016 - II, 2017- III) - dimensions.*

| | Means for dimensions 2015, 2016, 2017 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Dimensions** | **IKEA I** | **IKEA II** | **IKEA III** | Δ | **Möbelix I** | **Möbelix II** | **Möbelix III** | Δ |
| **Responsibility** | 1,87 | 1,86 | 1,98 | ↑ | 2,23 | 2,26 | 2,28 | ↑ |
| **Activity** | 1,78 | 1,82 | 1,97 | ↑ | 2,25 | 2,36 | 2,42 | ↑ |
| **Aggressivness** | 3,04 | 3,07 | 3,13 | ↑ | 3,07 | 3,20 | 3,22 | ↑ |
| **Simplicity** | 2,69 | 2,65 | 2,63 | ↓ | 2,38 | 2,38 | 2,46 | ↑ |
| **Emotionality** | 3,12 | 3,11 | 3,27 | ↑ | 3,60 | 3,45 | 3,46 | ↓↑ |

## 4. DISCUSION

IKEA

Table 2 illustrates modes for items 2015–2017; we can see the changes in items: Romantic, Sentimental (both from dimension Emotionality), Dynamic and Ordinary. IKEA is seen as Ordinary Sentimental in the third research and definitely not as romantic. According to the weighted means for items (IKEA III — 2017) our respondents mostly see IKEA as Innovative, Active, Responsible, Stable, Down to earth, Dynamic, Simple and Bold. Table 3 illustrates the weighted means for dimensions; we can see that scores are increasing during three years except for dimension simplicity.

Möbelix

A significant change compared to the previous years (Möbelix modes, table 2), we can see only on item Ordinary — Möbelix is seen as ordinary according to modes. The respondents (sample III — 2017) mostly see Möbelix (weighted means) as Stable, Active, Responsible, Down to earth, Simple, Ordinary, Innovative and Dynamic. As for final results on dimensions (see table 3), the scores are increasing during three years. An exception is dimension Emotionality (2015–2016).

If we compare the results from 2017 (table 3 – weighted means for both companies) the IKEA scores at the midpoint of the scale as for item Ordinary (respondents neither agree nor disagree that IKEA is ordinary) but Möbelix scores at 2.46, it means that respondents see Möbelix as Ordinary. Möbelix scores higher than IKEA on every item except for: Aggressiveness and Ordinary. IKEA is not seen more aggressive than Möbelix.

In general as for result from the survey conducted in 2017: Möbelix scores higher than IKEA on every dimension except dimension Simplicity.

## 5. CONCLUSION

The main aim of this paper was to reveal the brand personality profiles of IKEA and Möbelix using the measure of the brand personality (MBP) during 2017 and to compare revealed profiles from our previous studies from 2015 and 2016

The final results suggest that IKEA is mostly seen as Innovative, Active, Responsible, Stable, Down to earth, Dynamic, Simple and Bold but not aggressive; Möbelix is more or less seen as Stable, Active, Responsible, Down to earth, Simple, Ordinary, Innovative and Dynamic but not too much Sentimental, Romantic and Aggressive.

Ikea declares corporate values such as Humbleness and willpower, Leadership by example, Daring to be different, Togetherness and enthusiasm, Cost-consciousness, Constant desire for renewal, Accept and delegate responsibility. If we compare our results (Innovative, Active, Responsible, Stable, Down to earth, Dynamic, Simple and Bold) with IKEA's core values we can find a match.

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## REFERENCES

1. Aaker, J. L. (1997). Dimensions of brand personality. Journal of marketing research, 347-356.
2. Ahmad, A., & Thyagaraj, K. S. (2017). An empirical comparison of two brand personality scales: Evidence from India. Journal of Retailing and Consumer Services, 36, 86-92.
3. Alpatova, A. and Dall'Olmo Riley, F. (2011), "Comparing brand personality measures", paper presented at the Academy of Marketing Conference: Marketing Fields Forever, Liverpool, July, available at: http://marketing.conference-services.net/resources/327/2342/pdf/AM2011_0049.pdf (accessed April 14, 2017). [Google Scholar]
4. Bosnjak, M., Bochmann, V., & Hufschmidt, T. (2007). Dimensions of brand personality attributions: a person-centric aproach in the German cultural context. Social Behavior and Personality: an international journal, 35(3), 303-316.
5. Davies, G., Chun, R., da Silva, R. V., & Roper, S. (2001). The personification metaphor as a measurement approach for corporate reputation. Corporate Reputation Review, 4(2), 113-127.
6. Davies, G., Chun, R., da Silva, R. V., & Roper, S. (2004). A corporate character scale to assess employee and customer views of organization reputation.Corporate Reputation Review, 7(2), 125-146.
7. Geuens, M., Weijters, B., & De Wulf, K. (2009). A new measure of brand personality. International Journal of Research in Marketing, 26(2), 97-107.
8. Gorbaniuk, O., Razmus, W., Firlej, K., Lebiedowicz, A., & Leszczyński, M. (2017). Measuring corporate personality: A critical review and new insights.Journal of Brand Management, 1-16.
9. Haji, I., Evanschitzky, H., Combe, I., & Farrell, A. (2012). The forgotten brand personality dimension. NA-Advances in Consumer Research Volume 40.
10. Kaputa, V., Paluš, H., & Vlosky, R. (2016). Barriers for wood processing companies to enter foreign markets: a case study in Slovakia. European Journal of Wood and Wood Products, 74(1), 109-122.
11. Loucanová, E., Parobek, J., & Palus, H. (2014). Identification of slovak customers'requirements for storage furniture based on the kano model. Acta Facultatis Xylologiae Zvolen res Publica Slovaca,56(1), 109.
12. Loučanová, E., Kalamárová, M., & Parobek, J. (2015). The competitiveness of wood products from the perspective of used material. Acta Facultatis Xylologiae Zvolen Res Publica Slovaca, 57(2), 155-163.
13. Loučanová, E., Parobek, J., & Kalamarova, M. (2016). The Perception of Respondents of Packaging Innovations in Slovakia. Studia Universitatis Vasile Goldiş, Arad-Seria Ştiinţe Economice, 26(3), 33-43.
14. Maťová, H., Triznová, M., & Dzian, M. (2016). Different profiles of brand personality–the result of two independent measurements. The path forward for wood products, 181.
15. Milas, G., & Mlačić, B. (2007). Brand personality and human personality: Findings from ratings of familiar Croatian brands. Journal of Business Research,60(6), 620-626.
16. Parobek, J., Loučanová, E., Kalamárová, M., Šupín, M., & Štofková, K. R. (2015). Customer Window Quadrant as a Tool for Tracking Customer Satisfaction on the Furniture Market. Procedia Economics and Finance, 34, 493-499.
17. Sung, Y., Choi, S. M., Ahn, H., & Song, Y. A. (2015). Dimensions of luxury brand personality: Scale development and validation. Psychology & Marketing,32(1), 121-132.
18. Whelan, S., & Davies, G. (2007). A comparative study of the corporate reputation of Irish versus British retailers: lessons for retail brand practice. Irish Marketing Review, 19(1/2), 37.

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# END-USERS' VIEWS ON SELECTED GREEN PROPERTIES OF PAPER PRODUCTS

Kaputa, V., Paluš, H., Dzian, M.

## ABSTRACT

Enormous grow in utilisation and consumption of paper and paper products relates to the growth of demand as well as progress in printing technologies and paper production itself. This paper presents results of survey implemented as barometer of public opinions on selected green characteristics of pulp and paper industry products. Survey was carried out using the implemented CATI (Computer Assisted Telephone Interviewing) system. Environmental awareness of end-users rise-up to significant level especially in case of paper products. According to findings, majority of surveyed respondents expressed preferences for specific green properties of certain paper products. Preferred green and other properties vary according to demographic characteristics of surveyed end-users.
**Key words:** survey, paper products, attitudes of end-users, green properties, environmental attributes.

## 1. INTRODUCTION

Environmental conscious behaviour of wood processing companies needs environmental conscious consumers. This phrase could be a label of recent decades when environmental marketing proved in environmental certification and labelling of wood products has received worldwide attention (Kaputa, 2013). Consumers in growing numbers seek and prefer products without negative impact on the environment. By purchasing such products they support and contribute to the promotion of sustainable consumption. Wood as a natural material has unique properties and serves for different purposes. It is considered to be ecological, aesthetic and renewable material with exceptional physical and mechanical properties. It is mainly used in construction, paper production, furniture making and a number of different related sectors and activities. Kaputa (2006) points out that the most of the Slovak wood processing companies considered their consumers as not environmentally sensitive and they think that there is no real demand for environmentally appropriate wood products. However, more than 60% of questioned companies anticipated changes in customers' preferences for environmental characteristics of wood products. Competitive advantages of wood can be found in its properties. However, these properties are specific to any particular use of wood or wood products. One may prefer wooden furniture to plastic one because of nature of the material as well as ecological and aesthetic properties. On the other hand, wood as building material will be used because of its durability and other mechanical and physical properties. Taking into account the different properties of wood (stability, durability, aesthetic properties, ecologic properties, renewable resource, etc.) there are different possibilities for wood utilisation and a different number of competitive (substitutive) products and materials existing on each of the markets. A real technical compatibility and possibility to meet the same needs and expectations of consumers are the basic precondition for products substitution. One of the main conditions of substitution is the technical compatibility of the materials and price level of substitutes (Paluš, 2002).

There are many different ways how consumers are informed on how product life cycle and use impact the environment. A number of programs and labels worldwide are available to assists consumers to make their purchasing decisions. Environmental labels and declarations can help consumers decide about products they buy and whether they are environmentally preferable. The overall goal of environmental labelling is to encourage the demand for, and supply of, those products and services that are environmentally preferable through the provision of verifiable, accurate and non-deceptive information on environmental features of products and services. By enabling environmental criteria to be

considered during purchasing decisions, labelling and certification programs help consumers to "vote through the marketplace" for more environmentally responsible products (IISD, 2017). Products bearing eco-label should have the potential to reduce certain negative environmental impacts, as compared with other products in the same product group. The characteristics of such products should address environmental factors which are of interest from the point of view of society and the environment.

Integrated product policy is the main tool of the EU, which seeks to minimise environmental impacts of products through looking at all phases of a products' life-cycle thus covering all the areas from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale and use to their eventual disposal as waste in the whole production and consumption chain. The policy incorporates a variety of voluntary and mandatory tools including economic instruments, substance bans, voluntary agreements, environmental labelling and product design guidelines. The EU eco-label scheme (as laid down in the new Regulation (EC) No 1980/2000) is a part of this integrated policy. The objective of the Community eco-label award scheme is to promote products which have the potential to reduce negative environmental impacts, as compared with the other products in the same product group, thus contributing to the efficient use of resources and a high level of environmental protection. The eco-label may be awarded to a product possessing characteristics which enable it to contribute significantly to improvements in relation to key environmental aspects. As of April 2017 EU environmental labelling scheme covered the categories of converted paper, newsprint paper, printed paper, copying and graphic paper and tissue paper (EC, 2017). Apart from other criteria dealing with production processes and hazardous substances, waste management, the requirements regarding wood as natural material are covered under the criterion "Fibres – sustainable forest management". The fibre raw material in the paper may be recycled or virgin fibre. Where virgin fibres are used, the product should be covered by valid forest management and chain of custody certificates issued by an independent third party certification scheme with a defined maximum percentage of the uncertified material, which, however, must be covered by a verification system which ensures that it is legally sourced and meets any other requirement of the certification scheme with respect to uncertified material.

There have been several studies examining consumer attitudes and preferences towards wood and paper products. Rametsteiner et al. (2007) analysed attitudes of European consumers towards wood and wood products. Preferred are general properties such as naturalness of wood or its feature to be environmentally friendly material. In terms of environment friendliness, paper is consistently seen as more friendly than most materials except wood. Regarding paper as packaging material, some 93% of the general public agreed that paper-based packaging and labels are more environmentally friendly than other materials. Other studies carried out in Slovakia confirmed that wood and paper are preferred for their environmental, ecological and natural properties (Paluš et al., 2012; Loučanová et al., 2014a; Loučanová et al., 2014b; Olšiaková et.al, 2016), although the consumer awareness of environmental labels is very low (Rusko and Peková, 2006; Paluš et al., 2014)

## 2. OBJECTIVE AND METHODS

The aim of the paper was to evaluate end-users' attitudes towards selected environmental attributes (green properties) of paper products. Computer Assisted Telephone Interviewing (CATI) was chosen to carry out the survey of end-users' attitudes. CATI is an interactive front-end computer system that aids interviewers to ask questions over the telephone. The answers are then keyed into the computer system immediately by the interviewer (ESCAP, 2013). Comparing to the traditional data collection (via face to face interview) is CATI considered to be more productive approach for data collection which reduces manpower needs, lowering costs and speed up the process of data collection. Comparing to mail/e-mail data collection has CATI not any delay in completing the form or returning it what has severe implications for the response rate (Kaputa et al., 2013).

Data were acquired on the basis of a random sample of respondents within the whole Slovak Republic. Due to the fact that research is consumer oriented, survey was carried out within a sample of adult population (over 18 years of age). Respondents have been asked to provide: a) demographic data such as sex, age, achieved educational and income of respondents and b) their views on green properties of selected paper products. There were the options to express a positive, negative and indifferent response (3-point scale). The survey has dealt with the following topics:

- importance of a **graphic paper** price over its quality,
- preferences for a **graphic paper** which production is less harmful for the environment,
- preferences for purchase of **tissue** made from recycled paper.

Moreover, respondents expressed how important are the next attributes of **paper packaging** comparing to its substitutes:

- preservation of its utility attributes,
- simplicity of handling and storability,
- ecological attributes (e.g. sorting possibility, recycling).

Classification of paper products introduced on Figure 1 was used in order to clarify what kind of material substitutes could be considered.

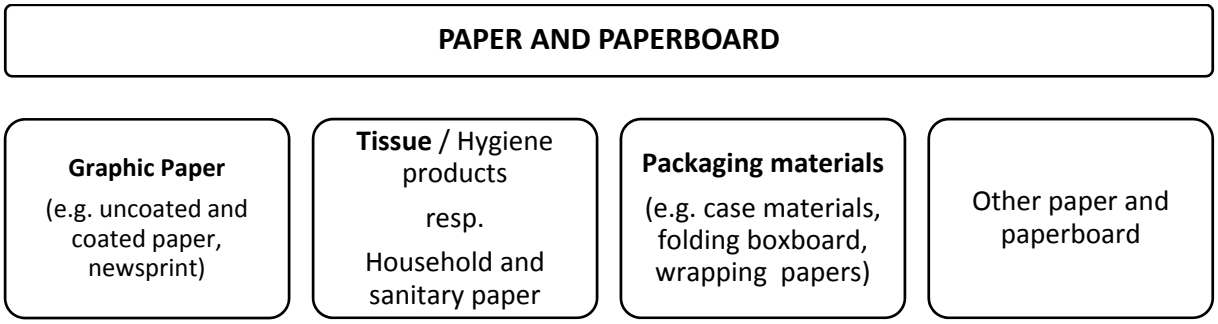



*Figure 1 - Classification of paper products (Based on FAO classification – FAO, 2017)*

While hygiene and sanitary paper products are usually substitute by other natural or artificial fibres (e.g. based on cotton silk, synthetic), packaging paper products could be substitute by wide spectrum of materials (e.g. based on plastic, metal, glass). Specific is a case of graphic paper as information bearer where digital platform/medium plays a role of significant substitute from the market point of view.

Methods of descriptive and inductive statistics have been used for processing and interpretation of research data. Random sampling was a basic assumption for using the inductive statistical method.

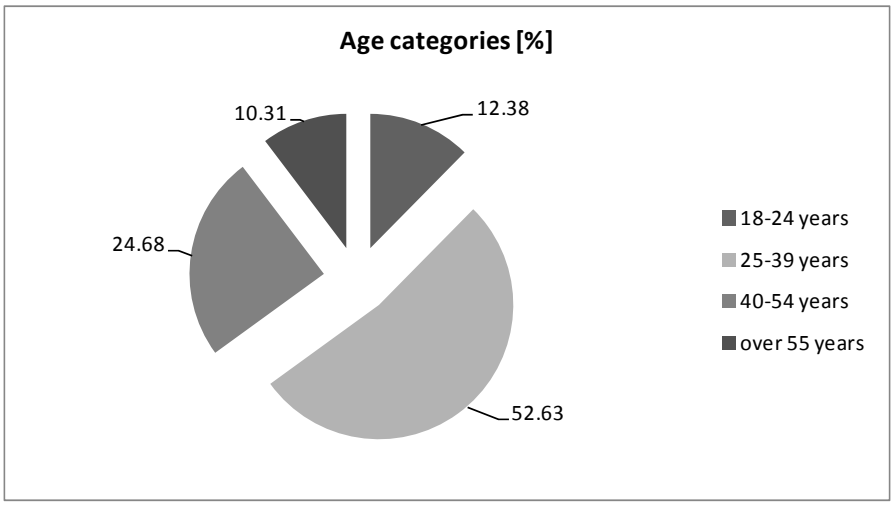
## 3. RESULTS

Overall, responses were received from 1503 respondents. Regarding the sample size and random sampling as method used for data gathering, it can be argued that the sample is representative. The demographic structure of the sample introduces Table 1.

*Table 1 – Demographic structure of respondents (n = 1503)*

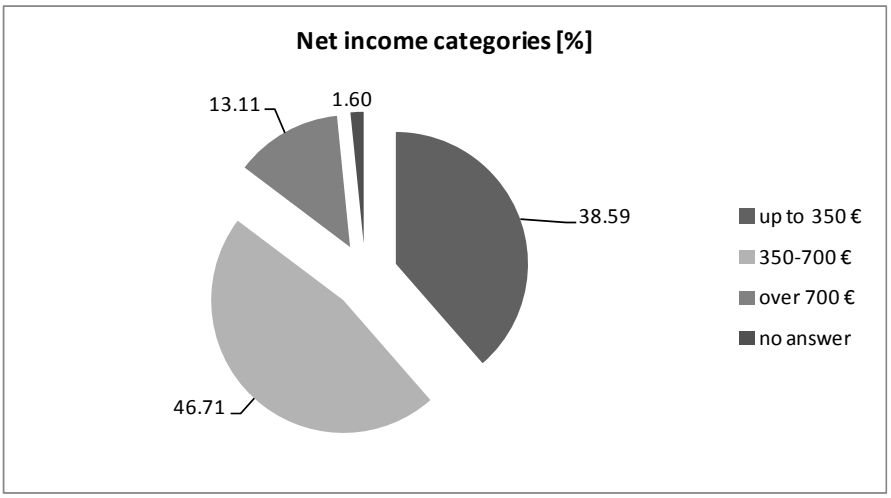
| Sex | | Residence | | Age category | | | | Achieved education | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Men | Women | Urban | Rural | 18-24 years | 25-39 years | 40-54 years | over 55 years | Primary school | High-school | University |
| 42.2% | 57.8% | 78.2% | 21.8% | 12.4% | 52.6% | 24.7% | 10.3% | 1.9% | 79.9% | 18.2% |

There is a higher share of women (57.8%) in the sample and the largest age category is created by 25 up to 39 years old respondents (52.6%). High-school educated people are the most represented in the sample – almost 80%. This fact could be interpreted by the statement that part of them has not been completed university studies yet. The urban area (cities, towns) as the residence is the most represented – 78.2% of respondents live here.




*Graph 1 Age categories distribution (n = 1503)*

In terms of respondents' income, the largest share (46.7%) has the category with a net monthly income of 350-700 Euro. Second large category (38.6%) creates respondents with a net monthly income of up to 350 Euro.




*Graph 2 Net income categories distribution (n = 1503)*

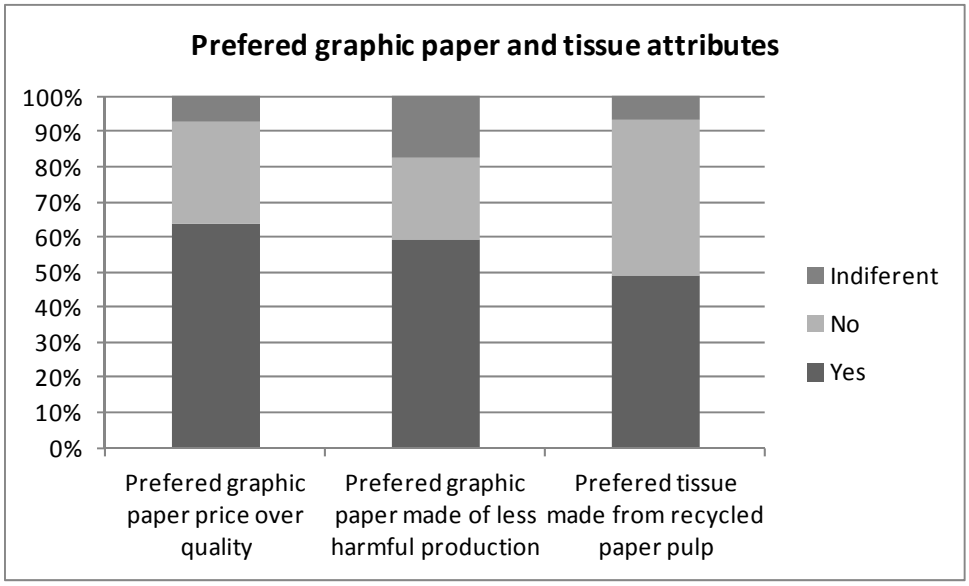
Overall frequency analyses showed high share of respondents (almost 64%) with inclination to make purchase decision in favour of price of graphic paper rather than of his quality. Similar share of respondents' sample (over 59%) expressed preferences for graphic paper of which production is less

harmful to environment. Here, some 17% have indifferent attitude what indicates either unclear query or certain distance or reluctance to develop awareness about product properties further.

*Table 2 Respondents attitudes towards selected paper products attributes (in percentage, n = 1503)*

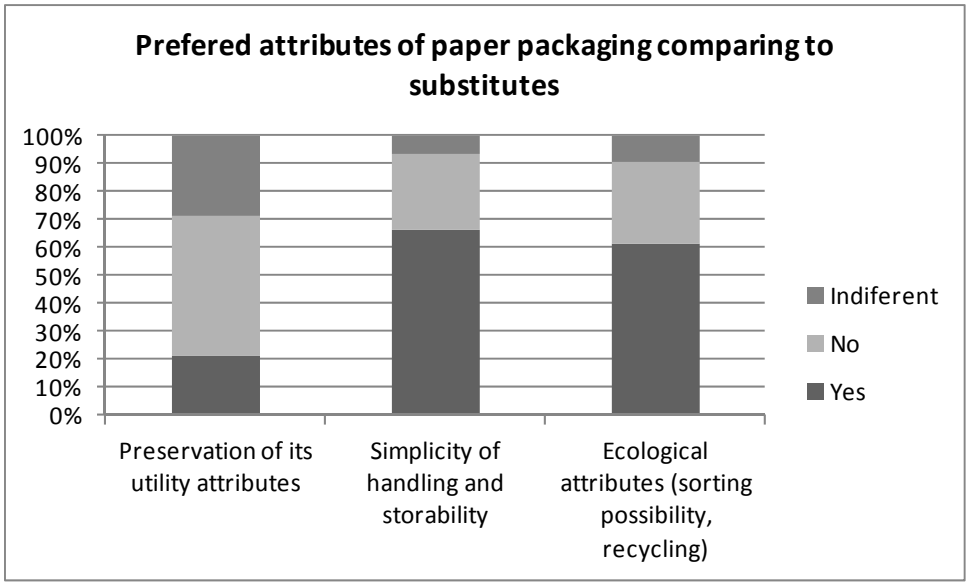
| | **Graphic paper** | | **Tissue** | **Preferred attributes of paper packaging comparing to their substitutes** | | |
|---|---|---|---|---|---|---|
| | Preferred graphic paper price over quality | Preferred graphic paper made of less harmful production | Preferred tissue made from recycled paper pulp | Preservation of its utility attributes | Simplicity of handling and storability | Ecological attributes (sorting possibility, recycling) |
| **Yes** | 63,9 | 59,2 | 49,0 | 21,6 | 66,4 | 61,0 |
| **No** | 28,9 | 23,5 | 44,4 | 49,8 | 26,8 | 29,9 |
| **Indiferent** | 7,2 | 17,3 | 6,5 | 28,5 | 6,8 | 9,1 |

Almost half of respondents (49%) would prefer a tissue made from recycled paper while some 44% do not consider this fact.




*Graph 3 Shares of preferences for certain graphic paper and tissue attributes (n = 1503)*

Different attributes of paper packaging play a different importance in purchase decisions of surveyed end-users. Preservation of paper packaging's utility attributes (as hygienic or protection properties) has just a minor importance (see Table 2) comparing to packaging from substitutive materials. On the other hand, simplicity of handling and storability of paper packaging are considered as important for over 66% of respondents. Similar share (61%) of respondents is aware of importance of paper packaging's ecological attributes (as sorting possibility and recycling) comparing to its substitutes.




*Graph 4 Shares of preferences for selected attributes of paper packaging comparing to its substitutes (n = 1503)*

Statistical significance of distribution of demographic variables' frequencies (using Pearson's Chi-square test at level of p = 0.05) introduces Table 3. Based on the results of contingency analyses and testing of frequencies distribution we can conclude that preferences for *graphic paper price over its quality* statistically significantly depend on age of respondents ($\chi^2$ = 27.80, p = 0.000) where group of end-users over 55 years old has the highest share (some 38%) of those not preferring price over quality.

Preferences *for graphic paper price over its quality* statistically significantly depend also on the level of achieved education ($\chi^2$ = 29.65, p = 0.000) where group of university educated end-users has the highest share (some 38%) of those not preferring price over quality.

*Table 3 Statistical significance of demographic factors (values of the Pearson's Chi-square test at level of p = 0.05), n= 1503*

| | | **Graphic paper** | | | | **Tissue** | | **Preferred attributes of paper packaging comparing to their substitutes** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Preferred graphic paper price over quality | | Preferred graphic paper made of less harmful production | | Preferred tissue made from recycled paper pulp | | Preservation of its utility attributes | | Simplicity of handling and storability | | Ecological attributes (sorting possibility, recycling) | |
| | **df** | **$\chi^2$** | **p** | **$\chi^2$** | **p** | **$\chi^2$** | **p** | **$\chi^2$** | **p** | **$\chi^2$** | **p** | **$\chi^2$** | **p** |
| **Sex** | df= 2 | 4.944 | 0.051 | 4.292 | 0.117 | 4.141 | 0.126 | 0.368 | 0.832 | 1.685 | 0.431 | 1.869 | 0.393 |
| **Residence** | df= 2 | 0.660 | 0.719 | 0.968 | 0.616 | 1.214 | 0.545 | 4.314 | 0.116 | 1.026 | 0.599 | **6.222** | **0.045** |
| **Age** | df= 6 | **27.800** | **0.000** | **17.911** | **0.006** | 12.529 | 0.051 | **13.887** | **0.031** | 6.309 | 0.389 | 10.854 | 0.093 |
| **Achieved Education** | df= 4 | **29.654** | **0.000** | 6.527 | 0.163 | 2.141 | 0.710 | **23.506** | **0.000** | 8.981 | 0.062 | 2.737 | 0.603 |
| **Income** | df= 6 | 5.017 | 0.542 | 11.435 | 0.076 | 11.707 | 0.069 | **15.996** | **0.014** | 1.370 | 0.968 | 7.226 | 0.300 |

Preferences for *graphic paper which production is less harmful for the environment* statistically significantly depend on age of respondents ($\chi^2$ = 17.91, p = 0.006).

There are not significant differences in preferences for purchase of ***tissue made from recycled paper*** between certain categories of demographic characteristics (sex, residence, age, achieved education, and income).

Respondent of different age categories perceived significantly different ($\chi^2 = 13.88$, $p = 0.031$) ***the preservation of paper packaging utility attributes*** *comparing to its substitutes* (e.g. packaging from materials like plastic, metal). Statistically significant differences in frequencies at this criterion have been also proved between respondents of different achieved education ($\chi^2 = 23.50$, $p = 0.000$) as well as between income categories ($\chi^2 = 15.99$, $p = 0.014$).

The variable *importance of paper packaging* ***storability and simplicity of handling*** *comparing to its substitutes* is independent of all the tested demographic variables.

Importance of *ecological attributes of paper packaging comparing to its substitutes* was statistically significantly different between respondents from different residence ($\chi^2 = 6.22$, $p = 0.045$).

## 4. CONCLUSIONS

Environmental consciousness of questioned end-users achieves high level since majority of them expressed purchase preferences which favour paper products of higher environment-friendly properties comparing to other one. Certain differences between demographic categories have been proved at the statistically significant level. Most of differences occurred between respondents of a different age following by those of different achieved education. Price is a crucial purchase decision factor for majority of end-users of graphic paper. Green properties of graphic paper as well as of paper packaging (given by production less harmful to environment, resp. possibility of sorting and recycling) are sensitively perceived by more than half of respondents. Paper packaging is also valued for its functional attributes such as simplicity of handling and storability since two-third of respondents consider them for important. Generally, environmental awareness of Slovak end-users rise-up especially in case of paper products. The main findings are that majority of surveyed respondents expressed preferences for certain paper products with specific green properties.

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# REFERENCES

1. EC (2017) European Commission. Environment. Available online: http://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html
2. EC Regulation (EC) No 1980/2000. REGULATION (EC) No 1980/2000 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 July 2000 on a revised Community eco-label award scheme. Available online: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000R1980&from=FRN
3. ESCAP. (2013) Computer Assisted Telephone Interviewing (CATI). [online]. [cited April. 2013]. Available at: http://www.unescap.org/stat/pop-it/pop-guide/capture_ch04.pdf – web site of The Economic and Social Commission for Asia and the Pacific (ESCAP - The United Nations)
4. FAO. (2017) Forest products statistics. [online] March 2017. Available at: <http://www.fao.org/forestry/statistics/80572/en/>
5. IISD (2017) Available online: http://www.iisd.org/
6. Kaputa. V. (2006) Environmental attributes of wood products and competitive advantage. Intercathedra. 2006. 22. p. 49 – 51.
7. Kaputa. V. (2013) Trh a environmentálne atribúty výrobkov z dreva. Vedecká monografia. Zvolen: Technická univerzita vo Zvolene. 2013. - 56 s. ISBN 978-80-228-2620-4.

8. Kaputa. V.; Paluš. H.; Blažková. S.; Šupín. M. (2013) Barometer of public opinion in attitudes towards wood products: a methodological approach. Zagreb: WoodEMA. ISBN 978-83-63978-07-5. p. 16.
9. Loučanová. E.; Parobek. J.; Paluš. H. (2014a) Identification of Slovak customers' requirements for storage furniture based on the KANO model. Acta Facultatis Xylologiae Zvolen. 2014. 56(1). p. 109-117.
10. Loučanová. E.; Kalamárová. M.; Parobek. J. (2014b) The competitiveness of wood products from the perspective of used material. Acta Facultatis Xylologiae Zvolen. 2014. 57(2). p. 155-163. doi: 10.17423/afx.2015.57.2.16.
11. Olšiaková. M.; Loučanová. E.; Paluš. H. (2016) Monitoring changes in consumer requirements for wood products in terms of consumer behavior. Acta Facultatis Xylologiae Zvolen. 2016. 58(1). p. 137-149. doi: 10.17423/afx.2016.58.1.15.
12. Paluš. H. (2002) Modelovanie dopytu po výrobkoch z dreva na trhu v SR. Vedecká štúdia 3/2002/A. Zvolen:TU. 2002. 49 s. ISBN 80-228-1153-X.
13. Paluš. H.; Lis. W.; Maťová. H.; Kaputa. V.; Popyk. W.; Parobek. J. (2011) End users´ preferences for joinery products and furniture. Intercathedra. 2011. 27/2. p. 58-61.
14. Paluš. H.; Maťová. H.; Kaputa. V. (2012) Consumer preferences for joinery products and furniture in Slovakia and Poland. Acta Facultatis Xylologiae Zvolen. 2012. 54(2). p 123-132.
15. Paluš. H.; Mat'ová. H.; Križanová. A.; Parobek. J. (2014) A survey of awareness of forest certification schemes labels on wood and paper products. Acta Facultatis Xylologiae Zvolen. 2014. 56 (1). 129-138.
16. Rametsteiner. E.; Oberwimmer. R.; Gschwandtl. I. (2007) Europeans and wood: What do Europeans think about wood and its uses? A review of consumer and business surveys in Europe. (2007). URL: http://www.foresteurope.org/documentos/Eur_Wood_net.pdf.
17. Rusko. M.; Peková. K. (2006) Povedomie spotrebiteľov na Slovensku o environmentálnej značke. Environmentální značení. 2006. 8. 1. s. 3-5.

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# ENTERPRISE RESOURCE PLANNING: CASE STUDY OF CROATIAN WOOD PROCESSING COMPANIES

Perić, I.; Debelić, A.; Grladinović,T.

## ABSTRACT

Enterprise Resource Planning (ERP) systems are packaged software designed to integrate and optimise the business processes of a company. The ERP systems have been embraced by industry as a de facto solution to integrate their business functions. This paper reports a survey study conducted on Croatian wood processing companies. The study used the elements of survey questionnaires used in previous surveys done on manufacturing firms. Our objective is to determine the extent of adoption of the ERP system in the Croatian wood processing companies, their motivations and benefits obtained.
**Key words**: Enterprise Resource Planning (ERP); Croatian Wood Processing Companies; Questionnaire survey

## 1. INTORDUCTION

In recent years, many companies world-wide have been focusing on their core business, downsizing and outsourcing, due to adverse global economic conditions (Loh and Koh, 2004). This global change in business is refers to all areas, especially questioning the company's effectiveness and trying to find optimal solutions for doing business (Hernaus, 2009). According to the European Commission small and medium-sized enterprises (SMEs) and entrepreneurship are key to ensuring economic growth, innovation, job creation, and social integration in the EU. Considering in that part s wood processing industry in Croatia, wood industry is in the same situation like in other European countries, it consists of many SMEs that face difficulties in reaching a good market position and becoming competitive (Perić, 2015). In addition, the important fact is that wood industry is a resource-intensive industry, and as such does not have a high added value (compared to ICT, pharmaceuticals, etc.), but it is important for the Croatian economy (notable share in employment, export and rural development) (Kersan-Škabić, 2014). However, it is not enough to succeed in foreign markets, because the performance depends not just on the availability of resources, but also on subtle factors, such as investment in knowledge, technology, or design on other words to be competitive in the market SMSs have to be innovative in all possible aspects (Belak & Ušljebrka, 2014). Furthermore, in recent years' sustainable development trends have spread over wood products industry and numerous wood industry companies were obliged to implement Chain Custody certification in order to retain their customers (Klarić *et al.* 2017).

To improve their performance and competitiveness companies, in particular SMEs within a supply chain that involves larger companies, must now turn to more outward-looking approaches such as providing higher added value to customers and developing better working relationships and ultimately partnerships, in other words competitive trends are pushing executives to rethink traditional business design configurations (Loh and Koh, 2004). Considering a wood processing industry, where inventory problem is significant, even an improvement in material-flows managements is a one of the way how to extend business results (Grladinović, *et al.*, 2003), this imply the fact that the primary goal of inventory management, is to have adequate quantities of high quality inventory available to serve customer needs, while also minimizing the costs of carrying inventory (Chow *et al.*, 2000). According to the result conducted by study of Pric Barčić *et al.* (2016) related to the innovation activity of furniture manufacturing companies in Croatia, results showed that R/D investments are correlated the most to production process innovation elements. Further, other studies have shown that the effectiveness of an inventory management system depends on the quality of information it takes in and the capacity of the company's information technology (IT) (Dumas, 2008).

Improvements in information systems over recent years mean that feedback can be much more frequent and in some cases, can be almost instant, thus offering real-time control capabilities. With the development of information and communications technology (including computer components and software packages), there has been also an impact on the development of all forms of computer applications and specialization of individual applications intended for business systems, known as ERP systems, which evolved from Materials Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II) systems. All these software's, since their introduction, they all have the main goal - integration of processes across functional areas with improved workflow, standardization of various business practices, improved order management, accurate accounting of inventory, and better supply chain management. Basically, the concern with the demand predictability became more evident from the World War II end. At that time, many companies had competence to carry out its production plans based only on firm orders. To minimize this mismatch between production and demand, were initiated sales forecasts on a quarterly basis (Santin, *et al.*, 2015).

The MRP concept has spread, especially in the United States and Europe, where changes were included in the model, mainly to get information of capacity requirements, and also to do a more reliable cost approach. These developments culminated in the 1980s, with the emergence of MRP II (Manufacturing Resource Planning), replacing the traditional MRP, the production management system that has been deployed by more companies since 1970 (Mabert, Soni, & Venkataramanan, 2003). The Gartner Group coined the term ERP in the early 1990s to describe these systems and stipulated that such software should include integrated modules for accounting, finance, sales and distribution, human resources, materials management and other business functions based on a common architecture that links the enterprise to both customers and suppliers. According to industry reports at least 30,000 companies worldwide have implemented ERP systems (Mabert, *et al.*, 2003). Their planning capability could offer substantial gains in productivity, dramatic increases in customer service, much higher inventory turns and a greater reduction in material costs if they are used efficiently and facilitated by necessary support (Loh & Koh, 2004).

Since 1990s many research have been published studies within the topic "improving the success rate of ERP implementation", and were primarily based on studies at large organizations (Zach, 2012). According to the Snider *et al.* (2009) the absence of SMEs was because of differences between SMEs and large organizations. Further, SMEs top management is usually involved in day-to-day activities, managers may have limited formal training, absence of long term planning is another dominant factor. On the other hand, SMEs have relatively informal structures and culture, which increase cross-functional exchanges, and small management teams, which results in efficient decision-making. For major disadvantage authors pointed out a lack of human and financial resources within the SMEs. However, SMEs often cannot afford extensive training, find it difficult to implement reengineering projects due to limited spare resources. The cost of an ERP implementation may be proportionally higher for SMEs than for large organizations.

According to the literature review, none of the research related to the implementation of ERP systems among wood processing companies in Croatia was carried out, as above mentioned this paper presents a preliminary work. Further, the aim of this study was to find out a level of usage of ERPs, examine factors of ERP implementation within SMEs in Croatian wood processing industry, and to determine their motivations and benefits obtained.

## 2. RESEARCH METHODOLOGY

The framework of the present study was tested with the use of a newly developed questionnaire on a sample of Croatian wood processing companies. The initial target population was taken from the Register of Business Entities supervised by Croatian Chamber of Commerce. The mailing list included all active companies with more than 10 employees, and according to their core business activities, were

classified in the field as *C 16 - wood processing* and *C 31 - furniture manufacturing*, based on *National Classification of Activities (2007).*

A mailed survey, via www.survs.com, was approaches used in this study. The design of the questionnaire for this research required a variety of measures and items. The items have been collected and adapted from different sources (Dumas, 2008; Loh and Koh, 2004; Mabert, *et al.*, 2003; Maditinos, *et al.*, 2011; Pertoni, 2002; Santin, *et al.*, 2015; Shatat, 2015; Snider, *et al.*, 2009; Zach, 2012). Open questions and five- point Likert scale was used for some of measurement of included variables (1 = "strongly disagree" to 5 = "strongly agree") or (1 ="very unimportant" to 5 =" very important"). Only 22 usable questionnaires were returned.

## 3. RESULTS

According to the results obtained, totally 22 companies were identified that have implemented an information business systems, precisely 13 of them furniture manufacturing and 9 wood processing companies. Software's are mostly applied (86%) for doing both - business and production processes. Regarding type of production processes within the company, 9% of them stated to have single production, 41% small-scale production and 50% large-scale production.

Most of them applying customized software programs (55%). Considering the well know ERP provider, 18% are using the Oracle, per 10% are using QAD and Navision (Microsoft Dynamics NAV) and per five percent of them are using SAP and Mapics. Further, 55% of respondents answered that they apply the above-mentioned software more than 5 years, while rest 45%, applying it for a period of 3 to 5 years.

About half of (45,5%) of questioned companies belongs to group that have between 10 to 50 employees and them 40,9% to have from 51-250 employees (table 1). Analysing the educational structure of the surveyed companies, more than average of all respondents (more precisely 64,2%) reported to employee people with secondary education and 30,6% with no education or primary education (table 1).

*Table 4 Qualification structure and number of employees within the word-processing companies (n=22)*

| *Number of employees* | *(n)* | *%* | Qualification of employees | *%* |
|---|---|---|---|---|
| 10-50 | 10 | 45,5 | No education and primary education | 30,6 |
| 51-250 | 9 | 40,9 | Secondary education | 64,2 |
| 251-500 | 1 | 4,5 | Bachelor's degree | 2,2 |
| 501-1000 | 1 | 4,5 | Master's degree | 2,6 |
| >1001 | 1 | 4,5 | Postgraduate degree | 0,1 |

Analysing the criteria for selection above mentioned software, shown in table 2, the main factors according to the respondents' answers were ability to customize the specific requirements of companies, ability to upgrade and employee IT competencies and company IT infrastructure (M=4,36; SD±0,91).

*Table 2 Criteria for selection of software (n=22)*

| Variables | M | SD |
|---|---|---|
| The ability to customize the specific requirements of companies | 4,36 | 0,77 |
| IT infrastructure of company | 4,10 | 0,81 |
| Software price | 3,82 | 1,03 |
| Cost of maintenance | 3,95 | 0,82 |
| Employees IT competencies | 4,32 | 0,76 |
| Implementation costs | 3,68 | 0,92 |
| The ability to upgrade | 4,32 | 0,76 |

On the question regarding to the decision of implementation software's used within the companies, it was measured with the 11 factors competencies (M=3,98; SD±0,91), the main factors were: reducing production costs, improving product quality, better inventory control, standardization of working procedures. But, on the other hand, the lowest rating was obtained for factors such as: new production line (2,05), then quality control, and reducing delivery lead time (table 3).

*Table 3 Decision criteria for software implementation (n=22)*

| Variables | M | SD |
|---|---|---|
| The ability to customize the specific requirements of companies | 3,45 | 1,72 |
| Reducing production costs | 4,23 | 0,85 |
| Better meeting of delivery promises | 4,00 | 1,09 |
| Reducing delivery lead time | 3,88 | 1,13 |
| Quality control | 3,87 | 0,90 |
| Improving product quality | 4,38 | 1,08 |
| Better inventory control | 4,32 | 0,82 |
| Standardization of working procedures | 4,14 | 0,87 |
| Greater responsibility of employees | 4,00 | 1,04 |
| Providing "real-time" support for customers | 4,00 | 1,04 |
| New production line | 2,05 | 0,90 |

The survey contained thirty-four open question, grouped into seven modules, regarding the activities of software usage within the surveyed companies. The following modules were offered, as follows: *financial module, human resources, management and production processes, inventory management, purchase management, quality management* and *sales management*. Obtained results have shown that the *financial module* is the most commonly used module, for activities such as: input accounts, open accounts, financial reporting and ledger (more than 80 percent of responses). Observing the *human resource* module, activities like managing employee's salary calculation, health and pension insurance were most commonly used within the respondents. Considering a *management and production process* module, production planning (81,8%), material management (63,6%) and work order control (68,2) showed as most common tools. When analysing an *inventory management module,* activities like material requirements, reservation and inventory adjustment, respondent companies apply the most. For *purchasing management* module, there were activities like managing orders and procurement reports. Further, the *quality management* module, 22,73% respondents were not using it, those who did use it for activities such as control of incoming material, quality control in production and for complainants. In sales management module results have shown usage for activates: pricing (90,9% respondents) and sales report (63,6%).

Question related to the benefits obtained considering post-implementation ERP phase, measured with five point Likert scale. Results have shown that factors such as *sales efficiency* (M=3,70; SD±1,69), measured with 6 variables, and *inventory planning and management*, measured with 5 variables (M=3,71; SD±1,66) been high score evaluated. On the other hand, factors *employee skill and competences*, variable measured with 4 variables (M=3,52; SD±1,01), then organizational effectiveness (M=3,59; SD±1,60), 4 variables, *overall* productivity (M=3,53; SD±1,63),9 variables, showed a slightly lower rating.

## 4. DISCUSSION AND CONCLUSION

Considering the number of employees within the surveyed companies, they belong to classification of small and medium sized enterprises. The study shows that conducted companies mainly have implemented customized ERP system for doing both-business and production processes. Main criteria selection of ERP software was ability to customize the specific requirements of companies, ability to upgrade, employee IT competencies and company IT infrastructure. Well know ERP providers are using mainly by large companies with more than 250 employees. This results and above mentioned results are correlated with previous research done by Dumas (2008), Loh and Koh, (2004), Snider, *et al.* (2009) and Zach (2012), where authors pointed out factors which may influence ERP implementation success in SMEs, such as: lack of human and financial resources, needed extensive trainings, reengineering of overall business processes, complex implementation process, high resource requirements etc. The main reasons for ERP software implementation, according to respondents' ratings were: improving product quality, better inventory control and reducing production costs. This lead to conclusion to be competitive, to leverage business performance, to improve organizational effectiveness, companies have to be innovative in all areas of business. That ERP system brings some improvements, can be seen from the obtained results, when assessing the factors: sales efficiency, inventory planning and management. According to the Shatat (2015), practice have shown that companies are only used between 50 and 75% of the ERP system functionalities or modules, comparing that with our case study, results are similar. Information business software's, within the surveyed companies are mainly used for following modules: financial module, human resources, management and production processes, purchasing and sales management.

Based on all the data that have been raised, it can be seen the importance of an ERP system usage within Croatian wood processing companies, as a useful management tool. A limitation of the present study is the relatively small size of the sample. This may be attributed to the nature of the population of the study which is rather small and difficult to be defined due to lack of available data. Another limitation can be prescribed to the timeframe of gathering the data.

## REFERNCES

1. Belak, S.; Ušljebrka, I. (2014): *The Role of ERP Systems in Changing Business Processes*. Oeoconomica Jadertina, (2), pp. 33-52.
2. Buckhout, S.; Fery, E.; Nemec, J. (1999): *Making ERP Succeed: Turning Fear into Promise*. IEEE Engineering Management Review, 3(27), pp. 116–123.
3. Chow, G.; Dubelaar; C.; Larson, P. D. (2000): *Relationships between inventory, sales and service in a retail chain store operation*. International journal of physical distribution and logistics management, 31(2), pp. 96-108.
4. Dumas, C. (2008): *Effective Inventory Management in Small and Medium-Sized Enterprises*. Potchefstroom: North-West University, PhD thesis.
5. Grladinović, T.; Benić, D.; Jelačić, D.; Motik, D. (2003): *A Dynamic System of Material Flows in Wood Industry Companies*. Strojarstvo, 45(1-3), pp. 65-73.

6. Hernaus, T. (2009): *Process-based Organization Design Model: Theoretical Review and Model Conceptualization*.
7. Kersan-Škabić, I. (2014): *Croatian wood industry – clusters, competitiveness and perspectives of development in the framework of European Union membership*. Poslovna izvrsnost, 7(2), pp. 55-77.
8. Klarić, K.; Greger, K.; Klarić, M.; Andrić, T.; Hitka, M.; Kropivšek, J. (2016): *An Exploratory Assessment of FSC Chain of Custody Certification Benefits in Croatian Wood Industry*. Drvna industrija, 67(3), pp. 241-249. doi:10.5552/drind.2016.1540
9. Loh, T. C.; Koh, S. C. L. (2004): *Critical elements for a successful enterprise resource planning implementation in small-and medium-sized enterprises*. International Journal of Production Research, 42(17), pp. 3433–3455.
10. Mabert, V. A.; Soni, A.; Venkataramanan, M. A. (2003): *The impact of organization size on enterprise resource planning (ERP) implementations in the US manufacturing sector*. Omega, (31), pp. 235 – 246.
11. Maditinos, D.; Chatzoudes, D.; Tsairidis, C. (2011): *Factors affecting ERP system implementation effectiveness*. Journal of Enterprise Information Management, 1(25), pp. 60-78.
12. Perić, I. (2015): *Assessment of Factors of Competitiveness in Furniture Manufacturing Companies*. Zagreb: University of Zagreb, Facutly of Forestry, PhD thesis.
13. Pertoni, A. (2002): *Critical factors of MRP implementation in small and medium-sized firms*. International Journal of Operations and Production Management, 22(3), pp. 329-348.
14. Pric Barčić, A.; Motik, D.; Oblak, L.; Vlosky, R. (2016): *Management Activity Linkages to Innovation Deconstruction: An Exploratory Study of the Furniture Industry in Croatia*. BioResources, 11(2), pp. 3987-4005.
15. Santin, K.; Santos Guimarães, S. L.; Marcelo Cardoso, B; Domingos, A. P. (2015): *MRP implementation on supply management process: a Brazilian furniture industry case study*. European Journal of Business and Social Sciences, 1(4), pp. 158-173.
16. Shatat, A. S. (2015): *Critical Success Factors in Enterprise Resource Planning (ERP) System Implementation: An Exploratory Study in Oman*. The Electronic Journal of Information Systems Evaluation, 1 (18), pp. 36-45.
17. Snider, B.; da Silveira, G. J.; Balakrishnan, J. (2009): *ERP implementation at SMEs: analysis of five Canadian case*. International Journal of Operations and Production Management, 29(1), pp. 4-29.
18. Zach, O. (2012): *ERP System Implementation in Small and Medium-Sized Enterprises*. Kristiansand: University of Agder, Faculty of Economics and Social Sciences, PhD thesis.

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# THE ECONOMIC PROFITABILITY OF POLISH FURNITURE MARKET AGAINST A BACKGROUND OF THE INDUSTRY SECTOR

Grzegorzewska E., Więckowska M.

## ABSTRACT

Running a business requires making sound economic decisions. It is more important in the conditions of market imbalances and economic downturn that are becoming more common both on the domestic and globally market. This was confirmed by the economic crisis, ongoing for few recent years. The crisis beggining and the key events connected with them occurred admittedly mostly in the US economy, but in a certain extent consequences were affected most countries in the world. Economic situation on foreign markets has particular importance for the economic profitability of export-oriented industries. To such industries in Poland include among others the furniture branch, which has demonstrated for years the highest positive trade balance.

In this article were analyzed the economic viability of the activities of enterprises operating on the furniture market. Empirical studies comprised selected economic indicators calculated for the furniture industry, i.e. the gross turnover profitability rate, the net turnover profitability rate, the return on assets, the return on total fixed assets, the return on total current assets and the indicator, which is particularly important from the point of view of business owners, i.e. the return on equity. Analyses for Polish furniture industry were carried out against the background of manufacturing and industry, to which the furniture branch is also included. The research time period was adopted for the years 2006-2014. As the primary source of research material were used reports published annually by the Central Statistical Office (GUS), i.e. " Balance financial results of economic entities".
**Key words:** furniture market, economic viability, industry, profitability

## 1. INTRODUCTION

The profitability of an enterprise is generally regarded as an important precondition for long-term firm survival and success [Yazdanfar 2013], and it is influenced by different financial assets and macroeconomic factors, structural conditions in the sector as well as individual technical and economic characteristics of individual enterprises [Gołaś 2016]. As Hansen claims [2010], better understanding of the current branch and market situation can lead to a better vision for future competitiveness. So each member of the sector can better implement its roles and responsibilities.

The business environment and sources of competitiveness in the furniture industry in Poland have changed notably since the 1990s, since the political transition exactly. In recent years, Poland moved up from 10th to 7th place in the world in terms of production volume of furniture. As data of Polish Chamber of Commerce of Furniture Manufacturers shows [2015], in this category Poland is overtaken only by China, the United States, Germany, Italy, India and Japan. In the world ranking of the value of exported furniture, Poland occupies the 4th place (9.74 billion USD). China dominates (60.08 billion USD), and then - Germany (13.62 billion USD) and Italy (11.68 billion USD). A significant increase in the production of furniture Poland recorded in 1997-2006 - an average of 11.5 % growth per year [Grzegorzewska and Stasiak-Betlejewska 2014]. Now the furniture branch plays an important role in Polish economy. It particularly applies to the furniture industry with 90% of its production heading abroad [Grzegorzewska, Więckowska 2016]. The Yazdanfar's studies [2013] has found that firm productivity is the strongest determinant of profitability. On the other hand, the growth of existing establishments rather than from new ones contributes to the growth of industry [Mäkinen et al. 2002, Arenius et al. 2005].

Due to the above, it is of great significance to keep a certain level of profitability for a longer period of time in companies that constitute the furniture sector in Poland. It has an even greater meaning as in times of ongoing globalisation of the world economy all markets are tightly bound. From that reason in this article were analyzed the economic viability of the activities of enterprises operating on the furniture

market in Poland. Profitability as a synthetic measure of the capacity to generate profit and financial success can be expressed in the form of various indicators showing different aspects of profitability [Gołaś 2016]. So the empirical studies comprised selected economic indicators calculated for the furniture industry.

## 2. OBJECTIVE AND RESEARCH METHODS

The aim of this study was to determine trends in terms of rentability of the furniture enterprises in Poland. The study covered the period 2006-2014. As the primary source of research material were used reports published annually by the Central Statistical Office (GUS), i.e. "Balance financial results of economic entities". The changes have been presented in contrast to industry and manufacturing (industrial processing) which comprises furniture sector enterprises. The research presents changes in the values of chosen ratios of profitability, that is: gross turnover profitability rate, net turnover profitability rate, return on assets, return on total fixed assets, return on total current assets and return on equity (table 1).

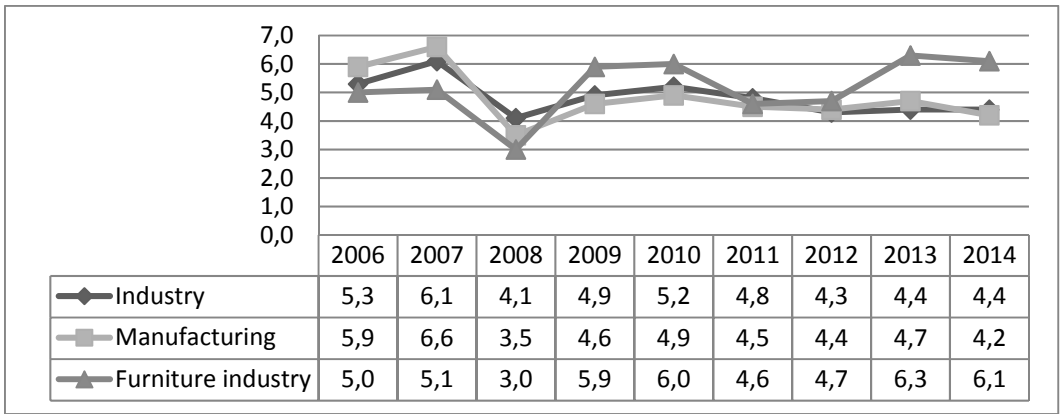
*Table 1. Profitability ratios covered by the study.*

| Specification | Numerator | Denominator |
|---|---|---|
| Gross turnover profitability rate | Gross financial result | Revenues from total activity |
| Net turnover profitability rate | Gross financial result | Revenues from total activity |
| Return on assets | Net financial result | Value of the assets |
| Return on total fixed assets | Net financial result | Value of the total fixed assets |
| Return on total current assets | Net financial result | Value of the total current assets |
| Return on equity | Net financial result | Value of the equity (fund) |

*Source: own studies on the background of the CSO's report entitled " Balance financial results of economic entities in 2014"*

## 3. RESULTS OF THE STUDIES

From the research conducted by the Central Statistical Office it follows that in the years 2006-2014 the gross turnover profitability rate in industry decreased from 5.3% to 4.4% (figure 1). A smaller fall in profitability in this field was noted in manufacturing (industrial processing). At the end of the analysed period the ratio amounted to 4.2% and was 1.7% lower than 8 years earlier.



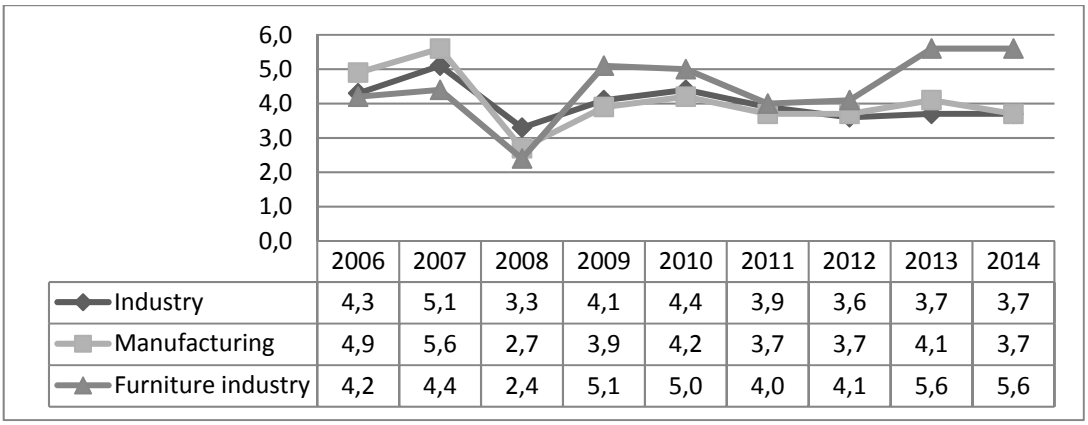

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 5,3 | 6,1 | 4,1 | 4,9 | 5,2 | 4,8 | 4,3 | 4,4 | 4,4 |
| Manufacturing | 5,9 | 6,6 | 3,5 | 4,6 | 4,9 | 4,5 | 4,4 | 4,7 | 4,2 |
| Furniture industry | 5,0 | 5,1 | 3,0 | 5,9 | 6,0 | 4,6 | 4,7 | 6,3 | 6,1 |

*Figure 1. Gross turnover profitability rate in the furniture industry against the background of manufacturing and industry Source: own studies on the background of the CSO's reports entitled " Balance financial results of economic entities" in the years 2006-2014*

In turn, in the furniture industry were seen different trends. In the analysed period there was an increase in gross turnover profitability – from 5.0% in 2004 to 6.1% in 2014. It should be emphasized

that in the years 2006 – 2008 this rate, reached by the furniture enterprises, was below the average for both manufacturing and industry. On the other hand, in 2009 – 2014 (except 2011) the furniture industry gained the gross turnover profitability rate higher.

As regards the relation between net financial result and revenues from total activity, in the years 2006 -2008 again the lowest results were observed in the manufacture of furniture (figure 2). In that period net turnover profitability of these companies significantly dropped, i.e. from 4.2% to 2.4%. However, since 2009 the furniture industry recorded a higher rate than the average achieved in the manufacturing and industry. The highest increase in net turnover profitability (from 4.1% to 5.6%) in the furniture branch was observed in 2013, and one year later this good result was maintained. At the end of the analysed period, industrial processing achieved the net turnover profitability rate at the level of 3.7%. The same result was obtained by the industrial enterprises. It should be emphasized, that while the furniture industry achieved much better results in this area than in 2006, the other analysed groups had a lower level of the net turnover profitability rate.

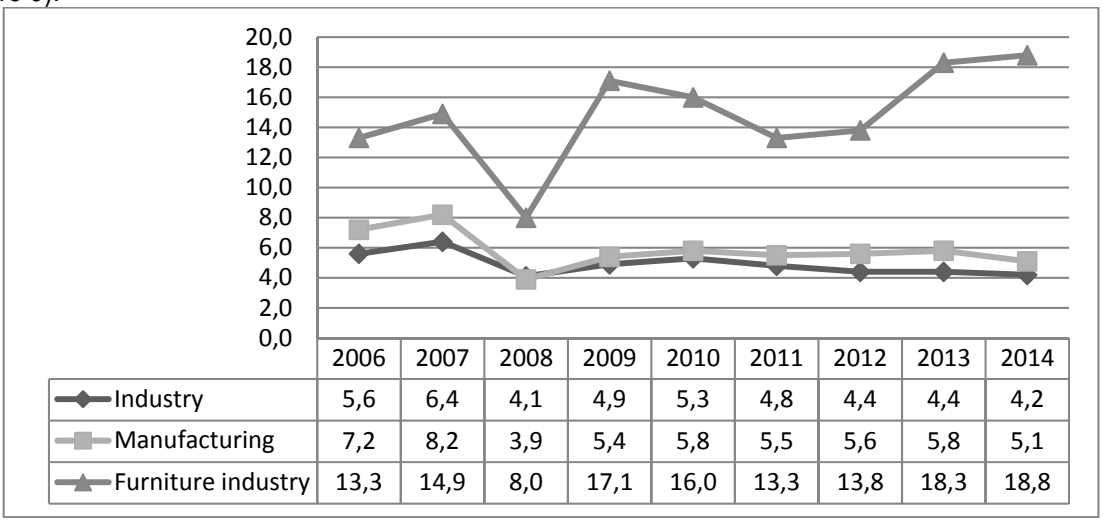



| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 4,3 | 5,1 | 3,3 | 4,1 | 4,4 | 3,9 | 3,6 | 3,7 | 3,7 |
| Manufacturing | 4,9 | 5,6 | 2,7 | 3,9 | 4,2 | 3,7 | 3,7 | 4,1 | 3,7 |
| Furniture industry | 4,2 | 4,4 | 2,4 | 5,1 | 5,0 | 4,0 | 4,1 | 5,6 | 5,6 |

*Figure 2. Net turnover profitability rate in the furniture industry against the background of manufacturing and industry.*

*Source: i.e. figure 1.*

In the analysed period there was a visible increase (from 13.3% in 2006 to 18.8% in 2014) in return on assets (ROA) in the furniture industry, well above the average of both manufacturing and industry (figure 3).




| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 5,6 | 6,4 | 4,1 | 4,9 | 5,3 | 4,8 | 4,4 | 4,4 | 4,2 |
| Manufacturing | 7,2 | 8,2 | 3,9 | 5,4 | 5,8 | 5,5 | 5,6 | 5,8 | 5,1 |
| Furniture industry | 13,3 | 14,9 | 8,0 | 17,1 | 16,0 | 13,3 | 13,8 | 18,3 | 18,8 |

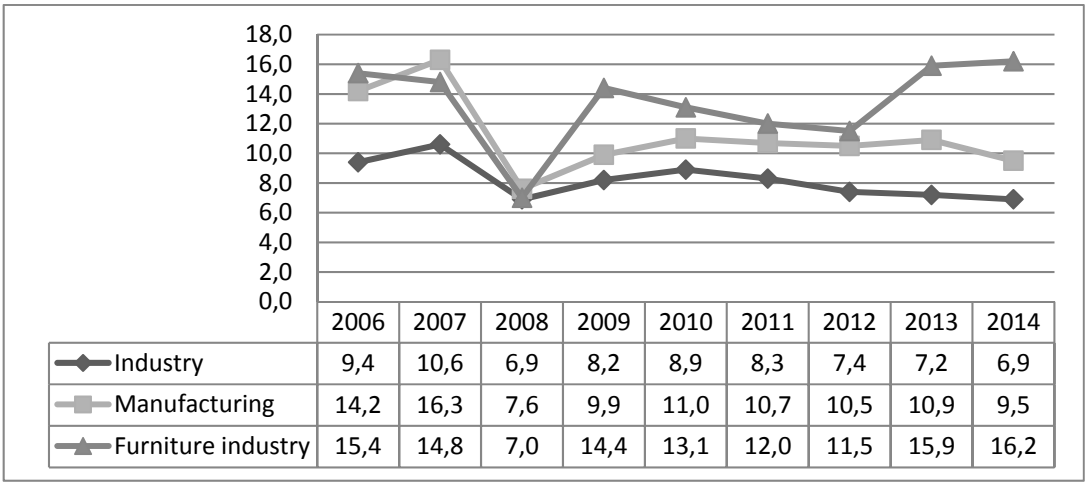
*Figure 3. Return on assets in the furniture industry against the background of manufacturing and industry*

*Source: i.e. figure 1.*

The key value of this indicator is that it takes into account the impact on the financial performance of the use of profitability property resources more widely than other viability ratios [Bednarski 2007]. In

literature, you can find a variety of views about the desired value of the ROA. For example, M. Nowak [1998] pointed out that its average value should oscillate between 5-8%. This means that in the analysed period (except 2007), enterprises included in manufacturing have achieved an average return on assets. On the other hand, industrial enterprises received weaker results. Since 2011, the ROA has not exceeded the 5% threshold. The furniture industry has achieved a much higher return on assets over the period under review, and in recent years it has grown from 13.3% to 18.8%.

In the years 2006-2008 there was a decrease in the profitability of fixed assets, i.e. assets with a reliably defined value that will be consumed or sold above a period of 12 months (figure 4). This situation was related to the furniture industry, industrial processing and industry. In subsequent years, the profitability of fixed assets of furniture companies increased significantly and at the end of the analysed period it reached 16.2%. In the same year, this ratio was 9.5% for manufacturing and 6.9% for the industrial enterprises.

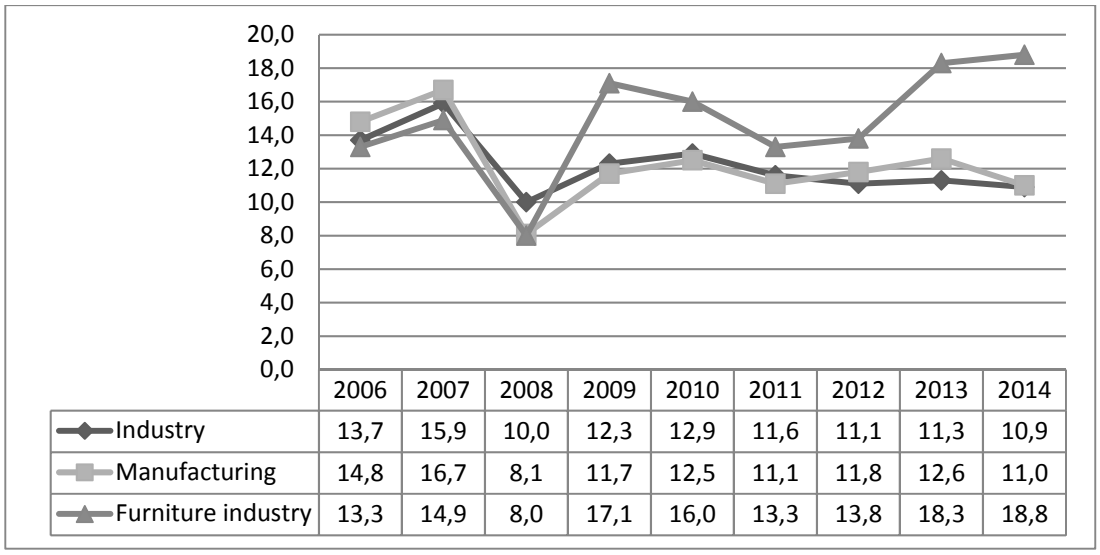



| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 9,4 | 10,6 | 6,9 | 8,2 | 8,9 | 8,3 | 7,4 | 7,2 | 6,9 |
| Manufacturing | 14,2 | 16,3 | 7,6 | 9,9 | 11,0 | 10,7 | 10,5 | 10,9 | 9,5 |
| Furniture industry | 15,4 | 14,8 | 7,0 | 14,4 | 13,1 | 12,0 | 11,5 | 15,9 | 16,2 |

*Figure 4. Return on total fixed assets in the furniture industry against the background of manufacturing and industry.*

*Source: i.e. figure 1.*

Similar trends were observed in the case of working assets, i.e. property resources of a reliably defined value. These resources are generated as a result of past events that will in the future affect the entity's economic benefits, and it is expected that these benefits will emerge for up to 1 year (figure 5). Starting from 2009, the highest values of this ratio were obtained by the furniture companies. At the end of the analysed period, the return on current assets stood at 18.8% and was significantly higher than in the case of industrial processing and industry (11.0% and 10.9%, respectively).

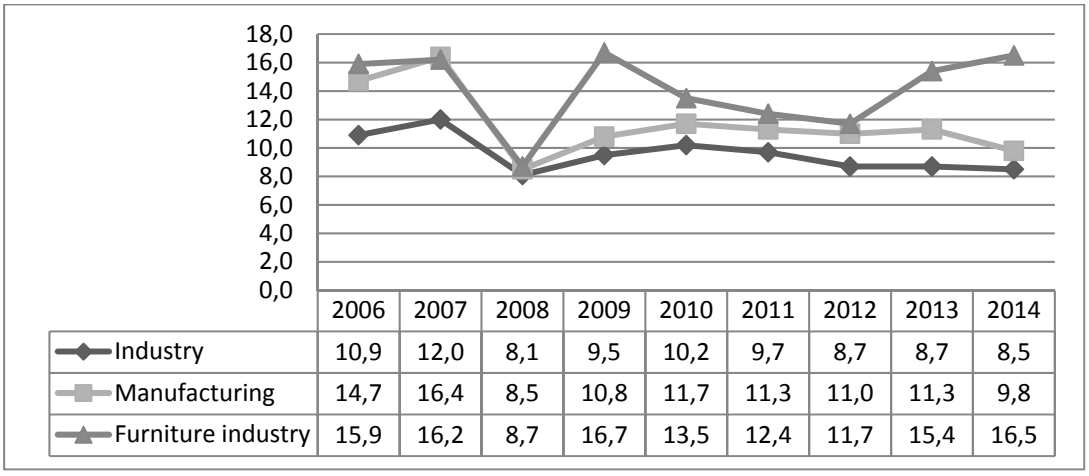



| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 13,7 | 15,9 | 10,0 | 12,3 | 12,9 | 11,6 | 11,1 | 11,3 | 10,9 |
| Manufacturing | 14,8 | 16,7 | 8,1 | 11,7 | 12,5 | 11,1 | 11,8 | 12,6 | 11,0 |
| Furniture industry | 13,3 | 14,9 | 8,0 | 17,1 | 16,0 | 13,3 | 13,8 | 18,3 | 18,8 |

*Figure 5. Return on current assets in the furniture industry against the background of manufacturing and industry*

*Source: own studies.*

The return on equity ratio (ROE) is particularly important because it allows to assess the financial performance of invested ownership capital. Business owners and external stakeholders are interested in the highest rate of return on capital employed. Research conducted by CSO shows, that in 2006 the highest return on equity (15.9%) was achieved by furniture companies (figure 6). Manufacturing and industry recorded a lower value of this ratio (14.7% and 10.9%, respectively). In all the distinguished business groups, there was a clear decline in the ROE in 2008. In the next years, the largest fluctuations in the return on equity were recorded by furniture companies. Since 2013 this ratio has grown in this group of companies and in the last two years of analysis it was 15.4% and 16.5%, respectively.




| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| Industry | 10,9 | 12,0 | 8,1 | 9,5 | 10,2 | 9,7 | 8,7 | 8,7 | 8,5 |
| Manufacturing | 14,7 | 16,4 | 8,5 | 10,8 | 11,7 | 11,3 | 11,0 | 11,3 | 9,8 |
| Furniture industry | 15,9 | 16,2 | 8,7 | 16,7 | 13,5 | 12,4 | 11,7 | 15,4 | 16,5 |

*Figure 6. Return on equity in the furniture industry against the background of manufacturing and industry*

*Source: i.e. figure 1.*

## 4. SUMMARY

The furniture branch plays an important role in Polish economy. It particularly applies to the furniture industry with 90% of its production heading abroad. Economic situation in foreign markets may then influence the level of profitability of Polish entrepreneurs operating in that branch.

From the analysis conducted by the Central Statistical Office it follows that the gross turnover profitability ratio decreased in both manufacturing and industry. In turn, in the furniture industry was seen the opposite trend. In the analysed period there was an 1.1% increase in gross turnover profitability. Similar tendencies were noted as regards net turnover profitability rates. Since 2009 the furniture industry recorded a higher rate (5.1%) than the average achieved in the manufacturing and industry. At the end of the analysed period, both industrial processing and industry achieved the net turnover profitability rate at the level of 3.7%, while the furniture industry achieved much better results, i.e. 5.6%. Additionally, in the analysed period there was a visible increase (from 13.3% in 2006 to 18.8% in 2014) in return on assets (ROA) in the furniture industry. On the other hand, enterprises included in manufacturing have achieved only an average (5.1%) return on assets, and ROA of industry since 2011 has not exceeded even that threshold. Similar trends were observed in the case of fixed assets. There is worth to note that since 2009 the profitability of fixed assets of furniture companies increased significantly and its level has been visibly higher than in manufacturing and industry. As results from the analysis, during the period under study return on assets, return on total fixed assets, return on total current assets in the furniture branch in Poland exhibited a rising tendency.

The last, but very important ratio, that was analyzed, is the return on equity ratio (ROE). In this case for furniture enterprises also was exhibited a positive, rising trend, while the trend of industry was even slightly decreasing, and in manufacturing was rather stable.

The conducted analysis showed, that furniture industry in Poland against the background of manufacturing and industry has good economic condition and in the near perspective its positive trend of profitability should be maintained.

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## REFERENCES

1. Arenius, P., Autio, E., Kovalainen, A. (2005): Finnish entrepreneurial activity in regional, national and global context. TEKES, Technology Review Miktor, Helsinki 176: 52
2. Bednarski L. (2007): Analiza finansowa w przedsiębiorstwie, PWE, Warsaw
3. Gołaś Z. (2016): The level and conditions of profitability of furniture manufacturing enterprises in Poland between 2005 and 2014. Intercathedra 32[3]: 7 – 14
4. Grzegorzewska E., Stasiak-Betlejewska R. (2014): The Influence of Global Crisis on Financial Liquidity and Changes in Corporate Debt of the Furniture Sector in Poland. Drvna Industrija 65[4]: 315-322; DOI:10.5552/drind.2014.1342
5. Grzegorzewska E., Więckowska M. (2016): The influence of export activity on innovativeness of Polish furniture market, The path forward for wood products: a global perspective - Proceedings of scientific papers, Baton Rouge, Louisiana, USA October 5th-8th 2016
6. Hansen E. (2010): The role of innovation in the forest products industry. Journal of Forestry 108[7]: 348 – 353
7. Mäkinen, P., Petäjistö, L., Selby, A., Elovirta, P. (2002): Success factors for forest and wood industry SMEs. In: P. Mäkinen (ed.), Success factors for forest and wood industry SMEs. Working Paper [869], The Finnish Forest Research Institute, Helsinki. p. 42-50
8. Nowak M. (1998): Praktyczna ocean kondycji finansowej przedsiębiorstwa. Metody i ograniczenia, Fundajca Rozwoju Rachunkowości w Polsce, Warsaw
9. Yazdanfar D. (2013): Profitability determinants among micro firms: evidence from Swedish data. International Journal of Managerial Finance 9[2]: 150 – 160; DOI 10.1108/17439131311307565
10. Central Statistical Office (GUS) (2007): Financial results of economic entities in 2006, Warsaw
11. Central Statistical Office (GUS) (2008): Financial results of economic entities in 2007, Warsaw

12. Central Statistical Office (GUS) (2009): Financial results of economic entities in 2008, Warsaw
13. Central Statistical Office (GUS) (2010): Financial results of economic entities in 2009, Warsaw
14. Central Statistical Office (GUS) (2011): Financial results of economic entities in 2010, Warsaw
15. Central Statistical Office (GUS) (2012): Financial results of economic entities in 2011, Warsaw
16. Central Statistical Office (GUS) (2013): Financial results of economic entities in 2012, Warsaw
17. Central Statistical Office (GUS) (2014): Financial results of economic entities in 2013, Warsaw
18. Central Statistical Office (GUS) (2015): Financial results of economic entities in 2014, Warsaw
19. Polish Chamber of Commerce of Furniture Manufacturers (OIGPM), B+R Studio (2015): Polish Furniture Outlook 2015

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# INNOVATIVE TECHNOLOGICAL PROCESSES IN WOOD BONDING AND POSSIBILITIES FOR REFINANCE THESE PROCESS INNOVATIONS IN COMPANY

Giertl, G.; Krajčírová, L.; Daxnerová, M.; Kožiak, R.

## ABSTRACT

Adhesives are in wood and furniture industry important auxiliary material that contributes greatly not only to the improvement of product quality, but at the same time adhesives are also the basis for the development of new wooden products. The benefits of using foamed adhesives have technological and economic aspects, which in the article we try to validate through the test of delamination of bonded joints according to the methodology of Institut für Fenstertechnik, IFT Rosenheim (Germany). In the article we try to describe the economics aspects of such modified process and we try to find the proposal for refinancing of initial investment associated with such process innovation from external sources.
**Key words**: wood bonding, adhesive, solid wood panels, calculation, costs

## 1. INTRODUCTION

Polyvinyl Acetate (abb. PVAc) adhesives have in the furniture industry an important role in last years. The reason for the growing demand for this type of adhesive is not only its ecological safety (no formaldehyde), but also his qualities and ability to form high quality adhesive bonds. As reported BUDAKCI (2010) in his study, which examined the PVAc dispersions in the manufacture of plywood, these adhesives exhibit the highest bonding strength in compared with urea formaldehyde adhesives (UF) and contact adhesives. PVAc adhesives have a 6% greater strength than UF adhesives and 40% greater bond strength than contact adhesives. In another study from KILIC (2006) is stated that when applying the PVAc adhesive the glued joints have improved strength of 45,50 % in compare with the contact adhesives.

RATNASINGAM - IORAS (2013) reported that PVAc adhesives have a higher tolerance to changes in the thickness of the coating of adhesive to the bonding joints, which makes precisely this type of adhesive more suitable for bonding of solid wood panels in the furniture industry.

SEDLIAČIK - ŠMIDRIAKOVÁ (2012) in its study emphasize, that in the process of wood bonding is important the amount of adhesive, which is applied on the bonded surface. There is a direct correlation between the amount of adhesive and the amount of water which is introduced into the adhesive joints. By the increasing of adhesive amount the water which is introduced into glued joints is also increased. This fact has a negative impact on the plane stability of glued panels, deterioration quality of glued surface and final bonded joints. During the bonding of wetter wooden panels can be achieved reducing the amount of water by several ways:

- *by the reducing of adhesive amount;*
- *by the adjustment of the adhesive (fulfillment, foaming...).*

The official manufacturing process of wood bonding recommends the volume of dispersion adhesives for solid wood panels bonding at the level 180 g/m$^2$. The foaming of dispersion adhesives gains a significant attention in last year in wood processing industry.

GIERTL (2015) a SEDLIAČIK et. al. (2015) in his studies point out, that the optimum rate of dispersion adhesives foaming is 30%. In other studies SEDLIAČIK et al. (2014) describes, that the advantages of foamed PVAc adhesives applications are significant not only in the technological but also in the economic field of research. With foamed adhesives which is used for wood bonding is reduced the supply of water to the glue joints.

In the same weight of the foamed and non-foamed adhesive, used in wood bonding, is the coating thickness of foamed adhesive to glue joints higher. Such technology of wood bonding creates

prerequisites for the reducing the quantity of adhesive application and brings a positive economic impact in the process of wood bonding in the form of savings of direct production costs.

The quality of wood bonding must be tested through the regulated tests designed for adhesive bond strength in any case. There are several quality tests for bonding strength. In our research we apply IFT Standard for massive and laminated glued wood profiles, which is used by accredited test centers in Austria, Germany and Switzerland.

## 2. MATERIAL AND METHODS

Methodoloy of quality test adhesive bond strength, specified in the IFT Standard, was applied to 5 test files, in 2 independent measurements (measurement A, measurement B). Five following test files was prepared (for 2 measurements), that have been glued/bonded together with PVAc adhesive, type RAKOLL® 4340:

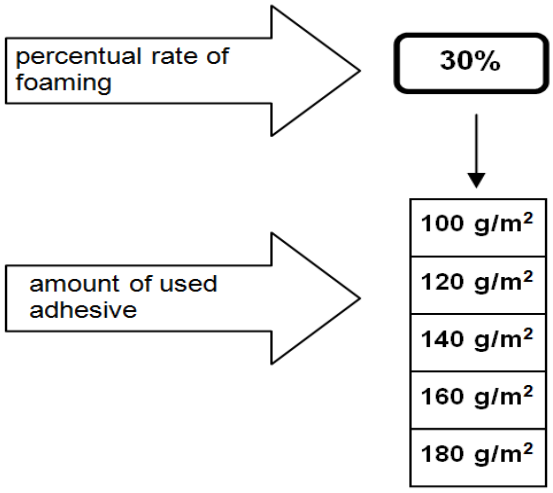


*Figure 1. Scheme of prepared test files for measurments by IFT Standard*

There were 5 test files depending of the amount of adhesive coating (100 g/m$^2$ – 180 g/m$^2$). From each tests file, respectively from glued spruce solid panels, 5 cm test specimens were made, which were marked by numbers 1-9 as is shown in following Figure:

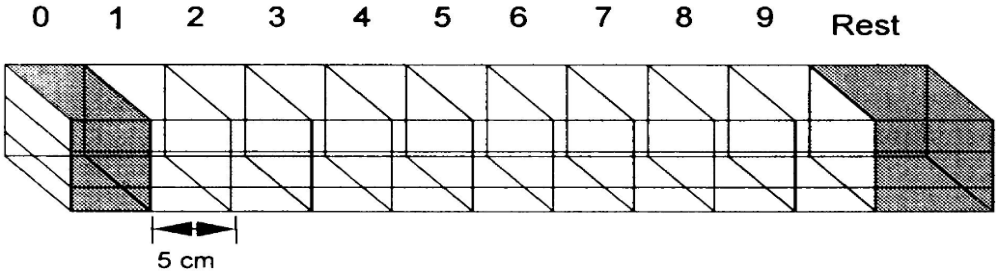


*Figure 2. Scheme of the specimens preparation from tests files (spruce solid wood panels)*
*Source: IFT Standard, 2001*

By this way, 9 test specimens from each of the 5 tests panel/files, mentioned above (100 g/m$^2$, 120 g/m$^2$, 140 g/m$^2$, 160 g/m$^2$ and 180 g/m$^2$), were prepared. The end sides from the each tests panel, have been excluded as is illustrated in the Figure 2. Thus prepared test specimens, within the instructions of IFT Standard, were soaked in water for 24 hours and 72 hours were air conditioned. After conditioning were specimens subjected to mechanical tests of bonding strength by using a Chisel test (Figure 3).

The main purpose of such chisel test is the delamination of glued joint and following visual inspection and evaluation of bond line violations. For a better estimation and exact interpretation of bond line violations, mechanically damaged adhesive joints by Potassium iodide was coated. The following Figure 3 shows the chisel test which is aimed at detecting strength of the adhesive joints, as is required by the IFT Standard:

*Figure 3: Illustration of Chisel test*

After mechanically damage of adhesive joint by the chisel test and after the application of potassium iodide to mechanically defective surface of the joint, the percentage of the adhesive bond of the infringement of the wood to the nearest 5% is estimated. The quality requirements, by IFT Standard, are met when the adhesive joint breach in the wood in more than 95% of the total surface. Quality requirements are met when the adhesive on all joints has no open gaps. In tested panel (file) may be a total of the surface of open joints up to 5% on average of the total bonded area from all specimens in test file. The permissible surface of open glued joints on 1 test specimen from the test file is max. 10%. The test was carried out on 5 test files (Figure 1), independent in 2 different times - (measurement A, measurement B), from each test file was made 9 specimens.

## 3. RESULTS AND DISCUSION

The quality test of the adhesive bond consisted from evaluating the strength of bonded joints in 2 measurement "A" and "B" in 5 test files with different volumes of adhesives coating. In terms of methodology by IFT Standard, after the conditioning, the test files, which were divided to the specimens 1- 9 (Figure 2), were tested by chisel test (Figure 3). The results of the measurements (A and B) were analyzed for each of 5 test files. Results were entered into the tables and there were calculated average percentage of bond line violations. The results of measured bond strength were then also analyzed and described by descriptive statistics tools:

*Table 1. Evaluation for bonding strength of adhesive joints according to Standard IFT*

| Volume of used adhesive ($g/m^2$) | Number of specimens (n) | Mean value ($\bar{x}$) | Variance (r) | Standard deviation (s) | Variation coefficient (v) |
|---|---|---|---|---|---|
| 100 | 18 | 18,13 | 685,30 | 26,18 | 144 % |
| 120 | 18 | 8,61 | 57,14 | 7,56 | 76 % |
| 140 | 18 | 4,375 | 10,27 | 3,20 | 73 % |
| 160 | 18 | 5 | 14,29 | 3,78 | 76 % |
| 180 | 18 | 2,5 | 7,14 | 2,67 | 107 % |

Based on the above results in Table 1, we can state with respecting the terms of the IFT Standard requirements, follows:

*Table 2. Analysis of results*

| Volume of used adhesive ($g/m^2$) | The average value adhesive bonding breaches ($\bar{x}$) | Violation of any adhesive joint from the tests files (max. 10 %) | Compliance with the conditions of IFT Standard |
|---|---|---|---|
| 100 | 18,13 | YES | NO |
| 120 | 8,61 | YES | NO |
| 140 | 4,375 | NO | YES |
| 160 | 5 | NO | YES |
| 180 | 2,5 | NO | YES |

At the volume of used adhesive of 120 $g/m^2$ tested file of specimens does not meets the criteria to the bonding quality, following IFT Standard (at the measurement A, and B too). The average violation of adhesive bond is indeed at the limit of 8,61% of the total bonding surface, but 3 test specimens had a higher percentage of violations in the adhesive bond (one of them 25%).

Based on the above results and findings we can expect, in our analysis of test files, that the optimal volume of 30% foamed adhesive RAKOLL® 4340, when the adhesive bond achieved the quality requirements of IFT Standard is at a loading (volume) of 140 $g/m^2$, respectively in the interval <120 $g/m^2$ ; 140 $g/m^2$). The adhesive application at volume 140 $g/m^2$ means savings of used adhesive of 40 $g/m^2$, what is a significant saving compared with the constant application at volume 180 $g/m^2$ at the level of 22.22%.

SEDLIAČIK et. al. (2014) in his research report, that technology of adhesive foaming can reduce the amount used of adhesive from the conventional volume (180 $g/m^2$) which is recommended in the solid wood panels bonding to the adhesive coating (volume) of 125 $g/m^2$, while maintaining the required quality of the adhesive bond. GIERTL (2015) in his research indicates that the optimum volume of PVAc adhesive (water resistance D3) used for spruce solid wood panels bonding, which was foamed at 30% of its volume, is at the level 142,15 $g/m^2$. In his research used methodology and the evaluation of measurements according to European Standard 13354:2009.

Longitudinally bonded glued wood panels with thickness of wooden slats of 40 mm were used in our research. This type of product belongs to the solid wood panels with high demand. For production of 1 $m^3$ of such product approximately 8,50 kilograms of PVAc adhesive was used. Based on the above findings following calculation can be done. Presentation of direct cost savings for adhesive consumption for the production of 1$m^3$ such type of solid wood panel is interpreted in the following Table 3:

*Table 3. Calculation of costs savings*

| ADHESIVE TYPE | ADHESIVE CONSUMPTION | ADHESIVE PRICE | TOTAL COSTS |
|---|---|---|---|
| PVAc dispersion (not capable of foaming) | 8,50 $kg/m^3$ | 1,30 EUR/kg | 11,05 $EUR/m^3$ |
| PVAC dispersion foamed - Rakoll® 4340 | 6,61 $kg/m^3$* | 1,30 EUR/kg | 8,59 $EUR/m^3$ |
| Direct costs saving (cots for adhesive) | 2,46 $EUR/m^3$ | | |

*reflected savings of used adhesive at 22,22%

For technological process of adhesive foaming is required procurement the special technological equipment that is capable foam the adhesive by air of the required percentage of the volume. The cost of such technology equipment, including costs related for the acquisition, transportation, installation and training ranges, are around € 50 000,-. This initial investment, which is associated with innovation process, can be financed from external sources. In the programming period 2014-2020 it is possible in the Slovak Republic to obtain financial support from the European Structural and Investment Funds (ESIF) within the framework of the Operational program of Research and Innovation.

Depending on the character of the technological equipment which is capable of foaming adhesive with air and in accordance with sector brake-down by SK NACE the output is directed to the furniture manufacturing sector, it is possible to obtain financial support in calls of above mentioned operational program aimed at specific object 3.1.1 Increase of new, competitive SME´s and 3.3.1 Increase of competitiveness MSP in the phase of development. The basic parameters of the decision-making process of seeking external sources of ESIF is the price of the technology, the support intensity provided in the appeal, the minimum and maximum contribution of ESIF and also the location of the project realization. The provision of subsidies is implemented through the non-repayable grant.

Non-repayable grant may not exceed 60% of eligible expenditure with the following exception: the support intensity will be increased by 15 percentage points up to 75% of eligible expenditure for projects to be implemented in less developed districts. The cost of process equipment, including costs related to the acquisition, transportation, installation and training ranges around € 50 000,-.

Direct costs saving of the adhesive is 2.46 EUR/$m^3$. To ensure the return of investment, which would be financed from its own resources the company would need to produce about 20 325 $m^3$ glued solid wood panels. At the equipment value of € 50 000,- could company/applicant obtain a contribution of up to € 30 000,-. The remaining € 20 000,- would be financed by own company funds or loan funds. To ensure return of investment, which would be financed in such a ratio of ESIF and resources of the applicant would need to produce about 8 130.00 $m^3$ glued panels of solid wood. The financial savings that the company can obtain is directly proportional to the time savings, in which investment can be repaid. In the case of realization of the project in less developed districts of Slovakia, applicant could obtain a contribution of up to € 37 500,-. To ensure return of investment, which would be financed in such a ratio of ESIF and resources of the applicant would be required to produce only around 5 081,30 $m^3$ glued solid wood panels.

*Table 4. Summary of results in promoting the purchase of technology from ESIF*

| Location of the realization | The support intensity (in %) | The maximum non-repayable grant (in EUR) | The own resources necessary (in EUR) | The required output of glued panels for the repayment of the own resources (in $m^3$) |
|---|---|---|---|---|
| Slovak territory outside the Bratislava region | 60 | 30 000,00 | 20 000,00 | 8 130,00 |
| Less developed counties of SR - selected districts under Act no. 336/2015 | 75 | 37 500, 00 | 22 500,00 | 5 081,30 |

In the ideal case it would be possible to get the support of 75%, which would mean, that the repayment of the remaining part of the investment financed from company's own resources would be sufficient only 25% of the initial time compared with the implementation of the project with the support of non-repayable grant. If this was a company existing for more than three years it would be possible to implement the project of acquisition of such technological equipment within the specific aim appeal of Increasing the competitiveness of SME´s in the development phase but to meet the conditions of min. amount of support € 50 000,-, it would be required to purchase at least two pieces of such equipment to

make the project eligible for support, or to obtain other technological equipment necessary for an innovative process of wood bonding.

## 4. CONCLUSION

In general, we can summarize the advantages of using foamed dispersion PVAc adhesives during bonding process to the following - the most important points, from the technological and economic view:

- *better wetting of the adherend surface* - due to a better and more evenly application of adhesive;
- *weaker, respectively slower penetration of water from the adhesive to the wooden cells* - due to lower adhesive volume. This situation causes better flat stability of the glued wooden panels and during the bonding process the quality of the surface at the interface wood – adhesive is increased;
- *cost savings* - reducing of direct material by the reduction of the amount (volume) of used adhesive, which is applied to the glued joints. Direct cost savings has positive impact to the reduction of indirect cost also (lower volumes of adhesives - reduced costs for transport, storage, manipulation…).

Active support from ESIF aims to support the improvement of quality and efficiency of production and technological processes by raising the level of technology and innovation in manufacturing factories. Creating a stable environment conducive to innovation for all relevant subjects and support to increase the efficiency of innovation as an essential pillar to boost competitiveness, sustainable economic growth and employment is a priority within the Operational Program Research and Innovation. The result of the support project must be: inovvation of product, process or organizational innovation.

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## REFERENCES

1. Budakci, M. (2010). The Determination of Adhesion Strength of Wood Veneer and Synthetic Resin Panel Adhesives. In : *Wood Research.* 2010, Vol. 55 (2), 125 – 139 p., 2007. ISSN 1336 – 4561.
2. Giertl, G. (2015). Vybrané faktory procesu lepenia pri výrobe dosiek z rastlého dreva a jeho ekonomická podstata. Technical University in Zvolen: Dissertation thesis. 2015. 138 pp.
3. Kilic, I. (2006). *Determining the adhesion strength of veneer on some wood-based boards.* M.Sc. Thesis. Ankara: Gazi University Institute of Sciences. 2006. 71 pp.
4. Ratnasingam, J.; Ioras, F. (2013). Effect of adhesive type and glue-line thickness on the fatigue strength of mortise and tenon furniture joints. In: *European Journal of Wood and Wood Products (2013).* 819-821 p. VOLUME 72. ISSN 1436-736X
5. Sedliačik, J.; Šmidriaková, M. (2012). Heat Resistance of Adhesive Joints for Wood Constructions. In: *Acta Facultatis Xylologiae Zvolen.* vol. 54 (2): 2012. 79-94 p. ISSN 1336-3824.
6. Sedliačik, J.; Schmidtová, J.; Šmidriaková, M. (2014). Foaming of polyvinylacetate adhesives – improved technologic parameters for a solid wood gluing process. In: *Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology No. 87.* 2014. s. 224 – 228. ISSN 1989 – 5912.
7. IFT. 2001. Richtline. Massive, keilgezinkte und lamellierte Profile f*ür Holzfenster. Anforderungen und Prüfung*. Rosenheim: Institut für Fenstertechnik, 2001.

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# THE APPLICATION OF CLUSTERS AS PART OF REGIONAL AND SECTORAL INDUSTRIAL POLICY

# THE EXAMPLE OF THE TIMBER CLUSTER IN THE KHANTY-MANSIYSK AUTONOMOUS REGION OF UGRA

Damary R.; Pryadilina N.; Starikov E.

**ABSTRACT**

The Russian forestry industry does not lend itself easily to the creation of economic structures. Yet this industrial sector is key to the economic development of number of regions. Often there is practically no alternative to forestry and timber processing for the economic development of many municipalities, remote settlements, towns and villages, and it is their only source of employment. Moreover, the timber industry can play a significant role as a starting point in the diversification of the regional economies with dominant economic activities, such the Khanty-Mansiysk Autonomous Region of Ugra. In the light of the relevance and importance of increasing the effectiveness of the industrial policy as a whole, and with focus on the timber industry in particular, the authors have analysed the prevailing prerequisites for the establishment of a timber industry cluster in the Region studied. The authors review the operation in the region of its industrial policy tools aimed at the creation and development of a cluster in the timber sector. They reach conclusions about the expected positive economic effects.
**Keywords:** industrial policy, cluster approach, timber cluster, State support, competitiveness, Khanty-Mansiysk Autonomous Region of Ugra.

## 1. INTRODUCTION

Industry is the structural basis of the economy of developed countries. One of the most important economic functions of government in a market economy is to ensure overall industrial competitiveness and growth, as well as for its individual branches and sectors. The main tool for this function is, traditionally, the establishment and implementation of government industrial policy at both sectoral and regional level [1].

At the Russian state level today industrial policy is defined in documentary form as a series of sectoral economic policies making up "a complex of legal, economic, organisational and other measures aimed at the development of the Russian Federation's industrial potential, and ensuring the production of competitive industrial products" [2].

Many studies by both domestic and foreign researchers and practitioners have been conducted on the development of industrial policies and their implementation [3, 4, 5, 6, 7]. A number of Russian researchers have recognised that one of the most successful mechanisms leading to industrial policy is the cluster approach [8, 9, 10].

Global experience quite clearly shows the effectiveness for the emergence of clusters and the conditions required. In the last decade, encouraging the formation of clusters in various forms and spheres of activity has become an important part of the governmental economic and industrial policies in many countries, including Russia. [11]

Cluster initiatives have proven a most successful method and tool to enhance competitiveness, as they encourage effective industrial and economic ties amongst the actors of the regional economy. The incorporation of clusters into the institutional environment, allows business and the authorities to seek ways to promote joint initiatives more effectively, including laws and regulations, as well as to lobby for regional and sectoral projects based on public-private partnerships.

Another significant advantage of clusters is the ability to facilitate outsourcing. This widespread practice lets larger companies focus on their main activities, transferring to small and medium-sized enterprises the production of intermediate products, and the provision of various services. Clusters have therefore a major influence on the development of small and medium-sized enterprises, and consequently on the creation of employment.

In view of the effectiveness of the cluster approach for the implementation of industrial policy in social and economic development, the Government of the Russian Federation has ordered the creation of competitive regional clusters as advanced development zones by 2020. In its turn, the Government of the Khanty-Mansiysk Autonomous Region of Ugra ("Khanty-Ugra") has established, and is constantly improving, conditions for business development and investment in projects to modernise industrial enterprises. Their actions include the development of regional sectoral clusters [12].

## 2. CHARACTERISTICS OF THE REGION STUDIED

It would be a mistake to see Forestry as the main specialisation of the economy of Khanty-Ugra. Nevertheless, the sector plays an important role in ensuring the diversification of the regional economy. The Autonomous Region is among Russia's top five regions endowed with forest resources. According to the State Forest Register, as of 01.01.2016, the area of forest land of the Autonomous Region amounted to 49.36 million hectares, of which 46.59 million hectares were productive forests. Timber reserves amounted to 3.15 billion $m^3$, and the total average growth of wood was 30.0 million $m^3$ per year. This allows an annual cut of 39.6 million $m^3$, of which 20.1 million $m^3$ are coniferous. The timber sector in Khanty-Ugra processed 2.3 million $m^3$ of timber in 2014.

The forestry industry in the Region is made up of over 130 enterprises and individual entrepreneurs, of which ten may be counted as large or medium operations. The largest is amongst the ten largest Russian forestry companies: JSC "Ugra Timber Holding" (Khanty-Mansiysk) (hereinafter "UTH").

The bulk of the production capacity of the forestry complex in the region is concentrated in the western part of the Autonomous Region in the districts called Soviet, Cohn-Dinskoy and Oktyabrsky. The timber industry now represents about 1.7% of the entire manufacturing sector of Khanty-Ugra. The sector has more than 7,500 employees. Moreover the districts devoted to timber processing are the social core around which depend not only economic issues, but also social, environmental, municipal and other matters.

Today in Khanty-Ugra there are three industrial complexes for the production of panels and biofuels, which make use of waste and low-grade wood:

- OOO "MDF plant" (village Mortka, Kondinsky Region.)
- JSC "Yugra-Plate" (in the district of Soviet)
- LLC "Surgutmebel" (Barsovo village, Surgut district).

The total volume of low-grade timber and sawmill waste processed by these enterprises amounts to more than 500 thousand $m^3$ per year.

Wooden prefabricated houses are manufactured in the Khanty-Ugra by the following four companies:

- JSC "Ugra Timber Holding" (JSC "LVL - Ugra", Nyagan);
- LLC "Surgutmebel" (Barsovo, Surgut District.);
- LLC "MPAS Stoi" (Beloyarsky);
- «Partner Group", OP "Plant for frame-panel construction", (Khanty-Mansiysk).

In 2015, the volume of production of wooden houses by timber plants in Khanty-Ugra amounted to only 8,900 $m^2$, which is 3 times less than in 2010, even though the total daily production capacity amounts to 120,000 $m^2$.

The development of the major indicators of the timber industry in Khanty-Ugra for the period 2010-2015 is given in Table 1.

*Table 1. The development of the major indicators of the timber industry in Khanty-Ugra for the period 2010-2015.*

| Indicator | Units | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Timber Processed | | | | | | | |
| Untreated wood | '000 $m^3$ | 1 497.5 | 1 413.8 | 1 366.5 | 1522.6 | 1 205.9 | – |
| Processed Wood | | | | | | | |
| Sawn wood | '000 $m^3$ | 315.5 | 298.3 | 280.5 | 298.0 | 279.4 | 268.0 |
| Sawn wood exports | '000 $m^3$ | 158.5 | 150.8 | 161.6 | 185.8 | 178.3 | – |
| Window units | '000 $m^2$ | 19.09 | 15.2 | 12.4 | 27.5 | 10.08 | – |
| Door units | '000 $m^2$ | 32.1 | 24.3 | 34.4 | 27.5 | 23.52 | – |
| Pellets | '000 t | 7.0 | 11.8 | 11.8 | 14.8 | 23.1 | 20.4 |
| Technological chips | '000 $m^3$ | - | 148.5 | 151.2 | 148.2 | 154.5 | 163.8 |
| Chipboard panels | '000 $m^3$ | 22.9 | 19.4 | 30.6 | 39.9 | 50.8 | 40.8 |
| Particleboard including laminates | '000 $m^3$ | 2.6 | 101.1 | 15.8 | 88.6 | 156.75 | 177.1 |
| Laminated veneer lumber | '000 $m^3$ | 7.0 | 4.3 | 3.2 | 4.1 | 2.0 | 7.2 |
| Soft plywood | '000 $m^3$ | - | 4.0 | 10.9 | 16.1 | 17.2 | 7.6 |
| Wooden houses | '000 units | 26.8 | 25.8 | 24.4 | 20.1 | 7.8 | 8.9 |

** Source: Department of Natural Resources and Manufacturing Sector of the Economy of Khanty-Ugra.*

## 3. RESEARCH FINDINGS AND DISCUSSION

The data in Table 1 show some positive trends in the development of the region's timber industry in recent years. In particular, there has been steady growth in products requiring a high degree of processing - pellets and panels (chip and particle board, soft plywood). Furthermore, a new sub-sector is emerging in the form of bioenergy, which creates huge demand for wood waste and low-grade wood. This opportunity is being taken up especially in the Soviet and Oktyabrsky districts of Khanty-Ugra.

In the light of existing capacities and prevailing trends in the sector's development in Khanty-Ugra, the authors have formulated a number of objective conditions for the formation of a forest industry cluster. They are as follows:

1. *Sufficient forest resources for the development of a variety of timber-based industries, including high-level processing of raw materials*. Existing forest resources must not only meet local demand for wood and its products, but also allow for sales outside the region.

2. *The presence of large timber processing enterprises, which can serve as building blocks of a timber industry cluster, along with a range of small and medium enterprises engaged in logging and wood processing.*

According to the Department of Natural Resources and Manufacturing Sector of the Economy of Khanty-Ugra, timber-based activities in the autonomous region accounted for more than 120 enterprises: small and medium-sized businesses and individual entrepreneurs.

3. *The presence of enterprises producing products from low-grade wood.*

In this regard one of the measures aimed at increasing the use of low-grade wood is the construction and conversion of municipal boilers to the use of biofuels and wood chips in the districts of Surgut, Soviet and Kondinsk.

4. *The presence of enterprises producing wooden prefabricated houses.*

In the Region there are large reserves of production and technology for large-scale development of wooden housing construction.

5. *The presence of scientific and educational institutions* which can provide training and support for investment projects on modernization and the introduction of new technologies in wood processing enterprises and forestry institutions.

For example, in 2014 the "Ural State Forest Engineering University" (Ekaterinburg) created the Innovation Centre for the development of the Forestry-Industrial Complex of the Khanty-Mansiysk Autonomous Region of Ugra. Building on the work of two innovation centres "RAS - Ugra" and "Technopolis Ugra", a number of research institutions and five universities are engaged in research and educational activities in the Khanty-Ugra, not least through the creation of a Scientific and Innovation Complex with the support of the Khanty-Ugra Scientific Council,

*6. A sufficiently favourable investment climate*

On 31.03.2012 to improve the attractiveness of its investment environment, the Region adopted Law № 33-OZ "On State Support of Investment Activity in Khanty-Mansiysk Autonomous Region - Ugra." Accordingly the Government of the autonomous region formed a Council for the development of investment activity. The Investment Fund of Khanty-Ugra was set up, one of the aims of which is to call upon public funds to create the transport infrastructure necessary for the implementation of investment projects. An investment declaration for Ugra was duly adopted.

A wide range of mechanisms of state support of investment activity were introduced, notably of government guarantees, special tax regimes, subsidies for reimbursement of costs for the construction of utilities and engineering infrastructure facilities and covering interest costs on borrowed funds. A list of priority investment projects, was established with a view to applying tax breaks. The list included the project of JSC "Ugra - Panel" to expand the production of particle board and chipboard.

7. *Availability of investment sites, and an adequate infrastructure provided by the authorities.*

According to the investment map of Khanty-Ugra, the territory of the autonomous region currently has 352 investment sites with provisions for infrastructure.

8. *The existence of an appropriate state programme*. For Khanty-Ugra is found in the official document "The Development of the Forestry and Timber Industry of Khanty-Mansiysk Autonomous Region - Ugra for 2014-2020" [13].

This programme concerns activities encouraging integrated sustainable development and improving the economic efficiency of the organisations of the forestry complex. In addition to the variety of measures of state support for the development of the forestry sector, the programme covers forest management and fire fighting measures, offering various subsidies from the Autonomous Region budget for industrial and investment activities. Thus, the framework of the state programme already provides the legal and regulatory support mechanism for the creation of a timber cluster in Khanty-Ugra.

9. *The establishment of a legal structure for the cluster.* In 2013 a not-for-profit partnership was registered under the name "The Timber Industry Cluster of Khanty-Mansiysk Autonomous Region of Ugra." This could be the institutional basis for the formation of a regional timber Cluster in Khanty-Ugra. The founders of the partnership are AU Khanty-Ugra "High Technology Park" and "Fund of the Khanty-Mansiysk Autonomous Region - Ugra."

In general, the establishment and development of forest industry clusters in the Russian regions is a topic well studied. The research includes how the structural characteristics of regional economies determine whether and how clusters can be created. The experience in our country of research and practice on the formation and development of the forest industry clusters points to the conclusion that their creation reverses negative trends, stimulates economic growth of forest industries and individual

businesses, improves the investment environment and generally leads to more attractive conditions for increasing the efficiency of forestry business [14,15,16].

The investment projects of participants are key for the development of cluster structures. An important mechanism for the implementation of such projects can be state-municipal-private partnership involving financial resources within the framework of the activities of state and municipal development programmes. [17]

Today, in Khanty-Ugra, a number of regional state programmes provide a whole set of instruments for industrial policy, all sufficiently effective and aimed at encouraging the investment activity of business entities, including targets for the organisation of timber industry participation in cluster initiatives.

Key among them are the following:

1) *The State Programme Khanty-Ugra "The Development of the Forestry and Timber industry of Khanty-Mansiysk Autonomous Region of Ugra for 2014-2020".*

This provides for the granting of subsidies from the budget of the Autonomous Region:

- Small businesses (including micro-enterprises) in the field of timber processing are eligible for reimbursement of expenses for the development of material and the technical base. They can be compensated for up to 50% of the cost of work completed on the development of engineering infrastructure, construction, purchase and modernization of timber preparation and processing;
- Investors can be reimbursed of the cost of interest on funds borrowed for implementation of investment projects in the timber industry complex of the autonomous region;
- Investors can be reimbursed of leasing costs for technological equipment used in harvesting, hauling and processing of wood, and the manufacture of wood products linked the development of the Autonomous Region's timber industry;
- Enterprises in the production of sawn softwood with moisture content up to 22% (according to GOST 26002-83) for export benefit from actions to reduce the financial burden of high transport costs due to the remoteness from the major export markets of the autonomous region's exporting companies );
- Enterprises active in the production and sales of Fibreboard (MDF), plywood and LVL timber may be supported;
- Enterprises may be reimbursed for the cost of interest on loans obtained from Russian credit institutions for working capital used for pre-season stocks of wood, fuel and raw materials;
- Firms active in the production and sale of biofuels (pellets, briquettes) may be supported;
- Enterprises for the production and sale of ready-made objects for wooden housing construction expressed per 1 $m^2$ total area of the finished housing are eligible for subsidy
- State Employer Programme: Department of Natural Resources and the Manufacturing Sector of Khanty-Ugra.

2) The State Programme Khanty-Ugra "The Social and Economic Development, Investment and Innovation in the Khanty-Mansiysk Autonomous Region of Ugra for 2014-2020" .

This provides for the expenditure in the budget of the Autonomous Region:

- Subsidies for investment projects in the sphere of consumer markets;
- Grants to small start-ups, including participants of innovative regional clusters;
- Subsidies to small and medium-sized enterprises, including the participants in innovative regional clusters, for the reimbursement of costs or lost income due to production and sale of specific goods, works or services;
- Grants for the creation and/or development of private industrial parks.
- State Employer Programme: Department of Khanty-Ugra Economic Development.

In addition, entrepreneurship in Khanty-Ugra has state support from the Support Fund of Entrepreneurship and the Khanty-Ugra "High Technologies Technopark".

## 4. CONCLUSION

This study of the prerequisites for creating a timber cluster in Khanty-Ugra shows that the existing instruments of regional industrial policy are well suited to its creation and development. In view of domestic experience in the implementation of clusters, it can predicted that further expansion of the forestry complex in the autonomous region on the basis of the cluster model will encourage the development of the infrastructure necessary for better use of forest resources, including energy facilities, roads, timber depots and service centres for equipment.

The impact of creating clusters will be to upgrade existing jobs and to create new jobs, thereby providing an increase in the revenues for local and regional budgets. This will have a generally positive impact on the quality of life in Khanty-Ugra, especially in districts where the enterprises of the timber industry are located.

## REFERENCES

1. Aiginger K. Industrial Policy: A Dying Breed or a Re-Emerging Phoenix // Journal of Industry Competition and Trade. 2007. № 7.
2. Allabyan M.G. The mechanism of development and implementation of industrial policy. FES: Finance. Economy. Strategy. 2012. №12. p. 22-28.
3. Dosi G., Llerena P., Labini M.S. Evaluating and Comparing the innovation performance of the United States and the European Union/Expert report prepared for the Trend Chart Policy Workshop 2005. 2005. June 29.
4. Federal Law of Russian Federation dated 31.12.2014 № 488-FL «On the industrial policy in the Russian Federation» // Russian newspaper, №1, 12.01.2015.
5. Goloshapova I.A. Industrial Policy of the innovation growing areas: monograph / I.A. Goloshapova, V.A. Borodin. – Barnaul: Altai State Technical University Publishing House, 2014. – 185 p.
6. Government Decree of the Khanty-Mansiysk Autonomous Region of Ugra dated 22.03.2013 №101-d «On the Strategy of the socio-economic development of the Khanty-Mansiysk Autonomous Region of Ugra for the period till 2020 and further till 2030».
7. Government Decree of the Russian Federation dated 17.11.2008. № 1662-d «On the Concept of the Russian Federation long-term socio-economic development for the period till 2020».
8. Government Regulation of the Khanty-Mansiysk Autonomous Region – Ugra dated 09.10.2013№ 425-r «On the State program of the Khanty-Mansiysk Autonomous Region of Ugra «The development of forestry and timber industry of Khanty-Mansiysk Autonomous Region of Ugra for the period of 2014-2020 years».
9. Kiseleva A.A. The creation of a regional timber cluster as a basis of improving the competitiveness of the timber sector. Perm University Herald. Series: Economy. 2014. №3. p. 52-57.
10. Kravchenko R. About Arkhangelsk region timber cluster. Self-Management. 2015. №12. p. 32-35.
11. Kumysheva M.M., Abanokova N.B., Nagoev A.B. Cluster policy as a mechanism of an effective management of industrial enterprises. Fundamental Research. 2014. № 12-8. p. 1703-1707.
12. Romanova O.A. Industrial policy: evolution of the implementation mechanism. Modern Competition. 2008. №6 (12). p. 32-44.
13. Salikov Y.A., Zenin A.A., Barzenkova A.S., Bukreev A.M. The mechanism of formation and realization of cluster policy of industrial enterprises and sectors. Voronezh State University of Engineering Technology Herald. 2013. №4 (58). p. 252-257.

14. Status and prospects of long-term development of the territorial system of forest of the Kondinsk Municipality of the Khanty-Mansiysk Autonomous Region of Ugra: monograph / Scientific Editor: A.V. Mekhentsev, PhD in Engineering, Professor, Rector of USFEU. [Authors: A.V. Mekhentsev, M.V. Shishkin, I.A. Imatova, E.N. Starikov, N.K. Pryadilina, A.S. Opletaev]. Yekaterinburg: Ural State Forest Engineering University Press, 2015 – 177p.
15. Study of the institutional features of the formation and development of public-private partnership (using as an example the Sverdlovsk region industrial complex) [Text]: [Authors: I.N. Tkachenko, G.Y. Pakhalchak, E.N. Starikov, etc.]; Scien. Ed. I.N. Tkachenko; Ministry of Education and Science of Russian. Federation, Ural State. Econ. University – Yekaterinburg: [Publ. Ural. State. Econ. University Press], 2014. – 202 p.
16. The timber business management on the base of the strategic planning of the Region forest resources development (using as an example the strategy of development of the timber complex of Ltd. «ALMAS» (Republic of Sakha (Yakutia))): monograph. [Text]: [Authors: A.V. Mekhentsev, E.N. Starikov, L.G. Shvamm and etc.] / Scientific Editor: A.V. Mekhentsev. Yekaterinburg: Ural State Forest Engineering University Press, 2016 – 256 p.
17. Valitskyi D.A. The formation of the cluster policy as the mechanism of Russian industries development. Moscow State Regional University Volume. Series: Economy. 2010. №1. p. 52-58.

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# THE SUCCESSFULNESS OF SAWMILLING SMALL-SIZED ROUNDWOOD IN CROATIA
# PART III. – WILD CHERRY (*PRUNUS AVIUM* L.)

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## ABSTRACT

This paper is focused on small-sized roundwood yield factors of Wild Cherry (*Prunus avium* L.). The 60 pieces of small-sized roundwood were classified in 15 to 24 cm diameter groups and sawed by live sawing technique into unedged sawn boards with nominal thickness of 25 mm. All sawn boards were processed into dimension stocks and raw parquet staves by rip-cross sawing. The volume yield of the small-sized roundwood processing into dimension stocks and raw parquet staves was from 13.91 % to 43.61 %. The quality yield coefficient of the roundwood processing into dimension stocks and raw parquet staves was from 0.66098 to 0.93507 or from 694,02 EUR/$m^3$ to 981,82 EUR/$m^3$ of dimension stocks and raw parquet staves. The log value yield coefficient was from 0.09640 to 0.39870 or from 101,22 EUR/$m^3$ to 418,64 EUR/$m^3$ of the small-sized roundwood. The results indicate a possibility of rational processing of the researched Wild Cherry small-sized roundwood in sawmills.
**Key words**: Wild Cherry (*Prunus avium* L.), small-sized roundwood, sawmilling production, log volume yield, quality yield, log value yield.

## 1. INTRODUCTION

Sustainable lack of standard sawmilling logs makes Croatian sawmills fully utilize their capacities by processing round wood of smaller dimensions, so called small diameter roundwood. In such sawmill raw material diameter dimensions are smaller than prescribed by the norm, as well as the quality. The diameters of small diameter roundwood amounts from 15 to 24 cm and length is 2 m and over.

In addition to small diameter roundwood as a feedstock a high-quality stacked wood in the form of roundwood or split wood can be classified (pitt wood, pulpwood, fuelwood and wood for chiped board). However, this kind of raw material is rarely used in large industrial sawmills due to their small dimensions and shapes and special sawmill technological base, and profitability of such problematic sawmill processing (Ištvanić 2003).

Today, the importance of small sized roundwood as raw material for processing at Croatian sawmills is even greater. Exploring new areas of application and placement, and the rationalization of the processing of this raw material in the present conditions is a necessity, because the discrepancy between annual cut possibility in Croatian Forests and Croatian sawmill capacity has been increasing, while at the same time the quality of sawmill raw material and average diameter (dimensions) are declining.

When we talk about less represented wood species in the Croatian forests then we refer to species whose share in our growing stock is smaller but not negligible, and as such are less processed in sawmills.

From this group of tree species, fruit trees are particularly interesting. As we know, most of the fruit trees logs from our area, whether it was logs for processing into veneers or processing in sawmills, are sold in western European countries, especially Italy. The same thing happens with that part of logs that are processed at sawmills usually by service sawing with minimal primary sawn board processing and possibly by hydrothermal treatment - steaming. A small number of sawmills perform specific production of dimension stock of fruit trees, especially if there is drying included. It should be noted that there are several examples of sawmills that by processing fruit trees produce parquets and glued laminated boards. The fact is that the prevalence of fruit trees in our forests is relatively small, thus increasing the

range of sawmilling raw material and processing of low quality and small-sized roundwood the share and the representation of these types of wood in the production of semi-final and final wood products would be increased (Ištvanić et al., 2016).

Given that in this part of the research we will deal with wild cherry some research results related to sawmill processing of this type of wood will be stated.The researches made by Kersavage, 1972; Rosen et al., 1980; Stewart et al., 1982; Martinsson, 2001 has shown that american wood specie black cherry (*Prunus serotina* L.), that have very similar characteristics to European wild cherry as a fast-growing tree specie, gives positive results in plantation cultivation for the purpose of acquiring roundwood intended for sawmill processing. It's also found that a log volume yield, and therefore the financial impact of such raw material is slightly smaller in contrast to the usual standard raw material treatment. The conclusion is that low quality and small-sized roundwood of valuable wood species such as fruit trees have a wide space for competition with conventional sawmill raw material (Ištvanić et al., 2011; Rabadjiski et al., 2015).

## 2. AIM OF RESEARCH

In the first and second parts of this research, the aim was to investigate the successfulness of small-sized roundwood sawmill processing of sweet chestnut (*Castanea sativa* Mill.) and common walnut (*Juglans regia* L.).

In the third part of this research, the aim was to investigate the successfulness of small-sized roundwood sawmill processing of wild cherry (*Prunus avium* L.), and it's processing in rough dimension stock and raw parquet staves by means of roundwood volume, qualitative and value yield.

## 3. OBJECTS AND METHODS OF RESEARCH

### 3.1. Small-sized roundwood selection and measurement

For the research, the wild cherry (*Prunus avium* L.) roundwood was taken from the Zagreb forest, facility Medvednica mountain in the Republic of Croatia.

In roundwood selection, it was taken into account that samples must meet the criterias listed in Table 2 in terms of qualitative features. All roundwoods were cut to a 1 m length and classified in 15 to 24 cm diameter groups. A total of 60 pieces of roundwoods were sawn (Figure 1).

Length and mid diameter were measured to all roundwood in the sample. Descriptive statistics was performed for all analysed variables. These parameters, together with measured quality factors of logs, enabled the implementation of the analysis of the raw material structure for experimental sawing (Table 1).

*Table 1. Descriptive statistics for the dimensions of small-sized roundwood*

| Roundwood size | N | Min. | Median | Max. | Average | Std. dev. |
|---|---|---|---|---|---|---|
| **Length, m** | 60 | 1 | 1 | 1 | 1 | 0,00 |
| **Mid diameter, cm** | 60 | 15.00 | 18.50 | 23.00 | 17.92 | 2.63 |
| **Volume, m$^3$** | 60 | 0.01766 | 0.02704 | 0.04153 | 0.02573 | 0.00744 |

*Table 2. Classification criteria according to defects on small-sized roundwood*

| No | Defects on roundwood | Feature |
|---|---|---|
| 1 | Sound or (partially) intergrown or uncovered knots (d < 20 mm) and chinese maustacke | Permitted but placed on mutual minimum distance of 30 cm |
| 2 | Sound or (partially) intergrown or uncovered knots (d = 20 to 100 mm) and rose | One permitted |
| 3 | Water sprouts and epicormic shoot | Not permitted |
| 4 | Unsound and rotten knots | Not permitted |
| 5 | Drying check and sun cracks on roundwood ends | Permitted if they are small and contained in the oversized in length |
| 6 | Full and traversing cracks, star shake and fissure | Not permitted |
| 7 | Sabre or simple sweep | Permitted up to 5 cm in height arch tendon on roundwood length |
| 8 | Spiral grain and deflection of wood fibre flow | Not permitted |
| 9 | Taper | Permitted up to 10% of the diameter at the thicker end |
| 10 | Insect attack | Not permitted |
| 11 | Flutig and bark pocket | Permitted up to 2 cm |
| 12 | Avality | Permitted |
| 13 | Exscentric pith (tension wood) | Not permitted if very distinct |
| 14 | Animal damage, bird peck, rind gall, undercut, butt trimming, shear and carbonized wood | Permitted but only in shallow sapwood or in oversize on roundwood length |
| 15 | Double pith and fork | Permitted in oversize on roundwood length |
| 16 | Ring shake, weather shake, spiders, frost and lightning shake | Not permitted |
| 17 | Colour variation or rott in heartwood and sapwood, fustiness and doatyness | Not permitted |
| 18 | Double (included) sapwood | Not permitted |
| 19 | Cancer, burl, buckle and burr | Not permitted |
| Wood from which roundwood is made should be freshly cut and healthy. Roundwood can be made from parts of stem or parts of branches that meet the dimensional and qualitative requirements. | | |

The volume of individual roundwood and overall volume was calculated according to the equation 1:

$$V_{log} = \frac{D_{mid}^{\ 2} * \pi}{4} * L_{log} \qquad (1)$$

$V_{log}$ – volume of small-sized roundwood
$D_{mid}$ – mid diameter
$L_{log}$ – length

## 3.2. Yield of small-sized roundwood in rough dimension stock production

Roundwood were sawn on log band saw with wheel diameter of 1100 mm. For sawing was used 1,2 mm thick saw blade with extending teeth swaging 0,6 mm on each side and 45 mm tooth pitch. Sawing was done using live sawing technique, and sawn boards of 25 mm nominal thickness were made from the roundwood. Sawn boards thickness was calculated at 22 % moisture content according to conventional formulas (Brežnjak, 1997), and with all other necessary oversize it was 27 mm. All the sawn boards obtained by sawing roundwood were subsequently processed by rip-cross sawing by circular saws in to rough dimension stock and parquet staves (Figure 1). The amount of sawmill residues was not measured nor considered.

Thickness and width of dimension stock and raw parquet staves were calculated according to nominal thickness and width they should have in dry state at 22 % moisture content, corresponding explanation for calculating the thickness of sawn boards. Dimension stock and raw parquet staves of 25 mm nominal thickness that is of 25, 32, 50 and 80 mm nominal width were produced. Thickness, including all necessary oversize, was

27 mm, while the width with all necessary oversize amounted to 27, 35, 55 and 86 mm. The nominal length of elements for all thicknesses and widths ranged between 200, 250, 300, 350, 400, 500, 600, 700, 800, 900 and 1000 mm. Oversize on length was 20 mm. Thickness, width and length were measured on dimension stock and raw parquet staves, and considering the nominal dimensions, volume was calculated. Classification of dimension stock by quality is carried out according to the criteria commonly used in Croatian sawmills (Prka, 1987).

*Figure 1. Small-sized roundwood, sawn boards, dimension stock and raw parquet staves*

Volume yield of roundwood has been calculated as the ratio of produced sawn boards volume, that is dimension stock and raw parquet staves and roundwood volume according to equations 2 and 3. Volume yield of sawn boards has been calculated as the ratio of the produced dimension stock and raw parquet staves volume and sawn boards volume according to the equation 4.

$$Y_{\text{Volume log}\rightarrow\text{board}} = \frac{V_{\text{board}_1} \cdot N_{\text{board}_1} + V_{\text{board}_2} \cdot N_{\text{board}_2} + \ldots + V_{\text{board}_n} \cdot N_{\text{board}_n}}{V_{\text{log}}} \quad (2)$$

$$Y_{\text{Volume log}\rightarrow\text{dim.stock}} = \frac{V_{\text{d.s.}_1} \cdot N_{\text{d.s.}_1} + V_{\text{d.s.}_2} \cdot N_{\text{d.s.}_2} + \ldots + V_{\text{d.s.}_n} \cdot N_{\text{d.s.}_n}}{V_{\text{log}}} \quad (3)$$

$$Y_{\text{Volume board}\rightarrow\text{dim.stock}} = \frac{V_{\text{d.s.}_1} \cdot N_{\text{d.s.}_1} + V_{\text{d.s.}_2} \cdot N_{\text{d.s.}_2} + \ldots + V_{\text{d.s.}_n} \cdot N_{\text{d.s.}_n}}{V_{\text{board}}} \quad (4)$$

$Y_{\text{Volume log}\rightarrow\text{dim.stock}}$ – small-sized roundwood volume yield in form of dimension stocks and raw parquet staves

$Y_{\text{Volume log}\rightarrow\text{board}}$ – small-sized roundwood volume yield in form of sawn board

$Y_{\text{Volume board}\rightarrow\text{dim.stock}}$ – sawn board volume yield in form of dimension stocks and raw parquet staves

$V_{\text{board 1...n}}$ – single sawn board volume

$V_{\text{d.s. 1...n}}$ – single dimension stocks and raw parquet staves volume

$N_{\text{board 1...n}}$ – number of sawn boards of the same volume

$N_{\text{d.s. 1...n}}$ – number of dimension stocks and raw parquet staves of the same volume

$V_{\text{board}}$ – total sawn boards volume

$V_{\text{log}}$ – total roundwood volume

The aim was to produce as many dimension stock and raw parquet staves of better class quality and higher prices considering specification of elements dimension limit with considerable volume yield. Qualitative yield was expressed as mean quality coefficient of all dimension stock and raw parquet staves produced from logs according to the equation 5. As shown in Table 3, for the index of the quality 1 was selected the most valuable product, that means sawn dimension stock of the highest class or price. The quality indexes of other elements are defined in such way that their current market price is divided by the price of the most valuable element. If the average quality coefficient is multiplied by money amount for which as the quality index is taken value 1, average quality of all dimension stock and raw parquet staves is obtained, expressed in money per unit of elements volume according to the equation 6.

*Table 3. Dimension stock and raw parquet staves components sawed from small-sized roundwood*

| Thickness mm | Width mm | Length mm | Quantity pieces | Volume m³ | Price €/m³ | Quality index |
|---|---|---|---|---|---|---|
| 25 | 25 | 200 - 400 | 10 | 0.00211 | 635,00 | 0.60 |
| 25 | 25 | 500 - 1000 | 5 | 0.00182 | 905,00 | 0.86 |
| 25 | 32 | 200 - 400 | 179 | 0.04284 | 635,00 | 0.60 |
| 25 | 32 | 500 - 1000 | 52 | 0.02264 | 905,00 | 0.86 |
| 25 | 50 | 200 - 400 | 367 | 0.13607 | 735,00 | 0.70 |
| 25 | 50 | 500 - 1000 | 98 | 0.07238 | 1.050,00 | 1.00 |
| 25 | 80 | 200 - 400 | 132 | 0.08630 | 735,00 | 0.70 |
| 25 | 80 | 500 - 1000 | 74 | 0.08280 | 1.050,00 | 1.00 |
| $\sum$25x25+25x32+25x50+25x80 | | | 917 | 0.44692 | | |

$$Y_{\text{Quality d.s.}} = \frac{V_{\text{d.s.}_1} \cdot k_{\text{d.s.}_1} + V_{\text{d.s.}_2} \cdot k_{\text{d.s.}_2} + \ldots + V_{\text{d.s.}_n} \cdot k_{\text{d.s.}_n}}{V_{\text{d.s.}_1} + V_{\text{d.s.}_2} + \ldots + V_{\text{d.s.}_n}} \qquad (5)$$

$$Y_{\text{Quality €/d.s.}} = Y_{\text{Quality d.s.}} \cdot c_{\text{p}} \qquad (6)$$

$Y_{\text{Quality d.s.}}$ – quality yield

$k_{\text{d..s. 1....n}}$ – quality index of dimension stocks and raw parquet staves

$V_{\text{d.s. 1...n}}$ – volume of dimension stocks and raw parquet staves

$Y_{\text{Quality €/d.s.}}$ – monetary value of qualitative yield

$c_{\text{p}}$ – price of the most valuable dimension stock whose quality index is set as 1.

Value yield of roundwood in the form of dimension stock and raw parquet staves was expressed as mean coefficient of all dimension stock and raw parquet staves values in relation to the roundwood, which is the result of the multiplication of volume and quality yield coefficient according to the equation 7. If roundwood value yield coefficient is multiplied by the amount of money for which as the quality index is taken value 1, average value yield of logs is obtained, expressed in money per unit of roundwood volume according to the equation 8.

$$Y_{\text{Value log}} = Y_{\text{Volume log}\rightarrow\text{dim.stock}} \cdot Y_{\text{Quality d.s.}} \quad (7)$$

$$Y_{\text{Value €/log}} = Y_{\text{Value log}} \cdot c_{\text{p}} \quad (8)$$

$Y_{\text{Value log}}$ – value yield of small-sized roundwood

$Y_{\text{Volume log}\rightarrow\text{dim.stock}}$ – volume yield of roundwood in the form of dimension stock and parquet staves;

$Y_{\text{Value €log}}$ – amount of money of value yield

$c_{\text{p}}$ – the price of the most valuable dimension stock whose quality index is set as 1.

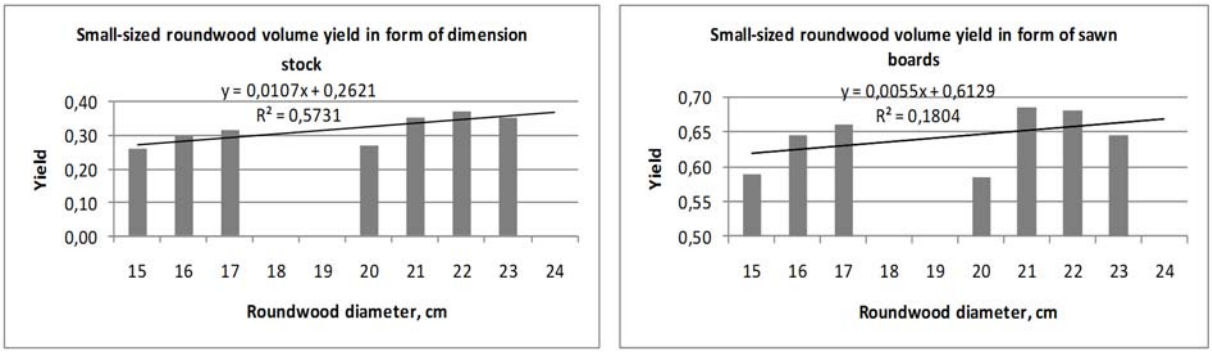
For statistical data analysis on the volume, quality and value yield, Microsoft Office Excel was used.

## 4. RESULTS

The total of 1.54386 m$^3$ of roundwood diameter class of 15-24 cm was sawed. Descriptive statistical analysis of data on its dimensions is shown in Table 2. A total 0.94825 m$^3$ of sawn boards was sawed from roundwood, and from these sawn boards was ultimately sawed 0.44692 m$^3$ of dimension stock and raw parquet staves.

*Table 4. Volume, quality and value yield of small-sized roundwood*

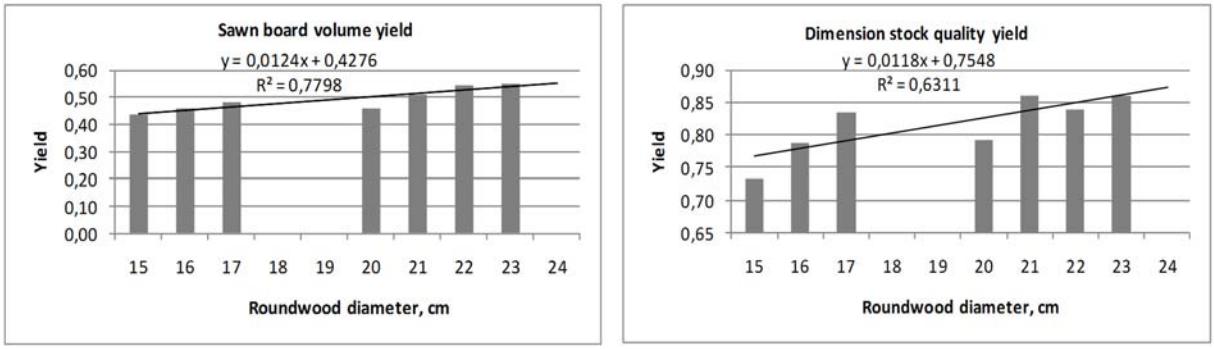
| Yield | N | Min. | Median | Max. | *Average* | Std. dev. |
|---|---|---|---|---|---|---|
| $Y_{\text{Volume log}\rightarrow\text{dim.stock}}$ | 60 | 0.13917 | 0.28669 | 0.43618 | 0.28430 | 0.06201 |
| $Y_{\text{Volume log}\rightarrow\text{board}}$ | 60 | 0.42197 | 0.61826 | 0.75682 | 0.61135 | 0.07260 |
| $Y_{\text{Volume board}\rightarrow\text{dim.stock}}$ | 60 | 0.29270 | 0.46025 | 0.59625 | 0.46261 | 0.07178 |
| $Y_{\text{Value dim.stock}}$ | 60 | 0.66098 | 0.78543 | 0.93507 | 0.78313 | 0.07671 |
| $Y_{\text{Value €/dim.stock}}$ | 60 | 694,02 | 824,70 | 981,82 | 822,29 | 80,54 |
| $Y_{\text{Value log}}$ | 60 | 0.09640 | 0.21652 | 0.39870 | 0.22497 | 0.06468 |
| $Y_{\text{Value €/log}}$ | 60 | 101,22 | 227,35 | 418,64 | 236,22 | 67,92 |




*a)* *b)*

*Figure 2. Comparison of average small-sized roundwood volume yields in form of:*

*a) dimension stock and raw parquet staves, b) sawn boards*




*b)* *b)*

*Figure 3. a) Comparison of average sawn boards volume yields in form of dimension stock and raw parquet staves, b) Comparison of average dimension stock and raw parquet staves quality yields*

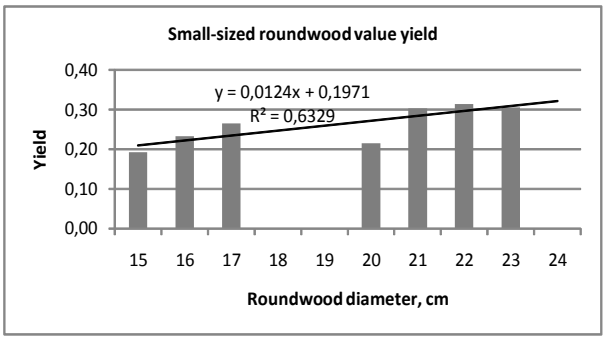



*Figure 4. Comparison of average small-sized roundwood value yields*

## 5. CONCLUSION

Yield outcomes resulting from this research can be summarized as follows (table 4.):

- Roundwood volume yield during its processing into sawn boards ranged from 42.20% to 75.68%,
- Roundwood volume yield during its processing into dimension stock and raw parquet staves ranged from 13.92% to 43.62%,
- Sawn board volume yield during its processing into dimension stock and raw parquet staves ranged from 29.27% to 59.62%,
- Roundwood qualitative yield during its processing into dimension stock and raw parquet staves ranged from 0.66098 to 0.93507 or 694,02 EUR/m$^3$ to 981,82 EUR/m$^3$ of dimension stock and raw parquet staves,
- Roundwood value yield during its processing into dimension stock and raw parquet staves ranged from 0.09640 to 0.39870 or 101,22 EUR/m$^3$ to 418,64 EUR/m$^3$ of roundwood.

From the results of this study the following conclusions and recommendations were derived, which confirm previous research results (Ištvanić et al., 2015 and 2016), or they partially agree:

- When preparing sawmill raw material from small dimension deciduous roundwood special importance should be given to avoiding defects (primarily tension wood and knots) that significantly adverse effect the dimensional stability and problems in further processing crafted sawmill products,
- Sawmill raw materials of small dimensions roundwood and the sawn boards and dimension stock and raw parquet staves made from it are relatively small in size and weight, which facilitates the necessary manual handling,

- We believe that in Croatian conditions for the sawmill processing of wild cherry small dimension roundwood simple technology based on long band and circular saws would be suitable, in the so-called family sawmills or even as a supplementary activity of agricultural households in the cooperative relationship with the larger sawmills or sawmill product merchants,
- In terms of determining the optimal dimensions of sawmill products that are recommended to produce, the realistic production is up to 80 mm width and length not exceeding 600 mm, although it is possible to create elements of widths larger than 80 mm and of length up to a maximum of 1000 mm,
- Assuming volume, quality and value yield of wood as a key factor to successful sawmill wood processing, we consider the possible rational sawmill processing of wild cherry small sized roundwood,
- Although integral yield was not considered in this paper, due to high share of sawmill waste, for efficient processing of this sawmill raw material it is necessary to consider it and thus increase the value of the obtained products or by-products.

## REFERENCES

1. Brežnjak, M. (1997): Pilanska tehnologija drva. I dio, Udžbenik, Sveučilište u Zagrebu, Šumarski fakultet, pp. 72-85.
2. Ištvanić, J. (2003): Pilanska obradba bukve (*Fagus sylvatica* L.) u Hrvatskoj. Šumarski list, 127, (7-8): pp. 373-378.
3. Ištvanić, J.; Moro, M.; Antonović, A.; Beljo Lučić, R.; Jambreković, V.; Pervan, S. (2011): Lumber yield from European walnut (*Juglans regia* L.) and Wild cherry (*Prunus avium* L.) sawlogs, Wood research 56 (2): pp. 267-276.
4. Ištvanić, J.; Antonović, A.; Greger, K. **(**2015**):** The successfulness of sawmilling small-sized roundwood in Croatia - Part I. Sweet chestnut (*Castanea sativa* Mill.); Second International Scientific Conference **"**Wood Technology & Product Design"**,** Ohrid, Republic of Macedonia, pp. 163-179.
5. Ištvanić, J.; Antonović, A.; Čunčić Zorić, A. (2016): The successfulness of sawmilling small-sized roundwood In Croatia - Part II. Common walnut (*Juglans regia* L.), 27th International conference on wood science and technology - Implementation of wood science in woodworking sector; Ambienta, Zagreb, Croatia, pp. 99-115.
6. Kersavage, P. C. (1972): Sawing method effect on the production of Cherry lumber, Forest Products Journal, 22, (8): 8 ref.; pp. 33-40.
7. Martinsson, O. (2001): Wild cherry (*Prunus avium* L.) for timber production: Consequences for early growth from selection of open-pollinated single-tree progenies in Sweden, Scandinavian Journal of Forest Research, 16 (2): pp. 117-126.
8. Prka, T. (1987): Proizvodnja elemenata na pilanama, Drvna industrija, 38, (7-8): pp. 157-161.
9. Rabadjiski, B.; Zlateski, G.; Trichkov, N.; Milchovski, Z. (2015): Quantitative Yield Of Walnut *(Juglans Regia L.)* Sawlogs, II-Nd Class Of Quality During One Phase Sawmill Conversion. Second international scientific conference „Wood technology & product design", Ohrid, Republic of Macedonia: pp. 226-231.
10. Rosen, H.N., Stewart, H. A., Polak, D. J. 1980: Dimension yields from short logs of low-quality hardwood trees, U.S. Department of Agriculture Forest Service, Research paper NC-184, 22p, North Central Forest Experiment Station, St. Paul, Minnesota.
11. Stewart, H.A.; Rosen, H.N.; Huber, H.A.; Rasher, A.A. (1982): 4/4 Hardwood Dimension From Short Bolts: Economic And Processing Comparison Of Conventional And Innovative Production, Forest Products Journal, 32, (11-12): 12 ref; pp. 71-76.

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