CONTROLLING OF BUSINESS AND PRODUCTION PROCESSES IN FOREST BASED INDUSTRY

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LOUČANOVÁ - PAROBEK - OLŠIAKOVÁ - ROKONALOVÁ - ŠUPÍN - ČOREJOVÁ - ŠTOFKOVÁ - REPKOVÁ ŠTOFKOVÁ - ŠUPÍNOVÁ - HYYTIA - HLAVÁČKOVÁ - ŠAFAŘÍK - PIRC BARČIĆ - KLARIĆ – KRUHAK - PERIĆ - KREMENJAŠ - KNOP - KRYNKE - ULEWICZ - WANAT - STASIAK BETLEJEWSKA - NOVÁKOVÁ - PLAKSIUK - ŠATANOVÁ

CONTROLLING OF BUSINESS AND PRODUCTION PROCESSES IN FOREST BASED INDUSTRY

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PREFACE

WoodEMA, i.a. is an international association for economics and management in wood processing and furniture manufacturing establihsed in the year 2007, with members from 19 countries on 3 continents. Since one of the main goals of the association is to promote science and results of scientific and professional work of its members, Association decided to start issuing scientific books. Each scientific book will be dedicated to a different topic and it will be related to a different field of expertize of the Association and its members.

This year we agreed that the topic for this issue should be dedicated to CONTROLLING OF BUSINESS AND PRODUCTION PROCESSES IN FOREST BASED INDUSTRY. Some of our members, but some non-members as well, who have research activites in fields of expertize related to the main topic are involved in creating of this scientific book. In this issue we have 11 chapters with 25 authors from 5 European countries who presented their research results in the area of controlling, related specifically to forestry, wood processing and furniture manufacturing.

Main goal of this scientific book is to stress the problems that forestry, wood processing and furniture manufacturing companies meet in their every day praxis, the way to solve those problems and to improve activities of that industrial branche using scientific methods and models.

This is the fifth scientific book issued by WoodEMA, i.a. to help collecting some knowledge and transfering that know-how further on. We hope to publish many other books this way providing scientific and professional help to our industrial branch in different managerial areas of expertize.

Editor-in-chief
Denis Jelačić

Authors of the chapters:

Chapter 1 – Erika LOUČANOVÁ, Jan PAROBEK, Miriam OLŠIAKOVÁ, Alena ROKONALOVÁ, Technical Univeristy in Zvolen, Faculty for Wood Sciences and Technologies, Zvolen, Slovakia (**1,21 Authors Sheets**)

Chapter 2 – Erika LOUČANOVÁ, Miriam OLŠIAKOVÁ, Mikuláš ŠUPÍN, Tatiana ČOREJOVÁ, Jana ŠTOFKOVÁ, Katarína ŠTOFKOVÁ-REPKOVÁ, Mária ŠUPÍNOVÁ, Technical Univeristy in Zvolen, Faculty for Wood Sciences and Technologies, Zvolen, Slovakia (**1,12 Authors Sheets**)

Chapter 3 – Annika HYYTIA, University of Helsinki, Helsinki, Finland (**0,54 Authors Sheets**)

Chapter 4 – Petra HLAVÁČKOVÁ, Dalibor ŠAFAŘÍK, Mendel University in Brno, Faculty of Forestry and Wood Technology, Brno Czech Republic (**0,70 Authors Sheets**)

Chapter 5 – Andreja PIRC BARČIĆ, Kristina KLARIĆ, Tajana KRUHAK , University of Zagreb, Faculty of Forestry, Zagreb, Croatia (**1,70 Authors Sheets**)

Chapter 6 – Ivana PERIĆ, Kristina KLARIĆ, Karla KREMENJAŠ, University of Zagreb, Faculty of Forestry, Zagreb, Croatia (**1,18 Authors Sheets**)

Chapter 7 – Krzysztof KNOP, Marek KRYNKE, Robert ULEWICZ, Czestochowa University of Technology, Czestochowa, Poland (**1,11 Authors Sheets**)

Chapter 8 – Leszek WANAT, Collegium Da Vinci, Faculty of Computer Science and Visual Communication, Poznań, Poland (**1,05 Authors Sheets**)

Chapter 9 – Renata STASIAK BETLEJEWSKA, Czestochowa University of Technology, Czestochowa, Poland (**1,37 Authors Sheets**)

Chapter 10 – Renáta NOVÁKOVÁ, Olena PLAKSIUK, University of Ss. Cyril and Methodius, Institute of Management, Trnava, Slovakia **(1,45 Authors Sheets)**

Chapter 11 – Anna ŠATANOVÁ, High School of International Management ISM Slovakia, Prešov, Slovakia (**1,32 Authors Sheets**)

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TIMBER VOLUME LOSS, CERTIFICATION ISSUES AND WOOD PRODUCTION PROCESSES

1. EVALUATION OF ECOLOGICAL INNOVATION AS A TOOL OF SUSTAINABLE DEVELOPMENT FROM THE EU PERSPECTIVE

Erika Loučanová, Ján Parobek, Miriam Olšiaková, Alena Rokonalová

1.1. INTRODUCTION

With the intention of provide solutions to environmental challenges caused by economic growth, EU countries adopted continuing strategic plans. Economic research has identified innovation as a key factor for economic growth, competitiveness and employment. This applies not only to high-tech industries, but also to all sectors, including forestry and wood processing. Global economic and environmental challenges and growing political awareness of sustainable economic growth have given new impetus to the development of innovation in many economics sectors including forestry and wood processing. For ensuring environmental sustainability, innovations that decrease impacts of renewable resource use on ecosystems are of central importance. The implementation of a circular flow economy requires novel technological, organisational and product solutions, e.g. with regard to cascading use concepts, to improve resource efficiency and close material flows. The resource management and its environmental quality have been improving in line with the increasing implementation of the principles of sustainable forest management. Economy-wide material flow analysis and cascading use concepts and the indicators derived from them are descriptive tools aiming to provide information on the material and energy coming into and leaving a society/economy. They are conceptually based on a simple environment-economy model where the latter is embedded into the former (Parobek et al., 2014). This necessitates innovations on the supply side of technologies and products, but also adjustments on the user side, e.g. with regard to consumption and waste generation patterns (Purkus et al., 2018).

The forest sector is generally perceived as traditional, slow to implement innovation. Innovation in forest sector has been slow in many countries, and largely restricted to the incremental form of innovation. There are many reasons for this, including risk-averse policy environments, an unwillingness to undertake transformative innovations and a long-term focus on process innovation, particularly as it relates to cutting the cost of production of a limited range of commodity products (Innes, 2009). Research and the first publications on innovation in this sector began to appear in the 1980s (Weiss et al., 2020). The beginnings of the research focused mainly on technological innovations in forest sector (Van Horne et al., 2006; Hansen, 2010), studying either the innovativeness of firms or innovation processes in a complex societal context, often including political-institutional, social-cultural and economic conditions (MacDonald a Clow, 1999; Jaculjaková, Štofková, 2021). Current research on innovation in the forest sector is carried out mainly by developed countries, especially the countries of northern Europe and North America. In general, innovation in traditional sectors is limited and less competitive than other sectors (Weiss et al., 2020; Hansen, 2010; Loučanová, Nosáľová, 2020). The European forest sector is currently influenced by bigger societal and economic changes: most importantly growing demands for recreation, growing demands for sustainable "niche products", growing demands for health care and natural products stemming from forests on the one hand and on the other with Kyoto goals for mitigating climate change as well as more resource efficient energy consumption (Weiss, 2017) and Innes (2009) points to the large-scale structural changes occurring in forest sector, with new producers and new markets emerging. To cope with these changes, the forest sector will need a massive cultural change that will see the adoption of genuine innovation as a prerequisite for the continued success of the sector. From a business point of view, innovations are needed for the diversification of forest industry business models and product portfolios (Stern et al., 2018).

In the last years, there has been a significant growth of academic papers focused on different formulations of eco-innovation. Nevertheless, an inspection of the researches advises that terms like eco-innovation, bio-innovation or sustainable innovation describe very similar things. On the other side, many definitions have been proposed for "eco-innovation". The first definitions is by Fussler and James (1996) who described eco-innovation as the process of developing new products, processes or services which provide customer and business value but signifi cantly decrease environmental impact. The European Commission defines eco-innovation as "the creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for all with a life-cycle minimal use of natural resources (materials including energy, and surface area) per unit output, and minimal release of toxic substances". The definition of the European Commission is a step forward because it contains very important concepts. The first is that eco-innovation is a specific kind of innovation, whose aim is not just to create new markets or replace obsolete ones, but mainly to satisfy "human needs". The second regards the environmental implications of innovation dynamics. (Pansera, 2011). The OECD also proposed an analogous definition. Their observer document declares that eco-innovation are "the creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and institutional arrangements which – with or without intent – lead to environmental improvements compared to relevant alternatives" (OECD, 2009). The OECD definition covers a simple and direct reference to organizations and institutional settings as a specific typology of eco-innovation.

The concept of eco-innovation is increasingly linked to the concept of bioeconomy, which aim at sustainably meeting food needs and some of the material and energy needs of societies while preserving natural resources and ensuring good quality environmental services through innovation (Jankovský et al., 2021). Guerrero and Hansen (2018) identify bioeconomy as an innovative solution for reviving the forest industry. The forest industry may play a significant role in a bioeconomy because it relies on renewable raw materials, bioenergy, and other services.

Many authors acknowledge that innovation is the most effective way to address the challenges the forest sector is facing. These challenges are multifaceted and complex. Juslin and Hansen (2002) and Van Horne (2006) have identified four major challenges facing the industry: restructuring, consolidation and search for profitability; cost reduction through production optimisation and technological innovation; customer orientation, centred on differentiation and adding value; confronting environmental challenges.

The sector has high economic development potentials, due to the growth of timber demand and the use of sustainable products in Europe in combination with a recent hype for using bio-technology, bio-energy and building with wood for climate change mitigation (Weiss, 2017). Stendahl (2009) points to the main drivers of innovation in the wood processing industry - increased interest in energy-efficient and environmentally friendly development of society. In many product categories, it has provided an opportunity to replace fossil fuels with renewable wood-based alternatives. The concept of sustainability is becoming increasingly important and is a driving force for innovation in the processing of wood and non-wood forest products. Businesses are increasingly focused on changing strategy and restructuring business models in accordance with the principles of sustainability. Resource efficiency, social relevance and engagement, product longevity, ethical resources are considered key principles in business sustainability models. Forest industry competitiveness is increasingly connected with various types of factors related to innovation and differentiation strategies at the firm-level (Stern, 2018). Studies suggest that innovation can be fostered through cluster collaboration. One of the main goals of business clusters is to create competitive advantages and companies should be open to such opportunities (Weiss et al., 2017). The main drivers of cooperation include: cost reduction, promoting competitiveness and environmental sustainability. On the contrary, mistrust between entities is a frequently cited obstacle. In connection with the production of wood products, beneficial cooperation between sawmills and timber companies is developing. The analysis of long-term cooperation in the Finnish sawmill and woodworking industry emphasizes value creation and performance improvement through cooperation with competitors. One of the main motives for firms to practice cooperation with competitors is to create greater value or benefit, that is, to improve the performance of the firms through coopetitive moves. The firms involved cooperate and compete with each other to obtain better financial results (Rusko, 2011; Štofková, Štofková, 2017).

Weiss (2017) studied forest-sector innovation systems in forest industry clusters across Europe. The study confirm that the lack of cooperation is an important hindering factor for the support of innovations. On the other hand, openness across sector boundaries strongly helps in translating policy goals and market opportunities into action. Authors emphasise the importance of company-level, cross-sector collaboration in the forest industry. Forest industry is a traditional business that builds on competition, where collaboration inside the sector, as well as with other industrial sectors, is neglected. Van Horne (2006) points to the importance of knowledge management and centres of expertise in the forest products industry in Canada.

Following other industries, the forest products industry is increasingly focused on the end customer. To improve customer service levels the industry needs to innovate better management its value creation network. In this sense, centres of expertise can develop a better understanding of their own processes and in turn develop better tools to transfer knowledge so that it is used to create effective value for the forest products industry. Daddi et al. (2012) did an investigation of the presence of a correlation between eco-innovation and competitiveness within district in Italy. The collected evidence emphasises that eco-innovation can strengthen the resilience of those companies of the district that, in the longer run, are able to upgrade their managerial and strategic behaviour, so to align with the most innovative competitive challenges (including environmental excellence).

Many forestry companies have entered into inter institutional cooperation with research institutes and universities on joint projects to facilitate research (Hansen 2016). Guerrero and Hansen (2018) identify drivers and barriers of cross-sector collaboration in the forest industry. They point out that cross-sector collaboration in the forest industry suggests the opportunity for diverse types and forms of innovation to develop new products and enhance profitability. On the other hand, lack of trust among partners is a key challenge for future implementation of company-level, cross-sector collaboration in the forest industry. Acording Näyhä and Pesonen (2014), forest companies are willing to collaborate with research institutes and companies outside the forest sector to diversify their business, reduce operational costs, create value and competitive advantage, and reduce environmental impacts.

Forest industry companies can create additional added value by promoting eco-tourism and contributing to carbon sequestration by reusing the material and creating a new value-added product, thus extending its life cycle. Management techniques that favor a system of sustainable forest management lead to natural or artificial reforestation (Paluš et al., 2017). In Romania, forest-based interaction with environmental protection, wood processing, and tourism industries have positively impacted the evolution of the forest industry. Further, collaboration and cooperation among environmental authorities and forest and tourism sectors have significantly increased the development of ecotourism. Now, ecotourism is a new priority for both forest and tourism businesses (Abrudan et al. 2009). Human capital is considered to be the basis of innovativeness. Laukkanen et al. (2016) in their study provide an overview of creativity and the development of innovation in the forest-based industry in the USA and Finland. They consider the creativity of employees to be a key factor in increasing the innovation of companies, which should be supported by the culture of the organisation. Managers should provide opportunities to increase interaction and communication between employees and various stakeholders. Interaction between people in sales, manufacturing, R&D and customers can facilitate the generation of ideas and a better understanding of a company's ability to innovate. Hovgaard (2005) point out that innovation can do more for a company than simply increase its competitiveness in the marketplace. The development of innovative products and technologies has several other advantages including providing ways to better meet consumer needs, capitalizing on a strategic market and realizing the financial rewards of creating successful innovations.

1.2. METHODOLOGY

The paper deals with the area of ecological innovations in the Slovak Republic from the EU perspective. Primary data for analysis were a selected from the Eco-Innovation Scoreboard (2020). Cluster analysis presents the elementary method that was used in the analysis. It presents a method relating to hierarchical clusters applying using an agglomeration approach.

Cluster analysis is a term used to describe a family of statistical procedures specifically designed to discover classifications within complex data sets. An outcome of cluster analysis will result in a number of clusters, where the observations within a cluster are as similar as possible while the differences between the clusters are as large as possible (Templ et al. 2008). Clustering is a family of methods undergoing rapid development. Clustering has been part of natural science for a long time; it has been used by numerical taxonomists and ecologists, and later joined by other researchers in the physical sciences, economics, and humanities. Most modern clustering methods have only been developed since the era of second-generation computers. Clustering methods are useful whenever the researcher is interested in grouping together objects based on multivariate similarity. Cluster analysis can be employed as a data exploration tool as well as a hypothesis testing and confirmation tool (Parobek et al. 2015). Each object of the research was considered as a separate cluster. The gradually the objects of the research merged in pairs into sub - clusters from the most to the least similar objects to the clusters. It was applied until they have resulted in one cluster. Similarity measures as well as denoted dissimilarity measures were used to examine the similarity of objects. For the quantitative data are used measures of distances. They are based on the presentation of objects in space. Individual variables are represented by their coordinates (Štofková, Štofková 2020).

The Euclidean distance is a distance measure (so - called metric) which is routinely used. The STATISTICA 10 programme was used to process the cluster analysis through the DE - Euclidean distance measures. The analyzed data set has operated with two basic variables: the survey objects (twentyeight EU countries) and 5 indicators (eco-innovation inputs, eco-innovation activities, eco-innovation outputs, eco-innovation socio-economic outcomes, eco-innovation resource efficiency outcomes). The increment has the minimum value of the total intra group from the cluster averages sum of squares of deviations of individual values.

The output of the process of clustering object distances is shown in a form of a dendrogram. It allows the graphical grouping of related objects into clusters. It is very significant to select the appropriate level for the number of resulting clusters in order to interpret the entire analysis and its next application. Both, the calculation of cluster averages and indicators clustering are supposed to be very helpful (Loučanová, 2021).

1.3. RESULTS AND DISCUSSION

The manuscript provides results of the ecological innovation in the European Union (EU) countries analysis. The cluster analysis is the main method applied in this survey. The analysis has reached to the conclusions that a great attention needs to be paid to eco-innovation. With respect to this idea, much effort has been done to evaluate development and other issues related to eco-innovation. The European Commission (2020) introduced the Eco-Innovation Scoreboard (Eco-IS). It is understood as an eco-innovation index with the aim to evaluate the performance of eco-innovation effectiveness in EU Member States.

The eco-innovation index allows capturing various eco - innovation aspects through sixteen indicators application. They are divided into five areas - dimensions: eco - innovation inputs, eco -innovation outputs, eco - innovation activities, resource use efficiency, and socio - economic results. The Eco - Innovation Index quantifies the performance of individual Member States of the EU in eco-innovation field in searched areas. Subsequently, it identifies their strong and weak sides. The Eco - Innovation Index completes other measurement approaches to innovation in the EU countries. It also focuses on the promotion of a holistic view of the environmental, economic and social results of monitored indicators within the eco – innovation.

With respect to the evaluation of eco - innovation performance, Slovakia is the part of the group of economies, which do not achieve such a high level of eco - innovation scoreboard. Luxembourg, Finland, Germany, Austria, Sweden, Denmark and France belong to the best-located countries. Average Eco-Innovation performers are, in descending order, Italy, Portugal, Slovenia, Czech Republic, Ireland, Belgium, Greece, Estonia, and Latvia. Countries in the category of Catching-up with eco-innovation include – in descending order of scores- Lithuania, Croatia, Slovakia, Cyprus, Romania, Hungary, Malta, Poland, and Bulgaria.

In these results, you can see the overview of the trends across EU as well as the European policies and initiatives that are expected to drive a better eco-innovation in the EU (Eco innovation Scoreboard, 2020).

"In the period monitoring the eco-innovation index, some EU Member States have achieved a considerable increase in material productivity, measures as Euro GDP per kilogram of material consumption. In countries with the highest improvements, such as Spain and Cyprus, the economic crisis led to a dramatic shrinking of material consumption, most notably in the construction sector, which explained a large part of the overall development. However, the initial levels in the year 2000 were different and the range between the lowest and highest values in the year 2015 diverged even more. Italy increased its material efficiency from a rather average level to a relatively high level, Cyprus increased its efficiency from a comparatively a level close to the EU average. Lowest growth rates across the EU-28 countries were observed for Malta and Romania. The increase in material productivity of the average EU-28 was around 72% since the year 2000" (Eco innovation Scoreboard, 2020).

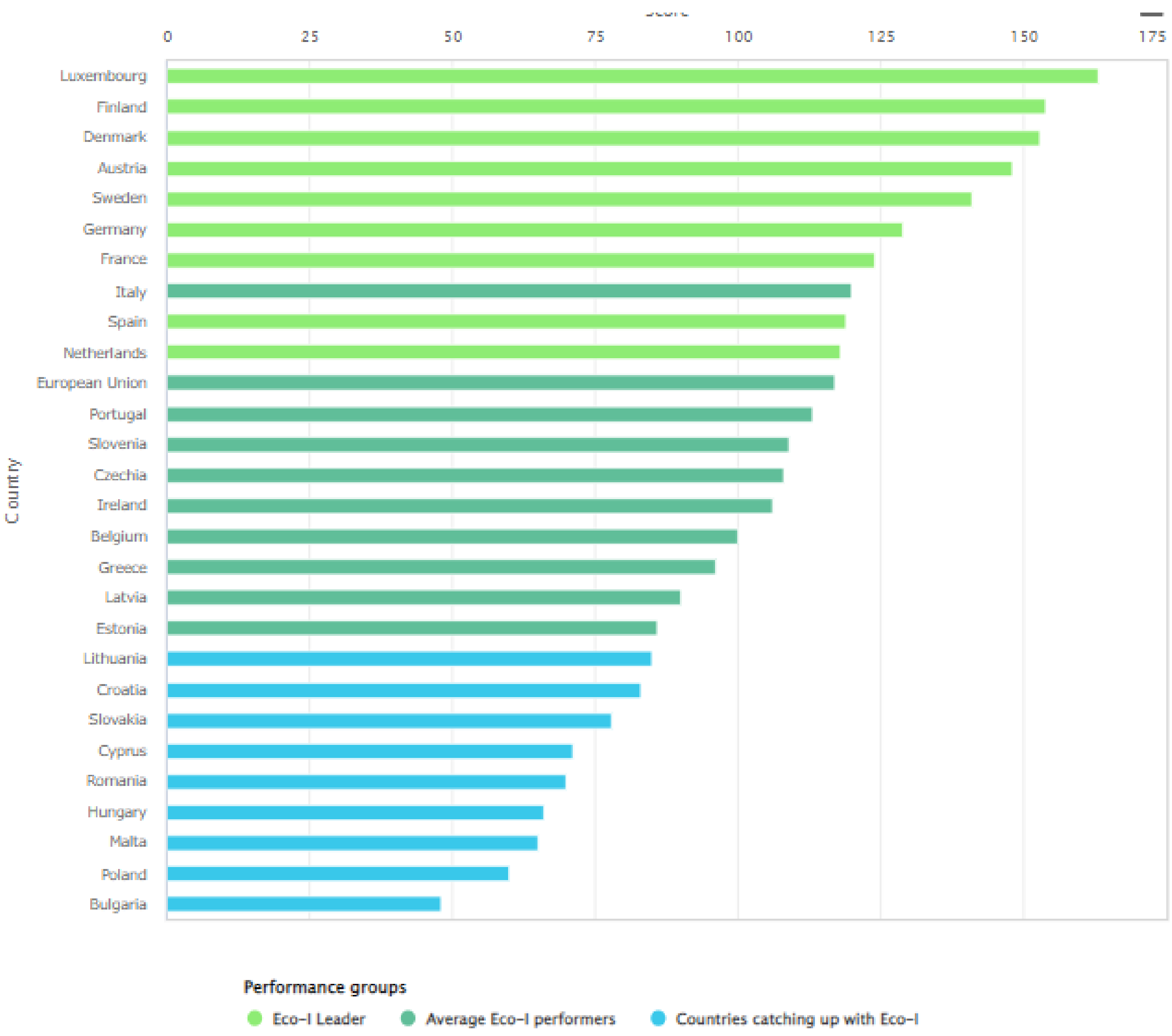

Figure 1.1. Performance of ecological innovation of the EU members
Source: Own processing according to Eco-Innovation Observatory Database (2020)

A cluster analysis was performed to obtain the Slovakia's position within the EU in the researched issue of eco - innovation. The input data were the values of the areas of eco - innovation index for individual v EU countries. Within the cluster analysis, a hierarchical cluster analysis was applied using the Ward method. As Trebuňa and Beres (2010) state, this method tries to minimize the amounts of variances across all newly formed clusters.

The cluster analysis dendogram (see Figure 2) which is created through the SPSS program shows clusters – homogeneous v groups of EU countries, from the point of view of eco - innovation so that the examined objects of one cluster are as similar as possible and at the same time the cluster is as different as possible from other clusters.

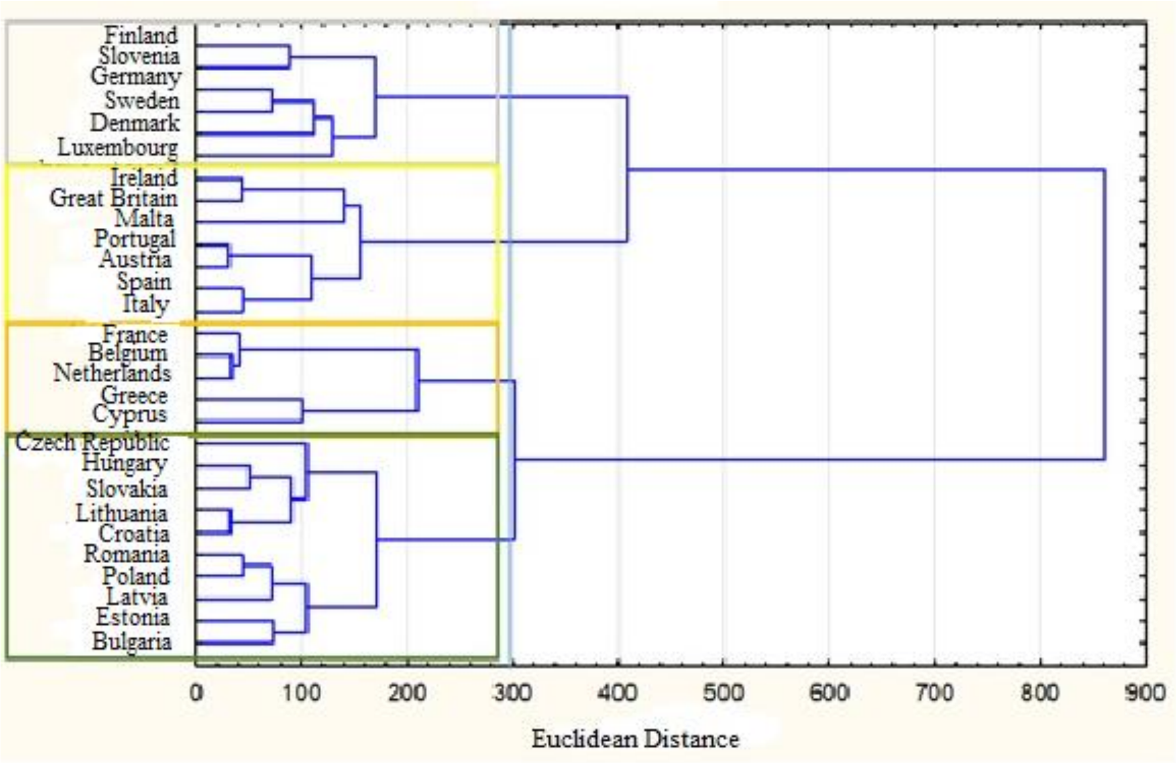

Figure 1.2. Dendogram of cluster analysis of ecological innovation of the EU countries
Source: Own processing according to data of the European Commision, 2019, Loučanová, 2021

Four clusters arose from 28 countries of the European Union at the Euclidean distance 300. They were determined based on the above-mentioned input parameters. Table 1 shows clearer representation of clusters with the respective countries.

Table 1.1. Clusters of the EU countries considering the ecological innovation Cluster

Cluster			
4	2	1	3
Czech Republic	Ireland	Finland	France
Romania	Portugal	Germany	Belgium
Estonia	Great Britain	Denmark	Netherlands
Poland	Austria	Sweden	Greece
Latvia	Spain	Slovenia	Cyprus
Hungary	Italy	Luxembourg	
Bulgaria	Malta		
Lithuania			
Slovakia			
Croatia			

We have subsequently calculated the average values of monitored areas of the eco-innovation index of individual EU countries to characterize the resulting individual clusters. Monitored areas include eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource use efficiency results and socio-economic results, for individual clusters. Then they have been interpreted as basic characteristics of the given clusters (high, slightly high, low, very low proportion in the investigated area).

Cluster 1 – Finland, Germany, Denmark, Sweden, Slovenia, Luxembourg

A high share of eco-innovated inputs, outputs, and activities as well as a slightly high share of socio-economic results and results of efficient use of resources characterize cluster 1.

Cluster 2 - Ireland, Portugal, Great Britain, Austria, Spain, Italy, Malta

A high share of resource efficiency results, a slightly high share of eco-innovation inputs and activities, but a low share of eco-innovation outputs and socio-economic results characterizes cluster 2.

Cluster 3 - France, Belgium, Netherlands, Greece, Cyprus

Cluster 3 is characterized by a high share of socio-economic results, a low share of eco-innovation activities and a very low share of eco-innovation inputs, outputs, and results of efficient use of resources.

Cluster 4 – Czech Republic, Romania, Estonia, Poland, Latvia, Hungary, Bulgaria, Lithuania, Slovakia, Croatia

A slightly high share of eco-innovation outputs, a low share of eco-innovation inputs and resource efficiency results, and a very low share of eco-innovation activities as well as socio-economic results characterizes cluster 4.

As Figure 3 shows, innovation leaders tend to form geographically close clusters. The average innovation performance of individual EU countries is declining with increasing geographical distance from innovation leaders.

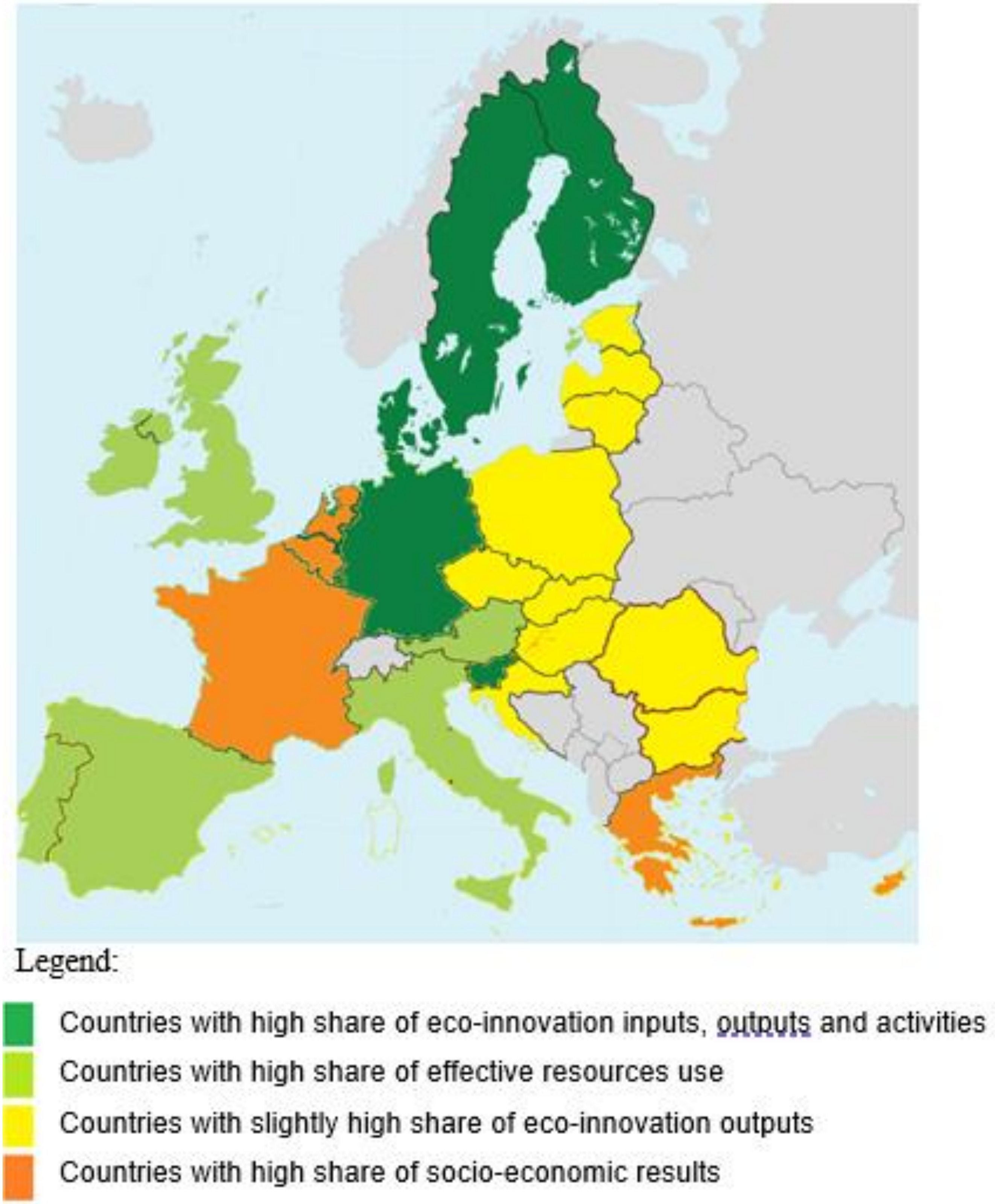

Figure 1.3. EU countries´ division according to eco-innovation performance
Sources: Loučanová, 2021

The results of the cluster analysis as well as the results of the studies of Hollanders et al. (2019) on innovation, and sustainable development point to the fact that countries of northern Europe, such as Denmark, Sweden and Finland, are leaders not only in sustainable development but also in the area of eco-innovation. Similarly, the geographical results (See Figure 3) mention that countries with a high share of eco-innovation tend to form geographically close clusters (Loučanová, 2021).

1.4. CONCLUSION

The study covered the relative and absolute variables of macroeconomic data and data focused on eco- innovation. Their variability among the European Union countries is significantly high, and macroeconomic data strongly affect the formation of clusters. Therefore, a relatively high Euclidean distance (300) was identified to determine the four main clusters. This finding is in favour of the statement that implementation of common EU eco-innovation policy shall take into account the differences and specific conditions in respective EU countries. The main finding can be summarised as follows:

1. In terms of eco-innovation as a tool of sustainable development, Slovakia is below the average of the EU and ranks among the countries with a slightly high share of eco - innovation outputs.
2. The countries of northern Europe - Denmark, Sweden and Finland - are leaders not only in sustainable development but also in the area of eco-innovation.
3. The countries with a high share of eco-innovation tend to form geographically close clusters.

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2. ABC ANALYSIS: A TOOL OF CONTROLLING DRIVERS OF THE ECOLOGICAL INNOVATION IN RELATION TO SUSTAINABILITY

Erika Loučanová, Miriam Olšiaková, Mikuláš Šupín, Tatiana Čorejová, Jana Štofková, Katarína Repková-Štofková and Mária Šupínová

2.1. INTRODUCTION

The environmental problems, as well as global economic competition have caused increasing awareness for the need to change and renew existing technological production and social behavioural patterns. Such awareness may gradually produce innovative responses leading to sustainability (Carrillo-Hermosilla et al. 2009; Könnölä et al. 2008). There are many innovative theoretical frameworks for achieving sustainability and a competitive advantage based on coherence between dyadic and social contexts for the benefit of society and all stakeholders. This theory is further amplified by a synthesized explanatory basis including an eclectic mosaic of interdisciplinary theories (institutionalism, non-institutionalism, viable systems approach, isomorphism, and identity) to improve the performance of business and supply chains (Czinkota et al., 2014). The World Commission on Environment and Development has defined sustainability as development that meets the present needs without endangering the ability of future generations to satisfy their own needs (Chabowski et al., 2011).

Innovation is the implementation of a new or significantly improved product or process, a new marketing method, or a new organizational method in business practice. The general definition of innovation is neutral regarding the content of change, the definition of innovation open in all directions. There is a strong emphasis on innovation and its importance is constantly increasing. A strong emphasis is also placed on sustainability associated with innovation (Loučanová and Olšiaková, 2020). Effectiveness of innovation and efficient performance of organizations significantly depends on skills and abilities of employees to create, design, and apply innovation. It is also influenced by many other factors. In contrast, emphasis on innovation toward sustainable development is motivated by the direction and content of the progress concern (Klemmer et al. 1999). Environmental innovation (eco-innovation) can be defined broadly as all measures by relevant subjects (companies, politicians, unions, associations, churches, private households) that develop new ideas, behaviour, products, and processes; apply or introduce them; and that contribute to a reduction of environmental burdens or to ecologically specified sustainability targets (Rennings 2000). Based on the Measuring eco-innovation - MEI European Commission project (Kemp and Pearson 2007), eco-innovation is the production, assimilation, or exploitation of a product, production process, service, or management or business method that is novel to the organization (developing or adopting it), and that results, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resource use compared to relevant alternatives.

Regarding the approach of eco-innovation, authors (Dangelico and Pujari 2010; Triguero et al. 2013; Lee and Min 2015) claim that the more innovative a company is, the more environmentally friendly it will be. Thus, effective management of both innovation and environmental issues assumes that companies with higher-quality innovation will take better care of the environment. Eiadat et al. (2008) and, subsequently, Zhen (2011) identified the equality and mutual benefit that proceed from the relationship between eco-innovation and a business's performance. Eco-innovation decreases material demands by using closed material flows or by creating or using new materials. At the same time, ecological innovations are focused on decreasing energy demands or creating/using alternative sources of energy. They also decrease the total amount of emissions or existing environmental load and health risks while supporting healthy lifestyles and sustainable consumption (Loučanová and Nosáľová 2020).

Ryszko (2016) reported that companies can, through technological eco-innovation, not only improve their corporate image and achieve better customer satisfaction, but can also generate an increase in market share, profit growth, return on sales, etc. Because technological eco-innovation reduces environmental impact and improves business performance, it simultaneously contributes to environmental and economic pillars of sustainable development.

Forest-based Bioeconomy and EU's Bioeconomy Strategy was underlined that forests and related industries (wood industry etc.) have always been an important part of the bioeconomy (Loučanová and Nosáľová 2020). To develop innovations, Rametsteiner and Weiss (2006) propose a more complex system view of innovation "as a complex non-linear process involving a range of players and different interactions", with the focus on the social elements of the system. New wood-based plastics and textiles products with lower environmental footprint are also emerging within the bioeconomy. Even though there are limitations on how much biomass can be produced there is still unlocked potential and further innovations to be discovered (Intergoup 2020; Loučanová and Nosáľová 2020).

Furthermore, Picazo-Tadeo et al. (2014) stated that a change in environmental performance is a part of proportionate eco-efficiency change and environmental technical change, too. Eco-innovation can serve as a tool by which companies attempt to transform environmental constraints into opportunities to reduce costs, to obtain a better reputation, and to take advantage of new markets. One of the most important consumer interests is the promotion of environmental product innovation and performance. (Carrillo-Hermosilla and Unruh 2006; Laperche and Picard 2013; Loučanová and Olšiaková, 2020).

This paper is mostly based on the approach of the European Commission. The Eco-Innovation Index and composite index indicator allow measuring the eco-innovation performance of different EU member states. The ranking of EU member states is dependent on their deviation from the EU average. In 2021, Luxembourg was the highest rated EU country, and it is the leader in this field, followed by Finland, Austria, Denmark, Germany and etc (Eco-innovation index, 2021).

The Eco-Innovation Index in 2021, compared with other EU countries, was below the EU average. Slovakia belongs among the ten EU member states with the lowest ranking in this field. The obtained score of 82 ranked Slovakia in 22nd place of 28 EU countries. Slovakia was in the group of moderate innovator countries with an innovation performance below the EU average (Eco-innovation index, 2021).

Regarding Eco-Innovation Index, a high overall ranking does not necessarily mean that a country has performed well in all eco-innovation areas covered by this index. The results can only provide an indication of the overall country eco-innovation performance. Rizos et al. (2015) emphasized that drawing conclusions about specific eco-innovation aspects and country trends requires a careful analysis of the sub-indicators covering these fields. The aim of this paper is to analyse the current situation of eco-innovation's development in Slovakia from a sustainability.

2.2. METHODOLOGY

The paper deals with the ABC analysis, as a tool of controlling drivers of the ecological innovation in relation to sustainability situation in Slovakia which is defined according to the SDG index (Sustainable Development Goals index) and Eco-innovation Index.

The data are obtained from the database server European Commission, Eurostat, Environment, Eco-innovation Action Plan, SDG index (2021), The Eco-Innovation Scoreboard and the Eco-Innovation Index (2021). Indicators relevant to the analysis of parameters of ecological innovation and sustainability are sorted by selection of examined indicators. Subsequently, the study of dependencies between total ecological innovation index and the growth of sustainability is realized through correlation and regression analysis.

In regression analysis we examine whether the relationship pattern between two values of variables can be described as a straight line, which is the simplest and most used form

$$Y = a + bX \qquad (1)$$

where:

Y is the dependent variable, measured in units of the dependent variable, X is the independent variable, measured in units of the independent variable, and a and b are constants defining the nature of the relationship between the variables X and Y.

a or Y-intercept (also known as Yint) is the value of Y when X = 0.

b is the slope of the line, and it is known as the regression coefficient, and it is the change in Y associated with a one-unit change in X.

The greater the slope or regression coefficient, the more influence the independent variable has on the dependent variable, and the more change in Y associated with a change in X.

The regression coefficient is typically more important than the intercept from a policy researcher perspective as we are usually interested in the effect of one variable on another" (Regression Analysis, 2019).

"Because visual examinations are largely subjective, we need more precise and objective measure to define the correlation between two variables. We use the linear correlation coefficient to quantify the strength and direction of the relationship between two variables:

$$r = \frac{\sum \frac{(x_i - \bar{x})}{s_x} \frac{(y_i - y)}{s_y}}{n-1} \qquad (2)$$

Where:

$\bar{x}$ and sx are the sample mean and sample standard deviation of the x's, and
$\bar{y}$ and sy are the mean and standard deviation of the y's,
n is the sample size.

This statistic numerically describes how strong the straight-line or linear relationship is between the two variables and the direction, positive or negative.
In ANOVA, we partitioned the variation using sums of squares so we could identify a treatment effect opposed to random variation that occurred in our data.
The sums of squares and mean sums of squares are typically presented in the regression analysis of variance table. The ratio of the mean sums of squares for the regression and mean sums of squares for error form an F-test statistic used to test the regression model.
The relationship between these sums of square is defined as

Total Variation = Explained Variation + Unexplained Variation (3)

The larger the explained variation, the better the model is at prediction. The larger the unexplained variation, the worse the model is at prediction. A quantitative measure of the explanatory power of a model is R^2, the Coefficient of Determination:

$$R^2 = \frac{Explained\ Vatiation}{Total\ Variation} \quad (4)$$

The Coefficient of Determination measures the percent variation in the response variable (y) that is explained by the model. Values range from 0 to 1. An R^2 close to zero indicates a model with very little explanatory power. An R2 close to one indicates a model with more explanatory power" (Kiernan, 2007; Loučanová, E., Olšiaková, M. (2019).
Using ABC analysis, the aim is to identify the most important areas influencing eco-innovation development in Slovakia. According to European Commission the Eco-Innovation Index (Eco-innovation Action Plan |, n.d.) shows how well individual Member States perform in different dimensions of eco-innovation compared to the EU average and presents their strengths and weaknesses. The intention of the Index is to acquire various aspects of eco-innovation by applying 16 different indicators that are grouped into five thematic areas: eco-innovations inputs, eco-innovations activities, eco-innovations outputs, resource efficiency and socio-economic outcomes (Table 1).
Every area is presented by an index. The Eco-innovation Index is counted individually for each country, where specific figures of a single indicator were weighted with the share of the population. "Distance-to-reference" method is used to normalize different indicators. The EU average is defined as the reference and a set is defined as a value of 100. Countries whose figures are higher than the EU average obtain a higher score than 100 and countries whose figures are lower achieve less. The specific value is dependent on the deviation from the EU average (Eco-innovation Action Plan (n.d.); Eco-innovation index, 2021).
At first, to evaluate the current situation in the area of eco-innovation in Slovakia we analysed the Eco-innovation Index data for the year 2021 and the causalities in its developments during years 2010-2021.

Table 2.1. Thematic areas of Innovation index

Eco-innovation inputs	Eco-innovation activities	Eco-innovation outputs	Resource efficiency outcomes	Socio-economic outcomes
Governments environmental and energy R&D appropriations and outlays	Enterprises that introduced an innovation with environmental benefits obtained within the enterprise	Eco-innovation related patents	Material productivity	Exports of products from eco-industries
Total R&D personnel and researchers	Enterprises that introduced an innovation with environmental benefits obtained by the end user	Eco-innovation related academic publications	Water productivity	Employment in eco-industries
Total value of green early stage investments	ISO 14001 registered organizations	Eco-innovation related media coverage	Energy productivity	Turnover in eco-industries
			GHG emissions intensity	

Source: authors according to Eco-Innovation Index, European Commission (Eco-innovation Action Plan (n.d.)

As the second step, ABC analysis of individual areas influencing the value of Eco-innovation Index in Slovakia was calculated based on Eco-Innovation data of European Commission (Eco-innovation Action Plan (n.d.). ABC analysis can be used in various situations applying various criteria to group “items” resulting in various groupings. The use of ABC analysis to rank items depends on the goals that management need to achieve (Coyle et al., 2009). According to Li et al. (2018) ABC analysis is a popular and effective method used to classify items into specific categories that can be managed and controlled separately according to three predefined and ordered categories:

- category A contains very important items (approximately 70 – 80 % share of the total value of the parameter and about 10 – 15 % share of the total number of elements),
- category B includes the moderately important items (approximately 15 – 20 % share of the total value of the parameter and about 15 – 20 % share of the total number of elements)
- category C contains the relatively unimportant items (approximately 5-10 % of the total value of the parameter and about 60-80 % of the total number of elements).

This classification is based on the Pareto principle and the analysis of a range of items that have different levels of significance and should be handled or controlled differently. Graphic presentation of the ABC analysis results is carried out using Lorenz curve, an indicator that reflects the concentration of the studied phenomenon. The curve plots the cumulative expression of the individual variables (OECD Glossary of Statistical Terms - Lorenz curve Definition, n.d.).

ABC analysis is the most widely used technique in inventory management (Douissa & Jabeur, 2016). According to Chen et al. (2008) recent trend is to develop various procedures to conduct ABC analysis in terms of multiple criteria. In our study, ABC analysis provides information on how the individual thematic areas contribute to the absolute value of the Eco-innovation Index of Slovakia. It provides a mechanism for identifying areas that will have a significant impact on the overall eco-innovation situation in Slovakia. It is important for deciding whether to support or eliminate these thematic areas within the strategy in Slovakia.

All thematic areas of Eco-innovation Index were chosen as the evaluation object, and they were listed in descending order according to their contribution to the Eco-innovation Index of Slovakia. Subsequently, percentage shares of individual thematic areas were calculated and according to the calculation of the accumulated value (%) the results were presented graphically by using the Lorenz curve (Loučanová, Nosáľová, 2020).

2.3. RESULTS AND DISCUSSION

Based on the data from Eurostat (2021) and the European Commission, Environment, Eco-Innovation Action Plan, The Eco-Innovation Scoreboard, the Eco-Innovation Index (2021) and SDG index (2021) we made the correlation and regression analysis of the dependence between total ecological innovation index and sustainability index to Slovakia, Table 2. (Source: authors' computation).

Table 2.2. Results of statistical evaluation

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,718846
R Square	0,516739
Adjusted R Square	0,436196
Standard Error	1,58283
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	1	16,07348	16,07348	6,41566	0,044504
Residual	6	15,03211	2,505351		
Total	7	31,10559			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	63,88629	4,879364	13,09316	1,22E-05	51,94691	75,82566	51,94691	75,82566
Eco-innovation	0,17384	0,068632	2,532915	0,044504	0,005903	0,341778	0,005903	0,341778

The result of the correlation analysis is the first part of the regression statistics output. The value of the correlation coefficient is 0.718846. The closer this value is to 1, the stronger the dependence is. In our case it is a high degree of tightness of the relation between sustainability and ecological innovations in Slovakia. The value of R-Square is the value of the determination coefficient and in our case, it is the value of 0.516739. This multiplication value of 100 indicates that the selected regression line explains the variability in average sustainability to about 51.67 %. The other represents unexplained variability, the impact of random factors, and other unspecified effects. Adjusted R-square also considers the number of estimated parameters and the number of measurements. The Standard Error should be as small as possible. The analysis of the dependence between sustainability and ecological innovations was carried out for Slovakia. In the ANOVA section, we are testing a null hypothesis that argues that the chosen model to explain dependency, is not appropriate (an alternative hypothesis claims the opposite). The F test is used to evaluate this claim. Significance F = 0.044504 $<$ 0.05 (α - significance level). It means we reject H0, which means that the model has been chosen correctly and therefore sustainability is dependent on eco-innovations.

The analysis in this section is largely based on the approach of European Commission (Eco-innovation Action Plan (n.d.). The Sustainability index and Eco-Innovation Index, a composite index indicator, allows measuring the eco-innovation performance of different EU member states. Ranking of EU member states is dependent on their deviation from the EU average. The best-rated countries are Sweden as the absolute leader in this field, followed by Finland, Germany, Luxembourg, Denmark, Slovenia, Austria, Italy, Spain, Portugal, and the United Kingdom, which obtained more than EU average. Sweden has the highest score across the EU-Members.

The position of Slovakia according to Eco-innovation Index in 2021 compared to other EU countries is below the EU-average. Slovakia is among ten member states with the lowest ranking in this field. The obtained score of 74 ranks Slovakia at 21st place from 28 EU countries. Slovakia is in the group of moderate innovators countries with an innovation performance below the EU-average.

In the case of the Eco-innovation Index, a high overall ranking does not necessarily mean that a country has performed well in all eco-innovation areas covered by this index or does not. The results of the index can only provide messages about the overall country performance in relation to eco-innovation. Rizos et al. (2015) emphasize that drawing conclusions about specific eco-innovation aspects and country trends requires a careful analysis of the sub-indicators covering these fields.

Eco-Innovation Index also aims to assess how eco-innovation is unfolding in several relevant areas such as R&D investments, the performance of firms and socio-economic and environmental outcomes. The Index includes 16 different indicators that are classified into five thematic categories: Eco-innovation inputs, Eco-innovation activities, Eco-innovation outputs, Resource efficiency outcomes and Socio-economic outcomes.

For more detailed analysis we identified the value of all 16 individual indicators of Eco-innovation Index thematic areas of Slovakia according to the Eco-Innovation data of European Commission. We calculated their percentages as well as the cumulative values that tend to classify these indicators into A, B, C groups according to their importance for eco-innovation in Slovakia (Table 3).

Table 2.3. Data for ABC analysis Eco-innovation Index indicators of Slovakia in 2021 according to Eco-Innovation Database

Indicators of Eco-innovation Index of Slovakia	Value	% of total	Cumulative %
Water productivity	284	22.00	22
ISO 14001 registered organizations	187	14.48	36.48
Eco-innovation related media coverage	160	12.39	48.88
Eco-innovation related academic publications	115	8.91	57.79
GHG emissions intensity	113	8.75	66.54
Exports of products from eco-industries	65	5.03	71.57
Material productivity	64	4.96	76.53
Energy productivity	62	4.80	81.33
Total R&D personnel and researchers	59	4.57	85.90
Enterprises that introduced an innovation with environmental benefits obtained by the end user	54	4.18	90.09
Enterprises that introduced an innovation with environmental benefits obtained within the enterprise	53	4.11	94.19
Eco-innovation related patents	41	3.18	97.37
Governments environmental and energy R&D appropriations and outlays	20	1.55	98.92
Total value of green early-stage investments	14	1.08	100.00
Turnover in eco-industries	0	0.00	100.00
Employment in eco-industries	0	0.00	100.00

The impact of Eco-innovation Index individual indicators of Slovakia illustrates Figure 1. ABC analysis can help to manage various items more efficiently by breaking them down into 3 easily digestible categories A. B. C. regarding Pareto principle that explains that 80 % of consequences result from 20 % of total possible reasons (Sixta & Žižka, 2009). Category A items: Water productivity, ISO 14001 registered organizations and Eco-innovation related media coverage are the most important and contribute significantly to the eco-innovation index of Slovakia. Category B items: Eco-innovation related academic publications, GHG emissions intensity and Exports of products from eco-industries items but with a lot of potential to improve. Remaining items refer to the group C. They represent the most numerous group of indicators however with the lowest share on the total Eco-innovation Index effect.

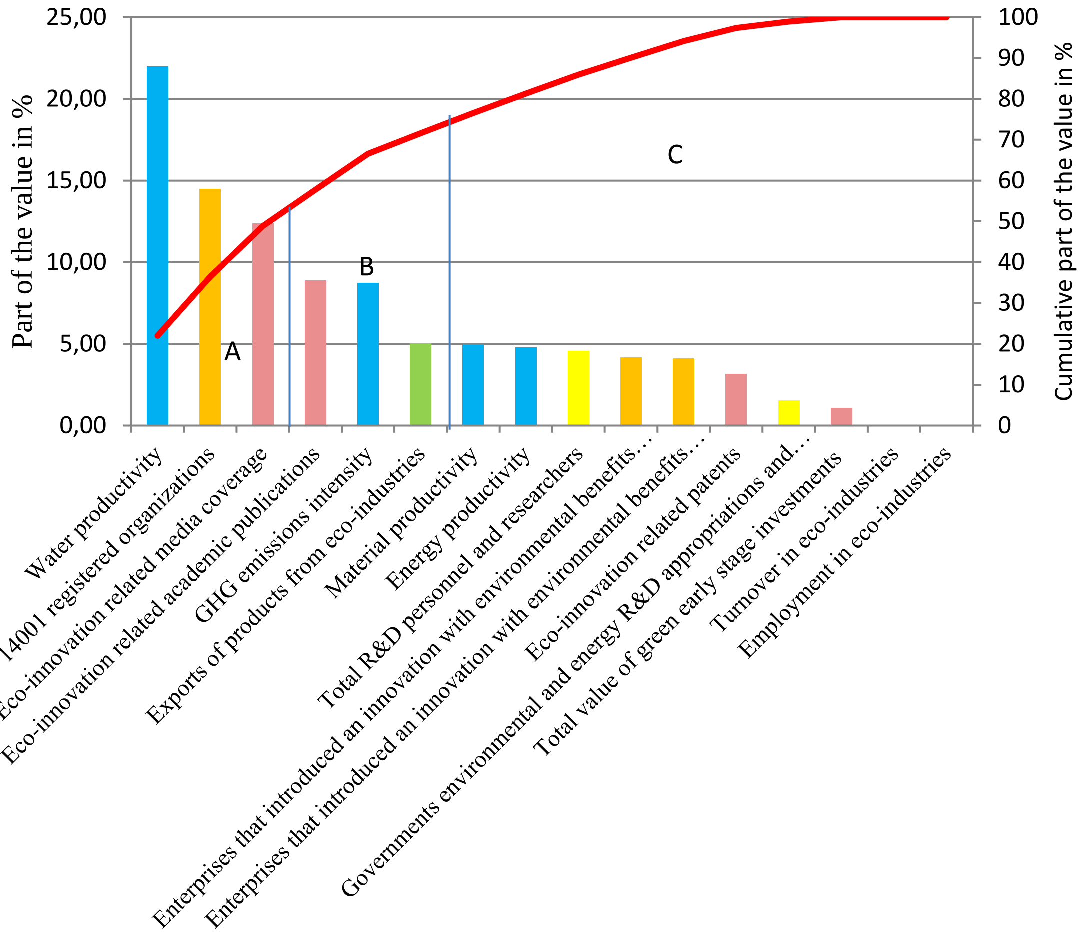

Figure 2.1. ABC analysis of Eco-innovation Index indicators of Slovakia in 2021 according to Eco-Innovation Database

Eco-Innovation Index is positively influenced mainly by the activities carried out in the mentioned areas (Resource efficiency outcomes, Eco-innovation activities and Eco-innovation output). These activities include Water productivity, ISO 14001 registered organizations, Eco-innovation related media coverage. The other conducted activities do not influence the positive development of eco-innovation in Slovakia so significantly.

Eco-innovation in Slovakia has a rising tendency (Figure 2). from the perspective of the development during the last eight years (2010-2021). It is worth noticing the year 2013 and 2019, what was heavily influenced by indicators in the area of socio-economic outcomes.

That decrease according to ABC analysis was significantly caused by negative development mainly in Governments environmental and energy R&D appropriations and outlays, Total value of green early-stage investments, Turnover in eco-industries and Employment in eco-industries. Stagnant is the area of Eco-innovation inputs and socio-economy outcomes. Their improvement should be a challenge for Slovakia.

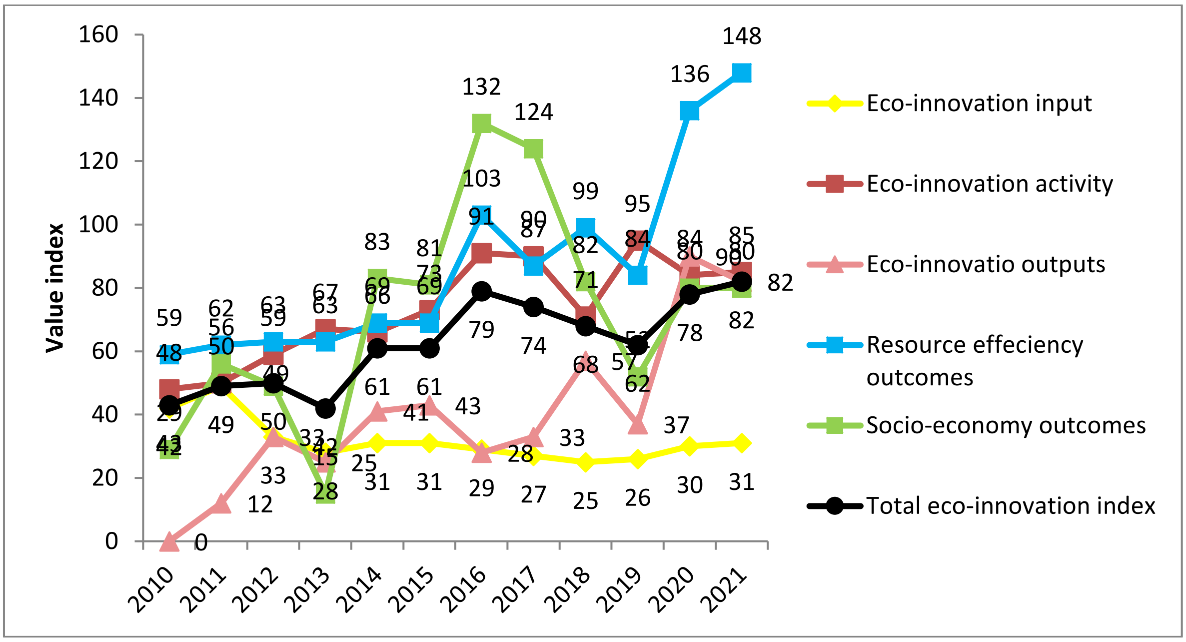

Figure 2.2. Development of Eco-innovation Index thematic areas of Slovakia in 2021 according to Eco-Innovation Database (Eco-innovation Action Plan |. n.d.)

To reverse this situation, it is convenient to support export of products from eco-industries, material and energy productivity research and development in the area of environment energy research within the open system of innovations and also to research in other areas connected to environmental policy of Slovakia for sustainability growth.

Based on the above findings, we can say that the promotion of eco-innovation in Slovakia has a growing tendency. Therefore, eco-innovation in Slovakia should continue to be implemented. Continued support for eco-innovation in Slovakia would encourage a positive rate of growth of the Eco-innovation Index and approaching the EU average, and sustainability growth too.

Eco-innovation is supported in particular by the National Strategy for Sustainable Development approaches (Národná stratégia trvalo udržateľného rozvoja. n.d.). in Slovakia. The strategy is directly linked to the major priorities of the EU, UN and OECD which support eco-innovation and sustainable development (Green Beings, 2015). This strategy deals with the economic growth focused on the long-term needs of society and respecting environmental approaches. It considers the criteria for maintaining and supporting biodiversity vitality and resistance of ecosystems. optimizing the spatial arrangement and functional use of the landscape and ensuring its territorial system of ecological stability maintenance and support of life-assurance systems maintaining a high quality of the environment minimizing the use of limited resources, i.e. wood.

2.4. CONCLUSION

1. The existing dependency between sustainability and the eco-innovation index.
2. The research of Slovak eco-innovative development has shown that Slovakia is the country with low level of eco-innovative efficiency.
3. Slovakia had reached the score below the EU-28 countries' average, and it needs more effective supporting program.
4. Water production, ISO 14001 registered organizations and eco-innovation related media coverage related to eco-innovation belong to the most important factors which contribute to Eco-innovation index in Slovakia in 2021.
5. The negative development during last few years in Slovakia is mostly in the field of eco-innovation inputs and socio-economic outcomes in 2021.

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3. SUSTAINABLE DEVELOPMENT – INTERNATIONAL FRAMEWORK – OVERVIEW AND ANALYSIS IN THE CONTEXT OF FORESTS AND FOREST PRODUCTS – OPPORTUNITIES FOR SUSTAINABLE MARKETS – LITERATURE REVIEW

Annika Hyytiä

Policy and regulation have an important role in the sustainable development processes. Forest policy with bioeconomy can enhance sustainable development globally. Product and process certifications are linked with circular economy and life cycle. Stakeholders' collaboration is crucial. Standards and forest certification are increasingly used nowadays.

This study shows an increasing policy interest from the companies for the circular economy. An international scale is a prerequisite in most cases. Sustainable development is a common goal in the policy and strategical sector in the sphere.

This is a qualitative research based on academic scientific databases and policy literature.

3.1. INTRODUCTION

Global forest goals include: Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change; Enhance forest-based economic, social and environmental benefits, including by improving the livelihoods of forest-dependent people; Increase significantly the area of protected forests worldwide and other areas of sustainably managed forests, as well as the proportion of forest products from sustainably managed forests; Mobilize significantly increased, new and additional financial resources from all sources for the implementation of sustainable forest management and strengthen scientific and technical cooperation and partnerships; Promote governance frameworks to implement sustainable forest management, including through the United Nations forest instrument, and enhance the contribution of forests to the 2030 Agenda for Sustainable Development; Enhance cooperation, coordination, coherence and synergies on forest-related issues at all levels, including within the United Nations system and across member organizations of the Collaborative Partnership on Forests, as well as across sectors and relevant stakeholders. (The Global Forest Goals Report 2021)

3.2. FROM FORESTS TO BIO-BASED ECONOMY, BIOECONOMY AND CIRCULAR ECONOMY

Bio-based economy has been regarded as an opportunity to diminish the dependency on fossil resources (Majer et al. 2018). Sustainability certification and standardization of bio-based products can help in managing resources and products in a sustainable manner (Majer et al. 2018). Sustainability is the key concept behind the growing bioeconomy and it can contribute to a transition towards sustainability (Gawel, E.; Pannicke, N.; Hagemann, N. 2019). Sustainability governance initiatives and schemes have increased essentially. Governance as a collaborative tool can contribute in finding solutions to sustainability challenges and in building appropriate levels of legitimacy and trust for their initialization and implementation. (Stupak, I., Manso, M. and Tattersall, S. C. 2021). National and regional actors are encouraged to carefully and holistically develop their bioeconomy monitoring systems (Linser, S. and Lier, M. 2020)

The bio-based economy relates to bioeconomy which relates to green economy, and circular economy, and there are obvious synergies between these concepts, notably between the bioeconomy and circular economy concepts. (Kardung et al. 2021) Sustainable forest-production management means understanding, planning, and balancing different goals and actions to obtain optimal ecosystem services to legitimate stakeholders, and avert risks of negative environmental effects. (Högbom, L. et al. 2021)

Circular Economy based in forests is a significant framework for maximizing and optimizing both the economic and environmental benefits of wood (Baldwin, R. F. 2020). The sustainable use of renewable resources has become an important issue globally with the change to a less fossil-fuel world. This is possible increasing the share of renewable energy and materials to substitute fossil fuels in the long-term. (Karvonen, Jaakko, H. et al. 2017) Sustainable development processes are useful in firms in Circular Economy and knowledge around new business models in governments and firms is growing (Barbaritano, M.; Bravi, L. and Savelli, E. 2019).

Industries reuse materials for value-added production and promote. (Pitti el al. 2020)

3.3. CSR, TRADE, FOREST CERTIFICATION AND ECOSYSTEM SERVICES

For quality and competition as well as for global trade of legal and sustainably harvested timber, forest certification plays an important role. (Chen et al. 2020). Sustainable forest management is a crucial part of sustainable development and requires ecological, economic and social sustainability, a consensus among stakeholders and an approach and partnerships crossing sectors (FOREST CERTIFICATION – DO GOVERNMENTS HAVE A ROLE 2005). Demand is an important driver for the forest and CoC certification. With the consumer market impact the demand is essential in global corporations, governments, NGOs, and investors (Holopainen, J.; Toppinen, A. and Perttula, S. 2015). Enterprises highlight sustainable forest management for the acquisition of their certification scheme. (Sugiura, K. and Oki, Y. 2018)

International processes and certification schemes collaborate (Freer-Smith, P. and Carnus Jean-Michel 2008). The concept of forest certification emerged in tropical deforestation and forest degradation. As an independent certification for the quality of forest management, forest certification was developed in the 1990s as a voluntary tool to promote sustainable forest management and the trade of products from sustainably managed forests (FAO 2021b).

Firms can promote sustainable products differentiating in the competition using certification systems. Firms produce circular wood products and provide their consumers with differentiated, immaterial properties as unique aesthetics, intrinsic sustainability, local production, historical significance and sentimentality. With wood raw material utilization for value-added production, there exist significant environmental benefits. (Pitti, A. R.; Espinoza, O.; Smith, R. 2020)

With economic globalization and the spread of corporate social responsibility, the CSR, corporations are changing more and more from reactive to more proactive strategies in their environmental, social, and governance strategies. Wood-based panel processing enterprises are essentially sensitive to environmental and social issues and ever more developing their CSR strategies. With new strategies and practices in sustainable environmental and social aspects, the leading enterprises in the Chinese wood-based panel processing industry are improving the CSR. (Lu et al. 2018)

Results indicate that forest certification is positively appreciated as a supporting tool for ecosystem services (Paluš, H.; Krahulcová, M. and Parobek, J. 2021). Forests provide many ecosystem services including wood and fibre production. The management of forests for improved ecosystem-services contributes importantly to sustainability. With forestry, forests endorse multiple United Nations Sustainability Goals and EU policies. Carbon sequestered by growing trees is a key factor in the planned transition from a fossil-based to a bio-based economy. (Högbom, L. et al. 2021)

Forest certification has been widely recognized as a market-based mechanism compared to government-led policies and regulations (Lewin et al. 2019). Sustainable forest-production management means understanding, planning, and balancing different goals and actions to obtain optimal ecosystem services to legitimate stakeholders, and avert risks of negative environmental effects. (Högbom, L. et al. 2021)

The primary certification requirements include: compliance with the law, well-written and coherent forest management plans, the implementation and monitoring of operations to reduce forest damage, adequate working conditions and good relations in and around the forest under the certification process. Certification has been shown to be a valuable tool in the marketplace for products. So, certification is very common in the major markets. Legal requirements can also be shown to be fulfilled with a confirmation for a product – preventing the trade of illegal timber products. Forest certification can enhance the working conditions and safety and health of forest workers. It can improve forest conservation outcomes. It can also encourage use of forests sustainably. Forest certification can advance the image of companies using certification in their forest operations and favoring certified products. (FAO 2021)

Over 330 million hectares of forest area are managed in compliance with the PEFC's internationally accepted sustainability benchmarks. According to a joint research, the PEFC and the FSC concluded that in mid-2020, of global forest area were double certified with an increase of 3% since mid-2019. Altogether 55 national members, with 48 endorsed national certification systems have joined under the PEFC umbrella. (PEFC 2021) In January 2020, double certification existed in 33 countries. This data only covers forest area certified by FSC or a PEFC-endorsed system and not the areas certified by other schemes. (FSC PEFC 2020).

3.4. FOREST CERTIFICATION, STANDARDS AND MARKETING

Standards act as regulations (Singh et al 2021). Certification can be regarded as a proof of sustainability. Collaboration between multiple parties is often crucial as for forest certification. (Forest Certification Update 2021: The Pace of Change 2021)

Forest certification is a voluntary process by which an independent third party estimates the quality of forest management and production with requirements, standards, by a certification organization which can be public or private. Forest certification with a label gives a certification for consumers about the sustainability of the forests from which wood and other forest products originate. Certification of forest management assesses whether forests are being managed by specified standards. Certification of the chain of custody, CoC, verifies the certified material in the whole production process. Forest certification is a mechanism for marketing the sustainable use and management of forests and sustainably produced products for the consumer. (FAO 2021).

The majority of the certified area is situated in Europe and North America (in 2019) (FAO 2021b). Use of forest certification schemes in the UNECE Region is growing constantly (Forest management certification in the UNECE region 2021). The UNECE region constitutes of more than 47 million square kilometres including as member states the countries of Europe, Canada and the United States of America in North America, Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) and Western Asia (Israel) (UNECE Geographical Scope 2021).

3.5. CONCLUSION

Policy and regulation have an important role in the sustainable development processes. Forest certification features also the corporate social responsibility approach. It is important to acknowledge the opportunities of the sustainable development approach, standardization, policy and industry.

Grounded on forest ecosystem services, within a bio-based economy, forest certification is a voluntary market-based mechanism. It can serve as a participatory process. Standards and forest certification can be part of regulation. Forest policy can enhance sustainable development globally. Stakeholders' collaboration is crucial.

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4. ACCOUNTING AND TAX ASPECTS OF LOSSES ON THE QUANTITY OF HARVESTED AND TRADED TIMBER

Petra Hlaváčková, Dalibor Šafařík

4.1. INTRODUCTION

Losses in the amount of timber, especially the accidental ones, are a long-term issue for both the forestry public and forest owners. The objective determination of accidental losses – the natural decreases in amount, has always been an important factor for determining the liability of employees for any damage caused to the forest owner or for the loss in the amount of timber.

Often times, harvested timber is measured several times and therefore its reported dimensions differ (there are objective reasons for this).

A significant phenomenon are differences between the values measured by the seller and the buyer caused by differences in methods used for determination of the timber quantity. Often times, final timber processors are in the position of the dominant subject in transactions (i.e. demand dominates over supply) and thus it is them who sets the method or various factors for determination of amount of timber. Given that it is the decisive processing capacities who typically do this, the suppliers of timber do not have much choice.

These days, this issue is approached in various ways that significantly differ in individual forest or timber owners. Although some of them define their approaches in internal directives, the issue is not addressed consistently in terms of financial management.

A realistic solution seems to be the use of liberal regulation in recording the amounts of losses by employing the institute of accidental losses, i.e. losses up to the amount of an accidental decrease standard.

The aim of the chapter is to present a methodological approach to determining loss standards for the quantity of harvested and traded timber in the context of accounting and tax legislation in the Czech Republic.

The article is an important contribution from the accounting theory point of view but also it has practical implication for forest owners and accountants in forest enterprises.

4.2. MATERIAL AND METHODS

Regarding the related accounting and tax, this chapter mainly builds on bibliography research in both domestic and foreign publications, accounting and tax legislation, and experience of the authors in the issue. From the global perspective, the chapter proceeds from the IAS 2 and IAS 41 International Accounting Standards, the method by Mowen, Hansen, Heitger (2012), who mainly focused on cost and management accounting, and articles by Aziz (2015), who dealt with material losses in cost accounting, available on the Internet.

From today's perspective and considering the territory of the Czech Republic, even more important are the accounting and tax regulations on deficit standards. These mainly include Act No. 563/1991 Coll., on accounting, as amended (hereinafter referred to as the "ZoÚ") and the related implementing regulation – Decree No. 500/2002 Coll., on implementing certain provisions of Act No. 563/1991 Coll., on accounting, as amended, for entities representing businesses that use the system of double-entry accounting, and Czech Accounting Standards (hereinafter referred to as the "CAS") for business entities. The issues are mainly covered by the standards No. 015 and No.007. The CAS 015 (part 4.4.4.) stipulates that an entity may lay down standards of natural stock losses for the respective period.

The CAS 007 pays more attention to standards, focusing mainly on the inventory difference and losses within the scope of the natural stock losses standards (part 2.2.). Part 3.2. thereof deals with specific accounting procedures. In the cases when a stock was purchased from other entities, the inventory differences and losses within the scope of natural stock losses shall debit the group of accounts No. 50 – Consumed purchases (CAS No. 007(3.2.1a)). If the losses within the scope of natural stock losses arise from own production, they shall debit the relevant accounts of the group No. 58 – Change in stocks from own activities and capitalisation (CAS No. 007(3.2.2a)).

The issue of inventory differences in stock and fixed assets and their accounting was also addressed by the Czech National Accounting Board, see the Interpretation I-39 approved on 15 April 2019 (Březinová, Vácha, 2019).

As for the tax legislation, the most important regulation in the Czech Republic with respect to the natural loss standards is Act No. 586/1992 Coll., on income taxes, as amended (hereinafter referred to as the "ZDP"). The natural loss standards are dealt with in Section 25 thereof. It stipulates the economically justified level for the natural loss standard and the shortage rate as well as that the tax administration may assess whether the level of the set standard reflects the character of the taxpayer's activity and the usual level for standards of other taxpayers with the same or similar activity (Section 25 of the ZDP).

The Income Tax Act does not stipulate any rules for preparation of natural loss standards. There is also no regulation obliging an entity to create the standard in question. Nevertheless, if a business operator carries out an activity from which natural losses arise, it is in their own interest to lay down such standards. Of the regulations which addressed this issue before the year 1989, it is particularly worth noting Decree No. 210/1954 of the Ministry of Internal Trade, which stipulated the standards of deficits arising from natural loss of solid compacted fuels and fuel wood, and Decree No. 189/1964 Coll. of the Ministry of Internal Trade, on standards of non-culpable deficits in internal trade organisations.

4.3. ACCOUNTING AND TAX INSIGHT INTO THE TIMBER SALES

From the perspective of Act No. 563/1992 Coll., on accounting and implementing regulations (Degree, Czech Accounting Standards), the logged wood in varying states of processing (unfinished products, semi-finished products, products) falls within stocks of one's own production. Based on the stage of processing, accounting is performed on the following locations: stump (S), collection site (CS) and shipping warehouse (SW). The stock of standing timber registered in the records of the forest management plan are not subject to stocks within the framework of current assets.

The state and the movements of stocks of one's own production are listed in units of measure and monitored at the end of the billing period (usually a month or a year). The basic unit of measurement is m^3. For stacked up wood, the unit is stacked cubic meter, which is converted to m^3 based on a reduction factor. The in-house price of wood, calculated from "own costs", is entered into the financial accounting. These costs are posted on cost accounts as a counter value of revenue accounts of the accounting group called Changes in status of stocks of one's own production. The basic change of the status of stocks of wood occurs if:

- the stocks of wood increase – receipt at: S site – logging, purchase of logged wood at the stump, receipt and manipulation at the S; CS – gathering wood, purchase of wood at the CS, receipt from handling at the CS; SW site – transporting wood from the CS to the SW, purchase of wood at the SW, receipt from handling at the SW.
- the stocks of wood decrease – handing over from: S site – collection of wood, sale of wood to the CS, handover for handling at the S, wood consumption at the S; CS – transportation from the CS to the SW, sale of wood at the CS, handover for handling at the CS, wood consumption at the CS; SW – deliveries of wood from the SW, handover for handling at the SW, wood consumption at the SW.

In the above quantified flows of wood in units of measure, a gradual increase of one's own production expenses occurs. Thus, the value of the stocks at the individual sites grows (lowest at the stump, highest at the shipping warehouse). The accounting expression of this change uses the method of "phase calculation".

The final stage of the movement of the stocks within the business is their removal from the warehouse and the subsequent sale. The stocks of wood are released from the warehouse using a bill from the group Changes in status of stocks of one's own production. When selling wood, the company receives revenue i.e. takings from the sale of one's own products.

From the perspective of Act No. 586/1992 Coll., on income taxes, as amended, the changes in the status of stocks of one's own production also include revenues from sale achieved via tax revenues, which may be reduced by expenditures demonstrably made for achieving, securing and maintaining such sales.

Other accounting and tax aspects of the logged wood arise in the case of registering the volume of wood. The accounts record the volume of wood registered for the purposes of production and the purposes of keeping forestry records; they also record the volume of wood registered during sale. The accounting unit (organization) is, based on the accounting Act, obligated to regularly determine and compare the accounting and physical status of the stocks of wood on a per-warehouse basis (sites, organizational units, companies), i.e. to perform a stocktaking of property and payables. Regular stocktaking of wood supplies is performed at least once a year, extraordinary as needed. Based on the facts determined during the stocktaking of volume stocks (amount of wood in m^3 or other technical units) and qualitative stocks, it is the duty of the wood owner to bring the physical and accounting status of the wood into accord by the date of stocktaking. Obviously, in case of divergent documents, differences occur between the amount of wood produced and sold in either negative (shortages) or positive (overages) values. One of the reasons for the divergence may be the new measurement performed by the customer during delivery. In terms of accounting, overages are viewed as revenue while shortages as non-deductible tax expenses. The resolution of stocktaking differences must be based on an in-house directive, which states in what ways the shortages and overages will be handled and posted. Since these expenses are non-deductible, this fact must be taken into account when compiling a tax return, and the item must be added to the economic result when calculating the basis for the income tax.

4.4. A PROPOSAL TO SOLVE THE ACCOUNTING AND TAX IMPLICATIONS OF TIMBER LOSSES

4.4.1. Timber volume losses

Losses in the amount of timber can be divided into three groups: culpable losses, uncaused losses and losses caused by a third party.

1. Culpable losses are further divided into:
   a) losses due to incorrect measurement,
   b) losses due to improper storage (these relate more to losses on quality than quantity),
   c) administrative errors in the stock register.
2. Uncaused losses include:
   a) losses during technical procedures of wood transportation and handling,
   b) natural wood losses,
   c) differences based on different measurement, rounding and volume detection methods,
   d) wood losses in natural disasters,
   e) depreciation of wood stocks due to technological unavailability,
   f) depreciation of wood due to long-term storage.
3. Losses caused by third parties:
   a) theft of wood,
   b) natural disasters caused by negligence.

If culpable losses cannot be corrected in accounting when detected, these are treated in the accounts as Shortages and damages – analytic non-tax expense.

Uncaused losses shall be elaborated on further below. Losses during technical procedures of wood transportation and handling are of two kinds.

2. a) 1 Loss of volume of wood measured in bark (bark abrasion): log loss: 1 % – loss of bark by abrasion at skidding distance of up to 400 m; 2 % – loss of bark by abrasion at skidding distance of above 400 m; 0.5 % – loss of bark in the skidding technology (forwarders). For larch, the values increase up to a double.

2. a) 2 Wood loss during handling: wood loss, where the excess (technological addition) according to Czech State Standard during the first measurement is not sufficient to cover the excess required by the processor; also includes the loss in length due to deburring and levelling off the rootstock of the log before handling, as well as loss of thickness of the required amount of cuts needed for certain products. Loss in log volume: 4 % for stocked coniferous wood, 5 % for stocked deciduous wood, 1 % for long coniferous or deciduous wood. Wood losses for these reasons up to the specified amount are treated as Shortages and damages – analytic non-tax expense.

2. b) Natural wood loss by drying up – natural wood loss caused by the most important influences on the dry-up rate can be applied only to wood logged since the end of the dormancy period to the 30th of June (for non-debarked wood) or to the 31st of July (for debarked wood): 1 % volume loss in a non-debarked log stored for more than 90 calendar days in a period when the rainfall deficit amounts to at least 50 %; 2 % volume loss in a debarked log stored since debarking for more than 30 calendar days in a period when the rainfall deficit amounts to at least 50 %; 3 % volume loss in a debarked log stored since debarking for more than 30 calendar days in a period where the rainfall deficit amounts to more than 75 %, or debarked wood stored for more than 50 calendar days at a rainfall deficit of between 50 to 75 %. Higher decreases in wood mass due to drying up can be officially recognized only after remeasuring. Loss caused by drying up to the set limits or confirmed by remeasuring are treated in accounting as Shortages and damages – analytic non-tax expense.

2. c) Different measurement, rounding and volume detection methods used during sale lead to differences between the amount of wood released from storage and the amount of wood received. These are differences which cannot be influenced and will likely be eliminated by the transition from ČSN to EU standards. Differences are charged to the debit of the party responsible for wood shipment (transport). The stocked out supplies are not corrected based on the consignment note if the total difference for the delivery is as follows:

- round logs, up to +6 % of the amount,
- pulpwood, up to +10 % of the amount.

When selling wood via a trade organization with a contractual obligation to issue a credit note to the trader only for the difference in price, the credit note is issued without affecting the stock records. Therefore, only the decrease (increase) of financial claim and revenue is posted, and not the increase (decrease) of the stock in the warehouse. Larger differences (negative) must be resolved within a complaints procedure. For pulpwood, a record must also be made at the shipping warehouse in case substandard material (rotted out rootstocks and wood affected by rot) has been delivered for weight inspection. Based on the results of these solutions, the difference is either charged to the debit of the sale performance up to the established limit or up to the total difference (in case of delivery of substandard material); alternatively, the total or partial difference is returned to the warehouse, while issuing a credit note (debit note).

2. d) Wood losses in natural disasters – the amount is ascertained via exceptional stocktaking. It is charged as Shortages and damages – analytic non-tax expense.

2. e) Write-off of wood supplies due to technological unavailability – an exceptional case, where, based on a contract, due to obtaining a complete order, the logging company undertakes to also log and purchase wood from the forest owner (often for a symbolic amount) which is located at a site which is difficult to access. Based on economic assessment, it is known or later discovered that the expenses for skidding would significantly (often several times) exceed the potential revenue for the sale of this wood. Thus, an economic result would occur which would be much higher than during the stock write-off. The loss is proven by a quotation from the skidding provider or by calculation. Based on a proposal by the stock commission, the wood is written off from the stocks and is charged as Shortages and damages – analytic non-tax expense.

2. f) Depreciation of wood due to long-term storage – an exceptional case where, within the complete order and on the request of the forest owner, disseminated trees are also logged, but at a time when there is no demand on the market, while the wood type depreciates quickly, such as is the case with birch or beech. After an evaluation by the stock committee on whether these conditions are met, the wood is written off from the stock as Shortages and damages – analytic non-tax expense. Other cases will be charged to the analytic account – non-tax expense.

3. In losses caused by a third party, the amount is ascertained via exceptional stocktaking. Write-offs from the stock are performed to the Shortages and damages – analytic non-tax expense account depending on Act No. 586/1992 Coll., on income tax, whether the culprit has been found or not, with a potential for financial claim to be filed.

4.4.2. Procedure when resolving differences in stock found during stocktaking

The stock registry is adjusted based on the problems found in the registry. If losses found according to 2. d), e), f) or losses caused by a third party were not written off from the stock during the year, they are written off now.

The calculation of the amount of uncaused losses from point 2. a) 1 is performed from the amount of wood logged in the period between the stocktakings of wood stocks in relation to auxiliary records which will be used to ascertain the skidding distances of the individual logged areas (stands). Further calculation is performed from the registry of skidding technologies.

The calculation of uncaused losses according to 2. b) is performed from auxiliary records which provide the necessary data. The rainfall deficit amount is taken from the data provided by the Czech Hydrometeorological Institute for the given area.

The total difference between the actual wood stocks and the warehouse stocks is compared with the sum of the calculated uncaused losses. If the difference in wood stocks is lower than the calculated uncaused losses, a correction (reversal) of the production accounting is made in the amount equal to this difference.

If the difference in wood stocks is higher than the calculated uncaused losses, the difference in the amount of calculated uncaused losses is charged as a correction (reversal) of the production. Amounts exceeding the acceptable losses are charged to the account of Shortages and damages – analytic non-tax expense.

4.5. CONCLUSION

Based on the analysis of the available documents, there is no specific regulation or guideline in either the Czech Republic (mainly in ZoÚ; CAS; ZDP; Dušek, 2018; Morávek, 2015; Procházka, 1972, etc.) or abroad (Herbohn, Herbohn, 2006; Aziz, 2015; Pecenka, Lenz, Hering 2020, etc.) which would specifically stipulate the method for establishing standards of natural losses of individual biological assets, including timber, and the method of keeping a record of items of cost or management accounting (see Mowen, Hansen, Heitger, 2012; Aziz, 2015).

All publications recommend entities to lay down their own internal rules which should stipulate the standard natural loss for the given entity based on their experience and considering the character of their activities and the usual level of standard of their competitors. Consequently, the tax administration shall assess the methods individually based on the specific conditions of the given entity. This, then, are some recommendations based on the experience of the individual authors and entrenched practice.

As early as in 1972, the Ministry of Agriculture and Nutrition of the Czechoslovak Socialistic Republic presented only recommended standards of deficits, known as “Listovka” (see Procházka, 1972), as an aid for the formation of internal directives. It mentioned (Procházka, 1992) that losses of biological stock which arose from natural loss in amount or change in the quality of stocks in storage were determined by a percentage of the set material basis and deficit standards were established to cover the natural and non-culpable losses originating, among others, from long-term storage (drying out, evaporation, rotting, degradation, etc.).

It follows from the accounting rules that an entity should lay down internal rules for:

- Selected stock types (item-based) to which the standards do not apply,

- The level of the natural losses (as a percentage) for the individual stock items,
- The purpose of the stipulated standards, in this case of the standard of natural losses due to shrinkage at long-term storage,
- Conditions on which the loss standards may be applied,
- The basis from which the total loss is calculated,
- The method for calculation of the loss for standards,
- Cases to which the loss standard does not apply.

The formation of a standard of losses must be based on the correct stock record and inventory results, which is also stressed in the mentioned Decree No. 210/1954 Coll. of the Ministry of Internal Trade. At the same time, it is necessary to observe the actual losses for a certain period with respect to their nature. An entity shall carefully observe and record the natural loss due to spray, shrinkage, etc. and regularly weigh, measure and control a certain amount of stock and keep records thereof, which can be used to determine the cause of the losses.

If the financial administration could be consulted concerning an internal directive upon its creation and potential disagreement could be discussed, there would be fewer irregularities. The problem is that if there is a need to assess the set standards stipulated in and required by Section 25(2) of the ZDP, the institute of a binding assessment by a tax administration pursuant to Section 132 of the tax code (Act No. 280/2009 Coll.) cannot be used. According to Dušek (2018), this is only possible in the cases mentioned in the tax law, i.e. there are 7 such cases according to the and 3 cases according to other acts, i.e. not in the case of natural stock losses. However, it can be said that since the value of natural losses is accounted as a cost and hence is included in the product price in advance, it cannot be seen as a tax error from the perspective of tax laws.

Pursuant to Section 25(2), the tax administration shall assess whether the level of the set standard reflects the character of the taxpayer's activity and the usual level of the standard of other taxpayers with the same or similar activity, and correct the tax base with the found discrepancy. The taxpayer shall get economically justified standards for tax eligibility.

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14. ***: Decree No. 189/1964 Coll. of the Ministry of Internal Trade, on standards of non-culpable deficits in internal trade organisations.

5. THE ROLE OF LIFE CYCLE ASSESMENT IN BUSINESS AND PRODUCTION PROCESSES IN WOOD INDUSTRY: A LITERATURE REVIEW

Andreja Pirc Barčić, Kristina Klarić, Tajana Kruhak

5.1. INTRODUCTION

Sustainable development concept is an effort to achieve the balance between economic, social and ecological demands, with the final goal to satisfy needs of nowadays without endangering abilities of future generations to satisfy their future needs (Brundtland, 1987). Socially responsible business regards to responsibilities of a company to contribute to sustainable development with its manufacturing and business activities. The lack of knowledge on sustainable development concept makes many actors in a chain of creating value of a product to misunderstand principles of sustainability of environment with activities of decreasing impact of production process to environment. However, according to principles of environment sustainability, the goal of so-called green process is to try to decrease impact of all activities in all life cycle phases of product and/or service (material-production-use-re-use/recycling) on environment through: emission decreasing, giving priorities to renewable material and decreasing the total costs of product/service life cycle (Shrivastava and Hart,1995). Total tracking of product or service, life cycle in perspective of sustainable development can give decision makers clear view and better understanding on three pillars of sustainable development (3P): People, Planet and Profit/Prosperity during the full supply/demand chain. All activities based on principles of sustainable environment using suitable methodology, techniques and tools, and which can contribute to this goal, are recommended. In the area of products and processes assessment, particular methodologies, techniques and tools for supporting politics and strategies of all sustainable development dimension are developed. One of the techniques for establishing and assessing the total impact on environment during production, using and displacement of products and possible re-use, is *Life Cycle Assessment* (LCA).

According to Bullinger and Gunnar (2002) the management can apply LCA as a supporting instrument for strategic planning purposes as well as for the regular gathering of product related environmental information as internal performance indicators. Furthermore, in research and development LCA comprises application areas from strategic planning to the development of procedures for the controlling of the continuous improvement process. Additionally, in order to be able to supply information efficiently about all objects to all kinds of management processes, for an example, in a marketing perspective LCA can be used as an instrument for product development, product comparison, proceeding product related information to customers, while in the context of production planning, material management, or controlling it can be used as an instrument for gathering information on purchased materials.

The fundamental premise of controlling is the comprehensive optimization of the internal business processes that result in improved economic and financial results which are an imperatve in achieving company’s competitive position in the market. According to Nesterak et a. (2016) controlling can be seen as a system that strongly supports managers at different levels, from top management to operational managers, in strategic, tactical and operational decision-making.

The developed form of controlling, i.e., executive controlling referes to the need to move from a functional operation system to an approach utilizing process management of an enterprise. This can be done, for example, in one integrated database. Bullinger and Gunnar (2002) discussed that in that case all relevant data on the objects can be taken from the integrated database within any management process to be used for the support of individual decision making processes. Nowadays, in the current economic environment, one of the most interesting issues is the implementation of the principles and tools of executive controlling as an effective and innovative instrumentation presenting a part of the executive controlling system which significantly contributes to the the management activities of the modern enterprise (Nesterak and Malinovska 2017). According to Arzoumanidis et al. (2013) some incentive researches have foreseen a connection between Enterprise Resource Planning (ERP) systems and LCA tools. Moreover, Ferrari et al. (2020) conducetd research in which they developed the Dynamic LCA system that integrates the ERP system with a customized LCA tool as avaluable tool for the evaluation and monitoring of environmental impacts related to the production process in indutry companies.

Wood products consist carbon which is absorbed during the process of photosynthesis in the phase of tree growing. Considering that for every cubic meter of growth, tree absorbs 1 tone of CO2, produces 0,7 tons of oxygen and saves 0,9 tones of CO2 in wood itself, it represents the first class carbon container (Beyer et al. 2006). That same carbon is removed from atmosphere for as long the wood is in use, but also in every following phase of a life cycle, for instance, if the project at the end of its life cycle is re-used for some other purpose/product (re-used) and/or if the product is recycled and used as a secondary material or for re-gaining energy. Even if, at the end of the products life cycle we use wood for gaining thermal energy, during burning it will release just the amount of CO2 contained during growth. Climate benefits of wood-based products can be demonstrated through life-cycle assessment (LCA). Comprehensive LCA for woodbased systems is more complex than for many non-wood alternatives (Sathre and González-García 2014).

5.2. LIFE CYCLE PERSPECTIVE

Life cycle perspective (thinking, calculating, assessing…) is the key to operationalize sustainability in supporting: policy development, decision making, circular economy (closing the loop like natural systems do!); standardization, labelling, scientific guidance, corporate responsibility, and helping reaching political goals. Furthermore, it can be discussed that Life Cycle thinking is a way of thinking that includes the economic, environmental and social consequences of a product or process over its entire life cycle.

Life Cycle Assessment (LCA) is a comprehensive life cycle approach that quantifies ecological and human health impacts of a product or system over its complete life cycle. It uses credible scientific methods to model steady-state, global environmental and human health impacts. It also helps decision makers understand the scale of many environmental and human health impacts of competing products, services, policies or actions. Life Cycle Assesment method establish the impact of the product life cycle on environment, while the analysis of impact on environment during life cycle of product (Life Cycle Impact Assessment – LCIA) is a part of LCA method since LCA involves defining the frame of analysis, process analysis, influence analysis (LCIA) and interpretation. LCA method represents important contribution to tracking sustainable development since is combines economic and ecological results in total understanding and evaluation of all products life cycle phases with an accent on social responsibility. With this technique, by using particular tools (computer softwares with particular data bases) systematic evaluation of ecological aspects of product and/or service through all phases of its life cycle on principal of inter-dependence is conducted. The assessment of a cycle is based on principle „cradle-to-cradle“. It means that the evaluation of products life cycle will include all activities and influences since gaining and distribution of raw material, production and distribution of semi-products and products, to use and turning back of the product in a form of material back to environment and/or re-use of product in some other purpose (re-cycled, re-used) (Braungart et al. 2012).That kind of approach puts in focus the importance of observing relationship between sustainable production and sustainable consumption. According to Znkhan and Carlson (1995), the primary goal for producers is to choose production, process and management activities which will have the lowest impact on humans health and environment, and for final consumers the primary goal is to choose product or service which will have the lowest impact on environment, taking into consideration the costs. Further on, the costs analysis through life cycle and analysis of costs on environment during product life cycle are methods pointed to evaluation of direct costs and benefits for environment. According to Wever and Vogtländer (2013) low values of costs on environment in the structure of product costs become key indexes in defining competitive advantage of a company, since community more and more refuses the fact that industry is able to pollute the world for free! However, the value of the product must not be left out, and that value is considered as market acceptable price of a product which customer is willing to pay. Customer considers the product value through satisfying of his needs and all activities in his life, which is enabled by buying certain product. In models for evaluation of economic and ecological elements in products life cycle, manufacturing side of influence of product (e.g. wood floor covers) on the environment (how to make products with the lowest costs on environment during life cycle) and customer side of impact on environment (how to give proper information on installing, place of use, way of maintaining, importance of habits and other „feel good„ aspects) are connected. Inlightning the manufacturers on decreasing the costs on environment, tracking the preferences of customers and inlightning the customers in decision making process for buying products with lowest costs on environment, make it possible to influence on customer readiness to give more money for ecologically acceptable product (Joint Research Centre European Commission, 2006). For instance, if potential users of wood floor covers are provided with information on importance of choosing type of product, way of installing, way of maintaining it in the context of reducing costs for customer, it is to be assumed that customer will be willing to pay more money for more expensive product if it is more acceptable for environment. In other words, the way to create sustainability requires double goals: 1) production with lower costs on environment and 2) consumption of increased value products (higher selling price). Eco-efficient value creation (EVR) puts accent on ecologically acceptable activities/results in product life cycle with a goal to create optimal values with a condition to create the lowest possible costs on environment, but not the minimal production costs. The basic condition for evaluation of previously said is for product to still be competitive on the market (for selling price of the product to be competitive on the market) with matching all quality standards, safety and functionality of a product.

Further on, if activities in tracking product life cycle enables reducing the costs on environment during product life cycle, and if its market value is increased, the „fertile ground“ is created for development of eco-innovations (Wever and Vogtlander, 2015). Regarding the fact that wood industry belongs to so-called low-tech industries (Kirner et al., 2009; Grimpe and Sofka, 2009; Sterlacchini, 1999), the accent is put on business innovations, since in such industries it is to be expected that improving of existing and/or implementation of new business innovations in chains, can bring to production process innovation and product innovation. In companies of low-tech industry, dividing innovations according to „new“ in product, process or business, is observed from a point of a company, so if some product, process or business is totally new, no matter if they are implemented in some other company, it is defined as radical innovation, and if product, process or business is improved according to previous status in the company, it is called incremental innovation (Nybakk et al., 2009). Further on, eco-innovation considers all forms of innovation activities which result or which goal significantly improves environment protection, which means that they refer to innovative products, processes or services which influence on lowering the negative impact on environment, prevent pollution and bring to more efficient use of resources.

One of the possible results of business eco-innovation in wood floor cover manufacturers is European eco-label. Development of platform and methodology for evaluation of economic and ecological benefits of wood floor covers in a product life cycle (LCA) on the principle of C2C concept, and suggested LCA models with calculated EVR indexes creates conditions for development of eco-innovative business process. Out of 83593 products with EU ECOLABEL, 2800 is from wood industry sector, where 1908 is issued for floor coverings and 892 for furniture.

5.3. LIFE CYCLE ASSESMENT

Life cycle assessments (LCAs) are an important tool to identify and to present the environmental impact of our products, based on transparent and reliable methods. By better understanding the environmental impact throughout our products lifecycle, we can make conscious decisions and prioritize our resources to benefit our environment as much as possible. Life cycle assessment (LCA) is most popular strategy to manage waste (Yay et al. 2015). By performing LCAs, we can also prove our solutions positive contribution in terms of reducing the environmental impact.

Since the 1960s, there has been public interest in reducing the harmful effects of production on the environment, especially in Europe and North America. The change of general awareness also leads to the reaction of the market itself, i.e. it requires products that are eco-friendly and can be recycled. As a result, an Environmental Product Life Assessment (LCA) methodology has emerged. The LCA first appeared in the 1960s in the United States. The first analyzes were done for Coca Cola, in order to assess the environmental acceptability of different types of packaging. At the time, this method was known as REPA19, and the focus of the analysis was energy and material consumption, as well as waste generation (Wenzel, 1997).

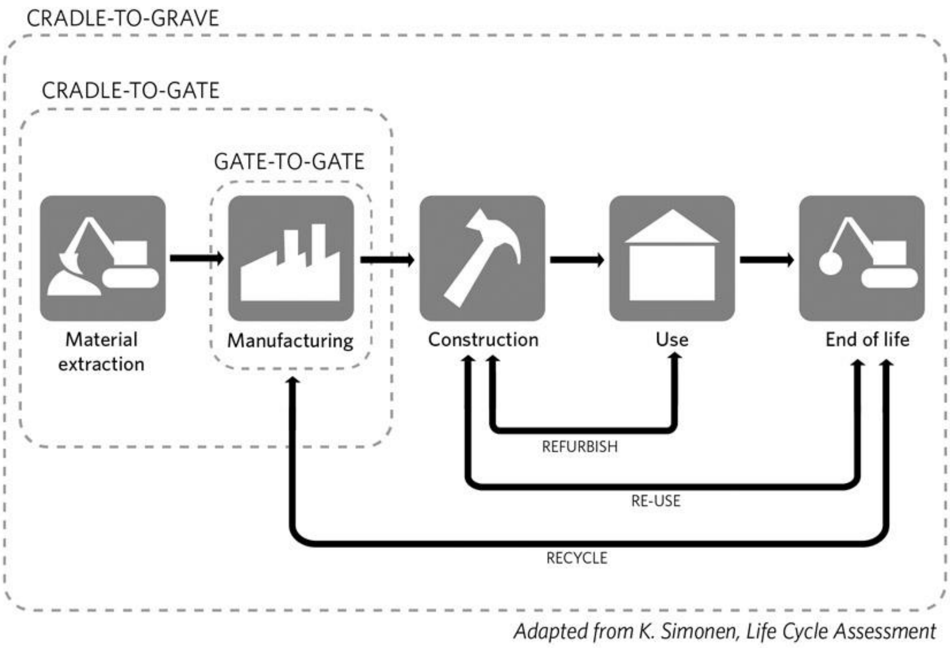

Figure 5.1. Methods for assessing the environmental impact of a product life cycle: (a) CRADLE-TO-GRAVE; (b) CRADLE-TO-GATE; (c) GATE-TO-GATE (Source: Life Cycle Assessment, Kathrina Simonen)

Figure 1, The “gate-to-gate” method which involves research on the environmental impact during production. The "cradle to gate" method involves research during material extraction and manufactoring. The "cradle to grave" method involves research during material extraction, manufactoring, construction, use and end of life. In the early 1980s, interest in assessing the environmental impact of products began to grow, and the first LCA analyzes were carried out in some European countries (again, packaging). As databases and methods were diverse, the results were difficult to compare and generally unsatisfactory, and a need for a more systematic approach to the development of a methodology for assessing product life cycle was identified. From the late 1980s to the present day, interest in the LCA method has grown and is increasingly used in various fields of human activity (politics, production, public information…) (Wenzel, 1997). The field of application of the LCA method is very wide. In principle, it can be used as a decision support or as a data processing tool at both the political and production levels. At the political level, the LCA can serve as a basis for decision-making in the following cases: as a basis for informing the public (for example, most eco-labeling programs are based on the LCA method), when ranking products for allocation of incentive funds, when determining the development strategy of the industry at the local or state level (Chapman and Hall, 1997). On the other hand, manufacturers also benefit significantly from the LCA method, namely: in forming a public relations strategy, in product construction and reconstruction, in decisions on improvements in the technological process, in marketing (for example, emphasizing the use of LCA as an advantage over the competition, eco-labeling and the like) (Ćosić, 2009).

Since the early 2000s, there has been an increasing need for research on the impact of the wood industry on the environment, so the wood industry is trying to reduce the emissions of harmful gases emitted during processing. The result is the introduction of electric tools and sawmills boiler rooms that are heated with natural gas. Many sawmills have introduced exhaust control devices. Although there is a decrease in the concentration of harmful gases in the atmosphere, the side effect is an increase in the "energy footprint" of the product, i.e. more energy is needed to process the product (Mills, 2001). It is important to point out that since there are several types of wood products (e.g. OSB, plywood, fiber, etc.) the assessment of the impact of the life of this product on the environment must be categorized in some way according to the type of wood products because not all wood products have equal impact on the environment. We can divide products according to product mass, volume or economic value, but this is a problem because the results vary with different methods (Taylor et al., 2017). The assessment of the environmental impact of a product varies if we compare the test method according to the economic value and the mass value of the product. There is a difference if e.g. we compare the product from Croatia and Austria under the assumption that their masses and manufacturing processes are the same, but that resources in Austria (such as electricity, fuel, etc.) are cheaper. In this case, the economic method (input and output) of the Croatian product will have a greater impact on the environment because its inputs are higher than the Austrian.

The application of the LCA methodology also has its drawbacks, and according to the author Simonen (2014) they are as follows: the first drawback is the time required to conduct the LCA analysis. Requires significant resource consumption, requires access to a large number of LCI databases, extensive knowledge of the product and production techniques, and extensive expertise in assessment; another drawback is the incompleteness of the data. The LCA reports only on global impacts but not on local ones, for example, the LCA monitors exhaust gas levels while not monitoring the destruction of local animal habitats, which is a very important and significant figure in forest-based industries. Another problem is the lack of data. It is rare that data is complete for one area, so gaps need to be filled in with data from another area. The LCA requires expert assessment, i.e. the selection of the method by a competent expert. Thus, the possibility of human error is brought into the analysis. The "cradle to grave" method requires the prediction of certain scenarios over the life of the product. e.g. an item that is exposed to insect attack and rot will have a shorter lifespan, and thus will have a greater impact on the environment in the production phase than the same item that will experience recycling.

5.4. REQUREMENTS FOR LIFE CYCLE ASSESMENT

The first ISO standard for LCA is published by The International Organization for Standardization (ISO) in 1997 as part of ISO 1400 family of environmental management standards and they are, until today, the one and only relevant international standard documents on LCA which are broadly referenced by users and other standardization processes (Finkbeiner, 2013). The framework for LCA established by ISO during the period 1997 to 2000 consisted of ISO 14040, 14041, 14042 and 14043. Updates to these standards were completed in 2006 and the first edition of ISO 14044 together with ISO 14040:2006, cancelled and replaced ISO 14040:1997, ISO 14041:1998, ISO 14042:2000 and ISO 14043:2000, which have been technically revised. Guidelines and requirements for conducting a Life Cycle Assessment according are provided by standards ISO 14040:2006 and 14044:2006.

LCA has broad spectrum of applications but specific use, adaptation and practice of LCA for all potential applications are based on ISO 14044: 2006. LCA technique can be applied to cradle-to-gate studies, gate-to-gate studies, and specific parts of the life cycle (e.g. waste management, components of a product (ISO 14040:2006).

Current and valid requirements for LCA can are defined by following standards:

- ISO 14040:2006, Environmental management – Life cycle assessment – Principles and framework, that provides a clear overview of the practice, applications and limitations of LCA to a broad range of potential users and stakeholders, including those with a limited knowledge of life cycle assessment (ISO, 2006).

- ISO 14044:2006, Environmental management – Life cycle assessment – Requirements and guidelines, is designed for the preparation of, conduct of, and critical review of, life cycle inventory analysis. It also provides guidance on the impact assessment phase of LCA and on the interpretation of LCA results, as well as the nature and quality of the data collected (ISO, 2006).

Although ISO 14040 defines the requirements for LCA, it is not intended for regulatory purposes or registration and certification.

According to ISO 14040:2006 there are four phases of LCA:

1. the goal and scope definition phase,
2. the inventory analysis phase,
3. the impact assessment phase and,
4. the interpretation phase.

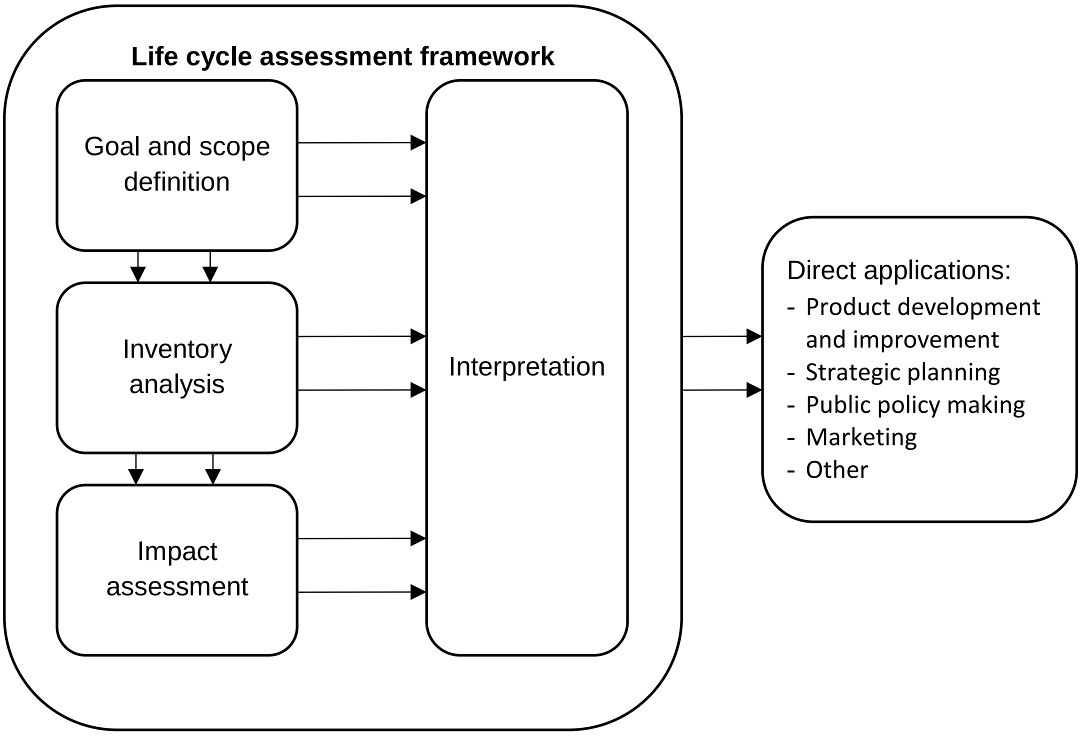

Figure 5.2. – Stages of LCA (source: ISO 14040:2006)

In the first phase that refers to definition of goal and scope of LCA includes definition of system boundary, level of application that mostly depends on subject of the LCA and can differ depending on the goal of a particular LCA (ISO 14040:2006). The second phase of LCA is the Life Cycle Inventory analysis phase (LCI phase). It is an inventory of input/output data with regard to the system being studied. It involves the collection of the data necessary to meet the goals of the defined study (ISO 14040:2006).

The third phase of LCA is the life cycle impact assessment phase (LCIA). The purpose of LCIA is to provide additional information to help assess a product system's

LCI results so as to better understand their environmental significance (ISO 14040:2006).

In the last phase, interpretation phase, results of LCI and LCIA are summarized and discussed.

ISO 14040:2006 specifies principles and framework for life cycle assessment (LCA), while ISO 14044:2006 specifies requirements and provides guidelines for life cycle assessment including

(a) the goal and scope definition of the LCA,
(b) the life cycle inventory analysis (LCI) phase,
(c) the life cycle impact assessment (LCIA) phase,
(d) the life cycle interpretation phase,
(e) reporting and critical review of the LCA,
(f) limitations of the LCA,
(g) relationship between the LCA phases, and
(h) conditions for use of value choices and optional elements.

5.4.1. Goal and scope

Goal and scope definition is the first step in LCA, it is very important that the goal and scope are aligned with intended application. When defining the goal it shall be stated the intended application; reasons for conducting study, the intended audience and whether the results are intended to be used in comparative assertions intended to be disclosed to the public (ISO 14044:2006). The standard defines that for the scope of an LCA shall be clearly described: the product system to be studied; the functions of the product system or, in the case of comparative studies, the systems; the functional unit; the system boundary; allocation procedures; LCIA methodology and types of impacts; interpretation to be used; data requirements; assumptions; value choices and optional elements; limitations; data quality requirements; type of critical review, if any; type and format of the report required for the study.

5.4.2 Life cycle inventory analysis (LCI)

Initial plan for conduction LCI is definition of the goal and scope of the study. The next step of LCI is data collection that includes collection quantitative and qualitative data for inclusion in the inventory for each unit process within system boundary. It is important to describe each unit process in order to avoid misunderstandings. Data calculation procedures shall be documented, clearly stated and explained. An important step is refining system boundary that the sensitivity analysis that may result in: exclusion of life cycle stages or unit processes when lack of significance can be shown by the sensitivity analysis; exclusion of inputs and outputs that lack significance to the results of the study, or inclusion of new unit processes, inputs and outputs that are shown to be significant in the sensitivity analysis (ISO 14044:2006). The next step is allocation that represents partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems.

Operational steps of LCI are described in figure below:

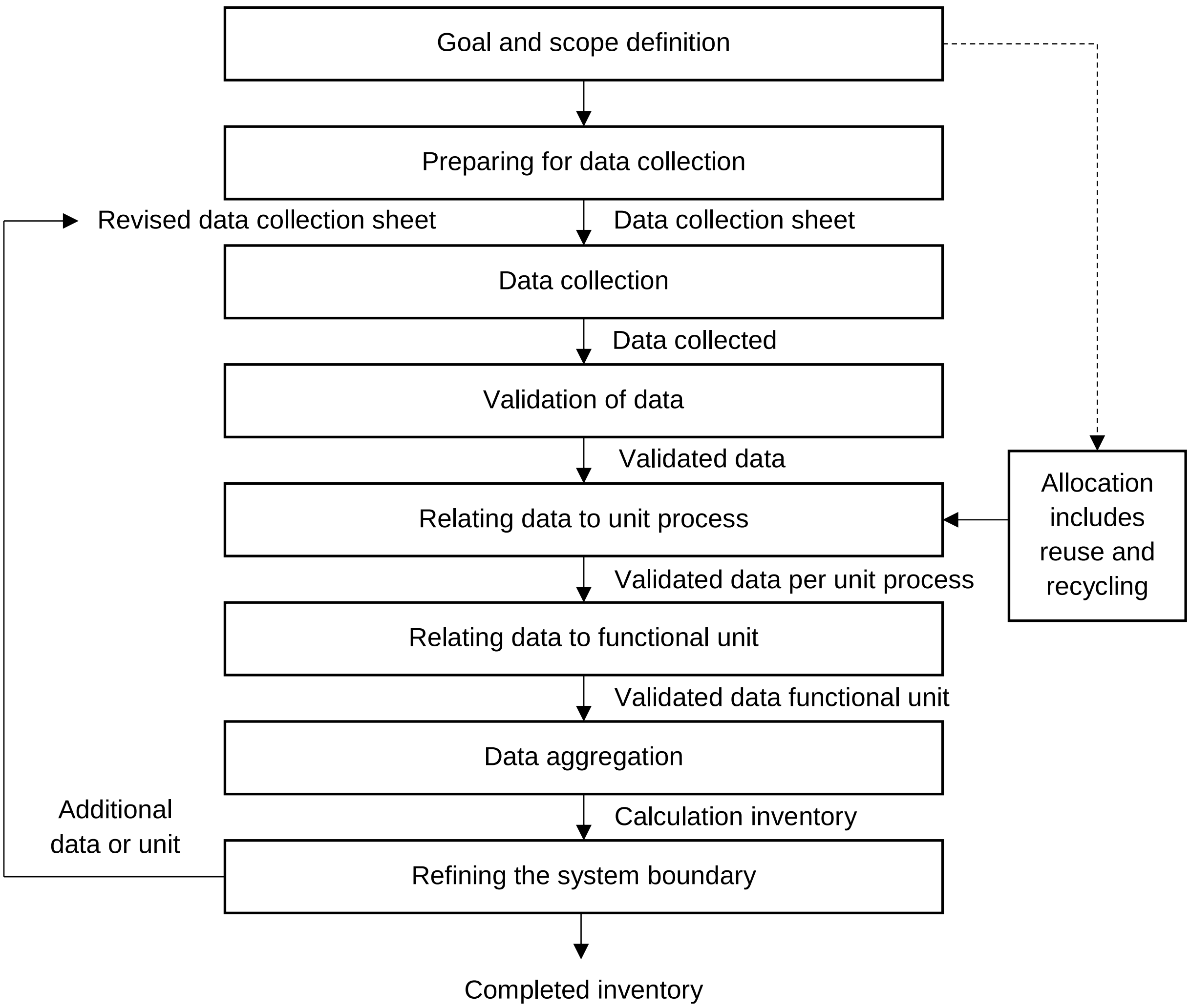

Figure 5.3. Simplified procedures for inventory analysis (source: ISO 14044:2006)

5.4.3. Life cycle impact assessment (LCIA)

LCIA is a phase of LCA aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product. This phase shall include the following mandatory elements: selection of impact categories, category indicators and characterization models; assignment of LCI results to the selected impact categories (classification); calculation of category indicator results (characterization) (ISO 14044:2006).

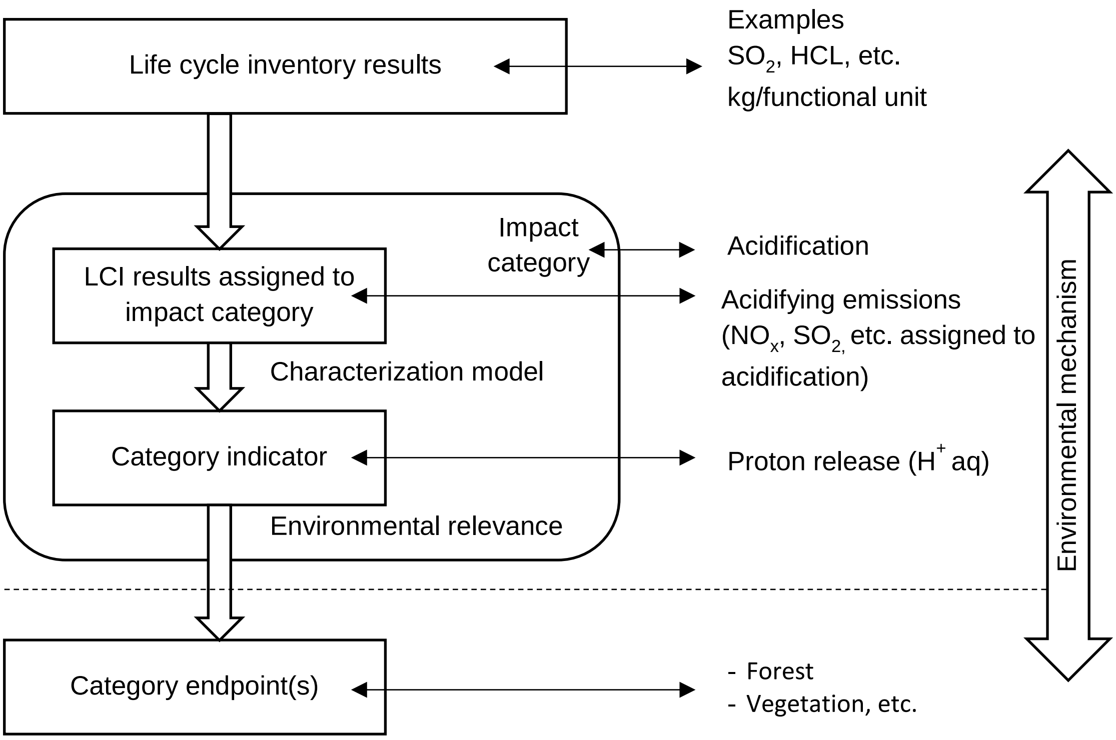

Figure 5.4. — Concept of category indicators on example for impact category "acidification" (source: ISO 14044:2006)

The life cycle interpretation phase has the following elements: identification of the significant issues based on the results of the LCI and LCIA phases of LCA; an evaluation that considers completeness, sensitivity and consistency checks; conclusions, limitations, and recommendations (ISO 14044:2006).

The **report** of LCA shall have all relevant results and conclusions. The standard ISO 14044:2006 in section 5 defines the specific items that report has to include: modification of initial scope; system boundary; description of the unit processes; data; choice impact category and category indicators. The **critical review** is done in order to confirm consistency between LCA and standard principles and requirements.

5.5. LIFE CYCLE ASSESMENT IN WOOD-BASED SECTOR

Klein et al. (2015) investigated studies in the forestry sector and found that wooden products are widely declared as "carbon neutral", although Medeiros et al. (2017) noted that life cycle literature shows that absolute carbon neutrality claims are incorrect. Manufacturers of wood products want to be able to understand the environmental impacts they cause in order to control or reduce them. They do this not only to meet increasing environmental regulations, but to promote their products as environmentally friendly. Every product requires energy to produce it, and many products require a large amount of processing and transport before they reach the consumer. Each process in product manufacturing requires transport, use, maintenance, and finally disposal, all of which use energy that can produce a large variety of emissions with very specific effects on the environment. These processes are connected with the transfer of inputs and outputs from one process to another making them all interdependent. Environmental impacts created during one process step are embodied within that product as it is transferred to another processing step. It is this systemic approach that is the basis for the LCA methodology (Puttmann and Wilson 2005).

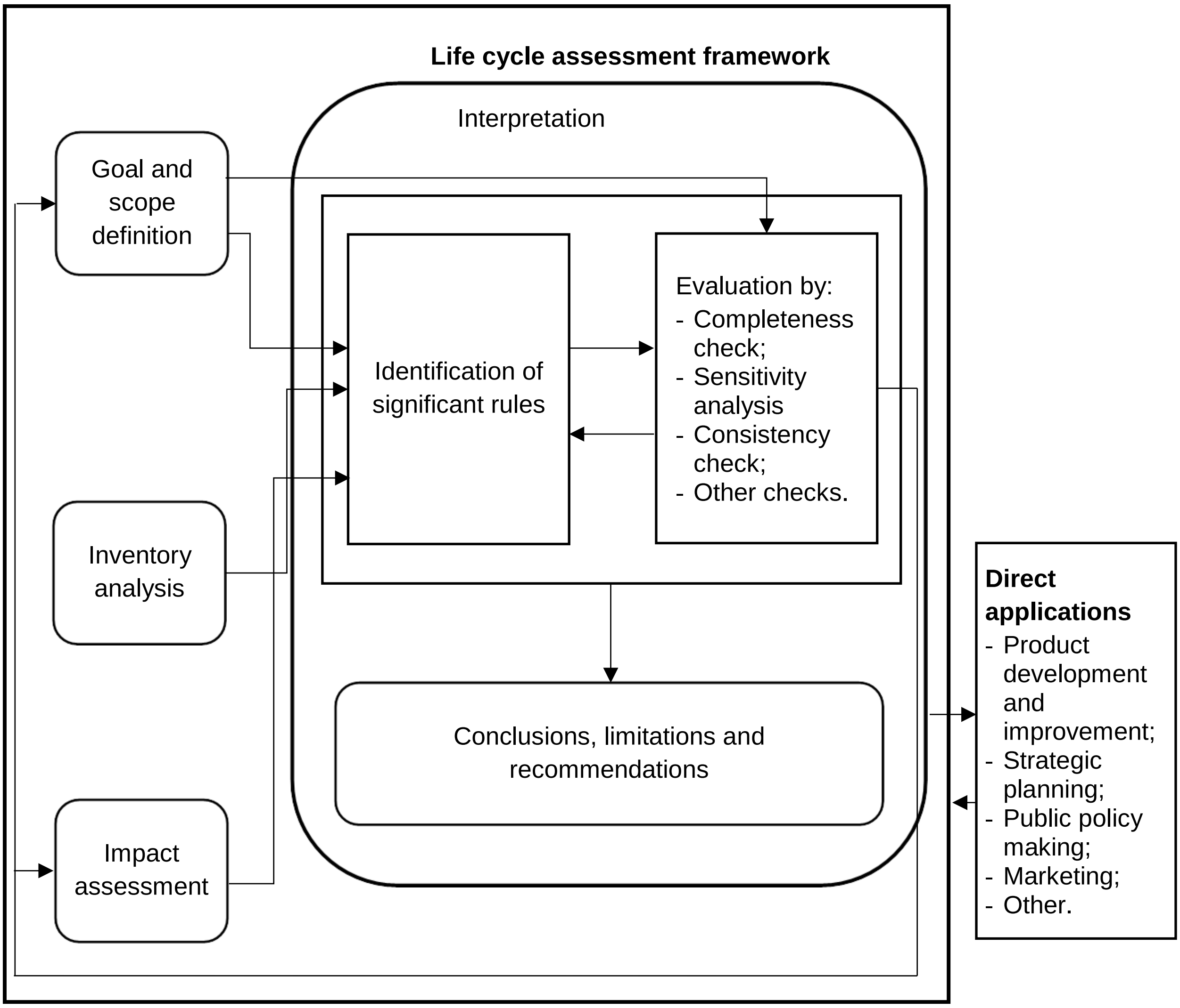

Figure 5.5. Relationships between elements within the interpretation phase with the other phases of LCA (source: ISO 14044:2006)

Wood is considered one of the primary biomass materials to substitute for fossil-based alternatives and different studies predict that establishing a sustainable bioeconomy can increase the wood demand and exceed the supply by 2030 in the European Union (Sikkema *et al*. 2017; Mantau 2012). According to Klein et al. (2016) timber products are regarded as products produced from renewable and sustainable environmental resources. However, as other products, timber products may create various kinds of environmental impacts at different stages of the timber product supply chain, from harvesting to their disposal (Eshun et al. 2012). Adhikari and Ozarska (2018) discussed that preventing wood waste to improve the efficiency of primary wood utilization significantly helps to reduce the environmental impacts on the one hand, and fulfill timber product demands without further damage to world forest resources on the other. Dionco-Adetayo (2001) has found that out of 1 m^3 of tree cut and removed from the forest, about 50% goes to waste in the form of damaged residuals, followed by branches (33.75%), stumps (10%), abandoned logs (3.75%), tops and, and butt trimmings (2.5%). Increasing the use of wood or wood-based materials in construction and in products such as furniture, cabinets, flooring, doors and window frames could present a significant opportunity for emission reductions, particularly when wood is used to substitute non-renewable materials such as concrete, metal, bricks and plastic.

The studies, in particular the ones based on LCA methods have provided comprehensive coverage of different processes such as energy consumption, manufacturing process and their impacts on the environments. The impacts can be minimized in various ways: changes in energy consumption behaviour, promotion of renewable energy, improved sawing and sawmilling practices, proper wood residues management, use of less toxic chemicals on the treatment of wood and timber products, and most importantly use of energy efficient and environment friendly drying techniques and energy sources such as effective air drying, improved solar and kiln drying, and microwave modification (Adhikari and Ozarska 2018). In early stages of R&D, many aspects of the future product system are inherently uncertain. For example, the end-of-life processes of forest products such as buildings and other constructions are expected to occur in a distant future (for buildings, often 50–100 years after manufacturing (Frijia *et al.* 2011). Sandin (2015) in his doctoral thesis discusses that such technological uncertainties of end-of-life processes can relate to how constructions are demolished, how demolished materials are transported from the demolition site to further reprocessing, what the demolished materials are used for (e.g. reuse, recycling or energy recovery), and what reused or recycled materials, or recovered energy, will eventually replace (e.g. primary or recycled materials, non-renewable or renewable energy). According to Bergman (2012) among three approaches (i.e., cradle-to-gate, gate-to-gate, cradle-to-grave), most studies followed the gate-to-gate approach in earlier studies because collecting primary data on traditional wood products is time-intensive and EPDs were not considered yet for green building certification systems, which require reporting LCIA results in a consistent framework. Saho et al. (2019) provide a comprehensive and systematic literature review of LCA of forest-based products including traditional wood building products, emerging wood building products along with mass timber building systems and nanocellulose in the U.S. The results show that most LCA studies were on traditional wood building products in North America, especially the U.S. Traditional wood building products (i.e., lumber, OSB, etc.) have been the most extensively studied products for their life cycle environmental impacts. Initially, gate-to-gate LCI studies were prevalent in the U.S. because generating the individual life cycle stages were hugely data-intensive exercises and were new both to the researchers along with the wood product industry being studied. For an example, results from Santos et al. (2014) research conducted in Brazil showed that that pine particleboard presented higher potential environmental impacts due to the distance raw material was transported to the production site in comparison to sugarcane bagasse (PSB) *(Saccharum sp.)*. The furniture industry is one of the oldest sectors of the economy and involves the production of durable consumer goods used for storage, hanging, supporting, lying, sitting, working and eating (Cordella and Hidalgo 2016). Rapôso et al. (2012) also argue that the furniture industry has limitations related to its process efficiency and reduction of material use, so demands for technological and managerial innovations are necessary. For an example, Chaves (2007) used LCA to develop design tools and strategies of environmental sustainability for the furniture industry, in order to guide designers to achieve effective results. The results indicated that the most significant environmental impact of the furniture life cycle was due to the distances covered and production of the main raw material, wood medium-density particleboard (MDP). The evaluation of transport scenarios showed environmental tradeoffs for truck fuel switches and environmental gains for the distribution of MDP from closer suppliers by truck, as well as from current supplier by truck and ship in the major categories. This conclusion is in line with Medeiros et al. (2017) findings that in the modern furniture manufacturing industry, most of the environmental impacts occur outside the plant, except for particulate matter. Additionally, the production and transportation of the main input, the wood medium-density particleboard (MDP), had the largest environmental impact. Furthermore, evaluation of the office cabinet post-use options showed that reuse, recycling, or energy recovery from waste cause significant environmental gains in the major categories (Chaves 2007). According to these results, the assembling stage is the most important contributor to the environmental profile with contributions between 60% and 83% depending on the category. This result mainly was due to the delivery of wood based materials (boards and timber) to the factory as well as the requirement of metals (specifically stainless steel) and plywood. In keeping with the results, several processes had a large contribution: the production of wood based materials (the main component of the playground in terms of weight), the production of metals (the second most important component in weight), and the transport related activities and finally, the alkyd paints production. In the context of sustainability, extended life cycle for furniture items, with continuous maintenance is one of the most effective ways to reduce waste generation. Considering that the European bioeconomy places an important focus on high-value products, the lack of relevant LCA studies represents an area of potential development D'Amato et al. (2020). Moreover, the intersection of LCA and bioeconomy could further shed light on circularity issues, also a priority in national policies at European level (i.e. circular bioeconomy). Finally, the link between bioeconomy and ecosystem services remains an under-represented area of research, including understanding the impacts and dependencies of diverse bioeconomy activities. On the other hand, there is a possibility of using LCA for an environmental technology valuation at an early stage in product and process development. For an example, study conducted by Hesser et al. (2017) aimed at answering the question under which circumstances the modification pays back from an environmental point of view to guide further R&D activities.

5.6. CONCLUSION

Wood is material that can be seen as positive in term of sustainable management, but must come from forest that are managed responsibly/sustainably. Wood based products and wooden furniture is a potential carbon sink if its life cycle does not emit more greenhouse gases than its materials can store. This all indicates that wood based products have environmental advantages over non wood alternatives. The impacts of substitution scenarios varied depending on the type of product avoided. Traditionally, life cycle analysis (LCA) approaches are key tools used to assess impacts through product life cycles, but they present limitations regarding the accounting of multiple ecosystem service-related issues, at both the land-use and supply chain levels. The LCA proved a powerful method to diagnose and manage environmental impacts in complex product systems. The sensitivity analysis showed that it is possible to reduce the environmental impacts and, at the same time, make the wood-based industry increase its economic gains and net carbon stock in the anthroposphere. LCA shall be alternative for wood residues and waste management strategies in wood industry. Wood biomass, residues form wood processing as well as products at the end-of life are low carbon energy sources and this shall be stand point in future wood management policies. Criteria in green procurement shall be based on renewable energy and reuse of materials, environmental selection criteria for materials, eco-design, environmental capabilities of producers, waste and water management etc. In wood industry shall be implemented integrative and innovative approach that will enable best environmental performance. As wood is very positive in term of sustainability, and circular economy principles are our future, this shall gave wood industry advantage in banding and gaining a competitive advantage over other industries. Life cycle thinking shall be integrated in management strategies and shall become a standard management and controlling tool.

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6. ERP IMPLEMENTATION FACTORS IN WOOD PROCESSING INDUSTRY: FMEA ANALYSIS

Ivana Perić, Kristina Klarić, Karla Kremenjaš

6.1. INTRODUCTION

The global world market for wood and wood products requires a wider and more variable range of products, in small and varying quantities, often unique. One way of meeting the demands of today's global market can be achieved with customer-oriented production (broad product range, high quality, competitive prices, customer services), environmentally friendly production, implementation of principals of modern production concepts and planning systems (Grladinović *et al.* 2007: Perić *et al.* 2019; Klarić *et al.*, 2016.; Kremenjaš *et al*, 2021.). All the above-mentioned attributes of modern wood production, present the principles of flexible production.

The introduction of flexible production is a conditional appropriate stage of component development of automation in production systems such as numerical controlled machine tools, robotic systems, computer-controlled transport systems, numerically controlled measuring machines, including the development of appropriate software tools for construction, calculation, analysis, management, and supervision (Hozdić and Hozdić, 2013). Flexibility in manufacturing is defined as ability to change or react with little penalty in time, effort, cost, or performance (Gultekin, 2012.). Characteristics of such flexible production driven by automated machines, in the case of the wood processing industry are high productivity, the width of an assortment of wood assembly material, accuracy, and high quality of production and processing products. Further, such production ensures the minimization of stocks of wood materials, semi-finished products, non-wood material, and unfinished production of wood products. In the wood-processing industry, very important is minimizing material waste, since the cost of raw material alone can account for 30-80% of total production cost (Grladinović, *et al.*, 2003). For this reason, in recent years, many companies have embraced a new class of planning and resource management software systems to integrate processes, enforce data integrity, and better manage resources. They are designed as integrated application platforms for enterprise business organization, management, and supervision named Enterprise Resource Planning systems (ERP) (Kremenjaš *et al.*, 2021; Perić *et al.*, 2017; Perić *et al.*, 2019).

6.1.1. Enterprise Resource Planning (ERP) systems

Integrated, enterprise-wide information systems such as an ERP system have evolved from Materials Requirements Planning (MRP) to Manufacturing Resource Planning (MRP II) systems.

After first use in American Bosch Company in 1959 and with information technology development in 1970s the MRP concept has spread, especially in the United States and Europe, where changes were included in the model, mainly to get information on capacity requirements, and also to do a more reliable cost approach.

The development of MRP 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.

Generally speaking, an ERP platform unites information, collected from all departments and functions across a company, into a single system that caters to the unique and varied needs of different departments (human resources, finances, supplies, etc.), while at the same time enabling all departments to access any other relevant business information. This integrated ERP bridge improves the integration benefits companies in many ways: quick reaction to competitive pressures and market opportunities, more flexible product configurations, reduced inventory, and tightened supply chain links. The departments that most benefit from ERP implementation are typically accounting and finance, production operations, sales, product development teams, purchasing and procurement, and quality management. Key Market Players in the ERP market are: Deskera, Epicor software corporation, IFS AB, Infor, Microsoft Corporation, Oracle Corporation, Sage Group, SAP SE, Syspro, Workday (ERP Market Statistics: 2021)

Much progress has been made since Dillard and Yuthas noted in 2006 that most multinational companies were using ERP software packages and even more small and midsize companies were on the route of adopting them. According to industry reports (Market Research Store, 2017), the Global ERP Software Market is expected to grow at a compound annual growth rate of around 7.4% over the next decade and reach approximately $63.1 billion by 2025. Enterprise software market has been growing steadily, and rapidly before COVID-19 pandemic hit in 2020 when slight decline occurred. Despite software market expected to resume growth in 2021 and to amount more than 570 billion US dollars in 2022. This market includes enterprise resource planning (ERP) software market, the customer relationship management (CRM) software market, and the content management software application market and out of this markets ERP is the largest (Enterprise Software Report 2021). The most noticeable current trends are growing demand for ERP from medium- and small-sized enterprises and moving to mobile and cloud applications. ERP solutions can be either generic or industry specific. Companies usually prefer industry-specific solutions which contain features addressing their specific challenges. Since creating or adapting an ERP product to a new industry is complicated and expensive, most ERP vendors nowadays choose to specialize in a few specific branches/sectors.

6.1.2. Enterprise Resource Planning Implementation

Enterprise resource planning (ERP) system solutions are a fundamental asset for most large companies (as well as for medium and small companies). Companies choose to implement an ERP system for many reasons, including to increase productivity, create a better experience for customers and reduce costs. An ERP system can eliminate many paper- or spreadsheet-based processes because it provides a unified set of business process tools and a single database with information from across the business that everyone uses. In addition, ERP implementation involves a complete revamping/overhaul of all existing business processes in line with best practices (Shehu & Masunda, 2018). Also, it is important to note that changing an existing ERP solution or transition to an new and improved ERP solution is a strategic decision of the company, and the benefits are: faster responses to customer requirements, availability of information, enhanced monitoring and forecasting of activities, perfectly integrated system that connects all functional areas of the company, increased productivity and efficiency (Kremenjaš 2019.). Authors Vukšić and Čerić state in their book that each information system during its implementation in the system of production and use goes through the basic phases of five. The first phase is the planning of the integrated information system (hereinafter IIS) strategy whose purpose is to make a plan for the development of IIS and to determine the objectives of the new system given the shortcomings of the existing IIS. In the second phase of the approach, the problem of the business system is analysed. After defining the program module, an information system is created that contains the modules mandatory for the company (Garača 2009). The last stage is the moment introduction of IIS into operation; be it direct, parallel, or phased commissioning. According to the literature review, several studies (Davenport 1998; Bingi, et al. 1999; Nah and Lau 2001; Mabert, et al. 2003; Wagner & Newell 2006; Maditinos, et al. 2011; Shatat, 2015; Sun et al., 2015) have investigated various factors affecting EPR adoption, defined as critical success factors (CSFs) presented below.

Implementation stages and costs

ERP implementation stages reflect the various phases through which an ERP project passes in an organization. An ERP project usually comprises several stages, including adoption decision, acquisition, implementation, use and maintenance, evolution, and retirement. The implementation of an integrated ERP system is not as technical as it sounds. It is more about an organization undergoing an organization-wide revolution. Extensive planning is the “first step” in of pre-implementation phase ERP system. Nevertheless, lack of preparation may result in negative outcomes for the company. This is because the ERP system components are complicatedly related to each other, such that entering wrong data into any one program will lead to “garbage in, garbage out effect” on the running of other modules. Implementing an ERP package sometimes takes several years, from six months to two years, according to the Huang *et al.* 2004, and needs a lot of capital investment. In addition, the practice has shown that less than 75 % of the ERP system' effectiveness is utilized, which translates to 25 % of investments not being fully justified. Even though prewritten software is typically cheaper than in-house development work, the implementation cost can be several times more than the purchase price. The complexity of the project and the degree of customization can add up to a third of the overall budget.

Top management support

Implementing an ERP system is not a matter of changing software systems. Rather, it is a matter of repositioning the company and transforming the business practices. Some companies make the grave mistake of handing over the responsibility of ERP implementation to the technology department. Top management must ask themselves several questions before embarking on a project. Does the ERP system encourage an organization's competitive position in the market? How would this possibly distort the competitive position of the corporation? How does ERP affect organizational form and lifestyle? What is the scope of ERP implementation - just a few dedicated devices or the whole company? Are there alternatives that satisfy the desires of the organization greater than the ERP system? Top management must also take an active role in the planning and implementation of each project. This can help avoid getting stuck in implementing an expensive and time-consuming solution.

Training time

Training and getting employees used to ERP is a long and expensive challenge. People are one of the hidden costs of ERP implementation. Without proper training, about 30 to 40 percent of front-line employees will not be able to handle the demands of the new system. People in databases now make important buying and selling decisions - important company commitments and need to understand how their data affects the rest company. This way of "transferring knowledge" is difficult if employees do not have computer literacy or have a computer phobia. Companies should provide opportunities to improve employee skills by continuously providing training opportunities to meet the changing needs of businesses and employees. Therefore, initially, companies tend to assign only a few employees to the task of setting up an ERP system and later rely on them to train others.

Data migration

It is recommended to develop an ERP data migration strategy when moving data to the ERP system as the migration process can often prove to be very complex. The migration team is required, this group of people will be responsible for determining what data should be transferred to the ERP system and how (usually includes representatives of different departments groups who can give insight into how their groups use the data). It is also crucial that data is mapped and analysed, examined in each source system, making sure there are no inconsistencies. It is often the case that older systems have outdated information, vendors that no longer operate, customers who have not placed a single order in years, obsolete products, etc. A lot of this information is not needed in the new system and can be stored on an archive server or offline. The migration of historical data to the new information system is often overlooked. However, companies need this data for forecasting purposes and sometimes for compliance or legal reasons.

Consultant support

ERP implementation demands multiple skills, such as functional, technical, and interpersonal. Finding the right people with hands-on experience and keeping them through the implementation is a major challenge. The partnership between the top management and the consultant support is critical to the ERP implementation and its successful integration. The primary goal of an ERP consultant is to ensure that the software runs smoothly and efficiently. They also make sure that the right solutions are implemented and integrated seamlessly. A good ERP consultant will keep the project on track by following a set of guiding principles and implementing best practices.

It is interesting to note research done by Debelić (2019) and Kremenjaš (2019), conducted on a sample of wood industry companies in Croatia, where results have also shown that companies in the implementation phase are also facing the abovementioned difficulties (using a 5-point Likert scale, where the responses 4 and 5 were considered positive, 1 and 2 were considered negative and 3 was taken as neutral) average grade for key factors was above M=4.

The importance of ERP systems to an organization's competitiveness and the magnitude of ERP expenditures related to the firm resources imply that executives who implement these systems and academics studying ERP need to recognize which factors are likely to improve the chances of successful implementation (Shirouyehzad *et al.,* 2011). This study seeks to examine those critical factors leading to ERP success. Motivated by the theoretical importance of ERP systems and the empirical failure in fully harvesting their potential, the proposed conceptual framework includes variables that, according to the best of our knowledge.

6.2. METHOD OF RESEARCH

In this paper Failure mode and effects analysis (FMEA) is used for the identification and analysis of potential risks in the implementation of ERP in wood industry companies. FMEA is a prominent engineering technique for eliminating the potential failures that emerged from various systems such as products, processes, designs, or systems (Baykasoğlu and Gölcük, 2020). Failure mode and effects analysis (FMEA) is a very common process analysis tool and many other quality tools developed by United States Military. This technique was developed as military procedure MIL-P-1629 (now MIL-STD-1629A) under the title “Procedures for Performing a Failure Mode, Effects and Criticality Analysis” (Ericson, 2015). The first significant and wider use of the FMEA technique was in the aerospace industry during the mid-1960s and was focused on safety issues and served well in getting a man on the Moon (Ericson, 2015), while only in the late twentieth century did this technique begin to be used more widely outside the field of safety (McDermott, et al. 2009). Later, the application of FMEA spread to industry, especially in large companies e.g., Chrysler Corporation, Ford Motor Company, and General Motors Corporation in which become characteristics the official tool for quality improvement, particularly thanks to a task force created between. Today, the technique is used in many sectors and is perceived as a useful risk management and controlling tool. It is often requested by customers (e.g., Ikea) to obtain adequate warranties on suppliers' modus operandi. In the last decade, risk-based thinking has become very important in quality management systems (Sartor & Cescon, 2019). It is widely known that successful organizations are committed to preventing and minimizing risk in their operations and to make it happen, it is required to be committed to the whole organization but performing this may be extensive and demanding (Stamatis, 2019).

In traditional FMEA studies, the priority of a potential failure is determined through risk priority number (RPN), which is defined as the product of severity, occurrence, and detectability of a failure (Stammatis, 1995). The RPN enables the valorization of the value of each adverse event and thus creates their classification; it is an indicator that represents how hazardous an event can be.

$$RPN = S \times O \times D \qquad (1)$$

Under the RPN, three components help define the priority, and thus danger, of a harmful event (Sartor & Cescon 2019):

- Severity (S) or the severity of the damage;
- Occurrence (O) or the probability of occurrence; and
- Detection (D) or how easily/early an event can be detected.

According to McDermott, et al. 2009 FMEA has ten steps that are shown in Figure 1. *Severity* is an indicator that represents how serious the potential consequence of an event may be. The higher the score associated with this indicator the more a "failure" is unpredictable and can lock the system or alter production. *Occurrence* is an indicator that estimates how frequently the cause of a failure can happen, generating a problem (Sartor & Cescon 2019). For indicator *Detection* two interpretations are available according to Sartor & Cescon 2019:

- It can be seen as a measure of the ability to identify a potential design error before the component or system is released for production.
- It may represent an estimate of the possibility that the customer notices the problem.

The first interpretation is that the first is focused more internally and addressed to early stages of activity, while the second interpretation is focused more on the output provided to the customer. For our research, we used the first interpretation because it is related to the implementation of ERP and the investigation of system design errors.

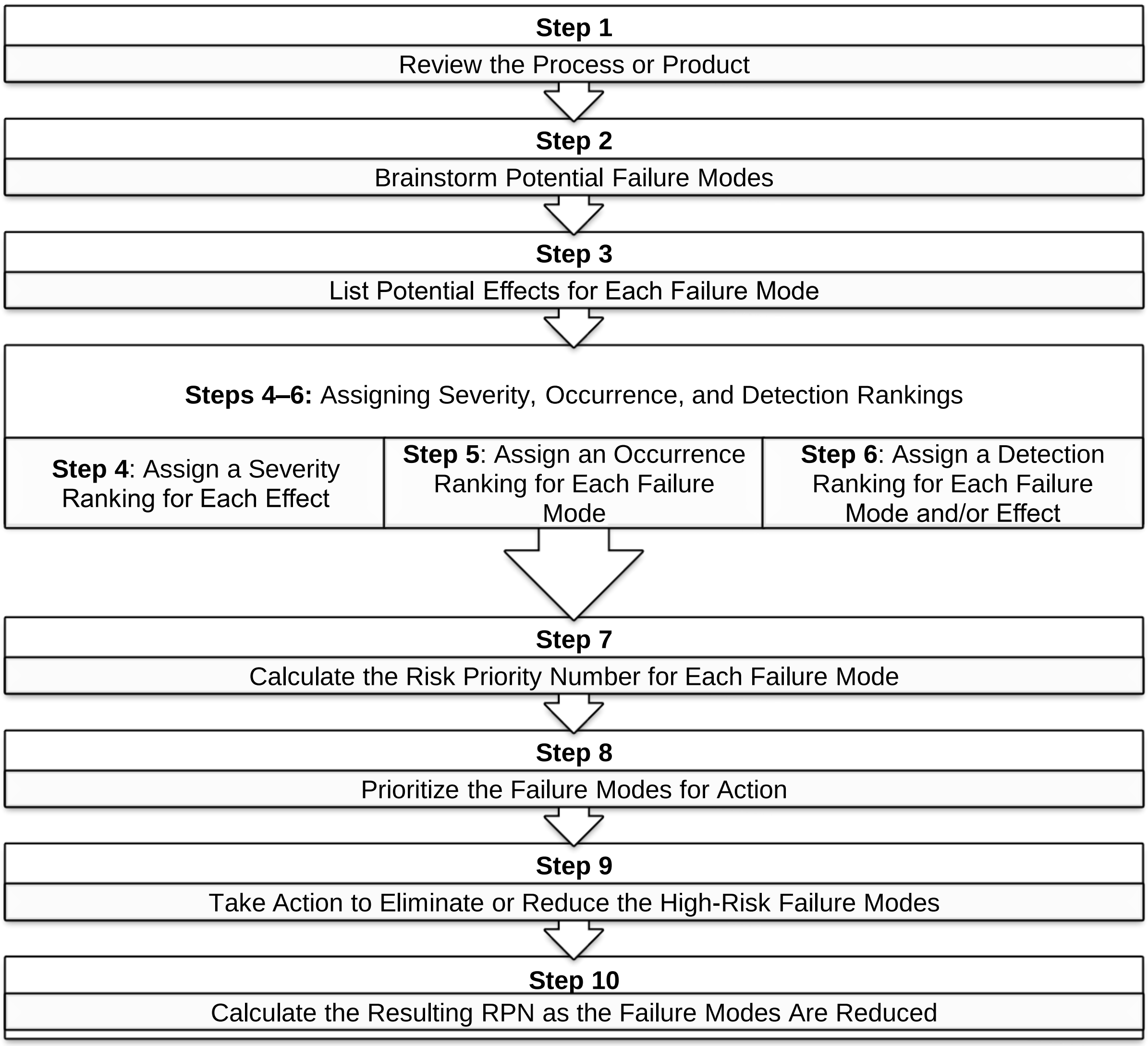

Figure 6.1. FMEA steps

Rating of risk of each is evaluated indicator is made by using a 10-point scale. Based on the RPN value that varies from 0 to 1000, prioritization of failure modes are determined, which are assessed as low, medium, and high risk, and decisions are made on the necessary actions for reducing failures. In the low-risk area, corrective actions are not needed; in the medium area only, limited actions are provided; in the high-risk area, besides defining an action plan, major changes in the system, design, product, and process are required. In case, faults with the same RPN are identified, typically those with greater Severity are dealt with before, to move then to Detection, and finally Occurrence (Sartor & Cescon 2019). Often, it occurs that 80 % of the total RPN is determined by less than 20% of the analysed failure modes.

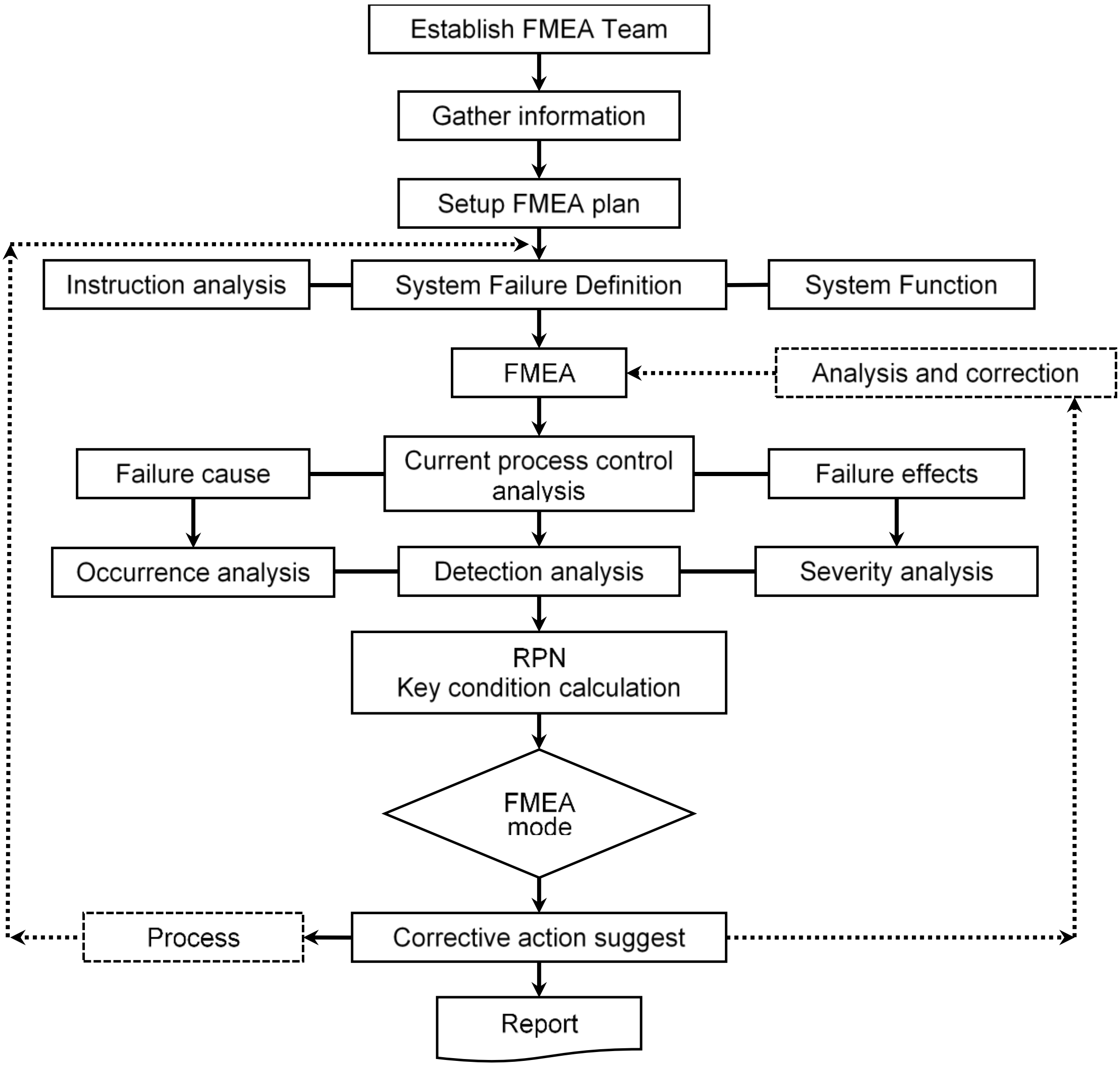

Figure 6.2. FMEA flow chart (Bao et al., 2017)

6.3. RESULTS AND DISCUSSION

Despite the benefits that can be achieved from a successful ERP system implementation, there is evidence of a high failure rate for ERP implementation projects in numerous industries (Jayawickrama *et al.* 2019; Loch *et al.*; Perić *et al.* 2019: Sum *et al.* 2015). In this research, traditional FMEA is used to prioritize critical failure factors in ERP implementation in wood industry companies. For this purpose, eleven factors are identified by the brainstorming method, presented in table 1 below.

Table 6.1. A sample of the table

	ERP implementation factor	S	O	D	RPN
1.	Adaptation and possibility integration of ERP to business processes	8	5	2	80
2.	Top management support	7	7	7	343
3.	Consultant support	10	9	9	**810**
4.	Stakeholders team	8	7	7	392
5.	Training employees	10	9	6	**540**
6.	Human resources technical skills	7	3	6	126
7.	IT infrastructure	10	9	9	**810**
8.	Performance assessment of ERP implementation	9	8	8	**576**
9.	Data migration	7	3	5	105
10.	Implementation costs	5	3	7	105
11	Implementation time	9	9	3	243

Legend: RPN – Risk Priority Number; S – Severity; O – Occurrence; D – Detectability

As shown in Table 1 results of risk mitigation and resulting RPN value the high risks factors (RPN values 810, 810, 576 and 540, respectively) in the implementation of ERP systems in wood industry companies have emerged: *consultant support; IT infrastructure; performance assessment of ERP implementation and training employees*. Those factors imply next.

Permanent *consultant support* should be a recommended action to succeed a successful implementation of ERP system. To decrease implementations failure, companies in selection process of an appropriate ERP vendor and suitable ERP package should evaluate if the vendor staffers are knowledgeable and available, due to the shortage of skilled consultants in the market. This is crucial especially in case of Croatian wood industry companies, where lack of necessary employees with IT competencies needed in ERP project implementation is evident (Perić *et al.* 2019).

Further, observing the next selected high-risk factor *IT infrastructure* and its influence on the unsuccessful implementation of ERP systems recommended action imply - timely IT company assessment. Therefore, it is recommended that some of the following actions shall be adopted, in order to increase the possibility of success in implementing ERP: review the pre-implementation process to date (upgrade IT infrastructure), apply enough IT budget, IT staff involvement in the software selection, active communication between IT administrator and ERP implementation partner and cloud hosted ERP solution (for small businesses cloud computing is particularly useful because it delivers access to fully functioning applications for a sensible subscription price. It can be a cost-effective way of installing and maintaining hardware and software). In order to use ERP effectively it is important to have production technology that enables connectivity. Among other sectors in wood industry, this is very useful in furniture production that is very complex and conducted in multiple phases. There is a lot of production data that have been collected manually in past what came out with many human errors. Using sensors for data collection can avoid human errors. By having production technology that can be integrated with ERP can help process optimization and collecting data accurately.

Table 1 also reveals that critical factor in implementation of ERP is *training of employees*. It is often said that ERP implementation is about people, not processes or technology. In order avoid failure in ERP implementation a pre-prepared training plan for employees and clearly defined roles and responsibilities of each key working position shall be introduced - because a lot depends on it, such as the length of employee training. Further, companies intending to implement an ERP system must be willing to dedicate some of their best employees to the project for a successful implementation. As mentioned, ERP systems are very large and complex, for this purpose companies shall request from ERP vendors multiple options for training in order to cover all areas of implementation. Also, companies should train employees on what they need to know regarding ERP, enhance ERP training manual and support manual. This action are also recommended for ERP implementation factor - *HR technical skills*.

FMEA analysis has shown that the Performance assessment of ERP implementation factor is also a high risk factor, for which actions need to be taken in order avoid failures in implementation. Sun et al. (2015) stated companies that companies which are introducing ERP solution, with goal to improve their business outcomes tend to pay attention whether the system helps them to achieve their intended goals, such as cost or inventory reduction, or better delivery reliability and speed. Futrher, researchers have suggested that is important to measure performance at each stage during ERP implementation to ensure success (because performance of the preceding stage is input for that of the succeeding stage). Recommended action/performance measures are: ERP cost and benefits control, customer satisfaction feedback, traceable operation cost, periodic system performance review (implementation process identification worksheet, an improvement process identification worksheet and weekly process progress reports), assessment of system operations efficiency, assessment of employee productivity and satisfaction. This actions makes continuous improvement, possible at each stage of ERP implementation when underperformance is detected for companies.

Since, the risk priority number of *Stakeholders team* is 392, this factor should be also considered and improved in ERP implementation projects. In general, RPN number imply that having a formed implementation team based on competency i important, as well as to distribute responsibilities to the team members and to ensure each person is accountable for their respective targets/achievements. It is very important to cover all implementation area with team responsible, e.g. IT; warehouse; production, accounting; sales; finance etc. Team responsible should be support in implementation for lower levels of implementation.

The RPN number of *Top management support* (RPN = 343) also shows the sensitivity of this factor and its influence on the unsuccessful implementation of ERP systems. RPN value for this risk factor imply that action like: commitment from upper management, carefully planned strategic goals, constantly monitor the progress of the project and provided direction to the implementation teams can increase the possibility of success in implementing of ERPs.

Table 1 also reveals that in order to decrease the amount of failure implementations caused by *data migration, implementation costs* and *time*, companies need to improve top management support, organization fit and software system design. Well-planned data migration strategy is necessary because it affect data integrity in the new system. To avoid this, recommended actions are: forecast ERP implementation costs and draft a budget, map out requirements before starting a search to avoid software that has far more functionality that is needed (this will keep costs down and reduce the training required for employees). Further, start with the migration process early to avoid delaying the ERP deployment, converting some data into a format that's compatible with the new platform (otherwise, this can lead to unexpected costs and delay), charge IT professionals to maintain the database regularly and form a ERP team who will be responsible for analysing the data, performing the migration and validating the results.

The length of implementation is connected to a great extent by the number of modules being implemented, extent of product customization, and the number of interfaces with other applications (Bingi *et al.*, 1999). As ERP systems usually come as modular, recommended action is to break an implementation process into pieces (average length of time for a "typical" implementation is about 14 months). Setting a realistic expectation and choosing to implement the features company need most first - over a shorter period of time - will let company to get the system up and running in business processes in a timely manner.

6.4. CONCLUSION

An ERP system integrates many functions across the business, such as financial management, human resources, sales, and manufacturing, to deliver benefits such as increased productivity and efficiency. ERP implementation consists of the process of planning, configuring, and deploying an ERP. The process typically lasts up to several month and it's complex because an ERP system supports and automates many different functions. Implementation of ERP systems often fail outright, go over budget or don't meet the proposed return on investment. In fact, 55 to 75 percent of ERP projects fail to meet their objectives. This research attempted to extend the ERP implementation research, in context of wood industry companies, by testing the CSFs effect on ERP implementation success using FMEA methodology approach. Eleven CSFs was observed based on previous studies and relevant literature. As a result of the findings, it is found that, the most critical elements affecting the implementation of ERP successfully were: IT infrastructure, Consultant support, Performance assessment of ERP implementation and Training employees. While contrary, the low risks priority element was Adaptation and possibility integration of ERP to business processes. To ensure a successful implementation, companies need to carefully define its requirements, determine how to redesign processes to take advantage of the system, configure the ERP system to support those processes and rigorously test it before deploying it to users. Successfully navigating all those steps on schedule requires careful planning and a structured, phased implementation approach.

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7. IMPROVING THE PRODUCTION PROCESS IN A FURNITURE INDUSTRY WITH THE USE OF SELECTED LEAN TOOLS

Krzysztof Knop, Marek Krynke, Robert Ulewicz

7.1. INTRODUCTION

Production processes are a series of operations leading to the production of products and services, which in turn makes it necessary for the management of the organization to focus on the ways of their improvement [14]. Knowing the process that want to monitor and improve is the first and fundamental element on the way to its improvement. Improving production processes is a task that requires a systematic, planned and fact-based approach to the topic [8]. The purpose of improving production or services processes is to influence the interactions between people, technology and all activities in such a way as to provide customers with unique products / services [5, 12]. The aim is also to achieve measurable economic and production effects, such as such as: efficiency of the production process, timely execution of tasks, identification of factors influencing the quality of products, shortening the time between operations, minimizing inventories [10]. Managing the production process is an important area of improvement [6]. E.W. Deming argued that if there are problems in a company's operations, if quality and performance do not meet customer expectations, then 85% of the time the causes are to be found in process management, and only in 15% of cases in the employees themselves [1]. Improving production processes is a systematic approach to closing gaps in their efficiency by reducing their implementation time, identifying and eliminating the causes of poor quality, reducing variability and eliminating non-value-adding activities [6, 9]. Production process improvement initiatives should be preceded by their evaluation [10].

Modern methods of organization and management of production processes, resulting from efforts to improve efficiency and reduce costs, play an important role in the improvement of production systems and processes or their redesign. There are many approaches to improving production processes, the most popular in manufacturing companies include: Lean Manufacturing, Six Sigma, Agile Manufacturing, TQM, Kaizen [4]. Lean Manufacturing aims to achieve high productivity and quality of products, with the maximum improvement of the organization and all work processes. When effectively implemented, it eliminates activities that do not add value to this product, which leads to cost reduction in the organization [13, 17]. Lean Manufacturing is currently one of the best-known and most widely used in practice concepts of managing a manufacturing enterprise [13].

7.2. METHODOLOGY

The aim of the study is to use selected Lean tools to improve the production process in a company producing upholstered furniture. The article is a case-study on the practical use of selected Lean tools in the area of production, such as the SMED, 5S and 5 WHY method.

The surveyed company is one of the leading companies on the Polish market in the field of production of upholstered furniture, such as sofas, couches, armchairs and pouffes. It is the largest Polish furniture group, a manufacturer and distributor of furniture and home furnishings, with an approx. 20% share in the Polish market in terms of sales value. It is one of the most famous and respected Polish brands.

The article presents the application of selected lean manufacturing methods, such as SMED, 5S, 5 WHY. It was from these methods that the Lean concept began to be implemented in the surveyed company. The success of their implementation in specific production areas in the company, the benefits of their use contributed to the spread of these tools to other production areas and contributed to the implementation of new Lean tools, such as VSM, Kanban, visual management. It is known that Lean is not only the tools and methods of lean management. The building of the Lean culture in the organization was also started, which is an element necessary to maintain the effects of the introduced changes and to continue following the path aimed at increasing the efficiency of employees, more effective processes and no waste.

The basic lean management tools are 5S, Kaizen, Kanban, SMED, TPM, TWI, VSM, 5 WHY, Poka-Yoke, Heijunka and DFMA [7]. Basic lean management tools are used to optimize production processes: increase efficiency, improve quality, shorten lead times, improve communication and quality of work in various areas of the company [16, 18]. All the Lean methods of the SMED, 5S, 5 WHY type used at first in the surveyed company were united by simplicity, relative ease of their implementation and measurable and immeasurable benefits related to their implementation.

The SMED method is a set of techniques and tools that enable shortening the changeover times of machines, devices and production processes. The main purpose of the method is to carry out each changeover in a unit number of minutes (up to 10 minutes) by dividing and simplifying the entire process so that changeovers are made with the use of the least number of tools. The benefits of implementing the SMED method result directly from the simplification of the way and shorter changeover times (less workload, higher safety, better transparency), and indirectly from shorter and more frequent changeovers, which is reflected in shorter production series and in higher production flexibility [1, 3, 7].

The 5S is a set of techniques and methods aimed at establishing and maintaining high-quality workstations. This method is directly related to the proper organization of the work environment, improvement of the company's organizational culture and allows for increasing the stability of processes. 5S is very often treated as a key Lean method, implemented in production and service companies as one of the first, constituting the basis for further Kaizen activities. The 5S system distinguishes five successive steps:

1. S - Sort (jap. *Seiri*), 2. S - Set in Order (jap. *Seiton*), 3. S - Shine (jap. *Seiso*), 4. S - Standardize (jap. *Seiketsu*), 5. S - Sustain (jap. *Shitsuke*) and includes the use of visual management (visual controls) tools [1, 3, 7, 11].

The 5 WHY method is a practice in the field of problem solving. It is based on a series of questions that help to find the underlying cause of a given problem, and its aim is to identify the real cause of the lack and eliminate it. The 5 WHY analysis covers two aspects - why the problem occurred and why it was not detected. The 5 WHY method encourages analytical thinking and independent search for a problem, which also increases the involvement of employees in the daily life of the company [1, 3, 7].

The article is a case study of the use of selected Lean tools in an enterprise producing upholstered furniture.

7.3. RESULTS

7.3.1. The use of the SMED method to reduce the machine changeover time

The tested production line, subject to the analysis of changeover times, was a sizing-tenoning line. This line is suitable for all kinds of tasks: bevel and miter cuts, profiling, folding, grooving, grinding, and corner machining. It is a modern production line that removes the allowance from the outer surfaces by machining. The line speed is 40 m / min, in three shifts, all days of the week. The device is equipped with automated material feeders, a sizing and tenoning machine intended for longitudinal processing of an element, a conveyor, an automatic receiver, a turntable, through-drills, a sizing and tenoning machine with pins that position them during transverse processing. Components such as the receiver, the feeder and the formatter-tenoners are numerically controlled, so the changeover is related to selecting the correct program. Only for the operation of drills the operator's intervention is required - replacement of heads and setting the drills in the spindles.

Table 1 shows the changeover process of the through-feed drilling machine before the improvement.

Thanks to the creation of the instructions for setting up the machine, it was decided that the drilling heads should be prepared by the sharpening room team in advance and then brought to the station before the line was stopped. Thanks to this, the operator will not be forced to perform this activity and can immediately proceed to disassembly of the heads and installation of new ones, already mounted, positioning them, and then proceeding to check whether the drilling is correct. Table 2 shows the average changeover time after the improvement using the SMED method.

Table 7.1. Time for retooling the through-feed drilling machine in the sizing-tenoning machine line before the improvement

Operation	Average time of realization [min]
1. Ordering another item	0
2. Dismantling the drill heads	12
3. Cleaning the machine	7.5
4. Disassembling the drill bits from the drill heads	16
5. Taking new technological documentation for a new product	5
6. Installation of drilling heads	8
7. Embedding the drill bits in the drill heads	23
8. Positioning the heads	9
9. Drilling a trial piece	3
10. Measurement of the distribution of drillings made on the measuring table	5
11. Correction of the setting of the heads	4
12. Measurement on the measuring table	5
13. Repeat steps 11-12 and start production	12
SUM	109.5

The changes made shortened the time of retooling the drill machine by as much as 58 minutes, which is over 50% of the time that was necessary before the changes were introduced.

7.3.2. Using the 5S method to improve the organization of workstations

Before the 5S method was introduced, all employees were trained in the company. During the training, employees were properly motivated by conducting monthly contests with awards for employees showing above-average commitment to the implementation of the 5S method. Signs about the implementation of this method have been placed throughout the plant. The following activities were carried out within the various stages of the 5S method:

Table 7.2. Measurement of the changeover time of the through feed drilling machine before and after the improvement with the use of SMED method

Operation	Average time of realization [min]		Comments
	Before	After	
1. Ordering another item	0	0	
2. Dismantling the drill heads	12	14	
3. Cleaning the machine	7.5	9	
4. Disassembling the drill bits from the drill heads	16	0	*They are made by the workers of the sharpening room*
5. Taking new technological documentation for a new product	5	0	*Supplied with heads*
6. Installation of drilling heads	8	7	
7. Embedding the drill bits in the drill heads	23	0	*Heads embedded in the tool room*
8. Positioning the heads	9	4	*Head setting instructions*
9. Drilling a trial piece	3	3	
10. Measurement of the distribution of drillings made on the measuring table	5	5	
11. Correction of the setting of the heads	4	3	
12. Measurement on the measuring table	5	6	
13. Repeat steps 11-12 and start production	12	0	
SUM	109.5	51	

1S – Sort

During the introduction of 1S, a team was appointed to audit designated workstations. The aim of this team was to prepare photo documentation before starting work. These teams were allowed to select themselves and make a selection card, and mark items with a red label that are of unknown purpose. The last goal was to make photo documentation after the action was carried out. Fig. 1 shows an example of the selection card used.

SELECTION CARD			WORKSTATION: **LOCKSMITHS TABLE WITH VISE**					
TOOLS								
NEEDED							UNNECESSARY	
		ALWAYS	OFTEN	RARELY	CONDITION	ZONE		
1	SCREWDRIVER			X	GOOD	2	1	DRILL
2	THREADER		X		GOOD	3	2	FILE
3	TRACKER MARKER	X			BAD	2	3	DRILL KIT
4	LOCKSMITHS HAMMER	X			BAD	1	4	
5	PLIERS			X	GOOD	1	5	
6	SCRIBER		X		BAD	2	6	
EQUIPMENT								
NEEDED							UNNECESSARY	
		ALWAYS	OFTEN	RARELY	CONDITION	ZONE		
1	MICROMETER	X			BAD	2	1	LOCKSMITHS CLAMP
2	CALIPER		X		GOOD	1	2	
3	CALIPER HEIGHT GAUGE	X			BAD	1	3	
4	LINE WITH GRADES			X	GOOD	2	4	
5	VICE	X			GOOD	3	5	
COMPLETED BY:		DATE:...................	APPROVED BY: .... DATE:................					

Figure 7.1. Selection card for the necessary tools at the locksmith's position

Items that were classified as unnecessary were marked with a red label, which indicated the further fate of such an item. Fig. 2 shows an example of a red label regarding an unnecessary item at the locksmith's position, which turned out to be a file, due to its damage.

2S – Set in Order

At this stage, the emphasis was on visualization (visual control). All items that are needed to be easily seen and used have been marked. Communication routes were marked as the first, thanks to which transport became safer and faster. Fig. 3 shows the effect of the changes made - the designated lines in the hall.

RED LABEL NO. 15/07/2021					
AREA		LOCKSMITH'S WORKSTATION			
1	**CATEGORY**	☐	raw material	☒	tool
		☐	production inventory	☐	equipment
		☐	semi-finished product	☐	instrument
		☐	product	☐	liquid
		☐	machine	☐	another
2	**CRITERION**	☐	frequency	☐	current plan
3	**NAME**	**Wood file**			
4	**RECORD CODE**	54631		11453	
5	**QUANTITY**	UNITS ………3…………		VALUE ……250 PLN …….	
6	**REASON FOR ELIMINATION**	☐	unnecessary	☐	surplus
		☒	broken	☐	outdated
		☐	difficult to handle	☐	defective
		☐	bad destiny	☐	another
7	**LOCATION**	☐	CE local warehouse	☐	CE central warehouse
		☒	tool magazine	☐	material warehouse
		☐	parts warehouse	☐	another
8	**SUGGESTIONS**	☒	throw away	☐	sell
		☐	return	☐	borrow
		☐	give out	☐	keep
COMPLETED BY: ………………………………………				DATE:………………..	
APPROVED BY: ………………………………………				DATE:………………..	

Figure 7.2. An example of the red label used on the locksmith's station

Figure 6.3. Marking with lines of communication routes

For easier use of tools, a shadow board was useful, thanks to which the tools always stay in place, workers are not wasting time searching tools, and do not disturb when no one is using them. Fig. 4 shows the shadow table which was used for the systematics of tools at the workstation.

Figure 7.4. Tool shadow board

3S – Shine

The third step involved cleaning of work stations combined with an inspection by which damaged or missing parts, tools, and components that needed to be replaced or repaired were noticed. The cyclical carrying out of such actions at workplaces in the plant allowed for quick problem detection, response, and effective removal, which resulted in maintaining a clean and more efficient workplace. Activities carried out in the 3S area constituted the foundation for the standards created at the 4S step.

4S – Standardize

The fourth step was based on defining the rules for 3S, creating visual standards, and ensuring that they are followed. The standards were designed by people who work in a given workstations. At this stage, a clear plan was created, thanks to which the repeatability of the activities and results was ensured. All activities were clearly assigned a standard. The task of the employees was to act in accordance with the established standards so that they became a habit and were integrated with everyday duties. The defined standards are subject to continuous improvement all the time. Fig. 5 shows the 5S control card assigned to the assembly station, where everyone can see what activity is performed, how long it takes, how often it is performed, and by whom and where.

5S control card		Workstation: Assembly table								Card code: KS 22/2021		
No	Description of activities	Time	Frequency	Who	When					How	Where	5S
					Mon	Tue	Wed	Thu	Fri			
1	Sweeping the position	5	once a shift	Operator	☐	☐	☐	☐	☐	Broom (magazine)	next to the workstation	3S
2	Washing the floor at the workstation	3	every day	Operator	☐	☐	☐	☐	☐	Wet mopping	next to the workstation	3S
3	Removal of debris from the table	2	after each operation	Cleaning lady	☐	☐	☐	☐	☐	Sponge - according to the stand washing procedures	at the workstation	3S
4	Cleaning a vice	4	every day	Operator	☐	☐	☐	☐	☐	Brush - according to the instructions	at the workstation	3S
5	Vise lubrication	2	once a week	Operator	☐					DW-21 grease according to the instructions	at the workstation	3S
6	Sweeping around the production cell	13	once a week	Cleaning lady					☐	Sweeper FR 30 T	around the cell	3S
7	Cleaning of assembly table	8	every day	Cleaning lady		☐					at the workstation	3S
8	Material quantity analysis	2	every day	Operator	☐	☐	☐	☐	☐		next to the workstation	2S
9	Red labels	1	once a month	Cleaning lady					☐	CE procedure	on items	1S

Responsible person: ……………………………………………………………

Approved: …………………………………………………………………… Date: ……………………………………

LEGEND
- every day
- once a week
- once a month
- once a shift
- for a specific date
- after each operation

Figure 7.5. Sample 5S control card

ASSESSMENT SHEET OF 5S IMPLEMENTATION		MECHANICAL MACHINING SOCKET					
AREA: ASSEMBLY TABLE GOM 22							
QESTIONS		Has a problem been spotted before?		Has the problem been resolved?		REMARKS	"S" POSITION
		YES	NO	YES	NO		
1	Have unnecessary tools and equipment been removed?	x		x			1S
2	Have unnecessary production materials been removed?	x			x		
3	Are all the necessary things in a place directly accessible?		x		x		
4	Are used items seldom stored properly?	x		x			
6	Is there a selection procedure?			x			
7	Are the storage areas well marked?			x			2S
8	Are aisles and work areas properly marked?		x		x		
9	Is each of the things in its place?	x		x			
10	Have all obstacles around the workplace been removed?		x				
11	Is each item put back in its place?		x				
12	Is complete documentation available?		x	x			
15	Is the work area clean?			x			3S
16	Is the equipment kept clean?			x			
17	Are the cleaning accessories easily accessible?				x		
18	Is cleaning used as part of the workplace inspection?	x		x			
19	Does the area meet the health and safety and fire protection requirements?		x	x			
20	Are 3S results assessed and monitored?				x		4S
21	Is all information visible?				x		
22	Is responsibility for the maintenance of the 3S assigned?			x			
23	Are all standards known and understandable?			x			5S
24	Are standards used in everyday work?				x		
COMPLETED BY: ………………………………………		DATE:……………….					
APPROVED BY: ………………………………………		DATE:……………….					

Figure 7.6. Sample 5S implementation assessment card

5S – Sustain

In the last step of the 5S tool, during the trainings, the need to work on oneself was emphasized in order to constantly remember the introduced steps. This step applied directly to every employee, regardless of the position he held in the company. To monitor the improvements made, the 5S implementation assessment cards were used to show the improvement or deterioration of the results. Fig. 6 presents the 5S introduction assessment card used in the examined enterprise.

7.3.3. The use of the 5 WHY method to reduce the chance of the emergence of quality problems

The 5 WHY method contributed to a significant reduction in the likelihood of chronic quality problems in the company related to "making inappropriate holes" in furniture elements (such non-conformities included: the wrong location of holes in wooden elements, no holes, too many holes, holes with the wrong diameter - too small, too big). The use of the 5 WHY method and brainstorming in a specially selected working team familiar with this problem helped to find the true source of its occurrence. It turned out that the examined problem was more complex, i.e. several factors had a significant influence on its occurrence. Organizational factors and factors related to the competencies of employees [15] - drill operators and training staff were indicated as the source of the problem. It was found that the production of inadequate holes was mainly caused by the low quality of on-the-job training of employees - drill operators, and the lack of people who would care for the appropriate level of such training and also take care of the continuous professional development of employees. The problem was solved by delegating a competent, experienced manager with the ability to effectively transfer knowledge to conduct internal training for employees - drill operators, introducing additional evaluation of the training effectiveness through a short, practical "final exam". The process of managing employee competencies was also verified and improved. An individual competence development plan was introduced for each employee in the company. An employee suggestion system [2] linked to awards was introduced to motivate employees to improve the drilling process. "Idea boxes" were installed at the plant, into which employees could throw cards with ideas for process improvement. Each positively considered and implemented idea was associated with an appropriate financial reward for the employee, depending on the benefits for the company associated with the implementation of a given solution. It motivated employees to take actions aimed at continuous improvement of the production process.

The result of the application of the 5 WHY method in relation to the analysis of the qualitative problem of the type of "making inappropriate holes" is shown in Fig. 7.

5 WHY	Problem: *Nonconforming holes in the furniture parts*	Form N°: *5/10/2020*	Line: *sizing and tenoning line*	Technical order N°:	Lider: *A. Nowak*

Start date: *14.10.2020*	Machine downtime: / Repair time:	Anomaly classification: ☐ Occasional ☑ Chronic	Potential Benefits: *Reduction of the number of non-conforming products, reduction of waste, reduction of repairs and alterations, elimination of "hidden factories", reduction of poor quality costs, quality improvement, improvement of the company's image among customers*	End date: *14.10.2020*

Problem (description, sketch, diagram)	1. WHY?	2. WHY?	3. WHY?	4. WHY?	5. WHY?	Verification	Actions: Temporary:	Actions: Target:
Nonconforming holes in the furniture parts	*Use of an unsuitable drill bit*	→	→	→	→	*OK*		
		Little experience and insufficient knowledge of drilling machine operators	→	→	→	*OK*		
			Insufficient level of training	→	→	*OK*		
				Inadequate adaptation time of the operator to new duties	→	*OK*		
					Poor quality of on-the-job trainings	*NOK*		*Delegating a competent manager to on-the-job training*
					Lack of professional development of employees	*NOK*		*Creation of an employee development system - development planning for each employee*
					Lack of an effective management system and employee competency improvement	*NOK*		*Creation of an employee development system - development planning for each employee*

Temporary actions:

N°	Intervention	Data	☺ / ☹

Target actions:

N°	Intervention	Data	☺ / ☹
1	*On-the-job training of employees along with the final exam*	*20.10.2020*	☺
2	*Implementation of the employee development system*	*27.12.2020*	☺

Results:
After employee training and the introduction of the employee competency development system and the suggestion system - the above-mentioned problem appeared only once within three months

Figure 7.7. 5 WHY card with the result of the root cause analysis of quality problems related to nonconforming holes in furniture elements

The benefits of using the 5 WHY method and the implemented organizational solutions were reflected in a significantly limited number of nonconformities such as "inappropriate holes" in furniture elements, reduction of the amount of non-repairable material, as well as time and resources needed to re-perform activities related to product repairs in the production process (minimizing so-called "hidden factories"), better collaboration between training workers and drill operators, and overall better job satisfaction.

7.4. CONLUSION

In the article was presented the result of using selected Lean tools in a company producing upholstered furniture located in Poland. The research part concerned showing the way of implementing such Lean tools in the examined enterprise, as the SMED, 5S, and 5 WHY. Positive effects related to the implementation of the above-mentioned Lean tools contributed to the dissemination of these tools to other areas in the organization and to the intensification of works related to the implementation of the Lean concept in the plant. Due to the application of the SMED method in the surveyed company, the time for retooling the drilling machine was reduced by over 50%, despite the small changes and expenditures undertaken. This result motivated the staff to further improve production at all workstations that require retooling. Using the 5S method and going through all its steps, clean, organized, and safe workstations were provided in the pilot area covered by the implementation. Due to the regular and comprehensive cleaning of the hall and production machines in this area, the number of machine failures was increased. It turned out that the most difficult and time-consuming step was to introduce self-discipline among employees in order to change the approach to the place and work. By using the 5 WHY method, the number of cases related to the nonconformities of hols in furniture elements was significantly reduced. A carefully selected working team, using the 5 WHY method, indicated the root causes of this problem, which turned out to be organizational and management issues, for which effective corrective actions were proposed. In the article was proven that Lean methods such as SMED, 5S, and 5 WHY if used correctly can bring significant measurable and non-measurable benefits to every enterprise. The article has also emphasized the need to involve employees when implementing these methods.

The use of each of the Lean methods in the surveyed company allowed to achieve the main goal, which was to improve the production processes of furniture. The positive implementation of Lean tools in the enterprise turned out to be a factor motivating employees to continue working with Lean tools and encouraging the company's management to disseminate the Lean concept to the entire plant. In order to maintain the effects of the changes introduced in the examined enterprise, it is undoubtedly necessary to build an appropriate organizational culture, i.e. collective programming of the mind of employees and management, in which the main value is individual creativity and teamwork, which is based on mutual trust and responsibility between employees and management. Employee development, improvement of their qualifications and motivation should also be the basic value for organizations that want to achieve lasting benefits from the implementation of the Lean concept.

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8. COOPERATION-BASED CONTROLLING IN THE FOREST ECONOMY - THE CASE OF POLAND

Leszek Wanat

8.1. INTRODUCTION

Home is a place where you want to return. It should be emphasized that the home is created primarily by people, our loved ones, dear to our hearts. At the same time, the home is a living space, which we probably spend most of our time in, trying to give personal life the highest quality possible. The individual components of the home have specific functions. It is amazing how important kitchen is for household organization (Supski, 2017). A kitchen room with its equipment usually satisfies two groups of needs: basic and higher ones. Basic needs include: preparation and consumption of meals, cleaning and food storage. In turn, meeting the needs of a higher order, the kitchen fulfills very important social functions: it is a place of meetings, building relationships, self-realization, and also has aesthetic functions (Nixon, 2017; Cowan, 2018; Kunce, 2018).

The contemporary image of the kitchen was shaped in the 1920s, the 20th century. At that time, Margarete Schütte-Lihotzky, referring to the modernist concept of 'socially engaged architecture', proposed a model of so-called 'Frankfurt kitchen. Referring to Frederick Winslow Taylor's scientific work and own research, Schütte-Lihotzky designed the ‘industrial kitchen laboratory’. A characteristic feature of this specific research workshop was the high level of task organization (functionality) carried out with the minimum number of moves (Schütte-Lihotzky, 2004). In a small room (dimensions 3.4m by 1.9 m), the necessary kitchen equipment and storage spaces were placed, available to the user sitting on a rotary stool. The project was created in response to the social needs of the inhabitants of Frankfurt. Based on the experience gained, 10,000 new, prefabricated kitchen modules designed in this original process were installed in the flats of the newly built housing estates. The developed model not only set a long-term standard of ergonomic kitchen. It also became a symbol of women's emancipation. This happened mainly due to the first Austrian woman - architectural engineer, who was the author of the solution Margarete Schütte-Lihotzky herself (Henderson, 1996). Women, who more and more often undertook 'male' paid work needed a functional kitchen. They couldn't spend too much time on traditional housework.

Isn't that a bit like of the modern world dominated by digital technologies? Each of those prefabricated ‘*Frankfurt kitchens*’ had the same functional parameters (dimensions). This greatly limited the adaptation of furniture to the needs of customers with special preferences. Contemporary designed kitchen furniture, although to some extent refer to their ancestors, have lost their industrial character. Today, customers can benefit from the so-called mass customization of the final product (Doiro et al., 2017; Wiechoczek, 2018). It results in multi-variant products, manufactured using efficient, modern technologies, offering simultaneously a typical productivity for mass production.

Although this does not always relate directly into functionality, ergonomics or even the environmental friendliness of products, but in return you get the ability to almost free customization of the designed furniture in the kitchen. It is possible to effectively involve the end user in the design process. Therefore, we are invited to participate in participatory design or co-design. In this respect, the world of digital technologies is already fully present and accessible to almost everyone. Designing individual furniture development using an application launched in a web browser usually involves the selection of modular cabinets and accessories from a certain limited collection. It is usually the source (resources) of the current commercial offer of a certain manufacturer or commercial retail chains. Each of the selected elements can be changed for its specific parameters. Therefore, the dimensions within the series (set of dedicated dimensions), surface finish, internal layout and other parameters change. These applications are usually part of more integrated industrial computer systems for enterprise resource planning (ERP).

As a result of the design process, the customer can see the effect of their decisions in the form of a visualization of the furnished kitchen room (Sjøbakk et al., 2018; Stone and Levine, 2019). After 2012, more design innovations appeared. Modern systems are no longer bound to closed sets of technological and dimensional solutions. It is possible to design furniture to any dimension, taking into account the technological rules implemented in the software. In addition, preliminary 'virtual' verification of the appearance of designed furniture in a specific kitchen room is available. This is another step in the process of customization of design, without increasing the cost of furniture production (Lihra et al., 2008; Sydor and Ligocki, 2017).

Does the end-use of kitchen design by such far advanced adjustability and the highly individualized commercial decision making by end users of furniture still make sense in examining their preferences? Is there any need to optimize such decisions?

8.2. MARKET IDENTIFICATION OF USERS OF KITCHEN FURNITURE

From the perspective of furniture manufacturers and building business models in this profile, the process of design customization is a challenge that is not always conducive to production optimization and effective management. Indeed, everyone seems to understand this, trying to adapt, but they are not always ready for multispecialization (Motik et al., 2004; Chudobiecki and Wanat, 2015; Kaputa et al., 2018; Mikołajczak et al., 2019). Can it be said that such exists at all? It has been noticed that wherever, as a kitchen user, a human focuses not only on functionality but on quality of life, he also allows his aesthetic needs to be heard. These, however, do not always fit the most adjustable collection of furniture modules or the catalog of available technologies. It may be assumed that the market will keep space for slightly narrower, which does not mean completely narrow specializations in the field of furniture design and production, not only kitchen related (Wanat, 2009). In this context, it seems reasonable to study the conditions and preferences of kitchen furniture users. It is worth of the conduct, if only to identify the main trends in this area, dare to create and design new ones (Liker et al., 2016; Bonenberg et al., 2019). Is it worth it?

Indeed, if we do not want the house to remain only a place of vegetation, but be a creative space, conducive to creativity, fulfillment and joy of life. To verify, if there are even small reasons for this, a pilot consumer opinion survey was first carried out on what functional types of kitchen they use in their flats. The study was conducted using a survey technique on a purposely selected sample of 200 users of newly built apartment flats and single-family houses in the Poznań Agglomeration, i.e. in Poznań, one of the largest cities in Poland and its immediate vicinity.

The respondents themselves had to describe and attempt to identify the kitchen they were using, while not being employees of the furniture industry. The respondents were also asked to indicate three additional, alternative types that they know and which they could take into account when furnishing the kitchen in their home.

In the study designed in this manner, 124 responses considered valuable were obtained. The four most frequently indicated types of a kitchen room were identified:

1. CLASSIC - a typical residential kitchen, adapted to the usually limited space available, construction conditions, with the necessary minimum of functionality.

2. MODERN - open, sometimes integrated with a self-designed residential space, using the latest technologies, including digital technologies, multifunctional, usually part of an intelligent building, the so-called smart kitchen.

3. RETRO - stylish, referring to the '*kitchen of our grandmothers*' and local cultural traditions, made of natural materials, environmentally friendly, meeting the most important functions and needs of users.

4. MIXED (*mix-kitchen*) - combining functionality with aesthetics and tradition, a variety of materials and elements of new technologies; taking into account users' fantasy, coexistence of styles and utility functions.

Based on such specific results, a study was designed in the next step to identify the preferences of future kitchen users, potential individual designers, and customers who dream of their own home in a definable perspective. Academic youth of full-time students of the city of Poznań, studying economics and IT, were invited to the study (Popek and Wanat, 2016).

It used the diagnostic survey method, using the survey and in-depth interview technique. A proprietary survey questionnaire was developed, also referring to selected methods of decision optimization (Orszulak-Dudkowska, 2012; Popek and Wanat, 2014; Zalega, 2016; Kościelniak and Tyszka, 2019). In particular, the algorithm referring to the analytical method for hierarchical decision problem AHP (the Analytic Hierarchy Process) was verified. It consists in decomposing the task (research problem) into simple components and then applying a comparative analysis carried out as part of an in-depth interview by the respondents (Saaty, 1988; Berrah et al., 2019; Liu et al., 2019). Why was this method chosen?

8.3. SELECTION OF A MULTI-CRITERIA METHOD OF DECISION MAKING

Among the multi-criteria decision-making methods, the most popular are: Analytical Hierarchical Process (AHP) and Analytical Network Process (ANP). The popularity of the AHP method is due not only to its effectiveness in solving problems, but also to its relative transparency and ease of use. The Analytic Hierarchy Process (AHP) method was designed and applied by Thomas L. Saaty of the University of Pittsburgh in the 1970s (Saaty, 1988, 2008). It was used to create the '*Super Decisions*' software, which Saaty is the co-author of. The method uses a general, hierarchical approach in the process of making multi-criteria decisions. It allows combining quantified and non-quantified criteria as well as objectively measurable and subjective factors (Asadabadi et al., 2019; Dos Santos et al., 2019).

8.3.1. Assumptions and application of the AHP method

The implementation of the assumptions of the AHP method consists in decomposing the research problem into simpler components, assessing these components by experts, and then processing aggregate assessments based on pairwise comparison. There are many applications of this method in supporting economic, technical or social decisions, which confirms their usefulness (Berrah et al., 2019; Cooke, 2019; Liu et al., 2019). Modeling using AHP hierarchical problem analysis is especially useful when:

- the functional relationship between the elements of the decision problem described in the form of a hierarchy of factors is unknown,
- at the same time, it is possible to estimate the effect of occurrence of given properties of the problem (product) under study and the practical effect of these properties (Tułecki and Król, 2007; Lima-Junior, 2019; Wang et al., 2020).

In this work, the Analytic Hierarchy Process (AHP) approach was chosen to verify the problem. This is an example of an algorithm for making complex decisions based on a large number of criteria. The starting point is the hierarchical decomposition of assessment criteria. The priority hierarchy in the AHP method has a predefined structure. First, the goal of the decision process is set, then the assessment criteria and solution options are set. In this approach, the decision maker has an impact on the entire process. He can choose the best solution among many variants. The decision maker assesses possible variants of selection in terms of specific criteria, as well as the weight of these criteria in terms of purpose, based on his knowledge and experience.

8.3.2. Programming the stages of research under the AHP method

There are basically five stages in the Analytic Hierarchy Process (AHP) convention:

* STEP 1: Hierarchy of the problem - the goal of this stage is a detailed description of the problem, identification of participants, determination of the goal of the main goal and expected results.

** STEP 2: Problem decomposition - isolation of the primary goal, main factors and partial factors as well as variants considered. The verified variants reflect a certain degree of implementation of the objective function, identified appropriately for each level of the hierarchical model.

*** STEP 3: Evaluation of the tested criteria by pairwise comparison - the assessment is made by an expert (decision maker) invited to the study. He compares the sub-goals (selected functions) with each other in pairs in relation to the criteria, and the criteria in relation to the superior goal. The comparison consists in a subjective determination of which of the criteria and to what extent is more important than the other in the expert's opinion. The relations between individual elements are usually determined by a 9-point scale (Saaty, 2008; Prusak et al., 2016; Abastante et al., 2019): 1 - equal significance; 3 - slight advantage; 5 - strong advantage; 7 - very strong advantage; 9 - absolute advantage; 2, 4, 6, 8 - intermediate values. Ratings with opposite relations are marked as the inverse of whole numbers. This stage ends with the creation of a result matrix.

**** STEP 4: Determining mutual preferences (weights) in relation to criteria and decision variants - after building the matrix, we calculate the weights of the criterion. The normalized rows of the matrix are added together and the matrix's vector is calculated. Ratings from experts are not always completely objective. Therefore, the inconsistency factor is taken into account (in parallel, the consequence factor and random index).

***** STEP 5: Analysis of selected results - the research scenario finalizes the selection of the best variant that would correspond to the achievement of the overarching goal. Dedicated software, such as ‘*Super Decisions*‘ or ‘*Expert Choice*’, is also used to perform this stage.

Obviously, when designing the author's research scenario, it is possible to distinguish main stages or specify them, according to the specific conditions of the study.

8.4. SCENARIO AND RESEARCH RESULTS

In the designed study, an attempt was made to identify the preferences of future kitchen users, designed for the surveyed own flats. In order to achieve this, the analytic

Hierarchy Process was used. The main research problem was divided into simple components determining its essence, and then respondents compared them in pairs.

8.4.1. Determining the scale of relative preference for the AHP model

In the process of comparing elements, a 9-degree scale of relative preference of Saaty was used. In accordance with this, separate elements of the scale were distinguished: 5 basic and 4 intermediate levels (Saaty, 2008; Abastante et al., 2019; Berrah et al., 2019; Cooke, 2019; Liu et al., 2019).

In particular, respondents' attention was paid to basic levels, distinguishing:

1) EQUIVALENCE: no preference for compared objects.

2) WEAK PREFERENCE: the first element is weakly preferred over the second, or vice versa.

3) IMPORTANT PREFERENCE: the first element is significantly preferred to the second, or vice versa.

4) CLEAR PREFERENCE: the first element is clearly preferred over the second, or vice versa;

5) ABSOLUTE PREFERENCE: the first element is absolutely preferred to the second, or vice versa.

The respondents' opinion was compared with an expert opinion, which was considered due to future actual users of kitchen furniture. The survey combined with individual in-depth interviews was conducted on a group of 120 full-time students. Unfortunately, the results of some surveys turned out to be contradictory (respondents making pairwise comparisons provided mutually exclusive answers). These surveys were excluded from the final analysis. Finally, the results from 40 positively verified questionnaires were included.

8.4.2. Selection of evaluation criteria for the AHP model

As mentioned in point 2 of this chapter, four functional kitchen types have been previously identified for the purposes of the study: classic (type 1), modern (type 2), retro-stylish (type 3) and mixed / mix-kitchen (type 4) .

The respondents chose the kitchen based on four criteria. Also, these criteria, defined as the main determinants of kitchen furniture preferences, were previously determined in a pilot study.

The following criteria for choosing kitchen furniture were taken into account: price (criterion 1), quality (criterion 2), environmental performance (criterion 3) and functionality (criterion 4).

The criteria thus defined are described in detail, listing:

1) PRICE - understood as a relation of quality to price, with an indication of the preference for the lowest possible costs of both equipment and use;

2) QUALITY - understood as durability, elegance, comfort and a high standard;

3) ECOLOGICAL (environmental performance) - understood as the preference for natural materials, including wood, environmentally friendly construction and technologies, conducive to a healthy lifestyle and natural nutrition, facilitating segregation, minimizing waste and recycling.

4) FUNCTIONALITY - understood as practicality and high usability of the kitchen, having all functions adequate to the needs of the user, reflecting a kind of universality for the user.

The study was optimized, extracting in this case three levels of research. They are illustrated in Figure 1.

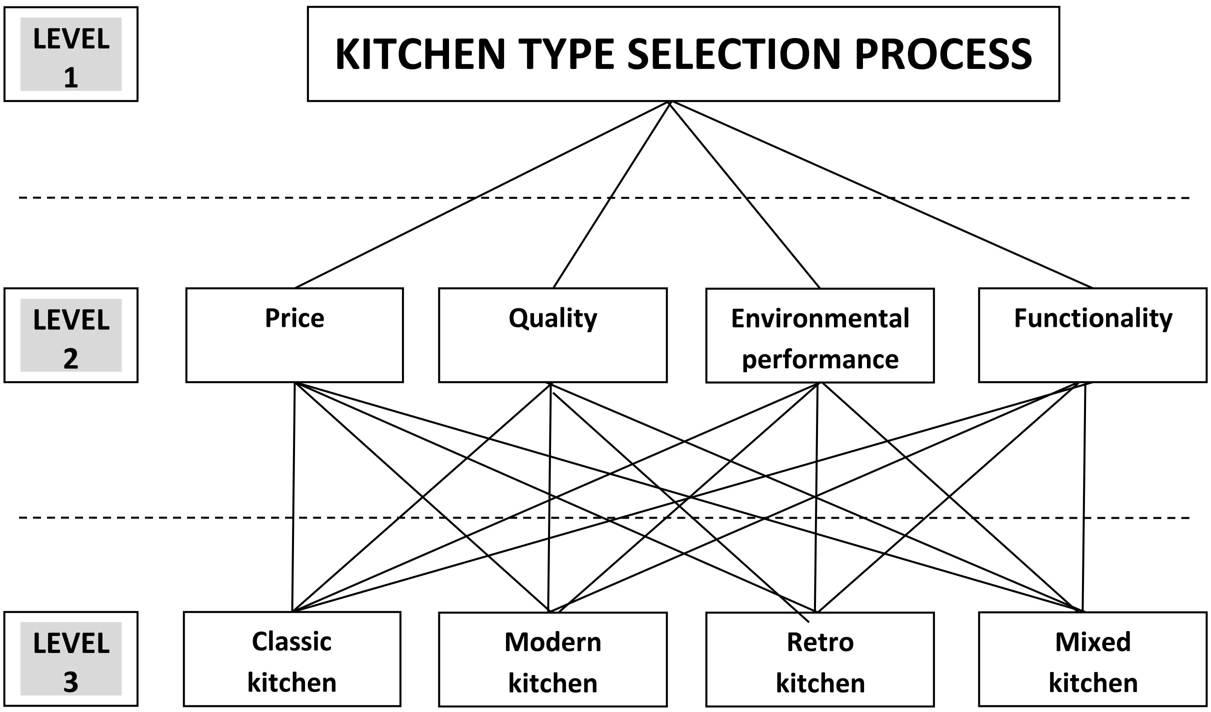

Figure 8.1. Visualization of the author's scenario according to the AHP method - research levels
Source: Own study

8.4.3. Results

Using the Analytical Hierarchical Process (AHP), results were obtained that made it possible to identify the most popular functional / utilitarian types of kitchen and key criteria for their selection, which might be made by young, future users (Table 1).

In particular, when analyzing aggregated data in the study of the popularity of various types of a kitchen, it was noted that:

- young students in the first place chose classic kitchen (85% of respondents indicated the preference for this type of a kitchen in the first place).

- at the same time, just behind the classic, modern kitchen was ranked (80% of respondents indicated the preference for this type of a kitchen in second place).

- retro and mixed kitchen were selected in turn (95% and 99.75% respectively indicated the first preference for these types of a kitchen in third and fourth places respectively). It is worth noting that the preference line in the AHP method is determined by the diagonal of the results matrix (Table 1).

Table 8.1. Preferences for choosing kitchen furniture / kitchen type after taking all criteria into account (aggregate results matrix table)

Hierarchy of kitchen furniture selection preferences / type of kitchen (places)	Classic kitchen (%)	Modern kitchen (%)	Retro kitchen (%)	Mixed kitchen (%)
Place 1	**85,0**	15,0	0,0	0,0
Place 2	15,0	**80,0**	5,0	0,0
Place 3	0,0	5,0	**95,0**	2,5
Place 4	0,0	0,0	0,0	**97,5**
Checksum	*100,0*	*100,0*	*100,0*	*100,0*

Source: Own elaboration based on aggregated results in the questionnaire and in-depth interview

The diversity of respondents' preferences and the direction of the conventional trend, a simplified model of the kitchen user market, is also illustrated in Figure 2

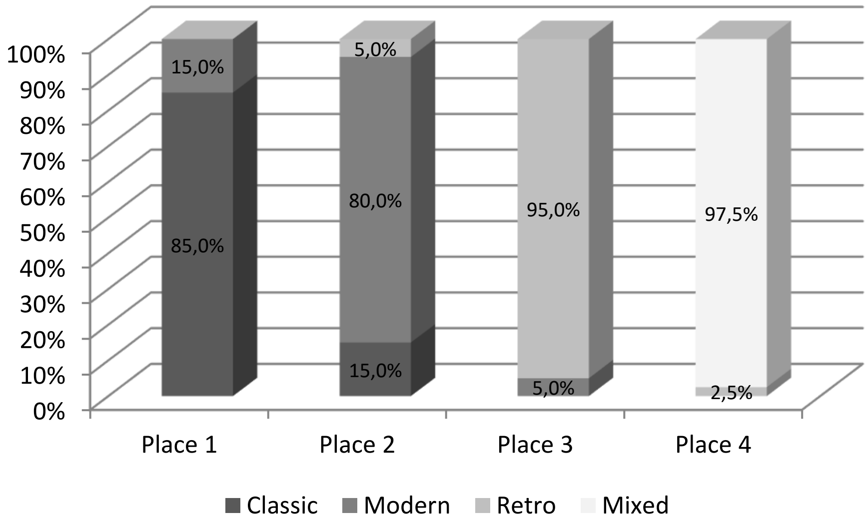

Figure 8.2. Visualization of the main preferences for choosing kitchen furniture / type of kitchen taking all criteria together into account
Source: Own study

In addition, by selecting the kitchen selection criteria, it was found that:
- for young students planning to buy their own apartment, the most important factor in choosing their home kitchen is the price (90% of indications);
- it does not prejudge the fact that the other factors previously described as important, namely quality, environmental performance and functionality, have no meaning; however, clearly informs that at this stage of life, young adults cannot mostly afford high expenses for furnishing the apartment, including the kitchen;
- at the same time, it is worth noting that, although a relatively small group of respondents (8%) gave priority to the quality criterion over price.

- only 2% ordered the analyzed criteria in a different order.

Eventually, taking into account the importance of only one of the selection criteria, the following trends were established on the basis of a pair-wise comparison:

1) PRICE: considering only the price criterion - 72.5% of respondents chose classic kitchen, 22.5% modern, while only 5% selected other types of kitchen;

2) QUALITY: considering only the quality criterion - classic kitchen was chosen by 65.0% of respondents, modern 30.0%, and other types of kitchen by analogy 5% of respondents;

3) ECO-FRIENDLINESS (environmental performance): considering the ecological criterion only - classic kitchen was chosen by 67.5% of respondents, modern kitchen by 15.0%, and other types of kitchen by 17.5%;

4) FUNCTIONALITY: considering only the functional criterion - classic kitchen was chosen by 72.5% of respondents, modern 25.0%, while other types of kitchen, which is worth emphasizing, only 2.5% of the surveyed students.

Detailed results are presented in Table 2.

Table 8.2. Preferences for choosing kitchen furniture / type of kitchen after considering only one criterion

Preference for ONE criterion (horizontal) for a specific functional type of kitchen (vertical)	**Price (%)**	**Quality (%)**	**Environmental performance (%)**	**Functionality (%)**
Classic kitchen	72,5	65,0	67,5	72,5
Modern kitchen	22,5	30,0	15,0	25,0
Other kitchens	5,0	5,0	17,5	2,5
Checksum	*100,0*	*100,0*	*100,0*	*100,0*

Source: Own elaboration based on aggregated results in the questionnaire and in-depth interview

In addition, the trends identified in the study, indicating a clear preference for classic kitchen, even in view of the tempting versatility of the functional model, is illustrated in Figure 3.

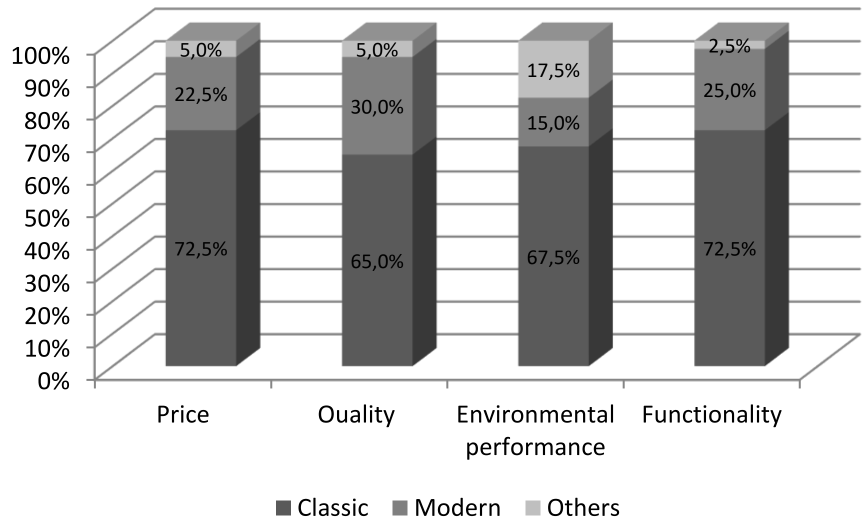

Figure 8.3. Visualization of the main preferences for kitchen furniture / kitchen type, taking into account only one criterion into account (Source: Own study)

The results of the study, although seemingly difficult to discuss, seem to allow for prediction of dominant market trends. Therefore, the main segment of the kitchen furniture market in terms of design and production was indicated, which in the era of almost customization of the design process and flexible decision making seemed impossible.

8.5. CONCLUSION

Optimization of business models in the production of kitchen furniture, although must assume flexibility of choice and almost unlimited customization of the kitchen design process, is needed. Rational management of inventories and the foundation chain will remain one of the key factors determining business efficiency. Even the temptation to completely customize the production process will not change this.

Even this perspective will have to face the length of the production cycle. It seems that this time, as well as the final price of the furniture, will decide on a certain compromise between customization and unification.

These conclusions and recommendations are prompted by an in-depth analysis of the results obtained under a relatively simple test scenario using the AHP algorithm. It can be assumed that this method will be used more and more widely. It may even be used as a tool to select the best tenders, as well as the best management practice (Wanat and Lis, 2009; Mikołajczak et al., 2020). The advantages of this method are: flexibility, ease of use, objectivity of variant selection, comparison of both qualitative and quantitative factors (Wanat et al. 2018a, 2018b). Many decision-making processes in forestry and the wood-based sector meet the assumptions of the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) methods (Chudobiecki et al., 2016; Wanat et al., 2019). For subsystems: benefits, costs, opportunities and risks, it is possible to formulate organizational, production, technological and economic criteria, for which, in turn, the values of priorities (weights) may be calculated. Thus, it becomes relatively simple and feasible to determine the optimal development variant of the examined project, indicating significant benefits and threats.

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9. THE INFLUENCE OF COVID-19 PANDEMIC ON THE FURNITURE INDUSTRY TRADE MANAGEMENT RESULTS

Renata Stasiak - Betlejewska

9.1. INTRODUCTION

Furniture retail and trade is an important part of the global economy. The furniture industry is comprised of the production, distribution, and retail of furniture for residential and commercial use. Be it in homes, offices, schools, or even outdoors, there are pieces of furniture to be seen almost everywhere. The global furniture market is a multi-billion U.S. dollar industry, which employs large numbers of people around the world. The United States is the largest furniture market in the world, however the APAC region is growing in size and importance, accounting for three of the top five leading markets.

As part of the fast moving consumer goods (FMCG) sector, the furniture market tends to rise and fall based on world economic trends. During a recession, the industry tends to be negatively impacted as consumers cut back on non-essential spending, putting off home redecoration and renovation projects due to lower disposable incomes. This happened most recently during the 2020 coronavirus pandemic, as reflected in IKEA's sales figures. The import and export of furniture is also impacted by such events, however trade values have been growing steadily in recent years. China is the dominant exporter of furniture and the United States leads for imports (Statista Research Department 2021).

The COVID-19 pandemic has had a significant impact on the global economy, causing revenues to decline in many industries. The furniture industry is one of those industries that suffered little from the pandemic crisis, largely due to changes in the structure of consumer spending. The increase in demand for furniture industry products resulted from the fact that consumers directed their spending towards durable consumer goods, especially related to home furnishings. Despite the shrinkage of the global furniture market in 2020 by 2% compared to the previous year, already in 2021 a rebound can be expected to a level 4.5% higher than in the year preceding the outbreak of the pandemic (Statista). The chapter present results of the analysis of the Polish furniture industry size forecasts until 2025 in the context of the industry's results recorded in various national reports.

The Polish furniture industry has for many years been characterized by a strong position in the global furniture market. In 2019, it was the third largest furniture exporter in the world. Poland has only been occupying a high position on the furniture market since 2018. The economic crisis triggered by the COVID-19 pandemic has stopped the upward trend in Polish furniture exports, which has been observed for many years. The exports in 2000 expressed in EUR closed by a 4.3% decrease compared to the previous year. This is a significant success compared to the German furniture market, which in 2020 decreased by 9.3% compared to the previous year. In 2020, the Polish furniture industry recorded an increase in sold production by 0.4%.

The factors strengthening and weakening the economic situation in the Polish furniture industry in 2020 include (Biuro Strategii i Analiz Międzynarodowych, Departament Analiz Ekonomicznych 2021):

- high demand for furniture in the second half of 2020, both on Western European markets and on the domestic market (stimulated, among others, by a high number of apartments commissioned for use),
- high flexibility of Polish producers and the ability to adapt to new conditions,
- good quality and a large variety of offers,
- bold investments in machinery in previous years and good use of EU funds,
- favourable EUR / PLN exchange rate,
- very large drops in demand in spring 2020 caused by the first lockdown related to the pandemic,
- a small share of non-European markets in exports (including Asian markets, which saw an increase in the size of the furniture market in 2020),
- an increase in the prices of wood and other raw materials used in the furniture industry at the end of 2020 (especially furniture boards and products petroleum derivatives used in furniture, including foams, adhesives),
- relatively large indebtedness and small liquidity reserves of enterprises,
- still insufficiently promoted brand of Polish furniture/Design on international markets,
- outflow of employees of Ukrainian origin in the first half of 2020.

In the years 2010-2019, the average growth rate of the furniture sector production was over 7% per year and it clearly exceeded the dynamics of the entire Polish industry (approx. 5% in the same period). The Polish industry ranks third in Europe in terms of size, second only to Italy and Germany. - The many years of successes of the domestic furniture industry are undeniable, and the knowledge in this field has penetrated beyond the industry environment and the sector is now commonly associated as one of the Polish international specializations. It is a mature industry, but at the same time evolving and still prospective. Bank Pekao analysts point out that the industry, despite a temporary drop in production, coped well during the pandemic. The biggest challenge she faced was in the first stage, when factories were stopped, supply chains had problems, and furniture stores were closed. However, most of these problems were temporary. In the first half of 2021, production was 14% higher than in the pre-pandemic first half of 2019.

Import value of furniture worldwide in period 2003 – 2019 *(*in billion U.S. dollars) has been presented in Figure 1.

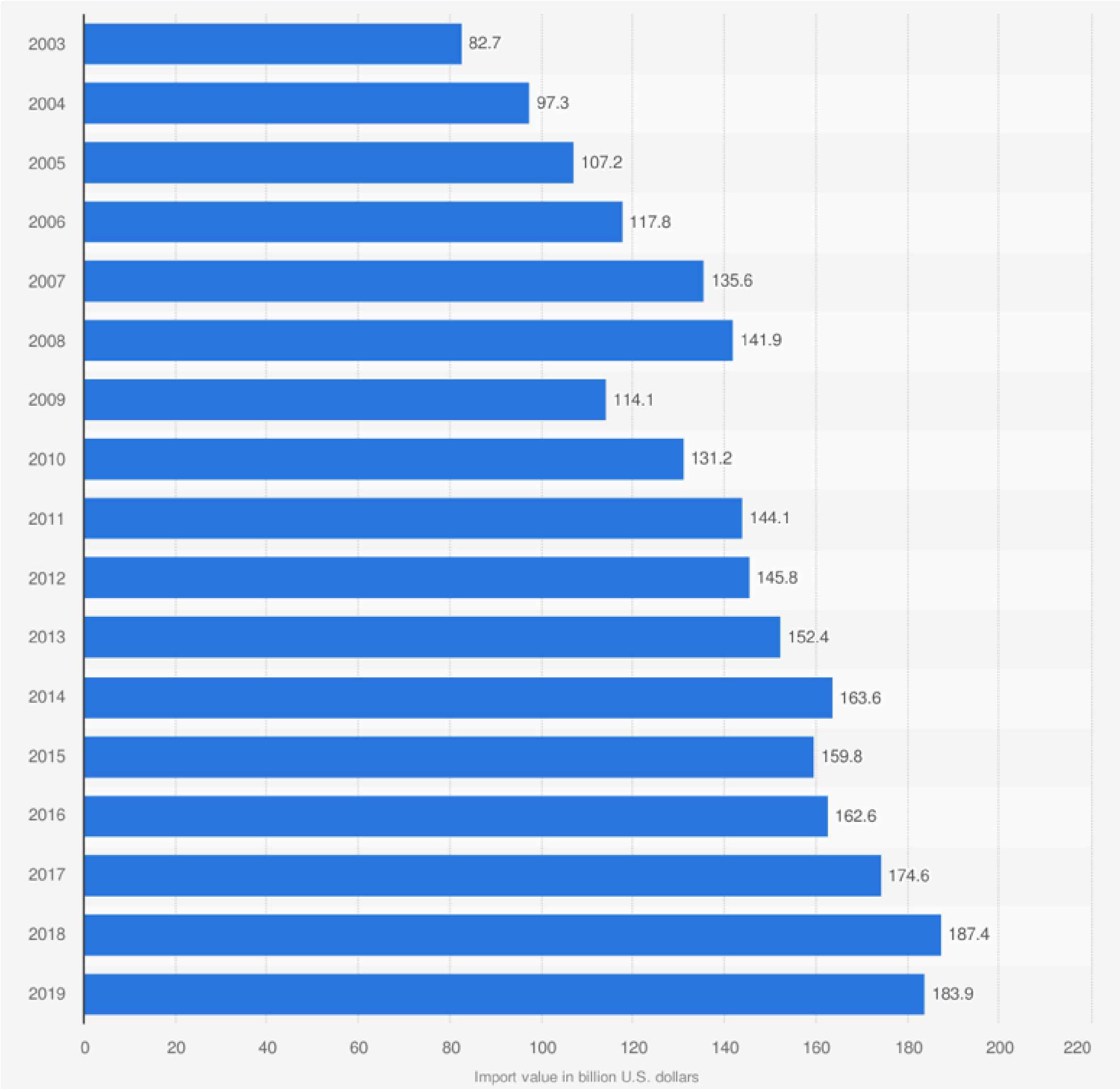

Figure 9.1. Import value of furniture worldwide in period 2003 – 2019 (in billion U.S. dollars).

Source: UN Comtrade Statista 2021.

In 2019, the worldwide import value of furniture was approximately 184 billion U.S. dollars. In 2003, the import value exceeded 82 billion U.S. dollars. The global export value of furniture noted approximately 190 billion U.S. dollars in 2019.

Export value of the worldwide furniture industry in period 2003 – 2019 has been presented in Figure 2.

It can be noted, that in in 2003, the worldwide export value was 76.1 billion U.S. dollars. The global import value of furniture was approximately 190 billion U.S. dollars in 2019.

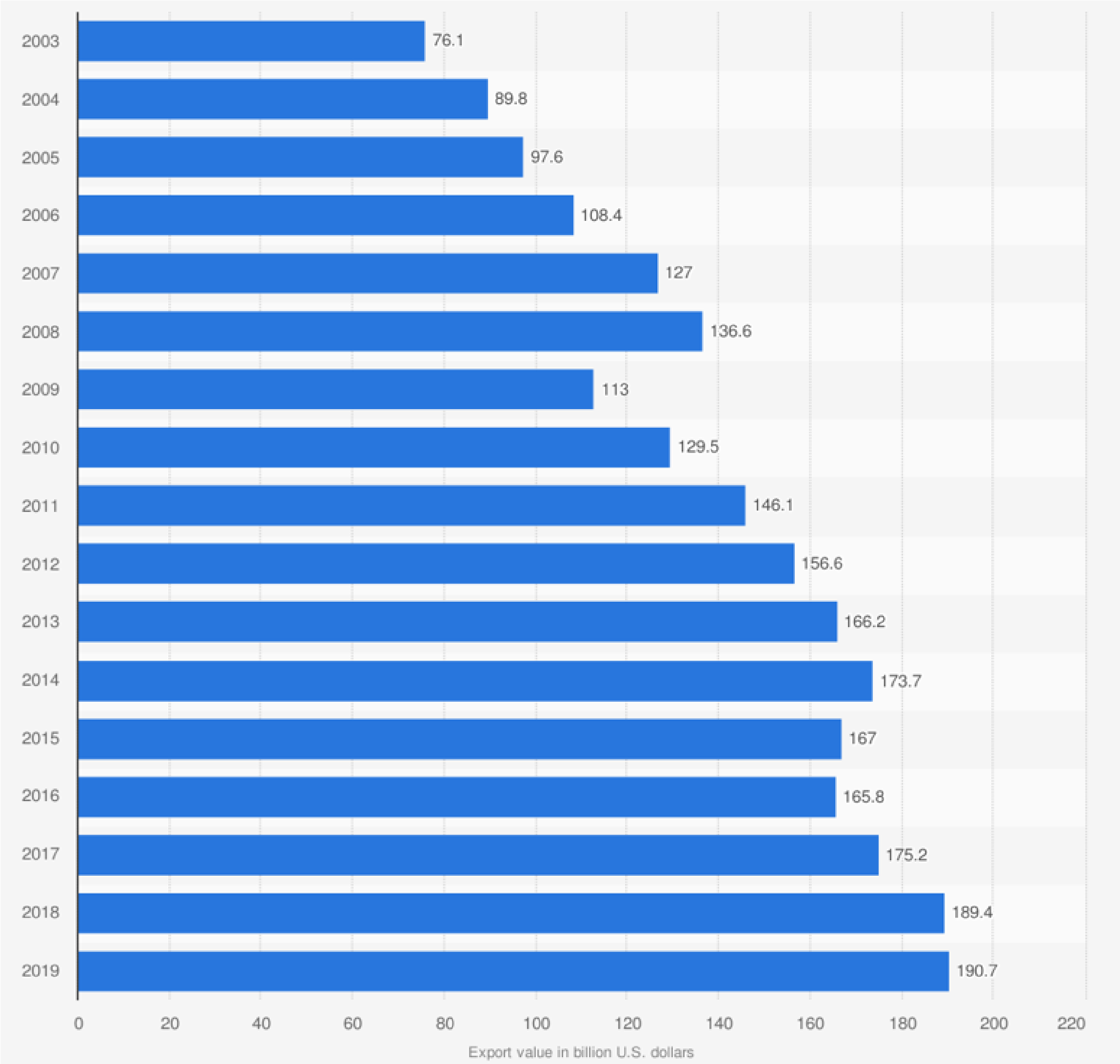

Figure 9.2. Export value of furniture worldwide from 2003 to 2019 (in billion U.S. dollars).

Source: UN Comtrade Statista 2021.

The largest market in the world for the furniture industry is the United States. In 2019, they generated revenues of EUR 230.0 billion (19.8% of global sales). This value is projected to increase to EUR 239.1 billion in 2025, a level 4.0% higher than in the year preceding the COVID-19 pandemic.

Leading exporting countries of furniture worldwide in 2019 (in million U.S. dollars) are presented in Figure 3.

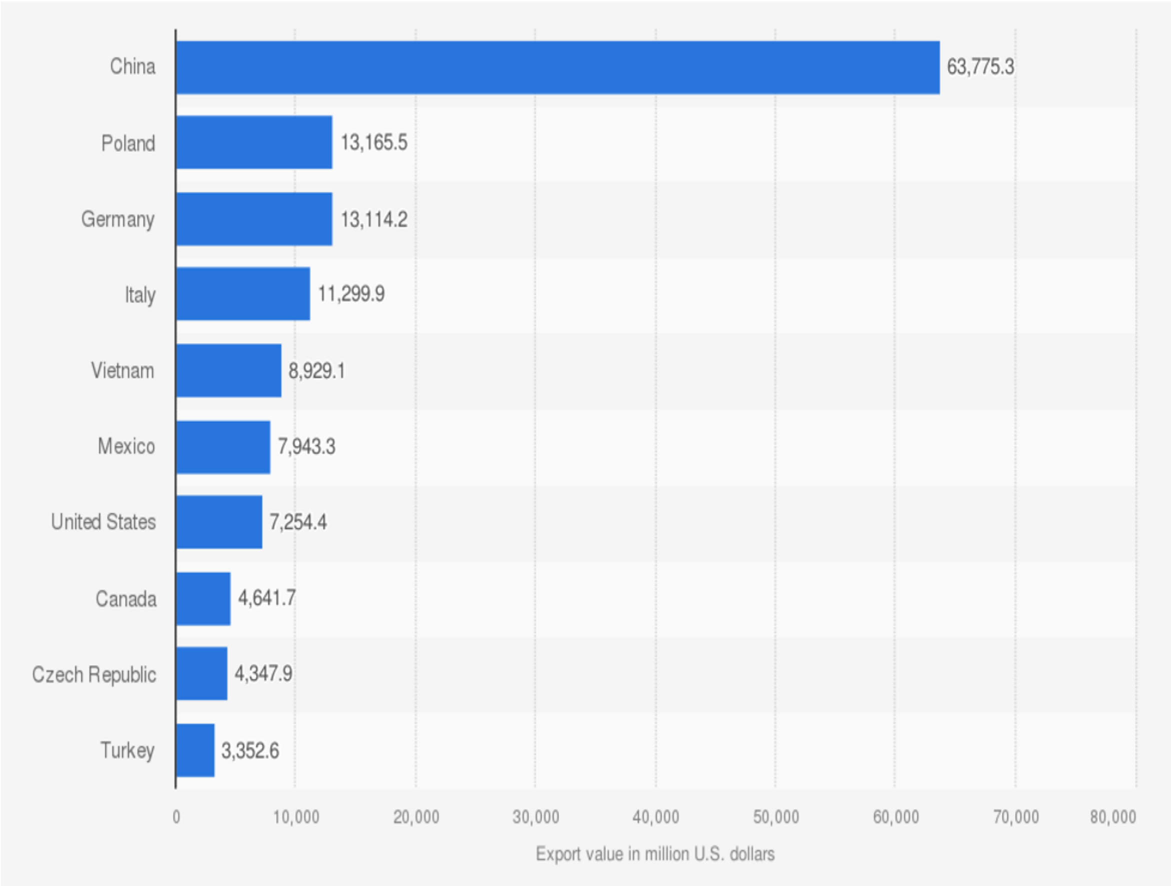

Figure 9.3. Leading exporting countries of furniture worldwide in 2019 (in million U.S. dollars).

Source: UN Comtrade Statista 2019.

In 2019, China was noted as the furniture export leader with an export value of approximately 63 million U.S. dollars. Poland was noted on the second position in the ranking with export exceeded 13.165 million U.S. dollars' worth of furniture that year.

Germany was noted on the third position of the worldwide furniture export leaders with export 13.112 million U.S. dollars that was quite close to the amount achieved by Poland. Italy was noted on the fourth position with export exceeded 11 billion U.S. dollars. United States noted export exceeded 7 million U.S. dollars.

Data on the furniture worldwide importers in 2019 has been presented in Figure 4.

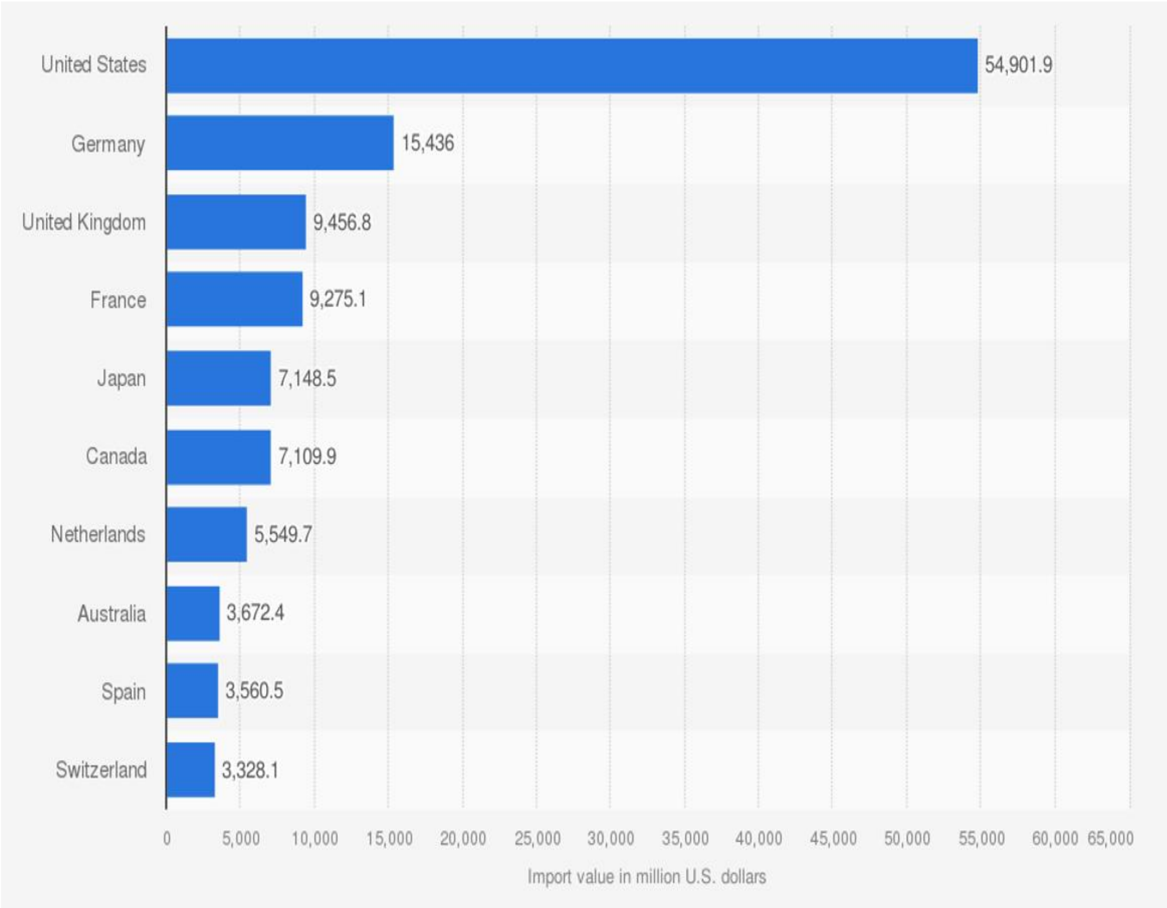

Figure 9.4. Leading importing countries of furniture worldwide in 2019 (in million U.S. dollars).

Source: UN Comtrade Statista 2019.

In 2019, the United States was noted as the leading importer of furniture from the rest of the world, with an import value of around 54.9 million U.S. dollars. Germany, ranked second, importing approximately 15.4 million U.S. dollars' worth of furniture that year.

In 2019, the average European spent about EUR 296 on a loan. The country with an above-average level of expenditure per capita in Europe is Switzerland - the country's resident spent on average EUR 1,009 on furniture.

The global furniture market generated sales of EUR 1,163.1 billion in 2019. It is estimated that as a result of the COVID-19 pandemic, the market size in 2020 decreased by 2.0% to EUR 1,139.8 billion. However, the market is projected to continue to grow at a pace 4.2% annually to the level of EUR 1,431.3 billion (CAGR 2022–25).

The highest furniture sales of EUR 492.9 billion in 2019 were generated by the Asian markets. After the expected decline in furniture sales in 2020, already in 2021, the return of the sales value to a level 4.5% higher than in 2019 is expected. In 2019, furniture sales in Europe amounted to EUR 250.3 billion. In the period 2017-2019, the furniture market grew by an average of 2.9% annually. According to Statista estimates, in 2020 the value of this market dropped by 6.3% to EUR 234.6 billion as a result of the recession caused by the COVID-19 pandemic. It is estimated that declines were recorded in all furniture segments, with the strongest decline in the kitchen furniture segment (-7.4%). In 2019, a resident of Poland spent an average of EUR 163.0 on furniture. This amount is projected to increase to EUR 198.4 in 2025.

9.2. THE POLISH FURNITURE INDUSTRY

Polish furniture industry exports in 2015-2019 increased by 33.4% from EUR 9.8 billion to EUR 13.1 billion, and imports by 58.5%, from EUR 2.2 billion to EUR 3.6 billion .

Furniture exports from Poland in 2017-2019 increased by 21.3% from EUR 11.1 billion in 2016 to EUR 13.5 billion in 2019, and imports by 44.0% from EUR 2.6 billion to EUR 3.7 EUR billion. In 2020, the upward trend observed in recent years broke down - as a result of the COVID-19 pandemic, Polish furniture exports fell by 4.3%, and imports by 2.3%.

The value of the sold production of Polish furniture in 2019 amounted to PLN 50.5 billion (an increase by about PLN 1.5 billion compared to 2018), while the estimates of the Central Statistical Office indicate similar results for 2020 amounting to PLN 50.6 billion (Kaczmarek and Jasiński 2021).

The main export direction for Polish producers are European Union countries. The largest recipient is Germany, which in 2020 received nearly 35% of Polish furniture exports. The remaining recipients are following: the Czech Republic, Great Britain and the Netherlands, which purchased a total of nearly 20% of furniture exported by Poland.

The Polish furniture industry is famous primarily for the export of its products, which in 2020 amounted to approximately USD 12.6 billion. In recent years, Polish companies have first overtaken Italy, and then Germany, and thus have become the European leader in furniture exports, and thus also the second largest exporter globally (behind the leading China). It happened already in 2019, and in the crisis year 2020, Poland turned out to be more resistant to economic perturbations and strengthened even more in the second place. It is worth noting that the share in world exports is constantly growing and currently amounts to approx. 7.7%. Polish companies try to maintain the most attractive prices for foreign buyers, but with the rapidly growing costs of labour and materials, this has an increasingly clear impact on our profitability and competitiveness, which is already visible in broad industry statistics. It is due to the subcontracting business model still dominant in the country (production to order, often under a foreign brand), which implies price competition. The aforementioned trends force the industry to evolve, and this is actually happening, although it occurs in a heterogeneous manner. One of the development possibilities is the search for new export directions. The pace here, however, is moderate. The operational quality is the second important adjustment measure. In recent years, Polish companies invested an average of 5% in relation to revenues in fixed assets, which was one of the highest results in the EU. As a result, in terms of the quality of the machine park and the production itself, we do not deviate from the highest European standards. The future should, in turn, be marked by the increasingly common use of new technologies, especially in the area of customer experience (The Polish Investment and Trade Agency 2020).

9.3. RESEARCH METHODOLOGY

According to the data published in the bank report on the Statista platform, "Sales value", also referred to as "market size", was calculated as: production increased by imports and decreased by exports of furniture products. The study presents the sale of furniture for 2019 and the forecasts for 2020-2025 prepared by Statista analysts in 2020 (i.e. taking into account the conditions caused by the COVID-19 pandemic). The data includes furniture and selected interior items, including: furniture for the living room and dining room, bedroom furniture, kitchen furniture, plastic and other furniture, office furniture, lamps and lighting, floor coverings. The category of furniture does not include: bathtubs, sinks, taps, tableware, kitchen utensils and other household items, consumer electronics, household appliances, and other home textiles.

The study presents the latest available data:

- data published by the International Trade Center https://www.trademap.org/: export and import of furniture worldwide in 2019; import of selected countries in 2020,
- data published by the Central Statistical Office https://stat.gov.pl/:

export and import of furniture in Poland in 2020.

Data on foreign trade are presented according to the Harmonized System (HS) developed by the World Customs Organization. They consist of goods classified in Chapter 94. The Statista portal presents data in USD. When converting the exchange rate to EUR, the portal used the exchange rate of USD 1 = EUR 0.88552 for all periods, both for historical data and data in the forecast period until 2025.

9.4. RESEARCH RESULTS ANAYLIS

The global furniture market grew at an average rate of 4.4% annually in 2017-2019, reaching EUR 1,163.1 billion in 2019. The United States is the largest furniture market in the world. In 2019, its value reached EUR 230.0 billion (19.8% of global sales). This country is also the largest importer of furniture as it accounts for 27.5% of global imports. China is a world leader in the export of furniture. In 2019, they achieved a market share of 38.2%. Poland is the third largest in the world with a share of 5.6% and the eleventh largest importer with a share of 1.6%. The global furniture market generated sales of EUR 1,163.1 billion in 2019. It is estimated that as a result of the COVID-19 pandemic, the market size in 2020 decreased by 2.0% to EUR 1,139.8 billion. However, further growth of the market is forecasted at a pace 4.2% annually to the level of EUR 1,431.3 billion (CAGR 2022–25).

Data presented in the chapter are related to the compound annual growth rate (CAGR) that is the annualized average rate of revenue growth between two given years, assuming growth takes place at an exponentially compounded rate. The CAGR between given years X and Z, where Z – X = N, is the number of years between the two given years, is calculated as follows:

CAGR, year X to year Z = [(value in year Z/value in year X) ^ (1/N)-1]

The highest furniture sales of EUR 492.9 billion in 2019 were generated by Asian markets. According to the portal's estimates of Statista, these markets proved resilient to the crisis caused by the COVID-19 pandemic and saw no decline in sales in 2020. It is estimated that the furniture market in Asia grew by 4.1% in 2020. Further forecasts assume that by 2025 Asian markets will record dynamic sales growth at an average annual rate of 4.9% (CAGR 2022-25), and this region will remain the world leader.

After the expected decline in furniture sales in 2020, already in 2021, the return of the sales value to a level 4.5% higher than in 2019 is forecast.

In 2020, the United States exported approximately 562 million U.S. dollars' worth of furniture and fixture products to Europe. In 2005, this figure amounted to around 460.05 million U.S. dollars.

Furniture and fixture product export to Europe from the United States in period 2005 - 2020 (in million U.S. dollars) was presented in Figure 5.

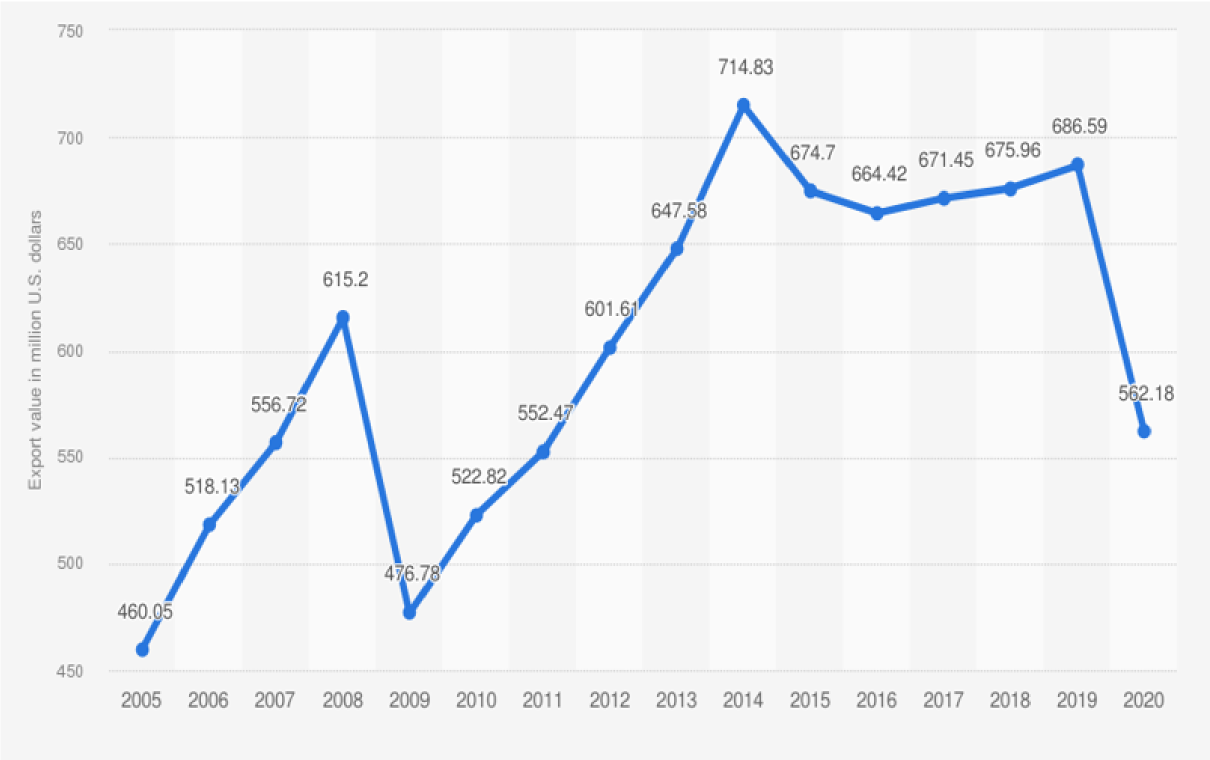

Figure 9.5. U.S. furniture and fixture products exports to Europe in period 2005 – 2020 (in million U.S. dollars).

Source: International Trade Administration, Statista 2021.

In 2014, the United States exported to European countries approximately 714 billion U.S. dollars' worth furniture and fixture products. In 2019 United States noted export exceeded 600 billion U.S. dollars. In 2020 export of U.S. furniture noted lower amount (562.16 billion U.S. dollars) comparing to 2019 year.

Furniture and fixture products imports from Europe to the United States in period 2005 – 2020 has been presented in Figure 6.

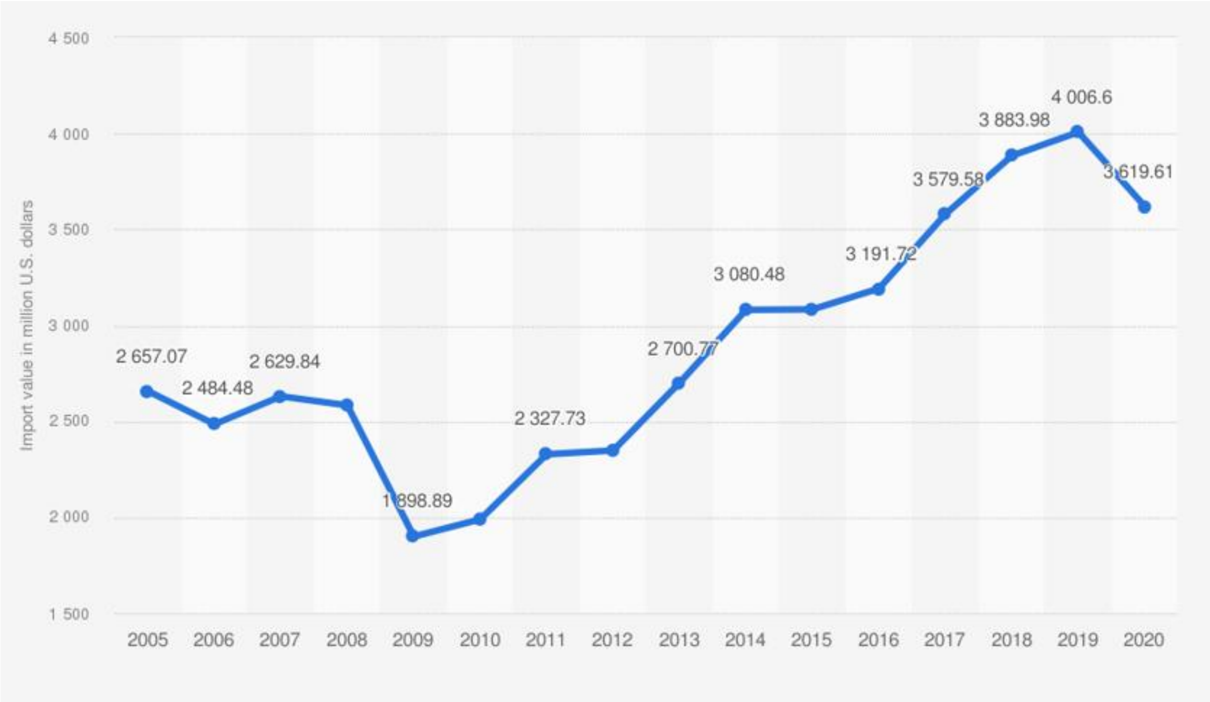

Figure 9.6. U.S. furniture and fixture products imports from Europe to the United States in period 2005 – 2020 (in million U.S. dollars).

Source: International Trade Administration, Statista 2021.

In 2020, the United States imported approximately 3.62 billion U.S. dollars' worth of furniture and fixture products from Europe. In 2010, this figure amounted to around 1.99 billion U.S. dollars.

Furniture, home furnishing and carpet share of total consumption expenditure in the European Union in 2020, by country have been presented in Figure 7.

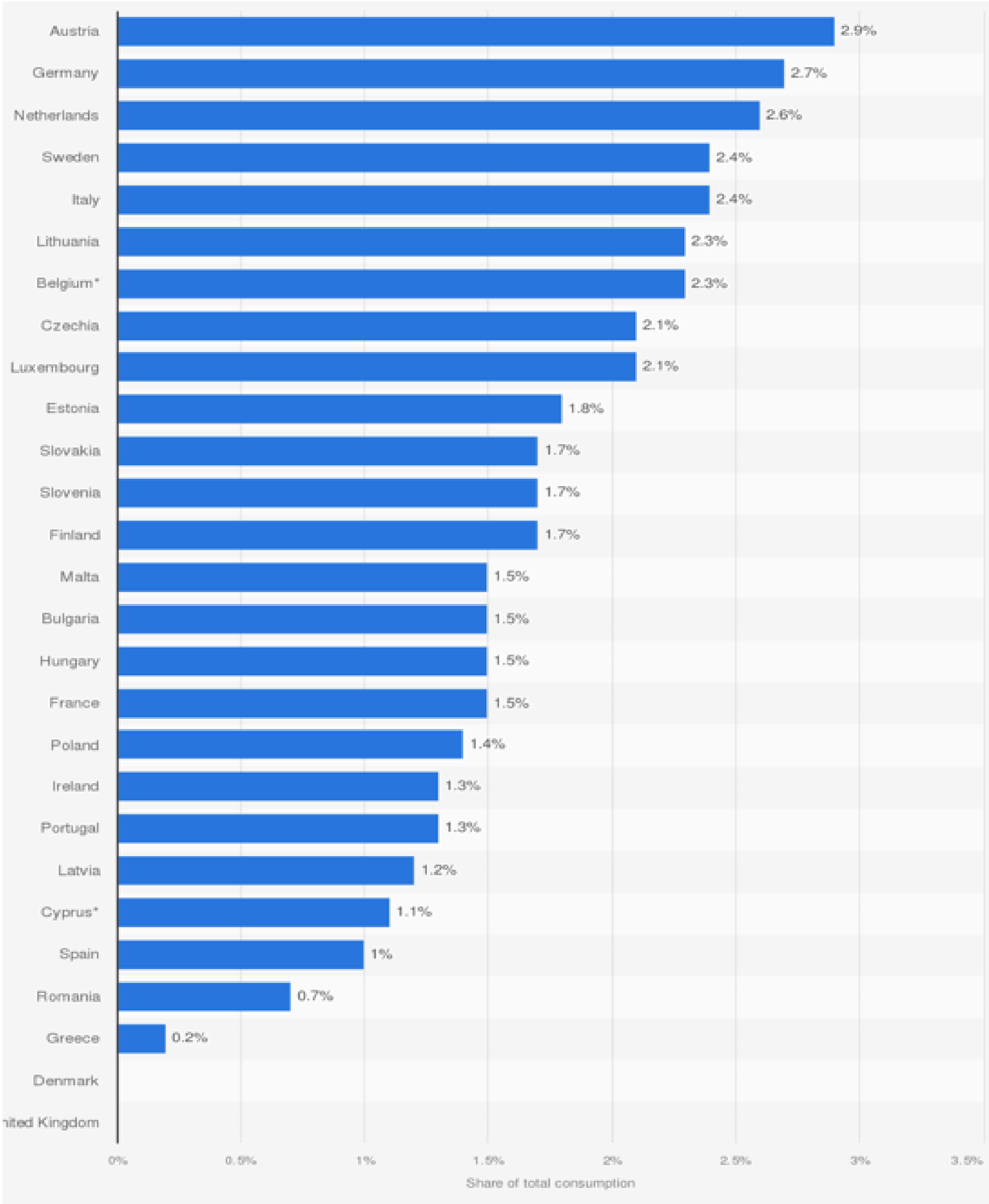

Figure 9.7. Furniture, home furnishing and carpet share of total consumption expenditure in the European Union in 2020, by country.

Source: Eurostat, Statista 2021.

Data presented in Figure 7 show that the highest share in the total consumption expenditure in the furniture industry is noted in case of Germany (2.7%), Netherlands (2.6%) and Sweden (2.4%).

This statistic depicts the share of total consumption expenditure going on furniture, home furnishings, carpets and other floor coverings in European Union (EU-28) countries in 2020. In Austria and Germany, furniture and other furnishings represented 2.9% and 2.7% of total household spending. Forecast turnover dynamics of the furniture industry due to the coronavirus (COVID-19) epidemic in Poland in 2020 has been presented in Figure 8.

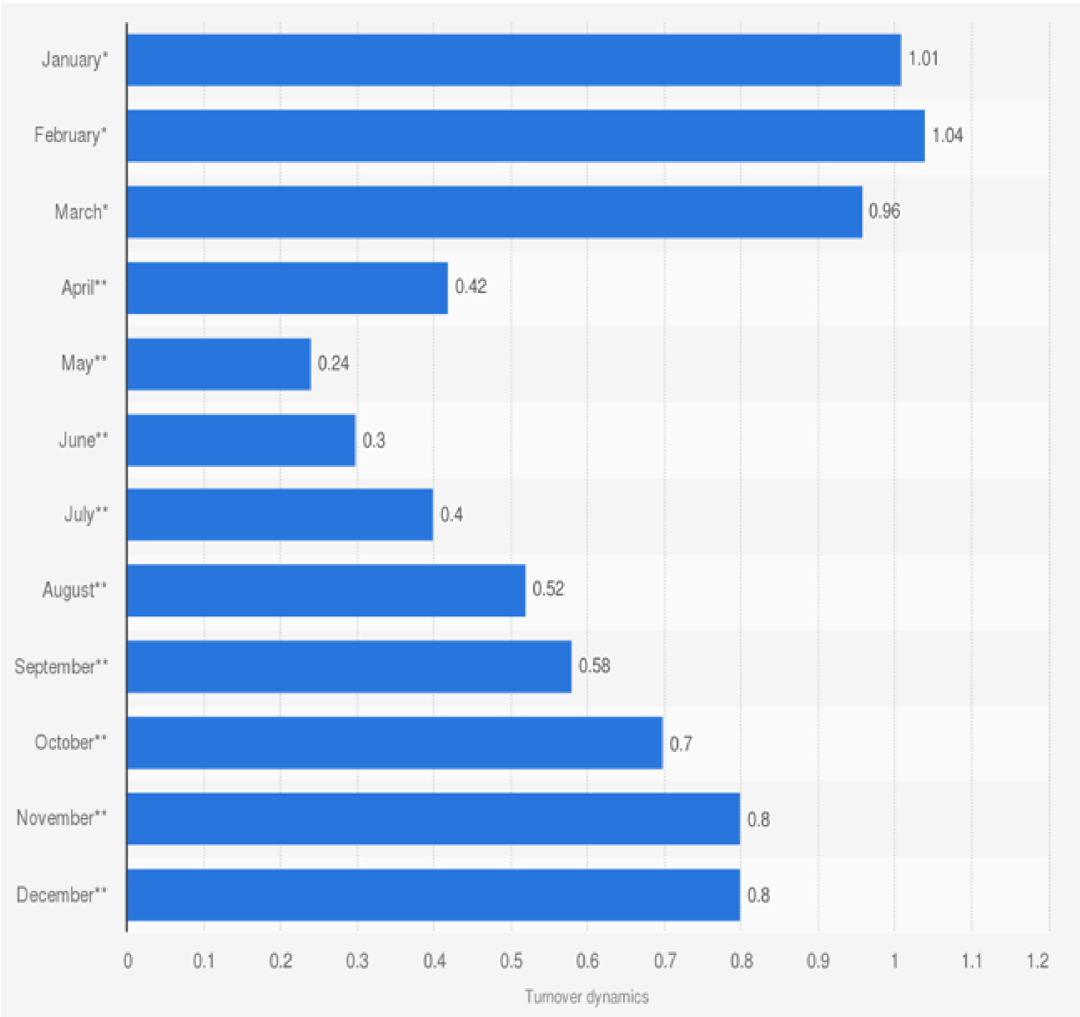

Figure 9.8. Forecast turnover dynamics of the furniture industry due to the coronavirus (COVID-19) epidemic in Poland in 2020.

Source: Eurostat, Statista 2021.

According to the source, the estimated result of the furniture industry's sold production in Poland in 2020 amounted to 33 billion zloty compared to 50.5 billion zloty in 2019, which constitutes a decrease of 35 percent. The most significant drop is in May. From this month onwards, an increase in turnover dynamics in the furniture industry is forecast (Sas 2020).

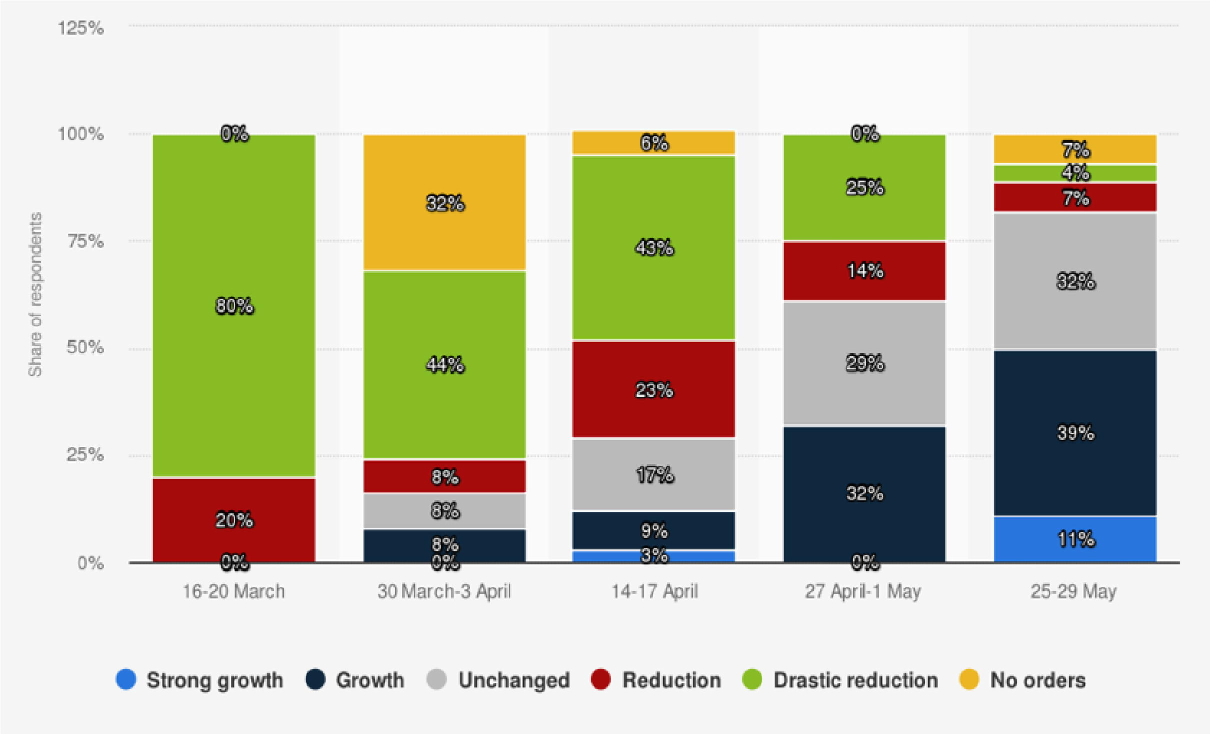

Figure 9.9. Impact of the coronavirus (COVID-19) pandemic on new orders in the furniture industry in Poland between March and May 2020.

Source: B+R Studio, Ogólnopolska Izba Gospodarcza Producentów Mebli, Statista 2020.

Currently there is observed a crisis that befell all countries in the world. So far, Polish manufacturers and exporters of furniture, when encountering the problem of the closure of a certain market, were looking for a new one. In this case, the situation is so dramatic that there is no market in the world that would not be affected by restrictions and a drop in customer confidence.

The main factor that negatively affects the Polish furniture industry is the closure of most stores in Europe. For several days, there has been talk of the ongoing work aimed at unfreezing trade, but today no one is sure when customers will return to their buying habits from before COVID-19.

The e-commerce market in Poland is constantly growing, mainly as a result of the purchase of food products and electronics. In the case of furniture, demand is declining and even those furniture companies that had developed e-commerce are strongly affected by the effects of the pandemic.

9.5. CONCLUSION

At present, it is not possible to look for new sales markets. The only solution is to focus on e-commerce. All solutions, new models and business strategies oscillate around the fact that companies have to learn to live and work in the era of coronavirus.

The main problems of the industry remain: demand, financial liquidity, absenteeism, supplies of raw materials and components.

As a result of the prevailing pandemic, it is estimated that layoffs in the furniture industry in March / April amounted to 5%. Companies are afraid of dismissing employees because they will have great difficulty rebuilding their team in the future, but a lack of demand may force employers to lay off more workers. In addition, recruitment has been suspended, and fixed-term contracts are not being extended.

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10. THE ROLE AND POSITION OF CONTROLLING IN THE QUALITY MANAGEMENT SYSTEM IN THE FORESTRY INDUSTRY

Renata Nováková, Olena Plaksiuk

"Stop looking for fault, look for a way to fix it." (Henry Ford)

10.1. INTRODUCTION

The term "controlling" is of English origin and in economic theory we encounter it for the first time in the 20th century. The translation of this term is quite problematic. If we look in the English dictionary, we could look up at least 50 equivalents of the term. In the Slovak language, in professional literature we can meet with the translation of the original to control how to regulate something, manage something, be informed about something, etc. Thus, in general, controlling is a tool for managing and regulating business processes. An important prerequisite for its functioning in organizations is to ensure that the planning and information system is functional. These starting points are common both for organizations operating in various areas of the national economy and for organizations operating in forest-based industries.

10.2. STRATEGIC QUALITY MANAGEMENT AS PART OF CONTROLLING IN FOREST BASED INDUSTRIES

Currently, the trend is to implement the basic principles of quality management in management processes. The process orientation of quality management is a prerequisite for ISO 9001: 2015 standards. Before we take a closer look at controlling activities as a management tool, we need to define what is and what is not controlling. Without claim to completeness, we present in the following table 1 most important milestones in the concept of controlling.

Table 10.1. What is and what is not controlling (own processing)

What is controlling	**What controlling is not**
Supervision	A means of finding and punishing the culprits
Methodical guideline	Method of eliminating detected errors
A method used to inform management	Form of sanction if the intended goal is not met
Coordination of activities in the company	Coordination of activities in the company
Method of proposing remedies	Possibility to eliminate damages and errors
A source of stimuli and information for the future	Controlling is not control as we have it defined in the professional literature
A means of detecting deviations from planned objectives	A source of information from the past

When we talk about controlling, we must focus on its two dimensions, namely (Foltínová et al, 2011, p.16):
a) Strategic controlling
b) Operational controlling

10.2.1. Strategic controlling

The content of strategic controlling is the control and management of measures taken in the implementation of the strategy and assists in measures to ensure future existence. Systematic identification, exploration and observation of future opportunities and risks. In the area of the strategic role of controlling, we monitor: analysis of strengths and weaknesses, the ability to develop the company's strategic goals, offer the company's strategic philosophy and take measures for management according to deviations. Strategic controlling information tools:

(a) analytical tools: potential and portfolio analysis, product life cycle analysis, competition analysis and strengths and weaknesses analysis.

(b) forecasting methods: qualitative and quantitative method.

Analysis, forecast of the company and its surroundings, elaboration, selection, formulation, control of strategy is the basis for internal planning of strategic controlling. (Chodasová, 2012, pp. 27-29)

Strategic quality management is primarily strategic quality planning. If we wanted to define what is the content of strategic quality planning, then we could use the following definition (Linczényi, Nováková: Quality Management, 2001)

"It is a set of activities arranged in a logical sequence, aimed at expressing objectives in management and quality assurance, to select and evaluate alternatives aimed at achieving these objectives and to express the necessary steps needed to achieve the set objectives."

Understanding and managing interrelated processes as a system contributes to the organization´s effeciveness and efficiency in achieving its intended results. This approach enables the organization to control the interrelationships and interdependencies among the processes of the system, so that the overall performance of the organization can be enhanced.

The process approach involves the systematic definition and management of processes, and their interactions, so as to achieve the intended results in accordance with the quality policy and strategic direction of the organization. Management of the processes and the system as a whole can be achieved using the PDCA cycle with an overall focus on risk-based thinking aimed at taking advantage of opportunities and preventing undesirable results.

The application of the process approach in a quality management system enables:

a) understanding and consistency in meeting requirements
b) the consideration of processes in terms of added value
c) the achievement of effective process performance
d) improvement of processes based on evaluation of data and information (STN EN ISO 9001:2015)

The organization in forest based industires shall determine the processes needed for the quality management system and their application throughout the organization and shall:

a) determine the inputs required and the outputs expected from these processes
b) determine the sequence and interaction of these processes
c) determine and apply the criteria nad methods (indcluding monitoring, measurements and related performance indicators) needed to ensure the effective operation and control of these processes

d) determine the resources needed for these processes and ensure their availability
e) assign the responsibilities and authorities for these processes
f) address the risks and opportunities
g) evaluate these processes and implement any changes needed to ensure that these processes achieve their intended results
h) improve the processes ad the quality management system

The orgaization in the forest based industries shall retain documented information to have confidence that the processes are being carried out as planned.

The organization shall plan actions to address these risks and opportunities and evaluate the effectiveness of these actions.

The organization shall estalish quality objectives at relevant functions, levels and processes needed for the quality management system.

The quality objectives shall:

a) be consistent with the quality policy
b) be measurable
c) take into accout applicable requirements
d) be relevant to conformity of products and services and to enhancement of customer satisfaction
e) be monitored
f) be communicated
g) be update as appropriate (STN EN ISO 9001:2015)

If we want to talk about strategic quality planning, we must realize that we can create several sub-quality plans within organizations, which depend on individual levels of management.

Then for example the sub-plan of quality at the top management level will contain the following information:

- Designation of staff responsible for planning, implementing, managing and monitoring the activities required by the quality system
- Ways of informing individual departments, subcontractors and customers about special requirements in contracts
- Review of quality system processes
- Establishment of methods for approving exemptions for the quality system
- Planning of activities aimed at correcting deficiencies
- References and evidence focusing on existing quality system documentation

The content of the sub-plan for research and development will be:

- Stages of solving a research task
- Ways of involvement and participation of research team members
- Methods of verifying the compliance of research outputs with customer requirements
- Ways of involving customers in solving a research task
- Possibilities of customer participation in tests and trials in the pre-production stage
- Defining the requirements of regulations, specifications and other rules
- Product reliability requirements and their evaluation

The sub-supply plan will contain answers to questions such as:

- How will supplier evaluation, selection and management be done?
- Which materials, according to the terms and conditions will be purchased?
- How will follow-up to suppliers' quality plans be ensured?
- What entry control methods will be used and how suppliers will be notified
- How will purchase contracts be concluded?
- How will records of the quality of individual deliveries be ensured?
- How will the labeling of products for a specific order take place?
- How will the output control be ensured during deliveries to the customer?
- How will disagreements be handled?

An important part of planning will be a partial **plan for the production process**:

- Traceability plan for products and materials in the production process
- Plan of records focused on the production process and working documentation
- Traceability record distribution and management plan
- A plan to monitor the ability of production processes and equipment to meet specified requirements
- Production quality assurance plan in specific production processes
- A plan for the use of tools, techniques and methods in the production process
- Plan for ensuring production and inter-operational control and forms of using statistical regulation methods

The partial **plan of quality management** is divided into:

- Plans of inspections and control procedures
- Subcontractor product compliance verification plan with specific requirements
- A plan for the location of test and inspection posts
- Plan of inspections, tests and use of meters in prescribed inspections
- A plan to identify product identification and testing sites
- A plan focused on the requirements of product certificates for the materials used
- Plan for the determination of control measuring and testing equipment
- Equipment calibration assurance plan and methods for indicating the calibration status
- Plan for ensuring segregation of non-conforming products
- A plan to ensure that the customer is informed about repaired failures
- A plan to allow deviations from the production documentation
- A plan to manage corrective action documentation
- The plan of quality inspections of suppliers, the so-called third party inspections

The **sub-plan for information provision of quality requirements** contains the following plans:

- Delivery record keeping plan
- A plan focusing on legal and legislative requirements following a specific delivery
- Plan of methods and forms of records
- Accurate identification of records management and archiving requirements
- Plan of ways and possibilities of passing information and documents to the customer

The partial **sales plan** focuses on quality parameters:

- Ways to review the sales contract
- Product liability solutions
- Forms and methods of evaluation of competing products
- Transfer conditions
- Marketing security conditions
- Conditions addressing specific requirements related to the handling, packaging and storage of products

A partial quality **plan for staffing** is also an important part of quality planning and consequently the controlling process:

- A plan to ensure the training of new staff
- A plan to provide staff training for the new processes in the production process
- Employee motivation plan - must take into account pre-established selection criteria

Partial **plan for economic** quality assurance:

- Plan for recording losses from poor quality production
- A plan for ways to identify and summarize quality-related costs
- A plan for the preparation of reports and financial analyzes concerning a specific product and its qualitative characteristics
- Plan for evaluation of economic indicators related to quality e.g. calculation of quality profitability indicator

Partial **quality plan focused on after-sales services**:

- Plan for harmonization of legislative requirements for provided service services
- Plan of methods of providing service services in connection with the usual conditions in the region
- Plan for concluding service level agreements
- Plan security and training of service staff directly at the customer

In terms of division of labor, large and controlling companies are being set up in large and medium-sized enterprises. Although these positions are established, controlling is not only a matter for the controller but also for each manager (Eschenbach et al, 2004, p. 116).

Through their consulting activities, controllers help to achieve corporate goals, preventing surprises when there is a danger that requires effective management measures to be taken to eliminate them (Chodasová, 2012, p. 16).

The specific position in the company depends on several facts. It depends on the size of the company, the nature of its activities and the quality of its management. Controllers are the bearers of controlling and can represent a separate subsystem in the company, which is equivalent to other management subsystems. Their role is defined on the basis of secondary coordination, which guides the operation of the management subsystems. Here we can talk about controlling as a subsystem that complements business management.

10.2.2. Controller - a manager with specific skills and competencies

The personality of the controller is also important in the performance of controlling as a manager who has competencies and knowledge in the field of financial accounting and management and knows the methods of registration and cost calculation. He knows the methods of planning and forecasting in the strategic and operational area of management. He is able to use tools for the analysis of deviations and in connection with the work of the controller are often combined with the mentioned soft skills (soft skills), which are based primarily on personality traits. The controller requires high flexibility, the ability to quickly adapt to various changes in the work process.

A controller is an employee who works with information from different parts of the company. It leads to deviation management, it helps management to find solutions to decisions. It presents the measures taken with the responsible staff.

If the position of controlling director is established in the organization, he is mainly responsible for:

- identification of deviations of costs and revenues from the binding indicators of the contract within the production activities through the information system,
- discussion and blocking of the investment plan in the information system on the basis of a proposal of the division director (VT),
- issuance of order numbers included in the production program on the basis of documents from the organizational unit
- Checking the documentation before commencing the execution of the contract,
- ensuring the assessment of processed offers in cooperation with the sales director's department,
- organization and management of economic and substantive audit of contracts,
- taking remedial action and monitoring compliance

In organizations operating in the forest based industry, quality control has become a natural part of corporate policy. All activities in this direction are declared by the quality management system and are a tool for quality improvement and cost reduction.

Quality assurance is defined as an independent and systematic review aimed at identifying quality activities. An important task is to assess whether the planned intentions are implemented effectively and are suitable for achieving the set goals.

The main goal of quality control is:

(a) identify weaknesses in quality assurance
(b) to take corrective action to address vulnerabilities
(c) monitoring the effectiveness of corrective action

From the point of view of the inspection object, we can divide the quality inspection into:

System-oriented verification - its aim is to assess the effectiveness of the quality management system by assessing the knowledge and skills of staff, testing the practical application of individual elements of the system and the relevant documentation and the results of inspections and tests.

Process-oriented verification - its task is to assess the effectiveness of quality assurance through the evaluation of the competence of processes in all basic stages, such as. the design and development stage, or the production stage itself. Work and testing procedures, technological and production procedures, test plans, process capability assessment, personnel qualification requirements serve as a basis for this form of assessment.

Product Oriented Verification - Part of such verification is the assessment of quality assurance activities by testing a number of final products or individual components. The basis is production and testing procedures, evaluation of testing and measuring equipment, evaluation of production equipment, which are part of the production program.

Process and product-oriented verification are internal business activities.

The stimulus for verification by the controllers can be, for example:

- reworking and developing a new quality policy in the organization
- quality cost planning
- efforts to reduce losses from low-quality production
- unsatisfactory level of testing, control and prevention costs
- placing orders with important suppliers
- change of production processes, etc. (Quality Professional pp. 2-99 - 2-100)

An integral part of quality control is operational planning and management (ISO 9001: 2015)

Therefore, it is important to know the requirements of the ISO 9001: 2015 standard, which states the following:

The organization shall plan, implement and control the processesneeded to meet the requirements for the provision of products and services:

1 determining the requirements for the products and services
2 establishing criteria for: the processes and the acceptance of products and services
3 determining the resources needes to achieve confromity to the product and service requirements
4 implementing control of the rpocesses in accordance with the criteria
5 determining, maintaining and retaining documented information to the extent necessary

The organization shall control planned changes and review the consequences of unintended changes, taking action to mitigate any adverse effectsas necessary.

The organization shall ensure that outsources processes are controlled.

In part 8.2. in ISO standard are informations about requirements for products and services and customer communication.

Communication with customers shall include:

1 providing information relating to products and services,
2 handling enquiries, contracts or orders, including changes
3 obtaining customer feedback relating to products and services, including customer complaints
4 handling or controlling customer property
5 establishing specific requirements for contingency actions, when relevant

Review of the requirements for products and services include:

The organization shall ensure that it has the ability to meet the requirements for products and services to be offered to customers.

The organization shall conduct a review before comitting to supply products and services to a customer:

- requirements specified by the customer, including the requirements for delivery and post-delivery activities

- requirements not stated by the customer but necessary for the specified or intended use, when known
- requirements specified by the organization
- statutory and regulatory requirements applicable to the products and services
- contract or order requirements differing from those previously expressed.

Table 10.2. Controlling process

Phase	Description of activities
Information phase	During this phase, the inspectors get acquainted with the manufactured products and production processes, they have to get acquainted with the production organization, quality management, company specifics. All information obtained is confidential
Detailed plan development phase	The detailed implementation strategy of the controlling process is determined, the tasks for individual controllers are defined, the sequence of steps and the key points of controlling are clearly determined.
Implementation phase	In this phase, fundamental interviews will be held with the responsible staff in the audited area. The most common form of question-based interview is. If the interview reveals deviations from the established rules, it is necessary to determine the cause of these deviations
Final phase	Here, the areas of shortcoming are directly defined for closer assessment and evaluation. This should include the preparation of a final report, which should be discussed with all stakeholders so that those whose outcome of the controlling process can comment on the findings. The conclusion should be corrective action.

The organization shall ensure that contract or order requirements differing from those previously defined are resolved.
The customer´s requirements shall be confirmed by the organization before acceptance when the customer does not provide a documented statement of their requirements.
The organization shall ensure that relevant documented information is amended, and that relevant persons are made aware of the changed requirements when the requirements for products and services are changed.
Very interesting is part 8.5.6 Control of changes in ISO standard 9001:2015.
The organization shall review and control changes for production or service provision, to the extent necessary to ensure continuing conformity with requirements.
The organization shall retain documented information describing the results of the review of changes, the presons authorizing the change and any necessary actions arising from the review.

10.2.3. Cost-oriented quality controlling

The issue of cost-oriented quality control plays an important role in quality management systems. Product quality is an important factor in the economic success of organizations operating in the forest-based industry.

The main idea should be to improve the course of all processes in the organization. Controllers should focus primarily on value-creating processes. Improvements should be reflected in cost reduction, shortening production lead times and continuous product improvement. An important part is the effort to reduce the so-called faulty performances. This means that it is necessary to monitor such factors as e.g. waiting times, storage times, waiting times for inspections and tests, inspection and testing times, waiting times for transport. We evaluate all these times as a waste of time, material and means of production.

Controlling in cost-oriented quality management can then be considered one of the main tools to combat such waste.

Tangible or intangible product is the result of a process into which inputs enter in the form of material, components, energy, information. All inputs are measurable and we can express them through costs. The outputs of the process can be expressed in a similar way. The difference between inputs and outputs in a process is called process efficiency.

However, there may be situations where the efficiency of the process will not be achieved. This is the case that additional unplanned costs enter the process, which cause deviations from the planned values. They are usually associated with poor performance. This is also the reason why it is necessary to pay great attention when controlling for poor performance. The costs of deviations are unitary and relatively easy to identify. Non-compliance costs do not relate to a specific product or process and are in the nature of total costs. It goes e.g. o costs of failures, costs of downtime of machinery and equipment, costs of time monitoring of deliveries.

Controlling in quality management focuses on the following requirements:

a) with the help of a system for monitoring costs, it is necessary to point out the issue of increasing productivity, resp. on the possibilities of reducing production costs.
b) Cost reduction must affect all processes in the organization
c) Monitoring of erroneous performances as a potential for possible cost reduction is sought not only in processes where such erroneous performances arise, but also in processes where unproductive use of resources occurs
d) Increasing the value of a product in the process must be assessed in relation to the consumption of resources in that process
e) The cost tracking system must identify those processes where improvement is a priority.

The starting point for cost-oriented quality management as a source of information for controlling is the involvement of all processes in the organization in the monitoring of the value chain. Quality control monitors all processes of the value chain and divides them according to their importance into different types of performance in the process.

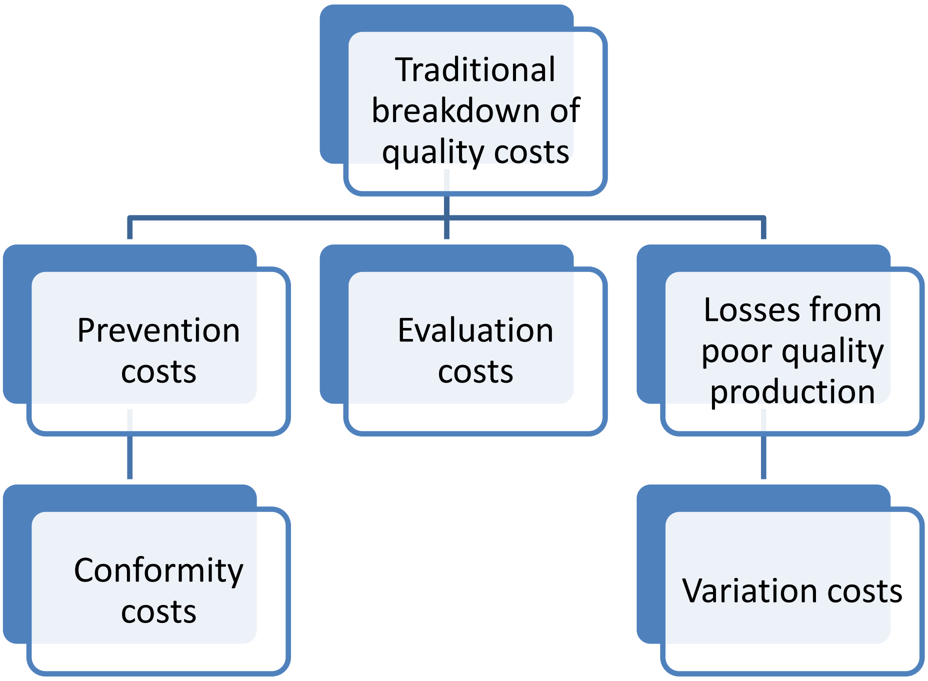

Figure 10.1. Crosby Cost Breakdown (Quality Professional, 2-139)

The importance of such an approach can be seen in the following activities:
- Production and business processes should be able to ensure leanness
- Quality control support
- Implementation of TQM principles
- Description of process rationalization
- Quality control supports managerial decisions through information

In general, we can divide the processes in the value chain into direct, superior and accompanying.

Direct activities include classic functional areas such as sales, service, customer service, research and development, construction, technical preparation, procurement, production and assembly.

Superior activities include human resources, finance, quality management and top management.

Accompanying activities are those that meet customer expectations and complement direct and superior activities.

The division of processes into value-increasing processes, processes whose product realization does not add value and processes that reduce the value of the product seems logical.

When we talk about value-adding processes, we must also consider value-adding processes to be those that bring value only to the customer, or are of an ideal nature. For example various marketing activities that bring the product to the attention of the general public. On the other hand, processes that reduce value may not obviously reduce the value of the product, but may combine e.g. with the loss of goodwill, or an increase in capacity, which on the other hand will increase costs and thus reduce profits.

The categorization of processes into those that increase value - those adding value, those that do not increase value and those that reduce value, is done in order to determine the effectiveness of the whole value creation process. Of course, processes that increase value need to be maximized, processes that do not increase value need to be optimized, and processes that decrease value need to be eliminated. In the previous text, we wrote about performances that are measured and monitored in individual processes. This is how we can divide the performances into:

A) **Useful performance** - these are planned processes that increase the value of the product. The sum of the useful performances in the value chain represents the increase in the value of the product itself.
B) **Apparent (supportive) performance** - these are processes that support useful performance and are usually planned performances. However, their problem is that they do not increase the value of the product. These are usually processes that must occur in the value chain because otherwise they would not be able to continue further operations on the product. E.g. transport within the internal environment of the organization, exchange of tools. Supporting services make the product more expensive and reduce profits. In this case, we must optimize or minimize all activities.
C) **Reactive performance** - these are unplanned processes that have no positive effect on the value of the product. Reactive performance is reflected in the higher price of the product and therefore it is necessary to minimize or even eliminate it.
D) **Faulty performance -** they occur unplanned as a result of ineligible processes, or processes that are outside the control mechanisms. They affect the product by reducing its value. The occurrence of faulty performances must be prevented. They have a negative effect on the profit, but also on the good name of the organization. The aim should be to eliminate such performances. A large number of erroneous performances is an expression of the inability of processes, or the incompetence and incompetence of staff.

In the literature we can meet with the identification of the so-called seven sources of losses, defined by the Japanese expert Taiichi Ohno. Seven sources of loss have been identified within the Japanese KAIZEN philosophy and are focused on waste. Toyota's Taiichi Ohno focused on employee work. The starting point was to identify waste in the movements of workers. In many cases, workers do not even realize that they are making unnecessary movements. Taiichi Ohno divided all forms of waste into the following categories:

1. Overproduction
2. Waste of time at machines (downtime, maintenance)
3. Waste associated with transport
4. Waste associated with material processing - production
5. Waste in supply and storage
6. Wastage of unnecessary staff movements
7. Wastage if faulty products are created

Yidohka is known in Japan as a basic tool for preventing waste in production. This is an automatic stop of the machine as soon as a problem occurs. In practice, most machinery is already equipped with such an automatic system, and at the time of digitization, this system is even more sophisticated.

It is important to identify the different types of waste that are a source of losses.

Loss from overproduction represents production to the warehouse, resp. production of non-marketable products. If we wanted to identify what the performance was, we could clearly confirm that it was a faulty performan.

Losses from downtime or maintenance e.g. if it is necessary to perform regular maintenance, resp. due to the supply of missing raw materials, we can classify it as reactive power.

Production losses that may occur e.g. they are clearly identified as poor performance by establishing a poor manufacturing process.

If losses occur as a result of supply or storage, it is a higher capital commitment, but we can consider these losses as reactive performance.

Traffic losses are a clear reactive power.

Losses from excessive movements in the provision of work tasks by employees can be considered an apparent performance. They can be caused by poor ergonomic layout, insufficient staff training .....

As already mentioned, controlling is associated with strategic management. For this reason, we can also express the objectives of quality control as follows:

- Transforming visions into strategies and ensuring that goals at middle management level are met
- Continuous motivation of employees to improve
- Make comparisons of data based on time and location of costs
- Analyze weaknesses through the cost of poor performance and propose corrective action
- Elaboration of final reports on the current state of quality at the analyzed workplace.

In practice, we want as many processes and activities as possible to be useful in them. This leads to a calculation of the efficiency of that process. The formula for calculating the process efficiency indicator in relation to the identified outputs is then as follows:

$$\textit{\textbf{Process efficiency}} = \textit{\textbf{U / U+A+R+F}} \qquad (1)$$

Where :
U – useful performance
A– apparent performance
R – reactive performance
F – faulty performance

Process efficiency: Towards an ideal value of 1, UP = 1, can be defined as the ratio between the useful performance (which the customer will appreciate in the market by buying the product) and the technical, personnel and organizational resources spent, which consist of the sum of four performances. The value of this indicator is always less than 1. The closer it is to 1, the more advantageous the indicator. If the effectiveness of the process is determined, its development is further monitored (the course of its changes over time).

If corrective action is taken after the effectiveness of the process has been determined, the difference between the effectiveness of the process before and after the corrective action reflects the effectiveness of the measures taken.

A prerequisite for using the calculation of process costs is the ability to precisely define activities and work procedures. The process of calculating the costs related to a particular process can be expressed by the following sequence of steps:

1. An analysis of all process activities shall be carried out first and a comparison made with the planned course of the process
2. The individual activities must be assigned to the main and sub-processes
3. Subsequently, we evaluate the whole process in financial terms
4. We classify individual activities according to the types of services (useful, apparent, reactive, faulty)
5. We calculate the process efficiency indicator
6. We determine the savings potential and express them in cost form
7. We will propose the optimization of activities using rationalization measures
8. We will examine all the effects that may have on optimization
9. We will propose measures to improve processes
10. We will implement the proposed measures
11. We repeat the calculation of the process efficiency indicator after the implementation of the proposed measures
12. We repeat all the above steps at the planned intervals

This sequence of steps differs from the approaches used so far, which have been used in the current quality cost monitoring system. The basic difference is that we focus on improving processes. This method can be used wherever we can identify individual types of performance.

In practice, however, there may be processes that cannot be evaluated as described above.

In such a case, it is necessary for the controlling officer to form a team of employees made up of individual organizational functions and be able to develop a process cost model, perform data collection and analysis, as well as identify opportunities to improve the process and report on results.

An important prerequisite for the success of controlling activities is the identification of the process itself based on the process outputs, process customers and a clear name of the process administrator. Process inputs and resources must also be identified.

Last but not least, it is necessary to identify all relevant process costs. In this case, the costs should be divided into two categories:
a) Conformity costs
b) Non-conformity costs

We should also take into account the accounting statement of cost items for:
a) Current costs that we obtain from the organization's information system and should be specifically identified
b) Synthetic costs, which are expressed by the product of the number of hours used for a certain activity and the hourly rate.

10.2.4. Classification of costs related to quality

Breakdown of quality costs according to p. prof. Leščišin:
The costs of quality preparation can be, for example:

- costs for forecasting the development of quality parameters,
- costs of creating quality standards,
- costs of marketing studies of quality and competition,
- costs for quality managers and quality departments,
- costs for preparing the quality of new products,
- costs of launching new production and launching new products,
- costs of assembly and operation of products at customers,
- costs of ensuring more suitable production conditions for quality,
- costs associated with ensuring more suitable production conditions for quality,
- costs of research, development and production of measuring instruments and aids,
- costs of engineering studies in the field of quality,
- costs of quality certification systems,
- costs of training and quality education programs,
- the cost of the quality information system,
- costs of new quality management methods,
- costs of quality consulting,
- the cost of documentation needed to improve quality,
- costs to ensure stability in the production base for consistently high quality,
- personnel quality assurance costs in the compa

The costs of internal quality deficiencies are, for example:

- costs - losses from reduced quality,
- costs of repairable failures,
- costs - losses from irreparable failures,
- costs of troubleshooting in production,
- costs - losses from poor storage of products at the manufacturer,
- costs of preparations for necessary repairs,
- costs of non-reclaimable failures from suppliers,
- costs of so-called internal failures in production,
- costs of various internal repairs,
- production costs to replace low-quality are amounts and whole products,
- costs of ensuring non-gift continuation of production,
- the cost of erroneous management decisions in the area
- quality,
- costs caused by an inappropriate production base for the required quality.

The cost of external quality errors can include the following most important types in this group:

- costs of handling complaints, including travel expenses for their examination,

• costs of warranty repairs during the warranty periods,
• costs - price discounts due to insufficient quality,
• costs of customer complaints, especially for their additional modifications,
• costs of post-warranty service,
• costs - penalties for delayed deliveries due to poor quality,
• the cost of emergency spare parts in the interest of quality at the user,
• costs - sanctions for poor quality deliveries to customers,
• costs of returning low-quality products and exchanging them for quality ones,
• costs of various repairs of substandard supplies,
• costs - sanctions of the bank for lending of poor quality production,
• costs of litigation in product quality disputes,
• costs - loss of good reputation of the company and existing markets,
• costs - lost profit due to poor quality deliveries,
• costs - consequences for faulty quality consulting services.

Quality costs in the post-production stage:

- Costs associated with products in use. They cover a wide range of costs, from the cost of creating instructions for transport, storage and operation of products, through routine service to a prompt repair system for customers.
- Costs associated with waste disposal. These include costs associated with, for example, the disposal of used plastics, which are difficult to dispose of.
- Costs associated with the storage of waste, especially highly toxic substances and various poisons.
- Costs associated with decommissioning products.

Quality inspection costs:

• costs of controlling information inputs in terms of quality,
• costs of company laboratory tests and service for devices, their calibration,
• costs of products destroyed in destructive tests,
• costs of tests in authorized testing laboratories,
• costs (fees) to external laboratories,
• costs of inter-operational inspection in production,
• costs of various inspections by control institutions
• maintenance costs of measuring and inspection technology,
• costs of analyzing the results of various measurements and inspections,
• costs of output quality inspection of production,
• costs of product testing at customers,
• costs of purchasing and maintaining one's own measuring equipment,
• costs of consulting in the field of quality inspection.

10.2.5. Cost tracking procedure

1) Make sense of why to monitor quality costs:
   - an effort to identify the location of recurring serious product cost issues in the organization
   - the need to have a tool for assessing the performance of the SMK being built
   - reveal the causes of repeated customer dissatisfaction with products
   - the need to monitor quality-related costs in selected business units in terms of specific processes
   - assessing the effectiveness of quality assurance remedies
   - the need to reduce the overall costs of the organization
2) Choose a model
3) Introduce people to cost tracking
4) adapt the accounting system to the needs of cost accounting for quality:
   - identification of items not included in the accounts (analytical accounts)
   - determine the place of monitoring, responsibility, form
   - monitoring frequency
   - accounting class 8-9 - track items from there

Monitoring and evaluation of efficiency indicators is also an important part of cost-oriented quality management in the forest-based industry.
The decomposition of efficiency indicators can cover the following three basic areas:

A) Monitoring and evaluation of quality costs

B) Monitoring and evaluation of quality efficiency

C) Pricing of products depending on their quality

Monitoring and evaluation of quality costs in the context of the product life cycle - through quality expenditures we can define the amount of losses, kt. are caused by shortcomings in ensuring the quality of products and services. We reveal all significant effects on Q of a particular business performance. We are forced to gradually eliminate the identified shortcomings, kt. are caused by increased quality costs. Through quality costs, we can reduce the company's total costs.

Monitoring and evaluating the effectiveness of quality - We can monitor the impact of quality on the economic results of the organization. We can quantify the benefits of high quality in the production, user sphere. We can detect those products kt. thanks to their Q, they become the main carriers of the economic prosperity of the company.

Product pricing depending on their quality - Creates the prerequisites for the correct determination of product prices resp. services to benefit both market participants. The quality economy should make it possible to transform otherwise difficult management activities into the language of money.

Quality costs are then the sum of these three main components, namely:

- costs of creating and achieving the specified quality of production
- costs of maintaining and ensuring the current level of quality
- costs necessary to increase the quality of products in accordance with the quality strategy in the company.

Many organizations are currently applying for certificates in the field of integrated quality management systems. There can be several reasons why organizations are trying to certify it, e.g. improving its position in a competitive environment, meeting the requirements of public procurement, the need to prove a quality certificate due to customer requirements, the use of the company's marketing message to its partners and stakeholders ....

Organizations can apply for certification of their management systems, personnel, and products and services. Controlling and its activities can also play an important role in this area.

The certification process involves specific costs, which we generally call **certification costs.**

Among the most common (without claim to completeness) we can include the following:

A) direct costs of the certification process:

- costs of preparing the certification,
- the cost of carrying out the certification itself,
- the cost of maintaining the certified system,
- costs of preparation for re-certification, resp. recertification after its expiry date

B) indirect costs of the certification process:

- the cost of analyzing the current situation
- Internal costs and costs of the supplier organization (must be distinguished)
- the cost of trainers conducting induction training for managers
- the cost of training internal quality auditors and the cost of internal audits
- the cost of purchasing meters, laboratory instruments and aids that are specified in the relevant ISO standard
- costs for metrological calibration of meters during certification
- costs for the purchase of identification plates (mark places in the warehouse, material, workplace identifiers)
- costs of consulting activities in the preparation of certification with consultants and consulting companies
- costs for the preparation of documented information, including strategic documentation, quality policies, quality manual, procedures, guidelines as required by the ISO standard
- costs of the quality management department's own activities (usually it should be resources made up of 40% of the sales volume - Juran)
- Fee costs for the organization that performs the certification process. In most cases, these are authorized and accredited institutions that are legally authorized to issue certificates in individual areas of integrated management systems.

In practice, we may encounter well-known and lesser-known models focused on quality-related costs. However, not all of them are used in practice, resp. quality managers know how to identify costs that should be monitored. Therefore, we commented on the more detailed identification of costs related to quality in the above text.

A very important part of controlling is also the evaluation of efficiency indicators. The construction of efficiency indicators is relatively simple as it is a ratio of profit to target cost items. The calculation is therefore relatively simple. However, a more important step is the interpretation of the result. The higher the value of some efficiency indicators, the more activities they map that benefit the organization and vice versa. If controllers want to assess the overall situation in the organization, they must be able to interpret the results of the portfolio of indicators that are important for the effective provision of processes in the organization.

Construction of efficiency indicators:
Efficiency indicators = output / input
Difficulty indicators = input / output

As already mentioned, the input to the evaluation of efficiency indicators is the previous analysis, namely:

a) ***analysis of the development of analytical efficiency indicators*** - this is a comparison of individual indicators for certain consecutive time periods. E.g. labor productivity, HIM efficiency, process efficiency. It is advantageous if we record growth tendencies in terms of efficiency indicators (difficulty - declining tendencies).

b) ***analysis of input change caused by 1% growth of output*** - quality inputs are a guarantee of quality outputs. Then we can evaluate the obtained results according to the following optimal criteria:

- if the 1% increase in output did not require an increase in input, this is an intensive development. The only factor of output growth is the change in the qualitative factor.
- if the growth of output by 1% required the growth of input (0.01 - 0.49)%, it is a predominantly intensive development. The main factor, not the only one, is the change in the qualitative factor represented by analytical efficiency indicators.
- if the growth of output by 1% required the growth of input in (0.5 - 0.99)%, the development is mostly extensive. The decisive factor for the change in output is the quantitative factor.

c) ***analysis of the share of quantitative and qualitative factors in the change in output*** - the essence is the expression of the influence of quantitative and qualitative factors on the change in corporate output, while the change can be expressed in relative% or in absolute terms in EUR. For this type of calculation, the so-called logarithmic method.

d) ***calculation of relative savings or absolute excess of inputs*** - tells about the relationship of inputs per unit of output. At relative savings - specific savings of inputs per unit of output. When the input growth per unit of output is absolutely exceeded.

Among the best known and most important performance indicators that should be the basis for evaluation are the following:

- quality expenditure indicators in terms of EUR gross turnover
- indicators of financial expenditures on quality converted into EUR sales
- an indicator of the ratio of internal losses from low-quality production to total production costs
- an indicator of the ratio of financial expenditures to quality per hour of unit wages

- the ratio of internal error costs to wages
- share of prevention costs from quality costs at the manufacturer
- the ratio of quality costs to added value

10.3. CONCLUSION

Quality is not free. Building quality management systems is associated with costs that can be spent efficiently or inefficiently. This is also the reason why it is necessary to monitor and evaluate whether the quality system brings, but does not bring, profits to organizations operating in the forest-based industry. The controlling process plays an important role. Quality managers should have at least a general knowledge of the composition of costs related to quality and should be able to evaluate whether the quality management system is beneficial for the organization or where there are reserves.

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11. QUALITY CONTROLLING AS A SUPPORT FOR COMPANY QUALITY MANAGEMENT

Anna Šatanová

11.1. INTRODUCTION

The aim of the presented chapter of the publication is to comprehensively present the theoretical basis of controlling with a focus on the current state of quality controlling. Quality controlling is understood as a part of company controlling to support quality management. It is based on the definition of controlling and its connection to quality management in the company, the concept of quality management focused on a process-oriented approach and economic concept. This methodology and procedure will be applied in the conditions of a wood processing company.

In the design of the quality controlling methodology, two concepts are combined, namely controlling and quality management, which mutually create a new concept of quality controlling, which has not been widely used in Slovak companies to date, but has been known in German practice for several years.

Originally, controlling was limited to the financial area, it gradually spread to all business areas that require regular reassessment and control. Quality control arose from the knowledge that quality in addition to costs, continuous production time, or delivery time is considered to be one of the main success factors, so this concept serves to support quality management through economic considerations (Hansen, Kamiske, 2003).

11.2. THEORETICAL DEFINITION OF THE PRINCIPLE, TASKS AND FUNCTIONS OF QUALITY CONTROLLING

As stated by Horváth (Horváth, 1997), the area of quality management tasks has changed significantly in recent years: the product-oriented interpretation of the concept of quality has been replaced by the process orientation of quality in the company as a basic feature of total quality management. In this way, there was immediately outlined the role of quality controlling, namely - in addition to profitability and liquidity, to make quality a measurable quantity, which is a necessary prerequisite for increasing the overall quality in the company.

Based on the very concept of "quality controlling", it can be considered as a part of the controlling system and at the same time the quality management of the company. Its general tasks are to support the achievement of the company's results with regard to customer requirements and the quality of competition, as well as to extend the hitherto more technically oriented quality management with economic aspects (http://www.quality.de).

"Quality controlling is the planning, management and control of quality-promoting activities from an economic point of view of quality management" (Bruhn, 1998). It should preventively achieve a quality assurance strategy not only by minimizing losses from poor quality production, but also by improving the company's performance (Männel, 2000).

Within quality management, the task of quality controlling is to coordinate individual business areas, to support quality management by providing appropriate information, and at the same time to control and re-evaluate the cost-effectiveness of measures. For this purpose, quality controlling uses several tools, such as quality costing, quality indicators and quality reporting (http://www.mkonetzny.de). It is also possible to use FMEA analysis, Pareto analysis, Ishikawa diagram, etc.

Based on the above definitions, the following can be stated:

Quality control is a partial system of corporate controlling and at the same time a supporting tool of quality management, focused on the support of future-oriented management concerning the minimization of costs, increasing the quality of processes and thus also customer satisfaction.

The goal of the quality controller is to minimize quality costs while maintaining the required level of quality. The controller must be able to participate together with the managers in all projects leading to the improvement of the company-wide quality in all company areas and at the same time inform the company management about the achieved results through regular reports.

The German literature (http://www.controllerverein.de) lists several possibilities for controllers to operate in the field of quality management. Some of them are shown in Figure 1.

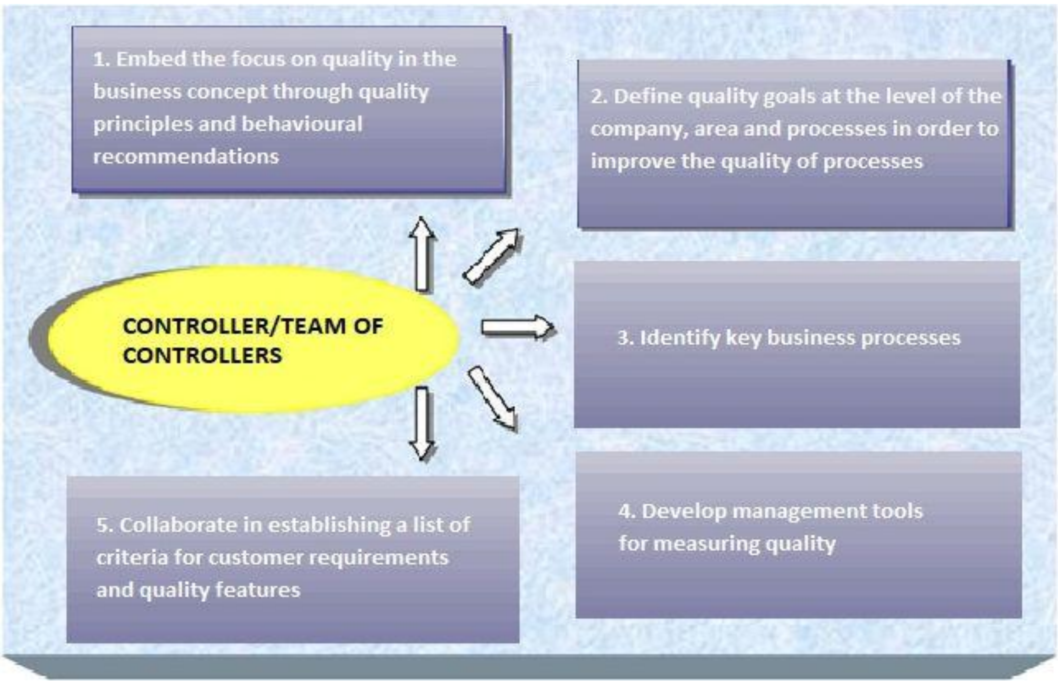


Figure 11.1. Possibilities controllers in the field of quality management (Holíková, 2010) of

In addition to the above, it can be stated that the controller in the field of quality management should be involved in defining quality objectives in cooperation with the quality manager, so that these can be quantified and tools for measuring quality can be developed. Its task should be, in particular, the effort to minimize, or cost optimization in order to achieve the best possible effects and overall results in the management of the company.

The concept of quality controlling is characterized by the functions shown in Figure 2.

Figure 11.2. Quality controlling functions (Holíková, 2010)

1. The coordination function shall ensure the coordination of quality-related tasks at the various hierarchical levels and in the different areas of the undertaking in order to align all sub-plans as components of the overall business development plan.

2. The information function consists in obtaining and providing the necessary information concerning quality. For this reason, it is important for a company to build an information security system that will provide such data, but this requires high costs to provide the necessary hardware and software.

Such an information system would consist of the following basic elements (Horváth, Urban 1990):

- planning of quality inspections, which would include inspections, resp. quality tests covering the process from the arrival of the goods in the warehouse to their sale from the warehouse,
- SPC, t. j. statistical regulation of processes, which verifies whether the process is stable,
- quality indicators.

1. Through the planning function, quality controlling represents planning support in the field of quality management (http://www.betriebswirtschafts.info).

2. The control function consists in the control, verification of individual activities related to quality assurance (Bruhn, 1999). At the same time, it represents a comparison of planned and actual values, monitoring of deviations and subsequent proposals for their elimination or adaptation to the plan (http://www.qi-bb.de).

These functions can be supplemented by an advisory function, because the role of quality controlling consists mainly in guiding, assessing and proposing recommendations.

11.2.1. Organizational integration of quality controlling

Since quality controlling can be considered as a partial area of the overall controlling system, the company thus assumes close cooperation of this area with other sub-areas. The possibilities of organizational integration of controlling are shown in Figure 3. (Horváth, Urban 1990).

Figure 11.3. Variants of organizational integration of quality controlling (Holíková, 2010)

Based on Figure 1.3., three ways of organizing quality controlling can be implemented in companies:

1 In large enterprises, the first option is preferred, in which quality control is assigned to a production unit, thus ensuring a relatively close relationship between the two areas.

2 In companies that have a wide production program, it is possible to create a staff place for the needs of quality controlling, which will be directly subordinate to the company's management.

3 If quality management has a very important position in the company, then a responsible job position can be created in the company. In this case, quality controlling is subordinated to the head of the quality management department.

11.2.2. Breakdown of quality controlling in terms of time

In terms of time, quality controlling is divided into two sub-disciplines:

- Strategic quality controlling
- Operational quality controlling

Strategic quality controlling is the support of strategic planning and management with strategically relevant information, which allows the formulation of a suitable quality strategy. In doing so, it takes into account future opportunities and risks, as well as the company's strengths and weaknesses (http://www.betriebswirtchafts.info). It deals with the effectiveness of long-term use of potentials for success (http://www.qm-trends.de).

Its goal in ensuring the long-term existence of the company is to set long-term quality goals, based on analyses of the market, competition and own company. For this reason, it largely covers sub-areas of business planning and marketing.

Operational quality controlling, as opposed to strategic controlling, is focused on tactical and operational planning and its goal is short-term to medium-term profit maximization. Its primary task is to focus on business processes and their economic side, then to ensure customer satisfaction.

Similar to strategic quality controlling, operational quality controlling also includes the determination of deviations of actually achieved values from the planned ones and the subsequent elaboration of proposals for measures to improve specific situations. In order to continuously improve the processes, the steps shown in Figure 4. must be followed.

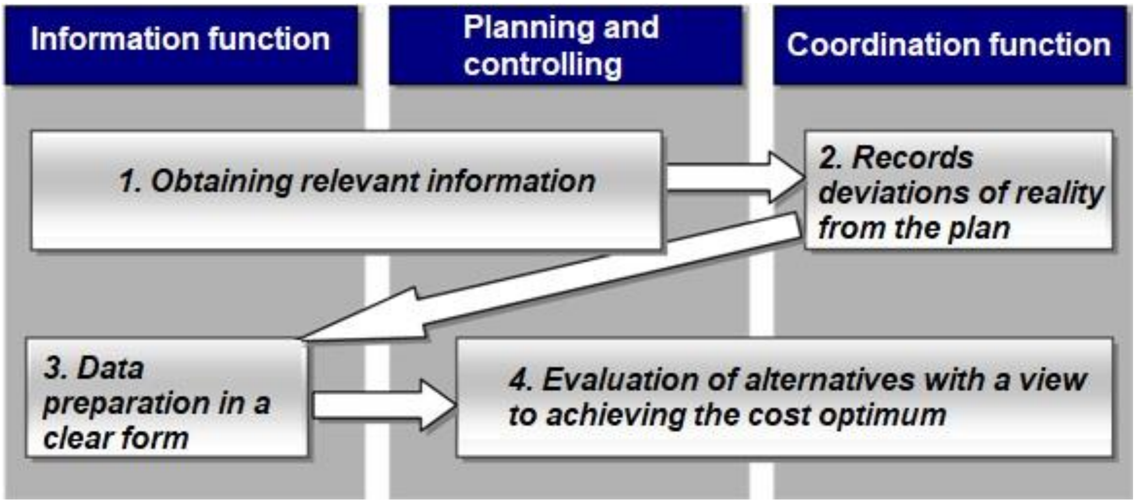


Figure 11.4. Application of quality controlling functions in process improvement (http://www.qm-trends.de)

According to Figure 1.4., in order to reveal the fact, it is first necessary to capture the relevant information. In the next step, the detected deviations from the planned values of the quality objectives are recorded. The achieved results will be evaluated in a clear form using tables and graphical representations. Subsequently, several alternatives for process improvement are identified, which will be evaluated in order to achieve the optimal level of quality costs

11.2.3. Development stages of quality management and quality controlling

The new understanding of quality through the focus on processes and customer requirements requires support and provision of relevant information, therefore quality control has become a basic building block of TQM. Quality management and quality controlling have been evolved in three stages, which are presented in Figure 1.5.

In terms of quality management, the second degree appears in most Slovak companies, i. e. integrated quality assurance presented by ISO standards. In the field of quality control, companies are to a greater extent in the first stage of development, or in the transition to the second stage, which represents a new process approach including process management, process cost management and process time as a "magic triangle" (origin of the term from German literature).

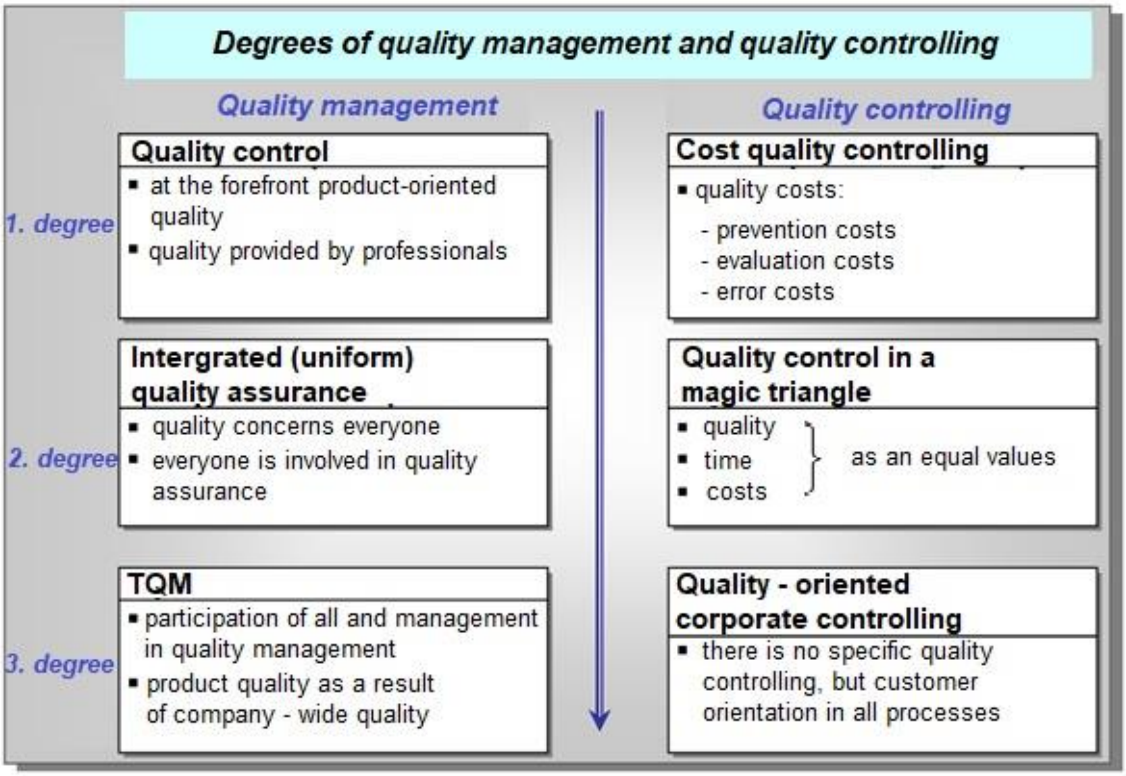


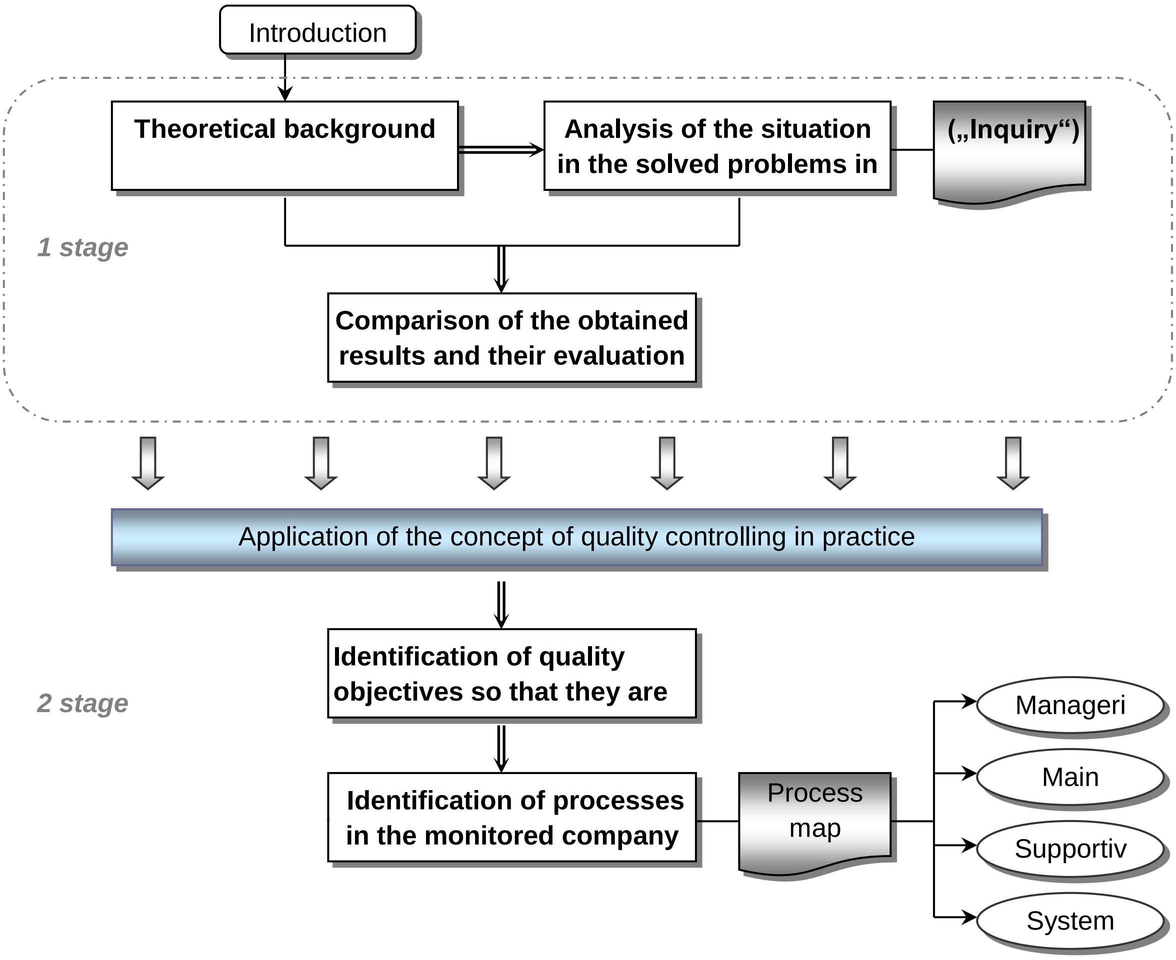
Figure 11.5. Degrees of quality management and quality controlling (Horváth, Gentner, Lingscheid, 1994)

Based on Figure 5., it can be stated that the cost of quality has become the basis of quality controlling, therefore, the following chapter explains the nature of these cost items.

11.3. PROPOSAL FOR THE APPLICATION OF QUALITY CONTROLLING IN A WOOD PROCESSING COMPANY

The process of applying the concept of quality controlling in a wood processing company can be divided into several parts.

The methodology of this procedure is schematically shown in Figure 1.6.


Introduction
Theoretical background
Analysis of the situation in the solved problems in
(„Inquiry“)
1 stage
Comparison of the obtained results and their evaluation
Application of the concept of quality controlling in practice
Identification of quality objectives so that they are
2 stage
Identification of processes in the monitored company
Process map
Manageri
Main
Supportiv
System

Proposal of quality control methodology

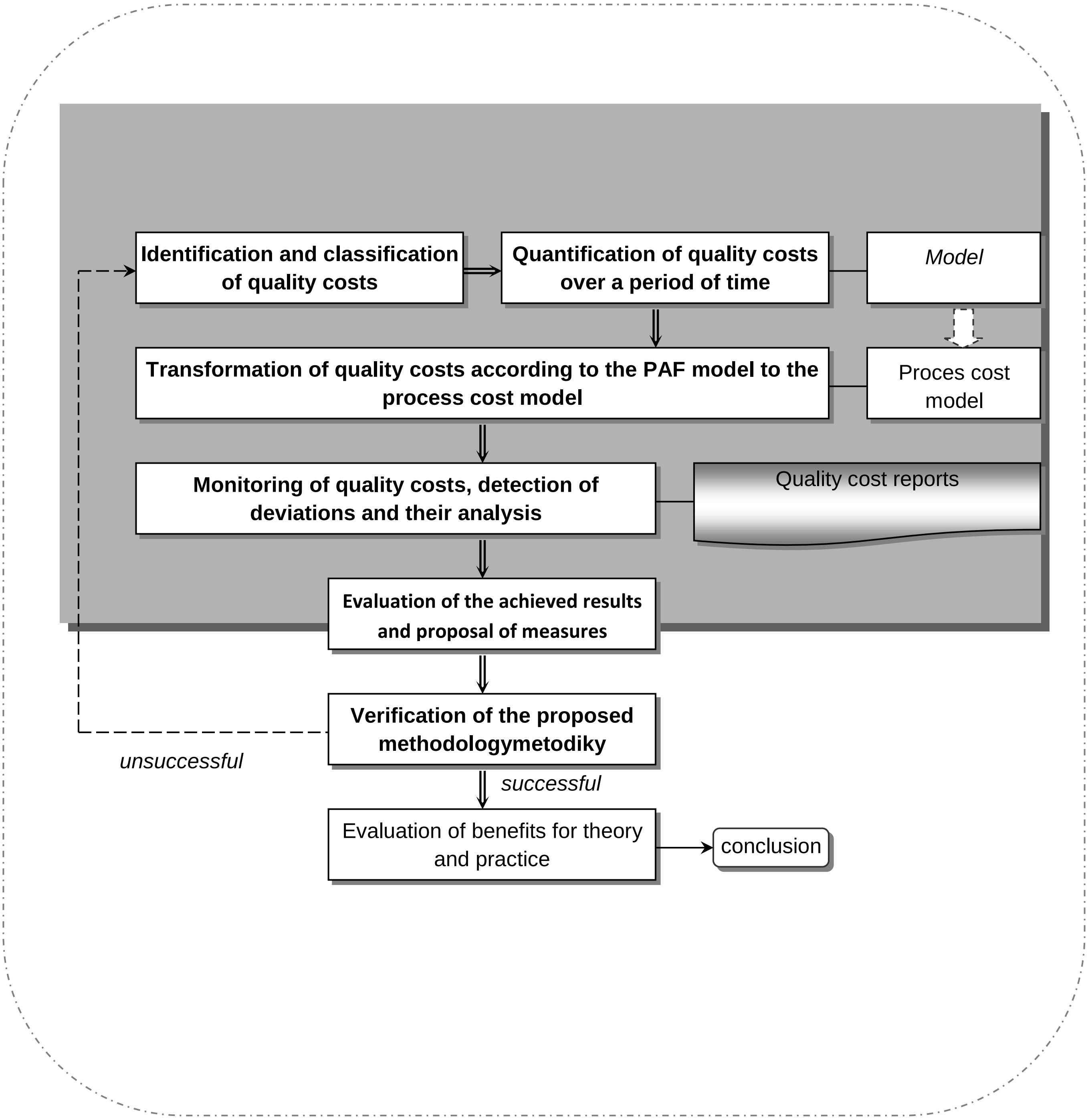


Figure 11.6. Methodology of applying the concept of quality controlling

The monitored furniture company has defined strategic goals; to achieve them, it has set several basic goals at the company level in a time horizon of one year and then it specified them at lower organizational levels - departments and subsequent workplaces.

At the level of basic goals, there are also quality goals that are necessary to be achieved so it has set strategic goals, and these can also be further specified at the levels of departments and workplaces. For quality control purposes, there are specified the main measurable quality objectives, which are illustrated in Table 1.

Table 11.1. Quality objectives

No.	Basic objectives(company level)	No	Auxiliary objectives (at unit level)	Unit	No	Auxiliary objectives(at workplace level)	Responsible person
1.	Identification of corporate processes	1.1	Compiling a process map	QMD			Quality Manager
2.	Overview of complaints	2.1	Tracking the number of complaints	QMD	2.1.1	Complaints received from customers	Quality Manager
				BD	2.1.2	Complaints addressed to suppliers	Business Manager
		2.2	Evaluation of the ratio of complaints to the goods	QMD	2.2.1	Accepted complaints about invoiced goods	Quality Manager
				BD	2.2.2	Accepted complaints about invoiced goods or material	Business Manager
3.	Production efficiency	3.1	Check points	QMD	3.1.1	Final inspection- according to control points points	Quality Manager
		3.2	Mass errors	QMD	3.2.1	- for production sections	Quality Manager
		3.3	Nonconforming products (failures)	PD	3.2.3	- for machines	Production Manager
		3.4	Productivity	PD	3.4.1	Furniture production	Production Manager
					3.4.2	Production of joints	Production Manager
4.	Education and training of employees	4.1	Training Plan	HRM	4.1.1	Internal training	Production Manager
					4.1.2	External training	Production Manager
5.	Quality assessment	5.1	Internal audits	QMD	-		Quality Manager
		5.2	External audits	QMD	-		Quality Manager

QMD – quality management department, BD - business department, PD - production department, HRM - human resources department.

Based on Table 1., it will be possible to identify the main groups of quality costs that should be monitored in the company.

11.3.1. Identification of processes

One of the basic quality objectives is to clarify the processes that can be achieved by compiling a process map clearly showing all the processes in the monitored wood processing company, as shown in Table 2.

Table 11.2. Breakdown of wood processing company processes into subprocesses

Type of process	No.	Process name	Process owner	Subprocess - level1	Process owner
MANAGERIAL PROCESSES	1.	Strategic planning	General manager	Determination of vision, strategy, policy	General manager
				Budget setting	Financial manager
				Setting of goals	General manager
				Management review	Quality Manager
	2.	Investment management	General manager	-	-
	3.	HRM	HRM Manager	Human resource planning	HRM Manager
				Education and training of employees	HRM Manager
	4.	Financial management	Financial manager	Accounting	Financial manager
				Controlling	Financial manager
	5.	Quality Management	Quality Manager	Corrective and preventive activities	Quality Manager
				Nonconformance management	Quality Manager
				Product identification	Quality Manager
MAIN PROCESSESSY	6.	Production of joints	Joint production manager	Timber preparation	Joint production manager
				Production and sorting of slats	
				Production of endless frieze	
				Pressing a joint	
				Joint repair	
				Leveling (fine grinding)	
				Sealing	
				Continuous material repairs	
				Interoperational control	Quality Manager
	7.	Furniture production	Production Manager	Machining of parts	Production Manager
				Manufacture of doors	
				Surface treatment	
				Assembly and packaging	
				Ongoing repairs	
				Interoperational control	Quality Manager

Type of process	No.	Process name	Process owner	Subprocess - level1	Process owner
				Checkout	Quality Manager
SUPPORT PROCESSES	8.	Maintenance	Technical manager	Machine maintenance	Maintenance Manager
				Operation maintenance	Plant maintenance technician, building manager, energy, waste manager
				Spare parts management	Technical assistant, spare parts officer, storage
	9.	OSH and fire safety	Technical manager	Safety at work	Health and safety technician
				Fire protection	Health and safety technician
				Property protection	Health and safety technician

Type of process	No.	Process name	Process owner	Subprocess	Process owner
SUPPORT PROCESS	10.	Power supply	Power Supply Manager	Electricity supply	Power Supply Manager
				Supply of thermal energy (gas, wood waste)	
				Steam production	
				Water supply	
				Sewer	
	11.	Waste Management	Technical manager	Wood waste management	Production Manager
				Production of briquettes	Joiner production technologist
				Other waste management	Technical manager
				Removal of non - returnable waste	Production Manager
	12.	Information technologies (IT)	Information technician	Hardware management	Information technician
				Software management	
				IT protection	
	13.	Production preparation	Development and construction engineer	Design development	Development and construction engineer
				Technological preparation	Technologist

Type of process	No.	Process name	Process owner	Subprocess	Process owner
ES	14.	Planning	Scheduler	Customer order planning	Scheduler
				Sales planning, shipping, transportation of goods	
	15.	Production scheduling	Production Managery	-	-
	16.	Purchase of materials	Business manager	Order management	Sales manager
				Supplier requirements management	
				Selection, approval and evaluation of suppliers	
	17.	Handling and storage	Logistics manager	Handling and storage of raw wood material	Logistics manager
				Handling and storage during the process	Production Manager
				Handling and storage of finished products	Logistics Manager
				Removal of returnable packaging	Logistics Manager
	18.	Customer requirements management	Quality Manager	Customer complaints management	Quality Manager
				Measuring customer satisfaction	
	19.	Metrology	Quality Manager	-	-
	20.	Organization	HRM Manager	Personnel administration	Payroll accountant
				Assessment and valuation of employees	HRM Manager
SYSTEMÉ PROCESSES	21.	Documentation check	Quality Manager	Checking internal system documents	Quality Manager
				Checking internal technical documents	Development and construction engineer
				Checking external documents	Quality Manager
	22.	Records management	Quality Manager	-	-
	23.	Audits	Quality Manager	Internal audit	Quality Manager
				External audit	

The compiled structure of processes becomes a prerequisite for the selection of processes that will be subject to monitoring in terms of quality costs according to the new process approach preferred by ISO standards and the TQM concept.

11.3.2. Classification and identification of quality costs

Based on the set measurable quality goals and the needs of the company, the next step is the classification and identification of quality costs, taking into account the specific situation in the company. The cost items listed in Table 3. will be monitored.

Table 11.3. Classification and identification of quality costs in a furniture company

Code	Type of quality costs	Contents of the item
N 1	Prevention costs	
N 1.1	Costs for selection, approval and evaluation of suppliers	Total expenditure on specification of supply quality requirements
N 1.2	Costs on internal audits	Payroll and overhead costs for regular audits initiated by senior management.
N 1.3	Costs on external audits	Invoiced amount by the audit site.
N 1.4	Internal costs of education and training of employees	Labour costs and overheads.
N 1.5	External costs of education and training of employees	The amount invoiced by the educational organization (seminars, courses, advanced studies, internships, etc.)
N 1.6	Costs of calibration services	The amount invoiced by the external organization.
N 2	Evaluation costs	
N 2.1	Entry control costs	Material, wage and overhead costs for input control of material inputs, auxiliary materials, chemical analyzes, etc.
N 2.2	Production control costs	Material, labour and overhead costs for production control.
N 2.3	Output control costs	Material, payroll and overhead costs for output control.
N 2.4	Costs of internal laboratory tests	Total operating costs of laboratories providing product verification processes.
N 2.5	Costs of external laboratory tests	Invoiced amount by an external organization.
N 2.6	Purchase and maintenance costs of measuring technique	One-off investments and operating costs, including repair costs for all types of measuring equipment in the enterprise.

Code	Type of quality costs	Contents of the item
N 3	Internal losses	
N 3.1	Cost of mass errors	Material, labour, overhead costs incurred as a result of improperly set up machine.
N 3.2	Extra labour costs at repairs of correctable nonconforming products (failures)	Costs of remediable discrepancies in semi-finished products, materials and products, i.e. direct wages, direct material and the corresponding part of overheads.
N 3.3	Losses from irreparable non-conforming products (failures)	Value of non-conforming materials, semi-finished products, products that must be discarded.
N 3.4	Non-reclaimable losses from supplier disagreements	The value of unusable and no longer reclaimable purchased material inputs, the discrepancies of which were not caused by the
N 4	External losses	
N 4.1	Costs of non-conforming and non-repairable products (complaints)	Value of external discrepancies.
N 4.2	Discounts of reduced quality product prices quality	The difference in loss between the normal selling price and the discounted price.
N 4.3	Transport costs incurred by non-conforming products	Shipping, labour costs for handling external discrepancies.
N 4.4	Travel costs incurred in non-conforming products	Travel expenses for external disagreements.

Depending on the type of an organization, a different classification and identification of quality costs may be provided.

11.3.3. Quality cost reports

Quality costs are monitored within the MS EXCEL program through partial quality cost reports (monthly "Quality cost reports") on a monthly basis. A quality cost summary report is compiled quarterly or semi-annually and annually. The draft report is shown in Table 4.

Its **horizontal structure** consists of columns of planned values, values of the recalculated plan, facts and deviations compiled in terms of time by months and subsequent cumulative totals. At the end of each quarter and half-year, the cumulative column is clearly highlighted.

The vertical structure consists of individual items of quality costs, which in terms of their content are more detailed into material, labour and other costs, or expenses.

Table 11.4. Quality cost report

QUALITY COST REPORT															
Code	Cost item	Monitored period (month)							Cumulative						
		Plan		Recalculated plan		Reality		Deviation	Plan		Recalculated plan		Reality		Deviation
		€	%	€	%	€	%		€	%	€	%	€	%	
N 1	Prevention costs														
N 1.1	Selection, approval, evaluation of suppliers														
N 1.2	Internal audits														
N 1.3	External audits														
N 1.4	Education and training of employees internally														
N 1.5	Education and training of employees externally														
N 1.6	Calibration services														
	Total														
N 2	Evaluation costs														
N 2.1	Check-in														
N 2.2	Production control														
N 2.3	Check-out														
N 2.4	Internal laboratory tests														
N 2.5	External laboratory tests														
N 2.6	Purchase and maintenance of measuring technique														
	Total														
N 3	Internal losses														
N 3.1	Mass errors														
N 3.2	Additional work on the repair of repairable non-conforming products														
N 3.3	Losses from irreparable non - conforming products														
N 3.4	Non-reclaimable losses from supplier failures														
	Total														
N 4	External losses														
N 4.1	Non-conforming non-repairable products (complaints)														

QUALITY COST REPORT																
Code	Cost item	Monitored period (month)							Cumulative							
		Plan		Recalculated plan		Reality		Deviation	Plan		Recalculated plan		Reality		Deviation	
		€	%	€	%	€	%		€	%	€	%	€	%		
N 4.2	Discounts on prices of reduced quality products															
N 4.3	Shipping invoked by non-conforming products															
N 4.4	Travel triggered by non-conforming products															
	Total															
	Total quality costs															

In order for quality cost analyses to be meaningful, they will be compared with selected variables, such as turnover, total costs, economic result, etc. Based on the achieved results from reports and values of indicators, it will be possible to reveal the benefits resulting from the applied methodology of the quality controlling concept, then inform the company's top management about the achieved results in quality and at the same time formulate the necessary measures in quality and quality improvement.

11.4. CONCLUSION

The emergence of new technologies on the market, the growing information needs of companies and the associated greater demands on the quality of the decision-making process require that, in addition to traditional methods, new methods and approaches should be applied that make this process consistent, systematic and clearer.

At present, quality is also perceived as an economic category that can be measured, and it is here that a tool appears that helps to make quality measurable, clear and plannable. It is controlling, which is also promoted in the field of quality assurance and improvement, known in foreign literature as **quality controlling**, representing the economic concept of quality. Its role is to ensure quality management with sufficiently relevant quality information in order to fulfil the set plans, identify weaknesses and shortcomings in the processes. Therefore, the presented scientific monograph deals with the issue of this new concept and outlines a simple way of applying quality control in the company.

In conclusion, we can state that the principles of quality controlling are closely related to the principles of total quality management, therefore quality controlling can be considered a supporting tool of the TQM philosophy. Its basic building blocks are quality costs, which are often underestimated in practice. In the presented scientific monograph the reasons for paying attention to this issue and it is importance for management have been stated.

The connection between quality controlling through quality costs and the TQM concept can be finally confirmed by the following quote from foreign authors:

"Understanding the cost of quality is the beginning of the path to the TQM philosophy." (Atkinson, Hohner, Mendt, Troxel, Winchel, 1991).

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