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Article

Sustainable Development Model of Performance of Woodworking Enterprises in the Czech Republic

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Abstract: The current requirements put on the Member States of the European Union ("EU") in the area of sustainability and climate-neutral economy through strategic visions such as "Agenda 2030" or "A Clean planet for all" demonstrate the increasing need for quick identification of the changes required in the use of renewable and nonrenewable natural resources. Forests are a particular specific area of such changes. They represent a part of the ecosystem that is important for society from the economic, social, and environmental perspectives. Current climate changes have had a negative effect on the state of forestry in the Czech Republic and have raised many questions of how to ensure its sustainability. Besides the changes in forestry, the situation has also affected the sector primarily depending on the production function of forests and whose coexistence is conditioned. Taking specific sectors as examples, the article presents some prospects that could result in more efficient use of resources and defines potential synergic effects. Analyses of primary and secondary information sources were used to create preferential models (the term "preferential" in the context of the article represents opportunities through which it is possible to achieve an improvement in competitiveness and market advantage over the current model of wood processing and timber trade in the Czech Republic. The model works with potential perspectives and respects the challenges in the field of sustainable development) of timber and wood raw material production and processing and preferential and of economic efficiency (the term "efficiency" in the article represents the technical efficiency of the use of resources to achieve maximum economic benefit and added value. The aim is to increase the economic potential of individual sectors of primary and secondary processing in relation to timber sources) of woodworking businesses. The production model indicates that the energy use of wood, the expansion of the production mix in construction, the use of biomass and digestate in agroforestry, and the logging waste recovery are the most prospective sectors. The model presenting preferential areas in the woodworking industry development with respect to sustainability identified the need to increase associated production and material efficiency in construction and energy sectors, as well as insufficient activity of the sectors associated with technological innovations, FSC and PEFC certification prospects, bioeconomy and circular economy, a considerable need for wage growth in the sector and increased use of the existing production capacities by both domestic and foreign sales.

Keywords: sustainable management; economic efficiency; wood processing industry; added value; model of performance; wood consumption balance; wood processing cascade

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1. Introduction

Support to domestic wood processing is a part of the current strategy of the Forestry department of the Ministry of Agriculture of the Czech Republic ("MAg CR"). One of its biggest challenges is increasing the level of production, consumption, and export of wood and paper commodities with increased added value. Its solution belongs to essential preconditions for the development of forestry and wood processing. The results of the analyses and particular claims presented in this article can also be supported by the results of the UNECE report [1], at the EU level by the authors [2–6], also by a study from Uruguay [7], a study from Japan [8], a study from Russia [9] and by a study from Czech Republic [10], which partially addressed this issue. These studies point to the potential for increasing added value in wood processing for the timber trade and related industries. These needs were also pointed out in the conclusions of the 4th Ministerial Conference on the Protection of Forests in Europe (Vienna 2003), which adopted the V2 resolution Reinforcing the economic viability of sustainable forest management in Europe. The National Forestry Programmes of the Czech Republic ("CR"), particularly the Czech National Forestry Programme of 2008, also belong here. The fact that restrictions on the export of unprocessed raw wood were already discussed as a priority at the Economic and Social Agreement Council of the Czech Republic in 2014, as well as the activities of the MAg CR supporting domestic processing by providing subsidies and efforts to establish a fund to support domestic wood consumption, demonstrate the significance of the issue. High raw wood exports, together with an increasing demand for wood products, create preconditions for a high potential of added value from both increased processing and optimisation of the entire production structure. Based on the forest inventories taken, standing stocks give presumptions for the examination their potential and create a realistic model of changes in the forestry-wood sector aiming at benefiting from the growth in the consumption of renewable resources and the strategic development of timber-based industrial production. Other impetuses for the application of an efficient model of the structural transformation and increasing the efficiency of raw wood processing include climate change, the Czech Republic's commitments resulting from international agreements, and overall optimisation including bioenergy sector utilising timber flow outside industrial wood processing. The solution of further development of wood processing in the Czech Republic with consequent decrease of the volume of raw wood export implies not only increasing the processor capacity, but also seeking the optimum arrangement of the structure of processing with respect to current possibilities and state of processing. On the one hand there is a decrease in wood sources, which was described in Material Flow Analyses (hereinafter referred to as the "MFA") within the studies carried out at the regional level [11,12], and [13] for the Netherlands, [14] Japan, [15] Slovenia, [16] Ireland, [17] China, [18] Finland, [19] Germany, and [20] Slovakia at the national level, as well as for the European Union as a whole [21]. On the other hand, the material balance of sources and their consumption lie in problems of capacity arrangement and seeking an optimum arrangement with respect to some key performance characteristics, such as the overall production volume, maximisation of timber inputs and processing cascade, which produce the biggest volume of raw material with added value possible for the subsequent processing. The article compares the processing structure on the basis of the available information about the structure of primary processing, material consumption, and timber volume at processing. The established structure of processing enables identifying the efficiency of timber sources above the current processing base, which characterises the economic potential of individual sectors of primary processing in relation to timber sources. Despite the joint effort of industrial, public and political bodies and bodies with decisive authority, very limited research focused on the business economy in wood-forestry sector was published [22]. The source-based view represents a mere part of the complex environment, and the society needs new methods and tools for better decision-making at the business, national, and global level. The utilisation of forest biomass is the main source of value-making in forestry, industrial processing and energy use of wood. Finding an optimum structure of raw wood processing and consumption in link to the existing sources and their distribution will enable long-term prospects of utilisation in domestic capacities as well as a decrease in raw material export. Optimisation of the processing structure will enable obtaining additional raw material resources for energy use which do not put industrial needs at risk. The aim of this paper was to analyse the flow of wood in the Czech Republic using the cascade principle of biomass utilisation and to assess alternative models of wood consumption leading to increased efficiency in the entire production chain.

2. Materials and Methods

The method of the output data and analysis processing employed herein consists of several methodological phases, whose content is structured into critical areas of the model's perspectives and creates a complex context of the issue.

The first phase creates the methodological framework and contains an analysis of secondary data from public registers and databases closely related to the issue, illustrating the stated facts with data and public information resulting from national or international analytics. Specifically, it includes the data from the Czech Statistical Office, the Ministry of Industry and Trade, the Green Report by the Ministry of Agriculture, the Rural Development Programme, international statistics by the FAO and the OECD, Intrastat, Extrastat, commercial databases such as Reportlinker, and other statistics which can be factually argued and provide the required level of relevance.

The next part of the methodology deals with primary data obtained using several research methods, which shall be defined, including their relation to the specific information provided in the article. The first method used is the back-calculation technique, which was used to revise the national statistics of raw material base of wood in the woodworking industry since there was a presumption that the method used to report the information was inaccurate and insufficient for the purpose of strategic decision-making. This aspect can be seen as a weakness of the majority of the known methods of wood flow monitoring, whether at the national or international level. The back-calculation technique is a method of reverse data monitoring from processors to production inputs using a wood consumption conversion factor for the production output (see Table 1). The method requires creating a database of roundwood processors and defining the focus of the prevailing production and processing technologies used by the businesses. This methodology was created under the NAZV 2018–2020 (National Rural Research Agency) project carried out by the authors of this article. The output report of the project (https://starfos.tacr.cz/cs/project/QK1820358, accessed on 29 April 2021) mentioned contains a more complex description of the method.

Table 1. Material utilisation of raw wood for various manufacturing in the Czech Republic.

Product	Raw Wood Use/m^3 of Product
Softwood lumber	1.72 m^3
Hardwood lumber	1.88 m^3
Impregnation	1.07 m^3
Softwood plywood	1.81 m^3
Hardwood plywood	2.43 m^3
Veneer	2.04 m^3
OSB *1	1.61 m^3
MDF *2	1.63 m^3
Pulp	4.85 m^3
Particleboard	1.53 m^3

*1 OSB—oriented strand boards; *2 MDF—medium-density fibreboards. Source: [23].

Furthermore, the raw material base forecast required a specification of the logging prospects including standardised needs of woodworking, pulp, and paper industries and the expected increase in dendromass left behind in the stands to decompose.

The input data for the forecast in question required the defining of the logging possibilities outlook and the main wood assortment (roundwood, pulpwood, and fuelwood). In the Czech Republic, this issue is currently tackled by the Forest Management Institute

Brandýs nad Labem ("FMI"). The stock estimates have been prepared based on the data project Monitoring of the Condition and Development of Forest Ecosystems ("MCDFE"), which followed the second cycle of the Czech National Forest Inventory 2011–2015 project ("NIL2") since 2016. The FMI carried out this survey under the authority of the Ministry of Agriculture in the period from the end of the NIL2 to the beginning of the next NIL cycle, i.e., between 2016 and 2020. As for the method and extent of data collection, the MCDFE equals the NIL2. (FMI 2020) Another methodological tool used by the FMI is the European Forestry Dynamics Model ("EFDM"). The EFDM simulates forest development and estimates the logging volume for the given forested area. The estimate can be detailed, for example, by species, site quality, management mode, and ownership category. The EFDM is designed as a flexible system for harmonised modelling of forests. It was created to process the European National Forest Inventories. Since the data are not standardised nor necessarily available outside the country of their owner, the EFDM was developed as a modular system using open software (R) [24]. The application of findings and information associated with the estimate of future capacities of basic assortment in the article is based on the data from the National Forest Inventory NIL 2 processed using the EFDM method.

To ensure the complexity of the preference model presented in the article, it was also necessary to identify the current barriers to sustainability. At the national level, the responsibility for interweaving the sustainability interests (forest/woodworking industry) at the international level can be attributed to the PEFC and FSC forest certifications. A collective of authors dealt with the issues related to the identification of social and economic aspects of the certifications' effects within two projects of the Internal Grant Agency ("IGA") in 2016–2019. One of them focused on identifying consumers' attitudes towards products made of certified wood, and the other concentrated on the economic impacts of certifications on the woodworking industry. The statistics related to the surveys of the effects of certifications on businesses in the CZ-NACE 16 sector and consumers' perceptions of the certifications proceed from data obtained by a questionnaire survey. The consumer survey covered 404 respondents and resulted in 127 questionnaire sheets completed by business operators. A more detailed description of the processing method and the results, which are not published herein, were contained in the previous publications by the authors.

The last part of the methodology is the creation of the actual preferential model, which refers to analyses, surveys, and information base verified by the secondary sources. This part of methodology mainly builds on a synthesis of the findings, in particular the process of identification of links between the reserved elements, features, relations, and facts, and their subsequent reproduction in the form of causes, dependencies, and trends of the phenomenon being studied.

3. Results

3.1. Development Potential of Production and Method of Processing of Wood and Raw Wood

The identification of production areas and methods of raw wood processing proceeds from the information analysed in Table 2, which demonstrates an increase in the logging volume and the consequent processing cascade at the lower level of inputs in the years before and during the disaster (a strategic referential period for the assessment of the impact of the disaster on the volume and structure of the raw material base).

Table 2. Dynamics of change of the raw material base volume in the Czech Republic in 2016–2019.

Year	2016	2019	% of Increase
Timber supplies [1]	17,616,553 m^3	30,385,563 m^3	42.02
Logging residues [2]	1,900,000 m^3	2,500,000 m^3	24.00
Roundwood [2]	10,341,000 m^3	18,915,364 m^3	45.33
Pulpwood [2]	4,932,000 m^3	6,448,578 m^3	23.52

Table 2. *Cont.*

Year	2016	2019	% of Increase
Chips, sawdust, bark [3]	3,955,380 m^3	4,820,290 m^3	17.94
Fuel wood [3]	2,344,000 m^3	5,021,621 m^3	53.32
Industrial wood processing [3]	13,724,007 m^3	16,138,975 m^3	14.96
Energy sector [4]	7,843,343 t	8,544,301 t	8.2

[1] CSO 2019 Total timber supplies. [2] Report on Condition of Forests and Forestry 2016 and 2019 (FMI). [3] Estimation using the internal method from the NAZV project No. QK 1820358. [4] Summary statistics by the MIT (Renewable energy sources 2016 and 2019), figures in tons (this statistical survey cannot be considered complete and accurate as it was prepared using balance sheets).

Table 2 serves as an input for the justification of the argument stated herein that the issue of the use of forest production inputs by the processing industry in the context of sustainability is very important. Looking at the information with an outlook for the next three decades (Figure 3), it is clear from the decennial potential of the stock that the logging volume will decrease compared to the enormously high values during the years of disaster. This poses a significant problem for the woodworking industry and associated sectors due to a significant drop in revenues from economic activity. It is, therefore, justifiable to seek the best and most efficient opportunities for obtaining the highest added value from the given input capacities and thereby preserve the idea of sustainability in its three fundamental pillars: economic, social, and environmental. The trend of the basic inputs from the forest production shows a considerable increase in the logging residues by 24% (it must be borne in mind that it is the best estimate, which means that the percentage may not be exact). Logging residues in forests are mainly used for energy purposes, which is evidenced by the increase in the consumption of biomass for energy generation by 8.2% over the period under review. Apart from its economic benefits (being used in the energy sector), the use of above-ground biomass has some negative effects, too, such as significant losses of high nutritional content (nitrogen, phosphorus, and potassium). To prevent the negative effect of soil degradation, it is reasonable to use biologically worthless agricultural land for energy purposes. One of the potential environmentally friendly methods of forest waste (logging residue) utilisation seems to be the fertilisation with bore dust or wood ashes. In this case, however, the aim is rather to ensure greater height increments of woody plants in forestry, and it cannot be seen as improving the potential of utilisation of material flows into the CZ-NACE 16 sector. It still can bring economic and technological opportunities for utilisation of spare capacities with low investment risk. In circular economy, considerations are also given to so-called spiked fertiliser (with digestate) from waste biomass. Such fertiliser should sort out the problem with soil degradation in both agriculture and forestry. Technological lines for processing of logging waste may also represent an appropriate exit strategy for utilisation of the capacities as well as a competitive edge in the sector. By the recent adoption of the strategic vision (A Clean Planet for All) of the new approach to the climate-neutral economy by 2050 by the EU in 2018, the Member States are bound to decrease their carbon footprints to the level of a carbon-free economy. This objective presupposes a creation of approximately four million jobs and anticipates a significant development of the sector due to implementing the energy-climate objectives of the EU. Considering the implementation of the EU's objectives and the progressive growth of the utilisation of raw wood for energy purposes, safeguarding the sustainability of the CZ-NACE 16 sector will highly depend on the adaptation of the technological possibilities for creating inputs for the energy industry. Being one of the priority elements of the model presented herein, the energy industry offers prospects for solving the problem with the increasing of the added value of low-quality wood, which the Czech timber market must currently settle, and which is rather difficult with the transformation process taking place in a problematic period. Sawdust processing appears to be an important production area, where the current market with pellets and briquettes (for utilisation in energy generation) faces a lack of production inputs. This situation is caused by the preferred deployment of the current capacities of sawmill businesses in the processing of more valuable construction and joinery lumber, whose price does not significantly decrease despite the crises. It opens opportunities for the construction of technological lines in the form of associated production of woodworking businesses in reaction to the need for increased efficiency of inputs/outputs and decreased costs of sawdust removal. Based on the analysis of secondary sources, the most promising seems to be the utilisation of wood for energy purposes in the form of sawdust processing for the trade with commodities such as pellets and briquettes, where the production input capacities are currently not covering the demand. The progress in production and biomass processing by the energy sector is also evident at the international level. Taking account of the utilisation of wood in the form of biomass for the energy sector, the utilisation rate is considerably lower in the Czech Republic than in more developed countries such as Germany, Finland or Denmark, where the biomass utilisation rate ranges between 7.5% and 13.1% compared to 2.7% in the Czech Republic. In this case, seeking an optimum proportion of the biomass utilisation in the energy sector is worth considering as the desirable proportion differs with the individual countries. This also gives scope for a synergy between the FSC and PEFC certification with plantation growing of fast-growing wood species, which might reduce the negative impacts of generation of impacts for biomass production inputs. The increasing trend of biomass production is illustrated by the statistics of the MAg [25] on development in fast-growing wood species, whose production has increased 249.93 ha (2008) to 2862.22 ha (2017) over the last 10 years. A similarly major progress can be observed in the paper industry, where the energy production based on own sources (mainly biomass) has risen to almost 100% of the overall energy consumption and the industry in question can qualify as fully self-sustainable in energy production [26]. The progressive growth rate is also evidenced by the statistics of utilisation of renewable energy sources at the national level as the consumption of solid biomass for energy production (fuelwood, chip wood, pulp leachate, nonagglomerated materials, pellets and briquets, and other biomass) increased by 31.3% (2010—3,216,947 t; 2019—4,683,045 t) between 2010 and 2019.

Another potential prospect at the level of intersector synergy introduced in the model is circular economy and bioeconomy. The selection of these fields is closely linked with the preparation of the strategic framework for the development of circular economy in the Czech Republic ("Circular Czech 2040"), the implementation of the Strategic Framework Czech Republic 2030 in sustainable development and Agenda 2030. Commencing the use of the Czech circular hotspot in 2019, the Czech Republic joined the states actively supporting the change in a transition from linear economic model to circular one. There have also been efforts in bioeconomy to decrease the dependency on fossil fuels and to diversify business lines and increase the number of product categories, which could bring many opportunities for the woodworking industry (e.g., production of innovative materials). Since the biomass supplies from forestry in the EU (for energy purposes) account for nearly 36% while secondary materials (recyclate) for production of products made of wood, pulpwood, and paper account for 47%, this area must be considered as important for future sustainable development of the sector.

Roundwood as a basic input source for further processing is another important area, with an increase in its volume by more than 45% between 2016 and 2019. The fundamental and key assortment for further processing of roundwood is the production of lumber from coniferous plants. Following further processing from assortments to semifinished to finished products, the lumber then enters other sectors, such as the furniture industry and the construction industry (construction elements, panels, and fine arts). Besides roundwood processing into lumber, the assortment also includes pulp and veneers, which also represent a significant part of the industry for which wood is the basic raw material for production. Regarding the mentioned industries, it is the construction sector which seems to be very promising as it has a big potential to increase the added value of the production outputs and, consequently, the economic stability of woodworking businesses in the period of limited sources for the processing industry. The most suitable appear to be environmentally friendly and renewable materials manufactured using specific technologies for constructions of multi-storey buildings and wooden houses, one of them being the high-strength cross-laminated timber technology ("CLT"). In Europe, this renewable environmentally friendly material is much demanded, and its production shows a growing trend. Other alternatives to standard materials (bricks, concrete) are laminated strand lumber ("LSL"), laminated veneer lumber ("LVL"), and 'konstruktionsvollholz'—solid squared structural timber connected by finger-jointing in length ("KVH"). A problem with material outputs for the construction industry might be the strong dependence on foreign demand and a highly competitive environment since the market with such products quickly established itself and has been expanding ever since. Based on the information provided in the panorama of the manufacturing industry of the Czech Republic 2018, there has also been a quick development trend in the construction of wooden houses. The year-over-year increase in the segment accounted for 36%, which represents an increase in the construction by more than 1060 wooden houses compared to 2017. The argument for increasing the production capacities of CLT, KVH, LSL, and LVL can also be partially justified by the information provided in the reports of StoraEnso from July and August 2019, which mentioned an increase in the then capacities in more countries including the Czech Republic (an increase by 120,000 m^3 in Ždírec) and opening of a new plant with capacity of 100,000 m^3 in Sweden in reaction to the enormous global demand for CLT boards. According to Reportlinker [27] (2019), a growth in demand for LSL and LVL boards can also be anticipated. The results provided in the report show that the market with laminated materials reached the value of USD 2.33 bilion in 2018. By 2024, the foreseen increase in sales should rise to USD 4.23 bilion. Although the biggest market share is in North America, an increase is also anticipated in Asia, Europe, Latin America, the Middle East, and Africa. The production of KVH structural timber is closely associated with decreasing thermal bridges and thermal protection of outer walls. The material is also suitable for construction of energy-saving and passive houses thanks to the increased stability and tightness of the cladding materials. The assumption of an increase in demands on construction of energy-efficient buildings is linked with the certifications Leadership in Energy and Environmental Design ("LEED") and Building Research Establishment ("BREEAM"), which rank among the most respected certifications worldwide. At the national level, the SBToolCZ certification is being developed, which should represent an alternative for the Czech conditions.

Concerning the increasing of the added value, which represents the linking element between the model's perspectives, it is necessary to specify the aspects indicating the low level of the added value of production outputs of selected basic assortment in the woodworking industry. It affects the timber trade pricing strategy at both the national and international level, which is therefore vigorously negotiated. It is estimated that the current missing processing capacity exceeds about 17 mil^3. This capacity could be used to transform the salvage felling timber into outputs with higher added value (the estimate builds on the annual logging volume of 2019 and the information obtained from the results of the "Analysis of Impacts of Increased Volume of Timber Processed in the Czech Republic" from 2016 prepared by the Grant Service of Lesy České republiky (hereinafter referred to as the "GS LČR"). Currently, there is a big scope to address the issue of more efficient processing of wood as the Czech Republic ranks among the countries with the lowest efficiency with the efficiency rate at approximately 36% (see Figure 1) and the capacity utilisation at about 60–64% (see Table 3).

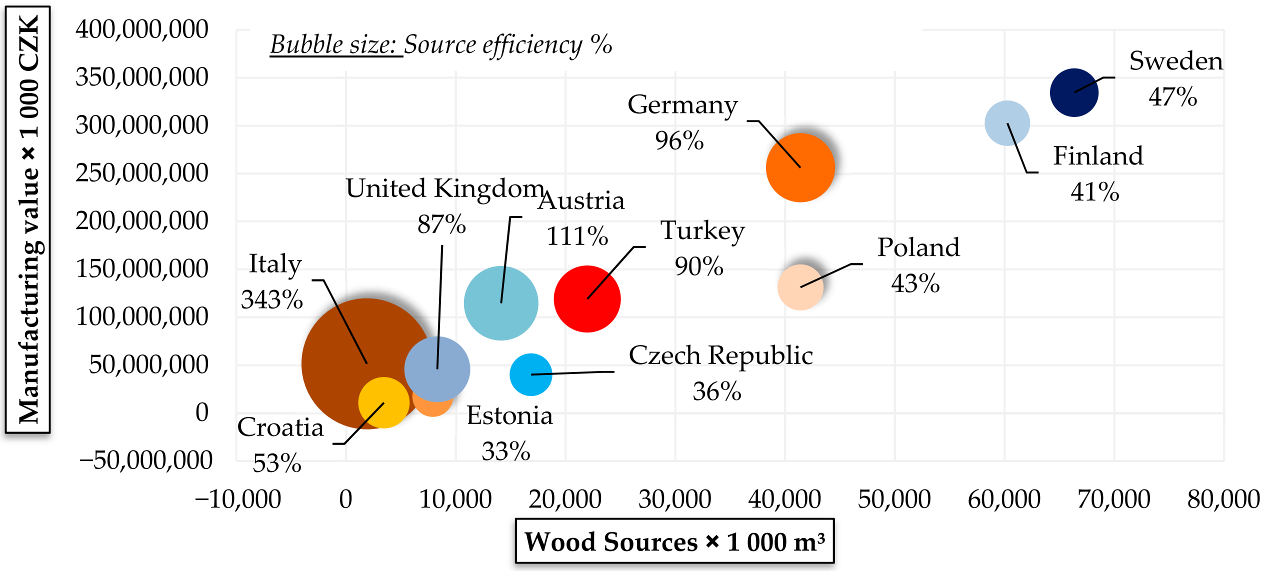

Figure 1. Efficiency of Czech woodworking industry compared to other countries. Source: own processing and calculation by data from UNECE (https://unece.org/DAM/timber/statsdata/tb-71-6.pdf, accessed on 20 April 2019).

When assessing the wood-processing capacity potential within the above-mentioned project, the interpreted analysis was carried out as a comparative research project funded by the GS LČR. The report by the LČR limits the potential for further processing to sawmill operations and their assessment of the increase in the volume of processing with respect to their concurrent technological equipment. A report prepared by APICON builds on the maximum achievable operational value and the actual achieved capacity at present. A more detailed specification of the method and presentation of the results are included in the final report of the project [28].

Table 3. Exploitation of the capacities of the woodworking industry in the Czech Republic in 2016.

Processor	Identified Capacity	Potential Capacity	Efficiency
LČR's analysis	7,000,200 m^3	11,598,300 m^3	60%
Apicon's analysis	5,315,650 m^3	8,247,800 m^3	64.4%

Source: own processing by [28].

This problem has several variables which have to be taken into consideration. The increase in the processing capacity can be seen from the perspective of model situations. One of them is the utilisation of the current potential capacity with a lower level of investment and wood processing primarily intended for export. Another alternative calculates with a higher level of investment and construction of new capacities as a long-term strategic goal. However, the investment in the construction of the additional capacity may not have the support in securing long-term future supplies and sales since the current shortage of capacities is mainly caused by unplanned logging and climate change and represents an exceptional condition. Each of the presented scenarios has a specific benefit, ranging from profits and employment to added value and other social and economic characteristics. The third alternative is formatting a national strategy for the creation of capacities depending on the sector needs and thereto adapted conditions for state support. The third alternative includes a continuous process of updating needs as well as increased investment into the sector to ensure more operative changes, which the current disaster, or any future one, might require. An important reaction to the capacity gap is constructing a new sawmill in Štětí in 2019–2020. Regarding the level of investment, the volume of the funds invested accounting for approx. 40% of the sector's total investments in 2019. Nevertheless, even this investment does not solve the future developments since the problem with insufficient capacity closely relates to long-term investments in the sector, which are irregular and rather low compared to the national level of investments related to the GDP (26.2%-2019) [29]. The above information may be demonstrated by Table 4, which shows the average year-over-year growth rate of investments in the sector in the reference period 2016–2019 at the level of 5.68%. The investment growth rate in Table 4 has to be put into perspective with the above-mentioned investment in the sawmill in Štětí, which has not yet been translated into the whole allocated volume and a part of which will first be reflected in the balance sheet of the Ministry of Industry and Trade ("MIT") for 2020. A long-term statistic of the year-over-year growth rate between 2010 and 2019 was at the level of 9.85%; however, the major influence of the years 2018 and 2019 has to be noted as there might be a connection with the above-mentioned investment of 2.9 milliards in the sawmill in Štětí.

Table 4. Growth rate of investments in the CZ NACE-16 sector in 2016–2019.

Year	2016	2017	2018	2019
Investment (in tsd. CZK)	4,141,155	4,544,824	6,070,783	7,136,761
Year-over-year growth rate in %	−38.19	9.75	33.58	17.56

Source: own processing by [30].

The negative trend of the investment index mainly results in the stagnation of technological innovations, which influence the efficiency of wood utilisation (material efficiency) and the extent and potential of the associated production.

A potential supporting basis for increasing the investments in the sector at the level of national policy is the subsidies from the Rural Development Programme ("RDP") and Support and Guarantee Agricultural and Forestry Fund ("SGAFF"), which provide partial financial support. The Ministry of Agriculture allocated funds in the amount of approximately CZK 300 million per year into the RDP and SGAFF. From the analysis of the data from the summary overview of support provided by the RDP to the woodworking sector, the drawing of funds of the woodworking sector amounted to only CZK 180,307,000, i.e., 0.20% share of the total allocation of funds in the RDP, including subsidies for forestry [31]. The financial resources were mainly focused on technical equipment for woodworking businesses. From this data, it is obvious that the allocation of the drawings in the last 6 years (the summary is provided for years 2014–2020) does not reach the value of the potential annual drawing of the funds.

The proportion of the primary allocation "in thousand CZK" was adopted from the paper "Information about the Current State of Implementation of the Rural Development Programme 2014–2020" as of 31 March 2019 (material from the 9th meeting of the Monitoring Committee of the Rural Development Programme 2014–2020). According to the above document, the primary allocation is considered as CZK 9 milliard. This information demonstrates the very low interest in technological innovations, and it is essential to identify the cause of this disinterest as well as the reason why the growth of the sector is experiencing a downturn.

A major problem, partially linked with the poor technological background of woodworking businesses, is the lack of qualified staff for the transition of the sector to newer technologies as well as the decreasing interannual total number of employees. In the last 10 years, the average number of employees in the sector dropped from 37,016 (2010) to 28,303 (2019). The decrease is connected with several aspects, one of them being the shutdown of many small and medium-scale sawmills in the Czech Republic and downsizing of the manufacturing capacity in several running operations (estimated at approx. 0.5 million m^3 of felling capacity). Another reason is the reaching of the post-productive age by employees and their retirement, which is anticipated with up to 16 thousand employees in 2014–2025 [32]. Another factor connected with the decrease is the low average wage in the sector at the level of CZK 25,350 (2019), which accounts for approx. 74% of the average salary in the Czech Republic of CZK 34,125 in 2019 and approx. 71% of the last record statistical value of average salary for 2020, which was CZK 35,402 (3Q/2020). A consequence of these facts is a low interest of potential employees in jobs in the sector and a problem with the potential saturation of expanded technological capacities of businesses. A way out of this situation is to increase the attractivity of the posts in the sector by motivating benefits and to put more emphasis on copying the curve of the average wage growth rate in the Czech Republic. In this, unions could play a crucial role in cooperation with the legislation of the state employment policy. The next problem is linked with the number of graduates from technical programmes focused on wood processing and their placeability in the labour market. This issue was addressed at the national level by authors [33]. The study points out the fact that students' interest in technical programmes is relatively constant (across all education levels), but the projections for 2000–2027 rank the Secondary sector 2c (timber, paper, and printing industry) among the fastest-decreasing groups as well as to the most decreasing groups in the sector with respect to the number of jobs and employment. Considering the ever-worsening situation with the lack of employees in the sector required for the transition to a higher level of automation and modern production, it is assumed that graduates seek employment in another sector because of more attractive salaries or do not have sufficient qualification for jobs in the wood processing sector.

Technological infrastructure, investment development, and the accompanying factors preventing the growth of the sector have a considerable effect on the added value, which belongs to the primary statistics addressed in this analysis. The added value pursued for the purposes of the data analysis herein was calculated in the following way: trading margin + sales − performance consumptions. The information presented herein points out the significantly low growth rate of the added value in the sector in the last 10 years, which is related to the actual realisation of the production outputs and, above all, their structure, which concentrates on outputs with low added value. The correlation of the data presented in Table 5 can also be viewed in the context of the obsolete technological infrastructure of the businesses as some technological lines are several decades old (e.g., the technology in Javořice sawmill is 35 years old; the first large technological investment was in 2019). As shown in Table 5, the growth of the added value was only more evident since 2018 and continued to stagnate in 2019; hence, it cannot be seen as a progressively growing indicator. This information is also illustrated by the average of year-over-year growth rate in 2010–2019, which was at the level of 4.05%. Between 2010 and 2012, the added value growth rate even reached negative values compared to the referential year.

Table 5. Growth rate of the added value in the CZ NACE-16 sector in 2016–2019.

Year	2016	2017	2018	2019
Added value in tsd. CZK	23,371,803	24,926,841	27,984,889	27,846,113
Year-on-year growth rate in %	100.99	106.65	112.27	99.50

Source: own processing by [30].

The justification for increasing the added value can also be illustrated by Figure 2, which shows the added value in correlation with the production outputs of the woodworking industry. This information must be viewed in the context of international demand for outputs with a higher added value.

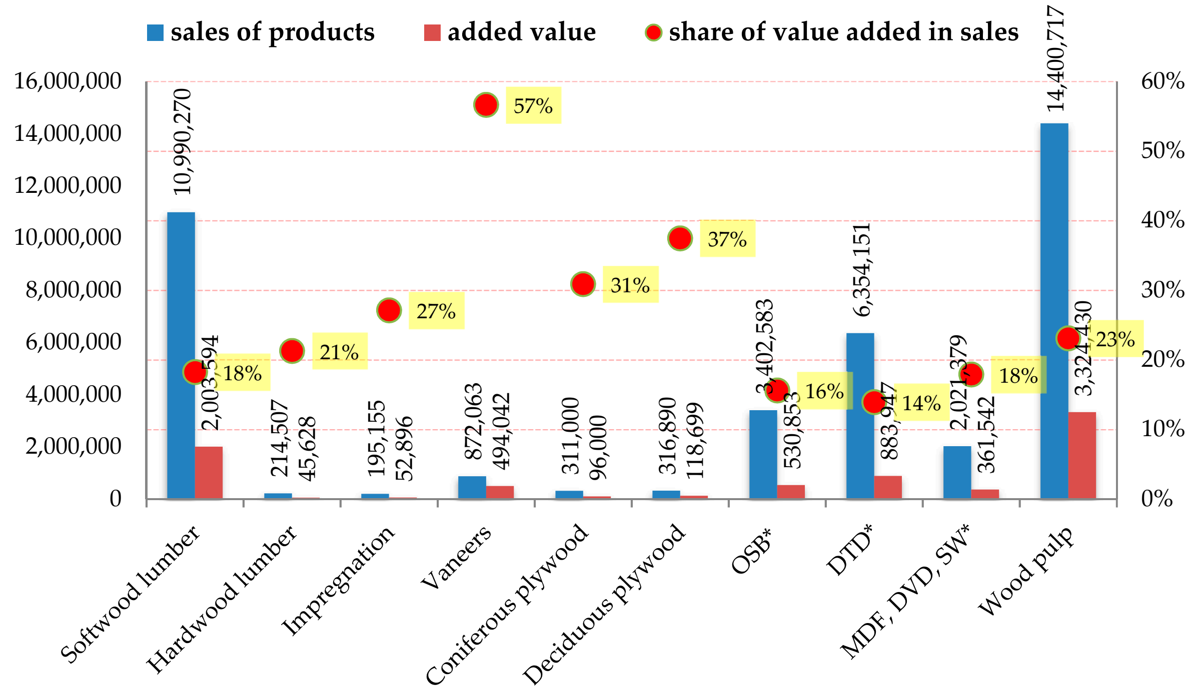

Figure 2. Percentage of added value of the basic production outputs of the woodworking industry. * OSB (oriented strand board); DTD (chipboard); MDF (medium density fibreboards); DVD (fibreboards); SW (coniferous round wood).

However, an increase in the added value in the sector must be viewed in a broader context. The ongoing disaster is a factor of the enormous volume of timber, which ends up abroad in the form of basic assortment (roundwood, pulpwood) due to the current capacity and production potential of the woodworking sector and the export orientation of timber trade. This information is substantiated with the proportion of the domestic and foreign sales (the trade balance). As for the foreign trade figures, the export volume has increased 306% (2010–5 364,000 m^3; 2019–16 439,000 m^3) over the last 10 years, and the share of the exported wood in the overall logging in 2019 accounted for more than 50%. The problem, however, is not the export-oriented timber trade (since the problem with capacities of processors and the follow-up sectors for other outputs is a long-term shortage) but the fact that the realisation of the outputs is oriented towards basic assortment and the domestic market will face a shortage of this raw material in the future. Its potential realisation in the form of more valuable outputs will translate into the sales and investment potential from the capital of businesses on the intersector level. It can also be presumed that the deficit in employment will continue to deepen, and the number of small-scale processing entities will decrease (unless they transform to another production structure and technology in time) due to the lack of inputs for processing. The situation could be solved by a higher extent of utilisation of the current capacities and streamlining and restructuring the production mix in the sector, which could lead to further development and correction of export at the trade balance, or to achieving a realisation of the output with higher added value. Promising areas with significantly growing demand for outputs include the energy industry (pellets, briquettes), the construction industry (construction materials—KVH, LVL, LSL, and CLT), associated production, connections to other areas of the circular economy and bioeconomy, links to the foreseen megatrends in connection with climate challenges and industrial design application (new materials, manufacturing prototypes, etc.) The efficiency of the investment capital thereby increases too, which is reflected in the GNP and taxation and can even lead to a neutral balance of bound CO_2 in the country. There is also scope for the state to seek new state incentives to support and develop the sector since it is a two-way flowing effect.

The issue of better realisation of production outputs and higher added value of the DSP has to be addressed without delay, also because it is becoming increasingly problematic to realise salvage felling timber on foreign markets. Unfortunately, these markets are increasingly saturated with domestic timber due to the ongoing bark beetle disaster, and an increase in timber import is unsubstantiated. A temporary solution to this situation is the Chinese market, where the timber export reached the value of 350,000 ton until May 2019 (supposing it concerns spruce timber, the weight of approx. 750 kg = 1 m^3, i.e., about 467,000 m^3 of timber, which would account for up to 1,000,000 m^3 in 2019). The context for these figures can be found in the trade war between the USA and China, where the timber supply from the USA to China dropped by almost 40%; therefore, the current Chinese timber market is willing to accept a higher price and complicated logistics. This trade model, however, bears a high-risk factor in the form of timber cracking due to quick losses of water, mainly in spring and summer. Upon checks, the buyers from China claim it as nonconformities with the agreed requirements of the contract, and the supplier does not get paid. In such a case, a potential transport back to the Czech Republic is irrational for economic reasons. Therefore, export in the form of trade with China can be perceived as an acceptable operational solution to the current lack of export to markets with more favourable conditions of logistics and with lower risks, but this capacity of resources implies a greater margin of uncertainty for the future as for the source base.

Considering the development of the disaster situation in 2016–2019, further conclusions of the analysis require defining the mentioned potential sources of basic assortment (fuelwood, roundwood, pulpwood) for the next 30 years. The outlook is based on the EFDM method and the data are adopted from the National Forest Inventory NIL2. A more exact specification of the calculation and data processing is provided in internal documents of the FMI, which provides the same data for noncommercial purposes at the national level for free. Based on the information in Figure 3, it is possible to say that the volumetric capacity of logging decreases in 5-year intervals (the interval was chosen with respect to the validity of the forest management plan and the forecasting period following the disaster) with forest stands of spruce (SM), spruce-pine (SM-BO), and spruce-other (SM-other). This loss will be compensated by an increase in the logging potential in other stand types (oak, beech, spruce-beech, and pine). With spruce, the logging volume loss between 2019 and 2049 represents the sharpest drop by about 20% (2,121,000 m^3/year).

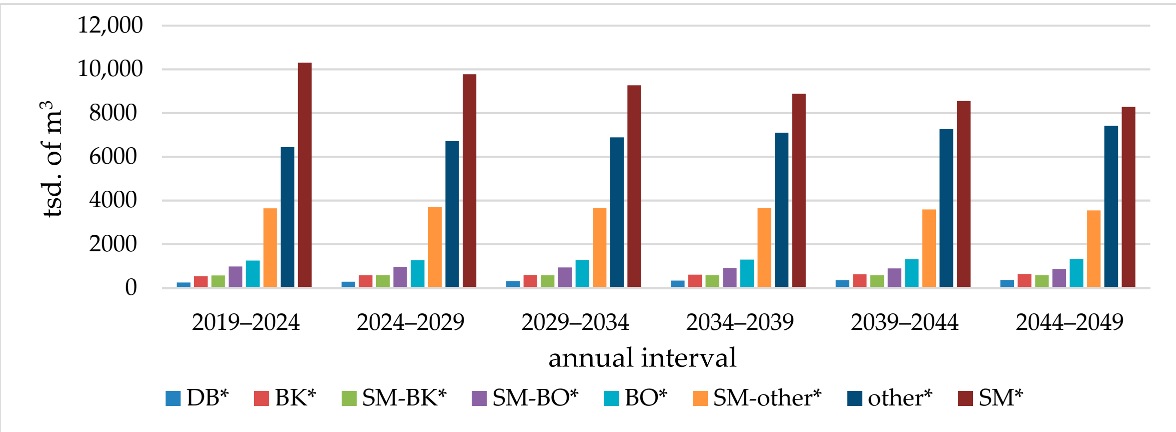

Figure 3. Trend in logging volume (5-year interval) by stand types for 2019–2049 (calculation by the FMI using the EFDM method and data from the NIL2). * DB (oak); BK (beech); SM-BK (spruce-oak); SM-BO (spruce-pine); BO (pine); SM-other (spruce-other); SM (spruce).

Figure 4 shows the logging potential outlook in 5-year intervals as sum values for all basic assortments (fuelwood, roundwood, pulpwood) and selected stand types. This estimate foresees a decrease in logging of forest types SM, SM-BO, and SM-other in the intervals of 2019–2024 and 2044–2049 at the level of approx. 34,970,000 m^3 (the conversion is based on the interinterval differences in logging with the factor of the 5-year interval).

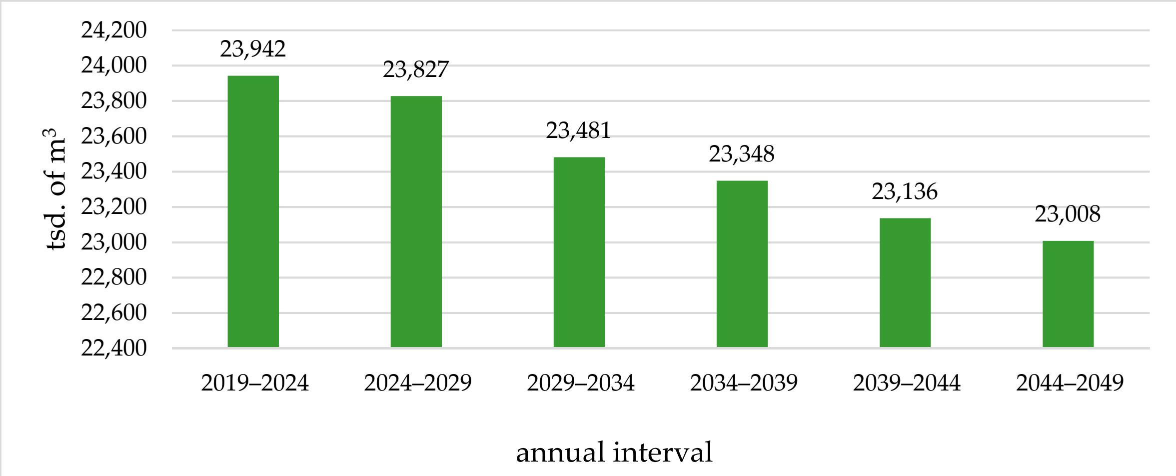

Figure 4. Trend in logging volume (5-year interval) of basic assortments (fuelwood, roundwood, pulpwood) for 2019–2049 (calculation by the FMI using the EFDM method and data from the NIL2).

This information indicates a future risk of SM shortage in all basic assortments for the woodworking industry as well as for the follow-up sectors, which utilise SM raw wood as a production input for further processing. At the same time, it is important to note that the outlook presumes a decrease in the proportion of SM in the overall logging volume from slightly more than 43% (2019–2024) to 35% (2044–2049). Taking account of the available data from 2019, the logging of SM amounted to 90.06% (29,350,347 m^3). These analytical data also confirm the need for alternative scenarios to increase the efficiency for the upcoming changes in the structure of the sector inputs as a condition for its development. Table 6 presents three potential scenarios (S1, S2, S3) and the initial state (S0) of development in the assortment composition of inputs for the processing industry with various outputs from DSP production and sales, added value, number of employees, and production volume with respect to taxes and levies. Considering the extent and complexity of the project from which the given information follow, the detailed description of the method as well as the summary data for the individual scenarios are provided in the final report on the NAZV projects [34].

The information provided in Table 6 allows for several conclusions which indicate the effect of the potential scenarios on the wood processing within the sector with a changed input structure. The S0 scenario represents the current state of the processing industry and hence the original state. It is the situation based on the found facts and data. The S1 scenario employs a version with increased processing capacity (maximisation of production) of basic assortment and reviews the impacts leading to increased employment. The economic efficiency of this model scenario has a major impact namely on the tax load of this structural change and the social levies associated with the higher number of employees. The S2 scenario works with a version of the highest added value per 1 m^3 thanks to the increased capacity of processing volume for products with higher added value (following Figure 3). This structural change leads to a greater extent of input utilisation (increased efficiency) while maintaining a significant number of employees from the S1 scenario. The S3 scenario has a version with increased production volume and sales from sawmill production and pulpwood, a decrease in production volume of agglomerated boards (a change in the processing structure), and a rather constant number of employees preserved from the original model (S0). This version should also lead to a decrease in the deficit of raw material volume.

Table 6. Model scenarios of assortment composition of inputs for woodworking industry. Numbers in bold point to the most optimal values for each model situation.

Indicator	S0	S1	S2	S3
Proportion to input	88.06%	90.26%	**91.08%**	89.59%
Produced volume m^3	12,064,932	**14,228,377**	14,176,903	13,578,202
Input	13,701,107	**15,764,551**	15,564,536	15,156,057
Sales per 1 m^3	4,173	4,182	4,239	**4,288**
Sales per person	7,769,220	7,788,120	7,913,102	**8,818,129**
Levies 1 m^3	63.89	64.93	**64.97**	60.42
Added value 1 m^3	823.90	827.40	**828.89**	828.83
Income tax per 1 m^3	68.42	68.43	68.61	**73.77**
Deficit/surplus	−1,066,892	−721,892	−521,877	**−121,842**
Nonallocated raw material	724,953	860,551	788,234	**369,750**
Roundwood	8,707,109	**10,565,553**	10,416,651	9,907,109
Pulp wood	4,993,998	5,198,998	5,147,885	**5,248,948**
Chip wood	2,003,303	**2,429,065**	2,394,709	2,279,303
Sawdust, shavings	1,351,840	**1,626,996**	1,603,967	1,531,840
Bark	1,012,641	**1,172,320**	1,157,388	1,126,487
Employees	7,360	**8,464**	8,337	7,369

The last area, which is often put in contradiction with the three fundamental pillars of sustainability and whose effect on economic results of woodworking (and forest) business is perceived as rather controversial, is timber certification. Two certification systems, PEFC and FSC, are used at the national level in the Czech Republic. The results presented further in this section originate from the two IGA project implemented in 2016–2019. The objective of the presented results is to demonstrate the problems of the certification systems, which could lead to a better interconnection of the preference areas in increasing the efficiency of the sector. To assess the effect of certification on the economic efficiency of businesses, the data primarily linked to economic effects of the use of certification were selected from the survey (a description of the project is provided in the methodology description herein). Table 7 provides answers to the question "How many years have you been employing the PEFC or FSC certification in your company?" assessed in contingency with the percentage increase (growth) of the individual economic indicators such as sales, profit, added value, and ROE. The input data for Table 7 were exclusively the questionnaire sheets from businesses which employ certification.

Table 7. Results of the questionnaire survey of companies from project IGA.

Followed Indicators	*p*-Value	Chi-sq	Cramer-V	Probability of Incidence of Abundance Occurrence
Profit	0.00346557	15.689391	0.501475759	≤1%
Sales	0.001789834	17.17185698	0.553639712	≤1%
ROE	0.04471499	9.757598039	0.43233906	≤4.5%
Added value	4.37139×10^{-5}	25.3034188	0.672060242	≤1%

Source: own processing by [35].

The results provided in Table 7 suggest that there is a statistical dependency between all the pursued economic indicators and the length of employment of the certification systems in the companies, which follows from the individual statistical probability indicators. They show that the probability of incidental occurrence of such abundance is lower than 1% of the profit, sales, and added value, which is less than the usual criterion for evaluation of hypotheses (5%). The percentage is higher in the case of ROE, but still within the range of a standard statistical deviation. The dependency was tested using three statistical analyses, namely *p*-value, Chi-square test, and Cramer's_V test. It should be mentioned that a purely positive impact of the FSC and PEFC certification of the economic indicators cannot be claimed on the basis of the study as the proportion of positive and negative economic effects with all respondents accounting for 59.8%/40.2%. The statistical significance provided in Table 7 only accounts for a significant dependency of long-term employment of certification systems on selected economic indicators of an undertaking. Another area under consideration was the survey on consumers' attitudes to products made of certified wood. The aim was to gain an overview of the level of recognition of certified products allowing for a creation of a concept to raise interest in such products. The results, which are provided in Table 8, only represent a part of the obtained data, which had already been published by the authors of this article.

Table 8. Results of the consumer questionnaire survey from the IGA project.

Responses to Question No.2	Responses to Question No.1	
	FSC	PEFC
"Yes, I know"	55	51
"No, I do not know"	77	47
Confirmation of recognition by control question	45	36
No answer	1	2
Number of respondents	133	100

Source: own processing by [36].

The results shown in Table 8 indicate that 57.8% (233 respondents) of the total of 404 respondents said that they recognised the FSC and PEFC logo, and 34.8% (81 respondents of the total of 233) managed to confirm the previous sensory recognition in the control question. This sample of respondents would stand for slightly more than 20% of the total, which would mean that only every fifth respondent in the Czech Republic associates the FSC and PEFC logo/label in timber products with landscape and nature protection. Another paradox is the fact that many respondents also considered names of companies, public institutions, civic associations, or the World Wide Fund for Nature to be environmental labels. For example, the respondents' answers included the following: WWF, Ekofol, IKEA, Swedwood, Fair trade, Holz 100, Real Wood, Trepp-art, Tectona, Wild Nature Friendly, FSC MIX, and Lesy ČR. A poor involvement is also perceptible in promotion as only less than 6% of the respondents identified the logo based on advertising in media (Internet, TV, radio). Another almost 6% of the respondents recognised the logo based on advertising materials (advertising spaces, advertising in shops, shopping malls such as OBI, BAUHAUS, and IKEA, and at trade fairs and exhibitions). Slightly more than 10% accounted for advertising at schools within the scope of classes, lectures, or conferences. Indirect advertising in the form of logos on vehicles, buildings, and documents of forestry and woodworking companies accounted for nearly 9%. The last pursued area was a direct promotion of the logo on paper and timber products, and there the products showed the biggest percentage of successful identification, namely almost 27%.

The above results confirm the nonconceptual nature and inconsistency in opinions in the perception of the certification by both professionals and broader public. The current setting does not work well with respect to either marketing or raising interest in the issue of sustainability of the timber trade. With the rising pressure exerted by large companies on supplier and subsupplier chains, the tools that demonstrate the sustainability interests can be said to have a certain level of lobbying influence of such. Since the certified forest area in the Czech Republic accounts for about 65% of the total forest area (2.9 mil. ha), it represents an important timber trade instrument across sectors and its influence needs to be diversified to the desirable level.

3.2. Preferential Model of Development of the Performance of Woodworking Businesses

This section concentrates on processing of primary and secondary data and information from the preceding conclusions of the analyses in a single summary model, which can lead to securing sustainable development of the performance of woodworking businesses, providing that all criteria and conditions considered in the analysis were fulfilled.

The creation of the individual components of the model builds on detailed analyses of both current and future prospects of the selected sector. The objective was to define the extent of an economically appropriate strategic management system, which would be able to fully utilise the market opportunities and thus ensure long-term efficiency. The analytical part of the paper provided the information which can be used as the criteria increasing the fruitfulness of the business strategy in the given sector. The model consists of two parts, specifically a production assortment structure of the timber market which could increase the efficiency of the sector, and the economic efficiency model, which offers possibilities of the orientation of the company's economic management in strategic areas.

The preferential model of development of the performance of woodworking businesses (which can be seen in Figure 5) aims at increasing the economic potential of businesses through selected components representing a set of promising opportunities in the sector. Its understanding requires a definition of all its components including their meanings. The arrows in the model represent one-way or multiple links with direct correlation. They should point out the opportunities for mutual utilisation of the individual main components of the model and hence create a schematic diagram of tracks which can be used as a strategic management system. The mutual influence of several components of the model can create a synergic effect and hence secure increased efficiency. The presumption of creation of the selected components of the model is based either on an identified need or a current existence characterised by regression or showing unexploited potential.

Another important model, which is based on the information analysed in Chapter 3 and works with the principles of the methodology of recalculation backflow wood of the wood cascade, is the model of production, wood, and raw wood processing (see Figure 6). The preparation of the production model was based on the current capacities of wood processing in the sector and the available sources limited by the unused capacities. The production model also works with a reserve of 35–40%, which represents the integration of the volume of current timber export or reserves in the form of wood increment in proportion to logging. The production mix components form the precondition for an increase in efficiency of raw material utilisation and cooperate with the possibility of an intersector increase in economic efficiency. The concept offers a new perspective of the current production capacities as well as a scope for new ones and hence creates preconditions for investment activities with the relatively foreseeable risk level. The areas of the model which can be considered strategic are the energy use of wood, industrial production of timber-based construction materials usable in construction, and partially the intersector use of wood material in agroforestry. At the same time, the model comprises the existing components of the wood processing cascade.

The model aimed at increasing the economic efficiency proceeds from the production model and is completed with specific areas of influence, which, according to the analyses, create the precondition for an increase in the economic efficiency of the sector. The importance of the individual areas of influence for securing the goal of the model is almost equal.

The complex interconnection of the individual areas (components) of the model and the use of the intersector opportunities provide many economic effects which can bring the current economic potential of the sector to a higher level. Environmental impacts of the mutual affecting of the model components will also play an important role in the interconnection. The formation of the analyses mentioned in the article into a preferential mode lining the individual facts in a complex way enables the stakeholders in forestry and wood processing to discover the theoretical and technical potential as well as the technical and environmental criteria allowing for increases in the economic potential of the sector.

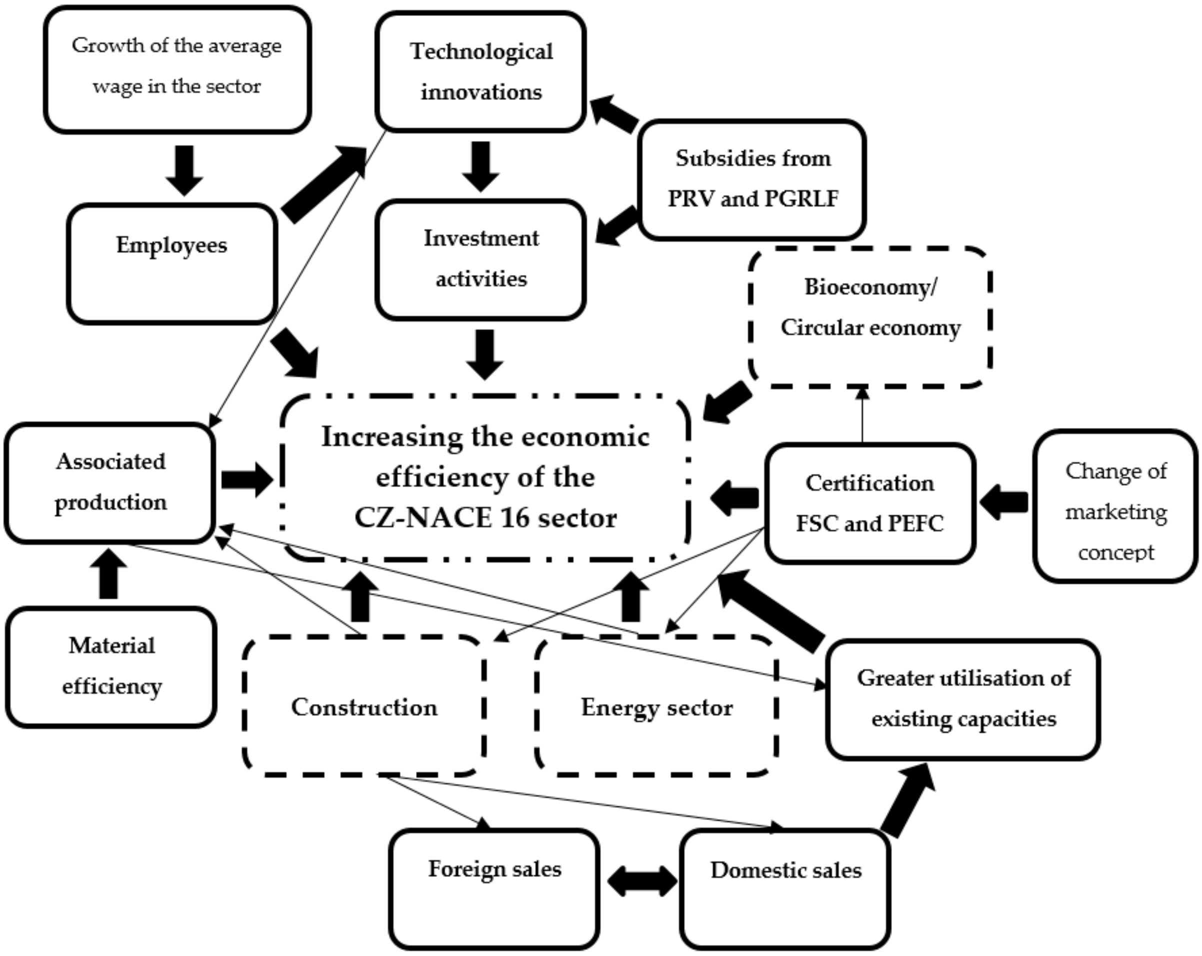

Figure 5. Preferential model of economic efficiency of woodworking businesses in the Czech Republic.

As there are no accurate statistics on the volume of utilisation of wood resources of individual market segments at the national level, it was necessary to find an effective method of recalculation from the available statistics, which would more accurately determine their capacity utilisation. For this model, consumption was determined by revenues of the company adjusted for the main product and the average price determined for it (by inquiry, calculation from foreign trade, analysis of price lists). This will give us the volume of production of the main product. Then, according to the breakdown according to the production technology, we find out the consumption of material for the main product and "waste", which is part of the processing cascade. Finally, we calculate the volume of wood required for the production of the main product on the basis of conversion factors determined by inquiries and calculations from the annual reports. The mentioned methodology is also applied for the material use of raw wood in Table 1.

The production model also works with a 35–40% reserve representing the integration of the volume of the current exports of timber or reserves in the form of wood increments in relation to logging. When preparing the model, production inputs and outputs which should have significant effects on the growth or stagnation of the sector were also taken into consideration.

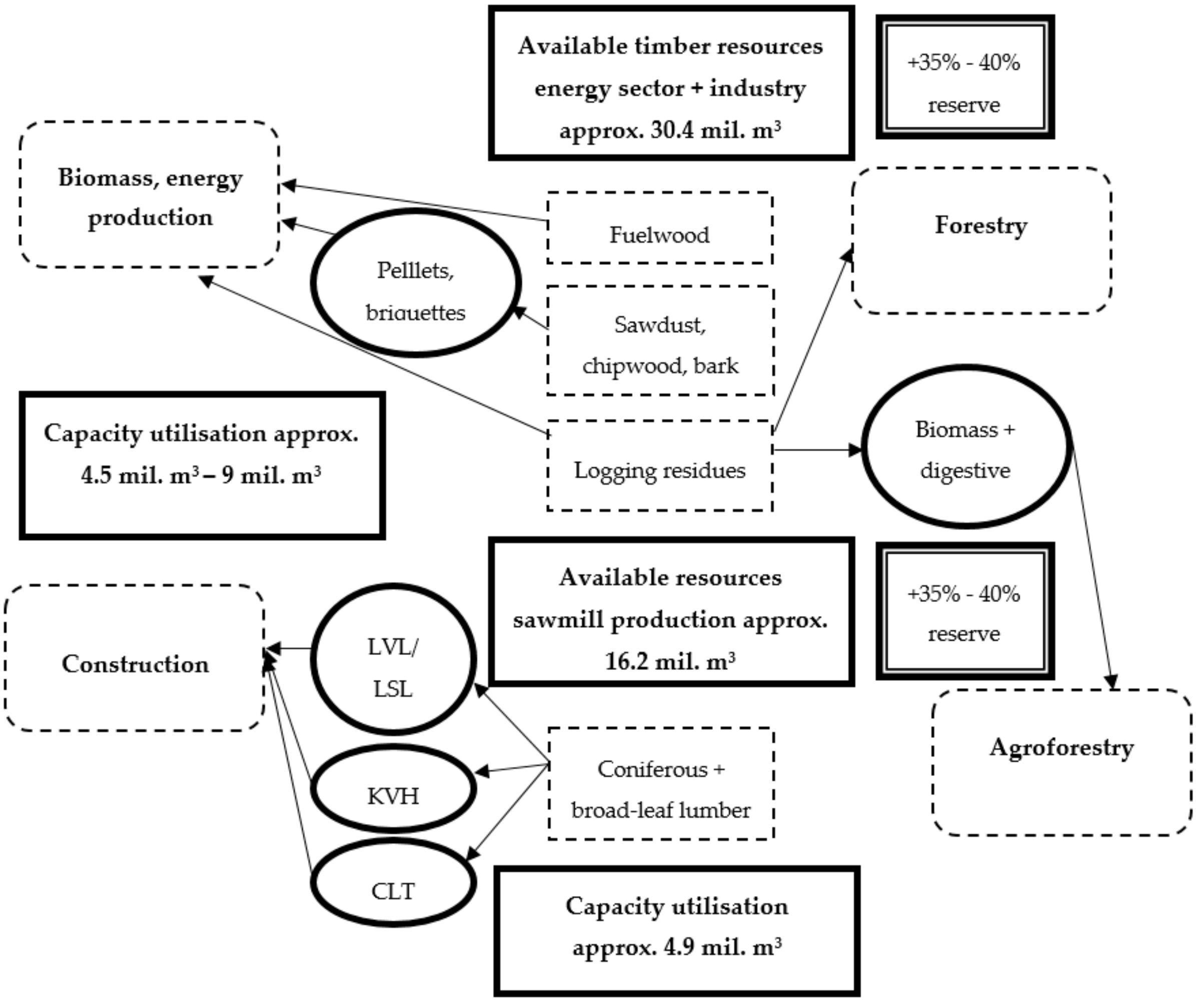

Figure 6. Preferential model of production; wood and raw wood processing.

4. Discussion

The environmental interests of the society exert more pressure on producers and processors to manage both renewable and nonrenewable resources in an efficient and sustainable way. The demand for wood can soon exceed the supply in Europe [37] thanks to the EU's strategy of subsidies supporting the energy use of wood. Despite its renewability, the use of wood as a raw material is limited by its long production. Therefore, new concepts in the use of wood are needed to satisfy the growing demand for wood. The approach we adopted represents a simple expression of the use of the renewable input raw material and obtained values within the processing cascade and the general flow of timber. We pointed out the need to increase the value of processing by increasing the total volume thanks to the increased capacities or a change in the structure of the processor capacities, or both.

The article provides a comparative base which can be further deepened and completed with more detailed dependencies in the wood processing cascade. A model of the utilisation of wood sources in border-crossing regions can be created depending on the development of consumption and production optimisation, as shown in the analytical part [38,39]. The entire forestry and wood-processing sector is interwoven and has several value chains. The forestry-based sector is complex, and the sector borders have not yet been well defined, which has been posing serious difficulties in analysing the sector [40]. An understanding of sector management requires more specific data and information in a continuous assessment.

A major factor [41] is the fact that the sector provides information about the past and present and tries to solve the problems with perspectives at a certain level, but they are not effective without a deeper application of structural changes, may they be de facto the key element of the future development. There are several methods to address the optimisation of wood utilisation. Cascading as a gradual use of wood material with the use of material for energy production as the last step can increase the efficiency of sources in the utilisation of wood. From this perspective, the Czech Republic can apply client-oriented methods of creative destruction of the strategic focus of the development, as implemented in Finland [42]. The methods, which need to be evaluated and refined, comprise the method of analytic reports of the sector data concerning the timber flow across the sectors, which has significant deviations under current trends and hence a significant level of uncertainty for the entities involved, which use the given information in their decision-making processes.

5. Conclusions

In principle, the economy of forest management in the Czech Republic is determined by the logging potential, with the coniferous wood accounting for more than 90% of the current logging. Given the long-term nature of the production processes, the crucial factor was the establishment of monocultures in the nineteenth century when the importance of wood as a raw material rocketed with the onset of the industrial revolution and the development of manufacturing and gave rise to many new industrial woodworking activities. The present level and trend of the achieved economic results of all segments of the timber-forest sector (TFS) build on it. The situation in the sector has long been problematic in spite of the longstanding postulate of the importance of forestry for the whole society and the economic utilisation of wood as an environmentally friendly and renewable raw material. In the case of forestry, the crucial sectoral specifics of forest management of the long-term nature of production processes have to be stressed. The salvage situation in the Czech Republic of the last years requires close cooperation of the TFS segments (starting with mutual information) more than ever. It includes available and competitive production factors (including qualified human resources), appropriate economic measures, machines and technologies, and investment activities, all in conditions of the economic viability of the TFS. From the economic perspective, the objective is sustainable forestry and utilisation of raw wood and its realisation mainly by domestic woodworking capacities. Unfortunately, the present economic viability of the Czech TFS builds on the export of coniferous roundwood and coniferous lumber to a substantial extent. The basic model of wood flow and processing cascade together with the back calculation method and identification of limitations in wood sources enable the use of the mathematical and statistical method of modelling variants of changes, opens up the scope for stakeholders in forestry and wood processing to identify technical and environmental criteria at the borderline between the theoretical and technical potential of the above-mentioned limitations enabling an increase in economic potential while minimising the negative impacts in the social and political aspects of the society. The analysed data and provided information clearly show that the current model of wood processing and the interconnection of the timber flows between sectors has the potential to increase the efficiency across all sustainability pillars, providing the opportunities are timely caught and converted in strengths of the sector.

6. Limitation of the Study

Based on the current state of knowledge, there is no significant barrier or critical assumption preventing the realisation of the study's goals. A critical element of the study is the availability and validity of information on wood sources and their structure. Methodologically, it is solved by back control based on the analysis of wood consumption in primary processing. An obstacle to the implementation of the results of the analyses mentioned in this article may be the insufficiently fast response to the current problems of the forestry and timber industry in primary and secondary wood processing. Unless the current problems of the timber trade, mainly related to the structure of production outputs, are addressed in the short term, the issue may be further exacerbated. Application practice in the coming years will prove whether the identified weaknesses, threats, and opportunities mentioned in the article were significant and will also prove their consequences in the event that the timber market fails to be modified.

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References

1. UNECE/FAO. *Forest Products Annual Market Review, 2019–2020*; United Nations Publication: Geneva, Switzerland, 2020; ISBN 978-92-1-117257-7. Available online: https://unece.org/sites/default/files/2021-04/SP-50.pdf (accessed on 4 May 2021).
2. Bojnec, Š.; Fertő, I. Forestry industry trade by degree of wood processing in the enlarged European Union countries. *For. Policy Econ.* **2014**, *40*, 31–39. [CrossRef]
3. Kallio, A.M.I.; Moiseyev, A.; Solberg, B. Economic impacts of increased forest conservation in Europe: A forest sector model analysis. *Environ. Sci. Policy* **2006**, *9*, 457–465. [CrossRef]
4. Barreiro, S.; Schelhaas, M.-J.; Kändler, G.; Antón-Fernández, C.; Colin, A.; Bontemps, J.-D.; Alberdi, I.; Condés, S.; Dumitru, M.; Ferezliev, A.; et al. Overview of methods and tools for evaluating future woody biomass availability in European countries. *Ann. For. Sci.* **2016**, *73*, 823–837. [CrossRef]
5. Courtonne, J.-Y.; Alapetite, J.; Longaretti, P.-Y.; Dupré, D.; Prados, E. Downscaling material flow analysis: The case of the cereal supply chain in France. *Ecol. Econ.* **2015**, *118*, 67–80. [CrossRef]
6. Keegan, D.; Kretschmer, B.; Elbersen, B.S.; Panoutsou, C. Cascading use: A systematic approach to biomass beyond the energy sector. *Biofuels Bioprod. Biorefin.* **2013**, *7*, 193–206. [CrossRef]
7. Dieste, A.; Cabrera, M.N.; Clavijo, L.; Cassella, N. Analysis of wood products from an added value perspective: The Uruguayan forestry case. *Maderas. Cienc. Tecnol.* **2019**, *21*, 305. [CrossRef]
8. Furubayashi, T.; Sumitomo, Y.; Nakata, T. Wood Flow Chart for Japan: Material and Energy Utilization. *J. Jpn. Inst. Energy* **2017**, *96*, 206–216. [CrossRef]
9. Gordeev, R. Comparative advantages of Russian forest products on the global market. *For. Policy Econ.* **2020**, *119*, 102286. [CrossRef]
10. Václav, K.; Richard, P. The Level of the Wood Raw Material Base Processing in the Czech Republic. *Procedia Econ. Financ.* **2015**, *34*, 557–564. [CrossRef]
11. Binder, C.; Hofer, C.; Wiek, A.; Scholz, R. Transition towards improved regional wood flows by integrating material flux analysis and agent analysis: The case of appenzell ausserrhoden. *Switzerland. Ecol. Econ.* **2004**, *49*, 1–17. [CrossRef]
12. Mantau, U. Wood flow analysis: Quantification of resource potentials, cascades and carbon effects. *Biomass Bioenergy* **2015**, *79*, 28–38. [CrossRef]
13. Hekkert, M.P.; Joosten, L.A.; Worrell, E. Analysis of the paper and wood flow in The Netherlands. *Resour. Conserv. Recycl.* **2000**, *30*, 29–48. [CrossRef]
14. Hashimoto, S.; Moriguchi, Y. *Data Book: Material and Carbon Flow of Harvested Wood in Japan*; Center for Global Environmental Research. Tech. Rep.; National Institute for Environmental Studies: Tsukuba, Japan, 2004.
15. Piskur, M.; Krajnc, N. Roundwood flow analysis in Slovenia. *Croat. J. For. Eng.* **2007**, *28*, 39–46.
16. Knaggs, G.; O'Driscoll, E. *Estimated Woodflow for the Republic of Ireland in 2007*; Tech. Rep.; No 18; COFORD Processing/Products: Dublin, Ireland, 2008.
17. Cheng, S.; Xu, Z.; Su, Y.; Zhen, L. Spatial and temporal flows of China's forest resources: Development of a framework for evaluating resource efficiency. *Ecol. Econ.* **2010**, *69*, 1405–1415. [CrossRef]
18. Metla, Wood Flows in Finland 2010. Finnish Statistical Yearbook of forestry. Tech. Rep., METLA. 2011. Available online: http://www.metla.fi/tiedotteet/2011/2011-12-12-statistical-yearbook.htm (accessed on 13 February 2021).

19. Weimar, H. Der Holzfluss in der Bundesrepublik Deutschland 2009. Tech. Rep, Methode und Ergebnis der Modellierung des Stoffflusses von Holz. Johan Heinrich von Thunen—Institut fur Forst und Holzwirtschaft, Arbeitsbericht. 2011. Available online: https://literatur.thuenen.de/digbib_extern/bitv/dn049777.pdf (accessed on 20 February 2021).
20. Parobek, J.; Paluš, H.; Kaputa, V.; Šupín, M. Analysis of Wood Flows in Slovakia. *BioResources* **2014**, *9*, 6453–6462. [CrossRef]
21. Mantau, U. Wood flows in Europe (eu27). Tech. Rep., Project Report. Celle 2012. Available online: http://www.infro.eu/downloads/studien/CEPIWoodFlowsinEurope2012.pdf (accessed on 20 February 2021).
22. Lähtinen, K. Linking resource-based view with business economics of woodworking industry: Earlier findings and future insights. *Silva Fenn.* **2007**, *41*. [CrossRef]
23. Babuka, R.; Sujová, A.; Kupčák, V. Cascade Use of Wood in the Czech Republic. *Forests* **2020**, *11*, 681. [CrossRef]
24. Packalen, T.; Sallnaes, O.; Sirkia, S.; Korhonen, K.; Salminen, O.; Vidal, C.; Robert, N.; Colin, A.; Belouard, T.; Schadauer, K.; et al. *The European Forestry Dynamics Model: Concept, Design and Results of First Case Studies*; Publications Office of the European Union, EUR 27004: Luxembourg, 2014. [CrossRef]
25. Hudáček, J. Pěstování RRD na Zemědělské Půdě. [Growing Fast-Growing Wood Species on Agricultural Land.] Department of Organic Farming, Ministry of Agrictulture, Seminar Contribution: Rychle Rostoucí Dřeviny pro Zemědělské a Lesnické Využití v Podmínkách České Republiky. 2017. Available online: https://www.vukoz.cz/dokumenty/tkcr/seminar%202017%20Pruhonice%20Kunovice%20platforma/prezentace/Hudacek%20-%20Pestovani%20RRD%204.-5.10%20final.pdf (accessed on 13 February 2021).
26. Panorama, M.I.T. *Panorama of the Manufacturing Industry of the Czech Republic 2018*; Ministry of Industry and Trade: Prague, Czech Republic, 2018; ISBN 978-80-906942-6-2.
27. Reportlinker. Laminated Veneer Lumber Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019–2024. by International Market Analysis Research and Consult. 2019. Available online: https://www.reportlinker.com/p04921060/Laminated-Veneer-Lumber-Market-Global-Industry-Trends-Share-Size-Growth-Opportunity-and-Forecast.html?utm_source=PRN (accessed on 10 February 2020).
28. GS LČR. Analýza Dopadů Zvýšení Objemu dříví, Zpracovaného na Územíčeské Republiky. [Analysis of Impacts of Increased Volume of Timber Processed in the Czech Republic.] Research project of the Grant Service of LČR. 2016. Available online: https://lesycr.cz/wp-content/uploads/2016/12/zpracovatelsky-potencial-web.pdf (accessed on 15 February 2020).
29. CZSO. Analýza Ekonomického Vývoje v Roce 2019. [Analysis of ECONOMIC trends in 2019.] Czech Statistical Office, Prague, Publication Code: 320305-20. 2020. Available online: https://www.czso.cz/documents/10180/143101909/32030520a.pdf/d20d1961-aaac-4315-b99d-dde2e0bb00b4?version=1.1 (accessed on 10 March 2021).
30. MIT. Interaktivní Prohlížeč Ekonomických Ukazatelů Zpracovatelského Průmyslu. [Interactive Browser of Economic Indicators in Manufacturing Industry]. 2016. Available online: https://www.mpo.cz/cz/panorama-interaktivni-tabulka.html (accessed on 25 February 2020).
31. RDP 2014–2020 9th Meeting of MI RDP 2014–2020 19 June 2019. Materials for Discussion. 2019. Available online: http://eagri.cz/public/web/mze/dotace/program-rozvoje-venkova-na-obdobi-2014/monitorovaci-vybor/podklady-z-jednani/x9-zasedani-mv-prv-2014-2020-19-cervna.html (accessed on 3 March 2020).
32. NPI. *Dřevozpracující, Papírenský a Tiskárenský Průmysl [Woodworking, Paper, and Printing Industry.], Information System Infoab-Solvent*; National Pedagogical Institute of the Czech Republic: Prague, Czech Republic; Available online: https://www.infoabsolvent.cz/Temata/ClanekAbsolventi/8-8-65 (accessed on 10 March 2021).
33. Úlovec, M.; Vojtěch, J. *Analýzy Trhu Práce a Vzdělávání: Nezaměstnanost Absolventů škol se Středním a Vyšším Odborným Vzděláním—2018. [Analysis of Labour and Education Market: Unemployment of Graduates with Secondary Upper-Secondary Education—2018.] National Árodní Ústav pro Vzdělávání*; NÚV: Praha, Czech Republic, 2018. Available online: http://www.nuv.cz/vystupy/analyzy-trhu-prace-a-vzdelavani (accessed on 30 October 2020).
34. Kupčák, V.; Babuka, R.; Michal, J.; Šebek, V.; Sujová, A.; Bartuněk, J.; Janák, K.; Červený, L.; Badal, T.; Pražan, P.; et al. *Potenciál strukturálních změn udržitelného lesnictví a Zpracování Dřeva. [Potential of Structural Changes of Sustainable Forestry and Woodworking]*; Summary Research Report of the NAZV Project; Non-Public Document; 2020. Available online: https://starfos.tacr.cz/cs/project/QK1820358 (accessed on 29 April 2021).
35. Michal, J. Model Trvalo Udržateľného Rozvoja Výkonnosti Drevospracujúcich Podnikov Produkciou Výrobkov z Certifikovanej Drevnej Suroviny [Model of Sustainable Development of Performance of Woodworking Companies by Manufacturing Products from Certified raw wood.]. Ph.D. Thesis, Mendel University in Brno, Brno, Czech Republic, 2021; p. 167.
36. Michal, J.; Březina, D.; Šafařík, D.; Kupčák, V.; Sujová, A.; Fialová, J. Analysis of Socioeconomic Impacts of the FSC and PEFC Certification Systems on Business Entities and Consumers. *Sustainability* **2019**, *11*, 4122. [CrossRef]
37. Mantau, U.; Saal, U.; Prins, K.; Lindner, M.; Verkerk, H.; Eggers, J.; Leek, N.; Oldenburger, J.; Asikainen, A.; Anttila, P. *Real Potential for Changes in Growth and Use of EU Forests*; Final Report; EUwood: Hamburg, Germany, 2010; 160p.
38. Hailu, A.; Veeman, T.S. Comparative analysis of efficiency and productivity growth in Canadian regional boreal logging industries. *Can. J. For. Res.* **2003**, *33*, 1653–1660. [CrossRef]
39. Salehirad, N.; Sowlati, T. Performance analysis of primary wood producers in British Columbia using data envelopment analysis. *Can. J. For. Res.* **2005**, *35*, 285–294. [CrossRef]
40. Teischinger, A. The forest-based sector value chain–a tentative survey. *Lenzing. Ber.* **2009**, *87*, 1–10.

41. Hurmekoski, E.; Hetemäki, L. Studying the future of the forest sector: Review and implications for long-term outlook studies, For. *Policy Econ.* **2013**, *34*, 17–29. [CrossRef]
42. Kivimaa, P.; Kangas, H.-L.; Lazarevic, D. Client-oriented evaluation of 'creative destruction' in policy mixes: Finnish policies on building energy efficiency transition. *Energy Res. Soc. Sci.* **2017**, *33*, 115–127. [CrossRef]