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ORIGINAL ARTICLE

Digitalization of small and medium sized sawmills in Austria: a survey about business processes

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Abstract
This study investigates the level of digitalization as well as opportunities and challenges from the perspective of sawmill representatives. The level of digitalization of business processes was assessed by a survey on digitalization criteria regarding business processes. The questions dealt with the existence of basic data processing, digitally networked information and communication and digitally networked products and services. Over 700 small and medium sized sawmills were contacted by e-mail or mail using enterprise directories. The response of 87 completed questionnaires was analyzed by means of cluster analysis. The companies were divided into different groups based on their similarity regarding the digitalization criteria. The study identified three clusters: the first cluster ($n_1 = 35$), the "manual small business", did not reach the first stage of digitalization. The second cluster ($n_2 = 26$), the "automated business", has partially reached the first stage of digitalization. The third cluster ($n_3 = 26$), the "solid developed" group, has reached the first stage of digitalization as the basic hardware and software is available. The increasing networking of the value chain, the workplace of the future and the increasing individualization of customer requirements are perceived as opportunities. The main barriers are data protection and data security whereas cloud solutions are considered as the biggest risk.

1 Introduction

The terms "Digitalization", "Industry 4.0", "The fourth industrial revolution", and "Internet of Things" are currently omnipresent and have become buzzwords in many publications (see e.g. Kies and Kleinschmit von Lengefeld (2018). German speaking countries coined the term "Industry 4.0" whereas "Internet of Things" is more often used in English speaking countries (Heilmann 2016). Both terms refer to the integration of information and communication technologies (ICT) into production processes resulting in networks of autonomous manufacturing (Kagermann 2013).

The increased use of digital data and digital technologies is referred to as digitalization and in its basic form means translating analog values such as human labor into a machine-readable digital language to perform computer and robotic activities (Saam 2016). Industry 4.0 can be referred to as elaborate digitalization as it goes beyond company boundaries and involves the networking of resources, primary products, logistics, processing machines and tools as well as the operational and strategic management of companies (Mertens and Barbian 2016; Kagermann et al. 2013). Digitalization can lead to innovations such as change of business models, increase in productivity, and customized products through the use of ICT (Reker 2013; Heilmann et al. 2016; Merforth 2016).

Note, a high level of automatization not necessarily equals Industry 4.0. In Industry 4.0, the physical world is merged with the virtual world constituting so-called cyber-physical systems which requires a comprehensive, strategic orientation across business processes and borders (Heilmann et al. 2016). Industry 4.0 is based on digital data that is linked and analyzed along the value chain and therefore requires a

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digitalization of business processes, next to the use of digital technologies in production processes. This so called "digitalization maturity" refers to the digitalization of processes and practices throughout the organization (Ghobakhloo 2020). For the digitalization of business processes an adequate infrastructure such as internet connection, servers and resource planning systems are required (Saam et al. 2016).

Digitalization is an important factor to contribute to companies' innovativeness and thus competitiveness (Busch et al. 2015). It has the potential to transform the production and value creation process leading to substantial changes regarding technical infrastructure, personnel, organization and legal frameworks (Müller-Jentsch 2007). Efficiency, effectiveness and time needed for the implementation of digitalization measures are considered decisive for companies' competitiveness (Peneder et al. 2016). However, many manufacturing firms struggle to understand the innovation potential and benefits of digitalization (Parviainen et al. 2017).

With the economic decline of the wood industry and increasing competition from emerging economies, the wood industry needs to develop new business models to remain competitive (Näyhä, et al. 2014; Mattila et al. 2016; Näyhä 2020). As in other manufacturing industries, wood value chains can benefit from digitalization by generating new business models, customizing products, increasing customer orientation, and accessing new customer groups through an increased network as well as on-demand services (Kies and Kleinschmit von Lengefeld 2018).

In this context, the question arises how wood value chains can anticipate this transformation and benefit from it. Only few studies and expert media as well as trade journals (Kortüm et al. 2014; Merforth 2016) addressed the future production in the wood industry. Kortüm et al. (2014) argue that the wood industry showed limited interest in Industry 4.0 and the majority of research funding was allocated to the automotive industry. Studies on die digitalization of wood industries so far addressed the state of the art technology (Tonk 2017) and the perceived business potential among company representatives (Makkonen 2018). Industry 4.0 should not only be considered an opportunity for large industry companies but used in an adapted form in small and medium sized companies (SMEs) as well (Gronalt and Teischinger 2015). SMEs generally show large differences in their level of digitalization, mostly due to a lack of resources and IT competence. For example, only about one fifth of companies in Germany have achieved the basic levels of digitalization before being able to engage in Industry 4.0 (Saam et al. 2016). However, literature on the use of digital technologies in SMEs as well as their risks and opportunities is scarce (Moeuf et al. 2020).

Wood products manufacturing is characterized by manual tasks. In comparison to other industries, such as the metal industry, the wood industry processes heterogenous raw material (Karltun 2007) and is culturally characterized as rather traditional (Makkonen 2018). Innovation in wood industry can be hampered by inadequate staffing and by the low educational level of white-collar workers (Stendahl and Roos 2008). Moreover, in Austria, wood industries are too conservative for radical approaches, and lead times of 10–15 years are needed for major technology leaps (Teischinger 2012). As sawmills stand at the beginning of the value chain, they are important actors for the digitalization of the wood industry (Makkonen 2018). The more than thousand sawmills in Austria have so far received only limited attention in the discussion on Industry 4.0.

The Austrian wood industry is characterized by small and medium-sized enterprises (SMEs) accounting for 98% of enterprises and 77% having less than 10 employees (Oschischnig 2018). There are many sawmills in Austria accounting for roughly 1,000 from total 1,350 enterprises which are processing 16.2 Million m^3 round wood and producing 9.65 Million m^3 sawn wood (Schatzl 2018). Of the 1,000 sawmills, there are 960 small and medium sized sawmills (SMSS) accounting for 10% of the production volume (i.e. 0.96 Million m^3 sawn wood) (Schatzl 2018).

Digitalization represents both, an opportunity and challenge to increase the competitiveness of the wood industry. The question arises whether the industry is ready for the 4th industrial revolution. As the Austrian wood industry is characterized by small and medium sized sawmills (SMSS) it is crucial to know whether they are able to adapt to Industry 4.0. Therefore, the aim of this work is to investigate which digital technologies are used at business process level and how digitalization is perceived by the sawmill owners. For this, the three stages of digitalization by Saam et al. (2016) are used which differentiate between three levels of digitalization: basic data processing (first level), digitally networked information and communication (second level), and digitally networked products and services (third level). Furthermore, this study will provide an understanding of the opportunities and challenges linked to digitalization. Therefore, following research questions are addressed to SMSS in Austria:

I. What is the level of digitalization at business process level?
II. What are the perceived opportunities and challenges of digitalization?

On a scientific level, the results of the descriptive study will empirically describe the digitalization maturity of SMSS as well as opportunities and challenges as perceived by the sawmill representatives. On a practical level, the results provide the basis to develop measures on how to advance the digitalization of SMSS. It will provide a better understanding of the need for action not only for enterprises, but also for associations and political institutions.

2 Background

2.1 Level of digitalization in small and medium sized sawmills

To assess the development of digitalization in a company or an industry, the model from the Verband Deutscher Maschinen- und Anlagenbauer (engl. Association of German Mechanical Engineering Industry) can be used which focuses on the digital competence based on their products and production (Stahl et al. 2015). Gronalt et al. (2017) and Tonk (2017) used the model to investigate the state of the art of the technological development in selected branches of the wood industry. They found that the wood industry is currently between the 3rd and 4th industrial revolution with the company-wide integration of production being well developed. However, there is a great potential especially in the area of ICT infrastructure, human–machine interaction and efficiency in small lot sizes. Regarding products, they found that the wood industry has a low level of digital development as barcodes are being used for product identification. Reason is that further processing (chipping, cutting) makes product identification expensive and not useful. The study illustrates the high level of automation but also gaps towards Industry 4.0 level.

Whilst a study by Unger (2017) indicates a positive attitude towards the increasing digitalization, another study by Merforth (2016) argues that the level of digitalization seems very diverse between companies, and Industry 4.0 is only found in a few large industrial groups, but rarely in SMEs. Even though, some wood processing companies have elements of Industry 4.0, many lack basic information and communication technology. Smaller companies often do not have electronic data processing to track their commodity flow. On the one hand there are companies that measure round wood with 3D-lasers, sensor-based planning machines, fully automatized quality sorting, and in some cases, production processes are supported by robotics and autonomous driving of logistic vehicles. On the other hand, there are companies with processes that are still from the time before the 3rd industrial revolution, for example order entry is done by pencil and paper.

Merforth (2016) further states that the basic requirement for Industry 4.0 is an increase in computer aided systems, connecting existing data, as well as cross company data exchange. Thus, the technical tools necessary for the Industry 4.0 are available but its realization is rather a management decision than one of technical restrictions, which was reported to be specifically the case for SMEs (Ghobakhloo 2020; Moeuf et al. 2020). While many large companies have already initiated innovation processes regarding digitalization, medium-sized companies seem to find it more difficult to do so (Schröder 2016).

Saam et al. (2016) report in their study on 2000 SMEs in Germany that 32% can be assigned to "laggards of digitalization" as many companies lack basic digital infrastructure such as their own website or an Enterprise Resource Planning System (ERP). In a study by Harl (2017), companies were asked about their digitalization status and most of the surveyed companies were classified as "Digital Newbie" and "Digital Conscious". According to another study (Lindner et al. 2017), one third of the companies use ERP or customer-relationship-management (CRM) systems, whereas one third have never heard of these. For Austrian SMEs, the use of ERP systems, CRM software and own homepage was above average, whereas cloud computing is below average (Neubauer and Zoder 2016). Bley et al. (2016) investigated the level of digitalization by 234 SMEs in Germany through their use of ERP-Software in comparison to their self-assessment. The study shows that many SMEs overestimate their level of digitalization: 53% use only one or no system at all but consider themselves as very good users of ICT.

2.2 Opportunities and challenges for small and medium sized sawmills

The digital data communication across the value chain can be used for roundwood procurement by connecting forest management with sawmill industries. Forestry logistics processes can be traced for harvesting, hauling, storing and distribution until wood enters the sawmill (Zhao et al. 2011).The Austrian cooperation platform Forst-Holz-Papier (FHP) offers the database FHPDAT to facilitate efficient data exchange between wood value chain actors such as sawmill, further processing and logistics (EUWID 2018). In Germany, ELDATsmart from the ministry of agriculture facilitates the steering of round wood flows for wood logistics in which 46 companies (with wood procurement of more than 20Mio m^3/year) from sawmills, PPI and board industry are participating.

The concept of the smart factory allows to optimize processes at the beginning of the value chain such as for wood industrial manufactures (Pödör et al. 2017). In the sawmill, processes can be optimized through round wood scanning using computer tomography (CT). Thereby, processes can be adapted automatically to optimize yield and quality of sawn timber as well as use potentials to increase productivity, for example customer-oriented manufacturing, linking drying with press data and bonding quality are further areas of optimization (Gronalt and Teischinger 2015).

Sawmills differ in terms of raw material, cutting quantity and markets. On the one hand, there are mass producers

with high cutting quantities of softwood with an intermediate depth of manufacturing (semi-finished) and a broad sales market. On the other hand, there are highly specialized products (finished), mostly hardwood, with optimized production costs (Merforth 2016). Digitalization (e.g., Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) programs) allow SMEs to distinguish from industrial mass production by offering efficient, flexible and customized production. This means that individual solutions must be found for which the interface is a challenge, as machine producers often create isolated applications for the production process. This hinders the linkage of production with other business fields, such as the purchase department, procurement and production planning (Merforth 2016).

Company clusters are also rated as useful network considering the knowledge transfer for Industry 4.0 to exchange experience regarding possibilities for implementation, networking and data exchange, as well as training to increase the IT skills of the employees (Teischinger 2012). According to Merforth (2016), digitalization provides higher machine use, less down time, shorter lead time, lesser stocks, optimized material flow and use, enhanced grading and sorting through scanners, traceability: wood origin from forest to plant, customization, and flexible products as opportunities to a sawmill.

SMEs have specific managerial features that can hinder the adoption of Industry 4.0 such as local management, short-term strategy, lack of expertise, non-functional organization, limited resources and a lack of methods and procedures (Moeuf et al. 2020). In Germany, barriers to Industry 4.0 among SMEs were a lack of a digital overall strategy with low financial resources, security concerns, and lack of standards and norms (Schröder 2016). Studies identified a lack of IT competence, data security (Saam et al. 2016) and the digitalization of specific knowledge and experience as major barriers. The latter is crucial as SMEs are often specialized in niche markets for which they produce small batches or individual pieces according to specific customer requirements (Ludwig and Pipek 2016).

A recent study by Salim and Johansson (2018) investigated the process leading to investment decisions on automation of manufacturing in the wood products industry and argued that investments succeed if they are the expression of informed and systematic decisions anchored in the manufacturing strategy. They found that the decision makers tend to heavily rely on the technical suppliers and focus on cost reduction from the investment. This leads to a limited involvement of the decision makers in developing specifications regarding automation, and a limited awareness of the opportunities offered by automation and thus potential gain of business wide competitive advantages. This poses the risk of standardized solutions, "copy-paste" solutions, which are also available to the competitors, and the competitive advantages of automation would therefore be relatively small (Salim and Johansson 2018).

For the implementation of Industry 4.0 in SMEs, a basic electronic data collection and processing, followed by data analysis, interconnectedness and integration to provide assisting systems is required. A recent study by Moeuf et al. (2020) identified a lack of expertise, short-term strategy of SMEs, obsolescence of technology investments, and employees' fear of surveillance as risks. In addition, old production plants are a barrier as they are difficult to connect with new systems (Wischmann et al. 2015). The heterogeneity of IT structures, machines in use, and standards of networking in production are a barrier as existing machines or production plants are often adapted stepwise with new modules and concepts, due to economic reasons instead of changing the whole production line (Spath et al. 2013).

In any case, the technical requirements for a simple and secure data sharing within and outside company borders along the value chain need to be established first (Bischoff et al. 2015). Companies must develop strategies, such as a digitalization strategy, to be able to identify and seize opportunities from digitalization. However, such a strategy is often missing (Saam et al. 2016; Schröder 2016). To achieve digital maturity, the benefits of Industry 4.0 first have to be recognized, and then the financial resources, management support and strategic road mapping followed by employee qualification are needed for structural changes (Ghobakhloo 2020).

3 Research methods

3.1 The survey

A standardized questionnaire was developed based on the literature reviewed. To begin with a list of criteria to measure the companies' level of digitalization was established and operationalized for the questionnaire (see Supplementary Material) based on Saam et al. (2016) and Leyh and Bley (2016). In addition, the list also served as support for better structuring of the questionnaire. For the first part of the survey, in which the level of digitalization was recorded, the study by Saam et al. (2016) and Leyh and Bleyh (2016) is used as a basis (see Fig. 1). The first part of the questionnaire is divided into three question modules: hardware and software use, internet use, and digitalization projects

Module one investigates the level of digitalization using questions regarding the type and extent of hardware and software systems used. With regard to hardware, it was determined which devices such as laptops and company cell

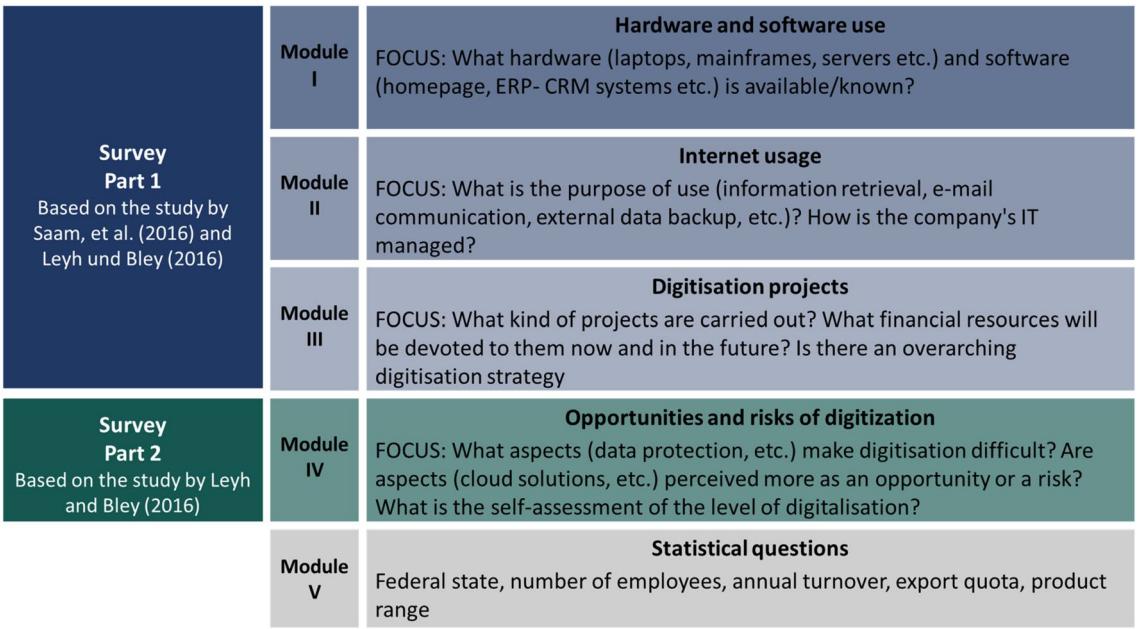

Fig. 1 Theoretical background and structure of the survey

phones are available, how many employees use these devices proportionately, and whether rarer hardware such as tablets, mainframes, servers, or computer-controlled machines and systems is also available. In the case of software equipment, it was not only determined whether basic equipment such as a company's own homepage, social media presence or office applications was available, but also whether applications such as ERP or CRM systems were at least known, if not already available. The second module investigates the level and purpose of internet use (e.g. e-mail communication, e-recruitment) and ongoing or planned projects regarding digitalization. It is investigated whether the internet is used purely for obtaining information and e-mail communication, or also to operate an online store or to back up data externally. This module also investigated whether corporate IT is managed by experts or by employees without respective training or education. The third module of questions deals with the implementation of digitalization projects. We further asked whether an overarching digitalization strategy in the company is the reason for it.

For the second part of the survey (see Fig. 1), the work of Leyh and Bley (2016) serves as a basis for focusing on the opportunities and challenges of digitalization in SMEs. The questions on barriers and enablers for digitalization, such as costs and required skills are structured in the fourth module of the questionnaire. For example, the survey asked which aspects, such as data protection, financing and IT skills, make the use of digital technologies more difficult.

The fifth and last module investigated background information about the enterprises such as location, number of employees, annual turnover, export quota and range of products. Table S1 in the Electronic Supplementary Material provides an overview of the questions asked in modules 1–4.

3.2 Data collection

According to the sector statistics of the wood industry, there are 1.019 sawmills in Austria (Oschischnig 2018). Knowing the size and contact information (i.e., registered enterprise) of the population allows to target the full sample. Therefore, all registered sawmills with an available e-mail or mail contact and an active enterprise were contacted. The sawmills were identified based on the "Holzjahrbuch Österreich 2016" (engl.: Wood Yearbook Austria 2016), a register of all wood-related enterprises in Austria, various online portals (www.firmenabc.at, www.herold.at), as well as the membership databank of the Austrian Wood Working Association (Fachverband der Holzindustrie Österreich). In total, 717 sawmills were contacted. Sawmills without available e-mail or mail address, as well as inactive sawmills such as timber trading companies without production, planning mills without own sawmill, or timber cutting companies were excluded.

To reduce the non-response bias among those without e-mail address, an identical paper survey was created next to an online survey. As a result, 537 sawmills (75%) were contacted via e-mail for the online survey and 180 sawmills (25%) via mail for the pen and paper survey. The online survey was created using the software Lime Survey. Sawmills received a personalized invitation and invitation link via e-mail using MailChimp. The envelope for the mail

contained a stamp to return the filled-out questionnaire as well as the option to scan and send it via e-mail instead. Data collection took place from May–June 2018.

3.3 Data analysis

The aim of the analysis was to group the surveyed sawmills regarding the digitalization criteria. Therefore, a cluster analysis was chosen, which is a structure-discovering procedure for group formation. To determine a distance and similarity measure for the application of the cluster analysis, the classification criteria must be defined (Backhaus et al. 2016). The digitalization criteria to measure the companies' level of digitalization based on Saam et al. (2016) were used. They comprise the internal digitalization (software, hardware equipment) and external digitalization (website, social media), as well as the knowledge base (Table 1). The three digitalization levels are named "Fundamental," "Information and Communication" and "Networked Products and Services" (Saam et al. 2016).

The more criteria in each digitalization level are fulfilled by the enterprises, the higher their level of digitalization. Table 2 shows the criteria and their operationalization as variables to assess the level of digitalization. Those variables that were not binary were transformed into binary variables, which was necessary as the original variables consisted of a mix of nominal, binary and ordinal scales (Backhaus et al. 2016). Furthermore, those variables, subject to more than one question (e.g., digitalization project, online presence, software equipment) were transformed into one variable.

The average linkage between groups method was selected for the analysis as the data is binary which is an agglomerative (hierarchical) cluster method that successively summarizes ungrouped cases. For the application of this method, the binary Euclidian distance is used as a proximity measure to calculate a similarity coefficient. The average linkage between groups method fuses those two clusters, which show a minimal increase in the sum of the squares of error due to the fusion. Thus, the number of clusters identified before a sharp increase in the error square sum is ideal. Therefore, the optimal number of clusters in this study is three, with the error square sum for 25 and less formed clusters.

4 Results

4.1 Description of the sample

In total, 83 online surveys and 13 paper surveys were received. Incomplete surveys (8) and one survey from a large company with more than 250 employees and more than 50 million EUR turnover were excluded from the sample, resulting in a sample size of 87 and a response rate of 12.1%.

Based on the criteria regarding employees and annual turnover of the European Commission (2003), the majority of respondents were from small enterprises with max. 9 employees (64%), see Table 3. A similar distribution was observed regarding the annual turnover: 60% are small enterprises with an annual turnover below two Million EUR. Surveyed companies mainly offered cut timber such as slats (77%), construction wood (69%), and packaging material (53%). Overall, the sample corresponds to the population of the wood industry, which is characterized by a high number of small and medium sized enterprises and the majority of them is located in Styria, Upper Austria, and Lower Austria (Oschischnig 2018). However, the sample has a lower amount of enterprises from Tyrol and Vorarlberg and higher amount of Styria and Carinthia in comparison to the

Table 1 Three levels of digitalization (modified after Saam et al. 2016)

Level of Digitalization	External Digitalization	Internal Digitalization	Knowledge Basis
1	Stationary Internet Homepage	PC ERP Automated data processing	Basic competence
2	Mobile internet Internet applications for information and communication External social media (e.g. Blog)	Analysis of large amounts of data Cloud computing Internal Social Media (e.g. Wiki)	Digitalization strategy Adapted organization Advanced skills IT-Professionals
3	Business models based on digital products and services Apps Industry 4.0	Industry 4.0	R&D in the field of own application of digital technologies and business models

Table 2 Variables used for cluster analysis with the transformed scales in column 3 (1 = Basic level for digital data processing; 2 = digital networked information and communication, 3 = digitally networked products and services)

Level of Digitalization	Criteria Measured	Scales or Transformed Scales (if not binary)
1	Company website	Available = 1; I don't know, not available = 0
1	ERP software	Available = 1; I don't know, not available = 0
1	Automated collection and transfer of data	Yes = 1, no = 0
2	Digital production	Three sub-criteria (more than one = 1, one and less than one = 0) 25% of employees that use machines that are operated with digital surfaces Computer-supported production programs Computer-operated machines and plants (e.g. CNC machines, 3D printers)
2	Hardware equipment	Two sub-criteria (at least one = 1, none = 0) 25% of employees have access to company mobile devices (mobile phone, tablet) Mainframe/server
2	Software equipment	Five sub-criteria (at least one = 1, none = 0) Cloud computing Big Data CRM PPS SCM
2	Online presence	Four sub-criteria (at least one = 1, none = 0) Blog Online advertisement Online shop Online payment system
2	Implementation of digitalization projects	At least one = 1 None = 0
2	Cross business digitalization strategy	Yes = 1 No = 0
3	Internet of Things digitalization projects	Offer apps for products or services (Yes = 1, No = 0) Implementation of Industry 4.0 projects (Yes = 1, No = 0)

Table 3 Description of sample by background variables (n = 87)

Number of Employees	%	Annual Turnover EUR	%	Products	%	Location	%	Distribution in Austria (Oschischnig 2018) (%)
0–9	64	≤ 2 Million	60	Slats	77	Styria	26	17
10–19	17	≤ 10 Million	30	Construction wood	69	Upper Austria	23	24
20–49	14	≤ 50 Million	8	Packaging	53	Lower Austria	18	18
50–99	2	> 50 Million	2	Planed sawnwood	51	Carinthia	13	10
100–249	2			Wood for garden	46	Salzburg	8	10
> 250	0			Carpenter products	41	Tyrol	6	13
				Laminated	16	Burgenland	3	2
				Window scantlings	5	Vorarlberg	2	5
				squared timber with wane	2	Vienna	0	< 1%

population. Vienna has only one sawmill, which did not participate in the survey.

Overall, it was observed that 71% of the companies surveyed have their own website. A simple ERP system (Holzmanager) is used by almost 68% of the companies surveyed. A more advanced ERP system is used by 5% of the companies. Altogether, 45% have computer-supported programs for production. Of these, 18% use a cloud, 3% use big data, 7% use CRM, 9% use a PPS system and 3% use an SCM system. Six percent of the companies surveyed have a cross-business digitalization strategy, while 24% are active in social media. Most of the projects related to digitalization are about purchasing new or better hardware (42%), new software (35%) and developing new concepts for marketing and sales using the internet (40%). Projects relating to apps

or Industry 4.0 are implemented by only 3% respectively 1% of the companies.

4.2 Results of cluster analysis

To group the surveyed sawmills, the variables measuring the digitalization criteria in Table 2 were used. The average linkage between groups method and the elbow criterion identified three clusters. Figure 2 shows the differences between the clusters regarding their level of digitalization based on the digitalization criteria as well as the level of digitalization of the whole sample. The results (also see Table S1in the supplementary material) show that digitalization projects are also carried out in different intensities between the clusters. In general, the more developed clusters have more digitalization projects and more interest in competence projects. Regarding the competence projects, the reorganization of workflow, Apps, Industry 4.0 projects as well as IT education for employees are neglected issues in all three clusters. The implementation of digitalization projects in the clusters also corresponds to their investments. The more projects are implemented, the higher their investments in digitalization. The differences between the clusters are described in the following paragraphs.

4.2.1 The manual small business cluster ($n_1 = 44$)

This cluster is characterized by enterprises with less than 10 employees (96%) and a turnover of less than 2 Mio EUR (89%). Only 32% of enterprises export their products. The majority of the enterprises are located in Upper Austria (32%). Among the manual small businesses, 43% consider themselves to be little to fully developed in terms of digitalization. The majority of this cluster invests nothing (57%) or less than 10,000 EUR (41%). If additional capital were available, 75% of the companies would invest it in other uses not related to digitalization. The majority of companies (41%) use external IT consultants and employees without formal education (34%) to administrate their IT.

This cluster did not reach the first stage of digitalization, as the basic equipment for this level, such as an ERP system is missing. Whilst 51% have their own website, only 36% use a simple ERP system such as the "Holzmanager" and 25% report to have automated collection and transfer of data. Regarding level 2, less than 5% have a mainframe/server. Digital production is only partly in place with 34% having machines that are operated with a digital surface, 21% with computer-operated machines, and 7% with computer-supported production software. Regarding the software equipment, advanced software such as Cloud Systems, Big Data, CRM, SCM, is missing. Nevertheless, the share of mobile devices is high (61%) and 30% implement at least one digitalization project such as investing in new or better hardware and new company website. A cross business digitalization strategy is missing (0%). In addition, they commented that they are happy with their production capacity and are not interested in increasing their production volume or turnover.

4.2.2 The automated business cluster ($n_2 = 30$)

This cluster is characterized by enterprises with less than 10 employees (40%) as well as 10–19 employees (30%) and 20–49 employees (27%). Similarly, it is characterized by enterprises with an annual turnover up to 2 Mio EUR (37%)

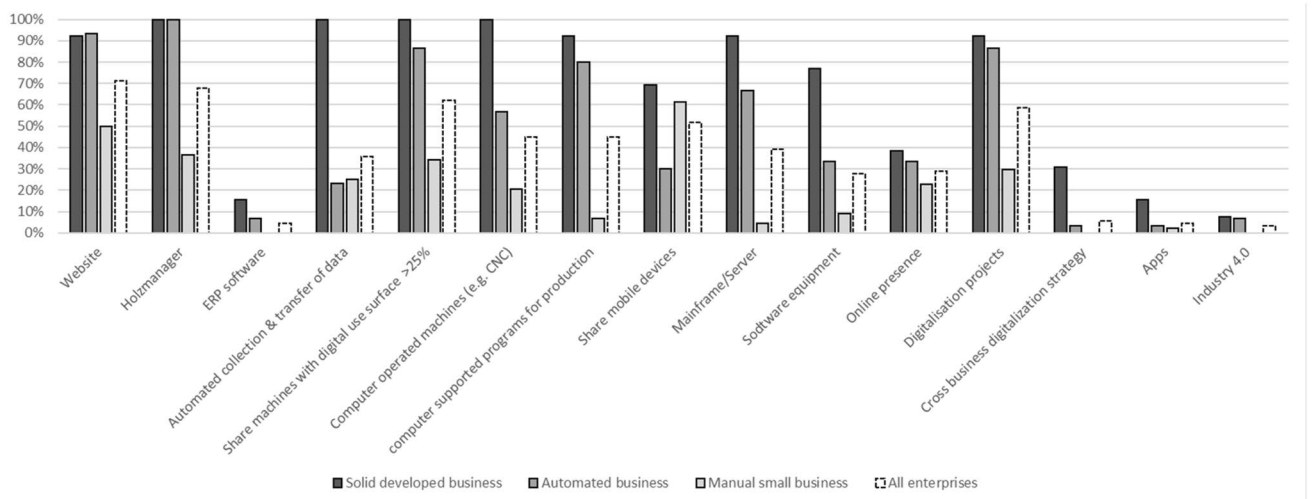

Fig. 2 Differences between the clusters regarding their level of digitalization based on the digitalization criteria. Three clusters were identified: The manual small business cluster ($n_1 = 44$), the automated business cluster ($n_2 = 30$), the solid developed business cluster ($n_3 = 13$)

and up to 10 Mio EUR (47%) and more than 50 Mio EUR (13%). Ninety percent of the enterprises in this cluster export their products. The majority of the enterprises is located in Styria (27%). In the automated business cluster, 70% assume that they are little to fully developed. 63% of the companies assigned to this cluster invest less than 10,000 EUR. If additional capital were available, 70% would invest it in other uses not related to digitalization. The majority of the companies (80%) use external IT consultants and IT personnel of the company (46%) to administrate their IT.

This cluster partially reached the first stage of digitalization as the majority of companies have their own website (93%), all companies use a simple ERP system (Holzmanager), but a more advanced ERP system is mostly missing (7%) and automatized data collection and transfer are only partly available (23%). The cluster is equipped with computer-supported production (80%), computer-operated machines (57%) and machines with digital surface (87%). Regarding hardware equipment, 67% have a mainframe/server, and 30% mobile devices. The second digitalization stage is already characterized by the systematic evaluation of large amounts of data and the use of applications for improved internal communication (e.g. cloud applications, social media, use of mobile devices, internet-enabled end devices, cross-company digitalization strategy), which is not achieved. Like in the manual small business cluster, advanced software (Cloud computing, Big Data, CRM, PPS, SCM) is not or rarely available with 33%. 87% have digitalization projects mostly related to new company website and new or better hardware. Only 3% have a cross business digitalization strategy.

4.2.3 The solid developed business cluster ($n_3 = 13$)

This cluster is characterized by a larger number of employees: 46% have 20–49 employees and 15% have 50–99 employees. More than half of them have an annual turnover of up to 10 Mio EUR (54%) and around a quarter of them up to 50 Mio EUR. The cluster has a strong export orientation with the majority of sawmills exporting more than half of their products. The companies are mainly located in Styria and Lower Austria (both 39%). All sawmills in the cluster consider themselves to be little to fully developed. In this cluster, the majority invests up to 39,000 EUR (70%). If additional capital were available, 62% would invest it in technology projects for digitalization.

This cluster has fully reached the first stage of digitalization as the basic hardware and software are largely available. More precisely, 92% have a website and every company has a simple ERP software (i.e., Holzmanager) as well as automated data transfer, but only 15% have a more advanced ERP system. Regarding level 2, 92% have computer-supported production programs and their own mainframe/server and 77% have at least one advanced software equipment. More precisely, 39% use a cloud, 15% use big data, 15% use CRM, 38% use PPS and 3% use SCM. The online presence is limited (39%) and 31% have a cross business strategy for digitalization. However, 92% have digitalization projects, mainly related to new and better hardware, software, IT security, and company website. Also 15% and 8% of companies have projects related to Apps and Industry 4.0, respectively.

4.3 Perceived opportunities and challenges towards digitalization by clusters

There are differences between the three identified clusters regarding their perceived opportunities and challenges for digitalization. Figure 3 shows that the solid developed business perceives challenges more often in comparison to the automated and small manual businesses. Lack of IT skills was mentioned by every company. Interestingly, only 55% of the *manual small businesses* and 67% of the *automated businesses* do consider a lack of IT skills as a challenge. This suggests that the more digitalized a business is, the more it knows its limitations and challenges regarding skills. Non-suitable financing options were not a major issue for any of the three groups, while high investment costs were seen as a challenge. Regarding the opportunities for digitalization, there are small differences between the clusters (see Fig. 4). The *solid developed business* considers the increased networking of the value chain, automatization and customization, as well as cloud solutions as the biggest opportunities. In contrast, the less developed clusters more often recognize the workplace of the future and the Internet of Things in addition to the customization and automatization. This suggests again, that *the solid developed businesses* have a more detailed understanding of the data use across value chains and company borders.

5 Discussion

The level of digitalization regarding the business processes was analyzed by modifying and applying an existing tool to the case of SMSS.

The analysis identified three clusters that vary in their level of digitalization. However, these clusters do not represent the three levels of digitalization identified by Saam et al. (2016) but show a more detailed differentiation of the first and second level. This is plausible as the wood industry is considered to be very traditional (Teischinger 2012) and according to Kortüm et al. (2014), digitalization has so far penetrated the wood industry. The model of Saam et al. (2016) was created in general for SMEs across all industries

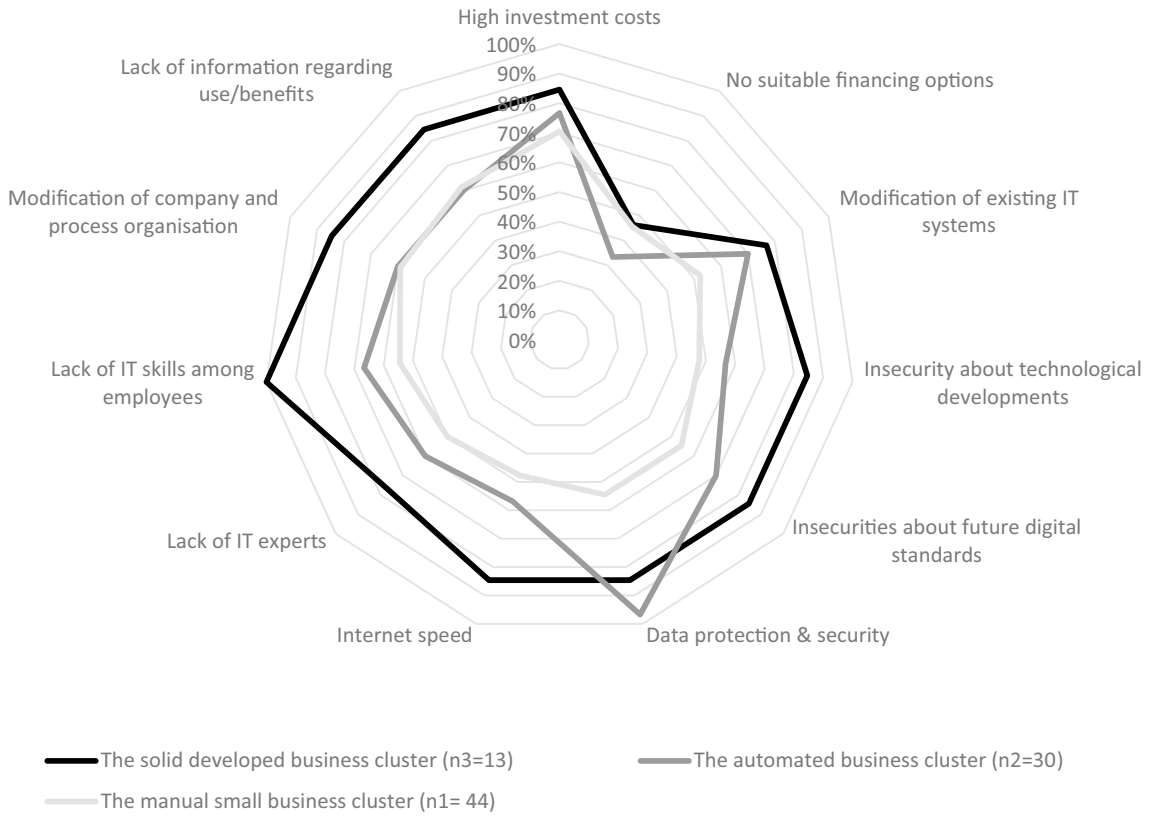

Fig. 3 Perceived challenges for the use of digital technologies in % by cluster ($n_1 = 44$, $n_2 = 30$, $n_3 = 13$)

and therefore cannot cover all specific characteristics of the sawmill industry.

The results suggest that *the manual small business cluster* will not reach the first level of digitalization as this cluster lacks the basic infrastructure, awareness of their shortcomings and the willingness to transform. This cluster mainly consists of very small enterprises, offering niche products, without the need to expand production capacity. Assuming that these companies are flexible, customize their products and do not perceive the pressure to increase productivity or competitiveness, main incentives to engage into digitalization are not given. The low level and interest in digitalization may also be the result of the business structure, being traditional family-owned businesses. *The automated businesses* partly reached the first level using computer-aided production but lacking automated data collection, networked software and implementation of digitalization projects. *The solid developed businesses* reached the first level of digitalization but lacks cloud application, big data solutions and a cross-business digitalization strategy to reach the second level according to Saam et al. (2016). *The solid developed businesses* can be assigned to the transition from the first to the second digitalization stage. However, a high level of automatization does not equal Industry 4.0, which is an enabler for new business models. Engaging into new business models needs of course more than just installing hardware and software. Having characterized the wood industry as being very traditional, we can rate this trait as barrier to the digitalization process towards Industry 4.0. As sawmills are positioned at the beginning of the value chain, they are important actors for the digitalization of the wood industry (Makkonen 2018) and might be a bottleneck for the sectors innovativeness and competitiveness. The consequences might be severe, if we think of the increasing demand for the traceability of wood resources along the whole value chain. From the present study, it can be assumed that the Austrian sawmills will not push the digitalization along the value chain. In turn, it can be concluded that it will only be a matter of time before sawmills are pushed towards digitalization. The gap between the strongly and little developed companies may be further increasing (Wischmann et al. 2015), and the question arises whether the less developed businesses will disappear or whether they are not impacted by the structural change.

The present study shows that digitalization is more often perceived as an opportunity than a challenge which is consistent with a recent study among sawmill owners (Makkonen 2018) and SMEs in Austria (Unger 2017). In particular, the increasing networking of the value chain, the workplace of the future, and increasing individualization of

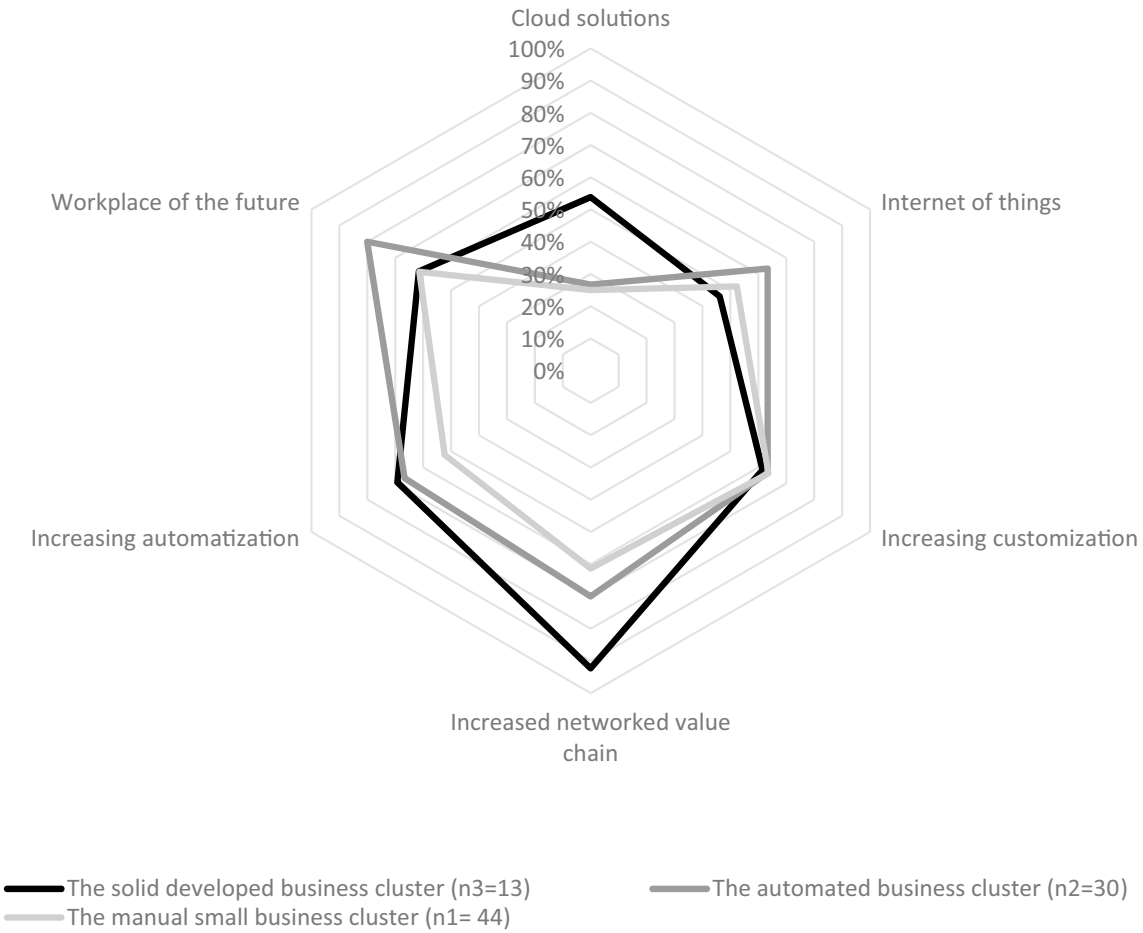

Fig.4 Perceived opportunities for digitalization technologies in % by cluster ($n_1 = 44$, $n_2 = 30$, $n_3 = 13$)

customer requirements (i.e., customization) are perceived as opportunities. The recognition of the value chain networking can be explained by the promotion of the FHPDAT platform (FHP 2018). In addition, in a previous study by Leyh and Bley (2016), the increasing customization was perceived as opportunity. Lack of qualified personnel was perceived as challenge, consistent with a recent study by Salim and Johansson (2018). As SMEs in rural areas, such as sawmills, face the challenge of acquiring highly skilled workers, modern working models can contribute to find personnel (Lindner et al. 2017), which was recognized by the respondents. Young companies that have been in existence for no more than 10 years carry out technological projects somewhat more frequently, but competence projects less frequently than SMEs as a whole. This could be related to a workforce that is often younger and has more basic IT skills, so there is less need for further training and education (Saam et al. 2016). However, it is not only about the skills but the possibilities managers can identify (Salim and Johansson 2018). Often managers focus on efficiency-related digitalization activities, whereas long-term issues such as changes to business models or the exploitation of external opportunities through digitalization are underrated and postponed (Pöschl 2020). This highlights the need for a digitalization strategy that goes beyond technical aspects and hardware equipment and that should rather focus on conceptual aspects, such as the benefit of additional flexibility and the possibility to plan small batches as a result of automatization (Salim and Johansson 2018).

Data protection and security, lack of IT skills and high costs are perceived as main challenges consistent with Saam et al. (2016). Similarly, as in Leyh and Bley (2016), cloud solutions are also seen as the greatest risk in the present study. Note, the limited recognition of cloud solutions in *the manual small business and the automated business* can be partly explained by their low number of employees and no need to use ICT to communicate with each other. However, they may not recognize the value of cloud solutions to communicate across company boundaries.

Dividing digitalization projects into competence and technology projects shows that sawmills focus on technology projects and put little emphasis on expanding their

competence. The introduction of new hardware was one of the most frequently mentioned projects, similar to the results from Saam et al. (2016). Despite the increased networking of value chain was considered as opportunity, the linking of IT between business processes was rarely planned or implemented as digitalization project in the enterprises investigated. Although data protection or data security and a lack of IT skills were mentioned as the greatest difficulties, projects in this area were seldom implemented. However, improving the knowledge base and skills is important to increase the level of digitalization. The more developed the sawmill was, the more aware it was about challenges and willing to invest in competence projects. Interestingly, financing was not perceived as a major challenge whilst investment costs were. Comparing the sample to the population regarding company size and geographic location shows only small differences and can be considered as representative for SMSS in Austria. However, it would have been useful to further specify the answer categories of 0–9 employees to identify the one-man companies, typical for the sawmill industry in Austria as well as whether their business serves as main or as additional income (i.e., sideline business). In addition, it would have been interesting to include large sawmills with more than 250 employees in the sample to gain results for the whole sawmill industry.

6 Conclusion

The study provides insights into the level of digitalization as well as its opportunities and risks from the perspective of SMSS representatives. The initial assumption that the level of digitalization is low, as suggested by the literature, was empirically confirmed in this study. Thus, it can be inferred that requirements for Industry 4.0 in terms of digitalization of business processes, are not fulfilled by the surveyed sawmills. Concluding from the present study, we suggest a more differentiated assessment of the levels of digitalization to better design target-oriented digitalization measures and instruments.

The positive perception of digitalization indicates a potential to increase the level of digitalization among Austrian SMSS. Whilst sawmill representatives recognize the opportunities from digitalization (e.g., custom-made products), they need support in translating these opportunities into actual changes tailored to their business which requires an individual, cross-business digitalization strategy. For this, the provision of information and training, external IT experts and financing models are recommended. Support could come from policy and industry associations, also regarding education for digitalization in schools and life-long learning programs. However, lastly it depends on the willingness of the owners to implement changes.

More precisely, to increase the digitalization of the sawmills in Cluster 2 and 3, support regarding the implementation is needed and should focus on conceptual and business management skills to reconsider the specific business models of the sawmills. Here, individual solutions are necessary which require willingness to adapt and to develop innovative ideas. For sawmills in Cluster 1, the basic technical requirements need to be established first, which depends on the motivations of the owners. Financing models for digitalization might not be appropriate, as the businesses are too far behind.

Note, the level of digitalization was analyzed regarding the business processes, not the production process, by modifying and applying an existing tool to the case of SMSS. For the identification of the level of digitalization of the production processes (i.e., which machines and equipment are used), it is assumed that the digitalization might be more advanced, but future research is required. In this study, the opportunities found in the literature, which were largely recognized by the respondents were described and surveyed. Nevertheless, how the sawmills will make use of these opportunities has not yet been answered. Another field of future research is how the increasing digitalization will affect sawmills that do not achieve the first level of digitalization.

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