

Sawmilling competitiveness from the perspective of industry competitiveness models : a review

Vhuhwavho Tshavhungwe^{1,2} and Schalk Grobbelaar^{2*}

1. Department of Forestry, Faculty of Science, Engineering & Agriculture, University of Venda, Thohoyandou, South Africa
2. Department of Engineering and Technology Management, Faculty of Engineering, Built Environment & Information Technology, University of Pretoria, Hatfield, South Africa

* Correspondence: schalk.grobbelaar@up.ac.za

Globalisation and changes to the world economy have brought new challenges and opportunities for many industries, including the sawmill industry. This has led to a need to evaluate the South African sawmilling industry's competitiveness by studying the factors affecting competitiveness in other sawmill industries. The review evaluated published research on sawmill industry competitiveness to identify and address the research gaps in the literature. The systematic literature review implemented a PRISMA protocol. Sankey diagrams showed the relationships between the factors driving change and those affecting competitiveness. The results showed that most factors affecting and driving industry competitiveness were similar. The reviewed papers pointed to the availability of wood, formation of clusters, policy implications, level of innovation and employment conditions as the factors affecting industry competitiveness. The research findings corresponded to some of the early ideas presented by Micheal Porter on industry competitiveness. The research will guide future research on the South African sawmill industry.

Keywords: industry competitiveness, competitive advantage, sustainable competitiveness, wood products, sawmilling, business management.

Introduction

The sawmilling industry has shifted substantially in terms of products, production processes and target customers over recent decades due to globalisation, shifts in global economic power, changes in consumer preferences, increased awareness of sustainability challenges, and a surge in ICT and big data methods (Heiskanen et al. 2022). This shift creates challenges and opportunities for the

future; hence it is crucial to study the future outlook of the sawmilling industry. The competitiveness issue is vital for all industries, governments, and economies under market economy principles. For industries to be competitive, competitiveness must be improved in all supply chain stages to avoid a deadlock in one of its areas (Lehtonen and Tykkyläinen 2014). To achieve a viable competitive advantage, firms must decide which criteria they want to compete in (Wellner and Lakotta 2020). Savić et al. (2011) emphasised the importance of knowing the main characteristics that can hold the sectors competitive and the problematic areas that should be considered to maintain the sector's competitiveness.

Industry competitiveness

In his research, Harvard Business School professor Michael Porter (Porter, 2008) evaluated the drivers of enterprise success. He suggested that the structure of an industry counted more than individual firm performance. He highlighted that knowing the competitive forces and their inherent causes exposes the roots of an industry's present profitability while presenting a framework for influencing foreseeing competition over time (Arshed and Mcfarlane 2016). Micheal Porter developed Porter's five forces model to explain industry competitiveness (Wu et al. 2012; Jaya and Yuliarmi 2019; Jucevi and Stankevi 2004; Stonehouse and Snowdon 2007; Arshed and Mcfarlane 2016). The five forces framework allows firms to assess their industries' attractiveness and competitive position within that industry (Stonehouse and Snowdon 2007). Table 1 shows Porter's five forces framework, which highlights the power of suppliers, the power of the buyers, the threats of new entrants, the threat of substitutes, and rivalry among existing competitors as the forces affecting competitiveness in the industry.

Table 1: Summary of some factors influencing Porter’s five forces.

Threat of new entrants	Power of suppliers	Power of buyers	Threat of substitute products	Rivalry among existing competitors
<ul style="list-style-type: none"> •Economies of scale •Product differentiation •Intellectual property protection •Time and cost of entry •Access to distribution channels •Government policies •Cost advantages •Barriers to entry 	<ul style="list-style-type: none"> •Number of suppliers •Size of suppliers •Availability of substitutes •Differentiation •Switching cost for supplier’s products 	<ul style="list-style-type: none"> •Number of customers •Order size •Differences between competitors •Ability to substitute •Buyer’s switching costs •Price sensitivity 	<ul style="list-style-type: none"> •Number of substitute products •Buyer’s propensity to substitute •Relative price performance •Perceived level of product differentiation •Switching costs 	<ul style="list-style-type: none"> •Number of competitors •Diversity of competitors •Quality differences •Product differentiation •Brand loyalty •Switching costs •Barriers to exit

The five forces are each influenced by several other factors within the industry structure. A summary of some of the factors influencing Porter’s five forces is shown in Figure 1 (Wu et al. 2012; Arshed and Mcfarlane 2016; Indiaty et al. 2014). The figure shows that many forces are at play within firms' industries.

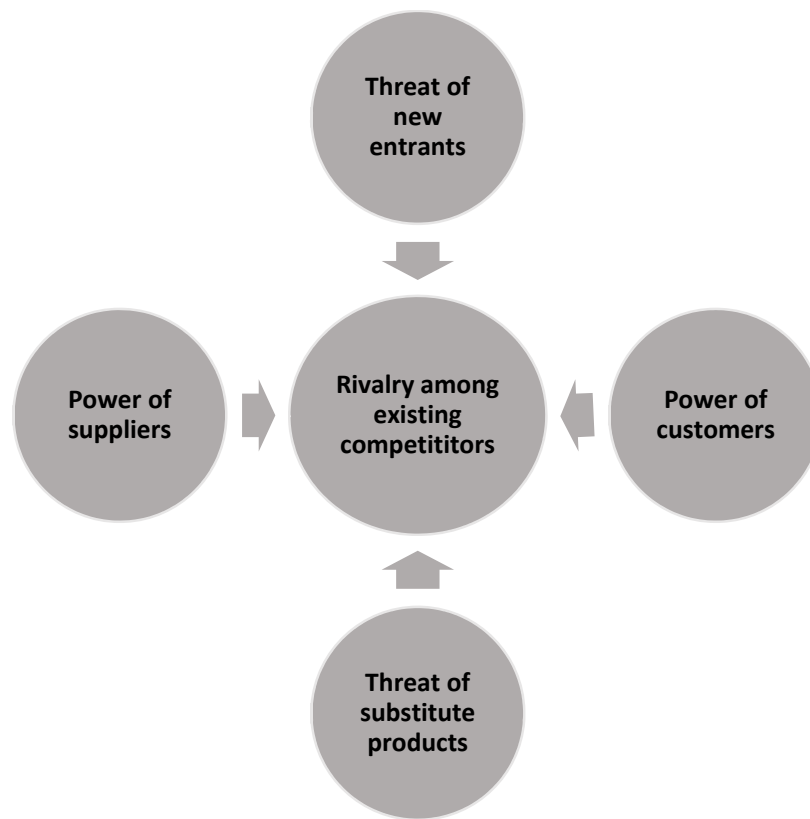


Figure 1: Porter’s five forces framework (Porter, 2008).

Drivers of industry competitiveness

Competitiveness can be evaluated on a single firm, industry level, or country (Korhonen et al. 2018). This systematic review focused on competitiveness on an industrial scale. Industry competitiveness was defined, and measures of industry competitiveness were identified from the literature. There are various definitions of competitiveness in literature. Independent Evaluation Group (2016) defines group competitiveness as the sustained ability of firms and industries to capture market share and grow the market through productivity improvements. According to Jaya and Yuliarmi (2019), competitiveness is a notion that refers to the ability of a company to compete with other companies to create value and can be created or enhanced by applying the correct competitive strategy. Toppinen et al. (2019) describe competitiveness as the superior performance within an industry assessed with chosen measures. The measures of competitiveness will vary from industry to industry. Table 2

summarises the identified variables affecting industry competitiveness outlined in the literature. According to Vrontis et al. (2018), the competitiveness of the manufacturing industry is affected by eight key drivers: the number and production capacity of the firms, entrepreneur characteristics, the level of investments, innovation, internationalisation, the ability to create networks and partnerships and to outsource part of the activity. Industry competitiveness depends on the power of firms to work together rather than compete by allowing ongoing relationships between industry partners (Korhonen et al. 2018). Jaya and Yuliarmi (2019) highlighted that resources, capabilities, core competencies, sustainable competitiveness, and performance excellence are components of forming competitiveness.

Table 2: A framework summarising the dependent and independent factors of industry competitiveness

Dependent factor	Competitiveness
Independent factors	<ul style="list-style-type: none"> • Number and production capacity of the firms • Entrepreneur characteristics • The level of investments • Innovation • Internationalisation • Sustainable competitiveness • The ability to create networks and partnerships (clustering) • Employment • Technological advancement • Differentiation • Government • Policies

Competitiveness in the sawmill industry

Following other industries, the forest products industry is increasingly focused on the end customer. Therefore, the industry needs to innovate to manage its value creation better to improve customer service levels (Van Horne et al. 2006; Acar and Acar 2012). However, it is apparent that innovations in traditional sectors, such as the forest industries, have been limited and that forest-based initiatives

are less innovative than in other sectors (Weiss et al. 2020). Porter (Porter, 1998) States that there is remarkable evidence that innovation and competitiveness success are geographically concentrated. According to Hansen et al. (2011), most of the business conducted by Swedish sawmills today is done through relationship-based practices, and mills are working to establish new product market strategies. A web article by International Forest Industries (2022) highlighted how over 270 million m³ of standing timber in Central Europe was damaged between 2017 and 2019 due to the spruce bark beetle outbreak, which resulted in a surplus of logs for the Czech Republic, Germany, and Austria, giving them a competitive advantage in both domestic and export markets. A study by Grobbelaar and Visser (2021) mentions that the top 50 most intensive lumber users used six times more wood per capita than South Africa. This indicates the potential to increase the demand for lumber in South Africa by increasing the intensity of utilisation per capita to similar levels experienced by the top 50 countries. Significant growth has occurred in the softwood plantation estates of New Zealand, Australia, Chile, and Brazil (Hansen et al. 2011). This has resulted in the development of sawmilling and, in some cases, has become highly competitive with traditional producers such as Nordic Europe, Canada, and the USA (Hansen et al. 2011).

Background of the sawmill industry

A preliminary data search was conducted to identify the global sawmill industry's key players based on the sawmills' production capacity. According to production volume, the top 26 sawmills in the world in 2021 are shown in Table 3 (Jauk 2021). The countries where most sawmills originate are Canada with seven mills, the USA with six mills, Finland with four, Austria with four and Russia with two, as shown in the Table. A map was generated from the website "our world in data" (Ritchie and Max 2021), showing the area of the available commercial forest area globally. The dark regions in Figure 2 show the countries with the most forests. Russia is the most shaded, followed by Canada, USA and Sweden. As noted in the discussion above, Although Russia has the most forest area, they have fewer sawmills on the list in Table 3 compared to Canada and the USA, which have more

competitive sawmills. None of the South African sawmilling companies appears on the list, nor does South Africa have a larger area of forests as seen on the map.

Table 3: The world's largest sawmilling companies in terms of sawn timber volume outputs in 2021

N.	Company	Headquarters	Total in a million m³	Global share in %
1	West Fraser (+Angelina)	Canada	11,15	2.9%
2	Canfor (+schwedische Tochterunternehmen)	Canada	10,73	2.8%
3	Weyerhaeuser	USA	8,32	2.2%
4	Interfor (+EACOM+4 Georgia Pacific mills)	Canada	7,86	2.0%
5	Sierra-Pacific (+Seneca)	USA	5,38	1.4%
6	Stora Enso	Finland	4,88	1.3%
7	binderholz (+Klausner+BSW)	Austria	4,80	1.2%
8	Resolute FP	Canada	4,75	1.2%
9	Georgia-Pacific	USA	4,13	1.1%
10	Hampton	USA	3,09	0.8%
11	Arauco	Chile	3,00	0.8%
12	Segezha Group (+IFR)	Russia	3,00	0.8%
13	Tolko	Canada	2,62	0.7%
14	Pfeifer Holz	Austria	2,20	0.6%
15	HS Timber Group	Austria	2,20	0.6%
16	SCA Timber	Sweden	2,15	0.6%
17	Rettenmeier Holz	Germany	2,12	0.6%
18	Moelven Group	Norway	2,11	0.5%
19	Mayr-Melnhof Holz	Austria	2,05	0.5%
20	Södra Timber	Sweden	2,00	0.5%
21	Idaho Forest Group	USA	1,96	0.5%
22	JD Irving	Canada	1,93	0.5%
23	PotlatchDeltic	USA	1,72	0.4%
24	Setra Group	Sweden	1,70	0.4%
25	GreenFirst (+RYAM)	Canada	1,69	0.4%
26	Ilim Timber	Russia	1,65	0.4%

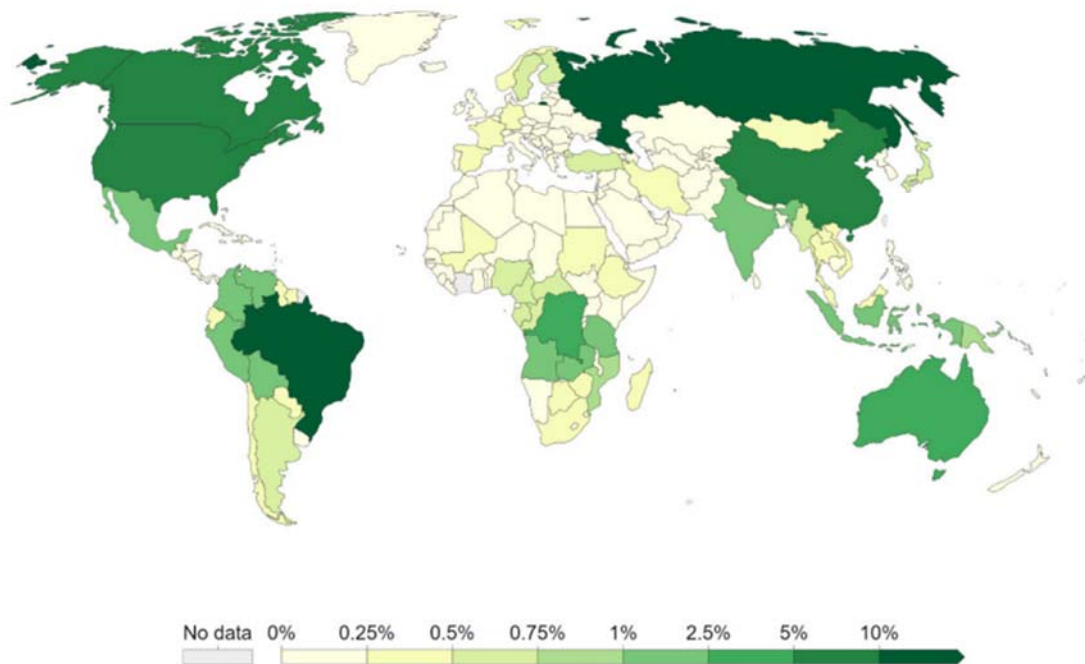


Figure 2: Map showing the countries with the highest commercial forest area, with the darkest shaded areas showing higher forest area.

The systematic review aimed to answer the following research questions:

- i. What factors drive change in the sawmill industry?
- ii. Which factors affect industry competitiveness, and what are Competitive advantages in the sawmilling industry?
- iii. How can the South African sawmilling industry improve and sustain its competitiveness?

Research Methodology

The systematic literature review implemented a protocol for planning, performing, and presenting a review, as utilised in prior studies (Weiss et al. 2020; Dean et al. 2017; Imran et al. 2021; Marshall and Brereton, 2013). The protocol followed was defining the search strategy for the articles, the inclusion and exclusion criteria for filtering out irrelevant articles, and methods for extracting and presenting data.

Search strategy

Research articles investigating sawmilling industry competitiveness were used. Only papers indexed in Scopus or Web of Science were used. The two were chosen as they form part of the three main research databases (Martín-Martín et al. 2019). The appropriate keywords were identified based on the research questions. Several factors were recorded, such as the search phrases and words used in the search, the number of results obtained, and the search date. The following search query was used in Web of Science:

Sawmill industry competitiveness (Topic) or Sawmilling industry competitiveness (Topic) or Sawmill industry sustainable competitiveness (Topic) or Sawmilling sustainable competitiveness (Topic) or sawmill competitive advantage (Topic) or Sawmilling competitive advantage (Topic) or sawmill drivers of competitiveness (Topic) or South African sawmill competitiveness (Topic)

Eligibility criteria for individual studies

Inclusion criteria:

Papers accessed by the initial search were assessed for inclusion based on the relevance of the title and abstract. Only peer-reviewed articles were included in the sample. A timeframe between 2001 and 2021 was used for the search.

The following papers relating to this concept were eligible for inclusion:

- Papers on sawmill industry competitiveness
- Papers relating to the competitive advantages of sawmills
- Papers on sawmill sustainable competitiveness
- Papers addressing challenges and opportunities in the sawmilling industry
- Papers highlighting the drivers of sawmill competitive
- Papers highlighting the overview of the sawmill industry

Exclusion criteria:

Articles not written in English were excluded from the systematic literature review. Inaccessible papers were excluded. Irrelevant papers and documents outside the context of the study were left out after abstract screening and full-text reading, respectively.

Data extraction approach

A list was generated, including all the articles used in the systematic literature review. The following data were extracted from each of the included articles:

- Bibliographic information.
- The abstract
- Aims and objectives
- Methodology used
- Type of study
- The key finding of each article as it relates to the research questions and author recommendations

The data were extracted and analysed using data analysis software (Atlas.ti).

Results

The steps followed in selecting articles included for the review are shown in Figure 3 below. The steps are shown in the PRISMA diagram. Eighty reports were obtained from Web of Science and 58 from Scopus. A total of 138 articles were obtained from the search. After applying the inclusion and exclusion criteria, the final documents included in the review were 25.

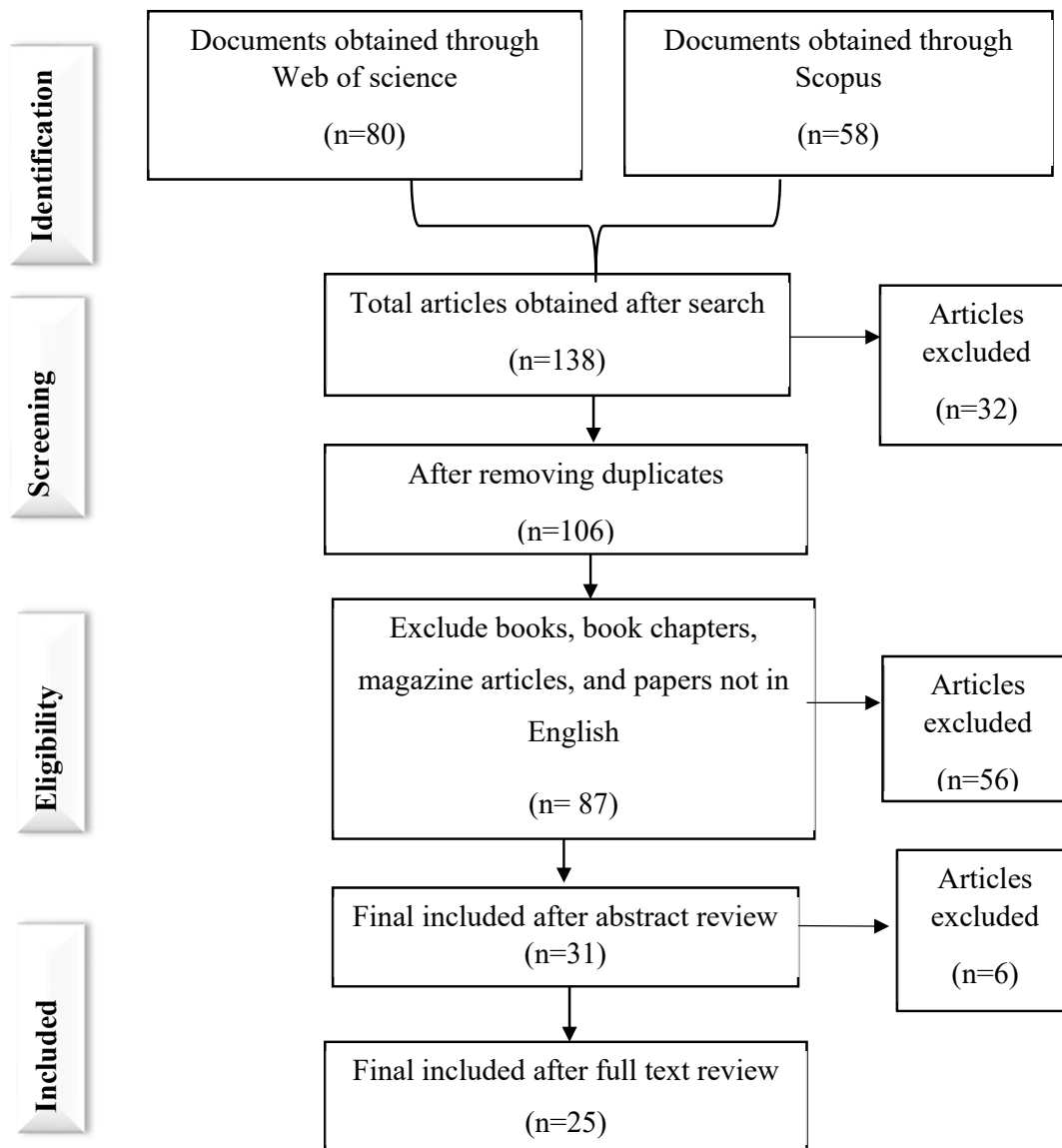


Figure 3: Documents sourcing step, presented according to the PRISMA Diagram (Moher et al., 2009 and Weiss, Ludvig and Živojinović, 2020)

The most frequently used keywords of the identified articles are shown in Figure 4 below. The keywords for each document were coded in Atlas.ti, and the results were exported to Excel for further analysis. The most frequently used keyword was wood products appearing six times, followed by competitiveness, strategy, sawmill and forest products which appeared four times. These words correspond to the words shown on the word cloud shown above.

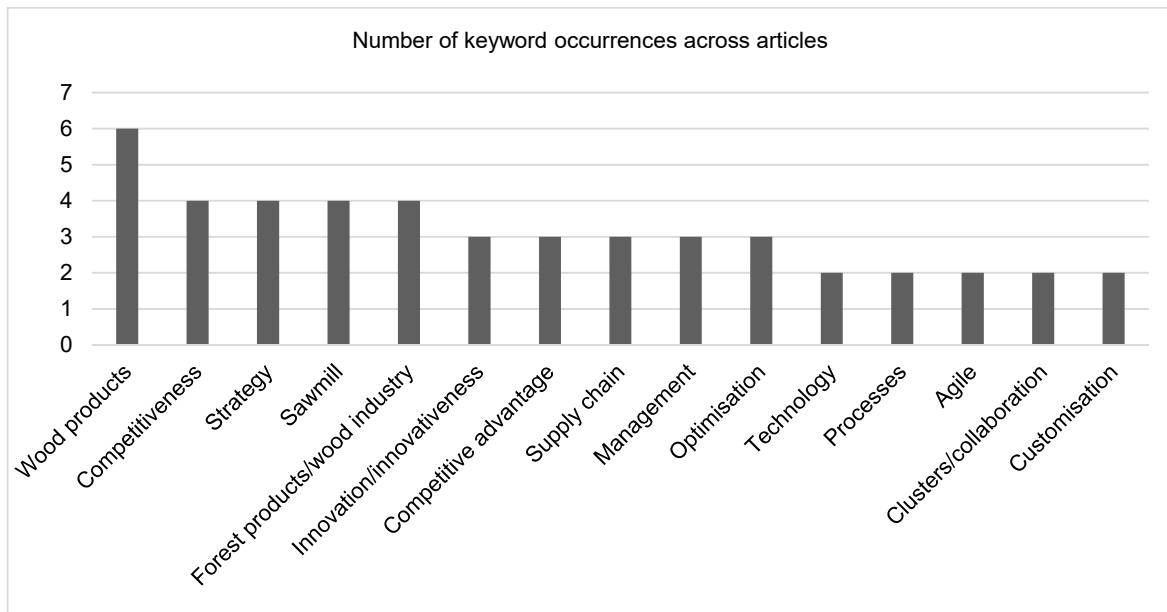


Figure 4: A keyword analysis showing the number of times a word appears as a keyword in the literature reviewed

The geographic context of the sources is shown in Figure 5. The graphs show that most research originated in the USA (nine papers), followed by Finland (five papers). These countries are some of the home countries of the top 12 identified sawmills, as shown in Figure 2 above.

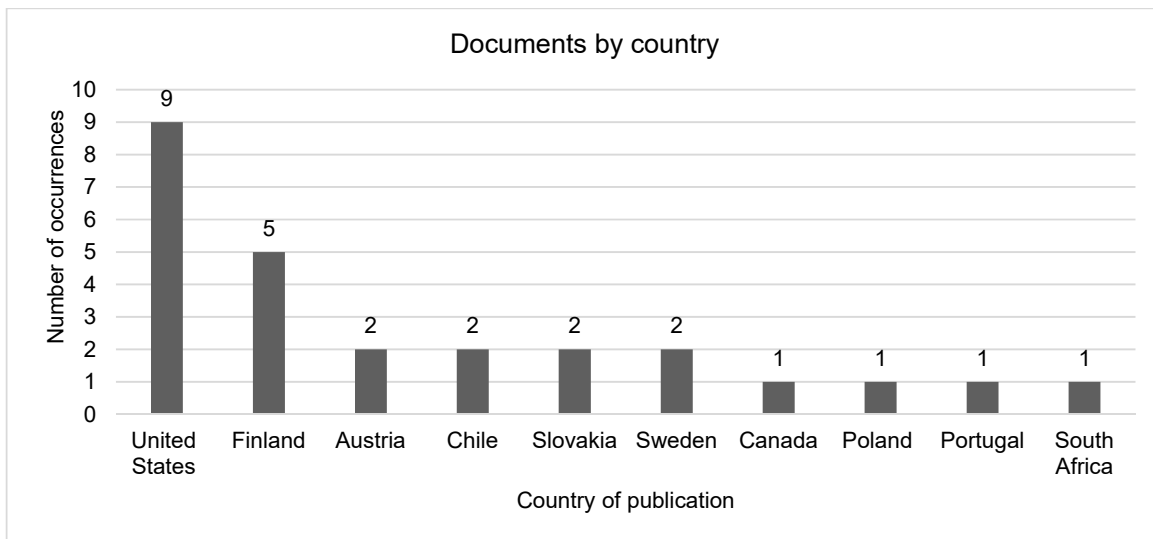


Figure 5: The geographic context of the reviewed sources

A graph showing the years of publication of the identified papers can be seen in Figure 6 below. The graph shows that most research was published between 2008 and 2012. It was interesting enough to note that this was during and just after the 2008 global recession. Figure 7 shows the identified document type. 79,2% were articles, 16,7% were review papers, and 4,2% were conference papers.

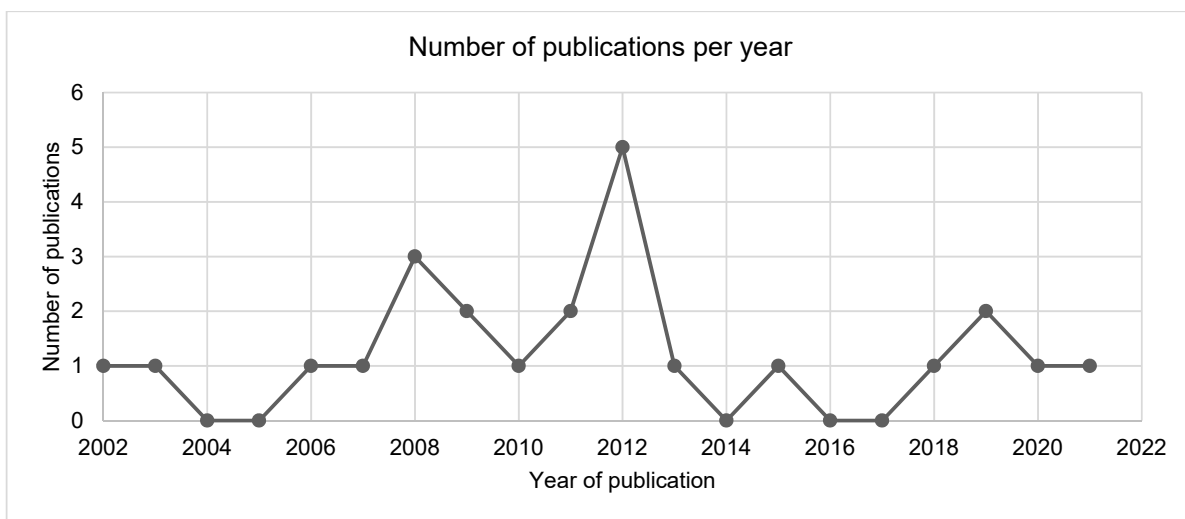


Figure 6: Years of publication for the reviewed articles

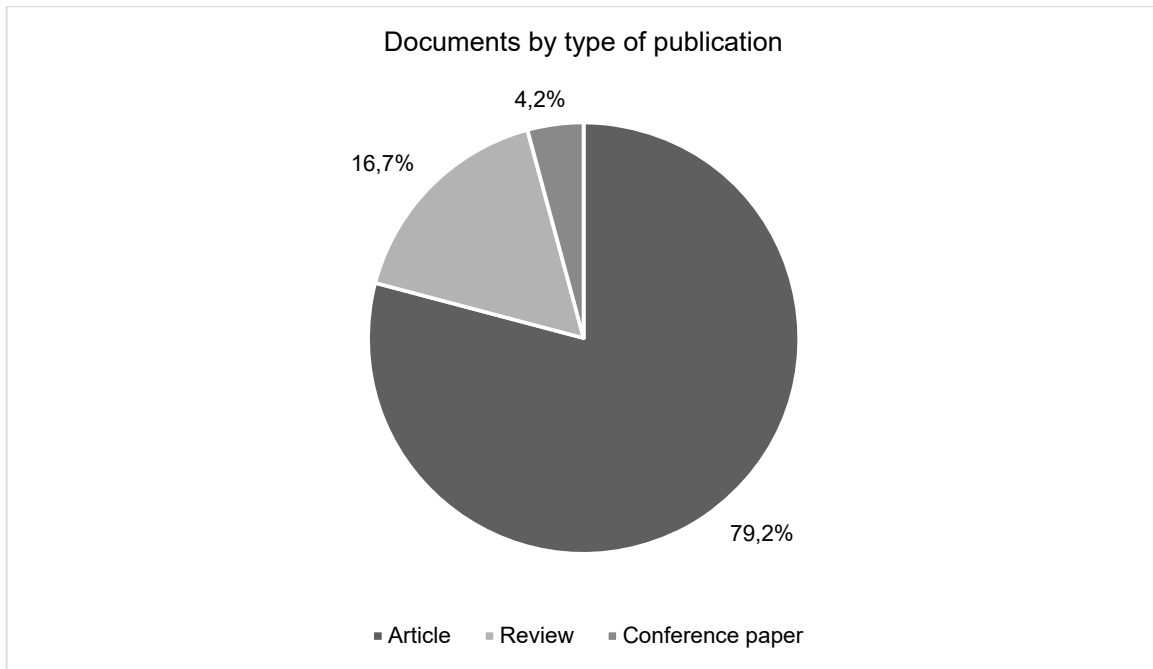


Figure 7: Reviewed documents displayed according to publication type

A summary of the targeted documents is shown in Table 4. The studies either followed a qualitative, quantitative or a combination of quantitative and qualitative approaches to conducting the study. The procedures used in the studies for gathering data were interviews, questionnaires, reviews, surveys, and case studies. Some of the analyses used were modelling, simulations and non-parametric programming. The objectives of the studies aimed to address the issues relating to sawmill competitiveness and or competitive advantages. The main findings of the studies showed the factors affecting, driving, hindering or sustaining competitiveness in the different areas of study within the sawmill industry.

Table 4: Literature review showing the summary of the identified documents included in the review.

Author	Objective	Method	Main finding
(E. Hansen et al., 2002)	To investigate the strategies implemented by the softwood lumber industry.	Personal interviews	It was found that companies may not fully understand the forces operating in their business environment.
(Toppinen et al. 2011)	The study examines the types and forms of sawmill cooperation, how the cooperation emerged, and which firm-specific resources are mainly related to cooperation.	Interviews	The study's findings showed that meaningful and beneficial cooperation partnerships exist in the Finnish sawmilling industry, but the sawmill managers do not perceive this collaboration as a strategic resource.
(Johansson, 2008)	The structure and present raw material, production and market conditions of the Swedish hardwood sawmill industry were studied to find ways to increase the industry's competitiveness.	Observations and interviews made during site visits to Swedish hardwood sawmills	Production in the sawmills should be developed towards new markets, products, more efficient production methods, and increased processing knowledge.
(Singer & Donoso, 2008)	Investigate a collaborative approach and propose a model for optimising production and inventory planning decisions within a system of plants.	Modelling followed by simulation.	The authors find an opportunity to increase profits by more than 15 % through higher capacity utilisation and a better assignment of production orders.
(Lahtinen 2007)	Examine the possibilities of employing the RBV in studying the woodworking industry.	Literature review and the methodological framework for applying RBV	Tangible and intangible firm resources have been crucial in creating value-added, enhancing competitiveness, and achieving success in a modern business environment.
(E. N. Hansen, 2010)	The article discusses current innovation research focusing on the forest products industry.	Review	Many competitor nations are actively pursuing innovation-focused strategies.
(Ghebremichael and Potter-Witter 2009)	To analyse the effects of tax incentives on long-run dynamics of total factor productivity (TFP) growth and capital formation in the Canadian sawmilling industry over 40 years (1961–2000)	Simulation	The data validated the hypothesis that tax incentives spur capital formation and growth in TFP (total factor productivity).
(Parhizkar et al. 2009)	To compare hardwood lumber exporting firms to other hardwood lumber firms concerning possible transportation and competitiveness factors for international trade.	Questionnaire	It was found that exporters differed significantly in their transportation methods, marketing activities, and production profiles.
(Gustafsson, 2003)	To specify retailers' basic logistic service requirements, quantify the needs and distinguish potential retail segments regarding these requirements.	Interviews and questionnaires	One way for sawmills to flourish is to develop accurate service elements and use them as a segmentation base to structure their customer base.
(Espinoza et al., 2012)	The work specifies retailers' service requirements and indicates potential segments. The indication is summarised in three hypotheses, which should be tested further.	Online survey	The factors that have impacted firms since the start of the recession (2008) were similar between states, including the housing market, transportation costs, energy costs, and changing customer demand.

(Biernacka & Sedliačiková, 2012)	Analyse the economic condition of wood industry companies listed on the Warsaw Stock Exchange.	The Mączyńska & Zawadzki's model.	Companies with a stable position in the market have the best economic conditions, namely the pulp and paper industry and the furniture industry.
(Šulyová & Koman, 2020)	To improve logistics processes and increase competitiveness in the wood processing sector by implementing new technologies in Slovak wood processing company.	Case study analysis	Implementing the IoT can reduce operating costs by up to 20%, increase added value for customers, and collect real-time data that can serve as the basis for support of management and decision-making at the operational, tactical, and strategic levels.
(Li et al., 2008)	To estimate technical efficiency and total factor productivity growth of the sawmill industries in various United States and Canada regions between 1963 and 2001.	Non-parametric programming	Technical efficiency and total factor productivity growth varied among regions, and all regions except the US West moved towards the industry frontier over time.
(Crespell et al. 2006)	To assess industry practices concerning innovativeness.	Survey	Innovativeness and market orientation were found to be positively correlated.
(Wan & Bullard, 2009)	To help understand competitive issues in the industry, such as the relationships among business-level strategy, competitive industry forces, and business performance.	Implementation of Porter's (1980) typology and survey	The threat of new entrants was somewhat ignored by managers in this industry when they formulated and implemented competitive business-level strategies for firm-level performance.
(Husgafvel et al., 2013)	Review some of the main elements and emerging sustainability management challenges within the Finnish forest products industry.	Review and a questionnaire survey.	Sustainability and life-cycle management are not receiving enough management focus now.
(Singer & Donoso, 2007)	To assist managers in solving strategic decision.	An analytical framework.	The analysis of the upstream-downstream dilemma must focus on the individual capabilities of each firm.
(Gazal & Wang, 2012)	To examine the export activities of the West Virginia Forest products industry.	Mail survey	The top three problems that hindered competitiveness among non-exporters were production costs, lack of capital, and raw material problems.
(Stern et al. 2015)	Assess the potential socio-economic impacts of international competitiveness, resource efficiency, forest product prices, employment and value-added regarding the forest-based sector in Austria.	Simulated by using a system dynamics model called FOHOW	Sawmills profit from biorefineries as they can increase their returns from selling sawmill residues, which secures their entire competitiveness.
(Hietala et al., 2019)	The study compared the Finnish and Swedish sawmill industries and market developments since 1990 and discussed the most eminent country and firm-level differences.	Review	Drivers of competitiveness were identified to stem from the firm-level strategic decisions and the use of internal resources and capabilities. In contrast, the factors related to the

			external environment were less prominent.
(Grobbelaar and Visser 2021)	To determine what aspects significantly impact overall competitiveness and, thus, if mills in a specific location, of a particular size or owner, were more competitive.	Spearman correlation tests	More comparative studies are needed to increase understanding of the developments and state of complex sawmill businesses influenced by myriad internal and external factors.
(Vlosky, 2011)	The paper compared the results of two studies conducted on Louisiana's primary and secondary sectors.	Mailed surveys.	Understanding the markets, plant location decisions, raw material availability, workforce training needs, and other issues can be a competitive advantage for Louisiana manufacturers.
(Nicholls & Bumgardner, 2018)	To find linkages to competitiveness for the North American hardwood industry, to discuss the literature regarding mass customisation and supply chain management.	Review and synthesis.	Elements of competitiveness are apparent in several existing models and research findings that individual firms can adapt to become more competitive.
(Lin & Wang, 2012)	To develop a cost-effective computer-aided log processing simulation system for lumber manufacturing optimisation.	Modelling	The optimisation system can significantly improve lumber value recovery and increase competitiveness in the ever-changing forest products market.
(Gonçalves et al., 2012)	To identify the CHP technologies that can be implemented in sawmills using the available biomass, assess their economic viability and evaluate the critical parameters that contribute to the economic viability of this solution.	Simulation and the economic viability assessment.	Clustering a set of pine wood producers from the same region could make the investment profitable for all the members of this cluster.

Discussions

Factors driving change in the sawmill industry.

Competition within, between and among sawmilling industries has increased over time (Lahtinen 2007; Hansen 2010; Toppinen et al. 2011). The effect of new producers from low-cost countries, export tariffs on wood, merged channels of distribution, trade disputes, and the establishment of limitations on wood availability imposed through forest conservation programmes are further increasing the competition for global market share (Toppinen et al. 2011; Crespell et al. 2006). Lahtinen (2007) highlights that the competitiveness of the companies can no longer be built on

abundant forest resources within national boundaries due to internationalised markets and global trade of wood products and raw materials. The studies also highlighted how sudden changes within the industry could impact its competitiveness. Storms in Sweden in the mid-2000 resulted in Swedish sawmills securing large amounts of logs at considerably lower prices which combated the high wood raw material costs from 2000 through 2014 (Hietala et al. 2019). The Great Recession significantly impacted the forest products industry, with many firms reducing output to remain competitive or closing operations (Espinoza et al. 2012 and Grobbelaar and Visser 2021). Vlosky (2011) showed how the sawmilling industry in some regions of the United States was affected by several factors, such as the housing crash in 2008; two Category 5 hurricanes, Hurricane Katrina and Hurricane Rita, destroyed an equivalent of more than two years' worth of pine saw timber harvest and more than 11 years' worth of hardwood sawtimber harvest for the entire state and the southern pine beetle outbreaks of 1985-86 in the Portuguese forests which threatened the pine wood economic activity as many trees were dying. These events emphasise how the sawmilling industry should be able to adapt to remain competitive.

The factors driving change and their frequencies are identified in the Sankey diagram in Figure 8. The main factors were globalisation (wood products are traded globally), the intensity of rivalry (sawmills are battling each other to supply markets), threats of new entrants (open markets and entry of foreign producers in the areas), non-wood materials (wood products compete with concrete, plastic and steel), and the power of customers (sawmills sell to the same pool of customers). Four of the most occurring identified factors correspond to the theory of Micheal Porter (Porter, 2008), which highlights the forces driving competition in the industry. This was also highlighted by (Wan and Bullard 2009).

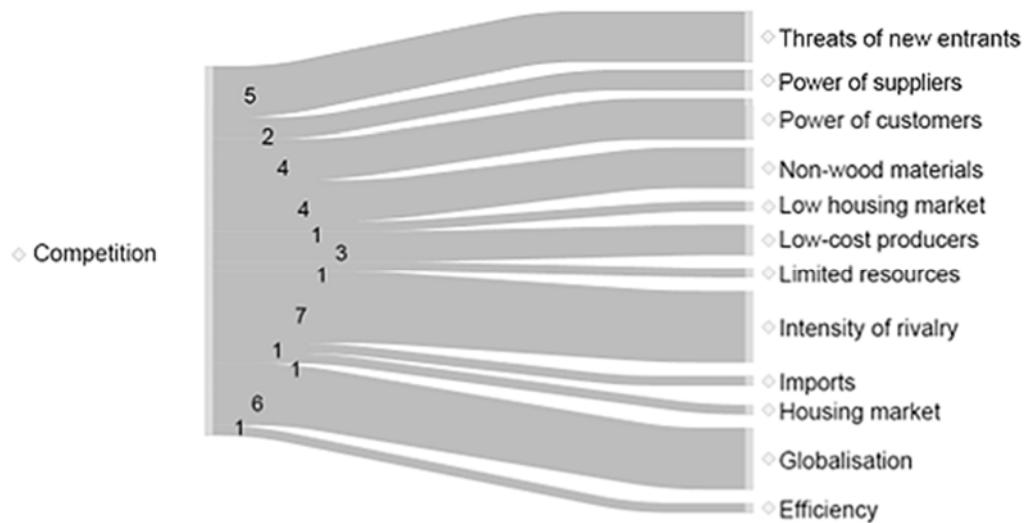


Figure 8: Factors and their frequency of occurrence, leading to competition in the sawmill industry as identified in the reviewed literature

Factors affecting industry competitiveness and the Competitive advantages and disadvantages in the sawmilling industry.

Understanding the variables that lead to competitive advantage in the sawmilling industry is essential. The Sankey diagram in Figure 9 shows the relationship between the identified factors affecting industry competitiveness and the competitive advantages within those industries.

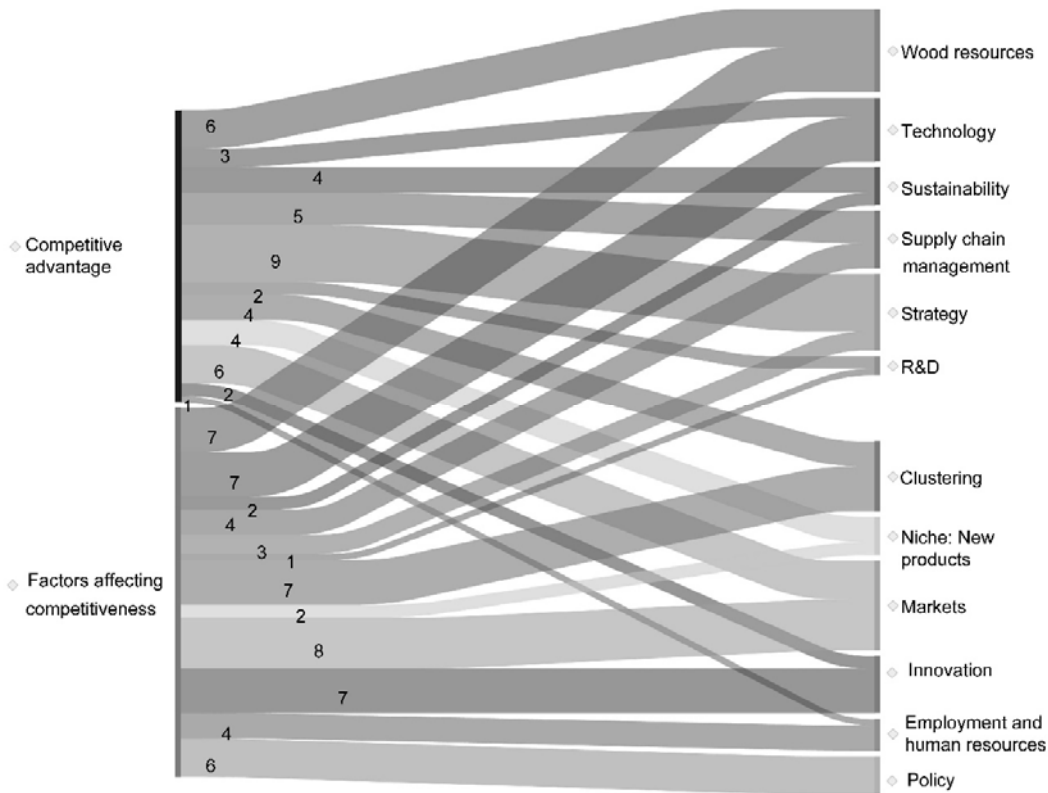


Figure 9: Relationship between the factors and frequency of occurrence, affecting industry competitiveness and sources of competitive advantage as identified in the the reviewed literature.

Different ideas on what leads to competitiveness in the sawmill industry were identified, and various competitive advantages were highlighted. Singer and Donoso (2007) and Singer and Donoso (2008) mention the availability of natural resources to ensure competitive advantage. A resource-based view argues that firms should mobilise resources likely to maximise returns in their chosen markets (Nicholls and Bumgardner 2018). The supply of logs makes use of logistics and the supply chain system involving other industry partners. Logistics and higher supply chain management practice levels can enhance competitive advantage and improve organisational performance in the sawmill industry (Gustafsson 2003; Gazal and Wang 2012; Nicholls and Bumgardner 2018; Hietala et al. 2019). Exporting products offers opportunities to expand market shares, increase sales, serve as an outlet for inventory, and reduce risk (Gazal and Wang 2012).

Grobbelaar and Visser (2021) mention that firms within the industry should develop adaptive leadership skills that will enable them to create competitive advantages. Similarly, Husgafvel et al. (2013) and Nicholls and Bumgardner (2018) state that adaptation is key to ensuring competitive advantage and that businesses should be strategic rather than reactive. Innovation is vital in creating a competitive advantage in wood-based industries (Crespell et al. 2006; Gazal and Wang 2012). Investing in equipment and people is a means to gain a competitive advantage (Gazal and Wang 2012 and Espinoza et al. 2012). Toppinen et al. (2011) argue that service speed and efficiency are necessary to ensure a competitive advantage in marketing products. According to Toppinen et al. (2011), business cooperation and inter-firm collaboration create a competitive advantage in global markets by achieving economies of scale. They also highlight that another way of ensuring competitive advantage is to possess strategic firm-specific resources that are valuable, rare, imperfectly imitable and not easily substitutable.

Šulyová and Koman (2020) argue that monitoring the influences of the external environment and knowing their internal processes can lead to competitive advantage. Nicholls and Bumgardner Nicholls & Bumgardner (2018) highlight that identifying external opportunities in both new and current markets (including niche markets) is a way of gaining a competitive advantage. A more significant competitive advantage can be achieved via product customisation. A study by Johansson (2008) mentions developing the business with new products. Considering that most industries are moving towards sustainable practices, this could explain why Stern et al. (2015) call for implementing biorefinery technologies. Husgafvel et al. (2013) highlight the sustainability of all operations and the reduction of environmental impacts of industrial activities, and sustainability and environmental management to gain a competitive advantage.

How can the sawmilling industry improve and sustain its competitiveness?

A study by Hansen (2010) mentions that research across different industries has shown that New Product Development is critical for long-term competitiveness. They also highlight the importance

of culture and innovation. This is because most resources providing sustainable competitive advantage are intangible, such as innovation, knowledge, customer service and relationship, cognitive change, firm culture, and branding (Hietala et al. 2019). According to Toppinen et al. (2011), creating sustainable competitive advantage depended on the companies within the industry's cooperative networks, which involved inter-firm collaboration between sawmills. Lahtinen (2007) emphasises that the capability to create value-added, rational strategic choices and creative usage of intangible and tangible resources are crucial for sustaining sawmill industry competitiveness in higher cost-level countries.

Gustafsson (2003) argues that logistic services are not easily copied; hence, they could be successfully used to develop a sustainable competitive advantage. Weyerhaeuser and West Fraser Timber (which were number 3 and 1 respectively on the list of the biggest sawmills in the world in 2021 in Figure 2) implement their software systems for simplifying logistical activities, procurement, installation, management, and decision-making support both in-house and externally, which results in sustainability and stable competitiveness in the market (Šulyová and Koman 2020). Johansson (2008) says that a secure raw material supply is necessary to maintain a strong hardwood sawmill industry in Sweden in the future. These findings suggest that each sawmill industry should find unique, relevant and sustainable ways to sustain its competitiveness.

The network diagram in Figure 10 below highlights the opportunities for sustaining the competitiveness of the sawmill industry, as highlighted by the reviewed studies. The main concepts were the availability of wood resources, the state of employment and human resources, the level of investment, technology and innovation, the level of collaboration and cluster initiatives and the influence of government and policies within the industry. The links between the identified documents and the main ideas relating to industry competitiveness help highlight the combination of aspects industries should focus on to sustain their competitiveness in Figure 10.

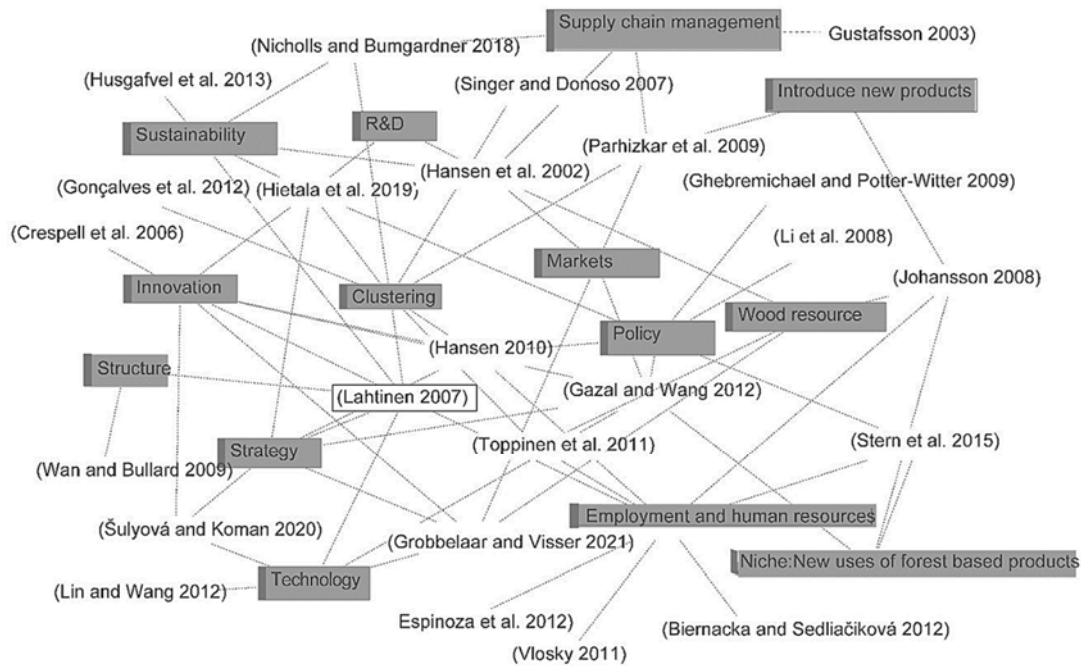


Figure 10: Links and relationships between the reviewed papers and discussed factors relating to industry competitiveness

The following is a discussion of the factors affecting the sawmilling industry’s competitiveness and how they can be implemented in the sawmilling industry to sustain its competitiveness. As discussed in the introduction, some factors include clustering, innovation, internationalisation, employment, technological advancement, differentiation, government, and policies. Exploring these factors within the South African context could be the opportunity to change the future of the sawmilling industry.

Clustering

The resource-based view says a firm can evaluate its current or potential partners by considering firm-level collaboration as a portfolio of complementary strategic resources (Toppinen et al. 2011). Clusters can benefit the industry by forming economic groups where resources are shared between firms (Lahtinen 2007). Wood and transportation industries’ collaboration could improve transportation efficiency (Parhizkar et al. 2009). An example of a cluster within the sector is the

Finnish forest cluster, which focused its research and development through a program called the Finnish Forest Cluster Research Program Wood Wisdom. It aimed to increase the competitiveness of both forestry and the forest products industry through research and cooperation along the value chain (Hansen 2010). This cluster has created a more robust network of researchers and practitioners in the Finish industry.

Policy

Hansen (2010) says policymakers often need to be reminded of the economic significance of the forest products industry. The policy affects industries either positively or negatively. Ghebremichael and Potter-Witter (2009) highlighted how the national taxation policy prescriptions that raised capital costs negatively affected the sawmill industry in Canada. A country's policy can positively drive industry competitiveness, like in the case of Europe, where policy tends to focus on innovation systems (Hansen 2010). Stern et al. (2015) showed how a policy favourable to implementing biorefinery technologies secured the competitiveness of the European pulp and paper industry since sawmills profit from biorefineries by increasing their returns from selling sawmill residues.

Innovation

Innovativeness has positively impacted the competitiveness and profitability of wood products enterprises. However, the innovative activity of the forest product cluster is well below numerous other clusters (Lahtinen 2007). According to Crespell, Knowles and Hansen (2006), softwood sawmills are usually characterised as being production-oriented and not seen as highly innovative. However, their study showed that more new products, highly used new product development tools, and a more structured new product development tools process were created by highly innovative and medium-innovative sawmills.

Technology

Investment in technology and equipment can result in immediate savings in production costs through increased output, better yields, and less waste (Espinoza et al. 2012). It is also emphasised by Šulyová and Koman (2020), who argued that firm culture must change and realise that technologies are not a threat or wasted expense but rather an opportunity to boost competitiveness, lower costs, retain loyal customers, and draw new ones. Their study showed how implementing Internet of Things technology in logistics offered a unique perspective on traditional operating activities.

Employment

Sawmills should focus not only on technological investments but also on their workforce. Vlosky (2011) emphasises the need for a trained and qualified workforce in the sawmill industry. It was, however, noted that investments in education and training are often the first things to be eliminated within firms during difficult times (Espinoza et al., 2012). Stern et al. (2015) noted that introducing biorefineries may positively affect employment. New jobs in the value chain are created, and current positions in the pulp, paper and sawmilling business are secured.

Conclusions

The sawmill industry is constantly changing in its structure due to factors such as competition and the effects of globalisation. Sudden changes within an industry can reposition the industry's competitiveness. This implies that for firms to remain competitive and sustain their competitiveness, there should be constant adjustments to align with the market conditions. Just as Michael Porter highlighted that the structure of an industry counted more than individual firm performance, it was noted that market conditions in the industry affect individual firms. This suggests that firms within the South African sawmill industry should consider forming clusters to maximise their local and international product offerings rather than focus on competing against each other. An analysis of the sawmill industry also revealed that innovation activities are limited. This presents an opportunity for firms in the industry to prioritise research and development to identify product niches that each firm within the industry can focus on to strengthen the industry as a whole. The main factors identified as

affecting competitiveness and the industry's competitive advantages were the strategy used in the industry, the market conditions, innovation activities, the formation of clusters, the use of new technologies, available wood resources and the policies in place.

Recommendations

The future study should evaluate the South African sawmill industry's competitiveness and why it lags behind other industries. Studies could focus on the available resources within the industry and how they can be exploited to ensure competitive advantage. Other studies could focus on the structure of the industry.

Acknowledgements — This work is based on the research supported partly by the National Research Foundation of South Africa (Grant Numbers 128910) and the DHET-nGAP funding.

Reference

- Acar, A. Z., & Acar, P. (2012). The Effects of Organizational Culture and Innovativeness on Business Performance in Healthcare Industry. *Procedia - Social and Behavioral Sciences*, 58, 683–692. <https://doi.org/10.1016/j.sbspro.2012.09.1046>
- Arshed, N., & Mcfarlane, J. (2016). *Enterprise and its Business Environment Porter 's Five Forces and Generic Strategies*. January.
- Biernacka, J., & Sedliačiková, M. (2012). Analiza konkurentnosti tvrtki drvnog sektora koje su na varšavskoj burzi metodom odabranog omjera i ranog upozorenja o bankrotu. *Drvna Industrija*, 63(3), 187–193. <https://doi.org/10.5552/drind.2012.1212>
- Crespell, P., Knowles, C., & Hansen, E. (2006a). Innovativeness in the North American softwood sawmilling industry. *FOREST SCIENCE*, 52(5), 568–578.
- Crespell, P., Knowles, C., & Hansen, E. (2006b). Innovativeness in the North American softwood sawmilling industry. *Forest Science*, 52(5), 568–578.
- Dean, B., Jones, L., Garfjeld Roberts, P., & Rees, J. (2017). What is Known About the Attributes of a Successful Surgical Trainer? A Systematic Review. *Journal of Surgical Education*, 74(5), 843–850. <https://doi.org/10.1016/j.jsurg.2017.01.010>
- Espinoza, O., Smith, R., Lyon, S., Quesada-Pineda, H., & Bond, B. H. (2012). Educational needs of the forest products industry in Minnesota and Virginia in 2012. *Forest Products Journal*, 62(7–8), 613–622. <https://doi.org/10.13073/FPJ-D-12-00106.1>
- Gazal, K. A., & Wang, J. (2012). Export activities of central appalachian hardwood products

- industry: The case of West Virginia. *Forest Products Journal*, 62(7–8), 607–612.
<https://doi.org/10.13073/FPJ-D-12-00097.1>
- Ghebremichael, A., & Potter-Witter, K. (2009). Effects of tax incentives on long-run capital formation and total factor productivity growth in the Canadian sawmilling industry. *FOREST POLICY AND ECONOMICS*, 11(2), 85–94. <https://doi.org/10.1016/j.forpol.2008.09.004>
- Gonçalves, N., Faias, S., & de Sousa, J. (2012). Biomass CHP technical and economic assessment applied to a sawmill plant. *Renewable Energy and Power Quality Journal*, 1(10), 1206–1211. <https://doi.org/10.24084/repqj10.638>
- Grobbelaar, S., & Visser, J. K. (2021). An analysis of South African sawmilling competitiveness. *Southern Forests*, 83(1), 28–37. <https://doi.org/10.2989/20702620.2020.1813646>
- Gustafsson, Å. (2003). Logistic services as competitive means - Segmenting the retail market for softwood lumber. *Silva Fennica*, 37(4), 493–504.
- Hansen, E. N. (2010). The role of innovation in the forest products industry. *Journal of Forestry*, 108(7), 348–353.
- Hansen, E. N., Nybakk, E., Bull, L., Crespell, P., Jelvez, A., & Knowles, C. (2011). A multinational investigation of softwood sawmilling innovativeness. *SCANDINAVIAN JOURNAL OF FOREST RESEARCH*, 26(3), 278–287. <https://doi.org/10.1080/02827581.2011.553198>
- Hansen, E., Seppälä, J., & Juslin, H. (2002). Marketing strategies of softwood sawmills in Western North America. *Forest Products Journal*, 52(10), 19–25.
- Heiskanen, A., Hurmekoski, E., Toppinen, A., & Näyhä, A. (2022). Exploring the unknowns – State of the art in qualitative forest-based sector foresight research. *Forest Policy and Economics*, 135(October 2021). <https://doi.org/10.1016/j.forpol.2021.102643>
- Hietala, J., Hänninen, R., Kniivilä, M., & Toppinen, A. (2019). Strategic Management Towards Competitive Advantage—Patterns of Internationalization in the Finnish and Swedish Sawmill Industries. *Current Forestry Reports*, 5(4), 199–209. <https://doi.org/10.1007/s40725-019-00100-8>
- Husgafvel, R., Watkins, G., Linkosalmi, L., & Dahl, O. (2013). Review of sustainability management initiatives within Finnish forest products industry companies - Translating Eu level steering into proactive initiatives. *Resources, Conservation and Recycling*, 76, 1–11. <https://doi.org/10.1016/j.resconrec.2013.04.006>
- Imran, S., Mahmood, T., Morshed, A., & Sellis, T. (2021). Big data analytics in healthcare. A systematic literature review and roadmap for practical implementation. *IEEE/CAA Journal of Automatica Sinica*, 8(1), 1–22. <https://doi.org/10.1109/JAS.2020.1003384>
- Independent Evaluation Group. (2016). Industry Competitiveness and Jobs. In *Industry Competitiveness and Jobs*. <https://doi.org/10.1596/25294>
- Indiatsy, C. M., Mwangi, M. S., Mandere, E. N., Bichanga, J. M., George, G. E., Mandere, E. N., & Bichanga, J. M. (2014). *The Application of Porter 's Five Forces Model on Organization Performance : A Case of Cooperative Bank of Kenya Ltd*. 6(16), 75–86.
- International Forest Industries. (2022). Spruce bark beetle and its impact on wood markets - International Forest Industries. *International Forest Industries*.
- Jauk, G. (2021). *The world's biggest sawmills in 2021*. Timber Online.
- Jaya, P. E. J., & Yuliarmi, N. N. (2019). Factors Influencing Competitiveness of Small and Medium Industry of Bali: Porter'S Five Forces Analysis. *Russian Journal of Agricultural and Socio-*

- Economic Sciences*, 89(5), 45–54. <https://doi.org/10.18551/tjoas.2019-05.06>
- Johansson, J. (2008). The Swedish hardwood sawmill industry: Structure, present status and development potential. *Wood Material Science and Engineering*, 3(3–4), 94–101. <https://doi.org/10.1080/17480270902778135>
- Jucevi, R., & Stankevi, J. (2004). *Clusters as a Tool for National Development*. 2(2), 37–45.
- Korhonen, J., Hurmekoski, E., Hansen, E., & Toppinen, A. (2018). Firm-level competitiveness in the forest industries: Review and research implications in the context of bioeconomy strategies. *Canadian Journal of Forest Research*, 48(2), 141–152. <https://doi.org/10.1139/cjfr-2017-0219>
- Lahtinen, K. (2007). Linking resource-based view with business economics of woodworking industry: Earlier findings and future insights. *SILVA FENNICA*, 41(1), 149–165. <https://doi.org/10.14214/sf.312>
- Lehtonen, O., & Tykkyläinen, M. (2014). Delphi path simulator for unveiling development opportunities in the forest industries by contrasting forest management practices - The case of North Karelia. *Technological Forecasting and Social Change*, 84, 171–185. <https://doi.org/10.1016/j.techfore.2013.08.005>
- Li, Y., Zhang, D., & Nagubadi, R. V. (2008). Productivity in the U.S. and Canadian sawmill industries: A nonparametric programming analysis. *Forest Products Journal*, 58(12), 33–40.
- Lin, W., & Wang, J. (2012). An integrated 3D log processing optimization system for hardwood sawmills in central Appalachia, USA. *COMPUTERS AND ELECTRONICS IN AGRICULTURE*, 82, 61–74. <https://doi.org/10.1016/j.compag.2011.12.014>
- Marshall, C., & Brereton, P. (2013). Tools to support systematic literature reviews in software engineering: A mapping study. *International Symposium on Empirical Software Engineering and Measurement*, 296–299. <https://doi.org/10.1109/ESEM.2013.32>
- Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & Delgado-López-Cózar, E. (2019). Google Scholar, Web of Science, and Scopus: Which is best for me? | Impact of Social Sciences. *LSE Impact Blogs*, 1–4. <https://blogs.lse.ac.uk/impactofsocialsciences/2019/12/03/google-scholar-web-of-science-and-scopus-which-is-best-for-me/?fbclid=IwAR2kaaLZwXq-LsgnHmFfdAHbnLhpt-sSEggCs4TPsO79T1u4Bn9sHYbgiu0>
- Nicholls, D. L., & Bumgardner, M. S. (2018). Challenges and opportunities for North American hardwood manufacturers to adopt customization strategies in an era of increased competition. *Forests*, 9(4). <https://doi.org/10.3390/f9040186>
- Parhizkar, O., Smith, R. (Bob) L., & Miller, C. R. (2009). Comparison of important competitiveness factors for small- to medium-sized forest enterprises. *FOREST PRODUCTS JOURNAL*, 59(5), 81–86.
- Porter, M. E. (1998). *Clusters and the new economics of competition* (Vol. 76, Issue 6). Harvard Business Review Boston.
- Porter, M. E. (2008). The five competitive forces that shape strategy. *Harvard Business Review*, 86(1), 78.
- Ritchie, H., & Max, R. (2021). *Forests and Deforestation*. Our World in Data.
- Savić, N., Stojanovski, V., & Stojanovska, M. (2011). Analyses of the Competitiveness of Forest Industry in the Republic of Macedonia. *South-East European Forestr*, 13–21.
- Singer, M., & Donoso, P. (2007). Internal supply chain management in the Chilean sawmill

- industry. *International Journal of Operations and Production Management*, 27(5), 524–541. <https://doi.org/10.1108/01443570710742393>
- Singer, M., & Donoso, P. (2008). Upstream or downstream in the value chain? *JOURNAL OF BUSINESS RESEARCH*, 61(6), 669–677. <https://doi.org/10.1016/j.jbusres.2007.06.043>
- Stern, T., Ledl, C., Braun, M., Hesser, F., & Schwarzbauer, P. (2015a). Biorefineries' impacts on the Austrian forest sector: A system dynamics approach. *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE*, 91, 311–326. <https://doi.org/10.1016/j.techfore.2014.04.001>
- Stern, T., Ledl, C., Braun, M., Hesser, F., & Schwarzbauer, P. (2015b). Biorefineries' impacts on the Austrian forest sector: A system dynamics approach. *Technological Forecasting and Social Change*, 91, 311–326. <https://doi.org/10.1016/j.techfore.2014.04.001>
- Stonehouse, G., & Snowdon, B. (2007). *Competitive Advantage Revisited: Michael Porter on Strategy and Competitiveness*. September. <https://doi.org/10.1177/1056492607306333>
- Šulyová, D., & Koman, G. (2020). The significance of IoT technology in improving logistical processes and enhancing competitiveness: A case study on the World's and Slovakia's wood-processing enterprises. *Sustainability (Switzerland)*, 12(18). <https://doi.org/10.3390/SU12187804>
- Toppinen, A., Lahtinen, K., Leskinen, L. A., & Osterman, N. (2011). Network Co-Operation As a Source of Competitiveness in Medium-Sized Finnish Sawmills. *SILVA FENNICA*, 45(4), 743–759. <https://doi.org/10.14214/sf.102>
- Toppinen, A., Sauru, M., Pätäri, S., Lähtinen, K., & Tuppuru, A. (2019). Internal and external factors of competitiveness shaping the future of wooden multistory construction in Finland and Sweden. *Construction Management and Economics*, 37(4), 201–216. <https://doi.org/10.1080/01446193.2018.1513162>
- Van Horne, C., Frayret, J. M., & Poulin, D. (2006). Creating value with innovation: From centre of expertise to the forest products industry. *Forest Policy and Economics*, 8(7), 751–761. <https://doi.org/10.1016/j.forpol.2005.06.003>
- Vlosky, R. P. (2011). Usporedba primarnoga i sekundarnog sektora drvnih proizvoda u državi Louisiani. *Drvna Industrija*, 62(3), 201–211. <https://doi.org/10.5552/drind.2011.1107>
- Vrontis, D., Tardivo, G., Bresciani, S., & Viassone, M. (2018). The Competitiveness of the Italian Manufacturing Industry: an Attempt of Measurement. *Journal of the Knowledge Economy*, 9(4), 1087–1103. <https://doi.org/10.1007/s13132-016-0397-1>
- Wan, Z., & Bullard, S. H. (2009). Competitive strategy and business performance in the U.S. upholstered, wood household furniture industry. *Forest Products Journal*, 59(9), 15–19.
- Weiss, G., Ludvig, A., & Živojinović, I. (2020). Four decades of innovation research in forestry and the forest-based industries – A systematic literature review. *Forest Policy and Economics*, 120(7), 102288. <https://doi.org/10.1016/j.forpol.2020.102288>
- Wellner, S., & Lakotta, J. (2020). Journal of Rail Transport Planning & Management Porter ' s Five Forces in the German railway industry. *Journal of Rail Transport Planning & Management*, 14(October 2018), 100181.
- Wu, K.-J., Tseng, M.-L., & Chiu, A. S. F. (2012). Using the Analytical Network Process in Porter's Five Forces Analysis – Case Study in Philippines. *Procedia - Social and Behavioral Sciences*, 57, 1–9. <https://doi.org/10.1016/j.sbspro.2012.09.1151>