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Identifying present drivers of product development and describing roles of identified actors primarily affecting the development of harvesters: a multiple-case study

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Highlights

- Legislators, logging contractors, and expert and research organizations are present drivers of product development of harvesters.
- They appear to prioritize meeting legal regulations and lowering costs for logging contractors as they outline requirements for manufacturing harvesters.

Abstract

Forest operations involve several different actors. Each actor imposes their own requirements on the harvester in relation to their differing roles in the industry, whether they are concerned with the harvester itself, information, environmental concerns, etc. The manufacturers of harvesters need to meet the requirements imposed by multiple actors, among them logging contractors, whose survival depends on their harvesters. This paper aims to identify the present drivers of product development and describe the roles of the actors who have been identified as those currently affecting the development of harvesters. A multiple-case study of harvester manufacturers was conducted. In total, 4 cases were studied. Each case was comprised of five interviewees: two from each harvesting manufacturer, two logging contractors, and one dealer. Following 20 interviews and 3 validation interviews (with experts from both the industry and academia), the paper concludes that the present drivers of product development of harvesters are legislators, logging contractors, and expert and research organizations. Harvester manufacturers appear to develop harvesters aligned with requirements coming from both logging contractors and legislators. Logging contractors are the primary customers, and they prioritize requirements that reduce cost and improve work environments. Legislators, and expert and research organizations are supporting development in relation to current regulations.

Keywords forest operations; industry driver; interview; logging contractor; softwood lumber supply chain
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1 Introduction

Logging contractors (henceforth referred to as LCs) are vital actors in the supply chain for softwood lumber and perform a significant share of forest work (Kronholm et al. 2021). According to Nordfjell et al. (2010), there are signs of declining productivity amongst Swedish LCs, and Kronholm et al. (2021) asserts that Swedish LCs suffer from low profitability. Further, Gustafsson (2017) found that many LCs perceive the harvesting industry as a capital-intensive industry, with high turnover and low profit margins for LCs. Most LCs are either man-to-man or have just 1–4 employees (Kronholm et al. 2021). Lefévre (2011) and Sandström (2014) have similarly addressed the ways in which actors in the harvesting industry struggle with problems such as low profitability (Lefévre 2011) and capacity losses (Sandström 2014). A similar study by Jylhä et al. (2020) shows that Finnish small harvesting companies also have problems with profitability.

Regardless of the problems faced by LCs, they depend heavily on their individual harvesters and the operational reliability of their equipment (Karvinen and Nummelin 2015). However, according to Björheden (2020), LCs are not able to utilize their harvesters' full capacity, largely because the development of harvesters has prioritized efficiency and maximum engine power. The development of forest operations has been rapid; from farm tractor development into forwarders in the 1950s to today's well-equipped Cut-To-Length (CTL) technique (Nordfjell et al. 2019). Currently CTL harvesting is conducted with a harvester and a forwarder (known as a two-machine system); harvesters fell and process trees into logs whereby the forwarder carries and transports the logs to the roadside (Nordfjell et al. 2010). The mechanization of forest operations occurred in Sweden during the 1960s and 70s resulting in industrial production of forestry equipment. During the 1970s, an economic recession led to stagnation and restriction, leading to the introduction of international brands into the domestic market (Andersson 2004). The Swedish market is dominated by Swedish and Finnish manufacturers; Rottne and Komatsu being two prominent Swedish manufacturers. Regarding forwarders, Nordfjell et al. (2019) state that one important driving factor for development is the increasing volume of harvested wood for industrial purposes; the authors continue to say that development is largely dependent on progress in other vehicle industries.

From a logistic perspective, LCs are considered as a customer to the harvest manufacturer. To continuously improve the efficiency of LCs' operations and reduce their costs, harvester manufacturers need to ensure that their product (harvesters) development and enhancement is respondent to the requirements of their customers (LCs). After all, understanding the current development in any industry requires identifying and understanding the existing drivers (Lindblad and Schauerte 2017). Understanding the present drivers allows manufacturers to support means of generating value for customers in what is called *customer-based product development*. In that sense, a company's success or failure depends on the level of value that it delivers to its customers. As a result, customers' requirements are highly valuable, if not essential (Christopher 2016). Cooper (2019) has even claimed that "the best ideas come from customers". Further, Kahn et al. (2006) lists the market as being one of the six dimensions for product development practice they suggest.

Market orientation positively impacts a company's profit level (Narver and Slater 1990). In forest industries, however, such value-oriented perspectives primarily address the manufacturing side (e.g., saw and pulp mills), not the development on the supply side (i.e., harvesting and forwarding) since research is primarily associated with issues of productivity and cost (Häggström 2015). For instance, a study conducted by Laitila and Väätäinen (2020) identified average harvesting volume and forwarding distance, as well as distance between working locations, to be key elements to productivity. This is supported in Nordfjell et al. (2010).

Further, LCs are important actors in the supply chain (Kronholm et al. 2021) for softwood lumber because they set the foundation for its continued operation. Amid intense competition and low profit levels in the harvesting industry (Penttinen et al. 2011; Gustafsson 2017; Kronholm et al. 2021), LCs depend heavily on their harvesters. The LCs are both the users and the customers of the harvester and are hence decision makers in the selection of a harvester. At the same time, technology for large-scale forest operations has developed quickly (Nordfjell et al. 2010). As a result, the practice of accounting for the current requirements of LCs will afford harvest manufacturers new possibilities for creating value. According to Vogel and Lasch (2018), it is fundamental for a company to quickly bring high quality products to the market that have been adjusted to meet customer needs.

According to Björheden (2006), the importance of different drivers and their effects differs between industries. In that light, the lack of knowledge regarding individual drivers of product development (henceforth referred to as DPD) of harvesters, is not only a practice-oriented problem but also a theoretical problem. It is a practical problem for the survival of LCs and the development of the supply chain for softwood lumber and a theoretical problem due to the limited capacity to extend theories on the specific DPD. In view of those problems and approaching from the perspective of the supply side with a focus on harvesters, in our study, we assess the need for supply chain development from the view that harvesting is a service provided as part of forest operations. Thus, the aim of our exploratory research was to identify the present DPD and describe the roles of the actors who have been identified as those currently affecting DPD of harvesters. This paper contributes to the field by examining the supply side and identifying DPD in the industry for harvester manufacturing. More specifically, we focus on harvesting. Fig. 1 illustrates the object of our study.

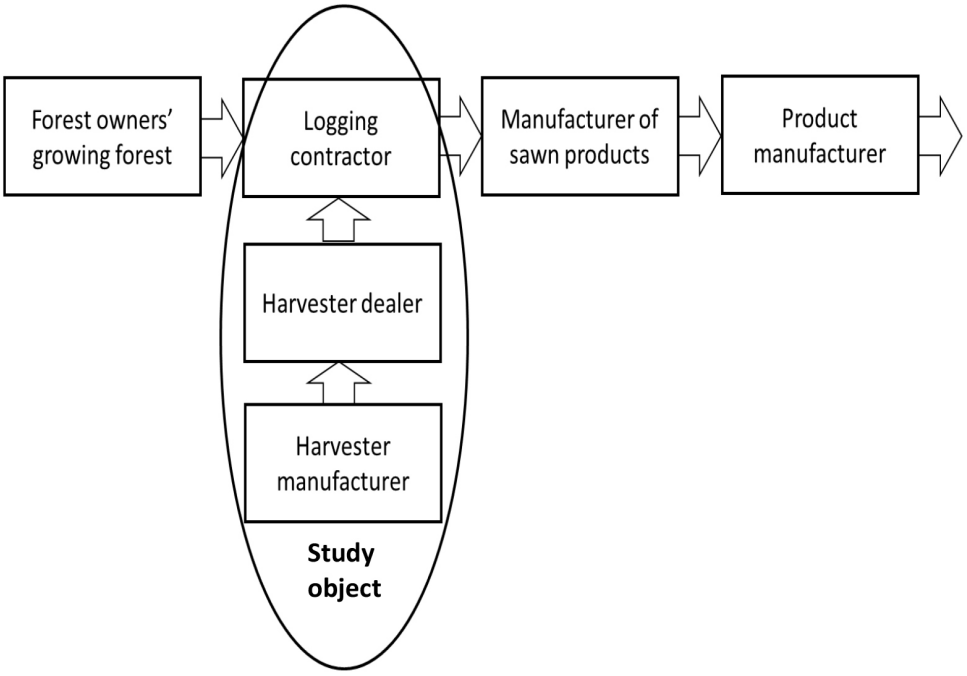

Fig. 1. Actors in forest operations in the softwood lumber supply chain in the studied area (Sweden) and illustration of the study object.

2 Materials and methods

2.1 Theory on development factors and development in the context of forest operations

Cooper (2019) describes three categories of DPD. The *first category DPD* is described as tactical, and may concern customer focus, preparation work, and thinking about the global aspects of the product as well as keeping value proposition aspects in mind. The *second category* includes DPD from a business level perspective and is related to aspects such as adoption of an innovation strategy, organization, leadership, and the overall formation of the climate and culture of the organization. The *third category* DPD focuses on systems and methods used for new product development in the organization. Success in development is further described, regardless of context, to have some things in common. For example, it is important to have an innovative strategy, do solid voice-of-customer research, and put together effective cross-functional teams.

Asikainen et al. (2011) reported that activities in research and development related to the handling of biomass in forest operations have focused on developments trending towards increased productivity through efficient use of manpower. Primarily, these developments have worked through improved harvest operator supporting systems that tutor the harvest operators in conducting their work, assist work cycle planning, and provide feedback.

A specific development factor of forest operations relates to mitigating the negative environmental impact caused by driving heavy machinery during forest operations. For example, soil bearing capacity can be estimated by advanced sensing techniques that can understand how the machine behaves in relation to the soil properties and account for it, for example, by adjusting machine nominal ground pressure through weight distributions (Asikainen et al. 2011).

According to Asikainen et al. (2011), harvest operators can develop and use the connection between different sensors monitoring both the machine and its perceptions as well as input from ground sensors as a means of guiding decision making, thereby, improving performance.

Picchio et al. (2019) also discuss advancements in information technologies used in forest operations. These authors focus on the need for an integrated use of new technologies. The interdisciplinary fields of mechanical and electrical engineering are posed as an ongoing important

Table 1. Overview of previous empirical studies that identified drivers of product development.

Author/s	Industry studied	Entrepreneurial innovativeness	Human capital	Organizational characteristics	Progress in technology	Competitive position and Occupy leading position	Market orientation and Consumer demands	Distribution channel and business image
Acur et al. (2012)	NPD in different industries					X	X	X
Boso et al. (2012)	Diverse	X					X	
Manley and Mcfallen (2006)	Construction			X				
Pantano et al. (2014)	Advanced-technology-based innovations	X	X	X	X	X		
Parrilli and Elola (2012)	Traditional manufacturing			X				
Rhee et al. (2010)	Technology-innovative	X					X	
Total		3	1	3	1	2	3	1

trend that should act together and be fully integrated in the development of new technologies to support forest operations services.

We identified possible DPD of harvesters by pinpointing and examining DPD previously identified in past empirical studies in relation to manufacturing or innovation in other industries (Table 1) to gain an overview of possible DPD in the harvest industry.

2.2 Empirical method

The case-study method is implemented in exploratory research aimed at understanding, for instance how different contemporary phenomena occur (Yin 2017). It is recommended when the phenomena under study need to be examined in their natural contexts (Eisenhardt 1989). According to Näslund (2002), solutions to practice-oriented problems ought to be sought using case studies, and Yin (2017) has highlighted their usefulness in studying contemporary, real-life phenomena in settings that researchers cannot sufficiently control. For those reasons, we deemed the case-study method to be appropriate for our research on DPD of harvesters, over which we have no control or means of control. The current research adheres to the case-study category of theory extension (Dinwoodie and Xu 2008; Ketokivi and Choi 2014), for we sought to extend our theory on DPD to the harvest manufacturing industry.

Despite a lack of generally accepted guidelines for assessing case-study research (Eisenhardt 1989; Näslund 2002), we followed Yin's (2017) principles for designing, presenting, and analyzing data. For example, we used multiple sources of evidence. We also maintained a chain of evidence and exercised care in using data from electronic sources. The criteria of research quality we established for each stage are specified in Table 2.

Case studies can explore single or multiple cases in-depth to identify common patterns and characteristics in a phenomenon (Yin 2017). For theory extension, multiple-case studies can be expected to facilitate more robust theories (Barratt et al. 2011) than single-case studies. Additionally, Eisenhardt (1989) has suggested that a study including 4 to 10 cases is preferable to one studying fewer cases than 4, as fewer cases can make it difficult to grasp the complexity of the phenomenon studied. In our multiple-case study, we followed Yin's (2017) procedure, which entails (1) defining and designing, (2) preparing, collecting, and analyzing in-case data, and (3) analyzing cross-case patterns and drawing conclusions.

To illustrate and understand the primary actors and possible future developments of harvesters, interviews were conducted with each actor involved in harvesting: Harvest Manufacturers (HMs), Harvest Dealer (HD), and Logging Contractors (LCs). Nordfjell et al. (2019) reported that the forest equipment used in Sweden is usually manufactured in Finland or Sweden and identified five main manufacturers related to forest equipment (harvesters and forwarders). The first case was chosen because both the headquarters and one of the production sites for one of the manufacturers

Table 2. Criteria of research quality fulfilled in the study.

Criterion	Research phase	Establishment
Construct validity	Data collection	Use multiple sources of evidence in data collection Have informants review the draft case-study report during data collection
External validity	Research design	Use replication logic in the research design
Internal validity	Data analysis	Complete pattern-matching Discuss alternative explanations for relationships
Reliability	Data collection	Use case-study protocols for data collection

identified by Nordfjell et al. (2019) is in close proximity to our research team. From there, each subsequent case was identified by asking the previous case organization to answer a final question in our interview, "Which manufacturers of harvesters would you consider to be at the forefront of development and ought to be included in our study?". Hence, subsequent individual cases were identified through linear snowball sampling (Alkassim et al. 2015). Snowball sampling is convenient to use when the researcher focuses on tracing connections (Bell et al. 2022:200). Interviewees from the harvester manufacturers were marketing or development directors, whereas interviewees at the harvester dealers were employees responsible for the identified manufacturer, and LCs were the owners of the identified harvester. Regardless of position or affiliation, all interviewees were asked to recommend, via snowball sampling within the case, additional respondents for supplementary interviews. Further, each respondent was asked, "Which manufacturers of harvesters would you consider to be at the forefront of development and ought to be included in our study?" to identify the coming participating manufacturer. Using multiple sources of evidence in data collection ultimately strengthened construct validity. In all, 20 interviews were conducted in four cases, each consisting of interviews with two manufacturer representatives, an interview with a representative of the dealers, and two interviews with representatives from the LCs. All HD and LC use harvesters from participating manufacturers, and this was a requirement for them to be included in the study. The interviews were carried out during 2020 and were evenly spread across Sweden. To maintain the interviewees' confidentiality, we coded them by case (i.e., Cases 1–4), actor (i.e., HM = harvester manufacturer, HD = harvester dealer, LC = logging contractor), and respondents such that, for example, "1.HM.1" indicates Case 1, in an interview with the harvester manufacturer represented by Respondent 1.

The interviews were structured to gather open-ended answers to questions posed by the interviewers (Supplementary file S1 *Interview guides,* available at https://doi.org/10.14214/sf.10660). Throughout each interview, which lasted approximately 1 hour, we asked follow-up questions, and afterward, the interview transcripts were sent to each interviewee for commentary, correction, and approval. Reliability was ensured by clear documentation according to case-study protocols, which generally aim to produce and present a common structure for the empirical data. To be able to identify DPD of harvesters in our study, we designed case-study protocols to pinpoint past developments and identify their DPD as well as to predict future developments and their distinct DPD. The connection between themes of the case-study protocols and the specific interview questions is illustrated in Table 3.

The case-study protocols were compared to determine the consistency of responses to each interview guide which enhance reliability. The individual cases had similar empirical patterns, which strengthens multiple-case studies (Yin 2017). To ensure validity, the sources of evidence used in data collection and the case-study reports have been verified by the interviewees via email. The final article was sent to the interviewees representing the manufacturers, and a Swedish version of the results was verified by the dealers and logging contractors. Further, validation interviews were conducted to assess the reliability and validity of our findings.

Table 3. Connection between themes of the case-study protocols and interview questions in the study.

Theme of case-study protocol	Question in the interview guide (see Appendices 1–4)
Previous developments and identification of their drivers	Please describe the development of harvesters in the past 10 years, including developments that you have prioritized in that time. Who or what drove those developments?
Predicted future developments and identification of their drivers	What do you think the development of harvesters will focus on in the next 10 years? Who or what will drive those developments?

Section 3 presents the empirical results of the multiple-case study of harvester manufacturers and the results of the within-case and cross-case analyses appear in Section 4. In within-case analyses, each case was written as a narrative according to a predetermined table of contents, and differences in answers among the interviewees were sorted and analyzed. The cross-case analyses captured two perspectives – that of the case and that of the actor – with the intention of discovering patterns of differences and similarities via pattern matching. That strategy follows the advice of Yin (2017), who has stated that pattern matching is an appropriate analytical technique if the pattern of predicted descriptive characteristics was described before the data were collected.

The final results of the multiple case-study were verified in validation interviews with experts both within industry and academia. The respondents for these validation interviews representing the industry included one representative from HMs and one from LCs. The respondents from the validation interviews agreed on the results of the multiple case-study and added that even though the work HMs do in product development is similar, the differences between manufacturers lie in the maintenance and services they offer.

3 Results

This section presents the empirical results in subsections that respectively treat each case. Each section first introduces the case then details the empirical data gathered (individual statements are presented in Suppl. file S2).

3.1 Case 1

Case 1 comprises a well-developed network of dealers in which the manufacturer has close contact with each individual dealer. The manufacturer and the dealer we interviewed have been working together since the manufacturer's establishment, during which time the manufacturer has continually sought to increase the technical utilization (i.e., productivity rate) of their harvesters. The LCs choice of manufacturer is based on the reliability of the manufacturers' harvesters and its additional service offerings.

The manufacturer's representatives stated that the actors in the industry for harvester manufacturing offer a standardized range of technologically mature harvesters. Since the harvester manufacturer launched operations, three phases of development – mechanics, hydraulics, and control systems – are described by all interviewees. In the past five years, development has (according to the HM) focused on improving the work environment for the LCs (meaning, development relating to the comfort and utility of the cabin, e.g., by adding elastic cabins) and fuel consumption of its harvesters, as well as on meeting legal requirements and preparing for anticipated legislation. Meeting the requirements from the LC is a focus for the harvester manufacturer (SF2;1.HM.1.).

The manufacturer's representatives stated that few actors possess enough capacity to lead and keep pace with development and innovation in the harvesting industry, and therefore, the manufacturer follows its competitors closely. Beyond that, the harvesting industry is subject to legal regulations. To identify DPD, the manufacturer's representatives identified competitors and expert and research organizations such as SKOGFORSK as important players. Representatives from the manufacturer and dealers meet at fairs and discuss suggestions for development and then the manufacturer determines which developments should be conducted. Once requirements are communicated, the manufacturer seeks to align each specific requirement with different production needs. If the requirement meets economic calculations and can be entered into the existing production line, then it is added to the harvesters (SF2;1.HM.2.).

Respondents representing the dealers and manufacturers identified improvements to ensure low-costs on a day-to-day basis for the LC, whereas the LC identified the comfort level of the harvester cabin (SF2;1.LC.1.) as important. The representatives for HM and HD predicted that future development will focus on automation and hybrid engines; automation is expected to increase productivity, whereas hybrid engines can offer environmental benefits and lower fuel costs. The manufacturer's representatives identified the LCs and the different expert and research organizations as DPD.

3.2 Case 2

The harvester manufacturer in Case 2 produces a full range of harvesters, sold on a market accessed by the dealers that it employs. The representatives of the LCs stated that they have continued using the manufacturer due to the size and exceptional reliability of its harvesters.

All interviewees agreed that the harvesters are standardized products and that their development has focused on increasing productivity (e.g., via mechanics, hydraulics, and control systems). According to representatives of the harvest manufacturer, the recent developments focused on the work environment of LCs (as required by the LCs) (SF2;2.HM.1.) and the reduction of emissions (as required by legislators) (SF2;2.HD.1.). However, it appears as if work comfort is prioritized. According to the manufacturer, the greatest developments in recent years have focused on "what's inside the shell" – that is, the engine – as well as in hydraulics (SF2;2.HM.2.).

In the 1970s, large forest companies invested in different development projects, but more recently, the development is supposed to be done by the manufacturers (SF2;2.HM.2.). Meanwhile, the dealer perceived the LCs to possess an interest in technology and therefore requires state of the art equipment. Even so, according to the respondents, the only development that has occurred has addressed the harvest operators' work environment (i.e., required by LCs) and the reduction of emissions (as legislated). On top of that, the dealer communicates with the manufacturer on a regular basis, and if an LC has a specific requirement, then the LC contacts the manufacturer (SF2;2.LC.1.).

Last, the interviewees agreed that future developments will follow the general trend in technological developments toward hybrid engines, especially with a focus on reducing the cost for each sawn m^3. Such development is driven by the LCs' interest in reducing costs (SF2;2.LC.2.).

3.3 Case 3

The harvester manufacturer in Case 3 started with the mission to create added value for forest owners in the long term (i.e. families). The manufacturer has direct contact with the LCs. The LCs have chosen the manufacturer for the special characteristics of its products, e.g. size of its harvester.

The manufacturer's previous development of harvesters was described as focusing on engine technology, primarily to meet emissions requirements. In recent years, however, development has focused chiefly on the work environment of harvest operators (i.e., because harvest operators spend their workdays in the same place), reliability (i.e., for the harvest operator to harvest throughout the workday), and efficiency. DPD of harvesters were perceived by interviewees to be LCs, harvester manufacturers, and expert and research organizations (e.g., Skogforsk).

According to the interviewees, the development appears to have been managed by different actors depending on the time, (SF2;3.HM.1.) including, for instance, large forest companies, expert and research organization, and LCs. Due to this environment of change, the interviewee expressed the perception that no profit margins exist for either the manufacturers of harvesters or the LCs (SF2;3.HM.1.). The respondent repeatedly stated that the harvesting industry is a mature industry with no profit margins.

The focus of each forest contractor is to offer private forest owners services aimed at maximizing the long-term value of forests. One interviewee stated that the company, as per its mission, should produce harvesters that the private forest owners appreciate so much that they request LCs to harvest using only that manufacturer's harvesters. Along those lines, another interviewee stated that private forest owners are the actors who ultimately drive development. Others at the manufacturer and dealer added that a new type of private forest owner has emerged because of the change from one generation to the next and that a new category of harvest operators will appear, which will prompt change focused on lowering costs in favor of increasing the value of forests in the future.

The manufacturer's representatives prefer direct contact with the LCs in order to be able to discuss their requirements and possible solutions (SF2;3.HM.1.). The LCs' requirements are communicated to the manufacturer at meetings with customers or when the requirements become apparent to the LCs, at which point they phone the manufacturer or dealer.

In the coming years, the manufacturer's representatives believe that development will focus on the laser scanning of timber and follow-ups on work done, as well as autonomous systems and remote-controlled harvesters, all of which are developments highly desired by forest owners and/or LCs. Another interviewee predicted the development of automation that will allow LCs to control harvesting remotely, in which case development may lead to harvesters without physical harvest operators. However, all interviewees maintained that LCs will continue to ask for increased productivity and efficiency and thus stressed the need for forest owners to drive future developments, for they have the generation-to-generation perspective on forest ownership (SF2;3HD.1. and SF2;3.LC.1.).

3.4 Case 4

The manufacturer in Case 4 produces harvesters at one assembly site but produces components at other sites to be delivered to the assembly site. The manufacturer exports about one third of their production and different markets are perceived to have different focuses—for instance, harvest operators' comfort. The representatives of the LCs stated that they chose the manufacturer due to the size and exceptional reliability of its harvesters. The manufacturer sells harvesters to dealers only, who handle all contact and communication with the LCs.

In the past decade, development has focused on reducing emissions levels and developing engines that meet legal requirements. The DPD, as perceived by interviewees, are legislators (e.g., with emissions requirements) followed by dealers and forest companies. According to interviewees, in recent years, the environmental movement has also started to ask for development by identifying improvements needed.

Because all sales are performed via the dealer network, the dealers have direct contact with the LCs. In discussions between dealers and LCs, which may take place at a fair or other social/business gathering in the industry, developments are proposed either by LCs or other dealers (SF2;4.HD.1. and SF2;4.LC.1.). Those proposed developments are then submitted to a database and handled according to the manufacturer's processes. The interviewee responsible for development at the manufacturer meets with the dealers twice a year to discuss harvesters.

Interviewees predicted that future developments regarding harvesters will focus on improving the efficiency of harvesters and reducing their fuel consumption, particularly because fuel consumption forms a large share of the LCs' costs (SF2;4.HM.2.).

4 Discussion

Following the procedure suggested by Yin, this section aims to identify common patterns and characteristics in the cases (i.e. an empirical within-case analysis was performed) followed by cross-case analyses from the perspectives of the various actors (HM, HD, and LCs). The results were interpreted considering the theory previously described.

4.1 Empirical within-case analysis

4.1.1 Case 1: study object 1

The interviewees in Case 1 clearly described how development in manufacturing harvesters has proceeded through three stages: mechanics, hydraulics, and control systems. Currently, the focus of development is in the LCs' work environment, as corroborated by interviewees representing the LCs. The harvesters are generally perceived to possess such good functionality that what remains to be developed concerns the LCs' work environment.

Interviewees representing the manufacturer stated that DPD are competitors and legislation, along with other expert and research organizations, whereas the other interviewees stated that meeting their own requirements (i.e., LCs' requirements) constitute DPD. On the one hand, because the industry for harvesters was characterized as mature, manufacturers that want to survive need to compare their offerings to those of competitors and meet them to the greatest extent possible. On the other hand, legislators set the rules for the industry (e.g., emissions regulations), but other expert and research organizations are perceived to strongly impact competitors as well as the legislators. The potential for future development rests primarily in following the development of competitors and thereby maintaining a strong market position.

4.1.2 Case 2: study object 2

All interviewees in Case 2 perceived harvesters as being standardized products and that development could be divided into the stages of mechanics, hydraulics, and control systems. At present, development is perceived to focus on the work environment of LCs and the reduction of emissions. The interviewees, primarily the harvester manufacturers, also perceived a shift in DPD. Whereas large forest companies previously conducted development as a part of their ordinary business, today's harvester manufacturers are expected to finance and manage the development of harvesters. According to all interviewees, development performed by the manufacturers aims to meet the requirements of LCs or legal regulations. All interviewees also believed that future development will focus on creating a hybrid engine that meets the LCs' requirements and can reduce costs.

4.1.3 Case 3: study object 3

The founder of the harvester manufacturer in Case 3 identified forest owners as the primary focus of their business, while the manufacturer's representatives identified forest owners as also driving the development of harvesters, together with LCs and legislators. However, according to the interviewees who represented the dealers and LCs, the manufacturer is a driver of development, as aligned with their strategic decision to focus on maximizing the long-term value of forests, which implies that forest owners expect ownership to span generations. In addition, the various interviewees identified different paths for future development: the laser scanning of timber, follow-ups on work performed, autonomous systems, and remote-controlled harvesters. Follow-ups on

work performed are considered to either control the work performed by LCs or to evaluate any work done in relation to cost.

4.1.4 Case 4: study object 4

In Case 4, all interviewees identified legislators, harvester dealers, and forest companies as DPD of harvesters. Harvest dealers act as coordinators for gathering requirements from the LCs and communicating them with the manufacturer. In turn, the manufacturer uses proactive customer relationship management by having the dealers submit their requirements to a database and, afterward, ensuring that manufacturer's standard routines are in place. One interviewee, representing the manufacturer, also identified the green movement as an actor affecting the development of harvesters. On the whole, the interviewees indicated that future developments will likely focus on improving efficiency and reducing fuel consumption in order to meet requirements from LCs and reduce costs.

4.2 Cross-case analyses

4.2.1 Harvester manufacturers

For a primary marketing channel, most manufacturers use dealer networks. In fact, only the manufacturer in Case 3 prioritized LCs over the dealer as a channel for market contact. The dealers were, therefore, described as being pivotal to accessing the market and for making secondary contact with LCs. The manufacturers discuss development-related needs with dealers and might contact LCs directly in several ways, including fairs.

Two manufacturers also described a shift in how development-oriented work is performed. Earlier, collaboration with large customers investing in development projects and supporting the manufacturers was the norm. Today, however, development-oriented work is performed by manufacturers only, who described harvesters as a mature technology sold on a market consisting primarily of a standardized range of harvesters. One manufacturer explained that suggestions for development are therefore benchmarked in relation to competitors before the manufacturer decides to either perform the work or not. In each case, competitive market positions are managed by the manufacturers, and in some cases, the companies uphold their missions to, for example, "create more long-term value for forest owners." Consequently, forest owners become important DPD as well.

According to the interviewees, technological development for improved productivity (i.e., mechanics, hydraulics, and control systems) and engine efficiency in relation to both cost and emissions never ceases. Reliability was another aspect highlighted by interviewees in relation to improvement-oriented work. The initiative for development that responds to environmental concerns comes from legislators, while cost reduction is important to LCs. In recent years, the work environment of LCs has received sustained focus when it comes to development. However, manufacturers noted a difference between markets, such that harvest operators' comfort – a priority for LCs in our study – is not especially important in some countries.

The interviewees also indicated that forest companies inject funding into the supply chain for softwood lumber and, in all cases, are the ultimate financiers. Thus far, their perennial aim appears to be reducing funding injected into the system, meaning that the actors involved need to focus on cost reduction. Concerning DPD, manufacturers, legislators, and expert and research organization are important, as are the requirements of LCs and the manufacturers themselves. However, expert and research organization' requirements, especially concerning environmental aspects, were described as increasingly important, along with supporting LCs with cost-efficient

solutions. Beyond that, future developments were predicted to follow general trends in technological development toward, for example, hybrid engines, both out of environmental concern and to reduce the cost for each sawn m^3. Thus, cost emerged as an important focus during the interviews, as manufacturers described price pressure on LCs despite their tendency to have low profit margins.

4.2.2 Harvester dealers

The dealers discussed the LCs' expressed needs and described the LCs as having an interest in technology and thus requiring state of the art technology to reduce costs. According to the dealers, DPD are LCs and the harvester manufacturers, as well as expert and research organizations. The dealers inform the manufacturers about the LCs' needs in different ways (e.g., recurring meetings and databases for reporting development-oriented suggestions).

4.2.3 LCs

The reliability and availability of services, the specific size of harvesters, and, in one case, their special characteristics justified the selection of harvester manufacturers. LCs specifically named a work environment that is comfortable for harvest operators as being important in the selection process, if not being a tacit requirement for manufacturers. In one case, the harvest operator's role was discussed in relation to technological developments such as autonomous vehicles, operator-less harvesters, and remote-controlled operation. The LCs added that they expect continued development toward more productive, cost-efficient harvesters.

4.3 Identification of drivers of product development

The individual cases matched in their descriptions of the phases of harvester development – from mechanics, hydraulics, and control systems to work environment and efficiency – as technological advancements aligned with general industrial development. The interviewees also indicated the steady pace of such development during the past five decades. However, in recent years, the pace of development was perceived as having decelerated, as each manufacturer has remained waiting but poised for the next move from either legislators or a competitor. The interviewees' descriptions also stress the shifting responsibility for the development of harvesters, from forest companies to harvester manufacturers. Today, however, few actors have the means to pursue the development and innovation of harvesters, at least from the perspective of the interviewees.

The DPD of harvesters as identified in the within-case analysis appear in Table 4. The DPD as concluded from the perspective of each actor appear in Table 5.

Table 4. Drivers of product development of harvesters identified by interviewees in the study, arranged by case.

Driver	Case 1: Study object	Case 2: Study object	Case 3: Study object	Case 4: Study object	Total
Expert and research organizations	X		X		2
Competitors	X				1
Forest companies				X	1
Forest owners			X		1
Harvester manufacturers			X		1
Logging contractors	X	X	X	X	4
Legislators	X	X	X	X	4

Table 5. Drivers of product development of harvesters identified by interviewees from the perspective of each actor.

Driver	Harvester Manufacturer	Harvester Dealer	Logging Contractor
Expert and research organization	X	X	
Competitors	X		
Forest companies	X		
Forest owners	X		
Harvester manufacturers	X	X	
Logging contractors	X	X	X
Legislators	X		
Total	7	3	1

Legislators and LCs were identified as DPD of harvesters in all cases. However, as DPD themselves, LCs struggled to identify other drivers. The LC pinpointed themselves as customers and therefore were entitled to determine requirements for the equipment. According to previous empirical studies (Table 1), market orientation and consumer demands (Acur et al 2012; Boso et al. 2012; Rhee et al. 2010) also drive development, and the industry for harvester manufacturing is no different from most other industries. However, in our cases, LCs were also users of the harvesters, and several interviewees identified LCs as having general interest in technology and thus requiring manufacturers to be at the forefront of developing technology. This is in line with Nordfjell et al. (2010) who stress that the development of forest machinery depends on progress in other vehicle industries with some specializations. Similarly, work environment is important to the LCs and LCs voiced demand for developments in improving the spaces where they spend their workdays. Interviewees in all cases also identified legislators as actors driving the development of harvesters, which corroborates Björheden's (2006) results. Legislators indeed possess the authority to apply restrictions (e.g., setting the conditions for the harvesting business), and previous empirical studies (Table 1) have identified regulatory demands as a DPD. This finding indicates that the industry for harvester manufacturing faces a situation like most industries. Legislation concerning different types of heavy equipment has received attention in recent years, and legislators have often imposed requirements on the operation of harvesters. The current focus in development for such legislators is emissions, as is the case in the general business environment. Harvesters also physically impact the environment by not only releasing emissions but by causing ground damage during operation as well. While emissions levels can be regulated by legislators, ground damage needs to be restored.

Expert and research organizations go hand in hand with legislators as actors that pinpoint necessary developments for harvesters. The interviewees characterized expert and research organizations as bearing influence on future changes as well as future regulations during specific periods of time. Expert and research organizations were perceived to constitute external actors in the development of harvesters, although the establishments that constitute expert and research organization are determined individually. DPD of harvesters reported by manufacturers, by comparison, were competitors, forest owners, and forest companies.

Competitors: The manufacturers of harvesters need to supply the market with competitive products and are thus perceived to be knowledgeable about their competitors. According to past empirical studies (Pantano and Viassone 2014; Aladwani, 2001), having a competitive position, if not a leading one, is DPD in any industry.

Forest owners: Forest owners, as identified in Case 3 (private forest owners), cultivate and maintain forests for coming generations. This is experienced as a shift from focusing on lowering costs in favor of focusing on increasing the value of forests in the future. This change shifts

conditions for manufacturers of harvesters with new needs on how harvesters operate, from cost reduction to an increase of value.

Forest companies: Forest companies continually strive for low-cost services provided by LCs, which might align with general business development toward controlling and monitoring its operations.

According to Lindblad and Schauerte (2017), DPD in the context of wood industries and forest operations are technology, the environment, and knowledge. While technological DPD relate to enhancing features and organizational development, environmental DPD include external trends and influences as well as the facilitation of innovation, and knowledge DPD relate to, for instance, information sharing. Among the results of our study, the DPD identified for the harvesters could be environmental (e.g., external trends and influences from the market, society, and competition). According to Picchio et al. (2019), forest operations need to integrate the use of new technologies along with applications of electronics and interdisciplinary knowledge and practices from fields such as mechanical engineering.

In a study conducted on forest energy in Sweden, Björheden (2006) categorized DPD as either indirect (e.g., general market development and legislation) or direct (e.g., possible technological developments). Björheden's (2006) work suggests a division of the identified DPD; in which competitors, legislators, forest owners, and expert and research organizations should be classified as indirect DPD who indirectly affect development (e.g., general market development and legislation) and LCs and forest companies should be classified as direct DPD who directly affect development (e.g., technological developments).

5 Conclusions, implications, and future research

5.1 Conclusion

The development of harvesters seems to follow technological development in general and aligns with regulations stemming from legislators who possess the executive authority to apply restrictions. Currently, the different manufacturers wait for their competitors to take the next step or for new regulations to be enacted. It would be possible for harvester manufacturers to consider taking a more proactive approach to development (Acur et al. 2012; Laugen et al. 2006). In that sense, we can conclude that the development of harvesters has stagnated.

From the results of our study, DPD are legislators, LCs, and expert and research organizations, among others. All identified DPD appear to be related to actors on different levels, either the individual or the group level (i.e., legislators and expert and research organizations).

According to Cooper (2019), the identified DPD represent the first category of DPD, for they include DPD with a strategic focus on customers. Most harvester manufacturers follow the mainstream of development to meet the requirements of those customers (LCs) as well as those from legislators. Because LCs are the customers, creating value for them is a prerequisite for their continued positive impact on a company's profit levels. However, expert and research organizations also play a role in the development of harvesters.

The results of our research extend theory by modifying existing frameworks regarding the DPD considering knowledge from the harvesting industry. We conclude that along with DPD identified in other industries, expert and research organizations are DPD of harvesters. That potentially places expert and research organizations in a powerful position with respect to the development of harvesters, for they affect the development of harvesters from an external perspective that keeps their own interests in focus.

5.2 Implications

Validity in this study has been secured by following the procedure suggested by Yin (2017) aligned with using standardized case study protocols. When scrutinizing the case-study protocols, the individual cases had similar empirical patterns, which strengthens the multiple-case study's validity. Further validity has been enhanced by using multiple sources of evidence, and the case-study reports have been verified by the interviewees via email. The final article was sent to the interviewees representing the HM and a Swedish version of the results was verified by the HD and LC. Reliability has been enhanced by comparing the consistency of responses to interview guides. Further, respondents indicated that forest companies potentially have had an impact on the development of harvesters. This is supported by Andersson (2004) who describes that forest companies traditionally took an active role on the development of harvesters. However, by using the linear snowball sampling technique, the present study did not include forest companies in the study object.

5.3 Future studies

Harvester manufacturers are responsible for the development of harvesters, and by familiarizing themselves with the DPD of their equipment, they can adjust to and counteract individual DPD. Thus, unless the developments pursued are ones that will be statutory, manufacturers will continue to wait to pursue developments given the perception that profit margins do not exist. The situation between the forest companies and the manufacturers thus appears to be tense; respondents described how forest companies are lowering prices on the harvesting work. LC's margin thereby decreases and likely their investment capacity, thus putting restrictions on LC's possibilities for further development.

Because each actor determines which organization is an authority, it remains unclear which interest groups and movements in society will impact the industry for harvester manufacturing. In the interviews in our study, expert and research organizations such as SKOGFORSK and the green movement were mentioned, but others are possible as well. In that light, future research might focus on identifying expert and research organizations to pinpoint their open and underlying interest.

To improve the supply chain for softwood lumber, the different DPD of harvester need to be considered. Future studies ought to focus on identifying additional DPD beyond the study object for this study.

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Authors' contributions

Åsa Gustafsson: Original idea of the article, planning and design of data gathering, data collection, selection of the theoretical framework and design of the analysis, implementation of the analysis, interpretation of data and the results, scientific writing of the manuscript, finalization of the manuscript.
Jimmy Johansson: Original idea of the article, planning and design of data gathering, part of data collection, interpretation of data and the results, scientific writing of the manuscript, finalization of the manuscript.

Supplementary files

S1.pdf; Interview guides,
S2.pdf; Individual statements,
available at https://doi.org/10.14214/sf.10660.

Declaration of openness of research materials, data, and code

The empirical data analyzed during the current study are available from the corresponding author on reasonable request.

References

Acur N, Kandemir D, Boer H (2012) Strategic alignment and new product development: drivers and performance effects. J Prod Innov Manage 29: 304–318. https://doi.org/10.1111/j.1540-5885.2011.00897.x.

Alkassim R, Etikan I, Abukabar S (2015) Comparison of snowball sampling and sequential sampling technique. Biom Biostat Int J 3: 6–7. https://doi.org/10.15406/bbij.2016.03.00055.

Andersson S (2004) Skogsteknik förr och nu. [Forest technology, past and present]. Skogshistoriska Sällskapets Årsskrift 2004: 102–116.

Asikainen A, Anttila P, Verkerk H, Diaz O, Röser D (2011) Development of forest machinery and labor in the EU in 2010–2030. Conference Paper, FORMEC Austria.

Barratt M, Choi T, Li M (2011) Qualitative case studies in operations management: trends, research outcomes, and future research implications. J Oper Manag 29: 329–342. https://doi.org/10.1016/j.jom.2010.06.002.

Bell E, Harley B, Bryman A (2022) Business research methods. Oxford University Press. ISBN 9780198869443.

Björheden R (2006) Drivers behind the development of forest energy in Sweden. Biomass Bioenergy 30: 289–295. https://doi.org/10.1016/j.biombioe.2005.07.005.

Björheden R (2020) Ökad produktivitet inte i focus. [Increased productivity not in focus]. Skogen 4: 18–21.

Boso N, Cadogan J, Story V (2012) Entrepreneurial orientation and market orientation as drivers of product innovation success: a study of exporters from a developing economy. Int Small Bus J 31: 57–81. https://doi.org/10.1177/0266242611400469.

Christopher M (2016) Logistics & supply chain management. FT Publishing International. ISBN

978-1292083797.
Cooper RG (2019) The drivers of success in new-product development. Ind Market Manag 76: 36–47. https://doi.org/10.1016/j.indmarman.2018.07.005.
Dinwoodie J, Xu J (2008) Case studies on logistics: a review and tentative taxonomy. Int J Logist Res Appl 11: 393–408. https://doi.org/10.1080/13675560802389130.
Eisenhardt KM (1989) Building theory from case study research. Acad Manage Rev 14: 532–550. https://doi.org/10.5465/amr.1989.4308385.
Gustafsson Å (2017) Assessing work order information quality in harvesting. Silva Fenn 51, article id 6989. https://doi.org/10.14214/sf.6989.
Häggström C (2015) Human factors in mechanized cut-to-length forest operations. Doctoral thesis, Swedish University of Agricultural Sciences, Acta Universitatis agriculture Suecia. http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-e-2644.
Jylhä P, Rikkonen P, Hamunen K (2020) Size matters – an analysis of business models and the financial performance of Finnish wood-harvesting companies. Silva Fenn 54, article id 10392. https://doi.org/10.14214/sf.10392.
Kahn K, Barczak G, Moss R (2006) Establishing a NPD best practice framework. J Prod Innov Manage 23: 106–116. https://doi.org/10.1111/j.1540-5885.2006.00186.x.
Karvinen S, Nummelin T (2015) Finnish wood harvesting contractors' risks in Russia. Silva Fenn 49, article id 1394. https://doi.org/10.14214/sf.1394.
Ketokivi M, Choi T (2014) Renaissance of case research as a scientific method. J Oper Manag 32: 232–240. https://doi.org/10.1016/j.jom.2014.03.004.
Kronholm T, Larsson I, Erlandsson E (2021) Characterization of forestry contractors' business models and profitability in Northern Sweden. Scand J For Res 36: 491–501. https://doi.org/10.1080/02827581.2021.1973087.
Laitila J, Väätäinen K (2020) Productivity of harvesting and clearing of brushwood alongside forest roads. Silva Fenn 54, article id 10379. https://doi.org/10.14214/sf.10379.
Laugen B, Boer H, Acur N (2006) The new product development motives and practices of Miles and Snow's prospectors, analyzers and defenders. Creat Innov Manag 15: 85–95. https://doi.org/10.1111/j.1467-8691.2006.00371.x.
Lefévre C (2011) Svenssons skog – integrerad skogsentreprenör i södra Sverige. [Svensson's forest – integrated logging contractor in Southern Sweden]. Thesis work no: TEK 067/2010, Linnéuniversitetet.
Lindblad F, Schauerte T (2017) Identifying drivers facilitating product development within the industry for wooden multi-family houses. Pro Ligno 13 :602–609.
Manley K, Mcfallen S (2006) Exploring the drivers of firm-level innovation in the construction industry. Const Manag Econ 24: 911–920. https://doi.org/10.1080/01446190600799034.
Narver JC, Slater SF (1990) The effect of a market orientation on business profitability. J Mark 54: 20–35. https://doi.org/10.1177/002224299005400403.
Näslund D (2002) Logistics needs qualitative research – especially action research. Int J Phys Distrib Logist Manag 32: 321–338. https://doi.org/10.1108/09600030210434143.
Nordfjell T, Björheden R, Thor M, Wästerlund I (2010) Changes in technical performance, mechanical availability and prices of machines used in forest operations in Sweden from 1985 to 2010. Scand J For Res 25: 382–389. https://doi.org/10.1080/02827581.2010.498385.
Nordfjell T, Öhman E, Lindroos O, Ager B (2019) The technical development of forwarders in Sweden between 1962 and 2012 and of sales between 1975 and 2017. Int J of For Eng. 30: 1–13. https://doi.org/10.1080/14942119.2019.1591074.
Pantano E, Viassone M (2014) Demand pull and technology push perspective in technology-based innovations for the points of sale: the retailers' evaluation. J Retail Consum Serv 2: 43–47.

https://doi.org/10.1016/j.jretconser.2013.06.007.
Parrilli M, Elola A (2012) The strength of science and technology drivers for SME innovation. Small Bus Econ 39: 897–907. https://doi.org/10.1007/s11187-011-9319-6.
Penttinen M, Rummukainen A, Mikkola H (2011) Profitability, liquidity and solvency of wood harvesting contractors in Finland. Small-Scale For 10: 211–229. https://doi.org/10.1007/s11842-010-9143-x.
Picchio R, Proto Rosario A, Civitarese V, Di Marzio N, Latterini F (2019) Recent contributions of some fields of the electronics in development of forest operations technologies. Electronics 8, article id1465. https://doi.org/10.3390/electronics8121465.
Rhee J, Park T, Lee D (2010) Drivers of innovativeness and performance for innovative SMEs in South Korea: mediation of learning orientation. Technovation 30: 65–75. https://doi.org/10.1016/j.technovation.2009.04.008.
Sandström U (2014) Skogsentreprenörerna verkar för ett hållbart skogsbruk. [Logging contractors act for sustainable forestry]. Skogsentreprenören 1: 3.
Vogel W, Lasch R (2018) Complexity drivers in product development: a comparison between literature and empirical research. Logist Res 11, article id 7. https://doi.org/10.23773/2018_7.
Yin R (2017) Case study research and applications – design and methods. SAGE Publications. ISBN 978-1506336169.

Total of 37 references.