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Article

The Impact of Industrial Context on Procurement, Management and Development of Harvesting Services: A Comparison of Two Swedish Forest Owners Associations

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Abstract: Increasing demands to harvesting production and quality require improved management practices. This study's purpose was to analyze the impact of industrial context on procurement, management, and development of harvesting services. Using interviews, functions were modeled at two forest owners associations (FOAs) with outsourced harvesting services. One FOA had its own sawmills, requiring frequent harvesting production adjustments to meet varying volume demand in the short-term. The long-term uncertainty was however low because of good visibility of future demand (>6 months). The other FOA did not own mills and produced wood according to fixed six-month delivery contracts. This meant few short-term production adjustments, but long-term uncertainty due to low visibility of future demand. Demand uncertainty resulted in corresponding needs for harvesting capacity flexibility. This could have been met by a corresponding proportion of short-term contracts for capacity. In this study, however, a large proportion (>90%) of long-term contracts was found, motivated by a perceived contractor shortage. It was also noted that although contractor investment cycles (4–6 years) matched the FOAs' strategic horizons (3–5 years), contractors' investment plans were not considered in the FOAs' strategic planning. The study concludes with a characterization of different FOA contexts and their corresponding needs for capacity flexibility.

Keywords: logging; contractor; wood procurement; operations management; function modeling

1. Introduction

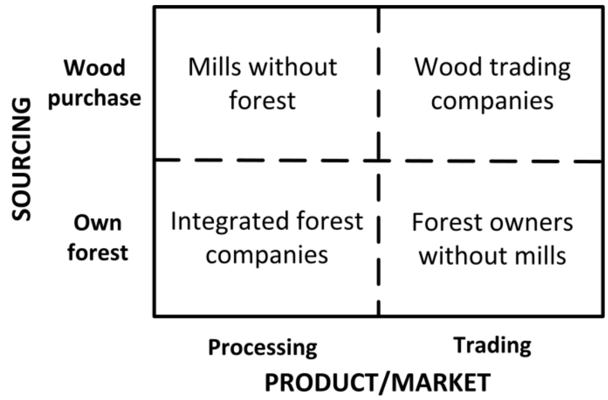
1.1. Industrial Contexts for Operations Management

The Swedish forest industry operates on a global market where effectiveness in all parts of the wood supply chain is crucial to stay competitive [1]. Because harvesting represents the highest proportion of total production costs [2], it has been a focus area for productivity development for decades. Since the start of the mechanization boom in the 1950s, machine systems have developed considerably [3]. During the last three decades, a stage of technological maturity has been reached where most harvesting operations are conducted with cut-to-length technology in a two-machine system consisting of a single-grip harvester and a forwarder. However, in the last few years there have been indications of a declining productivity [4]. This comes at the same time as an increase in market demands for quality and precision [5] as well as societal and environmental demands [6] on harvesting operations. Simultaneously, it has become increasingly challenging for the forest industry to purchase wood from the non-industrial private forest owners [7]. Approximately 100,000 of these private forest owners are organized in forest owners associations (FOAs), who together hold 6,1 million hectares of forest land [8]. Their wood is sold to FOAs or other forest companies and harvesting is done mainly by the companies themselves or their contractors. Thus, the forest owner is typically both a supplier of wood and a customer for harvesting services.

From a forest company perspective, the Swedish market offers business opportunities for various forest products businesses. If we use Nollet *et al.*'s [9] characterization of the main aspects of business strategy as the company's product, volume and market, two general business strategies can be identified among Swedish forest companies. These are (i) processing wood to sell on the international market, or (ii) trading roundwood (or by-products) on the national market. Among the companies aiming to sell products on the international market, there are numerous differences related to focus on generic bulk products *versus* more differentiated consumer-specific products. However, the same companies also have varying supply strategies in terms of how much of their supply structure consists of wood from own forests or from purchase from market sources. Given these general differences, four combinations of business and supply strategy can be characterized in terms of their various mixes of *processing versus trading* wood and sourcing from *own forest versus purchase* (Figure 1). For the companies, these different situations represent varying operating environments, commonly referred to as *industrial contexts* [10,11].

As mentioned before, the demands on harvesting operations have increased. Given the different situations (contexts) noted in Figure 1, the forest companies' harvesting activities also have to be adapted accordingly. All in all, management has become more demanding and in need of further improvements.

Figure 1. A classification of company situations depending on sourcing and product/market among Swedish forest products businesses.



1.2. Outsourcing of Harvesting Services

Outsourcing of harvesting services became a common strategy of all larger Swedish forest companies (including the FOAs) during the 1990s [3]. Yet, some companies still own part of their harvesting fleet and procure only some services from contractors, whereas other companies have chosen to outsource all their harvesting services to contractors. Ager [3] estimates that presently 75%–85% of the harvested roundwood volume in Sweden is carried out by specialized contractors. Typically they are small companies with one or two machine units (one harvester–one forwarder), and less than nine employees [12].

The main motives for outsourcing of harvesting services in Swedish forest companies seem to be a reduction of economic risks and a decrease of bounded capital in machinery, paired with increased incitements for productivity development by paying contractors a piecework rate [13]. To some extent, the outcome for the forest companies has been cost reduction and more rapid adjustments of their harvesting capacity level to current needs [3]. Since the mid-1990s, however, Hultåker [6] has noted a decline in harvesting contractor profitability. Recruiting competent machine operators has also proved to be a growing problem when the work environment is perceived to be stressful and the salaries low [14]. Similar experiences have also been reported from Finland [15,16].

1.2.1. Outsourcing Decisions

The decision to outsource an activity is primarily based on a comparison of the total costs for own production *versus* the total costs for outsourcing. The outsourcing costs include governance costs for managing business relationships, commonly referred to as *transaction costs* [17]. Arnold [18] identifies three key points to consider in the decision to outsource. The first concerns the activity's *specificity* of required assets (goods and services) and human capital. If the activity is highly specific, the market transaction costs for agreements and communication are normally high and outsourcing is not economically viable. The second point concerns the *strategic importance* of the activity where even if the activity has low specificity of assets or human capital, it is not beneficial to outsource if the activity is of high importance for the company's ability to survive. Connected to the strategic importance, the third point to consider is whether or not the activity constitutes a *core competence* in the sense of being a central part of the company's competitive advantage. Thus, activities that have both low specificity and low competitive contribution are typical objects for outsourcing.

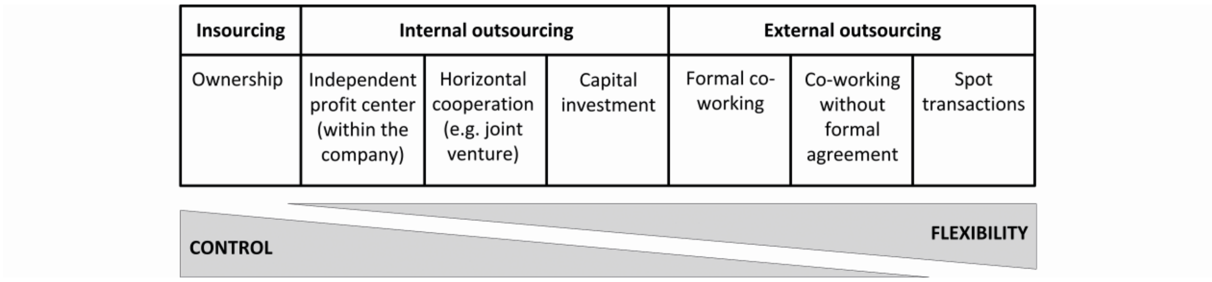
Apart from cost reduction there are other aspects for a company to consider when making a strategic outsourcing decision. These include the use of capital and resources to focus on core activities as well as the need to gain flexibility [19]. Regarding these, a company must balance between *flexibility* in the sense of being able to rapidly adjust capacity to market changes, and *control* in the sense of securing capacity and competence. Through outsourcing, the company's internal capacity can be held at relatively constant levels by having flexibility in the amount of outsourced capacity. Outsourcing however reduces the degree of control, and in situations of few suppliers, powerful suppliers could exploit the opportunity to demand more beneficial conditions [20]. This behavior is commonly referred to as *opportunism* [17,21] and for activities with high asset specificity, the risk for this behavior is higher [17].

With respect to gaining flexibility, the *extent* to which an activity should be outsourced is then influenced by environmental factors such as the seasonal nature of the activity and the degree and frequency of workload fluctuations [19]. Both these factors are particularly relevant to harvesting operations [22–24]. Another important factor influencing the extent of outsourcing is the degree of *uncertainty* for the activity. With an increased level of uncertainty in market demand, the extent of outsourcing can be increased accordingly [19]. However, if there is uncertainty about the production process itself due to complexity or changes in the activity or products, costs can be difficult to predict. If such an activity is outsourced, the risk for being exposed to opportunistic behavior is raised [17]. For harvesting operations in Sweden, the activities and products are homogeneous, offering a low risk for outsourcing. Thus, forest companies without their own forest resources or mills could be expected to have a higher proportion of outsourced harvesting services, as their business is more sensitive to changes in market supply and demand.

1.2.2. Outsourcing Design

A company needs to find a governance structure with low transaction costs [18]. Full ownership maintains full control of assets in a hierarchical governance structure. In a full market governance structure, market mechanisms enable price gains under efficient market conditions but at the same time increase the risk of being exposed to opportunism. The risk for opportunistic behavior can be reduced by increasing the *dependency* between parties, e.g. through risk and reward sharing agreements [21]. A strategic outsourcing decision is thus not simply a matter of adjusting between full ownership (insourcing) and full external outsourcing. Instead, it spans from full ownership and control (hierarchical governance) to only spot market transactions (market governance) of services with several possible mixes of design elements in between [18], as described in Figure 2. However, outsourcing does not necessarily lead to reduced control. In a situation where the supplier have to make relationship-specific investments, the increased dependency increases the buyer's control. Also, in relationships where there is a high level of mutual trust and solidarity, the need for control itself is lower [5,25].

Figure 2. Structural alternatives in outsourcing design which give varying possibilities with respect to control and flexibility. Based on Arnold [18].



Some Swedish forest companies have insourcing or internal outsourcing elements as a part of their outsourcing design. Formal cooperation with contractors (horizontal cooperation in Figure 2) seems uncommon in existing designs, but there are indications of a growing interest in this alternative. External outsourcing dominates, which mainly consists of formal co-working where services, volumes and price levels are contracted, often through invitations-to-tender. Spot procurement of capacity also exists to some extent [26,27].

1.3. Scope and Aim

The scope of this paper is to explore the influence of varying industrial contexts on managerial limitations and decisions for outsourced harvesting services. In order to enable comparisons a framework is needed to describe industrial contexts. Such a framework is a necessary prerequisite to enable more detailed studies on the adaptation of business models for harvesting services to varying industrial contexts. For the current study, two forest owners associations (FOAs) were selected as case companies. FOAs are interesting for studies in this respect, as they must not only meet demand uncertainty, but also supply uncertainty because their wood is purchased under free market conditions. Given typical market variations in demand and supply, FOAs can be expected to have a significant need for flexibility in harvesting capacity.

Both of the selected case FOAs have fully outsourced their harvesting services but are contextually *different in respect to their supply responsibilities*. One does not own mills and is only involved in wood trade, thus only having *external supply responsibility* to other companies. The other FOA also trades roundwood, but has its own sawmills, thus having an *internal supply responsibility*. Together, the two FOAs represent 43% (2.7 million hectares) of the total 6.2 million hectares of productive forest land connected to Swedish FOAs [8].

The aim of this study was to identify and describe the impact of industrial context on procurement, management and development of harvesting services within two forest owners associations (FOAs). In the following text, *procurement* refers to obtaining or buying harvesting services, including preparatory planning, negotiation and contracting. *Management* refers to organizing, coordinating and supervising harvesting activities to achieve defined business goals. *Development* refers to systematic improvements of business activities that involve harvesting services.

2. Materials and Methods

For the development of a framework to describe and enable comparisons of industrial contexts, a structure was needed. For this purpose, function modeling (a method for process mapping) was chosen.

The focus of the study was on harvesting functions at the two case FOAs. However, a general mapping of what set the constraints for harvesting functions was required. A first mapping was therefore done of the wood supply functions, with enough detail to understand how they affected the harvesting functions. Secondly, the harvesting functions were mapped in detail and analyzed.

The following three steps were followed at both FOAs: (i) Information about business activities was gathered through qualitative interviews; (ii) The current activities for procurement, management and development of harvesting services within the organizations were mapped through function modeling; (iii) Differences within and between the organizations were identified by comparing maps, and their causes and effects were further analyzed.

2.1. Interviews

Interviews were conducted at a sample of different FOA sections. Four central staff positions and one third of all wood supply districts (six of eighteen) were sampled. Sampling many districts was considered necessary to have a representative material with variety in both context and management, enabling the identification of differences.

A total number of 16 personal interviews were conducted. These were distributed between FOA sections in proportion to their wood volume turnover. The FOA without its own mills (hereafter referred to as the FOA-NM) had a volume turnover of twice the size of the FOA with its own sawmills (hereafter referred to as the FOA-M) (about 4–5 million *vs.* 1.5–2 million cubic meters annually). At the district level, volumes were similar between FOAs, as was staff size and organization. The FOA-NM was organizationally divided into two regions consisting of five and seven districts, whereas the FOA-M was directly divided into six districts. Due to the differences in total turnover and organizational structure, the interviews were distributed equally between three organizational units of similar size: the FOA-M was one unit and the respective regions at the FOA-NM were the two other units. Within each unit, respondents were selected according to function.

The interviews started with wood supply managers in leading positions. These were interviewed at their respective organizational unit. Further respondents, with the knowledge and experience required for further mapping, were continuously selected based on the suggestions of previous respondents according to a technique called *snowball sampling* [28]. A criterion for the selection of production managers and contractors was that they should have at least two years of working experience within the organization. In order to secure geographical variation, two districts were selected at each of the three organizational units (suggested by managers in leading positions). At each of the six selected districts, one production manager and one harvesting contractor were interviewed. This gave a complete coverage of all within the hierarchy relevant to the harvesting function (Table 1).

Table 1. Distributed number of respondents between the two studied forest owners associations (FOAs).

FOA without its own mills				**FOA with its own mills**		**Functions in focus**	**Number of respondents**
Region office 1 *1 manager*		Region office 2 *1 manager*		Head office *2 managers*		Order/Purchase /Production	4
District 1 Production manager	District 2 Production manager	District 1 Production manager	District 2 Production manager	District 1 Production manager	District 2 Production manager	Purchase/ Harvesting	6
Contractor	Contractor	Contractor	Contractor	Contractor	Contractor	Harvesting	6
Total number of respondents							16

Each interview was conducted individually, and the following three themes were discussed with both managers and contractors: (i) Business goals and directives; (ii) Management, information exchange and follow-up; (iii) Constraints, variations and problems.

A formal structure for the hierarchy of decisions and processes was also prepared and used during the interviews with managers. The structure was based on a generic framework for supply strategies by Nollet *et al.* [9] and is presented in Table 2. By using the framework as a foundation for discussions during interviews, firm strategy and goals of the organization could be systematically broken down to supply strategies in decreasing time horizons. Decisions and main processes were discussed at each level.

Table 2. The generic framework used for interview discussions. Based on Nollet *et al.* [9].

Firm strategy	**Supply strategies**		**Functions in focus for the interview**
	Perspective	***Processes and decisions***	
Business goals What? Why?	*Strategic perspective* Long-term horizon	*To be discussed*	Order/Purchase/Production
Organization How to?	*Tactical perspective* Medium-term horizon	*To be discussed*	Order/Purchase/Harvesting
Implementation Doing it	*Operational perspective* Short-term horizon	*To be discussed*	Purchase/Harvesting

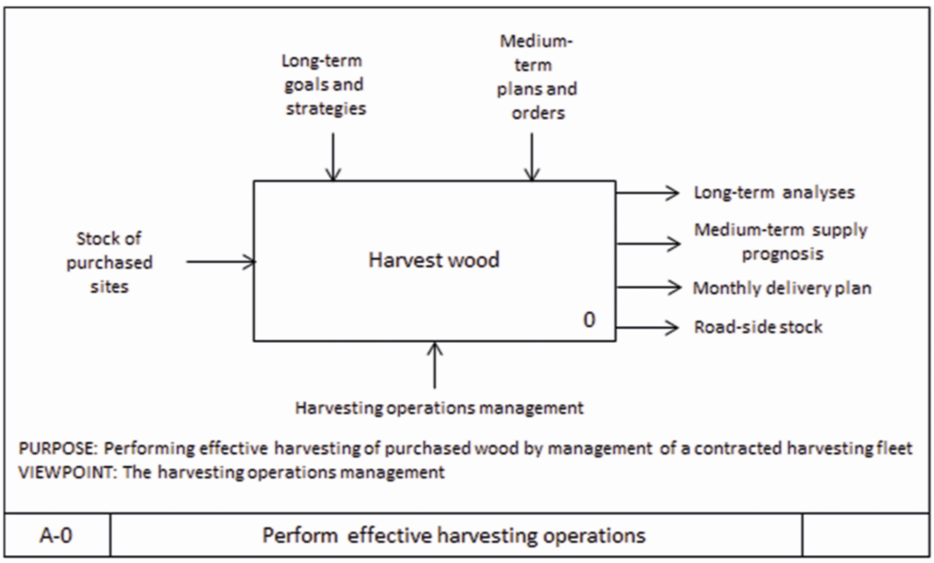
Interviews with managers in leading positions lasted between 2 to 2½ hours, and interviews with production managers and contractors lasted between 1½ to 2½ hours. The interviews were recorded and manually transcribed. During transcription, activities and constraints were identified and noted in the text. The resulting material consisted of about 30 hours of recorded material and 197 A4-pages of transcribed text. All respondent's answers were handled with anonymity.

2.2. Function Modeling

Processes were modeled based on the information obtained from the respondents. The interpretation of the respondents' answers was in terms of a hierarchy of independent parallel on-going activities (*i.e.*, function processes). Function modeling was therefore used to map these activities. An alternative framework for interpretation could have been that of sequences of activities (*i.e.*, flow processes where the initiation of a following activity was directly dependent on the completion of the preceding activity). The analysis of differences between the two FOAs required a structure that enabled a direct comparison between the two. The modeling technique applied for the function modeling was the Integration Definition for Function Modeling 0 standard (IDEF0) [29]. The IDEF0 standard offers detailed rules and techniques to consistently model functions with their hierarchies and interactions, independent of organizational structures. This enabled the comparison of the two cases which had similar functions but different organizational structures. Another alternative could have been the UML (Unified Modeling Language) standard, but it is primarily aimed for software development [30]. Another reason for choosing IDEF0 was because it had already been successfully applied in other forest industry-related studies [31,32]. These earlier experiences show that modeling with IDEF0 works well for describing and analyzing activities in operations management. The technique realistically captures coordination and feedback between and within functions, which were key elements for the present study.

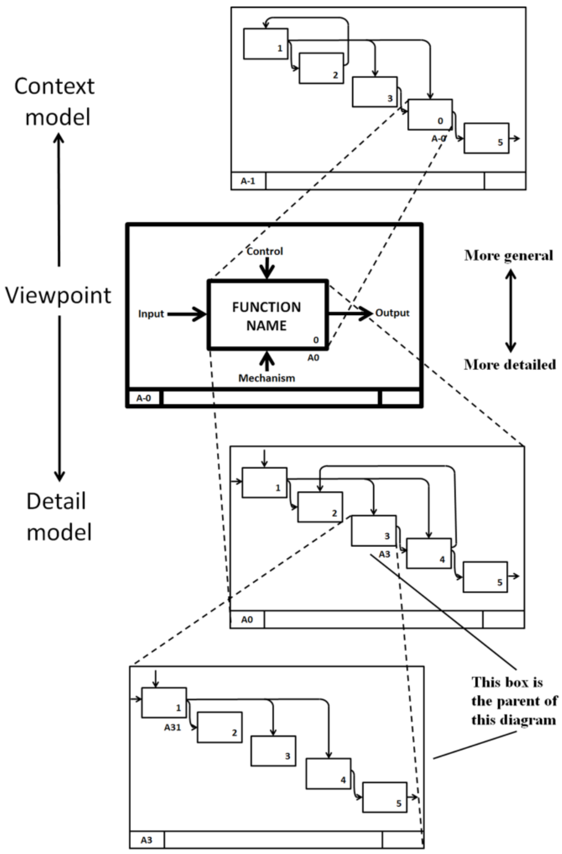
The first step of the modeling with IDEF0 technique was defining the top-level function, named A0 and the viewpoint. The A0 function was *Harvest wood*, and the viewpoint was the one of the harvesting operations management. The top-level function was then modeled in a context diagram, named the A-0 Diagram (Figure 3), describing the purpose of the function and all its inputs, controls, outputs and mechanisms (explained below). The *Harvest wood* function was the starting point for the modeling. The function's interactions with other functions were mapped through a *context model*, were functions were modeled with enough detail to understand the constraints for *Harvest wood*. A *detailed model* was then made of the activities within the top-level function.

Figure 3. The top-level context diagram (A-0) for the study.



All drawn models followed the IDEF0 syntax. This meant that each detailing of a function into its activities (or an activity into its sub-activities) had to consist of at least three and at most six activities. Each detailing was shown in individual diagrams where boxes represented the activities. The boxes were drawn in a stair-like structure, symbolizing the hierarchy of activities. The hierarchically highest activity was positioned in the upper left corner of the diagram, and the hierarchically lowest activity was positioned in the lower right corner. The name of each box was an active verb stating what happened in the activity. Each box has arrows attached to symbolize objects (physical or information) which are named with nouns. The objects that were modeled were each activity's *inputs, controls* and *outputs,* where each activity had to have at least one control and one output. An *input* is an object that is consumed or transformed in the activity to produce outputs, and enters from the left. A *control* specifies some conditions required for the activity to produce correct outputs, and enters from above. An *output* is an object produced by the activity, and leaves to the right. One object can be used in multiple boxes and can act as different types of objects depending on how it is used (e.g. either as an input or control to another box in the same diagram, or even in another diagram). Another object which can be used is a *mechanism.* This represents some means of supporting the execution of the activity and enters from below; however, none were modeled in this study. An illustration of the diagram levels and the detailing procedure is presented in Figure 4.

Figure 4. An illustration of diagram levels (A-1, A-0, A0, *etc.*) and the detailing procedure in IDEF0 function modeling. From NIST [29].



2.3. Analysis

Differences in activities between and within the FOAs were visually identified and highlighted in the IDEF0 models. Based on the models and the identified differences, an analysis of the interview material was done with respect to the causes and effects of the identified differences, focusing on how the industrial context affected procurement, management and development of harvesting services.

3. Results

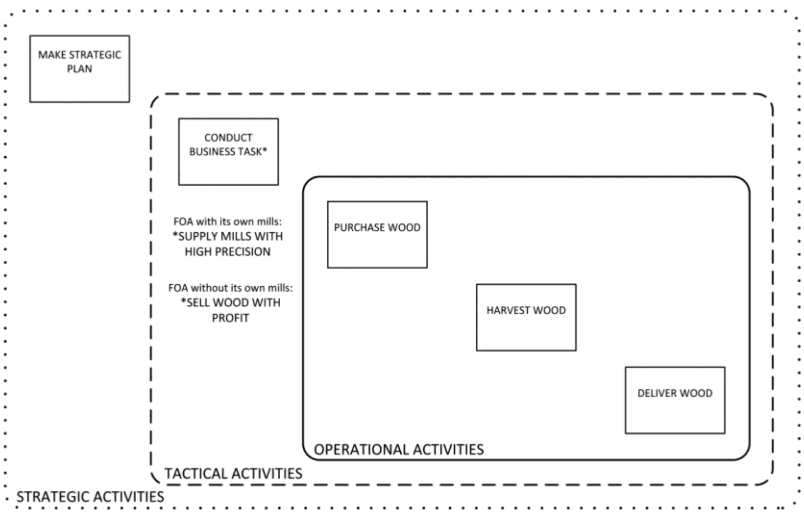
Context models were separately made for the two FOAs because of their differences in supply responsibilities (internal/own sawmills *vs.* external/no own mills). Different context models were also made for the strategic, tactical and operational perspectives. In the *Harvest wood* function, the FOAs' activities were similar and one common detailed model was made.

3.1. The Context Models

3.1.1. A General Context Diagram

Five general functions were modeled in a general context diagram of the FOAs' main business activities. The functions include *Make strategic plan*, *Conduct business task*, *Purchase wood*, *Harvest wood*, and *Deliver wood*. Though the functions worked parallel to each other, they have a clear hierarchy. The functions are described in Figure 5, where the hierarchically highest function is positioned in the upper left corner and the hierarchically lowest function is positioned in the lower right corner. At this level, the only observed difference between the two FOAs lay in the *Conduct business task* function. The business task for the FOA-NM was to sell wood purchased from forest owners to external mills with profit. For the FOA-M, the task was to supply their own sawmills with as high delivery precision as possible. In the FOA-M, there was no profit demand made directly on the *Purchase wood* function because profit goals were primarily focused on sawmilling. Activities in the strategic perspective occurred in all five functions. Tactical activities occurred in all five functions, except in *Make strategic plan*. Operational activities occurred mainly in *Purchase wood*, *Harvest wood* and *Deliver wood*.

Figure 5. General functions in the forest owners associations (FOAs), with a principal division of functions containing strategic, tactical and operational activities. The *Conduct business task* functions were different for the two FOAs, and their respective tasks are stated under the activity box (marked with asterisks).



3.1.2. Strategic Activities

The strategic planning horizon at the FOAs was three to five years, according to the interviewed managers. Strategic activities were conducted in all five general functions (Figure 5). At both FOAs, the *outputs* of the *Make strategic plan* function were business plans. These plans contained business goals for each of the coming years together with strategies for how to reach them. The purpose of the business plan was to give long-term guidelines for the management of all four subordinated functions. The *controls* for the *Make strategic plan* function were long-term market analyses, prognoses and outcome statistics from the four subordinated functions.

There were differences between the two FOAs in time horizon and revision routines of business plans, as they were described by the interviewed managers. At the FOA-NM, a new business plan was established every three to five years, depending on the market stability, and remained fixed for this period. At the FOA-M, the business plan was established for a three-year period, with annual revisions to meet market changes. At the FOA-M, a strategy document was also written for the coming five-year period. The document did not contain any defined goals but instead contained visions and principal guidelines to follow. The business plan was described as a realization of the strategy document.

3.1.3. Tactical Activities

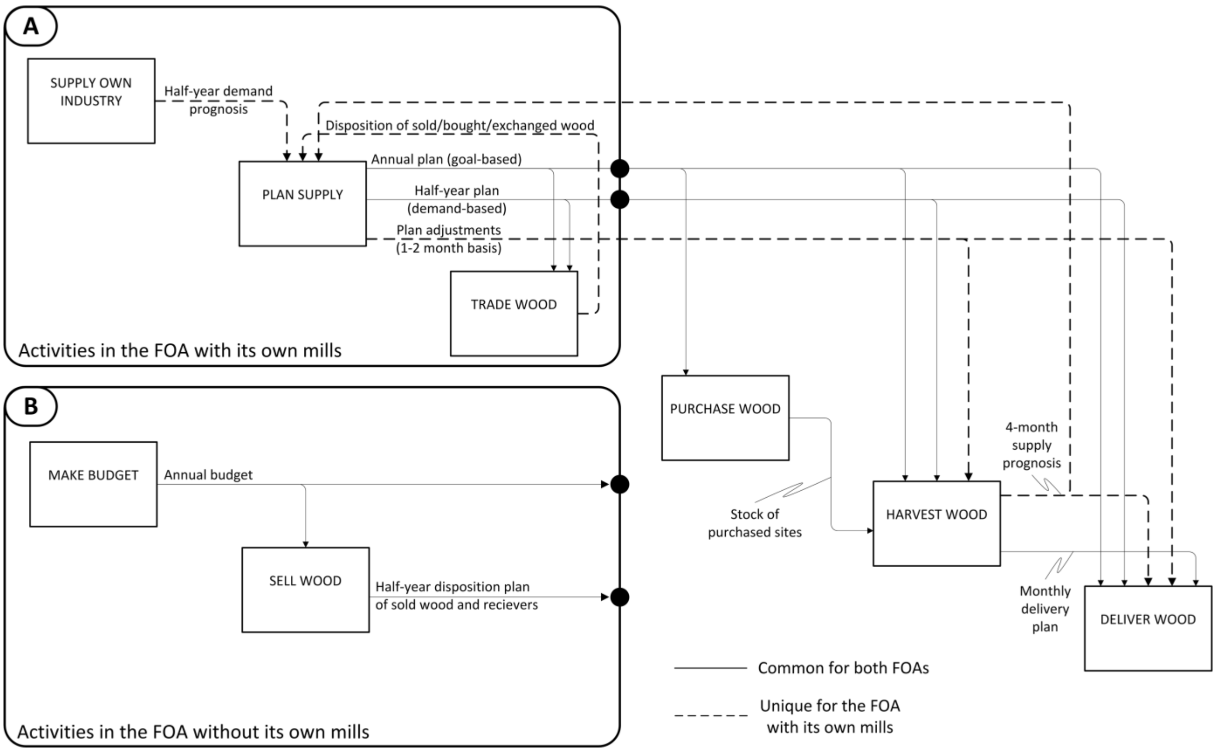
The tactical planning horizon at the FOAs varied from a month to a year, according to the interviewed managers. The tactical activities are described in Figure 6, where differences between the two FOAs are indicated. These differences are explained in the following text.

In the tactical perspective, the *Conduct business task* functions could be detailed into separate activities which differed between the FOAs. In the FOA-M the *Conduct business task* function consisted of the activities *Supply own industry*, *Plan supply* and *Trade wood* (Figure 6, *A*). The *output* from the *Supply own industry* activity was a half-year demand prognosis for volumes per assortment. The demand prognosis was a *control* to the *Plan supply* activity, in which a detailed, half-year plan was made which acted as a *control* to the other functions. An annual plan was also a *control* to *Plan supply*, but this plan was based on goals from the strategic business plan and not on the current demand. In accordance with the annual and half-year plans, wood was sold, bought or exchanged (mainly pulpwood for sawlogs) in the *Trade wood* function on a half-year basis. The *output* was a disposition plan that acted as a *control* to *Plan supply* in which a plan for purchase and production was made. Based on rolling monthly updates of four-month supply prognoses from the *Harvest wood* function, necessary adjustments were also signalled on a monthly or bi-monthly basis from the *Plan supply* activity to the *Harvest wood* and *Deliver wood* functions.

In the FOA-NM the *Conduct business task* function consisted of the *Make budget* activity and the *Sell wood* activity (Figure 6, *B*). The *output* from *Make budget* was an annual plan (budget) of wood to purchase and sell based on market information from the other functions. Based on the budget, wood deliveries to external mills were contracted every half a year in the *Sell wood* activity. The *output* was a half-year disposition plan of sold volumes, assortments and receiving mills, which in turn acted as a *control* to the other functions.

According to the mapped activities, the *Purchase wood, Harvest wood*, and *Deliver wood* functions were similar between the FOAs. The annual and half-year plans were *controls* to these functions, providing goals and frames for wood purchase and procurement of production capacity. The o*utput* from *Purchase wood* was a stock of purchased harvesting sites. With the stock of purchased sites as *input* and the half-year plan as *control*, the *output* from the *Harvest wood* function was a monthly delivery plan that acted as a *control* to the *Deliver wood* function. In these three functions, the maps in the tactical perspective revealed only two differences between the FOAs. These differences were the rolling four-month supply prognoses and the plan adjustment signals occurring on a monthly or bi-monthly basis which were unique for the FOA-M.

Figure 6. Information flows in tactical activities within the functions of the forest owners associations (FOAs). Inset *A* marks activities in the FOA with its own mills. Inset *B* marks the corresponding activities in the FOA without its own mills. The three right-hand activities (unmarked) were common for both FOAs. The dashed arrows indicate information flows that occurred only in the FOA with its own mills.



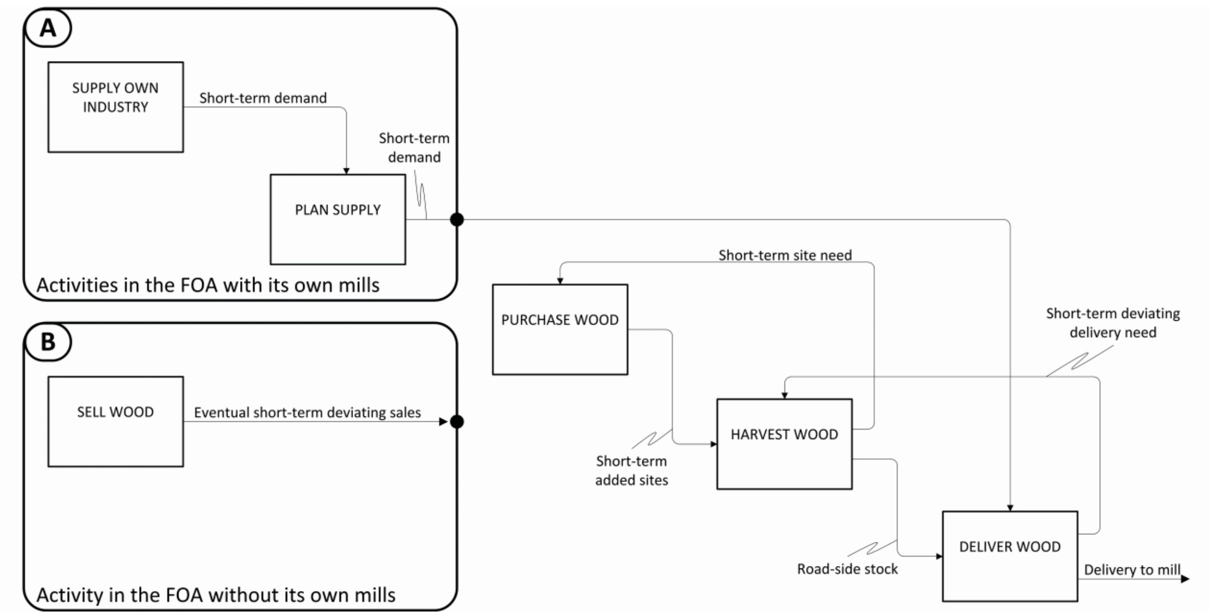
3.1.4. Operational Activities

The operational planning horizon at both FOAs was one month, according to the interviewed managers. The operational activities are described in Figure 7, where differences between the two FOAs are marked. These differences are explained in the following text.

Activities in the operational perspective consisted of continuous adaptations to short-term changes in demand. These adaptions were of a “fine-tuning” character, in comparison to the more general planning of the tactical perspective. Short-term sales deviations for the FOA-NM, and short-term demand deviations for the FOA-M, were signalled from the *Sell wood* function to the *Deliver wood* function. If adjustments to these changes in demand could not be met through transport rescheduling of current road-side stocks, a new delivery need was signalled from *Deliver wood* to *Harvest wood.* If the *Harvest wood* function could not compensate to the need through harvest rescheduling of the current stock of purchased sites, a need was signalled to the *Purchase wood* function. Sites that matched the changes in demand could then possibly be added to the stock of purchased sites in the *Purchase wood* function.

One difference between the FOAs in the operational perspective was the continuous adaptations to match changing sawmill demand for the FOA-M. In the FOA-NM, deliveries were generally made according to fixed six-month contracts with external mills. Even for these, some deviations in sales were also described by the interviewed managers but these deviations were normally described as marginal.

Figure 7. Information flows in operational activities within the functions of the forest owners associations (FOAs). Inset *A* marks activities in the FOA with its own mills. Inset *B* marks the corresponding activity in the FOA without its own mills. The three right-hand activities (unmarked) were common for both FOAs.



3.1.5. Summary of Differences

Beyond having different business tasks (supply mills with high precision *vs.* sell wood with profit), *the two FOAs differed in the number and occurrences of planning activities*. In the strategic and tactical perspectives, there was a higher occurrence of activities in the FOA-M compared to the FOA-NM concerning both supply (6 *vs.* 3 activities, respectively) and demand planning (8 *vs.* 5 activities, respectively). The more planning steps and greater frequencies in adjustments enabled the FOA-M to balance supply with variations in the sawmills' demands. In the operational perspective, only one difference in activities was found between the two FOAs and this concerned the occurrence of demand adjustments. The observed planning steps and their occurrences are summarized in Table 3.

Table 3. Observed occurrences of planning steps (marked with X) in the two case FOAs, concerning supply and demand planning respectively.

Perspective	Planning step	Frequency	FOA with its own mills		FOA without its own mills	
			Planning occurence & concern		Planning occurence & concern	
			Supply	Demand	Supply	Demand
Strategic	Strategy	5 years	X	X		
	Business plan (BP)	3–5 years	X	X	X	X
	BP revision	1 year	X	X		
Tactical	Goal-based plan	1 year	X	X	X	X
	Demand-based plan	½ year		X		X
	Supply prognosis	4 months	X			
	Adjusted demand plan	1–2 months		X		
Operational	Delivery plan	1 month	X	X	X	X
	Adjustments	<1 month		X		X
	Number of occurrences		6	8	3	5

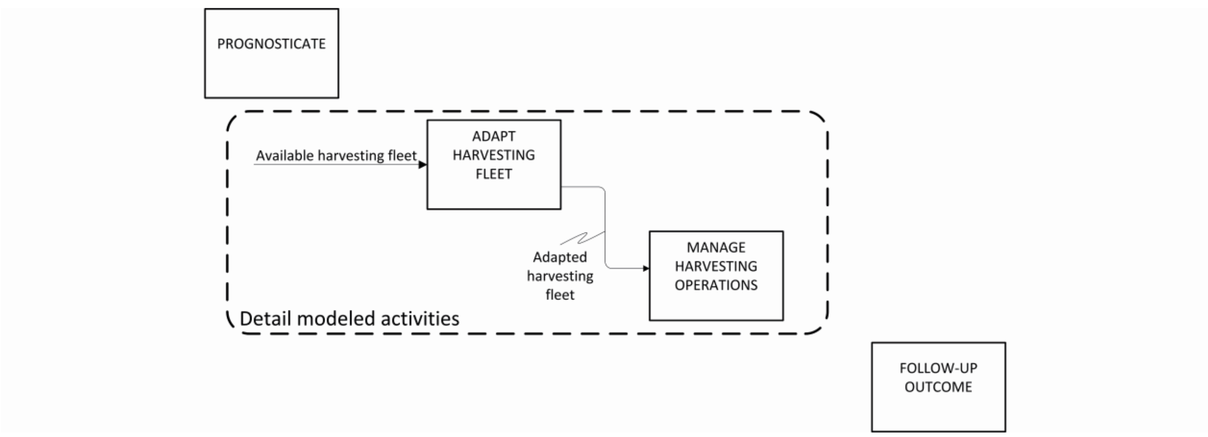
3.2. The Detailed Model

3.2.1. The Harvest Wood Function

The *Harvest wood* function was detailed into four activities. These were *Prognosticate*, *Adapt harvesting fleet*, *Manage harvesting operations*, and *Follow-up outcome*. The hierarchical order of the activities is described in Figure 8.

In the *Prognosticate* activity, market analyses, production prognoses and delivery plans were made. In the *Follow-up outcome* activity, the production outcome was measured in relation to what was prognosticated. The focus in this study was on procurement, development and management of harvesting services, all of which were included in the two middle-level activities *Adapt harvesting fleet* and *Manage harvesting operations.* Therefore, these two activities were modeled in further detail and described in the following text.

Figure 8. Activities in the *Harvest wood* function. The dashed square marks activities that were modeled in further detail.



3.2.2. The Adapt Harvesting Fleet Activity

Four sub-activities were modeled when detailing the *Adapt harvesting fleet* activity. The sub-activities included the *Estimate need*, *Procure*, *Follow-up performance*, and *Develop* activities. These are described in Figure 9, where differences between the FOAs are marked and the observed general order of priority is indicated. They are explained in the following text.

In the *Estimate need* activity, the need for harvesting capacity and harvesting fleet characteristics was continuously updated. The need was a balance between satisfying long-term goals, medium-term plans and short-term needs. More *controls* were considered for the FOA-M than for the FOA-NM. Common *controls* for both FOAs were the five to three-year goals from strategic business plans, the annual plan (or budget), a half-year plan and the short-term deviations in delivery needs. The FOA-M also had the five-year strategy and the monthly or bi-monthly plan adjustments as additional *controls*.

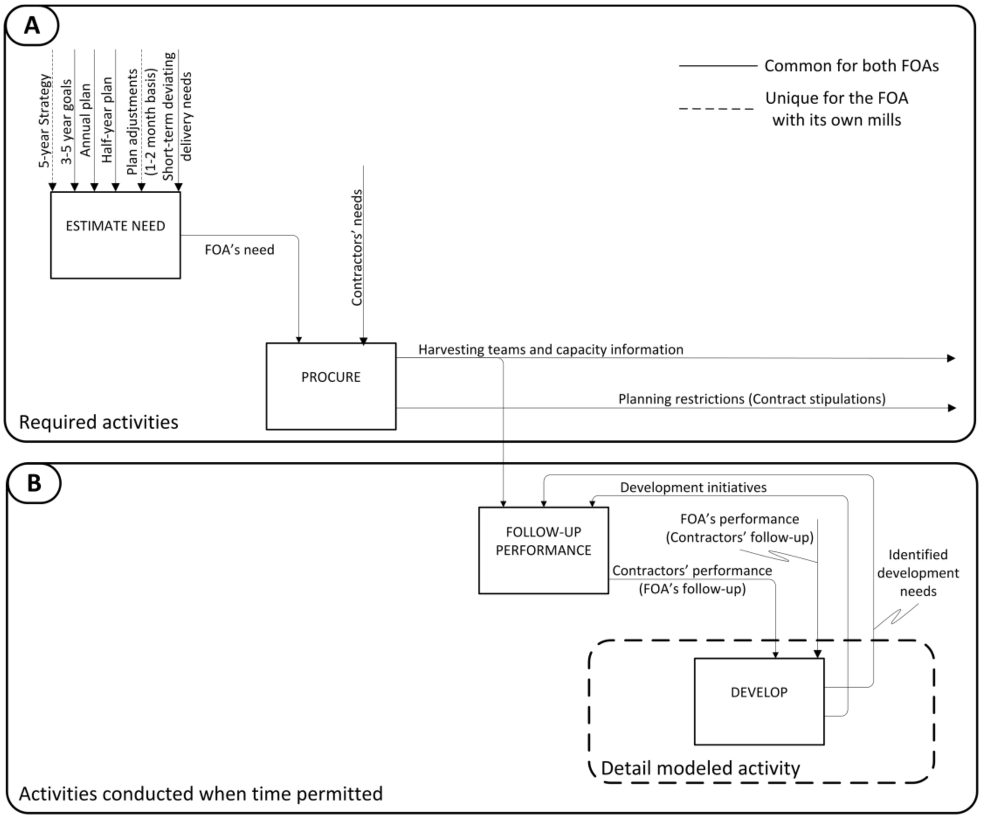
Harvesting capacity was procured in the *Procure* activity to match estimated needs, either by contracting new or by renegotiating with current contractors. Seasonal variation in the pace of harvesting operations gave rise to a general need for short-term capacity adjustments. All interviewed production managers preferred to satisfy this need through short-term contracts, however, some found this difficult due to two reasons. The first reason was a perceived increasing shortage of contractors capable of fulfilling all service requirements. The second reason was a perception of increasingly strict delivery- and quality demands. These demands were considered to require well-developed joint work routines, which in turn required long-term relationships. Two production managers considered that they had the opportunity to use short-term contracts to some extent (20% or more of the total capacity need) within their districts, and they utilized these opportunities. The other four interviewed managers however did not (two had 10% and two had no short-term contracted capacity), and they instead satisfied their needs for capacity flexibility by restructuring their harvesting fleet to include a larger proportion of mid-sized machinery. These machines were considered to be more flexible because they could alternate between clear-cutting and thinning, but were also considered to be a less economical alternative than operations specific machines (small for thinning and large for clear-cutting). The resulting higher harvesting costs are not taken into account for the FOA’s profit margins, because these costs are normally transferred directly to the forest owners in the majority of wood purchase contracts. High costs are, however, a competitive disadvantage for the FOA on the wood market. Changing machinery in the harvesting fleet was described to be a slow process because most contractors’ investment cycles were four to six-years.

Considering the *Procure* activity, controls did not only include the FOA need, but also the expressed needs and goals of individual contractors. It was here in the *Procure* activity that FOA managers and contractors tried to find the best solutions to satisfy each other’s needs and goals. Negotiations resulted in a number of contract stipulations, which would represent planning restrictions in the later management of harvesting operations. Such negotiations between FOA managers and contractors were described to commonly occur once per year, resulting in updated contract conditions for services, volumes and price levels.

Whereas the *Estimate need* and *Procure* activities were required in operational management (Figure 9, *A*), the *Follow-up performance* and *Develop* activities were not (Figure 9, *B*). The two latter activities were only conducted when time was available, after securing a production that satisfied demand. The production managers' descriptions on how much time they spent on follow-up and development varied depending on how much time their operational management required. Some follow-up efforts were considered as necessary in order to maintain control of the production, while more frequent follow-up and development efforts had a lower priority.

Besides the previously mentioned negotiations in the *Procure* activity, contractors and FOA managers also met in the *Develop* activity in order to give mutual feed-back from respective party's follow-up of the other party's performance. Here they could agree on further development initiatives. The *Develop* activity was therefore modeled in further detail and is described in the following text.

Figure 9. Sub-activities in the *Adapt harvesting fleet* activity. Inset *A* marks activities that were required in operational management. Inset *B* marks activities that were only conducted when time was available. The dashed arrows indicate controls that occurred only in the FOA with its own mills. The dashed inset on the lower right of inset B marks the activity modeled in further detail.



3.2.3. The Develop Activity

Three similar sub-activities were observed at both FOAs when detailing the *Develop* activity. These included *Have continuous dialogue*, *Analyze individual key ratios*, and *Conduct development initiatives*. The FOA-M had an additional sub-activity that did not exist in the FOA-NM; *Compile*. Their hierarchical order is presented in Figure 10.

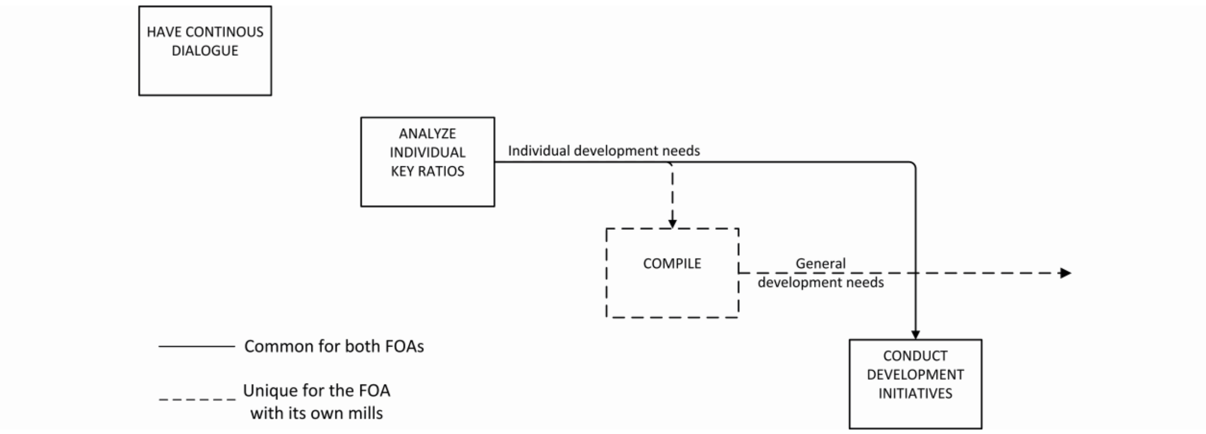
The *Have continuous dialogue* activity included informal continuous exchanges of follow-up information and development suggestions between contractors and FOA managers. These resulted in identified development needs which acted as *controls* to the more formal and structured activity

Analyze individual key ratios where a number of performance measures were compiled over time in a standardized procedure to identify contractor specific development needs. Formal individual business development meetings between contractors and production managers where commonly held one to two times per year. At these meetings, protocols of performance, development needs and agreements were written as memoranda for both parties.

The additional activity noted for the FOA with own mills was *Compile* where all individual protocols, written in a standardized template of content, were collected from districts to a single central staff function. Common development needs for the entire organization were then identified through the protocols and central resources were focused to improve the most important development needs.

Agreed development initiatives acted as *controls* to the *Conduct development initiatives* activity, where FOA managers and contractors took the agreements to implementation. The outcome from development initiatives then acted as *controls* to the other activities.

Figure 10. Sub-activities within the *Develop* activity. The dashed activity and information flows occurred only in the FOA with its own mills.



3.2.4. The Manage Harvesting Operations Activity

Three sub-activities were modeled when detailing the *Manage harvesting operations* activity. These include *Schedule*, *Order*, and *Supervise* and are illustrated in Figure 11. Observed variations in information flows between FOA districts are marked in the figure and explained in the following text.

In the *Schedule* activity, sites from the stock of purchased sites were allocated to the harvesting teams with a specific harvesting sequence. The *output* was a preliminary schedule for these. Numerous *controls* for Scheduling were described by production managers, but could be summarized in three categories: (i) physical restrictions, (ii) internal efficiency needs, and (iii) contractors' efficiency needs. *Physical restrictions* referred to accessibility factors due to soil bearing capacity (mainly weather dependent). *Internal efficiency needs* included three factors. The first factor concerned keeping promises given to forest owners such as conducting harvesting activities within a specific time period. The second was avoiding paying compensation to contractors due to unfulfilled contract stipulations. The third was harvesting contracted sites in due time in order to ensure the profit margin between contracted price for wood purchased and mill delivery. The latter was especially important for the FOA-NM, where the company profitability was solely dependent on the margins between period-specific prices for purchased and sold wood. This situation presented an economic risk when delaying harvesting to the following period when the profit margin was then no longer ensured. A similar system of price periods did not exist for the FOA with own mills, where profitability goals were focused on sawmilling. Harvesting purchased sites within reasonable time was a restriction also for this FOA, but not as conspicuously expressed as in the FOA-NM. With respect to *contractors' efficiency needs* three factors acted as controls to maintain high capacity utilization. The first factor was to offer few and short relocations. The second was to schedule sites suitable for the contractor's specific machinery. The third was to keep harvesting teams within their geographical home areas as much as possible. *Physical restrictions* always had first priority as a *control* to the *Schedule* activity. However, the balancing of consideration to *internal efficiency needs versus contractors' efficiency needs* varied between production managers within both FOAs.

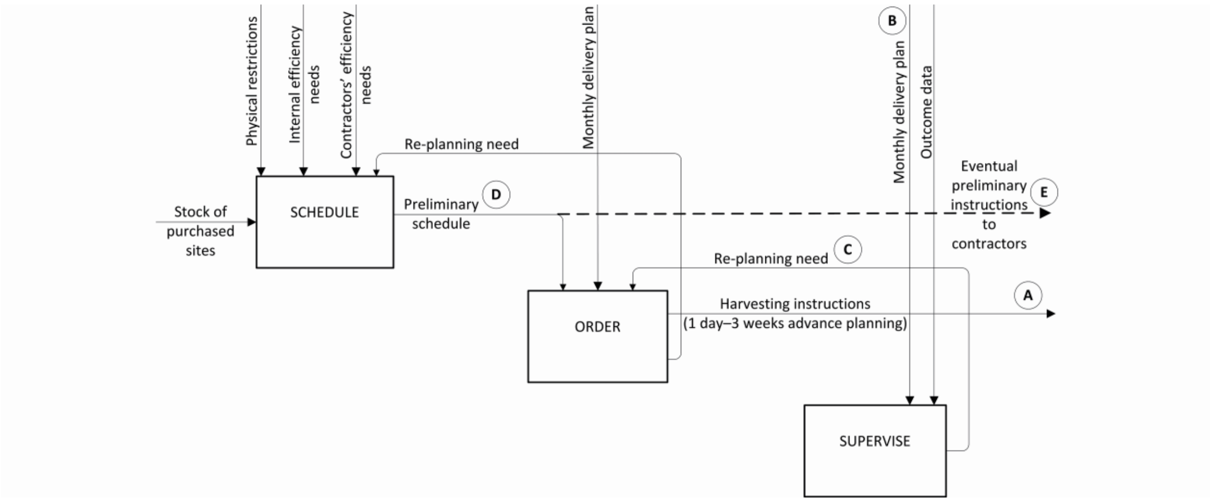
In the *Order* activity, preliminary scheduled sites were matched with the monthly delivery plan and bucking instructions were made to satisfy the district's *mill quotas* (volume shares of assortments to specific receiving mills). After this, final harvesting instructions for each site, including bucking instructions, were given to contractors. If the actual production did not satisfy mill quotas, a re-planning need was signalled to the *Schedule* activity and a more suitable selection of sites were scheduled.

The descriptions of how planning information and instructions were provided to contractors varied between districts. In general, production managers estimated the planning horizon for final harvesting instructions (Figure 11, *A*) to be one to three weeks, but sometimes as short as one day. The variation in planning horizons was explained to be partly dependent on the supply of accessible sites and partly dependent on the uncertainty in assortment volumes to satisfy mill quotas. Production managers explained that a greater number of mill quotas (Figure 11, *B*) resulted in a correspondingly more frequent re-planning need (Figure 11, *C*) due to differences between expected and actual production per assortment. A more frequent need for re-planning shortened the time horizon for giving definite harvesting instructions to contractors, correspondingly. All interviewed contractors pointed out that their possibility to maintain high capacity utilization was dependent on receiving instructions within a sufficient time horizon in order to plan relocations and balance harvester and forwarder production. Some contractors also communicated that proper preparatory planning at harvesting sites required timely distribution of site instructions.

All production managers made preliminary schedules on a one month basis, independent of uncertainty and re-planning needs (Figure 11, *D*). Some production managers chose to offer these schedules as preliminary instructions to aid contractor planning (Figure 11, *E*). Those who did not, justified this based on a perceived risk for contractor planning errors if the preliminary information was canceled or revised. They considered this to be the most efficient solution for their own work. It should be noted, however, that all interviewed contractors expressed a wish or need for as much information as early as possible in order to enable sufficient preparatory planning.

The production outcome in relation to mill quotas was continuously monitored by production managers in the *Supervise* activity. Except for automatically generated data of mill deliveries, the *controls* for this activity were production reports from harvesters and forwarders sent from contractors. According to managers at both FOAs, the precision in the *Manage harvesting operations* activity was dependent on reliable production reporting. More frequent production reporting was considered to offer faster and more precise re-planning. Many production managers however experienced missing production reports and low reporting frequencies from many contractors. The routines for production reporting varied between both production managers and contractors. Many contractors perceived increased production reporting as an extra workload.

Figure 11. Sub-activities in the *Manage harvesting operations* activity. Arrows *A–E* mark information flows that varied in content and frequencies between FOA districts.



Production managers' descriptions of how much time they spent on the *Manage harvesting operations* activity varied. From their descriptions, two categories of complexity factors were identified that increased the time required for this activity: (i) the need for supervision, and (ii) the need for administration. They explained that the *need for supervision* increased with the number of mill quotas because of more frequent need for re-planning in order to maintain sufficient delivery precision. The *need for administration* increased with the number of harvesting teams and the number of sites. The number of harvesting teams was in turn dependent on the geographical size of districts, and the number of sites was dependent on the average harvesting volumes of sites. Production managers explained that given a higher complexity, more time was required for the *Manage harvesting operations* activity. These managers experienced a resulting shortage of remaining time available for *Follow-up performance* and *Develop* activities.

3.2.5. Summary of Differences

In the detailed modeling of activities in the *Harvest wood* function, many differences were observed *within* the FOAs. These differences mainly concerned the production managers' varying perceptions, priorities and routines. *Between* the FOAs, the observed differences were mainly consequences of the contextual differences. Due to the more numerous planning steps in the FOA with own mills, there were more *controls* to consider in the *Estimate need* function. Due to the business task of selling wood with profit, the FOA-NM needed to consider the contract price period (to ensure profit margins on harvested wood) as an additional control to the *Schedule* activity. The only remaining differences *between* the FOAs concerned the additional sub-activities in the *Develop* activity at the FOA-M. All differences are summarized in Table 4.

Table 4. Observed differences in activities included in the *Harvest wood* function between and within the two case FOAs.

Activity	Sub-activity	Observed differences: Between FOAs	Observed differences: Within FOAs
Prognsticate	***Not detailed***		
Adapt harvesting fleet	**Estimate need**	2 more *controls* (strategy & bi-monthly plan adjustments) in the FOA with its own mills	
	Procure		Varying perceptions of contractor shortage, resulting in varying proportions of long-term contracts Varying use of operations specific machinery
	Follow-up performance		Varying descriptions of time spent on follow-up and development activities, depending on time required in operational management
	Develop	Standardized protocol template for business development meetings in the FOA with its own mills 1 more sub-activity (central compilation of development needs) in the FOA with its own mills	
Follow-up outcome	***Not detailed***		
Manage harvesting operations	**Schedule**	Contract price period was a *control* to the *Schedule* activity in the FOA without its own mills, as a consequence of the necessity to ensure a profit margin between price paid for wood and price received for mill deliveries	Variations in the balancing of consideration to internal efficiency needs *versus* contractors' efficiency needs when scheduling harvesting operations
	Order		Some productions managers gave no preliminary harvestings instructions to contractors, to avoid planning errors Varying descriptions of re-planning needs, correspondingly influencing the possible time horizon to provide definite harvesting instructions Some contractors communicated a need of timely instructions to enable proper preparatory planning
	Supervise		Varying routines for production reporting

4. Discussion

4.1. Contextual Differences

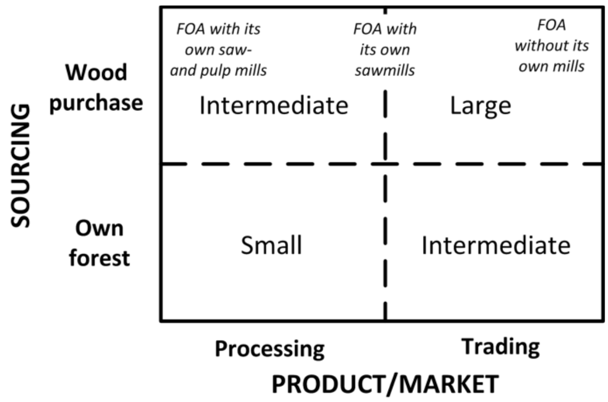
A structured functions framework for activities and information flows was established for strategic, tactical and operational levels. This enabled direct comparisons between the two studied FOAs. Using the framework, differences could be pinpointed, and their causes and effects tracked.

Given the different business tasks located on the strategic level (*Supply mills with high precision* at the FOA-M *vs. Sell wood with profit* at the FOA-NM, Figure 5), corresponding differences can be located on the tactical level (Figure 6). Both studied FOAs had a low uncertainty in total demand within the current plan period of half a year. For the next period, the FOA-NM had a high uncertainty in demand due to low insight in the plans of external mills. In comparison, the FOA-M had a lower demand uncertainty because of full insight in the sawmills' plans. Because of more frequently occurring adjustments within the current period (Table 3), the production management at the FOA-M had to adapt correspondingly. At the FOA-NM, the frequency of adjustments within the current period was low because of the fixed six-month contracts with external mills. Supply uncertainty was not handled in this study, but has been mapped in an international study by Audy *et al.* [24]. They conclude that forest ownership decreases supply uncertainty while market purchase increases uncertainty. Thus, both FOAs had high supply uncertainty outside the cover time of their current stocks of purchased sites. Audy *et al.* [24] position a Swedish FOA as having medium demand and supply uncertainty. This gives relevance of the current study to other countries where non-industrial private forest ownership is common.

Continuing on the tactical level, a higher frequency of adjustments in the FOA-M was observed in the more frequent information flow compared to that of the FOA-NM (Figure 6). A coordination activity, similar to the one at the FOA-M, was probably not needed at the FOA-NM, as the frequency of adjustments was low. The coordination of activities at the FOA with its own sawmills is similar to demand and supply coordination of pulpwood in the case of a Swedish FOA with its own pulp mills [33]. Similar adjustments and correspondingly increased information flows at companies with internal supply responsibilities for pulp mills are shown by Andrén and Fjeld [34]. Results from these previous studies show that differences depending on supply responsibilities are not unique for the FOAs in the current study. Instead, the FOAs share characteristics with other wood supply organizations. In general, internal supply responsibility requires more adjustments in production and a correspondingly increased information flow.

Uncertainty in demand and supply results in correspondingly increased flexibility needs for harvesting capacity. The FOA-NM had a large flexibility need between plan periods, due to higher uncertainty in both supply and demand. However, this uncertainty is likely to decrease as contract renewal approaches, The FOA with its own sawmills had lower uncertainty in long-term demand, and therefore a lower flexibility need between periods. In principle, this is described in Figure 12. In comparison, the case of a Swedish FOA with both its own saw- and pulp mills described in several previous studies [22,24,35] has an even lower uncertainty in demand but an equally high supply uncertainty. Thus, the FOA with its own saw- and pulp-mills could be considered to have an intermediate need for capacity flexibility. According to Arnold [18], this could present a possibility to increase the proportion of insourcing to gain a higher degree of control over harvesting resources (Figure 2), but this need has not been demonstrated in previous studies. Accordingly, even greater possibilities of insourcing could be expected at forest companies with both own forest resources and mills.

Figure 12. Flexibility need in harvesting capacity, depending on varying contexts (sourcing and product/market) among Swedish forest products businesses. Here, the two case FOAs as well as an FOA with both its own saw- and pulp mills are positioned.



4.2. Procurement of Harvesting Services

The need for capacity flexibility (identified in the context model) needed to be met in the *Procure* activity (Figure 9). Concerning the need for capacity flexibility, the managers in this study would have preferred to meet the flexibility need through a corresponding proportion of short-term contracts. However, some could not because of a perceived shortage of contractors capable of fulfilling all service requirements and instead chose to procure all capacity through long-term contracts. By doing this, they reduced their risk of being exposed to opportunistic behavior from less dependent contractors, which otherwise could be the case in a situation of a contractor shortage. These managers instead chose to gain flexibility through mid-sized machinery that could alternate between thinning and clear-cutting, which in light of Vining and Globerman [17], is interpreted as a lowering of asset specificity which again, reduces the risk for opportunism.

Given the results and literature, there appear to be two general options for an external outsourcing design when the contextual uncertainty is high. The required flexibility (Figure 12) can be gained through a large proportion of short-term contracts (as preferred by the managers in this study), thereby enabling a certain use of large machinery specialized for clear-cutting (operations specific). The advantage of this option is *the potential* to lower costs per harvested unit; however, this is possible only when there is a surplus of contractors. The other option is a large proportion of long-term contracts where flexibility is attained through mid-sized machinery for general use in both thinning and clear-cutting operations, thereby lowering the costs for opportunistic behaviour and governance. Governance costs in long-term relationships can also gradually be lowered as trust evolves with time [5]. Correspondingly, low contextual uncertainty enables the use and advantages of both a high proportion of long-term contracts (control) and operations specific machinery (with potentially lower unit costs). It should be mentioned, however, that while attaining flexibility through mid-sized machinery may be associated with higher costs per harvested unit [36], it also offers a potential to reduce the amount of time spent relocating between sites. Regardless, higher or lower unit costs do not directly affect the profit margins for wood purchase because these costs are typically carried by the forest owners. Higher specialization by using operations specific machinery, however, results in increased governance costs [17], which would have a direct effect on both the profit margins and the time required by production managers for supervision. Given this, the incitements are small for production managers to choose operations specific machinery, especially if they perceive a shortage of contractors capable of fulfilling all service requirements.

The choice of harvesting technology is typically a strategic planning issue [33,37], and in this study the gradual shift towards new technology was handled on an annual (tactical) basis during procurement procedures. In this study, contractors generally had a four to six year length in their machinery investment cycles which is similar to earlier studies [38–40]. This cycle also corresponds well to the FOAs' strategic planning horizons. This provides the opportunity to synchronize the FOAs desired technology with the contractors' investments. In a context with a surplus of available contractors it might not be as critical to consider the contractors' investment plans in the FOA's strategic planning, because technology can potentially be adapted by choosing alternative contractors. However, because many districts had growing proportions of long-term contracts, contractors' investment plans should be integrated in the FOAs' strategic planning.

4.3. Management of Harvesting Operations

In their scheduling of harvesting operations (Figure 11), production managers had to choose a balance between meeting FOA goals (located on the strategical level) and contract conditions (located in the *Procure* activity, Figure 9) *versus* maintaining high contractor capacity utilization.

For contractors, preparatory planning may offer an opportunity to increase capacity utilization, but this requires both site information and a schedule for relocations between sites. Some production managers supported this by providing *preliminary* instructions. However, the greater the number of mill quotas handled per manager, the more frequent the need for *re-planning* due to differences between expected and actual production (Figure 11); the more frequent the need for re-planning, the shorter the time horizon for giving definite instructions. A higher frequency of re-planning required more frequent updates of preliminary instructions, resulting in a higher risk for contractor planning errors. Therefore, some production managers only provided definitive instructions, and chose to not release preliminary (unsure) information. A lack of preliminary instructions leads to a shorter contractor planning horizon based only on definite instructions. Some contractors considered this a problem, as they needed sufficient time for their preparatory planning. The negative effect of insufficient preparatory planning on capacity utilization has been shown in earlier studies [41,42]. The high occurrence of this problem in Swedish forestry is noted by Norin and Furness-Lindén [27], as well as its negative effects [43].

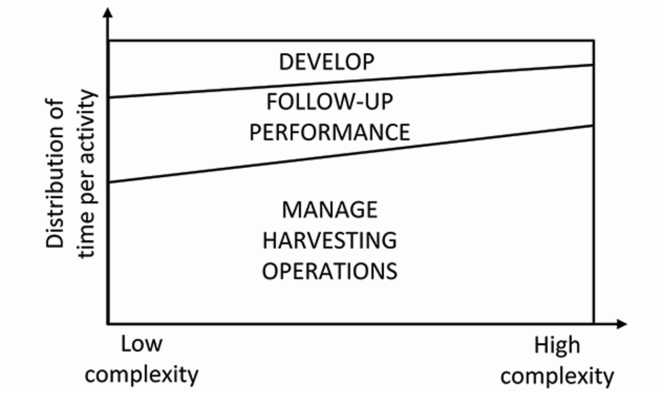
Just as contractors are dependent on timely instructions, production managers are dependent on reliable production reporting [44,45]. This is primarily due to a general lack of accurate information on stand characteristics and composition [23,46], necessitating frequent feedback on assortment specific production for re-planning purposes. In this study, a lack of complete and accurate reporting was considered a problem. The reason given for this was a perception of an unnecessary extra workload among contractors. Given the mutual dependence of both production managers and contractors on better planning- and reporting routines, this is an important area to focus on in future development activities.

4.4. Development of Harvesting Services

The current routines for development efforts included annual business development meetings between individual contractors and FOA managers, where contractor-specific key ratios were discussed (Figure 10). At the FOA-NM, the routines were developed at the individual districts. At the FOA-M, there was a standardized routine between districts also involving central staff. This enabled the FOA to continuously identify the most common and important development needs to focus central resources on.

The time available for development activities varied between production managers (Figure 9). This was a result of varying complexity in the supervision (number of mill quotas) and administration (number of teams and sites). Increased complexity reduced both the time available for development and performance follow-up activities. In principle, this is visualized in Figure 13. Despite the varying degrees of complexity between districts, the organization and number of production managers were similar. Securing sufficient time for follow-up and development requires therefore an organization adapted to the degree of complexity at individual districts. In principle, similar questions have been addressed in the management of other logistics systems. Hultén and Bolin [47] describe the limitations of managers in handling complex situations, and the need for attaining a so called requisite level of variety (referring to complexity) to gain system control. In the context of this study, the production could be controlled despite increased complexity in operational management. However, this blocked the possibilities to conduct development. A general solution is centralization of development efforts, freeing production managers to focus more on performance follow-up. If complexity cannot be reduced in some way, the only remaining alternative would be to allocate more management capacity to districts with high numbers of mill quotas, teams and sites.

Figure 13. A visualization of the distribution of available time for different activities depending on the complexity in operational management (in principle, not by estimations).



The use of standardized routines for analysis of information on contractors and development could also support the integration of contractors' investments with the FOAs' strategic planning.

5. Conclusions

From this analysis of two Swedish FOAs, it can be concluded that varying industrial contexts in respect to supply responsibilities (internal *vs.* external) and forest ownership gives varying degrees of uncertainty in demand and supply. Consequently, this leads to a varying need for flexibility in harvesting capacity. In this study, managers typically preferred to attain flexibility through a corresponding proportion of short-term contracts. However, some mangers perceived a shortage of available contractors capable of fulfilling all service requirements. These managers therefore chose a large proportion of long-term contracts to secure capacity and competence. In such cases, capacity flexibility can be attained by decreasing the use of operations specific machinery and increase the use of mid-sized machinery for general use. In situations where high proportions of long-term contracts are used, it can be recommended to integrate contractors' investment plans in the service buyers' strategic outsourcing planning.

It appears that complexity in operational management varied considerably between districts, and it is the author's hypothesis that this presents a risk for decreased focus on development efforts. Where there are limited possibilities to focus on development efforts, standardized follow-up of development needs could enable centralization of these activities. Such centralization could support the integration of the contractors' long-term plans in the service buyer's strategic planning.

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Conflicts of Interest

The author declares no conflicts of interest.

References

1. NRA Sweden. *A National Strategic Research Agenda (NRA) for the Forest-Based Sector in Sweden*; The Swedish National Support Group: Stockholm, Sweden, 2006.
2. Brunberg, T. *Skogsbrukets kostnader och intäkter 2011 [Forestry Costs and Revenue 2011]*; Skogforsk: Uppsala, Sweden, 2012 (in Swedish).
3. Ager, B. *Skogsarbetets rationalisering och humanisering 1900–2011 och framåt [The Rationalization and Humanization of Forest Work 1900–2011 and Forward]*; Swedish University of Agricultural Sciences: Umeå, Sweden, 2012 (in Swedish).
4. Nordfjell, T.; Bjorheden, R.; Thor, M.; Wästerlund, I. Changes in technical performance, mechanical availability and prices of machines used in forest operations in Sweden from 1985 to 2010. *Scand. J. Forest Res.* **2010**, *25*, 382–389.

5. Högnäs, T. *Towards Supplier Partnerships in Timber Harvesting and Transportation*; Metsähallitus: Vantaa, Finland, 2000.
6. Hultåker, O. Entreprenörskap i skogsdrivningsbranschen: En kvalitativ studie om utveckling i små företag [Entrepreneurship in the forest harvesting industry: A qualitative study of development in small enterprises]. Ph.D. Thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden, 2006 (in Swedish).
7. Berlin, C. Forest Owner Characteristics and Implications for the Forest Owner Cooperative. Licentiate Thesis, Swedish University of Agricultural Sciences: Umeå, Sweden, 2006.
8. Swedish Forest Agency. *Swedish Statistical Yearbook of Forestry 2012*; Swedish Forest Agency: Jönköping, Sweden, 2013.
9. Nollet, J.; Ponce, S.; Campbell, M. About "strategy" and "strategies" in supply management. *J. Purch. Supply Manage*. **2005**, *11*, 129–140.
10. Lapierre, J. Customer-perceived value in industrial contexts. *J. Bus. Ind. Marketing*. **2000**, *15*, 122–140.
11. Teece, D.J. Strategies for managing knowledge assets: The role of firm structure and industrial context. *Long Range Plann.* **2000**, *33*, 35–54.
12. Häggström, C.; Kawasaki, A.; Lidestav, G. Profiles of forestry contractors and development of the forestry-contracting sector in Sweden. *Scand. J. Forest Res.* **2013**, *28*, 395–404.
13. Norin, K. *Upphandling och försäljning av entreprenadtjänster i skogsbruket-en diskussion om affärskoncept som stöder drivningssystemens utveckling [Forestry-Contractor Services-Buying and Selling: A Discussion of Business Approaches that Support Developments in Logging Systems]*; Skogforsk: Uppsala, Sweden, 2002 (in Swedish).
14. Bergquist, E. *Varför Lämnar Skogsmaskinförare Branschen? [Why do Forest Machine Operators Leave the Forest Industry?]*; Swedish University of Agricultural Sciences: Umeå, Sweden, 2009 (in Swedish).
15. Rummukainen, A.; Dahlin, B.; Penttinen, M.; Selby, A.; Mikkola, J. Challenges to the forest machine business as a result of global economic change. In *Forest, Wildlife and Wood Sciences for Society Development*, Proceedings of the IUFRO Conference, Prague, Czech Republic, 16–18 April 2009.
16. Penttinen, M.; Rummukainen, A.; Mikkola, J. Profitability, liquidity and solvency of wood harvesting contractors in Finland. *Small Scale For.* **2011**, *10*, 211–229.
17. Vining, A.; Globerman, S. A conceptual framework for understanding the outsourcing decision. *Eur. Manage. J.* **1999**, *17*, 645–654.
18. Arnold, U. New dimensions of outsourcing: A combination of transaction cost economics and the core competencies concept. *Eur. J. Purch. Supply Manage.* **2000**, *6*, 23–29.
19. Quélin, B.; Duhamel, F. Bringing together strategic outsourcing and corporate strategy: outsourcing motives and risks. *Eur. Manage. J.* **2003**, *21*, 647–661.
20. Quinn, J.B.; Hilmer, F.G. Strategic outsourcing. *Sloan Manage. Rev.* **1994**, *36*, 45–55.
21. Cousins, P.D. The alignment of approriate firm and supply strategies for competitive advantage. *Int. J. Oper. Prod. Man.* **2005**, *25*, 403–428.
22. Carlsson, D.; Rönnqvist, M. Supply chain management in forestry—Case studies at Södra Cell AB. *Eur. J. Oper. Res.* **2005**, *163*, 589–616.

23. Uusitalo, J. A framework for CTL method-based wood procurement logistics. *Int. J. For. Eng.* **2005**, *16*, 37–46.
24. Audy, J.-F.; Pinotti Moreira, M.; Westlund, K.; D'Amours, S.; LeBel, L.; Rönnqvist, M. *Alternative Logistics Concepts Fitting Different Wood Supply Situations and Markets*; Interuniversity Research Centre: Québec City, Canada, 2012.
25. Tap, S.D.; Ganesan, S. Control mechanisms and the relationship life cycle: Implications for safeguarding specific investments and developing commitment. *J. Marketing Res.* **2000**, *37*, 227–245.
26. Furness-Lindén, A. *Affärsutveckling i relationen stor kund/liten leverantör—Vad kan skogsbruket lära? [Business Development: Large Customer-Small Supplier Relations. What Can Forestry Learn from the Process?]*; Skogforsk: Uppsala, Sweden, 2008 (in Swedish).
27. Norin, K.; Furness-Lindén, A. *Vägar till professionell upphandling av tjänster i skogsbruket—Erfarenheter, förslag och inspirationskälla [Ways to Improve the Procurement of Services in Forestry—Experience, Recommendations and Inspiration]*; Skogforsk: Uppsala, Sweden, 2008 (in Swedish).
28. Robins Sadler, G.; Lee, H.-C.; Hwan-Lim, R.S.; Fullerton, J. Recruitment of hard-to-reach population subgroups via adaptions of the snowball sampling strategy. *Nurs. Health Sci.* **2010**, *12*, 369–374.
29. National Institute of Standards and Technology (NIST). *Integration Definition for Function Modeling (IDEF0)*; National Institute of Standards and Technology: Gaithersburg, MD, USA, 1993.
30. Noran, O.S. *Business Modelling: UML* vs. *IDEF*; Griffith University: Nathan, Australia, 2000.
31. Cascini, G.; Rissone, P.; Rotini, F. Business re-engineering through integration of methods and tools for process innovation. *Proc. Inst. Mechanical Eng. Part. B*: *J. Eng. Manuf.* **2008**, *222*, 1715–1728.
32. Haapaniemi, M. *En generell processkartläggning av leveransplanering för biobränsle i Sverige [A Generic Process Model for Delivery Scheduling of Biofuels in Sweden]*; Swedish University of Agricultural Sciences: Umeå, Sweden, 2011 (in Swedish).
33. Carlsson, D.; D'Amours, S.; Martel, A.; Rönnqvist, M. Supply chain planning models in the pulp and paper industry. *Inf. Syst. Oper. Res*. **2009**, *47*, 167–183.
34. Andrén, M.; Fjeld, D. Information flow model for Swedish pulp wood supply. In *Silva Carelica*, Proceedings of the NSR Conference on Forest Operations, Hyytiälä Forest Field Station, Hyytiälä, Finland, 30–31 August 2004; Volume 45, pp. 150–158.
35. Kollberg, M. Beyond IT and Productivity—Effects of Digitized Information Flows in the Logging Industry. Licentiate Thesis, Linköping University, Linköping, Sweden, 2005.
36. Brunberg, T.; Lundström, H. *Rätt maskinval i gallring—Studie vid SCA skog [Smallest Harvester Cost-Effective in Small-Diameter Thinnings; Medium-Duty Harvester Best in Somewhat Larger Stands]*; Skogforsk: Uppsala, Sweden, 2010 (in Swedish).
37. D'Amours, S.; Rönnqvist, M.; Weintraub, A. Using operational research for supply chain planning in the forest products industry. *Inf. Syst. Oper. Res*. **2008**, *46*, 265–281.

38. Bergkvist, I. *Tvåskift är billigast, men låga räntor minskar gapet mot enkelskift [Two-Shift System Cheapest but Low Interest Rates are Closing the Single-Shift Gap]*; Skogforsk: Uppsala, Sweden, 2010 (in Swedish).
39. Norin, K.; Karlsson, A. *Så arbetar en vinnare—Djupintervjuer med tio lönsamma skogsentreprenörer [What Makes a Winner? —Searching Interviews with 10 Successful Forestry Contractor Businesses]*; Skogforsk: Uppsala, Sweden, 2010 (in Swedish).
40. Vestling, B. *Kostnadspåverkande faktorer för skördare—En analys av uppföljningsdata hos Stora Enso Skog [Factors Influencing Costs for Harvesters—An Analysis of Follow-Up Data at Stora Enso Skog]*; Swedish University of Agricultural Sciences: Umeå, Sweden, 2012 (in Swedish).
41. Mayo, J.H.; Greene, W.D.; Clutter, M.L.; deHoop, N.; Egan, A.F. Causes and Costs of Unused Logging Production Capacity. In *A Global Perspective*, Proceedings of the Council on Forest Engineering (COFE) Conference, Auburn University, Auburn, AL, USA, 16–20 June 2002.
42. Spinelli, R.; Visser, R. Analyzing and estimating delays in harvester operations. *Int. J. For. Eng.* **2008**, *19*, 36–41.
43. Mörk, A.; Thorsén, T. *Nyckelfaktorer för effektiva maskinlag [Key Factors for Improving Efficiency of Logging Teams]*; Skogforsk: Uppsala, Sweden, 2011 (in Swedish).
44. Arlinger, J.; Möller, J. *Standard för Skotarrapportering—Viktig Länk i Skogsbrukets Logistik* [*New Standard for Forwarder Reports—A Vital Link in Forestry Logistics*]; Skogforsk: Uppsala, Sweden, 2006 (in Swedish).
45. Arlinger, J. *Nya möjligheter med StanForD 2010 [Updated Standard for Forest Machine Data-StanForD 2010]*; Skogforsk: Uppsala, Sweden, 2011 (in Swedish).
46. Bjerner, J. *Betydelsen av felaktig information i traktbanken—Inverkan på virkesleveranser samt tidsåtgång och kostnad vid avverkningar [The Consequences of Erroneous Information in Stand Registers—Its Effect on Timber Delivieries and Harvesting Operations]*; Swedish University of Agricultural Sciences: Umeå, Sweden, 2004 (in Swedish).
47. Hultén, L.; Bolin, H. *Information Exchange and Controllability in Logistics*; Transport Research Institute: Stockholm, Sweden, 2002.