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Alternative Logistics Concepts Fitting Different Wood Supply Situations and Markets

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Abstract. In this research project, we developed a framework for describing different wood supply chains (WSC) in a generic way and assessing their agility and tailoring capabilities. The studied WSC comprises the planning and execution, at the operational level, of all activities, from selling agreements to delivery of forest products at the mill yard. These include the purchase or selection of harvesting blocks, harvesting scheduling and execution, as well as transportation scheduling and execution. The framework includes a set of descriptive templates including e.g. a description of the actors, their planning and execution processes, the decoupling points used, together with information, material and financial flows.

The proposed framework was applied to case studies in six countries (Canada, Chile, France, Poland, Sweden and USA) where fieldwork allowed us to collect information from 94 local actors and experts. The case studies allowed a list of options (i.e. catalogues) to be generated for different descriptive elements within the framework. We generated catalogues of 16 types of actors involved in a WSC, seven locations of decoupling points, four types of value commitment processes, eight standing timber and harvest timber pricing mechanisms and several payment methods for standing timber, harvested timber, harvesting and primary and secondary transportation. We also developed 17 generic processes for any planning and execution activities within a WSC, as well as 13 generic planning decisions at the operational level. Three basic designs of planning systems were identified: 1) integrated sourcing and harvesting planning, 2) integrated harvesting and transportation planning, and 3) decoupled sourcing, harvesting and transportation planning. We also identified six logistics techniques to adjust supply to demand.

The agility capabilities of the WSC were assessed in four dimensions: customer sensitivity, process integration, information drivers and network integration. The developed methodology used a 0-4 scale to rate how well different enablers and practices, identified along the main processes within a WSC, contributed to each of these four dimensions. A WSC should strive towards proper agility capabilities in response to uncertainty in their environment. The agility capabilities evaluated in the case studies and those theoretically

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required by the environment's uncertainties are compared and discussed. Finally, tailoring capabilities were assessed, based on the location of the decoupling points and their respective order fulfilment cycle time. Two processes were identified, where most of the product differentiation activities along a WSC occur: harvesting with the CTL method and merchandising at a roadside landing using the FT method. The capabilities to tailor product specifications are superior before rather than after one of these processes. Moreover, a typology of assortments according to the level of tailoring is provided and the financial incentive to produce a basket of assortments with a higher level of tailoring is discussed. Finally, when comparing the location of the decoupling point, the agility capabilities and the average order fulfilment cycle time, it was possible to reinforce the results from the literature, which state that supply chain agility is linked to shorter lead-time.

The framework is useful to organisations interested in describing their WSC and assessing their agility and tailoring capabilities. By assessing the tailoring and agility capabilities of a WSC, the framework can support an organisation in an exercise of self-diagnosis that leads to the identification of improvement opportunities to work on. Moreover, by assessing different scenarios for its WSC (e.g. the introduction of new technology, the addition of a new value proposition for a customer), an organisation can anticipate the impacts of changes.

Finally, the framework introduced a common vocabulary to be used by researchers and practitioners in different disciplines (e.g. forest engineering, management sciences, industrial engineering). It represents an original attempt to develop a reference model for future research addressing WSCs.

Keywords: Wood supply chain, descriptive framework, agility, differentiation, decoupling point, planning systems.

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Abbreviations

2O	: to-order
2UO	: to urgent order
CTL method	: cut-to-length method
ERP system	: enterprise resource planning system
FT method	: full tree method
n.a.	: not applicable
OFDT	: order fulfilment dwell time
OFPT	: order fulfilment process time
PH	: planning horizon
SCOR model	: Supply Chain Operations Reference model
TP	: time period
OR	: operational research
VC	: value commitment
WSC	: wood supply chain

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Executive Summary

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1. Introduction

This report is part of the *Flexible Wood Supply Chain* (FlexWood) research initiative (www.flexwood-eu.org). The objective of FlexWood is to propose a novel wood supply chain (WSC) that increases value recovery through higher flexibility and tailoring capabilities, the aerial/terrestrial laser scanning of forest inventory, enhanced optimisation models in procurement activities and in the definition of the demand of mills. To support the design of this novel WSC, a generic framework for describing it and assessing its agility and tailoring capabilities was developed in Working Package 5100. Agility means to respond quickly and efficiently to sudden and unplanned changes in the environment of a WSC (Li et al., 2009). Conceptually, agility capabilities consist of flexibility capabilities with the notion of effectiveness. Tailoring (known as customisation or personalisation in the literature) refers to a supplier's design of its value proposition (i.e. the product and logistics services in a WSC) to targeted customer segments.

Previously, timberland was owned in many forested countries by companies that also owned the processing facilities (e.g. sawmills, pulp and paper mills). Standing timber was harvested and hauled to the mill gate by employees according to internal planning processes. This situation leads to a closed and fairly stable wood procurement system in which the available supply dictated the demand requirements. However, in most countries today, wood procurement systems generally consist of several independent business entities interacting through complex business relationships involving material, information and financial flows. All execution and planning processes are no longer handled exclusively internally. Nowadays, it is the norm for contractors to carry out harvesting and hauling activities for companies that either own the timberland and/or the mills. Mills serve national-to-worldwide markets subject to sudden changes and have higher product and logistics service expectations. This, in turn, requires the supply of raw material in more precise quantities and qualities and with flexible logistics service, raising new challenges to wood procurement systems. Today, wood procurement systems constitute complex supply chains with different components (Figure 1). The field of supply chain management is well suited to address their challenges. We refer the reader interested in the supply chain management of the forest products industry to the reviews by Rönnqvist (2003), Weintraub et al. (2007), D'Amours et al. (2008) and Carlsson et al. (2009). Moreover, the cost of raw material accounts for a significant part of the total cost of the final wood products (e.g. between 26-30% of the cost of a metric ton of pulp for an average Swedish pulp mill). Given this large amount of money spent by wood procurement systems, a small cost reduction can lead to important savings.

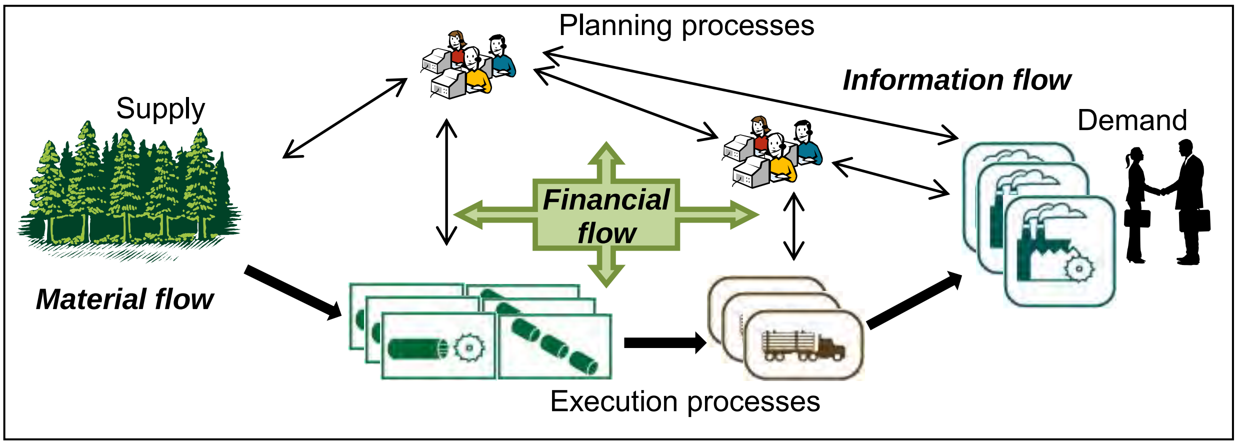


Figure 1: The main components of a wood supply chain.

A supply chain can be defined as a ''network of organisations that are involved, through upstream and downstream linkages, in different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" (Christopher, 2005). There are two core ideas in the supply chain concept:

a) Better collaboration between companies in the same supply chain will improve delivery service, better manage utilisation and save costs, particularly for holding inventories (Alicke, 2005);

b) Individual businesses can no longer compete as solely autonomous entities, but rather as supply chains (Christopher, 2005).

Supply chain management is ''the task of integrating organisational units along a supply chain and coordinating material, information and financial flows in order to fulfil customer demand with the aim of improving the competitiveness of a supply chain as a whole'' (Stadler and Kilger, 2008). That is why, rather than acting company by company, clusters of connected companies (i.e. supply chains) make up a more meaningful cohesive system that can be analysed and managed when it comes to logistics. This is a conceptual improvement of logistics management, which focusses solely on "the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from their point of origin to point of consumption for the purpose of conforming to customer requirements" (Kannegiesser, 2008).

The supply chain modelling methods available are generic and usually applied to one single company, with only a superficial description of the other partners and their involvement in the supply chain. The performance and competitiveness of a supply chain, as well as its contributions to the performance and competitiveness of its individual companies, are also diffuse knowledge domains, with no formal consensus on the best performance measurements and competitive strategies to follow.

With these current challenges in mind, and with the aim of supporting the design of a new innovative WSC for the forest industry which provides higher agility and tailoring capabilities, a generic framework for describing different WSCs was defined (Objective 1). Following the scope of Working Package 5000, the WSC analysed comprise the planning and the execution of all the activities involved from selling agreements to delivery of products at the mill yard. These activities include the purchase or selection of harvesting blocks, harvesting scheduling and execution, as well as transportation scheduling and execution. Moreover, following the scope of the FlexWood project, the focus is restricted to the activities planned and executed at the operational level (see Appendix 1 for more detail).

The framework was applied to six case studies of WSCs from different parts of the world. It clarified the role of private and public institutions and market mechanisms, as well as key issues in coordinating the different parts of the WSC (Objective 2). These cases led to the identification of three basic designs of the planning system (Objective 3).

In summary, the three objectives of the project were to:

1. Develop a generic framework to describe any WSC and evaluate the agility and tailoring capabilities of the system;
2. Use the developed framework to study WSCs in different forested countries;
3. Analyse and compare each studied WSC to identify the basic designs of planning systems.

The report is organised as follows: the next section presents the methodology adopted and introduces the case studies. Section 3 describes the developed framework and Section 4 presents individual case descriptions according to this framework. Section 5 provides the results and discussions based on a global analysis of the cases. Finally, Section 6 provides concluding remarks and recommendations for further research.

2. Research Methodology

The description of different WSCs and, with the objective of supporting the design of an innovative WSC, their impact on supply chain agility and tailoring capabilities, is a complex task applied to a complex system. Research questions initially defined were:

a) What are the business entities comprising the WSC, their roles, their decisions and objectives?

b) What are the interactions between them?

c) What are the material, information and financial flows between them?

d) How do we evaluate the competitiveness of a WSC?

e) How do we evaluate the agility and tailoring capabilities of a WSC?

f) How are agility and tailoring capabilities impacted by WSC configuration?

As the nature of the research questions are “what” and “how”, the variables cannot be easily identified beforehand and there is no specific theory or model available on WSCs. Thus, the research relied on a qualitative approach for understanding such a complex system (Creswell, 1998). For the development of the framework, the research methodology adopted was grounded theory[1]. With grounded theory, the rules of a process, action or interaction of participants in a study are derived by the researchers through the structured organisation of collected data (Corbin and Strauss, 2008). Data collection was based on case studies with interactive and iterative communication with interviewed actors during fieldwork as well as with experts in forest engineering, forest management, forest economics, industrial engineering and management sciences. According to Yin (2003), the research methodology of grounded theory is superior to other qualitative approaches to address exploratory and explanatory objectives. Moreover, this inductive approach facilitates the collection of perceptive information from different actors in the supply chain and is a useful means of extracting sensitive information related to environmental drivers, business strategies, structures, practices and performance of the parties (Lefaix-Durand, 2008). As represented in Figure 2, the research methodology was organised in three main steps discussed below.

[1] Grounded theory is a specific methodology with the purpose of building theory from data, through techniques and procedures for gathering, analysing, examining and interpreting data in order to elicit meaning, gain understanding and develop empirical knowledge (Corbin and Strauss, 2008).

Step 1: Experimental design
- Exploratory literature review.
- Design of basic questionnaire.

↓

Step 2: Case studies
- Researchers gather information through case studies (e.g. interviews, observations).
- Researchers ask open-ended questions to participants and record field notes.

↓

Step 3: Analysis and results
- Researchers analyse data to form themes or categories (initial framework).
- Researchers look for broad patterns, generalisations, or theories from themes or categories (Results).
- Generalisations, or theories to past experiences and literature (Future research).

Figure 2: Research methodology. Adapted from: Creswell (2003).

Step 1 – Experimental design: from the research project definition of WP-5100 and the initial research questions, an exploratory literature review was performed to provide a first theoretical basis for the research work. The review is available in Appendix 2 and covers supply chain performance measurement, agility, competitiveness, tailoring capacity, mapping and modelling techniques, and typologies. This review led to the development of an interview guide composed of two sections: i) 16 open-ended questions discussed during face-to-face interviews and ii) a questionnaire of 65 statements evaluated through Likert scales[2] after the interview. This interview guide was first tested in two field locations (i.e. US and France). Due to different challenges with the questionnaire (e.g. only an English version, low participation rate, too small sample size), only the first section with open-ended questions was retained in successive fieldwork. The open-ended questions are provided in Appendix 3. Moreover, due to limited interview time and the interviewed actors' difficulty in understanding their meaning, four open-ended questions related to performance indicators were removed.

Step 2 – Case studies: the studied WSC comprises the planning and the execution of all the activities from the selling agreements to the delivery of harvested timber at the mill yard. Following the principles of theoretical sampling[3] and strategic case selection[4], cases were selected to capture the complexity of the WSC in different countries. As shown in Table 1, variation was sought in the organisation's size to which the interviewed actors belonged (small to large), in forest types (plantation and natural), main commercial species, nature of timberland ownership (public, individual private, industrial private), and in the general location of the operations (Continental Europe, Scandinavia, North America, South America). A total of 52 interviews were conducted face-to-face (with the exception of one) with different actors from the public and private sectors who are involved in the WSC in the countries visited. Contacts with these local actors were possible through the professional networks of local hosts in each country visited. A set of 16 types of actor were identified among the cases studied and are described in Appendix 6. Due to the limited time of some interviewed actors, not all open-ended questions were systematically asked. Fieldwork occurred between August

[2] A Likert scale is a psychometric scale commonly used in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research. (Wikipedia, 2012)
[3] The choosing of new cases to compare with ones that have already been studied and where the goal is not to capture a representation of all possible variations, but to gain a deeper understanding of the analysed cases and facilitate the development of analytic frameworks and concepts (Wikipedia, 2012). See Strauss and Corbin (2008) for more detail.
[4] Choosing cases that vary across critical variables (Hillebrand et al. 2001).

2010 and May 2011. In some cases, a translator was required during the interview. Experts (mainly in forest engineering, forest management and economics) from the local host's institution in each visited country also contributed to the study during and after the fieldwork. As they were the home countries of the research team, the cases in Sweden and Canada required fewer interviews and used more expert contributions.

The contribution of a total of 94 interviewed actors and experts allowed the recording of field notes from direct observation, document analysis and additional material not included in the open-ended questions. Out of the 22 cases identified (see Appendix 4 for an overview of these cases), six main cases (one per country studied) are reported in Section 4. In the US, a partial case is also reported (see motivation in Section 4.2.4). The choice of the cases is motivated by their diversity and complementarity with other cases, as well as practical issues (e.g. further availability of the interviewed actor in a case to clarify or complete certain information). The studied countries are highly diverse and we emphasise that the selected cases do not aim to be representative of all the WSCs within their countries.

Step 3 – Analysis and results: the information and knowledge obtained from the cases were analysed according to inductive logic[5] by the research team with additional inputs from the literature, some interviewed actors and field experts. Using the data analysis techniques of grounded theory (Corbin and Strauss, 2008), an open coding (process through which concepts are identified and their properties and dimensions are discovered in the data) was followed by axial coding (process of relating categories to their subcategories, linking categories at the level of properties and dimensions), leading to the definition of an initial framework composed of five building components. This was followed by selective coding (process of integrating and refining the framework), identifying broad patterns, generalisations and allowing the refinement of the framework, which is presented in the results section. This step was reinforced by additional literature reviews on specific subjects (e.g. product-service systems, product substitution, postponement, contingency theory, supply chain agility, typologies and taxonomies of supply chain/business strategy), as well as feedback from experts in different fields (e.g. forest engineering, forest management, forest economics, industrial engineering and management sciences). Some participants (interviewed actors and experts) in the case studies were also re-contacted to clarify or complete certain information.

[5] Inductive logic is a method of reasoning in which we begin with specific observations and measures, begin to detect patterns and regularities, formulate some tentative hypotheses that we can explore, and finally end up developing some general conclusions or theories (SRM, 2011).

Table 1: Summary of the six main case studies.

	Chilean case 1	US case 4	French case 11	Canadian case 15	Polish case 18	Swedish case 19
Organisation size	Large	Small, Medium, Large	Medium, Large	Large	Medium, Large	Large
Forest type	Plantation	Plantation	Plantation	Natural forest, plantation and extensively to intensively managed natural forest	Natural forest, plantation and extensively to intensively managed natural forest	Plantation and intensively managed natural forest
Main commerical species	Pine, eucalyptus	Pine	Pine	Spruce, pine, fir, birch, poplar	Pine and several hardwood	Spruce, pine, birch
Timberland ownership	Private industrial and individual	Private industrial and individual	Private individual	Public and private individual	Public	Private industrial and individual
General location	South America	North America	Continental Europe	North America	Continental Europe	Scandinavia
Specific region	Concepcion and Valdivia	Alabama, Georgia and Mississippi	Aquitaine	Quebec province	Northwest	South and middle
Local host	Universidad Austral de Chile	University of Georgia, Mississipi State University	Institut technologique forêt cellulose bois-construction ameublement	Université Laval	Instytut Badawczy Leśnictwa	The Forestry Research Institute of Sweden (Skogforsk)
Number of interviews (total number of interviewed actors and experts)	14 (26)	13 (22)	15 (21)	3 (8)	7(10)	0 (7)
Total cases identified	3	5	6	3	1	4

3. Results – Proposed Framework

The challenge of this research is to better understand a WSC, represented centrally by the description of the structure of the WSC. It became clear, however, that the framework should also include the relationships of the supply chain structure to other key elements supporting the description and analysis of a WSC, as well as the assessment of its agility and tailoring capabilities. Therefore, besides the component for studying the WSC structure, the framework includes four additional components. These components are introduced below and detailed in Sections 3.1 to 3.5.

One of the first aspects that emerged from the analysis of the cases studied was the importance of the environment in which the WSC operates. This is also reinforced by the several mentions in the literature that agility and the development of agility capabilities are highly contextual (Zhang and Sharifi, 2000; Lin et al., 2006; Baramichai et al., 2007; Hofmann, 2010; Wang, 2011). These observations led to the utilisation of contingency theory in the research work. Contingency theory is an organisational theory that originated at the end of the 1960's, and is based on the open systems theory for organisational analysis (Stanley, 1993). This theory proposes that for an organisation to perform, there must be a proper fit between its structure and the conditions in its external environment, assuming that there is no universal set of choices that is optimal for all organisations (Daft and Armstrong, 2009). To support the contextual description of a WSC, a component designated 'External environment' was integrated into the framework.

The structure of a WSC (i.e. the 'organisation' in this project) is based on a supply chain strategy, which, in turn, is (or should be[6]) based on a competitive business strategy. Therefore, a component designated 'Competitive business strategy and supply chain strategy' was integrated into the framework. Moreover, enablers and practices are used to make the link between the competitive business strategy and the supply chain structure. Implementing adequate enablers and practices is a means for a supply chain to achieve a competitive business strategy. To capture the enablers and practices implemented within a WSC, a component designated 'Enablers and practices' was integrated into the framework. As further detailed in Section 3.5.1, the developed methodology to assess the agility capabilities of a WSC is partially based on the enablers and practices identified in each case study. Tailoring capabilities are also assessed in this research. For that, a component designated 'Performance' was integrated into the framework.

The five components forming the developed framework are illustrated in Figure 3 with an outline of their content described in Section 3.1 to 3.5. Detailed literature reviews leading to the choices in each component are provided in Appendix 5.

[6] There are several citations in the literature stating that there must be an alignment between the competitive business strategy and the supply chain strategy to provide the competitiveness (see e.g. the discussion in Soni and Kodali, 2011).

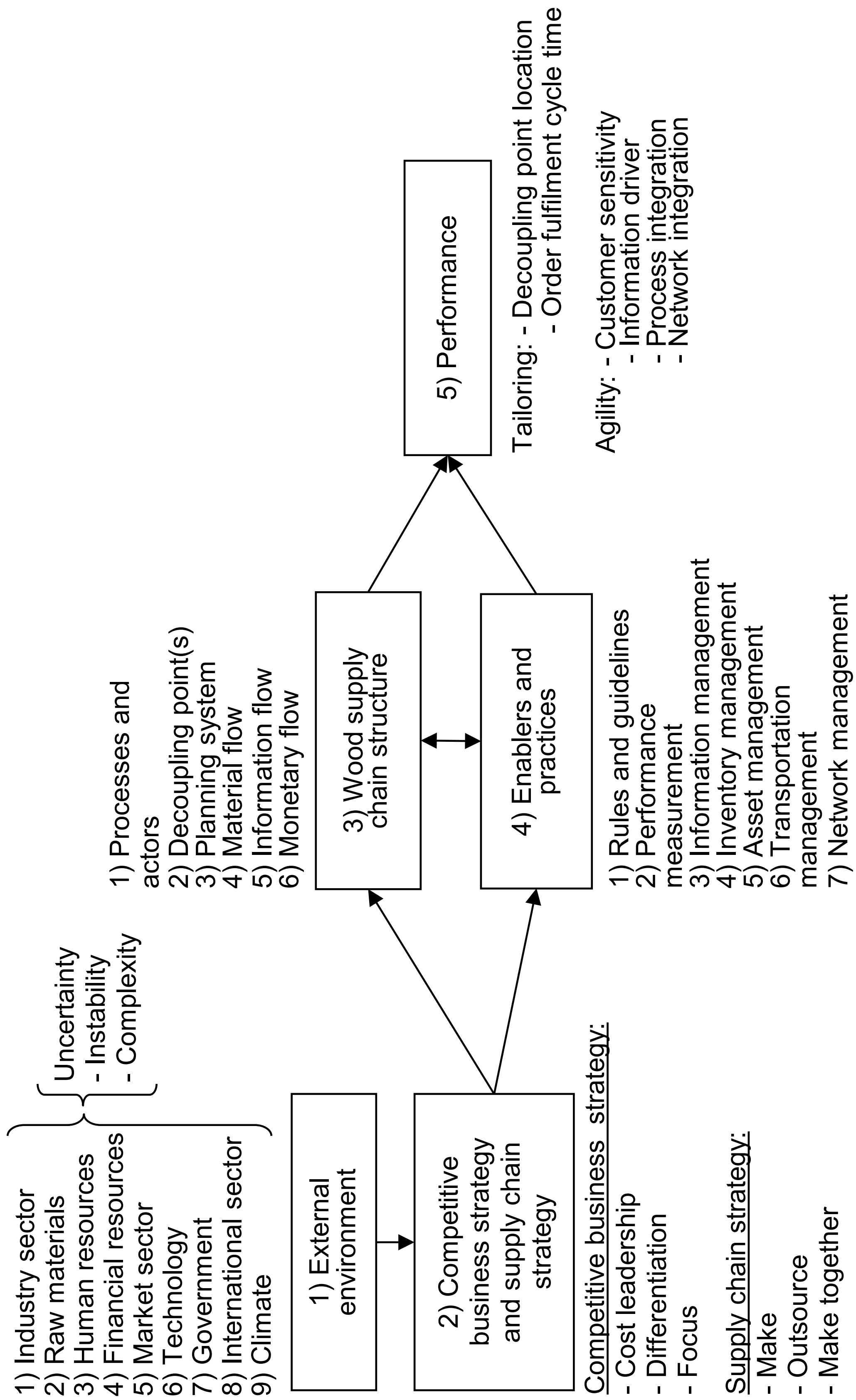


Figure 3: A contingency framework to analyse wood supply chains.

3.1. Component 1: External environment

To support the contextual description of a specific WSC, a set of environmental elements was adapted from Daft and Armstrong (2009): internal industry sector, raw materials, human resources, financial resources, technology, government, international sector and climate.

Moreover, the uncertainty of each environmental element is considered. Uncertainty is driven by changes in volume, variety and variability which, in turn, increase demand or supply unpredictability. Uncertainty is a function of instability and complexity (Daft and Armstrong, 2009).

High instability in the wood industry can mean that some environmental elements shift abruptly and unexpectedly in a matter of days. Considering today's business world, if an element remains the same, or highly predictable, for weeks or months, then it can be considered stable. Complexity means "the number or heterogeneity of external elements relevant to an organisation's operations. The more external factors that regularly influence the organisation and the greater the number of other organisations in the domain, the greater the complexity" (Daft and Armstrong, 2009).

This uncertainty can then be linked to specific impacts on the supply or on the demand side of a WSC, thus highlighting the key issues for business and supply chain strategies. It is also important to know that the greater an industry's environmental uncertainty, the greater is its need to develop an agile supply chain, to be able to forecast, detect and react quickly and effectively to changes (Christopher, 2000).

3.2. Component 2: Competitive business strategy and supply chain strategy

The competitive business strategy addresses "how an organisation chooses to compete in a market, particularly the issue of positioning the company relative to competitors with the aim of establishing a profitable and sustainable position'' (Hallgren and Olhager, 2006). How to describe a competitive strategy is still an open question in the literature. Many authors have proposed different dimensions to describe a competitive strategy (see Table 23 in Appendix 5). Distinguishing among three major business strategies for competitiveness (i.e. cost leadership, differentiation, and focus), the typology for the competitive strategy of a company developed by Porter (1998) is one of the most well-known and adopted. For instance, in the forest products industry, this typology was used for competitive strategy research in the sawmilling and pulp and paper industry in Europe and North America (Niemelä and Smith, 1997; Roos et al., 2001; Hansen et al., 2006; Lähtinen, 2007).

Cost-leadership means that the company takes the competition head-on, offering a product that is equivalent to those offered by competitors, but more efficiently (e.g. cheaper price). The main drivers for the company are basically low unit cost, operational excellence and high productivity. It usually has a standard or limited catalogue of the attributes of a product and service.

The differentiation strategy aims to avoid direct competition by differentiating the products and/or services offered to deliver higher customer value, making it possible to charge a premium price. The company is still concerned about costs, but these are not the primary drivers. Differentiation in a WSC can be achieved in mainly three different, but not self-excluding, ways (Hansen et al., 2006):

a) Services: a broad offer of personalised services (e.g. delivery time windows, payment conditions, packaging) and/or of additional services (e.g. maintenance, training, planning).

b) Product: products with higher quality, reliability or durability, frequent new product development, a high share of new products in the product portfolios, and the realisation of value-added transformation activities by the company.

c) Marketing: differentiation is achieved through branding, control of distribution channels, exclusivity contracts and innovative marketing techniques.

Several authors reduce the three strategies of Porter to two: cost leadership and differentiation, as a focus strategy is considered a “stuck in the middle” approach used by companies that are ineffective at concentrating on one strategy to implement it well (Davis et al., 2002; Hansen et al., 2006). We use such a simplification in the framework.

The choice of a competitive strategy applies to a single company. However, the literature on competitive business strategies in a supply chain level is very limited (Hofmann, 2010), concentrating mainly on the strategic choices of the relationship between two business partners (Blankenburg Holm et al., 1999; Yee and Platts, 2006; Lefaix-Durand; 2008). These papers highlight the need to include a relationship dimension in any supply chain study.

Yee and Platts (2006) notably propose a practical approach to portray and analyse the interaction of firms in a supply network and its linkages to the competitive business strategies deployed by the firms. It consists of describing, for each company in the network, the i) adopted competitive business strategy and ii) the implementation approach. The implementation approach refers to how a firm is willing to implement the adopted competitive business strategy: in an offensive, defensive or diversifying way, and with an individual or cooperative approach. Table 2 describes each one of these implementation approaches.

Table 2: Implementation approaches. (Source: Yee and Platts, 2006).

Offensive-individual	A company seeks to capture more market share at the expense of another firm(s) based on available resources that are internal to the firm.
Offensive-cooperative	A company seeks to capture more market-share at the expense of another firm(s) by utilising external resources from other network members.
Defensive-individual	A company seeks to maintain its current market-share based on available resources that are internal to the firm.
Defensive-cooperative	A company seeks to maintain its current market share by utilising external resources from other network members.
Diversifying-individual	A company seeks to explore new market segments based on available resources that are internal to the firm.
Diversifying-cooperative	A company seeks to explore new market segments by utilising external resources from other network members.

Once the business strategy and implementation approach are identified, it is time to define the supply chain strategy. From a value creation network perspective, an effort has to be made to determine which of the processes should be executed and/or controlled by the organisation, and which ones should be made by another enterprise. This is what we call the supply chain strategic options of make, not make, outsource or make together (Poulin et al., 1994).

More precisely, enterprises need to identify their skills as well as the business processes they can do efficiently. If these activities are well executed, at a low cost, and create value for the organisation, they should be classified as “make” operations. On the other hand, if activities are not necessarily executed economically or necessitate specific competencies that the organisation does not have, they should be outsourced (i.e. the use of an external network), executed with another organisation (i.e. development of network synergy) or not made.

Even if outsourcing or working with a partner can be very profitable, the enterprise cannot forget that this implies lower control, the need to share potentially sensitive information, the need for metrics and, in the case of real partnerships, a share of the benefits. These strategic options guide the company in how the supply chain processes will be structured and coordinated to support the achievement of the business strategy (Ketata, 2003).

3.3. Component 3: Wood supply chain structure

One main question for the description of a supply chain structure is to determine which structural elements should be described. A first element includes all the processes conducted in a WSC. According to Azevedo et al. (2009), two mains reference models are currently recognised when defining supply chain management processes: the Global Supply Chain Forum (GSCF) model of Ohio State University (Lambert, 2004; Lambert et al., 2005) and the Supply Chain Operations Reference (SCOR) model of the Supply Chain Council (SCC, 2008). Recently, Azevedo et al. (2009) proposed a reference model for the core processes in supply chain management. Based on five criteria defining a reference model, Blecken (2009) provides a review of six reference models addressing tasks and activities of supply chain management and logistics. One of them is the SCOR model. Details on these reference models can be found in Appendix 2. After comparing the documentation available in English and the level of description for these reference models, the SCOR model was chosen to support the description of the planning and execution processes in a WSC. A one year membership to the Supply Chain Council, the non-profit organisation managing the SCOR model, was taken to have full access to the documentation and support services for the SCOR model adaptation to WSCs. The SCOR model has been developed to describe the business activities associated with all phases of satisfying a customer‘s demand and is organised around five macro-processes (Plan, Source, Make, Deliver and Return) that each include a set of generic processes (Supply Chain Council, 2008). In the proposed processes of a WSC, we limited our use of planning processes to the Source, Make and Deliver macro-processes. The research project focuses on the planning and execution activities at the operational level. The planning decisions at the operational level (see Appendix 1) of such activities in the SCOR model could all be captured in the Source, Make and Deliver macro-processes. Thus, for the sake of brevity, we excluded the Plan macro-process. For its limited contribution to the research project, we also excluded the Return macro-process (e.g. when a truck with a load that does not meet the assortment specifications is refused by a customer). Moreover, the Deliver macro-process was separated into two categories (i.e. value commitment and secondary transport) to increase the differentiation between the processes related to sales and those related to the planning and execution of secondary transport.

According to the level of detail aimed for in the research project, the proposed WSC processes are an aggregation of SCOR model generic processes. Table 32 (see Appendix 7) describes the proposed processes in a WSC and their correspondence to the generic processes in the SCOR model. A non-aggregated adaptation of the generic processes in the SCOR model to a WSC can be found in Schnetzler et al. (2009). The processes in the Source macro-process are related to the supply in standing timber, while the process in Deliver (Value commitment) is related to the sales of harvested timber. The processes in the Make macro-process are related to harvesting activities, while the processes in Deliver (secondary transport) are related to transportation activities.

In addition to processes, other elements are part of the WSC structure. One of these is the decoupling point. Wikner and Rudberg (2005) define the decoupling point as “the point in the flow of goods where forecast-driven production and customer order-driven production are separated" or, in other words, "the point in the value-adding material flow that separates decisions made under uncertainty from decisions made under certainty concerning customer demand (…)". In a supply chain structure, a relationship exists, therefore, between the capabilities to tailor the attributes of a value proposition (i.e. the product and logistics services of a WSC) to a customer, the processes and the potential localisations of the decoupling point. However, the nature of a WSC as a product-service system (i.e. a WSC offers customers a combination of tangible products and intangible services) makes this relationship less obvious. This means that it is necessary to identify which main value proposition attributes can be set or adjusted according to the client's demand in any process. In the case studies, we condensed the attributes detailing the demand to three: product specifications, price and payment conditions, and quantity and delivery conditions.

The planning system is another important feature to be captured, described and analysed as part of the structure. To do so, the decisions to be taken or executed in each process, the actors responsible for them, the planning horizon, the planning period, the update frequency, the required inputs and resulting outputs also need to be captured. In the case studies, special attention is given to decisions in harvesting and transportation by classifying them according to four attributes: the harvest/transport resource, the input stock to harvest/transport, the harvest/transport instructions and the allocation of the output stock to demand. Regarding the attribute 'harvest instructions', Appendix 8 details the terminology employed in the case studies (e.g. cutting-list, price list, buck-to-value problem). Material, information and monetary flows between the processes and actors can then be properly discussed. For each monetary flow, special attention is given to identifying the pricing mechanism or payment method used (see Appendix 11 for a list of generic pricing mechanisms and payment methods).

3.4. Component 4: Enablers and practices

Enablers and practices are implemented in a WSC to make the linkage between the competitive business strategy and the supply chain structure. The utilisation of adequate enablers can help the supply chain to achieve its business objectives by "preparing, maintaining, and managing information and relationships upon which planning, sourcing, making and delivering execution processes rely" (Supply Chain Council, 2008). Enablers are the means to achieve the expected end results.

Based on a review of enablers and practices in supply chain management and agility, a list of more than 400 potential enablers and practices of supply chain agility was identified. This list is provided in Appendix 9. Following the macro-processes of the SCOR model, as well as the 'pseudo' macro-process named Enable, a set of seven categories of enablers and practices was identified. These categories are presented in Table 3 with some examples of enablers and practices. The objective here is not to judge whether the enabler/practice is good or not, but rather to identify and describe what was observed during the fieldwork. The evaluation of pertinence and contribution of enablers and practices is the objective of the next and last building component of the framework.

Table 3: Categories of enablers and practices

Categories of enablers and practices	Examples of enablers and practices
Rules and guidelines: processes that establish, maintain, and enforce rules for managing planning and execution processes in line with the business strategy, goals and objectives.	long term supplier agreements, yield tables, growth models, sorting rules, standards
Performance measurement: processes for developing, measuring and maintaining performance standards and analysis methods to compare actual performance against established standards.	reliable continuous improvement process and methodology, supplier performance assessment system, real time performance measurement reporting systems
Information management: processes for collecting, integrating, maintaining and communicating information to support the planning and execution processes.	integrated demand and supply planning, customer access to online tracking of order status and shipping information, forest information systems
Inventory management: processes for establishing and maintaining physical inventories and inventory information.	real time data on current status, mapping of the stocks, inventory sampling, prognoses about assortment of timber
Asset management: processes for acquiring, maintaining and administering an organisation's capital assets.	total preventative maintenance program, supplier managed inventory of parts, standard operating procedures and methodology
Transportation management: processes for defining and maintaining the information characterising the requirements for transportation and the management of transporters.	transportation requirements, transportation models, routing, information to identify the felling area, backhaul trading exchange
Network management: processes for defining and maintaining a unique network of partners to deliver a specific product or service.	vendor managed inventory programs, supplier certification programs, management of the addresses of the forest owners and parcels of land, standard contracts

3.5. Component 5: Performance

We can identify three main types of measurement of supply chain performance: financial quantitative measures, non-financial quantitative measures and non-financial qualitative measures. By non-financial qualitative metrics, we mean evaluations based generally on individual perception and open to a certain level of subjectivity, generally measured through Likert scales and the level of concordance to statements. As illustrated by the contribution of supply chain agility to quantitative performance measures (see Section 5.5.1), non-financial qualitative measures are usually considered to positively impact the other quantitative measures. A review of metrics for the three types of measure can be found in Appendix 10.

In the work definition of the WP-5100 research project, the performance attributes of a WSC to focus on are: agility capabilities, tailoring capabilities and competitiveness. The several definitions of these attributes and, in the context of this project, the lack of practical evaluation methodology in the literature, as well as the intrinsic limits of access to quantitative data, made it more suitable to use mainly non-financial qualitative metrics. For each attribute, we discuss the developed assessment methodology, which relies on one or more components of the framework (see Figure 4).

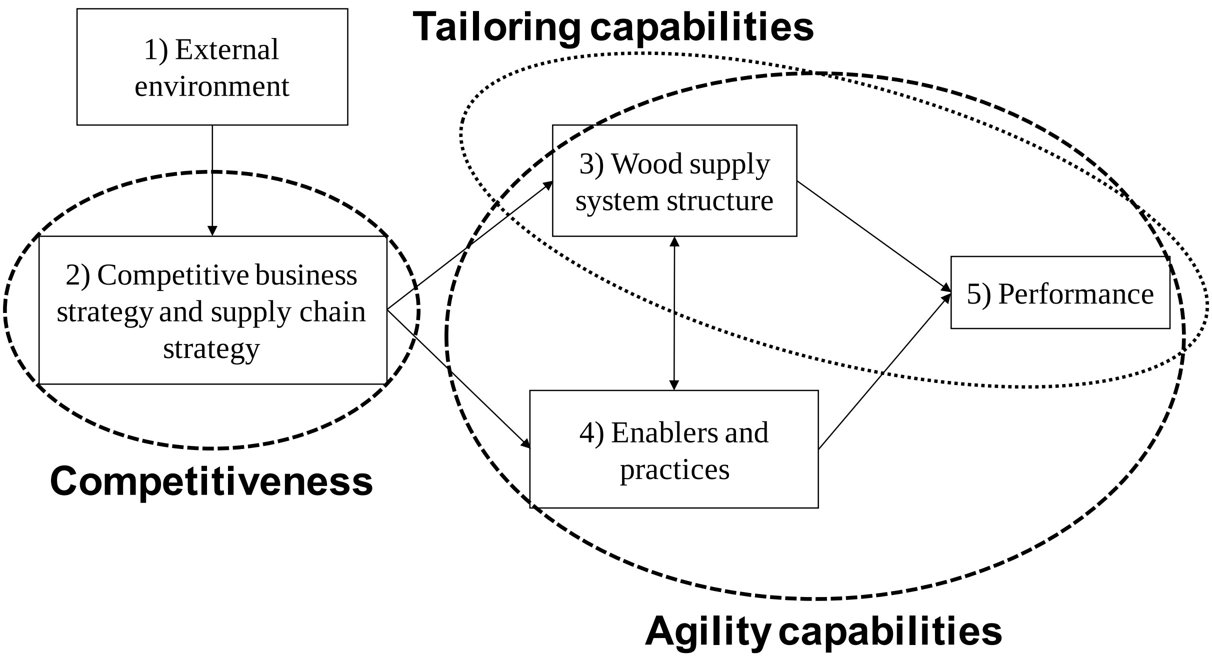


Figure 4: Components involved in the assessment methodology of each performance attribute

3.5.1.Agility capabilities

Three different Schools of thought on the concept of supply chain agility can be identified in the literature (see Figure 50 in Appendix 5 for details). In this project, the supply chain agility framework proposed by Christopher (2000) was used, mainly because it is a conceptual and strategy-oriented framework based on the contextualisation and adaptation to the enablers and practices implemented. In addition, documentation was also available for the framework application in different industries, such as clothing, manufacturing, retailing and electronics in different countries. This framework defines supply chain agility according to four dimensions: customer sensitivity, information drivers, process integration and network integration. Table 4 defines each dimension.

Table 4: Dimensions of supply chain agility

Dimension	Definition
Customer sensitivity	The capability to increase customer (i.e. mill) satisfaction/service level, or to maintain it at a high level, by reading and responding to real demand and/or using customer-based measures (instead of high levels of inventory).
Process integration	The capability to increase responsiveness, which means operating effectively and efficiently in a timely manner by having the processes properly integrated.
Information driver	The capability to access relevant information and knowledge by having accurate and frequent updates of key information, which is available to supply chain partners.
Network integration	The capability to integrate key supply chain partners in planning and execution processes by implementing and managing adequate business relationships with partners upstream and downstream of the supply chain.

Different methodologies have been proposed in the literature to measure supply chain agility. We reviewed ten methodologies in Table 29 (see Appendix 5). In Figure 51 (see Appendix 5), we provide a state-of-the art supply chain agility measure. Based on Christopher's framework and the works of Azouzi et al. (2009), a supply chain agility measure methodology is proposed. To reach a standardised agility assessment among the case studies, we used an external evaluation approach rather than a survey or self-rating questionnaire. In practice, this meant that the researchers were responsible for assigning a grade from 0 to 4 (no contribution 0 – 1 – 2 – 3 – 4 extremely high contribution) for the set of enablers and practices identified in each WSC macro-process [Source, Make, Deliver (value commitment) and Deliver (secondary transport)] and their perceived contribution to the four WSC agility dimensions. Moreover, this perceived contribution was based on two questions per agility dimension (see Table 5). To reduce subjectivity and bias in the assignment of grades, the first evaluation was made by at least two researchers together and then all evaluations were reviewed with all the researchers involved in the first evaluations.

Table 5: Guiding questions for evaluation of impact of enablers and practices on WSC agility.

Supply chain agility dimension	Are the enablers and practices of the macro-process…
Customer sensitivity	a) ...providing the capacity of reading and responding to real demand? b) ...allowing the identification of opportunities to increase customer value (capture emerging trends)?
Process integration	a) ...part of collaborative planning and joint strategy determination? b) ...facilitating rapid decision making between business functions?
Information driver	a) ...allowing frequent and accurate update of key information? b) ...making key information readily accessible throughout the entire supply chain?
Network integration	a) ...reinforcing trust-based relationships with customers/suppliers? b) ...minimising resistance to change and adoption of new practices?

3.5.2.Tailoring capabilities

Tailoring capabilities were firstly evaluated according to the location of the decoupling point(s) in each case studied. It is assumed that the closer the decoupling point is to the sourcing of standing timber, the easier it is to personalise the attributes of a value proposition (i.e. a product and logistics services in a WSC) to a customer. But tailoring is also linked with a time dimension: the length of time a customer must wait for an order with personalised attributes. Consequently, a time metric called 'order fulfilment cycle time' was captured in the cases (see Section 5.5.2 for more details).

3.5.3.Competitiveness

Lee and Wilhelm (2010) mention that ''competitiveness has been a controversial notion and few agree on a precise definition, although numerous definitions have been proposed''. For instance, Ambastha and Momaya (2004) defined competitiveness as ''the ability of a firm to design, produce and or market products superior to those offered by competitors, considering price and non-price qualities'', while the TCI Network (2010) (formerly The Competitiveness Institute) defines the competitiveness of a firm as ''the ability to provide products and services as (or more) effectively and efficiently than relevant competitors''. One key aspect raised among these definitions is the capability of an organisation to be superior to competitors in its value proposition (i.e. the products and logistics services in a WSC) to a customer. Such a key aspect is related to the concept of competitive advantage. After a first attempt to use 22 statements for a competitive advantage measurement (see Section 2.2.2 in Appendix 2), which did not prove to be practical in the context of this research project (e.g. respondents' difficulty in understanding statements, limited interviewing time), competitiveness is addressed through the competitive business strategy in the aforementioned component 2 of the framework.

Lee and Wilhelm (2010) report many studies on how firms generate and sustain a competitive advantage by using innovative management skills, and one of these skills is supply chain management practices. Indeed, the study by Li et al. (2006) mentions that ''effective supply chain management has become a potentially valuable way of securing competitive advantage and improving organisational performance, since competition is no longer between organisations, but among supply chains.'' This statement is one of two core ideas in the supply chain concept introduced in Section 1.

4. Results – Framework Application

This section presents the six cases studied and a seventh partial case (see motivation in Section 4.2.4). The detailed information supporting each case is presented in separate appendices. All cases are based on the interpretation of the information provided by interviewed actors and experts. As such, and although a diligent review has been performed, error of interpretation may have occurred.

4.1. Chilean case 1

Fieldwork in the region of Concepcion and Valdivia allowed three distinct cases to be identified (cases numbered 1 to 3 in Appendix 4). Chilean case 1 with a timberland-based wood procurement division as the central actor is the only case detailed. The supply chain strategy of all the Chilean cases is reported in Appendix 4, while in Section 5.3.2.1 we discuss a decoupling point identified in Chilean case 2.

Mr. Fabián Cid Yáñez from Universidad Austral de Chile was our local host during the two weeks of fieldwork. A total of 14 interviews were performed and meetings were held with a total of 26 local actors and experts. The fieldwork was complemented by two field visits: i) a skyline full-tree method with bucking at roadside in a clear-cut of a radiata pine plantation and, ii) a mechanised cut-to-length method in a clear-cut of a eucalyptus plantation.

4.1.1.External environment

WSCs in Chile are subject to a moderate seasonal pattern (there is a season with higher precipitation) in the supply, while the demand is fairly stable throughout the year. However, investments for improving road infrastructures have stabilised year round access to forest sites. Harvest and transport are therefore less subject to interruptions in Chilean case 1.

The supply is based on private timberland mainly owned by a timberland-based wood procurement division and, for a small percentage of the volume, on standing timber purchases from non-industrial private timberland owners. Harvesting on private timberland is not subject to specific regulations (e.g. environmental) compared to what has been observed in the other case studies.

The raw material is highly homogeneous and standard, since all harvested forests consist of mono-species plantations of radiata pine or eucalyptus (Globulus or Nitens), where the raw material is bred through genetic improvements. The timberland-based wood procurement division has its own nursery to produce its seeds.

Other external environment elements are reported in Table 37 (see Appendix 12).

4.1.2.Competitive business strategy and supply chain strategy

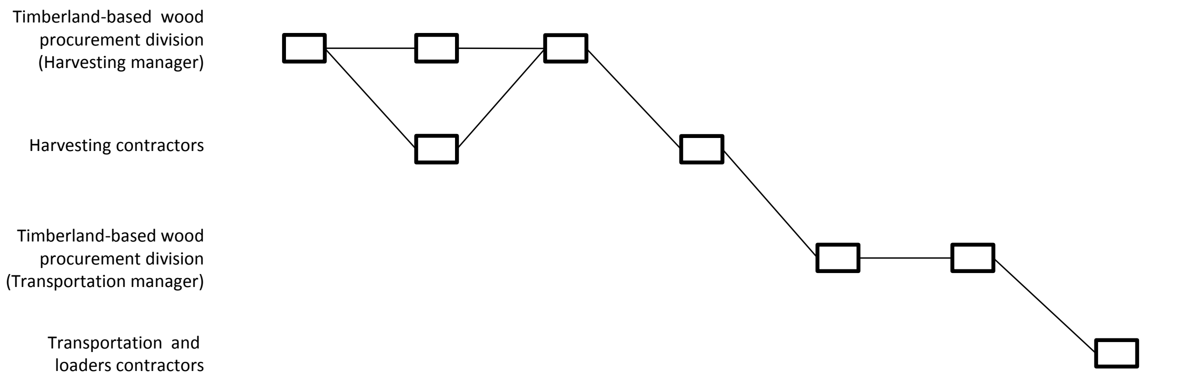
There are four actors in Chilean case 1: the timberland-based wood procurement division, the harvesting contractors, the transportation and loading contractors and the mills (internal and external customers). The analysis excludes the mills. The main drivers for the actors are operational excellence and high productivity in order to be a low cost producer. Thus, the primary strategy of all the analysed actors is cost-leadership subject to demand fulfilment. How each analysed actor implements this strategy is unclear, but the actors appear to use a defensive approach with a combination of individual and cooperative behaviours. Probably because of the complexity of skyline tower harvesting in steep terrain, air-based harvesting contractors have more planning responsibilities compared to ground-based harvesting contractors. For instance, they themselves plan the skyline tower and support pillar(s) layout by block and, depending on the production volume target by month, they choose the sequence in which they will harvest the blocks within a farm (i.e. a group of blocks). Thus, by providing a planning service to the timberland-based wood procurement division, air-based harvesting contractors also adopt some drivers from the differentiation strategy with a service focus.

The supply chain strategy in Chilean case 1 is illustrated in Table 21 (see Appendix 4). The timberland-based wood procurement division performs the source and value commitment processes internally, as well as the harvesting and secondary transportation planning processes, with the exception of the aforementioned limited planning responsibilities outsourced to air-based harvesting contractors. The execution of the harvesting and measuring (at roadside) is outsourced to harvesting contractors. The execution of loading and secondary transportation is outsourced to transportation and loading contractors, except in steep terrain, where the loading is outsourced to the harvesting contractor.

4.1.3. Wood supply chain structure

Planning and execution processes

Chilean case 1 involves eleven planning processes and ten execution processes; their description can be found in Table 38 and Table 39 respectively (see Appendix 12). Figure 5 presents some of these planning processes on the horizontal axis. The horizontal axis also presents the list of generic planning decision(s) (see Appendix 1) addressed by each planning process. The actors conducting the planning processes are listed on the vertical axis. Each rectangle defines the accountability between one or many actors and one or many decisions. The sequenced rectangles illustrate the logical sequence of the planning process. When two rectangles are vertically aligned, it means that two different actors can make the decision(s) addressed by the planning process.



Schedule harvesting 1	Schedule harvesting 2	Schedule harvesting 3	Schedule harvesting 4	Schedule secondary transportation 1	Schedule secondary transportation 2	Schedule secondary transportation 3
- Harvest equipment selection per harvest unit - Harvest units scheduling - Assortments to produce per harvest unit and allocation to demand -Harvest unit assignment to contractors/teams	- Harvest unit layout	- Bucking/ merchandising instructions and sorting rules per harvest unit	- Harvest crew scheduling	- Balance transportation with harvesting, inventory and reception	- Transportation equipment routing and scheduling	- Transportation crew scheduling

Figure 5: Actor(s) accountable and generic planning decisions per planning process in Chilean case 1

There are two Value commitment processes in the Chilean case 1. Value commitment 1 is made a few weeks to months in advance for an order with a supply agreement[7] of a 4-8 month period or less. Value commitment 2 is made a few months in advance for an order with a supply agreement of more than a 4-8 month period. Most of the demand arises from Value commitment 2. For the three aforementioned attributes characterising the demand in Chilean case 1, Table 41 (see Appendix 12) details how each attribute in a given planning process is described and whether this attribute is subject to further change. Even though the planning horizon goes on for several months, no change occurs after the demand attributes are fixed in the two value commitment processes (with the exception of the prices that are adjusted on a three-month basis). However, demand attributes fixed in the value commitment processes are highly aggregated (see discussion on data aggregation in Section 5.3) and become more detailed (i.e. disaggregated) as the planning horizon of the planning process shortens.

Material flow and decoupling points

Figure 6 illustrates the material flow between selected processes and the decoupling points in Chilean case 1, while Table 44 (see Appendix 12) lists the average inventory time of the material between consecutive pairs of processes. An average delay of 10 days is observed between harvest and delivery.

[7] Supply agreement: refers to the description of the attributes of the committed demand in an official agreement, see discussion in Section 5.3.1.2.

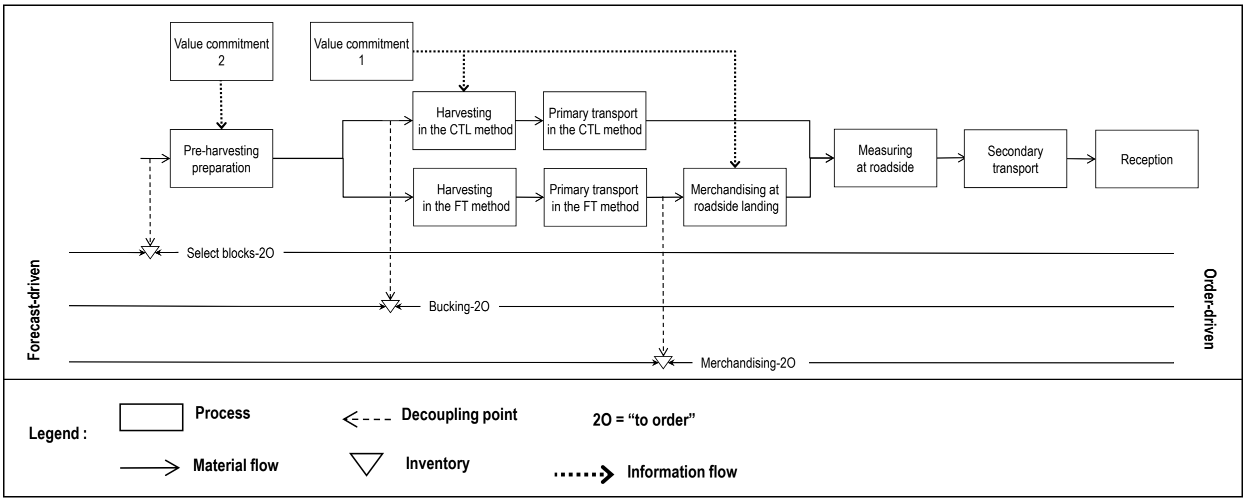


Figure 6: Material flow and decoupling points in Chilean case 1

Demand from process Value commitment 2 is managed with decoupling point Select blocks-2O. At the tactical level, a planning process decides which farm (i.e. group of blocks) must be harvested in each season for the next 5 years. With process Schedule harvesting 1.1, the group of blocks in each farm is better defined according to operational considerations (e.g. road construction). For each of these blocks, the volume by product available in the block is estimated by combining pre-harvesting inventory and historic production data from a similar block (e.g. species, clone, quality of the site). Then, the process Schedule harvesting 1 allocates the volume to be harvested in each block to: i) confirmed demand (from process Value commitment 2) and ii) forecast demand (will attempt to convert to confirmed demand in process Value commitment 1). Demand from process Value commitment 1 – thus demand confirmed after the selection and sequencing of the harvesting blocks – is managed with decoupling points Bucking-2O or Merchandising-2O. Bucking-2O is used in the mechanised CTL method, while Merchandising-2O is used in FT methods.

Information flow

In addition to traditional communication tools (e.g. paper document, two-way radio, telephone), information exchanges are facilitated by an intranet system hosted by the timberland-based wood procurement division. This system is either fed manually (e.g. at the end of the day, the harvesting contractor enters the volume scaled at roadside during the day and recorded on slate tablet by scalers) or automatically (e.g. the manually scaled volume recorded in a mobile handheld device with an in-field communication connection is sent during the day). The system centralises the information and feeds the different applications used to support the planning processes, as well as for the control and monitoring of activities. For instance, the intranet system hosts an application for the performance monitoring of each harvesting team/contractor and such an application is used by both the timberland-based wood procurement division and each contractor. Moreover, the intranet system also hosts an application to monitor the performance of trucks' arrival times at the mill according to the delivery logistics agreement. Such an application is used by both the timberland-based wood procurement division and the customer. Table 42 and Table 43 (see Appendix 12) detail the information flow for each planning and execution process respectively.

Monetary flow

Figure 7 illustrates the main monetary flows between the central actor of Chilean case 1 (i.e. the timberland-based wood procurement division) and the harvesting contractors, the transportation contractors and the mills. The details can be found in Table 45 (see Appendix 12). The monetary flows to the contractors are payments for their harvesting or transportation services during the month. They are paid within 5-10 days after the end of this month for all harvested timber at roadside/delivered during the month. The monetary flows from the mills are payments for the harvested timber delivered during the month. They pay 10, 15 or 30 days after the end of this month for all harvested timber delivered during the month.

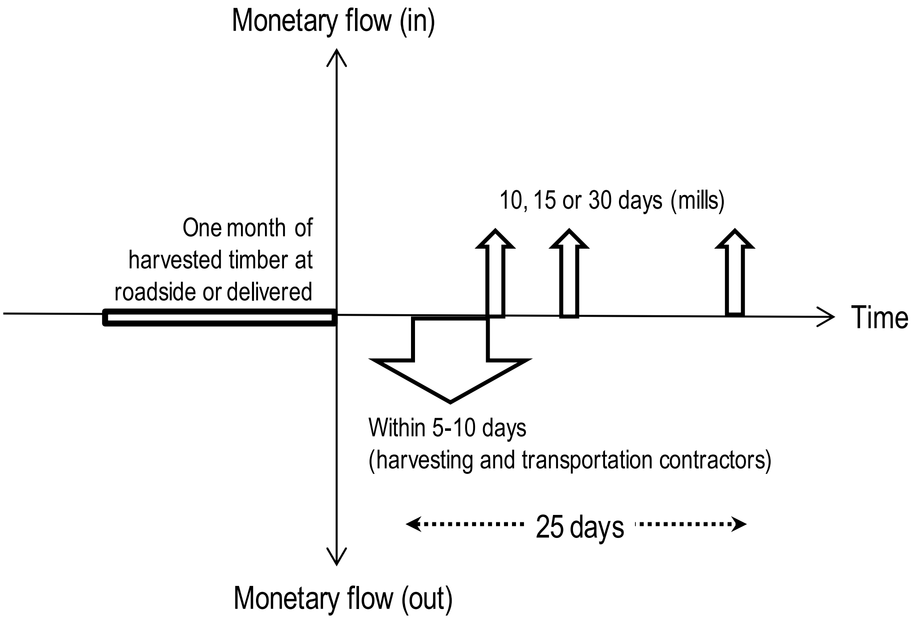


Figure 7: Main monetary flows for the central actor in Chilean case 1

4.1.4. Enablers and practices

In this case, 71 enablers and practices were identified. Table 46 (see Appendix 12) presents this complete list detailed by process and by category. The majority of the enablers and practices were identified as part of the Make (31 enablers) and Deliver (Secondary transport) (22 enablers) macro-processes.

In the Make process, the largest categories were Rules and guidelines (10 enablers) and Asset management (8 enablers). These include long-term agreements with harvesting contractors (4-5 years) and pre-negotiated rates, standard cutting-list template, salary bonus based on productivity, high concern for human resources programs (training, safety, absenteeism) and the use of several tools based on operational research for optimising the harvesting plan, which is monitored by a team highly specialised in engineering and computer programming. Inventory management also had a relevant number of practices identified (4 enablers), notably an intranet system to monitor the daily inventory level at roadside, with real-time updates provided by the harvesting contractors.

In the Deliver (Secondary transport) macro-process, the largest categories were Rules and guidelines (6 enablers) and Transportation management (8 enablers). These also include long term agreements with transport contractors and pre-negotiated rates, as well as the use of several tools based on operational research for optimising the transportation plan and road construction planning with LIDAR technology.

In a global view, the Network management category also deserves mention, with a total of 9 enablers identified and spread throughout the processes. We can mention, for instance, the nurturing of good business relationships with private timberland owners, the use of external consultants, research centres and universities to improve current planning tools or for prototype development, a company-based program to finance new equipment purchases by harvesting contractors and performing audits to maintain social acceptance (e.g. tolerable sound level of transportation activities).

4.1.5.Performance

The enablers identified were considered to make an overall high contribution to the supply chain agility. This high contribution is also fairly balanced within the dimensions (Figure 9). However, we can see in Figure 9 that the enablers of the Source macro-process make a smaller contribution to the agility dimensions of Process integration and Customer sensitivity when compared to the other macro-processes. This is because the harvesting blocks are selected for the entire season with no opportunity for later changes, and some blocks scheduled for harvesting are "pushed" according to silviculture, economic and operational aspects.

The enablers of the Source macro-process make a smaller contribution to the Customer sensitivity dimension in the Value Commitment macro-process, as internal customers receive priority for all the available supply volume, whereas external customers receive the residual volume. Table 47 (see Appendix 12) details the agility assessment by dimensions and macro-processes in Chilean case 1.

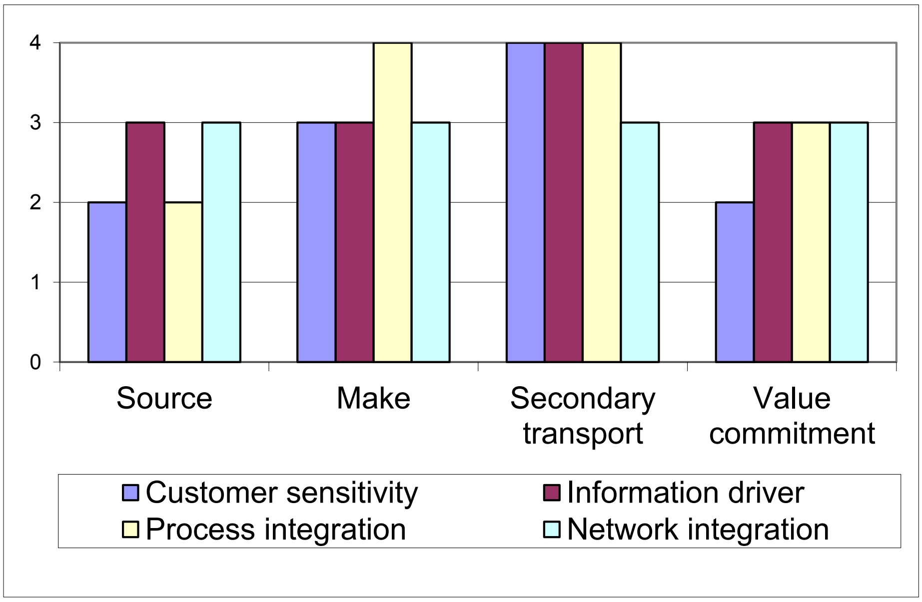


Figure 8: Agility capabilities results by dimension and macro-process in the Chilean case 1.

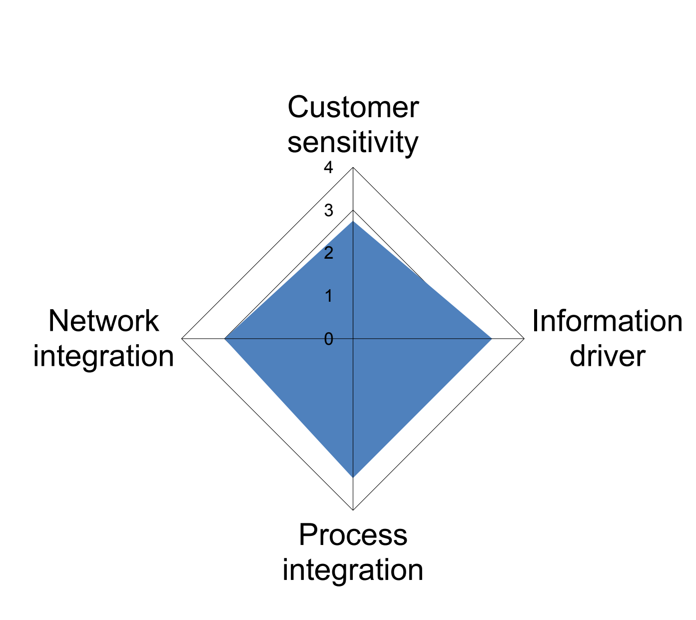


Figure 9: Agility capabilities results by dimension in the Chilean case 1.

4.2. US case 4

Fieldwork in the states of Georgia, Alabama and Mississippi allowed five distinct cases to be identified (cases numbered 4 to 8 in Appendix 4). US case 4 of a wood dealer as the central actor is the only case detailed. However, in order to evaluate the agility of a case in the US with larger scale harvesting and transportation activities than US case 4, the enablers and practices used in US case 7 were identified and its agility assessment was conducted. US case 7 involves a Timberland-based supplier as the central actor. The results are presented jointly with US case 4 in Section 4.2.4 and 4.2.5. The supply chain strategy of all the US cases is reported in Appendix 4, while in Section 5.3.2.1 we discuss the decoupling points identified in US case 7.

Dr. Dale Greene and Mr. Shawn Baker from the University of Georgia and Drs. William B. Stuart and Laurie Grace from Mississippi State University were our local hosts during three weeks of fieldwork. A total of 13 interviews were performed and meetings were held with a total of 22 local actors and experts. Fieldwork was complemented by field visits to a mechanised full-tree method with merchandising at roadside in a clear-cut and a thinning of southern yellow pine plantations.

4.2.1. External environment

Wood supply chains in the southern US are subject to seasonal patterns in the supply and, in turn, in the demand. As mentioned in Grace et al. (2010), seasonal pattern is induced partly by rainfall and partly by the inventory-procurement strategy of a mill. On average, soils tend to be wetter during the winter months due to the combined effect of heavy rainfall and reduced evaporation losses. Thus, mills start the year with a high inventory level to secure procurement in case of a wet winter and, with higher purchasing prices and no production quota restrictions, harvesting contractors are encouraged to produce whatever they can whenever weather permits until the end of March. Starting in April, rainfall moderates and harvesting conditions improve. Hence, harvesting continues all year round. If mill inventory is high, harvesting contractors may be put on quota (to reduce their production), the purchasing price is reduced and production is monitored so that the mill can begin reducing inventories for the summer. Wood in storage deteriorates quickly in warm weather. Thus, to keep inventories low, production is closely controlled (e.g. quotas, low purchasing prices) during the summer through early October, when production controls are lifted to begin building inventories through the holiday season.

The supply in US case 4 is based essentially on standing timber purchased from industrial and non-industrial private timberland owners, with low volume from public timberland managed by local authorities. Most of the purchases are made with little advertisement to potential buyers. Maintaining good business relationships with a network of timberland owners and foresters (mandated by some timberland owners to sell their standing timber) is essential for buyers. Harvesting on private timberland is subject to a low level of regulations compared to what has been observed elsewhere.

The raw material is fairly homogeneous on the block, coming from managed, mono-species plantations of southern yellow pine (e.g. loblolly), while variability increases in non-managed or untended plantations. The most common harvesting method is full tree.

Other external environment elements are reported in Table 48 (see Appendix 13).

4.2.2. Competitive business strategy and supply chain strategy

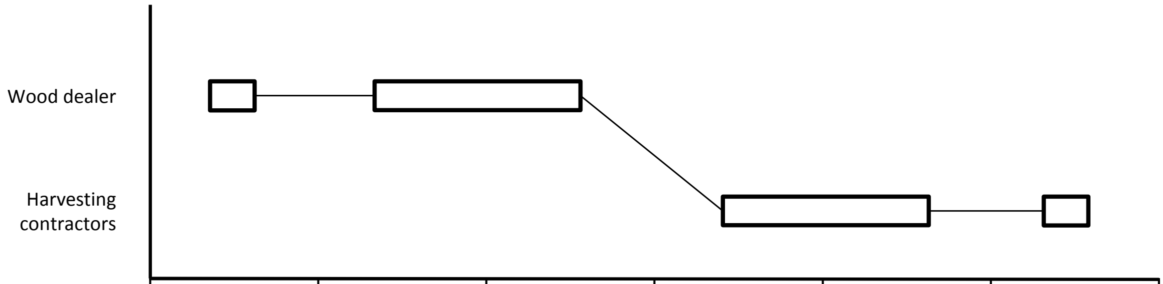
There are four actors in US case 4: the timberland owners, the wood dealer, the harvesting contractors and the mills. The analysis excludes the timberland owners and the mills. The main drivers for the analysed actors are operational excellence and high productivity to achieve, in turn, low unit cost. Thus, the primary strategy of the analysed actors is cost-leadership. How each analysed actor implements this strategy is unclear. The wood dealer appears to use a continuous offensive-individual approach to capture new quotas of harvested timber volume to deliver (see process Value commitment 1) while using a defensive-individual approach to maintain business relationships with mills in order to secure quotas of volume to deliver to these mills (see process Value commitment 2). The harvesting contractors appear to use a defensive-individual approach with limited cooperative behaviour in secondary transportation (e.g. sub-contract truckers). As a small-scale organisation, the wood dealer supplies a customer segment that is usually neglected by large-scale supplier organisations: low volume mills. Some of these mills have unique product specifications, thus the wood dealer adopts a differentiation strategy (with a product focus) for them. To be the preferred harvesting contractor in activities all year long [designated as all-weather suppliers by Grace et al. (2010) or contractors that 'waterproof' their harvesting operations by LeBel and Carruth (1997)], some harvesting contractors invest in equipment that can work longer in periods of rainfall (e.g. large flotation tires for blocks with slow draining soil). By doing so, these harvesting contractors adopt some drivers from the differentiation strategy with a services focus.

The supply chain strategy in US case 4 is illustrated in Table 21 (see Appendix 4). The wood dealer performs the source and value commitment processes internally and participates in the planning of the harvesting. The operational planning and execution of the harvesting, loading and secondary transportation is outsourced to harvesting contractors who, in turn, can outsource some trips to subcontracted truckers in circumstances of transportation under-capacity.

4.2.3. Wood supply chain structure

Planning and execution processes

US case 4 involves seven planning processes and seven execution processes; their description can be found in Table 49 and Table 50 respectively (see Appendix 13). Figure 10 presents some of these planning processes on the horizontal axis. The horizontal axis also presents the list of generic planning decision(s) (see Appendix 1) addressed by each planning process. The actors conducting the planning processes are listed on the vertical axis. Each rectangle defines the accountability between one or several actors and one or several decisions. The sequenced rectangles illustrate the logical sequence of the planning process. When a rectangle spans over two planning processes, this means that joint decision-making occurs during the planning phase.



Buy block 1	Schedule harvesting 1	Schedule secondary transportation 1	Schedule harvesting 2	Schedule secondary transportation 2	Schedule secondary transportation 3
- Harvest units sourcing - Harvest units scheduling - Assortments to produce per harvest unit and allocation to demand - Harvest equipment selection per harvest unit	- Harvest unit assignment to contractors /teams - Bucking/ merchandising instructions and sorting rules per harvest unit	- Balance transportation with harvesting, inventory and reception - Assigning transportation quotas to contractors	- Harvest unit layout - Harvest crew scheduling	- Transportation crew scheduling	- Transportation equipment routing and scheduling

Figure 10: Actor accountable and generic planning decisions per planning process in US case 4

There are two Value commitment processes in US case 4. Value commitment 1 is made 1-2 weeks in advance for an order with a supply agreement of one to a few weeks. Value commitment 2 is made 1-2 weeks or one to a few days in advance for an order of one to a few weeks. For the three aforementioned attributes characterising the demand in US case 4, Table 52 (see Appendix 13) details how each attribute in a given planning process is described and whether this attribute is subject to further change. Demand attributes in the first value commitment process never change, while the demand attributes in the second value commitment process are subject to change up to delivery. Planning horizons extend from a few days to a few weeks and demand attributes are highly detailed (i.e. no data aggregation, see Section 5.3).

Material flow and decoupling points

Figure 11 (A) and (B) illustrates the material flow between some processes and the decoupling points in US case 4, while Table 55 (see Appendix 13) lists the average inventory time of the material between consecutive pairs of processes. An average delay of 0.5-1.5 days is observed between harvest and delivery.

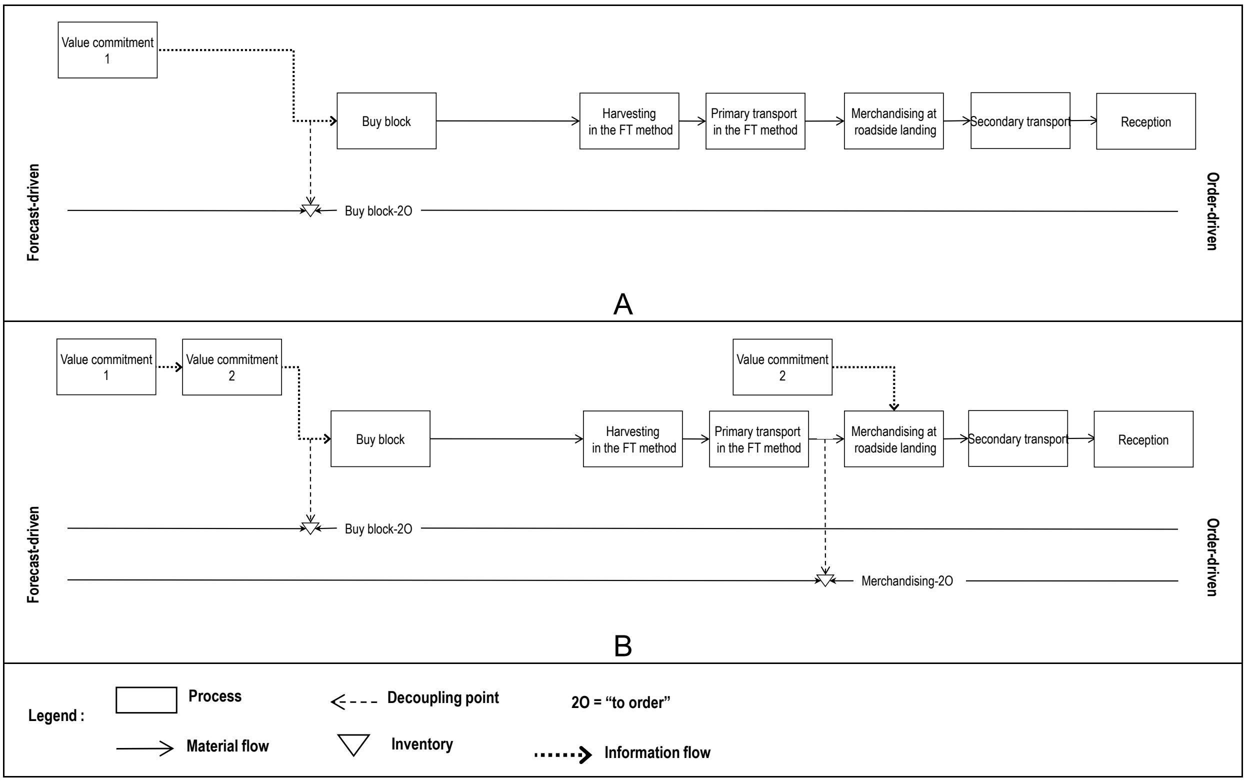


Figure 11: Material flow and decoupling points in US case 4

Demand from process Value commitment 1 is managed with decoupling point Buy block-2O. In the studied case, the demand in process Value commitment 1 is only for pulp quality grade timber. Figure 11 (A) illustrates the simplest situation to manage: when the only volume to be harvested in the purchased block is a product of pulp quality grade (e.g. thinning). When the volume of several products can be harvested in a block, the standing timber price of the block requires the wood dealer to find markets for these products to gain a profit. In the best situation, the wood dealer finds these markets (i.e. Value commitment 2) before purchasing the block. Thus, the demand in processes Value commitment 1 and 2 are managed with decoupling point Buy block-2O (Figure 11 (B)). However, usually some of the volume is not confirmed in an order before the block is purchased and the process Value commitment 2 continues after purchasing the block. These demands are then managed with decoupling point Merchandising-2O. Sometimes more than one block should be purchased to fulfil the demand in process Value commitment 1. For sake of brevity, this situation is not depicted. However, the same processes apply and if some standing timber in one purchased block remains, this volume could be used to fulfil part of a future demand in process Value commitment 1 or 2.

Information flow

Most information is exchanged by traditional tools (e.g. cellular, text-message, fax, CB-radio, post) and communication in person. Table 53 and Table 54 (see Appendix 13) detail the information flow for each planning and execution process respectively.

Monetary flow

Figure 12 illustrates the main monetary flows between the central actor of US case 4 (i.e. wood dealer) and the timberland owners, harvesting contractors and mills. The details can be found in Table 56 (see Appendix 13). The monetary flows to the timberland owners are payment for their standing timber. Only the lump sum payment method is illustrated, thus the payment is made at purchasing time. The monetary flows to the contractors are payment for their harvesting and transportation services for all harvested timber delivered during the week. The payment is made within 7 days after the end of the week. The monetary flows from the mills are payment for the harvested timber delivered during the week. The mills pay 7-10 days after the end of the week.

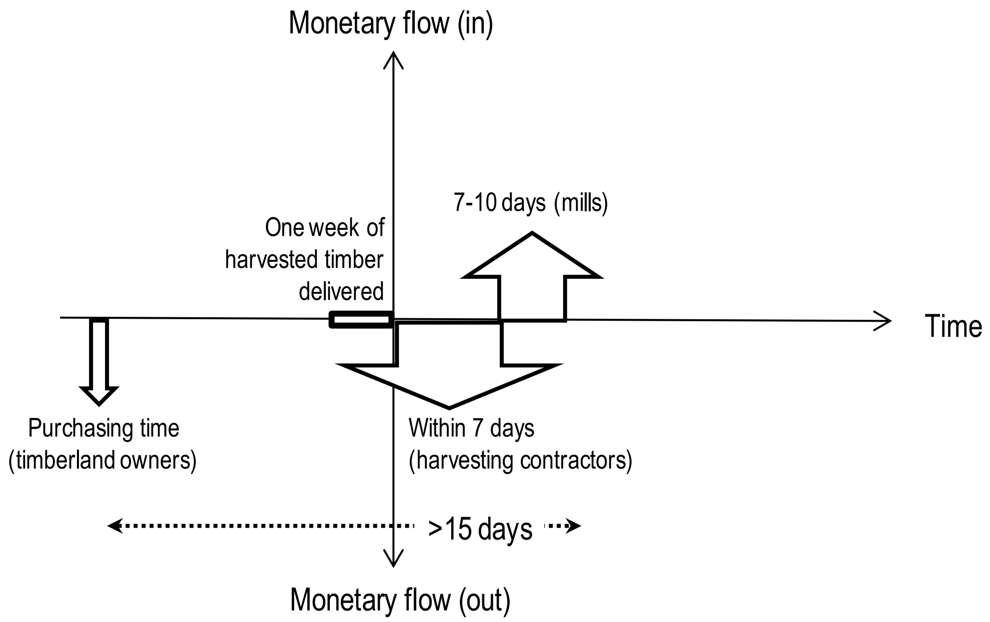


Figure 12: Main monetary flows for the central actor in the US case 4

4.2.4. Enablers and practices

In this case, 42 enablers and practices were identified. Table 57 (see Appendix 13) presents this complete list detailed by process and by category. The majority of the enablers and practices were identified under the macro-processes Make (17 enablers) and Source (10 enablers).

In the Make process, the most numerous categories were Rules and guidelines (5 enablers) and Inventory management (4 enablers), presenting also contractual agreements with harvesting contractors, pre-negotiated 'cut-and-haul' base rates, requesting Best Management Practices accreditation for contractors, payment based on scaled weight at delivery site, and fostering short inventory time between felling and delivery. Asset management also had a relevant number of practices identified (3 enablers), including the possibility of using various scattered accommodations for the harvesting crew, which increases geographic flexibility.

In Source, the most numerous categories were Network management (3 enablers) and Asset management (2 enablers). Long term business relationships with private timberland owners, business contact with different consulting foresters and silviculture flexibility in the pine plantations can be mentioned here.

From a global perspective, the categories of Transportation management and Performance measurement also deserve mention, with a total of 7 and 5 enablers identified respectively, distributed throughout the processes. They include the reduction of standing timber purchasing costs if road construction is needed, felling of specific trees to complete a truckload of a specific product, reduced handling by loading a truck as the merchandising takes place, and the use of delivery time windows to reduce truck queuing time. In order to evaluate the agility of a case in the US with larger scale harvesting and transportation activities, enablers and practices of a second case were also identified. Table 59 (see Appendix 14) details this list for US case 7, a large timberland-based wood supplier. In this case, 66 enablers and practices were identified. The majority of the enablers and practices were identified in the macro-processes Make (30 enablers) and Value commitment (14 enablers).

In the Make process, the most numerous categories were Asset management (12 enablers) and Rules and guidelines (6 enablers), including flexibility in reallocating and increasing the quotas among several harvesting contractors, having a manager dedicated to increasing the business competencies of the regular harvesting contractors, having a small logistics team to support decisions, classifying harvesting contractors to three levels of partnership, plus most of the practices highlighted above in the smaller US case.

In the Value commitment, the most numerous categories were Rules and guidelines (4 enablers) and Performance measurement (3 enablers). These include having a total volume under medium-long term supply agreement limited to 65-75% of the total harvested volume in order to guarantee operational flexibility while meeting these commitments, decentralised sales for regional customers but sales managers acting together for customers present in many regions to avoid internal competition, and charging a premium price for contract customers requesting additional volume on short term notice,

Viewed globally, the category of Transportation management also deserves mention, with a total of 9 enablers identified, including building better quality roads to avoid excessive road damage during high rainfall periods and most of the practices listed above for the smaller US case. Additionally, a pilot project for reducing empty distance with back-hauling among harvesting contractors is in place.

4.2.5.Performance

The enablers identified in US case 4 (small scale supply chain) were considered to contribute highly to the supply chain agility dimensions of Customer sensitivity and Process integration (Figure 13). This is because the blocks are purchased according to confirmed demand for most of the volume to be harvested in the block. The cutting-list with the sorting rules can also be adjusted at virtually any time by a telephone call. In addition, the small-scale size forces the organisation to be more aware and receptive to any requirements from the mills, which makes it easier to identify new market opportunities.

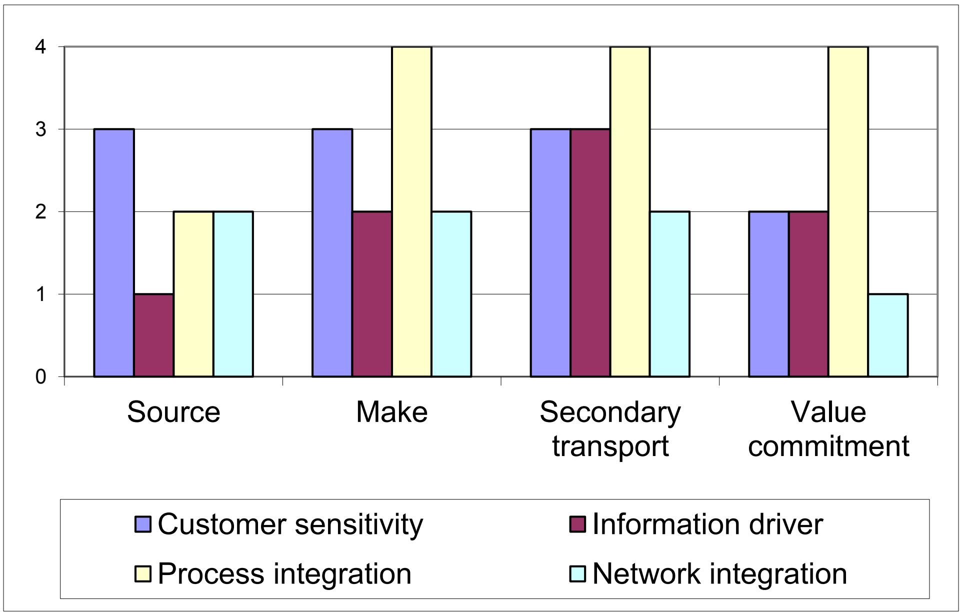


Figure 13: Agility capabilities results by dimension and macro-process in US case 4.

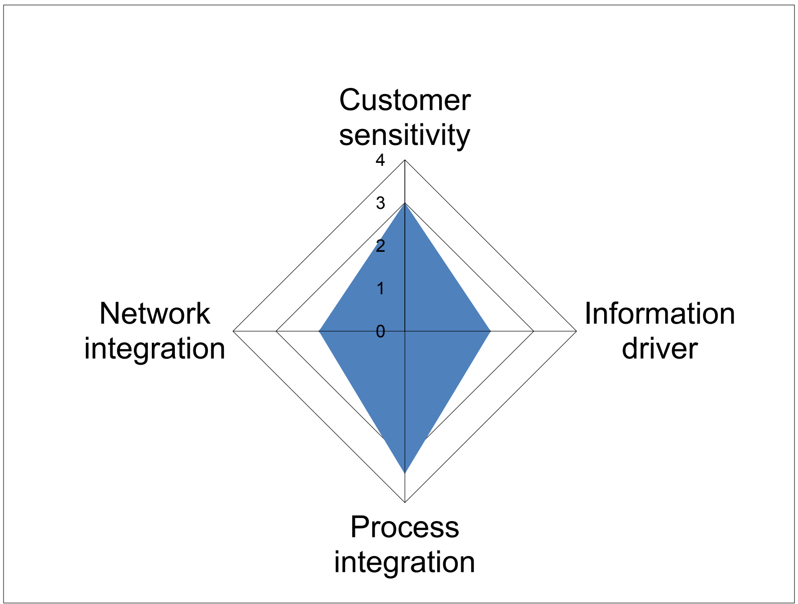


Figure 14: Agility capabilities results by dimension in US case 4.

The agility dimensions of Network integration and Information driver obtained a lower evaluation. Network integration in the Value commitment process of the small scale supply chain received a low evaluation because business relationships through Internet-based auctions or gate wood[8] deliveries do not foster trust-based relationships between a supplier and a customer. We can see in Figure 13 that the agility dimension Information driver has the lowest evaluation in the Source process, as mostly tacit knowledge of the available blocks is used for purchasing, and the accuracy of the forest inventory is variable (mainly all buyers conduct their own inventory cruise in the block). Overall, accessibility of sourcing information tends to be limited, considering the competition among buyers.

In the larger scale supply chain (US case 7), only the Information driver agility dimension exhibited a smaller contribution than the other dimensions (Figure 15). The Make process is the one with the lowest evaluation in this dimension. This is because in the large scale supply chain, even if information exchanges with harvesting contractors and among harvesting managers are frequent and fairly accurate, it is shared over a short time horizon. Network integration is better as the enablers and practices identified reinforce trust-based relationships with harvesting contractors, as they know what to expect when required production capacity changes.

Both cases (small and large) performed highly in Process integration in the Make, Deliver and Value commitment processes. This is because harvesting and transport are planned simultaneously when a volume is committed, and they are done very rapidly. The level of integrated planning and rapid decision-making is not as high in the Source process because there is some level of forecasted buying and “push” flow due to silviculture, economic and operational aspects.

Table 58 (see Appendix 13) and Table 60 (see Appendix 14) detail the agility assessment by dimensions and macro-process respectively in the small scale and large scale supply chain cases in the United States.

[8] Gate wood is a term that describes spontaneous deliveries of wood. Loaded trucks show up at the mill’s gate without prior engagement.

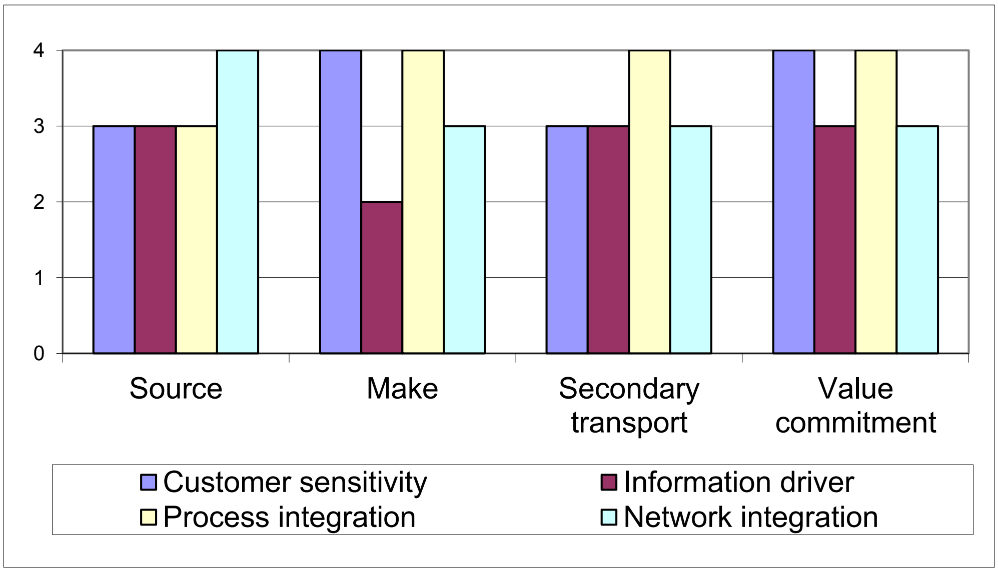


Figure 15: Agility capabilities results by dimension and macro-process in US case 7.

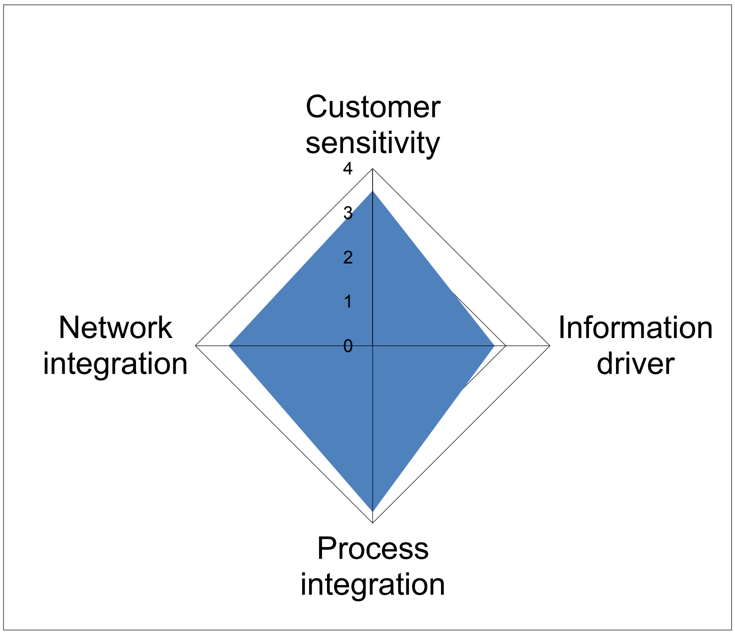


Figure 16: Agility capabilities results by dimension in US case 7.

4.3. French case 11

Fieldwork in the Aquitaine region allowed the identification of six distinct cases (cases numbered 9 to 14 in Appendix 4). French case 11 with a harvesting contractor as the central actor is the only case detailed. The supply chain strategy of all the French cases is reported in Appendix 4, while in Section 5.3.2.1 we provide additional detail on a decoupling point identified in French case 11.

Ms. Morgan Vuillermoz and Mr. Adrien Arraiolos from the Institut technologique forêt cellulose bois-construction ameublement (FCBA) were our local hosts during three weeks of fieldwork. A total of 15 interviews were performed and meetings were held with a total of 21 local actors and experts. Fieldwork was complemented by field visits to a mechanised cut-to-length method in a clear-cut and a storm wood recuperation operation in maritime pine plantations.

4.3.1. External environment

The harvesting and transportation activities are constant throughout the year with a decrease in activities during a few periods (e.g. August for the summer holidays, November for the dove hunting period, winter holidays). There is no seasonal demand except for products with quality grade packaging, where higher demand is observed from August to October. Potential disturbances of harvesting and transportation activities are rare and their impact is usually limited to a few days. For instance, some forest roads can be inaccessible during periods of heavy rainfall.

The supply in French case 11 is based on standing timber purchases mainly from non-industrial private timberland owners and, for approximately 10% of the harvested volume, public timberland managed by the Office National des Forêts (ONF), a public organisation. Most of the purchases on private timberland are made with little advertisement to potential buyers, increasing the importance of maintaining good business relationships with a network of timberland owners. Purchases from public timberland are advertised and open to all professional entities that provide guarantees of solvency. Harvesting on private and public timberlands is subject to moderate regulations, compared to what has been observed elsewhere. In the two last decades, two major storms have disrupted the availability of resources. At the moment, the supply is still sufficient, since logs are taken from the storage of storm wood. The inventory is decreasing and the lack of wood will affect supply in the near future. Moreover, by managing the harvesting of part of the public timberland internally, the public organisation is transitioning into also becoming a timberland-based wood supplier and consequently is reducing the amount of public standing timber to sell.

The raw material comes from mono-species plantations (Maritime pine), where genetic improvements are made to the trees, which makes the raw material fairly homogenous from intensively managed plantations. Variability in the raw material can increase after beetle infestation (standing timber and inventory), blue stain (inventory) and storms (standing timber). The harvesting method is cut-to-length.

Other external environment elements are reported in Table 61(see Appendix 15).

4.3.2. Competitive business strategy and supply chain strategy

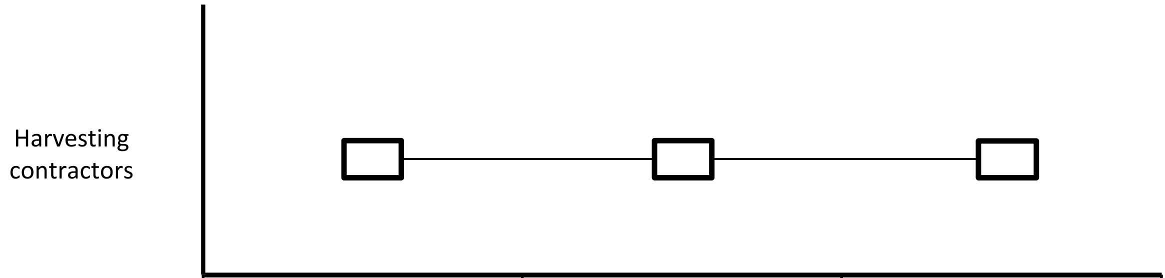
There are three actors in French case 11: the timberland owners, the harvesting contractor and the mills. The analysis excludes the timberland owners and the mills. The primary strategy of the harvesting contractor is differentiation with a services and product focus. The strategy is implemented with a defensive approach combining individual and cooperative behaviours (e.g. sub-contractor in primary transportation), but an offensive approach is implemented in the long term (e.g. new customers, increasing current markets, additional harvesting and transportation capacities). The harvesting contractor uses a cost-leadership strategy for customers with a low unit cost as the primary purchasing criteria.

The supply chain strategy in French case 11 is illustrated in Table 21 (see Appendix 4). The harvesting contractors perform all the planning and execution of the processes internally, from the source to secondary transportation, except for the execution of primary transportation, where forwarding subcontractors are members of some harvesting teams.

4.3.3. Wood supply chain structure

Planning and execution processes

French case 11 involves eight planning processes and six execution processes, described in Table 62 and Table 63 respectively (see Appendix 15). Figure 17 presents some of these planning processes on the horizontal axis. The horizontal axis also shows the list of generic planning decision(s) (see Appendix 1) addressed by each planning process. The actors conducting the planning processes are listed on the vertical axis. Each rectangle defines the accountability between one or many actors and one or many decisions. The sequenced rectangles illustrate the logical sequence of the planning process.



Schedule harvesting 1	Schedule harvesting 2	Schedule secondary transportation 1
- Harvest equipment selection per harvest unit - Harvest unit layout	- Harvest units scheduling - Assortments to produce per harvest unit and allocation to demand - Bucking/merchandising instructions and sorting rules per harvest unit - Harvest unit assignment to contractors/teams - Harvest crew scheduling	- Assortments (re)allocation to the demand - Transportation crew scheduling - Transportation equipment routing and scheduling

Figure 17: Actor accountable and generic planning decisions per planning process in French case 11

There are three Value commitment processes in French case 11. Value commitment 1 is made a few months in advance for an order with a supply agreement of one year. Value commitment 2 is made 2-3 days in advance for an order of one week. Value commitment 3 is made one day in advance for an order of one day. Few demands are from Value commitment 3. For the three aforementioned attributes characterising the demand in French case 11, Table 65 (see Appendix 15) details how each attribute in a given planning process is described and whether this attribute is subject to further change. Demand attributes in all value commitment processes are subject to change, even for a demand with a planning horizon of one day. At the time of value commitment, demand attributes are detailed, but for demand with a planning horizon of one month, customers can later specify delivery quantity by week.

Material flow and decoupling points

Figure 18 illustrates the material flow between some processes and the decoupling points in French case 11, while Table 68 (see Appendix 15) lists the average inventory time of the material between consecutive pairs of processes. An average delay of 5 to 7 days is observed between harvest and delivery.

The decoupling point Buy block-2O could also have been illustrated. However, it was decided not to do so because it was judged that the link between the purchased block and the specific demand in Value commitment 1.1 was not explicit enough at purchasing time. The purchase process builds a portfolio of blocks not only to secure the satisfaction of the demand in the supply agreements – not a specific demand – but also for several other objectives (i.e. to have additional supply for profitable spot demand, 'good' price opportunity, to maintain purchase with timberland owners having a regular business history with the company).

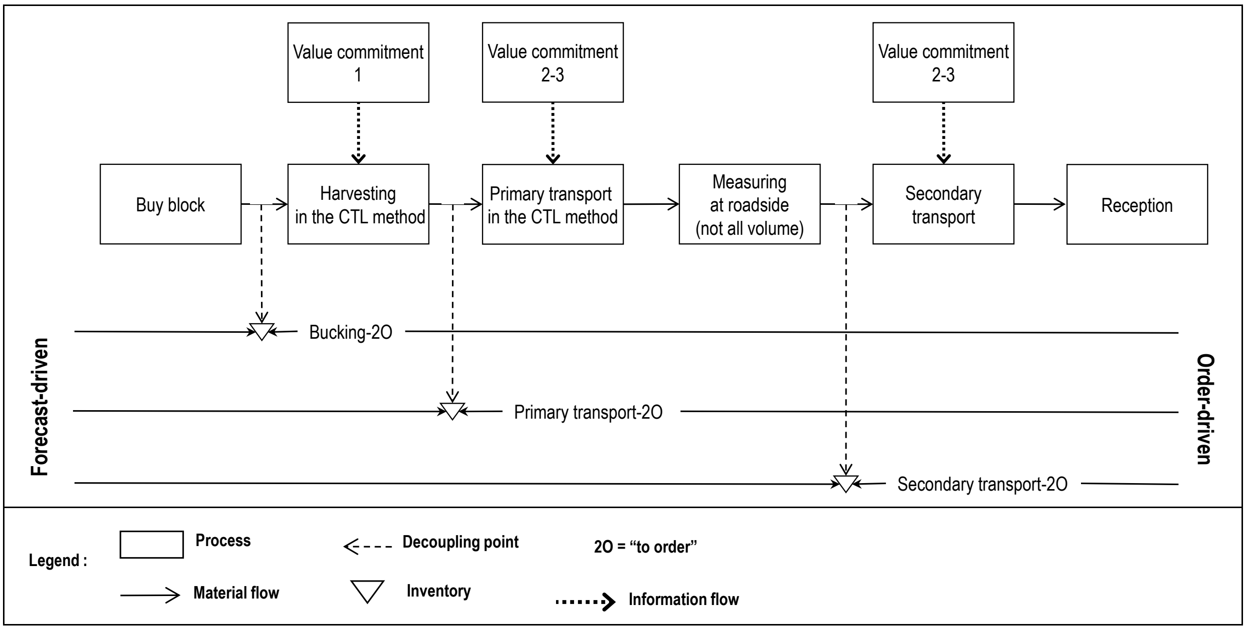


Figure 18: Material flow and decoupling points in French case 11.

Demands from process Value commitment 1 are managed with decoupling point Bucking-2O. In French case 11, the buck-to-value problem is solved by each harvester. Therefore, volume in some products will be produced in excess and will be used to fulfill demand in processes Value commitment 2 and 3. Demands from process Value commitment 2 are managed with decoupling points Secondary transport-2O only for deliveries after mid-week and if there is not enough inventory at roadside to fulfil the entire demand of Primary transport-2O. Demands from process Value commitment 3 are managed with decoupling point Secondary transport-2O, and to complete a truckload to delivery in the following afternoon, decoupling point Primary transport-2O can be used.

Information flow

Most information is exchanged by traditional tools (e.g. cellular, text-message, fax, CB-radio) and communication in person. A paper agenda and an internal Enterprise resource planning (ERP) system[9] are used as a centralised database to support the sales (value commitment processes) and the other processes from block purchasing to secondary transportation. Table 66 and Table 67 (see Appendix 15) detail the information flow for each planning and execution process respectively.

Monetary flow

Figure 19 illustrates the main monetary flows between the central actor of the French case 11 (i.e. harvesting contractor) and the timberland owners and the mills. The details can be found in Table 69 (see Appendix 15). The monetary flows to the timberland owners are payment for their standing timber. Only the lump sum payment method is illustrated, thus the

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[9] Enterprise resource planning (ERP) system: A class of software for "enterprise-wide" planning and managing the resources needed to take customer orders, ship them, account for them and replenish all needed goods according to customer orders and forecasts. (Vitasek, 2010)

payment is done at purchasing time. The monetary flows from the mills are payment for the harvested timber delivered during one month. The mills pay 30 days after the end of the month.

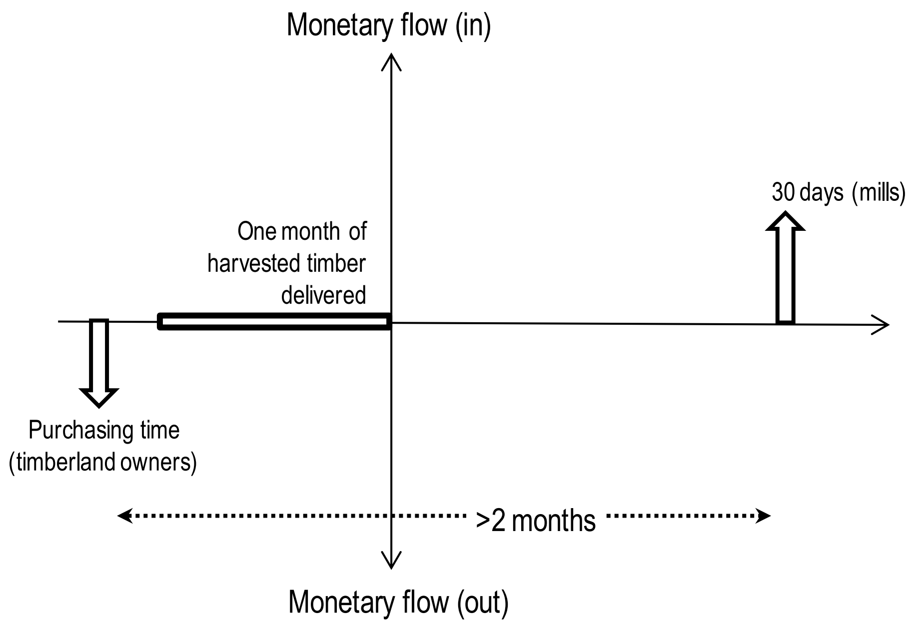


Figure 19: Main monetary flows for the central actor in French case 11

4.3.4. Enablers and practices

In this case, 51 enablers and practices were identified. Table 70 (see Appendix 15) shows this complete list detailed by process and category. The macro-process of Make had the highest number of enablers and practices identified (17 enablers). The most numerous category in this process was Asset management with 7 enablers. It is worth mentioning the practice of monitoring the monthly performance of harvesters, a full time internal staff for equipment maintenance, and the use of an ERP system to record all costs and productivity performance indicators, supporting a profitability evaluation by block before or after volume delivery.

Viewed globally, the categories of Inventory management and Asset management had the highest number of practices identified (10 enablers each). Besides the enablers and practices mentioned previously, we can also cite silviculture flexibility in maritime pine plantations, use of an ERP system to record all purchase offers, purchased blocks, volume at roadside, planned and executed deliveries.

4.3.5. Performance

The enablers identified in the case were considered to provide a medium contribution to the supply chain agility dimensions of Customer sensitiveness and Network integration, and a small contribution to Process integration and Information driver dimensions (Figure 21).

We can see in Figure 20 that the agility dimensions of Customer sensitiveness and Information driver are higher in the Deliver and Value commitment processes, basically because the decoupling point location follows a transport-to-order approach. The capacity of the secondary transport to fulfil demand with respect to logistics delivery conditions is based on inventory at roadside and also on the use of some logistics techniques, such as product substitution or product re-sorting during truck loading (see Section 5.3.1.1 for more detail on logistics techniques to adjust the supply to the demand). Precision and company-level diffusion of the data about the inventory level along the wood supply chain decrease as we move closer to the harvesting process.

Network integration in the Make process has a higher evaluation than the other processes, in particular because a general contractual agreement[10] is used with primary transportation subcontractors. The partnership with a research and development service provider is another factor positively reinforcing network integration. Table 71 (see Appendix 15) details the agility assessment by dimensions and macro-process in French case 11.

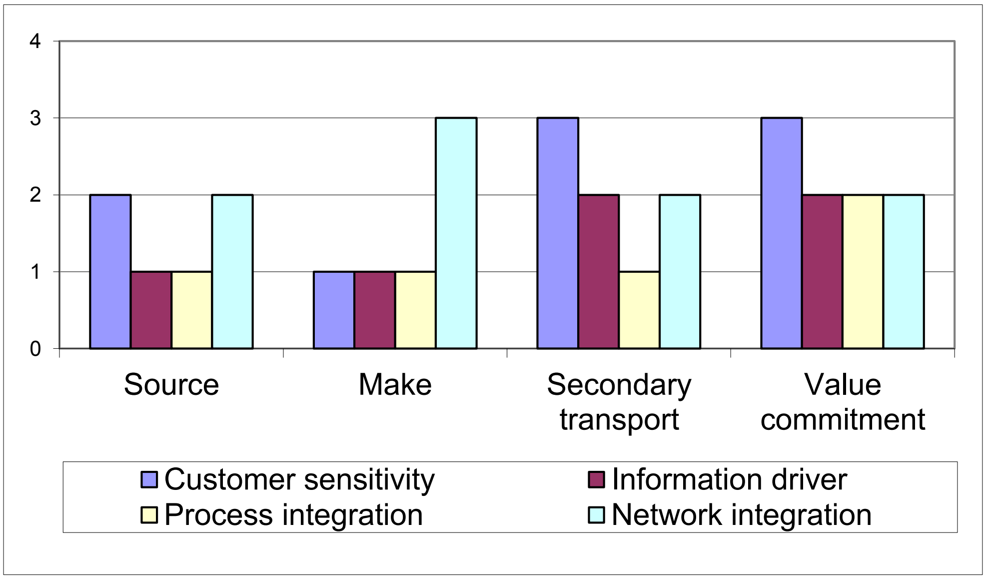


Figure 20: Agility capabilities results by dimension and macro-process in the French case 11.

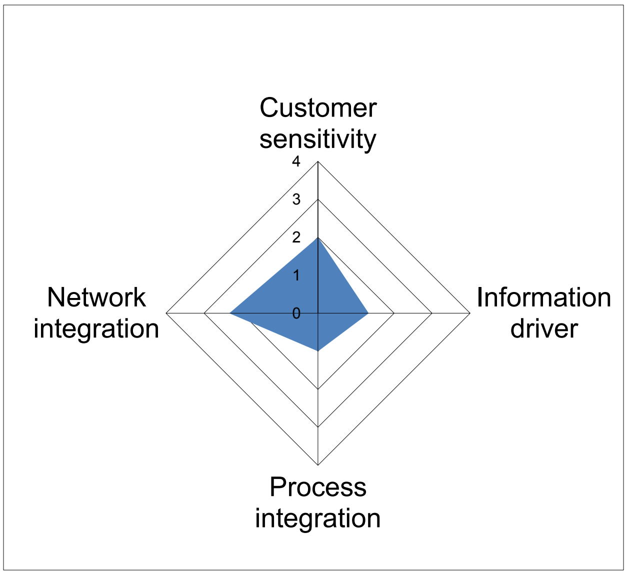


Figure 21: Agility capabilities results by dimension in the French case 11.

[10] An agreement where the conditions and requirements for future contracts are pre-negotiated in order to both shorten and ease the preparation of each future contract (e.g. pre-negoatiate harvesting rates according to three classes of diameter at breast height mean)

4.4. Canadian case 15

Fieldwork in the region of Lac Saint-Jean and experts' knowledge of WSCs in the Quebec province allowed three distinct cases to be identified (cases numbered 15 to 17 in Appendix 4). Canadian case 15 with a wood procurement division as the central actor is the only case detailed. This case is mainly based on doctoral research work conducted by Ms. Élaine Mosconi from Université Laval. The supply chain strategy of all the Canadian cases is reported in Appendix 4. A total of 3 interviews were performed and a total of 8 local actors and experts were contacted.

4.4.1.External environment

Wood supply chains in Canada are subject to seasonal pattern in the supply, while demand is fairly stable over the year, with increasing or decreasing trends lasting for several months to a few years. The thawing period implies bad road conditions and snow melt reduces the capacity for harvesting and use of primary transport equipment. Starting in autumn and up to before spring, inventories are built up at the mill to cover industrial needs. Indeed, secondary transportation with trucks is stopped/reduced during/after the thawing period (6-8 weeks of no transportation). Inventory at the mill yard plays a major role in leveling the fluctuations when procurement is insecure. Harvesting contractors are active, on average, 42 weeks per year. Production stops for 4 to 8 weeks in the spring (April - May) for the thaw. Main equipment maintenance and repairs are performed then. Production may also cease for short periods in June and July because of forest fire risks. Operations are more intense in the fall and winter and are usually conducted by working double shifts (24/24).

In Canadian case 15, supply is mainly based on public timberland and less than 3% of the volume comes from industrial and non-industrial private timberland owners. Harvesting on public timberland is subject to a high level of public regulation and requires a long-term contract with the government. Public timberlands are procurement areas shared among several companies with contractual obligation to acheive agreements among them. Purchasing pulpwood from private timberland owners is subject to an annual contract with local syndicates of timberland owners, whereas no contract is required for other products. Purchasing products from public timberland is also possible and subject to public regulation.

The forest consists mainly of natural forest in mono- and mixed-species blocks with a high level of raw material variability of up to seven commercial species.

Other external environment elements are reported in Table 72 (see Appendix 16).

4.4.2.Competitive business strategy and supply chain strategy

There are four main actors in Canadian case 15: the timberland owner, the wood procurement division, the harvesting contractors and the mills (internal and external customers). The analysis excludes the timberland owner and the mills. The government, as the owner of the forest, plays a major role, mainly by providing inventory information, regulating forest management policies and norms (e.g. silviculture, harvesting) and determining harvested timber price. There are two types of harvesting contractor in Canadian case 15: i) a turn-key harvesting contractor that has internal resources to execute all the activities from harvesting to secondary transport and ii) a 'virtual' turn-key harvesting contractor consisting of, at least, one harvesting contractor and one transportation and loading contractor that act as one single entity for the wood procurement division.

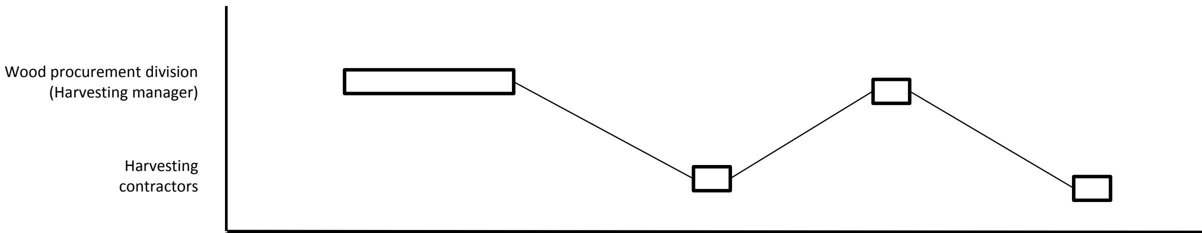
The main drivers for the analysed actors are operational excellence and high productivity to achieve, in turn, low unit cost. Thus, the primary strategy of all the analysed actors is cost-leadership subject to demand fulfilment. How each analysed actor implements this strategy is unclear, but the actors appear to use a defensive approach with a combination of individual and cooperative behaviours according to the level of trust between a contractor and the wood procurement division. By providing some planning service to the wood procurement division, the harvesting contractors also adopt some drivers from the differentiation strategy with a service focus.

The supply chain strategy in Canadian case 15 is illustrated in Table 21 (see Appendix 4). The wood procurement division performs the source and value commitment processes internally, as well as the harvesting planning process. The secondary transport planning is shared between the wood procurement division and the harvesting contractor; the first sets the delivery targets, while the latter sets the plan to meet the delivery targets. The execution of harvesting, primary transport and secondary transport are outsourced to harvesting contractors.

4.4.3. Wood supply chain structure

Planning and execution processes

Canadian case 15 involves seven planning processes and eight execution processes; their description can be found in Table 73 and Table 74 respectively (see Appendix 16). Figure 22 presents some of these planning processes on the horizontal axis. The horizontal axis also shows the list of generic planning decision(s) (see Appendix 1) addressed by each planning process. The actors conducting the planning processes are listed on the vertical axis. Each rectangle defines the accountability between one or many actors and one or many decisions. The sequenced rectangles illustrate the logical sequence of the planning process. When a rectangle spans over two planning processes, this means that joint decision making occurs during the planning phase.



Select blocks	Schedule harvesting 1	Schedule harvesting 2	Schedule secondary transportation 1	Schedule secondary transportation 2
- Harvest units sourcing	- Harvest units scheduling - Assortments to produce per harvest unit and allocation to demand - Harvest equipment selection per harvest unit - Harvest unit assignment to contractors/teams - Harvest unit layout - Bucking/merchandising instructions and sorting rules per harvest unit	- Harvest crew scheduling	- Balance transportation with harvesting, inventory and reception - Assigning transportation quotas to contractors	- Transportation crew scheduling - Transportation equipment routing and scheduling

Figure 22: Actor accountable and generic planning decisions per planning process in Canadian case 15.

There are three Value commitment processes in Canadian case 15. Value commitment 1 is made a few months in advance for an order with a supply agreement of one year. Value commitment 2 is made a few weeks in advance for an order with or without a supply agreement of a few weeks or months. Value commitment 3 is made a few weeks in advance for an order of a few weeks. Few demands originate from Value commitment 3. For the three aforementioned attributes characterising the demand in Canadian case 15, Table 76 (see Appendix 16) details how each attribute in a given planning process is described and whether this attribute is subject to further change. Demand attributes in all value commitment processes are subject to some change, even for a demand with a planning horizon of a few weeks. At the time of value commitment, demand attributes are fairly detailed but further specification of quantity to delivery by week can occur.

Material flow and decoupling points

Figure 23 illustrates the material flow between some processes and the decoupling points in Canadian case 15, while Table 77 (see Appendix 16) lists the average inventory time of the material between consecutive pairs of processes. An average delay of 3-4 weeks is observed between harvest and delivery.

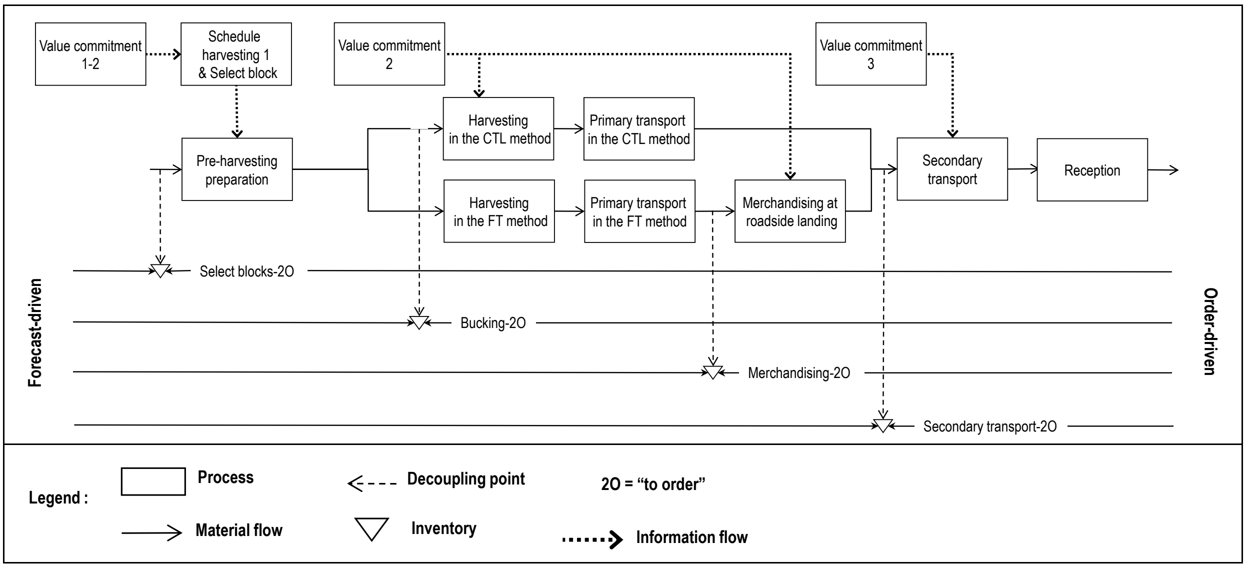


Figure 23: Material flow and decoupling points in Canadian case 15.

Demand from process Value commitment 1 is managed with decoupling point Select blocks-2O. Following the forest management norms on public timberland, a set of blocks is selected and sequenced in an annual harvesting plan in order to satisfy the monthly demand of each customer with an annual supply agreement. At least each month, the remaining annual harvesting plan is re-evaluated according to each customer's confirmation of the monthly volume fixed in the annual agreement, receipt of harvesting permit for selected blocks, etc. Change will occur (e.g. demand reduction from a customer, new demand), forcing an update of the remaining annual harvesting plan. Value commitment 2 refers to an update in the annual harvesting plan involving the commitment of a new demand. This new demand is managed with decoupling point Select blocks-2O if the demand involves sourcing additional blocks, and/or with decoupling point Bucking or Merchandising-2O if the new demand replaces a similar demand cancelled by a customer (thus, additional sourcing is not involved). Demand from process Value commitment 3 is managed with decoupling point Secondary-transport-2O.

Information flow

Most information is exchanged by traditional tools (e.g. cellular, email, text-message, fax, CB-radio) and communication in person. A standard documentation template is used to send information to harvesting contractors, but information received from the harvesting contractor uses a contractor's template. Several home-made excel files are used as a database for different needs, such as monitoring inventories according to the weekly inventory report from the harvesting contractor and the scaling report from the mills.

Monetary flow

Figure 24 illustrates the main monetary flows between the central actor of Canadian case 15 (i.e. wood procurement division) and the timberland owner (i.e. the government of Quebec), the harvesting contractors and the mills. The details can be found in Table 78 (see Appendix 16). The monetary flows to the timberland owner are payment for the harvested timber delivered during the week. Payment is made within 30 days after the end of the week. Also, not illustrated, all harvested timber in inventory at roadside is estimated every three months and an advance must be paid to the timberland owner. The monetary flows to the harvesting contractors are payment for the harvesting and transportation service during two weeks. The harvesting contractors are paid 15 days after the end of the two-week period for all harvested timber delivered during this period. Also, not illustrated, there is an annual payment to the harvesting contractors according to an annual harvested and measured volume adjustment. The monetary flows from the mills are payment for the harvested timber delivered. The mills pay 15 days after the end of the two-week period for all harvested timber delivered during this period.

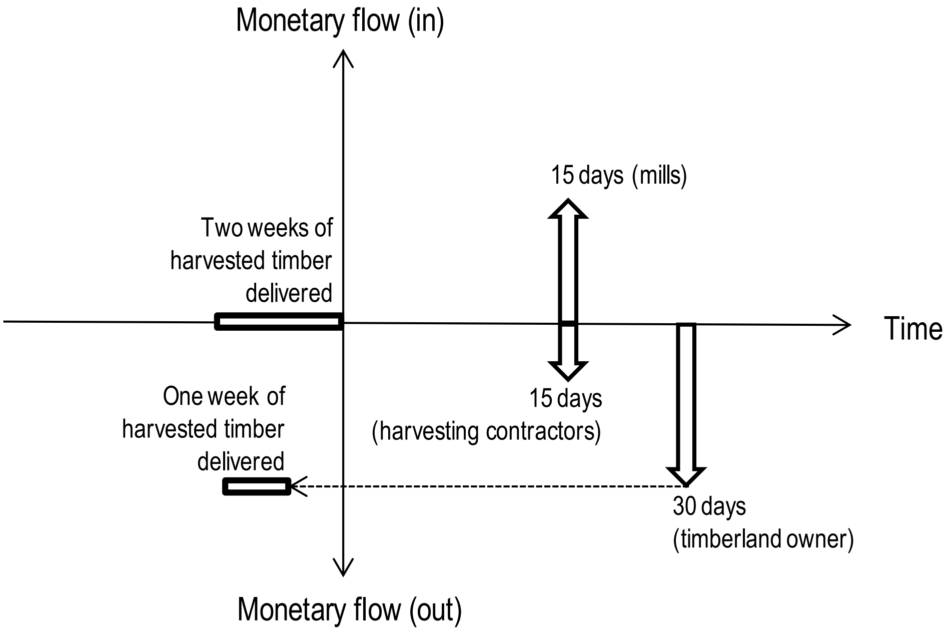


Figure 24: Main monetary flows for the central actor in Canadian case 15

4.4.4. Enablers and practices

In this case, 70 enablers and practices were identified. Table 79 (see Appendix 16) presents this complete list detailed by process and category. The majority of enablers and practices were identified under the macro-processes Make (28 enablers), followed by Deliver (Secondary transport) (20 enablers). The most numerous category was Rules and guidelines, with 12 enablers (Make) and 5 enablers [Deliver (Secondary transport)] identified.

In general, the harvesting contractor is also responsible for the transportation with cut-and-haul pre-negotiated rates adjusted by harvesting areas according to productivity factors and fuel index variations. We can also highlight the practices of annual contracts, standard documentation templates, different ISO certifications, financial compensation for moving equipment between two harvesting areas, and productivity and cost models for the harvesting and primary transport.

Viewed globally, the categories Network management and Asset management also deserve attention, with a total of 11 and 10 enablers identified respectively. Interesting practices in Asset management are the use of a monitoring system for the maintenance of the forest roads network, outsourcing maintenance and daily operation of forest camps, thorough consideration of training, safety and motivation of human resources (work shift template designed to allow holiday at home), and the use of pre-harvesting inventory and historic production data from similar blocks to increase the forecast precision of the productivity and cost models for a block.

In Network management, we can mention the use of a catalogue of potential contractors in order to stimulate competition, service quality based on annual contract tendering, a bonus system for small contractors and penalties for large ones (based on harvested volume), use of external resources such as consultants, research centres and universities to improve current planning methods and harvesting practices. Significant effort is invested in maintaining or improving relationships with other stakeholders of public timberland (e.g. first nations) to more easily meet the requirements of collaboration in the harvesting plan, maintain social acceptance and nurture business relationships as well with organisations of small private timberland owners and large private timberland owners to purchase additional volume.

4.4.5.Performance

The enablers identified were considered to make a medium contribution to supply chain agility. This medium contribution is also fairly balanced within the dimensions (Figure 26). We can see in Figure 25 that the Source macro-process has a lower level of agility dimensions. This is mainly due to the fact that several laws and regulations constrain the selection of a block not already in a portfolio of blocks for an annual harvesting plan. The level of accuracy and updating frequency of the information on available stands is also limited, considering the variety and variability of the natural forest.

The Process integration dimension is positively affected by the collaborative and joint planning of harvesting and transport from the Value commitment through Source, Make and Deliver. Additionally, the different incentives, contracts and programs fostering the adoption of best practices among harvesting and transport contractors, frequently supported by research and development service providers, set an acceptable base for Network integration. Table 80 (see Appendix 16) details the agility assessment by dimensions and macro-process in Canada’s case.

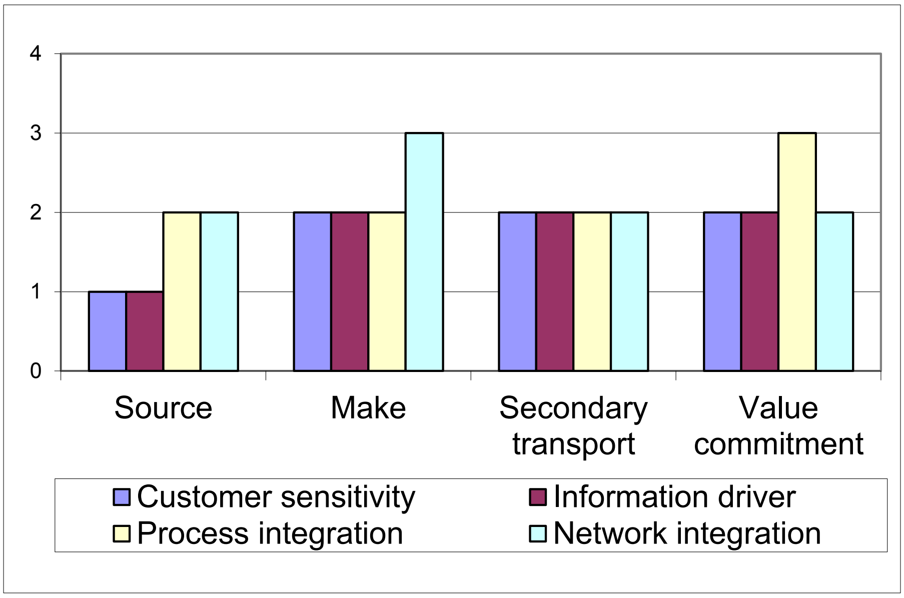


Figure 25: Agility capabilities results by dimension and macro-process in Canadian case 15.

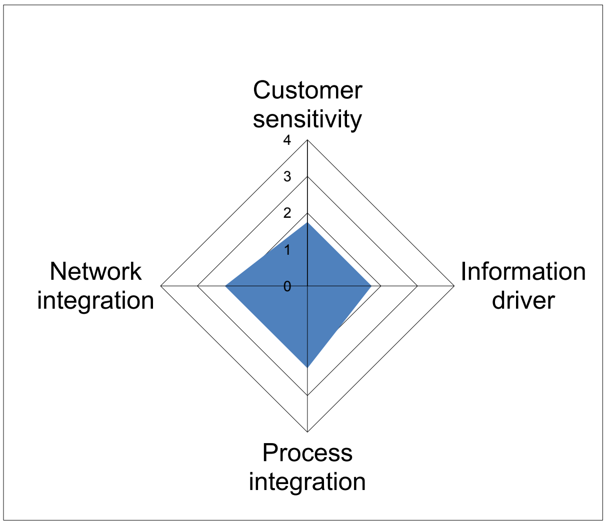


Figure 26: Agility capabilities results by dimension in Canadian case 15.

4.5. Polish case 18

Fieldwork in northwest Poland allows us to present the details of Polish case 18 with a public timberland-based wood supplier as the central actor. Dr. Krzysztof Jodłowski from Instytut Badawczy Leśnictwa was our local host during a one-week fieldwork. A total of 7 interviews were performed and meetings were held with a total of 10 local actors and experts. Fieldwork was complemented by a field visit to a non-mechanised full-tree method (e.g. chainsaw and tractor) in a selected cutting of a deciduous stand.

4.5.1.External environment

The harvesting and transportation activities are fairly constant over the year even if restrictions due to ground conditions can temporarily affect harvesting. Changing forest road conditions (e.g. during the thawing period) can force temporary closures. No clear information on the seasonality of potential demand was available.

The supply in Polish case 18 is based on public timberland managed by a public timberland-based wood supplier, sold through different online and traditional auction systems. Volumes are sold before or after harvesting and always delivered at roadside, with the buyer responsible for secondary transport. Since 85% of Polish forests are owned by the public timberland-based wood supplier, mills must rely on it for (most of) their supply if they are not big enough to import. The auction with the longest horizon is 6 months, therefore it is impossible to have a secure source of supply for more than 6 months, as the auction system must be entered each time a supply is required.

Public timberlands are composed of natural forests and extensive plantations of pines through reforestation, making raw material fairly heterogeneous. Three species dominate and the harvesting method are both cut-to-length and full tree, mainly in non-mechanised operations.

Other external environment elements are reported in Table 81 (see Appendix 17).

4.5.2.Competitive business strategy and supply chain strategy

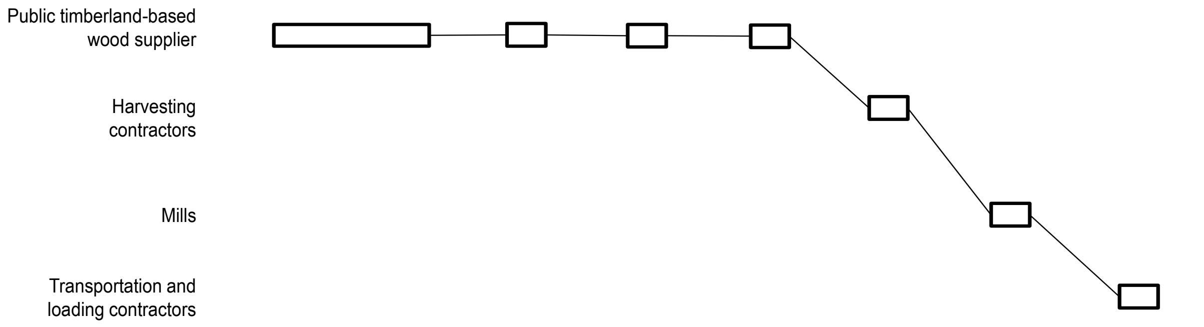
There are four actors in Polish case 18: the public timberland-based wood supplier, harvesting contractors, transportation and loading contractors and the mills. The analysis excludes the mills. The main driver for the analysed actors is low unit cost. Thus, the primary strategy of the analysed actors is cost-leadership. We can also identify a few drivers of the differentiation strategy with a product focus, as the public timberland-based wood supplier allows flexibility on product specifications in the sales process. How each analysed actor implements this strategy is unclear. The public timberland-based wood supplier appears to use a diversify-individual approach by making the purchase of a significant proportion of the sales volumes (i.e. blocks and products) from its timberlands accessible to any potential customer. The harvesting contractors and the transportation and loading contractors appear to use a defensive-individual approach by maintaining their current business.

The supply chain strategy in Polish case 18 is illustrated in Table 21 (see Appendix 4). The public timberland-based wood supplier performs the source, value commitment, harvest planning and scaling processes internally, while outsourcing the execution of the harvest to harvesting contractors. Mills are in charge of their own secondary transportation (from roadside inventory) and they outsource the planning (i.e. for most of the decisions) and execution processes to transportation and loading contractors.

4.5.3.Wood supply chain structure

Planning and execution processes

Polish case 18 involves ten planning processes and nine execution processes; their description can be found in Table 82 and Table 83 respectively (see Appendix 17). Figure 27 presents some of these planning processes on the horizontal axis. The horizontal axis also shows the list of generic planning decision(s) (see Appendix 1) addressed by each planning process. The actors conducting the planning processes are listed on the vertical axis. Each rectangle defines the accountability between one or many actors and one or many decisions. The sequenced rectangles illustrate the logical sequence of the planning process. When a rectangle spans over two planning processes, this means that there is joint decision-making during the planning phase.



Select block 1	Schedule harvesting 1	Schedule harvesting 2	Schedule harvesting 3	Schedule harvesting 4	Schedule harvesting 5	Schedule secondary transportation 1	Schedule secondary transportation 2
- Harvest units sourcing	- Harvest units scheduling	- Assortments to produce per harvest unit and allocation to demand - Harvest units scheduling	- Assortments to produce per harvest unit and allocation to demand - Bucking/ merchandising instructions and sorting rules per harvest unit - Harvest unit layout	- Harvest equipment selection per harvest unit - Harvest unit assignment to contractors	- Harvest crew scheduling	- Assigning transportation quotas to contractors	- Transportation crew scheduling - Transportation equipment routing and scheduling - Routing and scheduling adjustment

Figure 27: Actor accountable and generic planning decisions per planning process in Polish case 18.

There are four Value commitment processes in Polish case 18. Value commitment 1 is made two months in advance for an order with a supply agreement of a 6-month period. Value commitment 2 is made several weeks in advance for an order with a supply agreement of a 6-month period or less or one day to a few weeks in advance for an order of one to a few weeks. Value commitments 3 and 4 are made at least one day in advance for an order of one to a few days. Most of the demand is generated by Value commitments 1 and 2. For the three aforementioned attributes characterising the demand in Polish case 18, Table 85 (see Appendix 17) details how each attribute in a given planning process is described and whether this attribute is subject to further change. Demand attributes in all value commitment processes are subject to a few changes (e.g. delivery conditions in all value commitment processes, product specification in the first value commitment process) or no change (e.g. price in all value commitment processes, product specification in the third and fourth value commitment processes). At the value commitment process, demand attributes are highly detailed.

Material flow and decoupling points

Figure 28 illustrates the material flow between some of the processes and the decoupling points in Polish case 18, while Table 86 (see Appendix 17) lists the average inventory time of the material between consecutive pairs of processes. An average delay of 3-9 days is observed between harvest and delivery.

Demand in process Value commitment 1 is managed with decoupling point Bucking-20 (mechanised CTL method) or Merchandising-20 (FT and non-mechanised CTL methods). For each ten-year period, a forest management plan is made to identify the harvesting (e.g. clear-cut, selective cutting) required for each block within the ten-year period, detailing restrictions in specific year(s) for some blocks if appropriate. Based on the plan and according to a definition of generic assortments, a mean annual allowable harvest (MAAH) by assortment is determined at the forest district level (i.e. a regional set of blocks). Then, processes Source timberland 1 and Schedule harvesting 1 select and sequence blocks (with respect to the harvesting time windows in the forest management plan) in a preliminary annual harvesting plan that should more or less satisfy the MAAH by assortment.

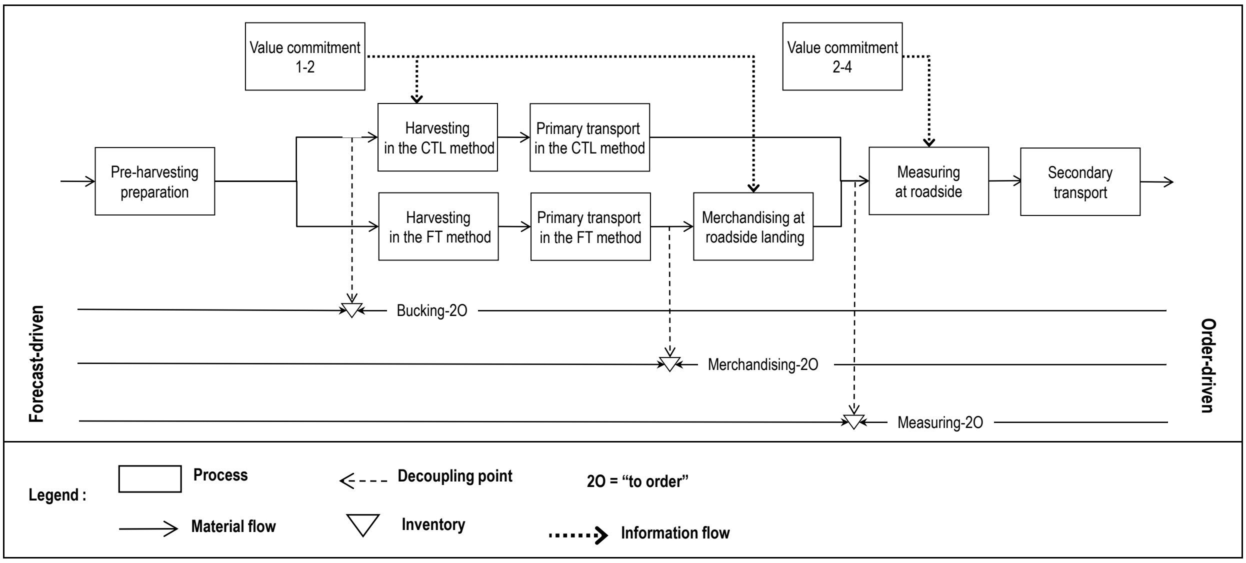


Figure 28: Material flow and decoupling points in Polish case 18.

The first six months of the preliminary annual harvesting plan are then used as a base to set the volume by assortment to sell in Value commitment 1 and to negotiate the several delivery time windows. The preliminary harvesting plan will change according to the committed demand in Value commitment 1. However, the public timberland-based wood supplier fundamentally aims to generate demand that fits as close as possible to the outputs of the preliminary harvesting plan, instead of selecting blocks in the harvesting plan that respond to the most profitable demand expressed by a set of potential buyers. This explains why we judged that the decoupling point Select-blocks-2O is not used in the Polish case.

Demand in process Value commitment 2 is managed with one of the three decoupling points. If the product is already bucked/merchandised at the moment of sale, the decoupling point Measuring-2O is used, and this is also the case for demand in the processes of Value commitment 3 and 4. If the product is not bucked/merchandised at the sale, decoupling point Bucking-20 or Merchandising-20 is used. Merchandising-2O is used in FT and non-mechanised CTL methods based on a cutting-list provided by the public timberland-based wood supplier to each harvesting contractor. Bucking-2O is used in the mechanised CTL method and seems to also be based on a cutting-list provided by the public timberland-based wood supplier to each harvesting contractor. Indeed, the harvesting operators seem to adjust the bucking values list in the harvester computer according to the cutting-list and it seems that the buck-to-value problem is solved by each harvester.

Information flow

Insufficient data was available to detail the information flow for input and output in the planning and execution processes of Polish case 18. However, it seems that most information is exchanged by traditional tools (e.g. telephone/cellular) and communication in person, while internet-based auction systems support information exchange for the majority of the sales volume (value commitment processes).

Monetary flow

Information was scarce regarding the main financial flows in Polish case 18, but we are able to discuss some of them. The harvesting contractors are paid (using the payment method 'flat unit rate' – see Appendix 11) on the basis of measured volume (at roadside by a scaler from the public timberland-based wood supplier) after the completion of the harvesting contract. The total measured volume is subject to mutual agreement between the scaler and the harvesting contractor. The payment is made within 30 days by the public timberland-based wood supplier. Customers pay usually after volume delivery and can select a payment time of 14, 21 or 30 days.

4.5.4. Enablers and practices

In this case, 28 enablers and practices were identified. Table 87 (see Appendix 17) shows this complete list detailed by process and category. The macro-processes of Make, Value commitment and Deliver (Secondary transport) showed 8 enablers each.

In all these three macro-processes, Rules and guidelines was the category with the most enablers identified (4, 2 and 4 enablers respectively). It is relevant to mention the existence of four types of sales mechanisms, including two internet-based auction systems, the selection of contractors also through an auction system and having a monetary penalty if the public timberland-based wood supplier or the buyer does not respect the agreed pick-up time windows. Information management had the second most enablers identified, with 5, notably the use of internet-based auctions with potential buyers and harvesting contractors.

Asset management and Transportation management showed the smallest number of enablers and practices identified in total (1 enabler each). It was difficult to identify these aspects in the case study, and there seemed to be a scarcity of enablers and practices related to these processes.

4.5.5.Performance

The enablers identified in the case were considered to make a small contribution to the supply chain agility dimensions in general, and even a smaller one to the dimension of Network integration (Figure 30).

We can see in Figure 29 that a certain level of network integration, meaning the nurturing of trust-based relationships with the actors and minimising resistance to change in the adoption of innovative practices, is identified only in the Value commitment process with clients. This is achieved mainly through a series of internet-based auctions for different types of clients based on the volumes requested and the credit record of the client. Even if purchasing price is the primary driver in this sales system, direct negotiations can take place in the first auction. In the other processes, network relationships seem to be basically driven by the lowest cost.

The fact that information on available blocks and volumes is relatively accurate, frequently updated and available in these internet-based auctions also justifies a higher evaluation of the Information driver dimension in the Value commitment and Source processes. Table 88 (see Appendix 17) details the agility assessment by dimensions and macro-process in Polish case 18.

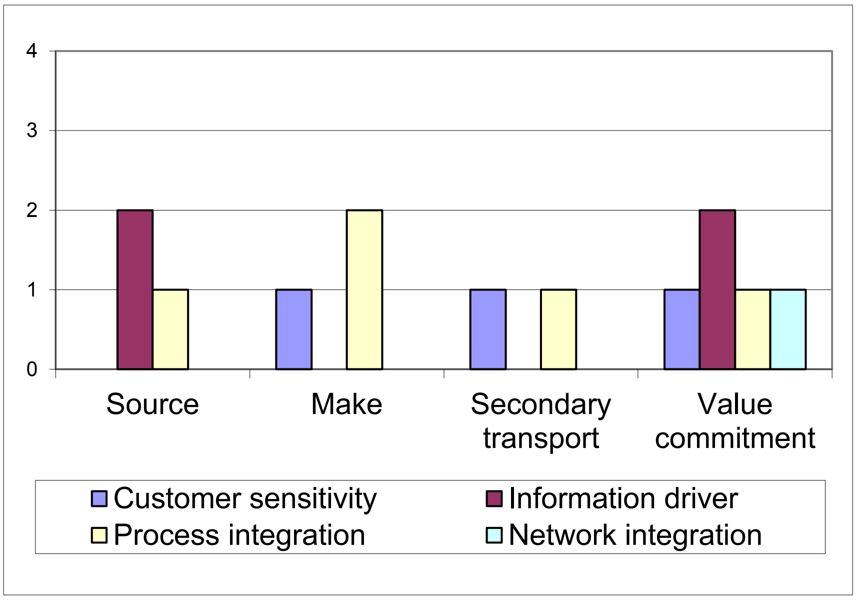


Figure 29: Agility capabilities results by dimension and macro-process in Polish case 18.

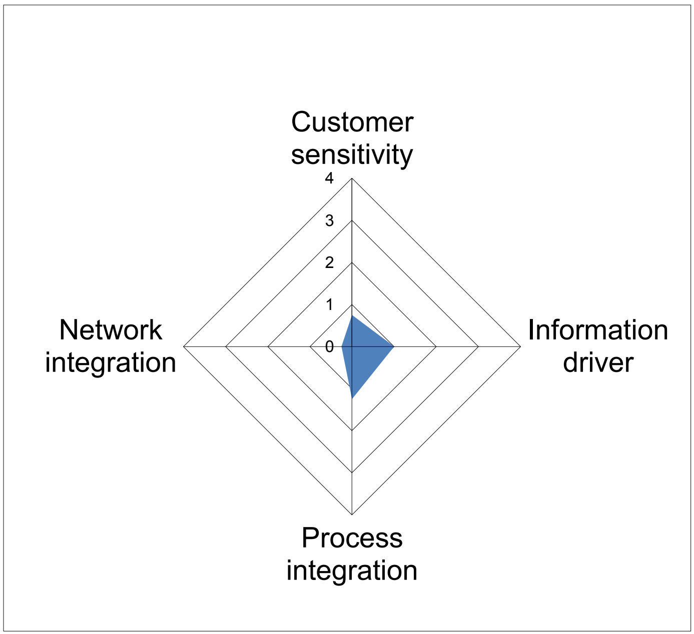


Figure 30: Agility capabilities results by dimension in Polish case 18.

4.6. Swedish case 19

This case was based on the contribution of 7 experts on WSC in Sweden. Their knowledge allowed the identification of four distinct cases (cases numbered 19 to 22 in Appendix 4). Swedish case 19 with an association of timberland owners as the central actor is the only case detailed. The supply chain strategy of all the Swedish cases is reported in Appendix 4.

4.6.1.External environment

Wood supply chains in Sweden are subject to a marked seasonal pattern in supply while demand is fairly stable over the year. The thawing period implies bad road conditions, fall and winter can imply wet harvesting areas and during summer, pine can acquire blue stains due to drying. During winter, before spring, inventories are built up to cover procurement to industry and intermediate inventories act as buffers to secure the supply to industry by leveling the fluctuations. Moreover, harvesting goes on all year round but is more intensive during winter as soil damage is then minimised.

In Swedish case 19, supply is based on standing timbers purchased from non-industrial private timberland owners who are members of an association. In rare situations, product can also be purchased from e.g. other associations. Most of the purchases occur with little advertisement to potential buyers, increasing the importance of membership for the association. Harvesting on private timberlands is subject to a moderate level of regulations, compared to what has been observed elsewhere.

The raw material is from intensively managed natural forests, but the level of variability is significant, both between similar blocks and within a block. Three commercial species dominate and the harvesting method is mechanised cut-to-length.

Other external environment elements are presented in Table 89 (see Appendix 18).

4.6.2. Competitive business strategy and supply chain strategy

There are six actors in Swedish case 19: the association of timberland owners, the harvesting contractor, timberland owners (members of the association), transportation contractors (may or may not be members of a trucking association), a national forestry service provider (The Swedish Forestry Authority SDC) and the mills. The analysis excludes the timberland owners, the national forestry service provider and the mills. The primary strategy of the timberland owners' association is the differentiation strategy with a marketing focus. The mission is to give members the highest possible price for their wood, but restricted by selling to internal and external mills at a competitive price compared to the price on the market. For the association, the implementation of this strategy involves balancing members' interests as raw material producers and the association's ownership of the mills. In general, the strategy is implemented with a defensive approach with cooperative behaviour based on their members' network. Over the long term, some effort is being made to diversify to new markets to secure the sale of their members' raw material.

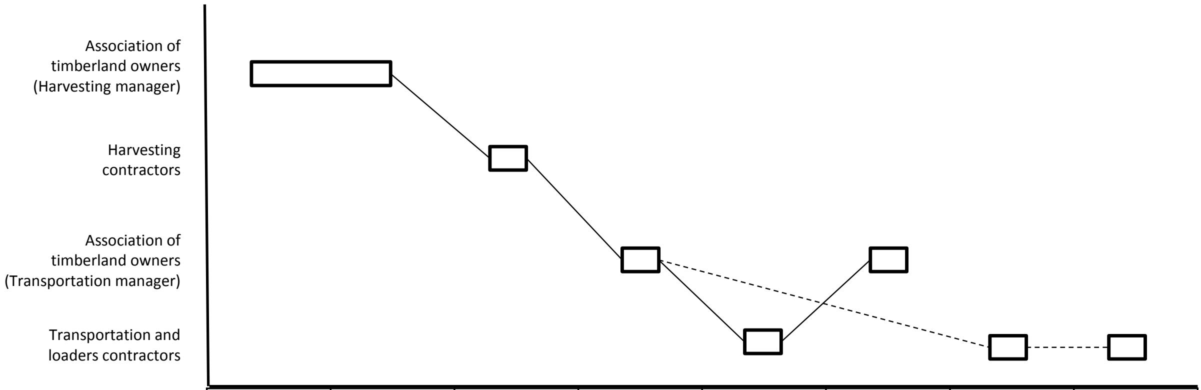
The main drivers for the harvesting contractors and transportation contractors are high productivity and operational excellence to achieve, in turn, low unit cost. Thus, the primary strategy of the contractors is cost-leadership, subject to production/delivery quota fulfilment and meeting quality-based requirements. The harvesting contractors use a defensive-individual approach, while transportation contractors use a defensive-cooperative approach, mainly cooperation between the drivers of the same transportation association. By providing planning services to the timberland owners' association, some harvesting contractors and transportation contractors in an association also adopt several of the drivers from the differentiation strategy with a service focus.

The supply chain strategy in Swedish case 19 is illustrated in Table 21 (see Appendix 4). The association performs and controls the source and the value commitment processes internally. The association itself conducts the harvest planning as well as transport planning, but part of the secondary transportation planning can be outsourced to a transportation association. The execution of harvesting, primary transport and secondary transport are outsourced to contractors. A third party, SDC (The Swedish Forestry Authority), keeps track of information from the specific block purchase (e.g. the buying contract with the timberland owner has a certain number) until the wood piles with the same number noted on the wood appear at the measuring station at the mill yard. SDC is a national service provider owned by buyer and seller organisations acting as an independent entity with the mission of measuring the wood and keeping track of transactional information in Swedish forestry from stump to mill yard.

4.6.3. Wood supply chain structure

Planning and execution processes

Sweden case 19 involves eleven planning processes and six execution processes, their descriptions can be found in Table 90 and Table 91 respectively (see Appendix 18). Figure 31 presents some of these planning processes on the horizontal axis. The horizontal axis also presents the list of generic planning decision(s) (see Appendix 1) addressed by each planning process. The actors conducting the planning processes are listed on the vertical axis. Each rectangle defines the accountability between one or many actors and one or many decisions. The sequenced rectangles illustrate the logical sequence of the planning process. When a rectangle spans over two planning processes, this means that there is a joint decision-making during the planning phase. Moreover, from the point of the process 'Schedule secondary transportation 1', the two distinct paths represent two different approaches used for the planning of secondary transportation.



Buy block 2	Schedule harvesting 1	Schedule harvesting 2	Schedule secondary transportation 1	Schedule secondary transportation 2	Schedule secondary transportation 3	Schedule secondary transportation 4	Schedule secondary transportation 5
- Harvest units sourcing	- Harvest units scheduling - Assortments to produce per harvest unit and allocation to demand - Harvest equipment selection per harvest unit - Harvest unit assignment to contractors/teams - Harvest unit layout - Bucking/merchandising instructions and sorting rules per harvest unit	- Harvest crew scheduling	- Assortments (re)allocation to the demand - Balance transportation with harvesting, inventory and reception - Assigning transportation quotas to contractors	- Transportation crew scheduling	- Transportation equipment routing and scheduling	- Transportation crew scheduling - Transportation equipment routing and scheduling	- Transportation equipment routing and scheduling

Figure 31: Actor(s) accountable and generic planning decisions per planning process in Swedish case 19.

There are three Value commitment processes in Swedish case 19. Value commitment 1 is made a few months in advance for an order with a supply agreement of one year. Value commitment 2 is made a few weeks in advance for an order with or without a supply agreement of a few weeks. Value commitment 3 is made a few weeks in advance for an order of a few weeks. Most of the demand is from Value commitment 1. For the three aforementioned attributes characterising the demand in Swedish case 19, Table 93 (see Appendix 18) details how each attribute in a given planning process is described and whether this attribute is subject to further change. Demand attributes in the first two value commitment processes are subject to some change, while demand attributes in the third value commitment are virtually never changed. At the time of the value commitment process, demand attributes are fairly detailed but some further specification of the quantity to be delivered within a shorter period can occur.

Material flow and decoupling points

Figure 32 illustrates the material flow between some processes and the decoupling points in Sweden case 19, while Table 96 (see Appendix 18) lists the average inventory time of the material between consecutive pairs of processes. An average delay of 1 month is observed between harvest and delivery.

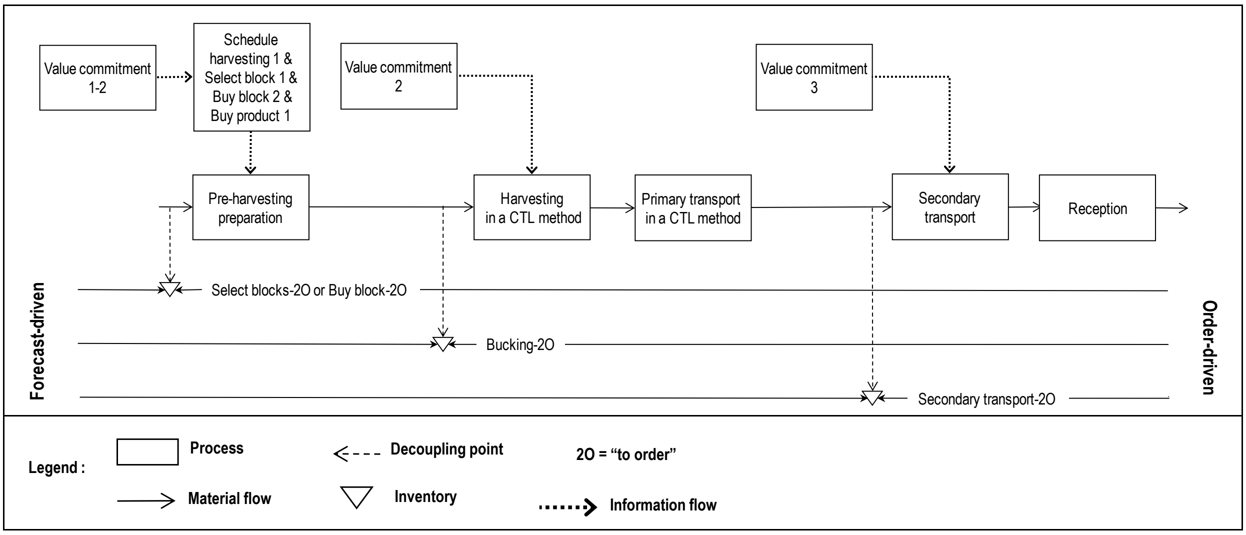


Figure 32: Material flow and decoupling points in Swedish case 19.

Demand from process Value commitment 1 is managed with decoupling points Select blocks-2O and Buy blocks-2O. Based on blocks already purchased (Select blocks-2O) and blocks to be purchased to follow the forest management plan of the association's members (Buy blocks-2O), a set of blocks is selected and sequenced in an annual harvesting plan in order to satisfy the monthly demand of each customer with an annual supply agreement. Each month, the remaining annual harvesting plan is validated according to e.g. each customer's confirmation of the monthly volume fixed in the annual agreement, acquisition of the selected blocks to be purchased, etc. Change occurs (e.g. reduction or increase of demand by a customer), forcing an update of the remaining annual harvesting plan. Value commitment 2 refers to an update in the annual harvesting plan that involves the commitment of a new demand. This new demand is managed with decoupling point Select blocks-2O if the demand involves sourcing additional blocks, and/or with decoupling point Bucking-2O if the new demand replaces a similar demand cancelled by a customer (thus, does not involve additional sourcing). In Swedish case 19, the buck-to-value problem is solved by each harvester based on a price list provided by the association. Demand from process Value commitment 3 is managed with decoupling point Secondary-transport-2O.

Information flow

The main feature in this case is the national forestry service provider SDC, which represents a central information hub for much of the information exchange in and among virtually all the actors involved in wood procurement. Privacy in the information flow is managed, but common data are shared, such as the Swedish forestry road network. Below we detail this central role.

When a block is signed for a harvesting contract, it is registered with a given number in the SDC. After harvesting, all logs (with information about the classification) on the numbered site are registered in a StanForD format (i.e. a standardized electronic form, see e.g. Marshall, 2007) and sent to the company and/or SDC, depending on the arrangement between SDC and the company, which keeps the data. The forwarded volumes are reported in the same way, at least once a day, to be able to follow the inventory at roadside. The data are used for transportation planning in different systems and collected most often from SDC. In addition to this, GIS applications are commonly used in forestry for practical and tactical planning, as well as for legislative concerns. The information flow in procurement activities requires good connectivity and many times this can be a problem.

Table 94 and Table 95 (see Appendix 18) detail the information flow for each planning and execution process respectively.

Monetary flow

Figure 33 illustrates one possible scenario of monetary flows between the central actor of Swedish case 19 (i.e. association of timberland owners) and timberland owners, harvesting contractors, transportation contractors and the mills. Details can be found in Table 97 (see Appendix 18). The monetary flows to the timberland owners are payments for the harvested, delivered and measured timber from their standing timber blocks. Payment is made a few days after the last volume has been measured. The monetary flows to the contractors are payments for their harvesting or transportation services performed during the week. Payment is made within 1-2 weeks. The monetary flows from the mills are payments for the harvested timber delivered and measured. The mills have 30 days to pay after they receive an invoice based on the measurement from the association.

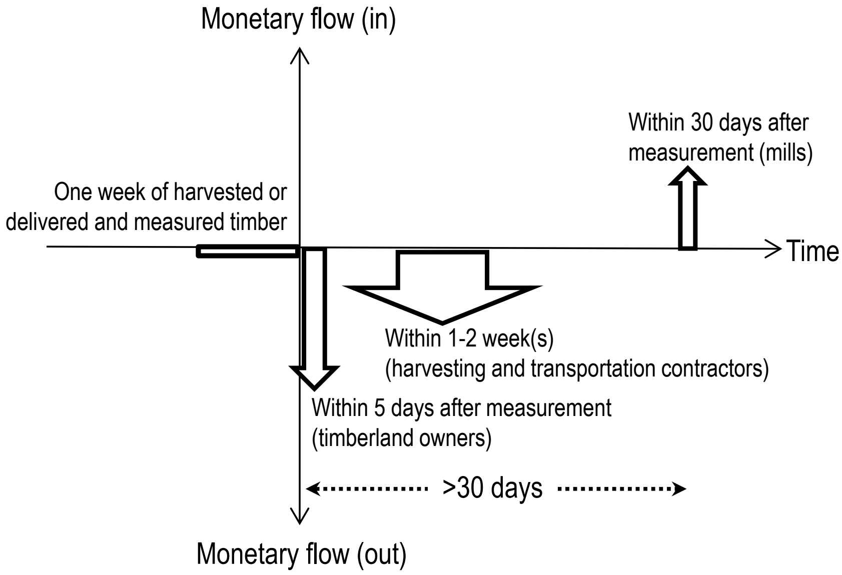


Figure 33: Main monetary flows for the central actor in Swedish case 19

4.6.4. Enablers and practices

In this case, 66 enablers and practices were identified. Table 98 (see Appendix 18) shows this complete list detailed by process and category. The majority of the enablers and practices were identified under the macro-processes Deliver (Secondary transport) and Make, with 22 and 20 enablers respectively.

In the Deliver (Secondary transport) process, the most numerous categories were Rules and guidelines and Inventory management, with 5 enablers each. Of notable mention are having annual and monthly delivery quotas by mill, as well as the use of intermediate land and train terminals to balance procurement and cope with thawing periods. In the Make process, the most numerous category was Rules and guidelines with 9 enablers, including a standard general contractual agreement for how the harvesting and primary transport service can be performed.

In a global view, the category Network management deserves attention, with a total of 12 enablers identified. These include having long-term business and personal relationships with the actors of the private forest, local and national lobbying, associations of harvesting contractors and carriers to improve business and support research and development in the field, including wood bartering to reduce empty travelling distances.

4.6.5. Performance

The enablers identified were considered to make a medium to high contribution to the supply chain agility, notably in the dimensions Information driver and Network integration (Figure 35). We can see in Figure 34 that the agility dimension of Information driver is especially high in the Make and Deliver processes. This is because data about harvested, forwarded and delivered inventories are accurate and updated daily, but the information is available only to the association.

For Network integration, long-term and personal relationships are frequent with timberland owners and harvesting contractors. There are, as well, different programs to foster the adoption of best practices among harvesting and transport contractors and to raise young people's interest in the business. Table 99 (see Appendix 18) details the agility assessment by dimensions and macro-process in Swedish case 19.

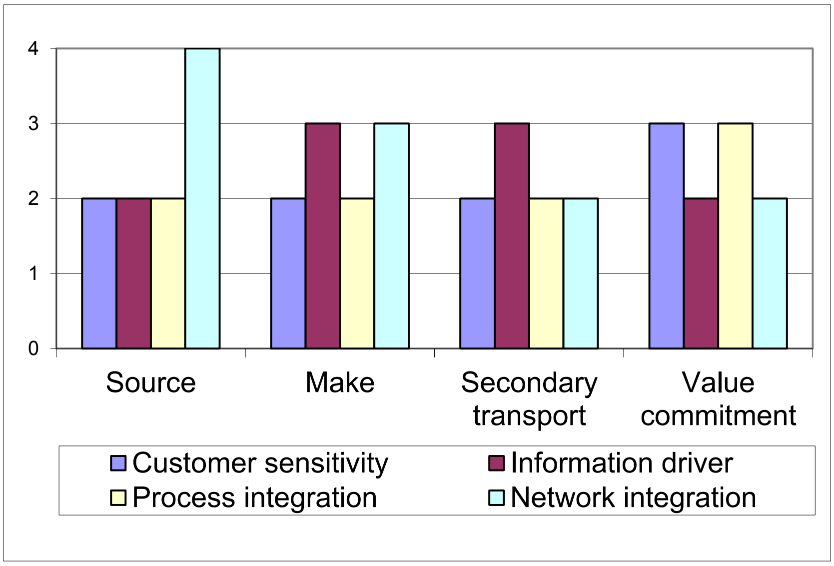


Figure 34: Agility capabilities results by dimension and macro-process in Swedish case 19.

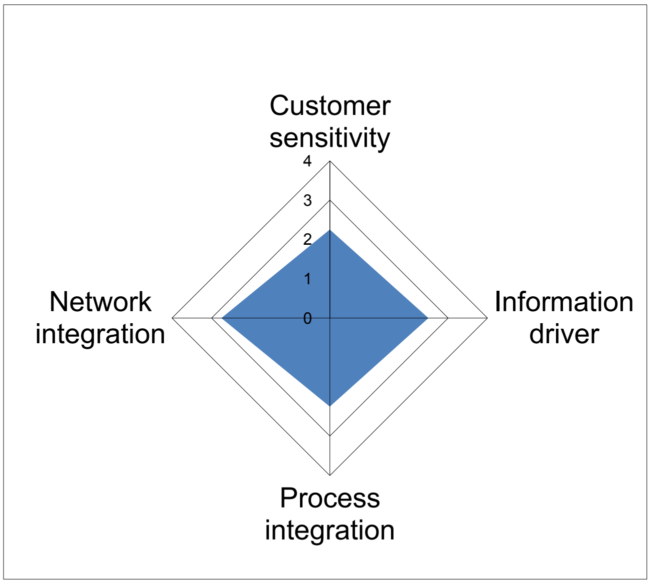


Figure 35: Agility capabilities results by dimension in Swedish case 19.

5. Discussion and analysis

The analysis of the framework application to all the cases leads to different observations, which are presented and discussed in this section.

5.1. External environment

By discussing the elements of the external environment captured in the case studies, it became clear that some of them had a more direct impact on WSCs. According to Lee (2002) and Gattorna (2011), uncertainty in demand and supply drives different needs for a supply chain. Inspired by these two supply chain analyses, specific environmental characteristics in the supply and demand dimensions were identified. On the supply side of a WSC, three main characteristics were identified:

a. Raw material heterogeneity: represents the variety of species encountered in a block and also the natural variability within the same species. For instance, a context with a plantation and genetically improved trees has lower uncertainty than one with a natural forest composed of mixed species.

b. Accessibility to acquiring harvesting rights to standing timber determines how fast and simple it is to purchase or obtain harvesting rights on standing timber blocks. For instance, a context with a supplier owning timberland has lower uncertainty than one where standing timber is purchased on the market.

c. Conditions of harvesting and transportation activities: how harvesting and transportation activities are subject to variation and complexity by environmental factors (e.g. seasonality pattern, forest fire), regulations (e.g. environmental, logging) and production fluctuation (e.g. steep terrain, qualification of the workforce, equipment reliability). The higher the impact, the higher is the uncertainty.

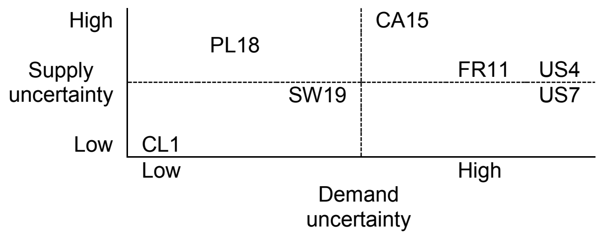
On the demand side, the two main characteristics identified were:

d. Length of the planning horizon in the value commitment processes: represents the visibility of committed demand for planning purposes. For instance, a context with visibility for a season has lower uncertainty than one with visibility for one week.

e. Frequency of change in the demand: the greater the frequency of change in demand, the higher is the uncertainty.

From these descriptions, the context of each case was discussed and evaluated in order to be categorised in a four-quadrant matrix of supply-demand uncertainty (Figure 36). The results show different contextual situations. The Chilean case, for instance, presented the lowest uncertainty levels, both in supply and demand. Following the supply chain typology by Lee (2002), this context is extremely appropriate for "efficiency-driven" supply chains, focussed on cost efficiencies, economy of scales and optimisation techniques to get the best capacity utilisation in harvesting and transportation activities. At the other extreme, we have the French and US cases, which present a medium supply uncertainty and high demand uncertainty, characterised by several short-term sales. According to Lee's typology, this calls for a "responsive" supply chain, with mechanisms for the quick transfer of order information and transformation of the final products, with the localisation of the decoupling point being a critical decision.

The Canadian and Polish cases show a higher supply uncertainty, being both contexts of state-owned natural forests, while the Canadian case showed a higher demand uncertainty due to the frequent changes in demand, what is not so common in the Polish case. According to Lee's typology, they should head towards a "risk-hedging" supply chain by "pooling and sharing resources so that the risks in supply disruption can also be shared, (…) sharing safety stocks with other companies" (Lee, 2002). Finally, the Swedish case has an intermediate position, with supply and demand uncertainties not as low as in the Chilean case, not as high as in the Polish and Canadian cases for supply, and the French and US cases for demand.



Legend: Chilean case 1 (CL1); US case 4 (US4); US case 7 (US7); French case 11 (FR11); Canadian case 15 (CA15); Polish case 18 (PL18) and Swedish case 19 (SW19)

Figure 36 : Environmental uncertainty of the cases studied.

From the general assumption in the literature that an environment with high uncertainty calls for high agility capabilities (Figure 37), we can say that drivers for agility are higher in the cases closer to the top-right quadrant of Figure 36. In this analysis, we consider that the level of environmental uncertainty cannot be changed while, in practice, some environmental characteristics could be changed (e.g. over-restrictive legislation on harvesting, but not the weather pattern impacting the harvesting). Thus, supply chains in the top-right quadrant should use strategies "aimed at being responsive and flexible to customer needs, while the risks of supply shortages or disruptions are hedged by pooling inventory or other capacity resources" (Lee, 2002). These recommendations support the analysis of how well the supply chain strategies, structures, enablers and practices of the cases are aligned with the environment to deliver a good performance level.

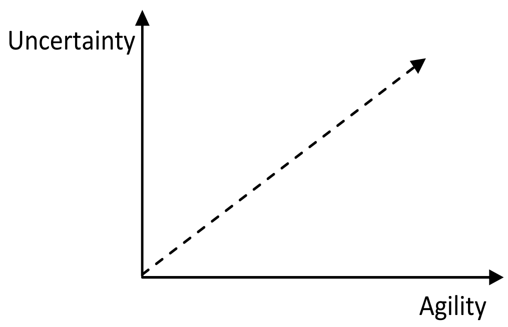


Figure 37: Uncertainty and the potential correlation with agility requirements.

This environmental analysis was conducted at a strategic and aggregated supply chain level. Further studies should focus on developing specific and more objective metrics for the environmental elements, as well as conducting an analysis by market and product segment.

In this way, it will be possible to more clearly capture differences in the level of environmental uncertainty for saw wood, pulp wood and bio-fuel market segments, for instance.

5.2. Competitive business strategy and supply chain strategy

For all cases, the competitive business strategy of the main actors involved was highlighted. Among the cases, it was clearly seen that the cost-leadership strategy dominates for the cases in Canada, Chile, Poland and US. For the Swedish and French cases, the leading competitive strategy is differentiation. But, it should be noted that the strategy for different market segments (e.g. saw logs and pulp logs) can differ as different product groups are not differentiated in the cases. For instance, a competitive strategy such as cost-leadership is more suitable on a market for mass produced assortment like pulp, while differentiation is more suitable with assortments of higher and more varied product specifications. Moreover, an observation from the last section regarding Chilean case 1 is that evolving in a lower uncertainty environment justifies the adoption of a cost-leadership strategy where the primary drivers (i.e. operational excellence, high productivity, low unit cost) are more likely to be achieved.

The methodology adapted from Yee and Platts (2006) to identify the competitive business strategy and strategic implementation approach by actor was useful to highlight the different choices among the actors within the same supply chain. However, Porter's typology (i.e. cost leadership or differentiation) proved to be too generic even with the extension from Hansen et al. (2006) on the three ways to achieve differentiation. A different approach to address competitive business strategy is discussed in the conclusion.

For the supply chain strategy, the results are that, in general, the central actor[11] in each case performs the sourcing, planning (harvesting and transportation) and value commitment processes, while outsourcing the execution processes (harvesting and transportation).

Exceptions are Polish case 18, where the main actor (the public timberland-based wood supplier) is not responsible for transportation (i.e. harvested volume is delivered to the customer at roadside) and French case 11, where the central actor performs all processes internally. Among the other cases reported from the fieldwork, some central actors that are suppliers of harvested timber maintain limited internal harvesting and/or transportation capacities in their activities. Regardless of possible historical considerations, the main motivation of such a hybrid strategy is to have in-house knowledge of the operating costs and productivity of equipment similar to that of contracted contractors and thus, be more aware of contractors' realities during negotiations (e.g. rate). Few logistics and information technology service providers were identified, while third party logistics seems to be more common in WSC, e.g. in secondary transport with Trimble Forestry Automation in the US with the Blue Ox transportation system (http://www.trimbleforestryautomation.com/) and Asset Forestry Logistics in New Zealand with the Despatch 3PL transportation service (http://www.asset.co.nz/).

[11] Reminder: the central actor in Chilean case 1 is a timberland-based wood procurement division, a wood dealer in US case 4, a harvesting contractor in French case 11, a wood procurement division in Canadian case 15, a public timberland-based wood supplier in Polish case 18, and an association of timberland owners in Swedish case 19.

5.3. Wood supply chain structure

The third component of the framework includes the richest detail about the cases. We first discuss several aspects related to the planning and execution processes, then the decoupling points and, finally, the monetary flow.

5.3.1. Planning and execution processes

The description of the processes in each case allows 17 generic processes to be proposed for any planning and execution process at the operational level in a WSC. Three of them are associated with the procurement of standing/harvested timber, eight with harvesting, five with secondary transportation and one with the sales of harvested timber. Each process is described in Appendix 7. Not all processes are used in each case and the type of actor responsible for a specific process is not always the same among the cases. In each case, Table 6 shows the main actor accountable for each process used. The seven execution processes related to harvesting activities are always performed by harvesting contractors except in Polish case 18, where measuring at roadside is executed by the central actor. The four execution processes related to secondary transportation activities are divided between transportation contractors or harvesting contractors with transportation capacities (defined as turn-key harvesting contractors in Appendix 6) and the mills. However, there is an exception for the process ‘measuring at the mill’ in Swedish case 19, where the national service provider is responsible.

We can identify three options for the accountability of the planning and execution processes:

1) The planning and execution processes are done internally;

2) The planning processes are done internally and the execution processes are outsourced;

3) The planning processes are shared (internally and outsourced) and the execution processes are outsourced;

Table 7 presents the accountability option per macro-process in each case study.

Table 6: Main actor(s) accountable per process in each case.

Macro-process	Generic process	CL1	US4	FR11	CA15	PL18	SW19
		Case					
Source	Select block	Done before the operational level		HC* (but mostly done before the operational level)	WPD* (but mostly done before the operational level)	PTWS*	ATO* (but mostly done before the operational level)
	Buy block		WD*	HC*			ATO* (but mostly done before the operational level)
	Buy assortment				WPD*		ATO*
Make	Schedule harvesting	TWPD*	WD*	HC*	WPD*	PTWS*	ATO*
	Pre-harvesting preparation	HC	HC	HC*	HC	HC	HC
	Harvesting in a CTL method	HC		HC*	HC	HC	HC
	Primary transport in CTL method	HC		HC*	HC	HC	HC
	Harvesting in an FT method	HC	HC		HC	HC	
	Primary transport in an FT method	HC	HC		HC	HC	
	Merchandising at roadside landing	HC	HC		HC	HC	
	Measuring at roadside	HC		HC*	HC	PTWS*	
Deliver (value commitment)	Value commitment	TWPD*	WD*	HC*	WPD*	PTWS*	ATO*
Deliver (secondary transportation)	Schedule secondary transportation	TWPD*	HC	HC*	HC	TC	ATO* and TC
	Loading	HC and TC	HC	HC*	HC	TC	TC
	Secondary transport	TC	HC	HC*	HC	TC	TC
	Measuring at the mill	Mill	Mill	Mill	Mill	Mill	FMSP
	Reception	Mill	Mill	Mill	Mill	Mill	Mill

Legend: Association of timberland owners (ATO); Forestry and marketing service provider (FMSP), Harvesting contractor (HC); Public timberland-based wood supplier (PTWS); Transportation and loading contractors (TC); Timberland-based wood procurement division (TWPD), Wood dealer (WD), Wood procurement division (WPD), designation of the central actor in the case (*) .

Table 7: Accountability option per macro-process in the cases.

Accountability option		Macro-process		
Planning process	**Execution process**	**Sourcing**	**Harvesting**	**Transportation**
Internal	Outsourced		CL1, CA15, PL18, SW19	CL1
Internal	Internal	CL1, US4, FR11, CA15, PL18, SW19	FR11	FR11
Internal and outsourced	Outsourced		US4	US4, CA15, PL18, SW19

The description of the harvesting and transportation plans in each case allows 13 generic planning decisions to be proposed at the operational level in a WSC. Each decision is described in Appendix 1. Seven of them are associated with the ‘Schedule harvesting’ process, six with the ‘Schedule secondary transportation’ process and one with the ‘Select block’ process.

Not all decisions are used in each case and the type of actor making a specific decision is not always the same among the cases. For each case, Table 8 shows the actor making the generic planning decision. The planning process (numbered) in which the decision is made is presented as well. The description of the numbered planning processes for each case can be found in their respective Appendices. Moreover, decisions are not always made in the same sequence[12] among the cases. Furthermore, some decisions are made simultaneously with others belonging to the same process or to different processes. Joint decisions belonging to different processes represent a level of integration in the planning system of the case. Among the cases, we observed two types of integration in the planning systems. First, integration between the processes ‘Select block’ and ‘Schedule harvesting’, and second - between the ‘Schedule harvesting’ and ‘Schedule secondary transportation’ processes. Thus, we can identify three basic designs of a planning system in the cases:

1) integrated sourcing and harvesting planning (Canadian case 15, Polish case 18 and Swedish case 19);

2) integrated harvesting and transportation planning (US case 4 and US case 7);

3) decoupled sourcing, harvesting and transportation planning (Chilean case 1 and French case 11).

Based on the 13 generic planning decisions, a decision matrix is proposed for each planning system design (Table 9).

One of the four supply chain agility dimensions proposed by Christopher (2000) involves the proper integration among the processes within a supply chain (see Section 3.5.1). Thus, the planning system designs having integrated processes should theoretically foster high agility capabilities in this dimension. This hypothesis is not conclusive in the three cases with design 1, while the two cases with design 2 obtain the highest agility capabilities. For the three cases with design 1, the limited contribution of their respective enablers and practices (evaluated with the agility assessment methodology) explains their low-to-average agility capabilities in regard to this dimension.

12 For more detail on the planning sequence, see Figure 5 for Chilean case 1, Figure 10 for US case 4, Figure 17 for French case 11, Figure 22 for Canadian case 15, Figure 27 for Polish case 18, and Figure 31 for Swedish case 19.

Table 8: Actor making the generic planning decision in all cases and for which process.

Process	Decision	Case: CL1	US4	FR11	CA15	PL18	SW19
Select block	Harvest units sourcing	Made before the operational level	WD* (SS1)	Made before the operational level	WPD* (SS1&SH1 but mostly made before the operational level)	PTWS* (SS1&SH1)	ATO* (SS1&SH1 but mostly made before the operational level)
Schedule harvesting	Harvest units scheduling	TWPD* (SH1)	WD* (SS1)	HC* (SH2)	WPD* (SS1&SH1)	PTWS* (SS1&SH1; SH2)	ATO* (SS1&SH1)
	Assortments to produce by harvest unit and allocation to demand	TWPD* (SH1)	WD* (SS1)	HC* (SH2)	WPD* (SS1&SH1)	PTWS* (SH2; SH3)	ATO* (SS1&SH1)
	Harvest equipment selection by harvest unit	TWPD* (SH1)	WD* (SS1)	HC* (SH1)	WPD* (SS1&SH1)	PTWS* (SH4)	ATO* (SS1&SH1)
	Harvest unit assignment to contractors/teams	TWPD* (SH1)	WD* (SH1&ST1)	HC* (SH2)	WPD* (SS1&SH1)	PTWS* (SH4)	ATO* (SS1&SH1)
	Harvest unit layout	TWPD* or HC (SH2)	HC (SH2&ST2)	HC* (SH1)	WPD* (SS1&SH1)	PTWS* (SH3)	ATO* (SS1&SH1)
	Bucking/merchandising instructions and sorting rules by harvest unit	TWPD* (SH3)	WD* (SH1&ST1)	HC* (SH2)	WPD* (SS1&SH1)	PTWS* (SH3)	ATO* (SS1&SH1)
	Harvest crew scheduling	HC (SH4)	HC (SH2&ST2)	HC* (SH2)	HC (SH2)	HC (SH5)	HC (SH2)
Schedule secondary transportation	Assortments (re)allocation to demand			HC* (ST1)			ATO* (ST1)
	Balance transportation with harvesting, inventory and reception	TWPD* (ST1)	WD* (SH1&ST1)		WPD* (ST1)		ATO* (ST1)
	Transportation quotas assignment to contractors		WD* (SH1&ST1)		WPD* (ST1)	Mill (ST1)	ATO* (ST1)
	Transportation equipment routing and scheduling	TWPD* (ST2)	HC (ST3)	HC* (ST1)	HC (ST2)	TC (ST2)	ATO* (ST1) and TC (ST4)
	Transportation crew scheduling	TC (ST3)	HC (SH2&ST2)	HC* (ST1)	HC (ST2)	TC (ST2)	TC (ST2) and TC (ST4; ST5)
	Total number of decisions	10	12	10	12	11	12
	Total number of actors involved	3	2	1	2	3	3

Legend: Association of timberland owners (ATO); Harvesting contractor (HC); Public timberland-based wood supplier (PTWS); Transportation and loading contractors (TC); Timberland-based wood procurement division (TWPD), Wood dealer (WD), Wood procurement division (WPD), designation of the central actor in the case (*) , Schedule sourcing process (SS), Schedule harvesting process (SH), Schedule secondary transportation process (ST); designation of a decision made in two integrated processes (&).

Table 9: Decision matrix for the basic design of the planning system.

<table>
<tr><th></th><th></th><th colspan="3">Basic design of the planning system</th></tr>
<tr><th>Process</th><th>Decision</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Select block</td><td>Harvest units sourcing</td><td rowspan="8">The decision ‘Harvest units sourcing’ is, at least, jointly planned with one of the decisions in the ‘Schedule harvesting’ process.</td><td>This decision is planned individually.</td><td>This decision is planned individually.</td></tr>
<tr><td rowspan="7">Schedule harvesting</td><td>Harvest units scheduling</td><td rowspan="12">At least, one decision in the ‘Schedule harvesting’ process is jointly planned with a decision in the ‘Schedule secondary transportation’ process.</td><td rowspan="7">No decision in the ‘Schedule harvesting’ process can be jointly planned with a decision in another process.</td></tr>
<tr><td>Assortments to produce by harvest unit and allocation to demand</td></tr>
<tr><td>Harvest equipment selection by harvest unit</td></tr>
<tr><td>Harvest unit assignment to contractors/teams</td></tr>
<tr><td>Harvest unit layout</td></tr>
<tr><td>Bucking/merchandising instructions and sorting rules by harvest unit</td></tr>
<tr><td>Harvest crew scheduling</td></tr>
<tr><td rowspan="5">Schedule secondary transportation</td><td>Assortments (re)allocation to demand</td><td rowspan="5">No decision in the ‘Schedule secondary transportation’ process can be jointly planned with a decision in another process.</td><td rowspan="5">No decision in the ‘Schedule secondary transportation’ process can be jointly planned with a decision in another process.</td></tr>
<tr><td>Balance transportation with harvesting, inventory and reception</td></tr>
<tr><td>Transportation quotas assignment to contractors</td></tr>
<tr><td>Transportation equipment routing and scheduling</td></tr>
<tr><td>Transportation crew scheduling</td></tr>
</table>

5.3.1.1. Adjustment techniques

To adjust supply with demand, different logistics techniques have been identified during fieldwork. The use of such techniques involves additional procurement costs but allows the actor using one (or more) of them to satisfy the urgent order. We detail these logistics techniques denoted as 'to urgent order' (2UO) to differentiate them from the decoupling points.

- Felling-2UO: priority felling of specific trees (or a specific sector of a block) to produce the required volume to satisfy the urgent order.

- Primary transport-2UO: execute the primary transportation of specific logs or stems to roadside in the required volume to satisfy the urgent order. This is usually used in combination with the 'Felling-2UO' technique when there is a short inventory time between felling and the primary transport.

- Resorting-2UO: in an already sorted inventory, only specific logs or stems are picked to meet the higher restrictive specifications of the urgent order. The technique was observed during fieldwork when a truck was loaded from inventory at roadside, but we can imagine it occurring in other locations of inventory along the WSC.

- Substitution-2UO: using the required volume of an inventory of product(s) with a higher grade(s) to satisfy an urgent demand for product(s) with lower grade(s)[13]. In several manufacturing contexts, the combination of product substitution with inventory management (known as the assortment problem14 in the literature) allows costs to be reduced in the supply chain (see the review by Pentico, 2008).

- Degrading-2UO: temporarily increasing the specification requirements of the products that are not in the urgent order to foster the bucking/merchandising of the required volume to satisfy the urgent order.

Another adjustment technique used in Chilean case 2 is discussed in Section 5.5.2.

5.3.1.2. Value commitment processes

The definition in each case of the different Value commitment processes and, for each of them, the description and modification possibilities of the committed demand attributes[15] allows four types of value commitment processes to be identified:

1) Long term supply agreement: refers to the description of the attributes of the committed demand in an official agreement that spans over one year or more. The agreement also specifies how these attributes are modified and detailed as the demand is fulfilled.

2) Medium-short term supply agreement: same as type 1) but the duration is less than a year.

3) Continuous business without a supply agreement: refers to a tacit knowledge of the attributes of the committed demand that is maintained between a wood supplier and a wood buyer through continuous business activities.

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[13] In the literature, such a technique is referred to as a one-way substitution. A one-way substitution assumes that the products are classified into different grades and that products of higher grades can be substituted for products of lower grades (Huang et al., 2010).

[14] The literature defines "assortment problem" as the determination of which possible set of products should be stocked (and at which level) when it is not possible or desirable to stock all of them and substitution is possible (Pentico, 2008).

[15] Reminder: there are three attributes of a committed demand: product specifications, the price and payment conditions, and the quantity and delivery conditions.

4) Spot order: refers to the specification of the attributes of the committed demand in a punctual and non-repetitive order during one day to a few weeks, rarely over a month.

The types of value commitment processes used in each case are reported in Table 10. All cases use at least two types, but all of them have customers with supply agreements. Even the attributes of the demand in most of these supply agreements could be modified by the wood buyer during the demand fulfilment; the supply agreement reduces planning uncertainty for the wood supplier by reducing the proportion of the total demand that is based on forecasts. Also, all cases, except Chilean case 1, maintain a spot market, mainly to dispose of their harvested volume not sold and capture interesting opportunities with volume not already committed. Finally, there are some value commitment processes that belong to more than one type of value commitment process.

Table 10: Types of value commitment processes.

	Case						
Type of value commitment process	**CL1**	**US4**	**US7**	**FR11**	**CA15**	**PL18**	**SW19**
Long term supply agreement	VC2		VC1	VC1	VC1		VC1
Medium-short term supply agreement	VC1	VC1	VC2		VC2	VC1, VC2	VC2
Continuous business without a supply agreement		VC2	VC2	VC2, VC3			
Spot order		VC2	VC2	VC2	VC2, VC3	VC2, VC3, VC4	VC2, VC3

Legend: Chilean case 1 (CL1); US case 4 (US4); US case 7 (US7); French case 11 (FR11); Canadian case 15 (CA15); Polish case 18 (PL18) and Swedish case 19 (SW19); Value commitment (VC).

When the value commitment process occurs, we observed differences among the cases in the level of detail in the description of their demand attributes. Indeed, in some cases, the detail of an attribute is highly aggregated[16] when the value commitment processes occur and become more detailed as the time nears for the fulfilment of the demand. For instance, in Chilean case 1, the level of detail on the quantity and delivery conditions starts from a volume by month, then proceeds to a volume by half-month, with the maximum number of truck arrivals by hour. At the opposite extreme, in some cases, the level of detail for the value commitment processes is similar to that of the more distant planning processes. In general, the value commitment processes that span the planning horizon of a case have an aggregated description and when their fulfilment (in its entirety or only a proportion) must occur over a short term, a more detailed description is provided.

Moreover, we observed differences among the cases in the level of modification to their demand attributes after the value commitment process occurs. Indeed, in most cases, the demand attributes fixed in the value commitment processes can be modified later on (with

[16] Data aggregation is possible in three main areas, most likely in combination with each other (Günther, 2005; Stadler, 2008):
- aggregation of time, i.e. consolidating smaller time buckets into larger intervals and eventually using time buckets of unequal length - smaller ones for the near future and larger ones towards the end of the planning horizon;
- aggregation of products into product groups;
- aggregation of resources into resource groups and elimination of non-bottlenecked resources during the planning process.

variable restrictions and potential penalties), while in a few cases, modifying all or most of the demand attributes is not allowed.

5.3.1.3. Decision support systems

In Chilean case 1 and Swedish case 19, several decision support tools are used by the actors in the planning processes and several of them are Operational Research (OR) based optimisation tools solving large scale planning problems. Decision support tools to support real-time (re)planning in transportation are also used in these two cases. For instance, in Chilean case 1, a real-time system supports the fleet managers to control the execution of the transportation plan (e.g. illustrating the actual and planned Gantt charts of each truck, geographic localisation of each truck, communication log with each driver), making it easier to reschedule a truck behind its original schedule.

In US case 4, no decision support tools are used by the actors in the planning processes. This situation is not surprising considering the small scale of the harvesting/transportation activities in the case (e.g. 1-3 harvesting teams) and the short planning time. Based on mental routines and field experience, planning decisions are made intuitively by the actors during the course of the activities and thus, the need for support tools is judged as low. At the opposite end, planning complexity increases rapidly in larger scale harvesting/transportation activities (e.g. the exponential number of potential solutions). In large scale US cases 6 and 7, an advanced decision support tool has been identified during fieldwork there. For instance, to support sales managers in the value commitment process in US case 7, an OR based optimisation tool is used to allocate volume from hundreds of blocks to the most profitable customers over an area covering several states. Moreover, by dividing the two planning processes ‘Schedule harvesting’ and ‘Schedule secondary transport’ that, in the southern US, are traditionally managed together at each block by the harvesting contractor, the wood procurement division in US case 6 centralised the planning of secondary transport - a large scale and daily planning problem involving nearly 200 trucks. A truck routing and monitoring system combining different technologies (e.g. GIS, OR based optimisation tool, truck onboard GPS) is used by the fleet managers of the wood procurement division.

In French case 11, Microsoft Office documents (e.g. excel spreadsheet) and an internal ERP system partially support the actors in their manual planning processes. Even with the significant scale of harvesting/transportation activities under the planning of a few managers of the harvesting contractor, the problem of planning complexity is reduced by the short planning time with continuous updates, the separation of harvesting and transportation planning, the flexibility allowed by buffers (i.e. inventory and in capacity) and the use of some of the aforementioned techniques to adjust current supply with current demand (e.g. product substitution, product resorting). As in French case 11, several Microsoft Office documents (e.g. excel spreadsheet) support the wood procurement division in Canadian case 15 for most of its manual planning processes. Considering the large scale of the harvesting/transportation activities in the Canadian case, problems of planning complexity are significant, increasing the apparent need for more advanced decision support tools. However, important inventories, both at roadside and in mills’ yards, provide flexibility to more easily handle such complexity.

Limited information is available on the decision support tools used in Polish case 18. Different internet-based auction systems are used to sell most of the volume. An internet-based auction system is also used by the public timberland-based wood supplier to sign annual general contractual agreements at lower rates with harvesting contractors. The decentralisation of harvesting planning to the forest district level for large scale harvesting activities of the public timberland-based wood supplier seems to reduce the need for decision support tools.

5.3.1.4. Harvesting time windows

The decision of when to harvest a block is subject to different considerations, which allow harvesting time windows to be of different lengths. Longer allowed harvesting time windows provide the wood supplier with more flexibility to decide when to harvest the block. We focus on two considerations encountered in determining harvesting time windows to illustrate differences among the cases. First, the harvesting time windows imposed by the silviculture (thinning and clear-cutting). Second, the harvesting time windows imposed by the purchasing agreement of the block. Table 11 shows the harvesting time windows for the cases.

Table 11: Harvesting time windows in the cases.

		Harvesting time windows		
Case	**Block**	**Thinning**	**Clear-cutting**	**Purchasing agreement**
CL1	Radiata pine plantation	2-4 years	4 years	n.a.
US4	Loblolly pine plantation	3 years (1st thinning)	9 years	1-1.5 years after purchase
FR11	Maritime pine plantation	4-5 years	10-15 years	1 year after purchase
CA15	Black spruce natural stand	15 years	≥15 years	n.a.
SW19	Norwegian spruce and Scottish stand	5 years	≥15 years	2 years after purchase

Cases with blocks having shorter rotation time face shorter time windows in silviculture, while this is the opposite for cases with blocks having a longer rotation time. However, a large part of this silviculture flexibility rests mainly with the timberland owner (e.g. to wait for a good price for standing timber). Indeed, after the purchase, the wood suppliers have a delay of one to two years to harvest and, usually, complete the secondary transportation. This delay is specified at purchasing time in addition to other conditions that constrain (e.g. no harvesting during hunting periods) or can constrain (e.g. no harvesting after severe rainfall) when the harvesting can be done. When there are such conditions, the delay is usually extended by the duration of the constraints and/or an extension of time is specified (e.g. a wet weather provision subject to weather conditions). Additional extensions of time may be possible by negotiating with the timberland owner and this usually involves compensation to the wood supplier.

5.3.2. Decoupling points

Seven decoupling points were identified in the cases: Buy block-2O, Select block-2O, Bucking-2O, Primary transport-2O, Merchandising-2O, Measuring-2O, Secondary transport-2O. The decoupling point Bucking-2O applies in the CTL method while decoupling point Merchandising-2O applies in the FT method. The location of these decoupling points along the material flow is illustrated in Figure 38. Depending on whether the material is standing timber or harvested timber in inventory before or at roadside, the seven decoupling points are located in one of the three sections along the WSC: sourcing (i.e. Buy block-2O, Select block-2O), harvesting (i.e. Bucking-2O, Primary transport-2O, Merchandising-2O) and transportation (Measuring-2O, Secondary transport-2O).

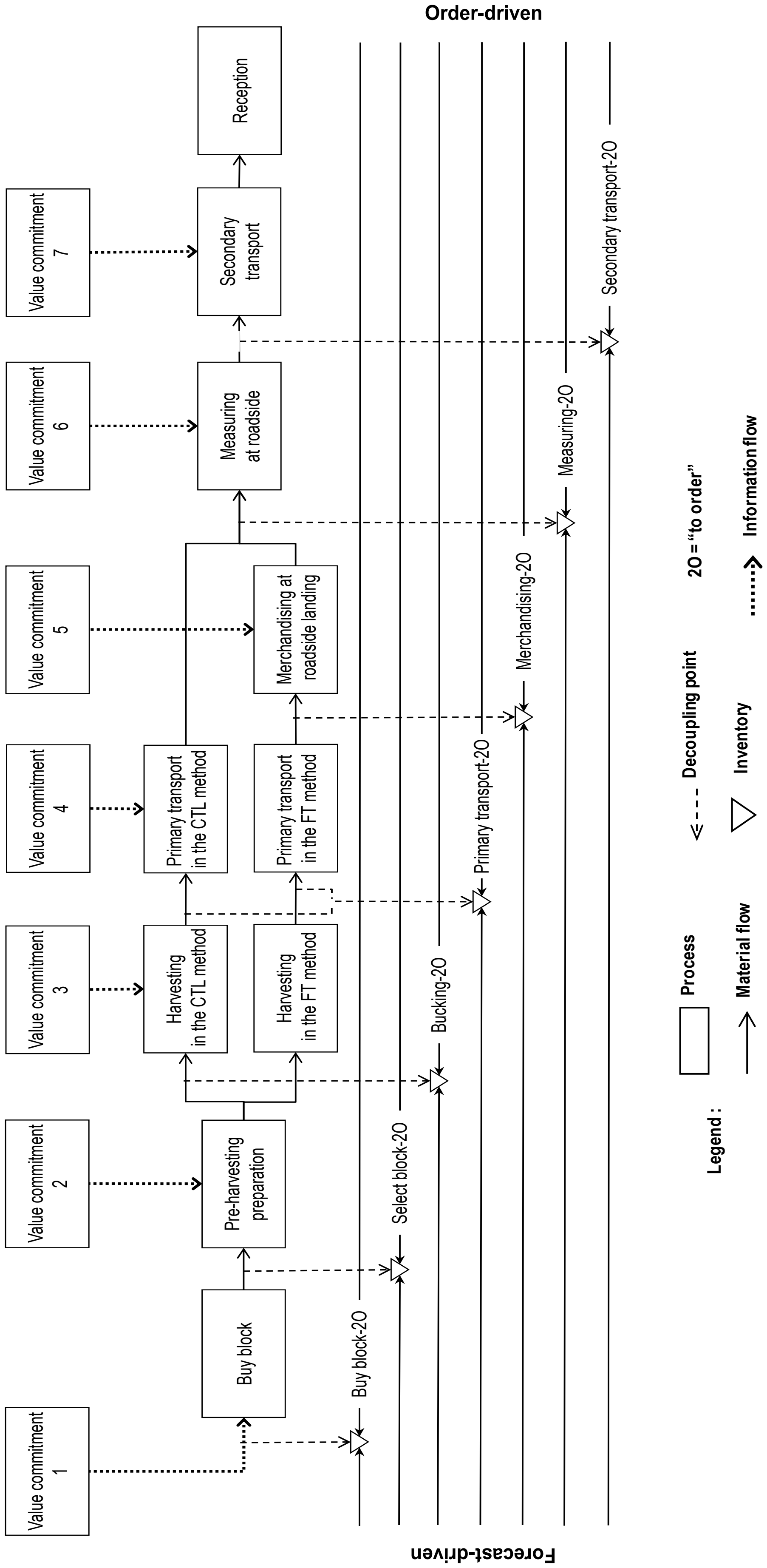


Figure 38: Localisation of the seven identified decoupling points.

The decoupling points used in each case are reported in Table 12. More than one decoupling point is used per case and they are located within at least two of the three aforementioned sections along the WSC. Table 12 also details whether the decoupling point involves a small, medium or large part of the total demand and the value commitment to which the decoupling point is linked. Roughly half of the value commitment processes use more than one decoupling point, which means that inventories located at different steps along the WSC are used to plan the fulfilment of a confirmed demand.

Table 12: Decoupling points used in each case.

Case	VC	Sourcing		Harvesting			Transportation	
		Buy block-2O	Select block-2O	Bucking-2O	Primary transport-2O	Merchandising-2O	Measuring-2O	Secondary transport-2O
CL1	VC1		+++	+		+		
	VC2		+++					
US4	VC1	++						
	VC2	++				+		
US7	VC1		++					
	VC2		++			+		
FR11	VC1			++				
	VC2				+			++
	VC3							+
CA15	VC1		+++					
	VC2		+	++		++		
	VC3							+
PL18	VC1			+++		+++		
	VC2			++		++	+	
	VC3						+	
	VC4						+	
SW19	VC1	+	+++					
	VC2	+	+	+				
	VC3							+

Legend: Chilean case 1 (CL1); US case 4 (US4); US case 7 (US7); French case 11 (FR11); Canadian case 15 (CA15); Polish case 18 (PL18) and Swedish case 19 (SW19); large part of the demand (+++); medium part of the part of the demand (++); small part of the demand (+); Value commitment (VC); to-order (2O)

5.3.2.1. Decoupling points not reported in the case studies

In Chilean case 2, another decoupling point used by a timberland-based wood procurement division was identified. This decoupling point occurs at the bucking plant under the responsibility of the wood procurement division. The bucking plant is composed of two multi-saw bucking lines feeding a multi-compartment sorting line with a three dimensional log scanner. The bucking plant manages two inventory yards: an input inventory yard for stocking the raw material (i.e. logs and pieces of trees up to 13.5 meters) from the forest and an output inventory yard for stocking the final products. The decoupling point is positioned in the output inventory yard.

The plant is located between a sawmill and a veneer mill in the same industrial complex. The two mills are internal customers of the wood supply department. Their respective demand in logs of Radiata pine is defined by a quantity of a specific quality grade, length and diameter class. Also, to respect their internal production plan, each demand must be delivered to their feeding deck at a specific time window during the day. The bucking plant has the responsibility to fulfil these demands through the Loader transport-2O decoupling point (Figure 39).

Each mill provides a forecast of its demand to the timberland-based wood procurement division. Based on these forecasts, the bucking plant sets the inventory replenishment rules for each product to be kept in stock. Thus, each demand is satisfied by picking the ordered quantity in the pile of stocked product and delivering it directly to the feeding deck with a loader. Based on the stocked products having reached their replenishment level, a daily production campaign is planned. To foster the production of the products requiring replenishment, the production campaign involves the adjustment of different parameters (e.g. update of the product price list in the log scanner, update of instructions to the bucking lines, update of the product-compartment allocation) and the volume of specific raw material is pulled from the input inventory yard, or even from the roadside inventory in the forest. The pulling of specific volume from the forest is possible by giving it a delivery priority and so notifying the transportation manager.

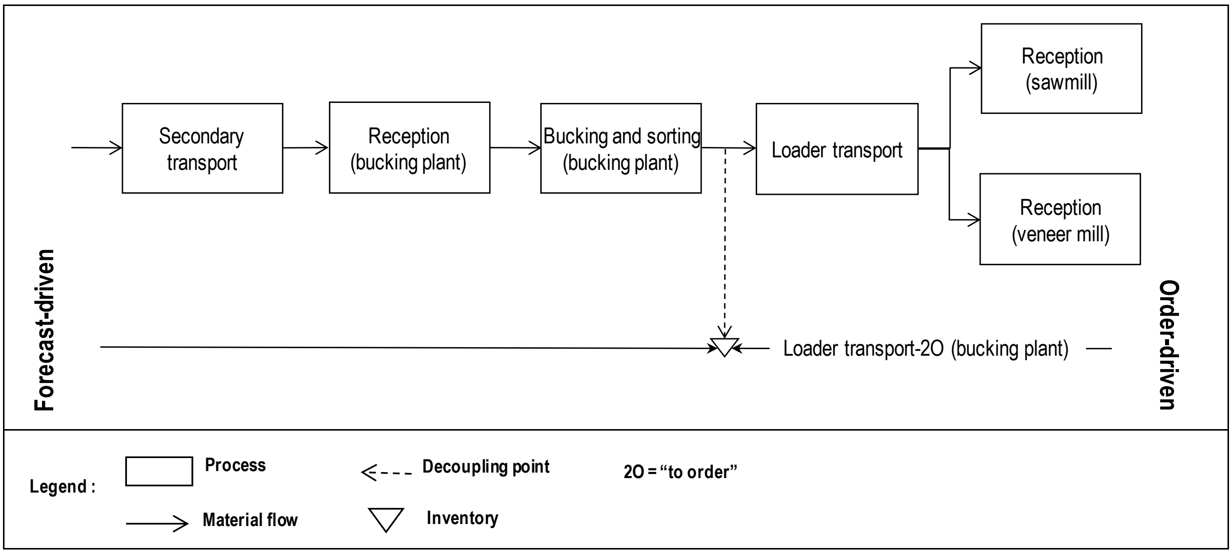


Figure 39: Material flow and decoupling points in Chilean case 2.

In the description of French case 11, we reported the decoupling point Secondary transport-2O. This decoupling point can be further detailed according to the location of the inventory used to fulfil the demand (Figure 40). Usually, roadside inventory in a forest is used in secondary transportation directly to a customer and for a minimum number of handlings (loading/unloading). However, sometimes inventory is moved from roadside to an inventory yard and usually, the yard is located closer to potential customers. By reducing the secondary transport distance, this practice of place postponement (see e.g. van Hoek (2001) for detail on postponement) is particularly useful for the demand of products by customers requesting a short delivery lead time (e.g. the demand managed by Value commitment 3 in French case 11). Moreover, the harvesting contractor also manages a special inventory yard with a large stock of a few products under water aspersion. This stock comes from volume harvested after the storm Klaus in 2009. The stock is gradually used to satisfy the demand from any Value commitment processes with a decoupling point Secondary transport-2O (inventory yard). Finally, when there is not enough volume in the inventory (in the cutting block or at roadside) to fulfill the entire demand from the Value commitment 2 process, decoupling point Bucking-2O could be used for deliveries at the end of the week. However, this requires shortening the average inventory time in the cutting block and at roadside by prioritising the primary and secondary transport of the missing volume.

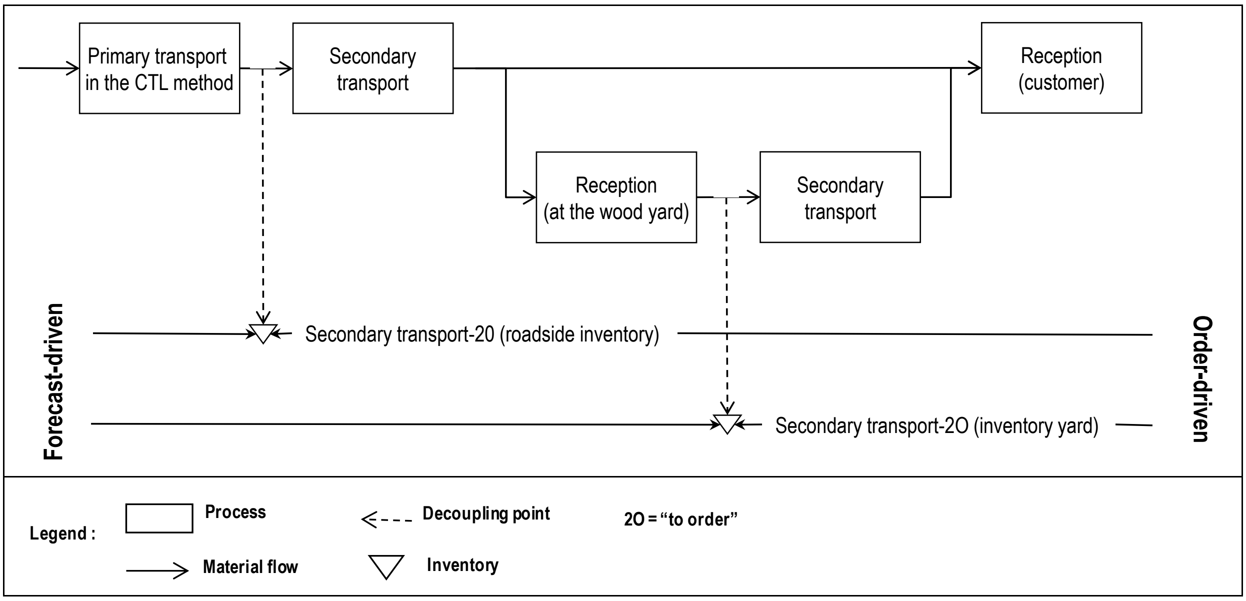


Figure 40: Material flow and additional decoupling points in French case 11.

Finally, two decoupling points are used in US case 7. The demand from customers with a supply agreement usually covering one to several years (designated as Value commitment 1) is managed with decoupling point Select blocks-2O. Indeed, to fulfil this demand, the timberland-based supplier selects blocks among a set of blocks that could be harvested according to the forest management plan of his timberland. The demand from customers with shorter supply agreements or punctual orders (designated as Value commitment 2) is managed with decoupling point Select blocks-2O (for the volume requiring additional sourcing) and Merchandising-2O (for the volume coming from blocks already planned to satisfy the demand of Value commitment 1).

5.3.3.Monetary flow

In each case (except Polish case 18, where insufficient information was available), the main monetary flows of the central actor of the case have been illustrated (i.e. Figure 7 for Chilean case 1, Figure 12 for US case 4, Figure 19 for French case 11, Figure 24 for Canadian case 15 and Figure 33 for Swedish case 19). The observations resulting from these figures are:

- in US case 4, French case 11 and Canadian case 15, the harvesting contractors are not paid for harvested timber not yet delivered, while these volumes at roadside are paid in Chilean case 1 and Swedish case 19.

- in Chilean case 1 and French case 11, payments are based on a monthly period, while this is biweekly in Canadian case 15 (for payment to/from harvesting contractors/mills) and weekly in US case 4, Swedish case 19 and Canadian case 15 (payment to the timberland owner).

-the delay between the first financial exit and the last financial entry is 25 days for the central actor in Chilean case 1 and 30 days for the central actor in Swedish case 19. The delay is at least 15 days for US case 4 and two months for French case 11.The delay is null in

Canadian case 15. In the literature of supply chain performance (see Appendix 10), this delay is designated as the metric 'cash-to-cash cycle time'.

5.3.3.1. Pricing mechanisms and payment methods

Based on the standing timber pricing mechanisms discussed by Kant (2010) (see Appendix 11), eight pricing mechanisms to sell and buy standing timber and assortments were identified during the fieldwork. Table 13 details the pricing mechanisms used in each case. No standing timber pricing mechanisms are used for Canadian case 15 and Polish case 18, since there is no purchase of standing timber in these cases.

Six payment methods of standing timber and harvested timber have been reported in the fieldwork (see Appendix 11 for their description). Table 14 details the standing timber and harvested timber payment methods used in each case and mentioned during the fieldwork. Usually in a supply chain, the transference of stock ownership between seller and buyer defines who is now responsible for i) storage and related costs (e.g. capital, maintenance), ii) planning and control of the stock level and iii) the risk of a loss in stock value (Fronia et al., 2008). In WSCs, a distinction must be made between the first two responsibilities (designated by the change-over of ownership of the stock in Figure 41) and the last one (designated by the change-over of the risk of a loss in stock value in Figure 41). Indeed, after the purchase of standing timber, the risk of a loss in stock value is shared between a seller (i.e. a timberland owner) and a buyer (e.g. any supplier of harvested timber in Table 31, see Appendix 6) in three pricing mechanisms (i.e. flat unit sale price, unit sale price by assortment, shares contract), while in the 'lump sum' pricing mechanism, this risk is only taken by the buyer. Moreover, this risk is shared until delivery except when the harvested timbers are measured at roadside. In this case, the buyer alone assumes the risk between measurement and delivery. When the harvested timber is delivered to a customer (i.e. a buyer of harvested timber) at roadside instead of at a mill, the risk is assumed by the customer after the harvested timber is picked up at roadside.

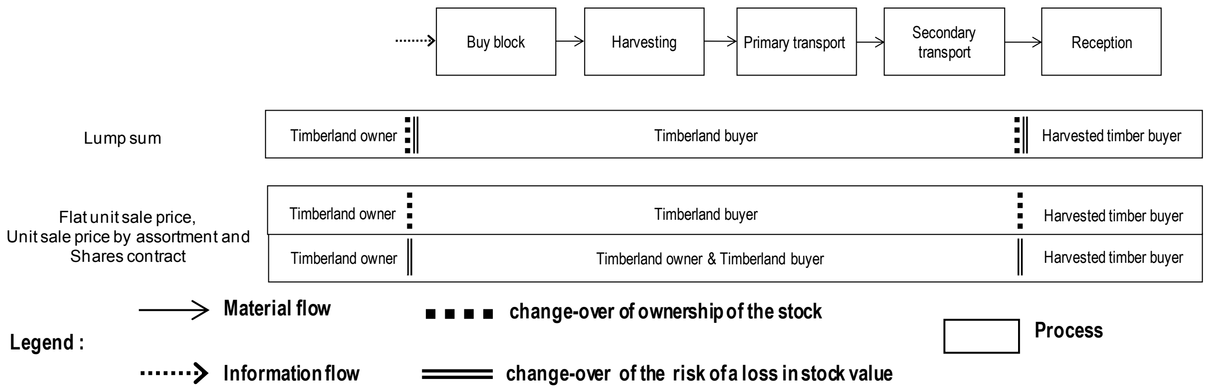


Figure 41: Change-over of ownership of the stock and the risk of a loss in stock value according to standing timber pricing mechanisms

The risk of a loss in stock value could result from unwanted events affecting standing/harvested timber, such as fire, wind storm, insect infestation, blue stain or theft. However, the risk could also result from the under-valorisation of standing timber at harvesting time, such as poor bucking/merchandising and sorting of the high value assortments or lack of demand for a higher value assortment. Another scenario is not capturing all the potential value of a block when a mix of assortments is produced to fulfill earlier committed demand while more profitable demand exists at harvesting time. When the standing timber pricing mechanism is not 'lump sum', such a scenario could raise some sensitive questions by the timberland owner to the timberland buyer. A performance metric that integrates this notion of loss in stock value is proposed in Section 6.

Five payment methods of harvesting and transportation activities have been reported in the fieldwork (see Appendix 11 for their description). Table 15 details the harvesting and transportation activities payment methods used in each case and mentioned during the fieldwork. The ‘cut-and-haul by assortment’ payment method is the only one that directly provides a financial incentive to the harvesting contractor to produce the most valuable product. Indeed, the rate by assortment follows a descending structure from higher value assortment to lower value assortment.

Table 13: Standing timber and harvested timber pricing mechanisms in the cases.

Standing timber and harvested timber pricing mechanism	Chilean case 1	US case 4	French case 11	Canadian case 15	Polish case 18	Swedish case 19
Administered prices based on the residual value approach				A		
Administered prices to supply internal markets	A			A		
Negotiated prices by bilateral negotiation	T, A	T, A	T, A	A	A	T, A
Negotiated prices in supply contracts	A	A*	A	A		A
Transparent timer auctions with ascending prices			T		A	
Transparent timer auctions with descending prices		A				
First-price sealed-bid auction	A	T				
Timber price at the mill (or an intermediate site) gate	A*	A		A*		

Legend: standing timber (T), assortment (A), used in another case study in the country (*)

Table 14: Standing timber and harvested timber payment method in the cases.

Standing timber and harvested timber payment method	Chilean case 1	US case 4	French case 11	Canadian case 15	Polish case 18	Swedish case 19
Lump sum (only for T)	T	T	T	T*		T
Flat unit sale price		T*		T*		T
Flat unit sale price by origin zone (only for A)				A		
Shares contract (only for T)		T*		T*		
Unit sale price by assortment	A	T, A	T, A	T*, A*		T, A
Unit sale price by assortment and by origin zone (only for A)			A*		A	

Legend: standing timber (T), assortment (A), used in another case study in the country (*)

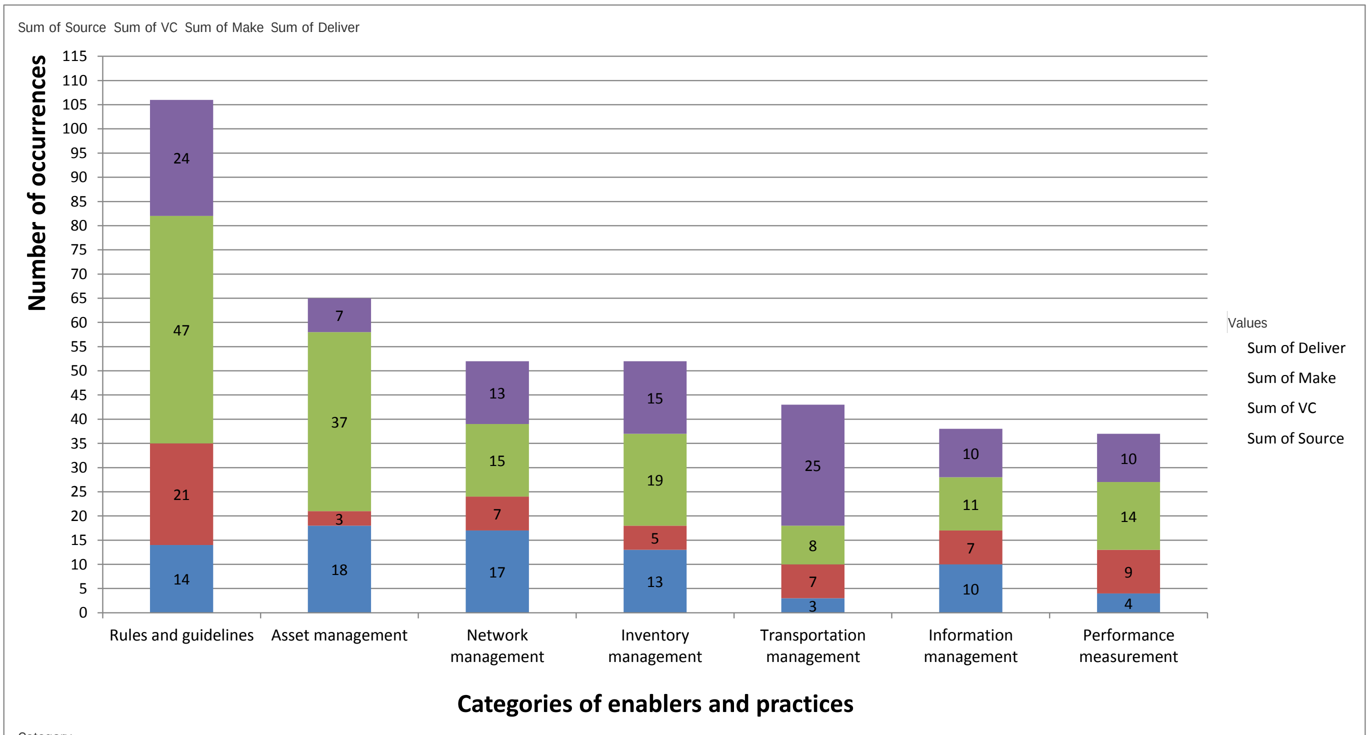
Table 15: Harvesting and transportation activities payment method in the cases.

Harvesting and transportation payment method	Chilean case 1	US case 4	French case 11	Canadian case 15	Polish case 18	Swedish case 19
Flat unit rate	H & PT and L & ST, H & PT & L and ST	ST*	PT, H & PT* and L & ST*	H & PT* and L & ST*	H & PT and L & ST	H & PT and L & ST
Unit rate by assortment (only for H, L, PT)		H & PT & L*				
Flat truckload rate (only for ST)			L & ST*	L & ST*		
Cut-and-haul rate by assortment		H & PT & L & ST				
Cut-and-haul rate				H & PT & L & ST		

Legend: harvesting (H), primary transport (PT), loading (L), secondary transportation (ST), combined rate for these activities (&), used in another case study in the country (*)

5.4. Enablers and practices

From a global analysis of the enablers and practices identified in the cases, we can see in Figure 42 that the categories of Rules and guidelines and Asset management had a higher number of occurrences. On the other side, the categories of Transportation management, Performance measurement and Information management had less than 45 occurrences. Along with this, the majority of these occurrences were identified in the Make process (Harvest) for all the categories, with the exception of Transportation management enablers which, for logical reasons, had more occurrences in the Deliver (secondary transport) process.



Legend: Source (blue); Make (green); Secondary transport (purple); Value commitment (Red);

Figure 42: Average agility capability by process within the dimensions.

Even if quantity does not necessarily mean quality, these results can be seen as a representation of the overall focus currently existing in WSC practice. This means more attention to rules and guidelines, as well as to asset management in harvesting and transportation processes, and in general a lesser focus on performance measurement (besides cost management) and information management techniques. A lesser focus is observed as well in the processes of sourcing and value commitment.

All seven categories contribute to the agility capabilities assessment in each case study, with slightly deeper insights from rules and guidelines, network management, inventory management and information management. Thus, the way is left open for further studies in order to better define and exemplify each of these categories, as well as to analyse the relative importance of each of them on the agility capabilities assessment. The integration of additional categories from the SCOR manual, such as Regulatory requirements and Risk management, or from other sources, can also be foreseen.

These results need to be viewed as an initial baseline to conduct future work on best and current practices in WSCs fitting different levels of environmental uncertainty. A first attempt at this is presented in Table 16, portraying some enablers and practices identified in the cases with higher agility scores under high demand uncertainty and high supply uncertainty.

Table 16: Enablers and practices of agile WSCs in an uncertain environment.

Category	Enablers and practices
Rules and guidelines	- purchasing price list by assortment - purchasing contracts - standard general contractual agreement with contractors - three-level classification of harvesting contractors - harvesting contracts must have a 'Best Management Practices' accreditation from a recognised program - total volume under medium-long term supply agreement is limited to 65-75% of the total harvested - sales managers are decentralised for 'regional' customers but act together for customers present in many regions to increase negotiation power and avoid internal competition/cannibalisation - continuous monitoring of the credit limit by each customer before the delivery to reduce the risk of loss
Asset management	- geographic information system combined with yield tables, growth models and economic analysis to support the management of timberlands - operators trained to perform thinning operations without tree marking - harvesting crew has a wide geographic flexibility - if a contractor faces production problems, his quotas are reassigned to other contractors to guarantee the fulfilment of the quotas - if a block has more high quality grade product than expected, a contractor can obtain additional production quotas - a manager position is dedicated to increase the business competencies of harvesting contractors - keep blocks with good draining soils for winter season harvesting - a logistics team is dedicated to support the top and regional managers in their decisions - OR optimisation tool to allocate volume from blocks to the most profitable customers over a wide supply area
Network management	- business and personal relationships with the actors of the private forest. - harvesting and primary transport contractors association e.g. to foster continuous learning - research centre/consulting support for harvesting and transport contractors. - trucking association and cluster for carriers - use of external resources such as consultants but also research centres and universities.
Inventory management	- roadside inventory updating from primary transport - use of one way product substitution or product sorting during loading to satisfy urgent demand - GIS-based timberland data base for forest management follow-up - different kinds of terminals are used as a buffer to face wood flow disruption periods such as thawing in boreal regions. - payment based on scaled weight at delivery site fosters short inventory time - combination of pre-harvesting inventory and historic production data from similar blocks to increase the forecast precision of volume by assortment in a block
Transportation management	- primary transport operators report to truck driver when roadside inventory is overfull - supply agreement includes details of the delivery logistics conditions - to complete a truckload or to fulfil an urgent demand, specific trees are felled - reduce handling by loading a truck as the merchandising takes place - supply agreement reserves delivery time windows to reduce truck queuing time - usage of backhauling and harvested timber exchange practices - use of place postponement for an assortment for which customers request a short delivery lead time

Category	Enablers and practices
Performance measurement	- forecast of m3/ha to be harvested - pre-harvesting evaluation of expected productivity - payment based on different criteria (e.g. terrain, distance, machine) - timberland manages to generate value not only from forestry (e.g. gravel rock) - can perform the harvesting of a block in two time periods when e.g. the market drops - customers under contract that solicit additional volume on short-term notice pay a premium price - to maximise selling prices, wood supplier is in continuous contact with current and potential customers
Information management	- database of available blocks to harvest and safe set of diversified blocks ready to be harvested - central database of the road network - daily harvesting and primary transport reports - update on inventory at roadside is based on measurement reports from unloading truck drivers - the bucking/merchandising instructions and sorting rules of each harvesting team can be updated at virtually any time with a telephone call.

5.5. Performance

In this component of the framework, the agility and tailoring capabilities were analysed in the cases. They are detailed in the next sections.

5.5.1. Agility capabilities

Supply chain agility capability was measured by an evaluation of the contribution of the enablers and practices identified in the four dimensions of supply chain agility (i.e. Customer sensitivity, Information driver, Process integration and Network integration) in the four macro-processes of Source, Make, Deliver (value commitment) and Deliver (secondary transport). The research team performed the evaluation based on a 0-4 scale, with 0 designating a null contribution and 4 an extremely high contribution.

In Figure 43, the average results of all the cases are shown by agility dimension and by macro-process. One initial observation is that no dimension showed an impressive result, all agility dimensions obtained similar average results, scoring at a medium level between 2.0 and 2.5. The lowest average is for the Information driver dimension (2.11). However, it is possible to see that most of the difference is in the Source and Make macro-processes. This means that in these macro-processes, accuracy and update frequency of key information, as well as its availability throughout the supply chain, can be improved.

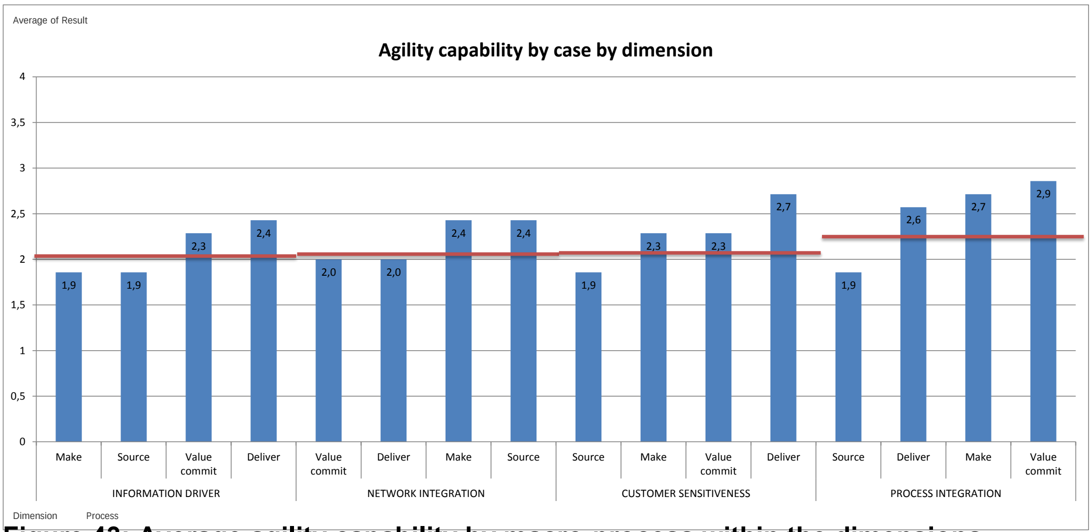


Figure 43: Average agility capability by macro-process within the dimensions.

The dimension Network integration (average 2.21) differs most in the Deliver (Value commitment) and Deliver (secondary transport) macro-processes. This means that the two themes guiding the assessment of this dimension (i.e. more trust-based relationships, reduced resistance to change and to the adoption of new practices) can be improved through enhanced interactions with customers and transport contractors.

Regarding Customer sensitivity (i.e. the capacity to read and respond to the real demand of mills, capturing emerging trends in demand), it increases as we get closer to the downstream processes [Make and Deliver (secondary transport)], which makes sense considering that these processes are closer to the customers.

Process integration is the dimension presenting the highest average (2.46), with only the Source process being below average for collaborative planning and rapid decision-making. Such a result is largely explained by the scheduling of harvesting blocks mainly according to silviculture considerations rather than demand in most cases.

Among the four macro-processes, sourcing (i.e. the purchasing or selection of harvesting blocks) is the weakest one in WSCs for agility, followed by Deliver (value commitment). However, exceptional cases exist, and they can be seen in Figure 44, which shows the scores of each case for the agility dimensions in the Source process. The scores of each case by agility dimensions in the Make, Deliver (value commitment) and Deliver (secondary transportation) are found in Appendix 19.

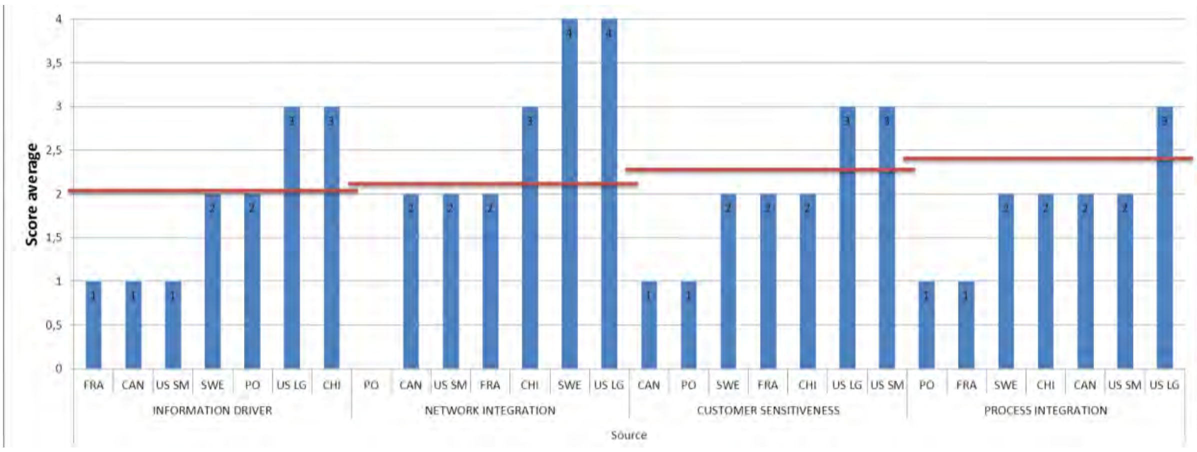


Figure 44: Agility capability by case within dimensions for the Source macro-process.

To improve their results, it appears important for the central actor in a case to first close the most significant gaps and/or the ones judged priority, but also to raise the average level of the dimensions in the medium to long term. The enablers and practices of the cases that stand above average can be adopted as a model. Attention should be paid, however, to the level of environmental uncertainty of the cases to be used as reference. If their environment differs considerably, then extra care should be used to adapt and adjust enablers and practices to different conditions. Based on the level of supply and demand uncertainty of each case (see Section 5.1), three clusters of cases can be made according to their levels of supply (Figure 45) and demand (Figure 46) uncertainty. Thus, a case aiming to improve its agility capabilities in the main processes of sourcing timber (source), harvesting (make) and/or secondary transport (deliver secondary transportation), should first review the enablers and practices of the case with higher agility capabilities in these processes that is located within the same clusters of supply uncertainty (Figure 45). The same comment applies for a case aiming to improve its agility capabilities in the main process of value commitment by searching for the same clusters of demand uncertainty (Figure 46).

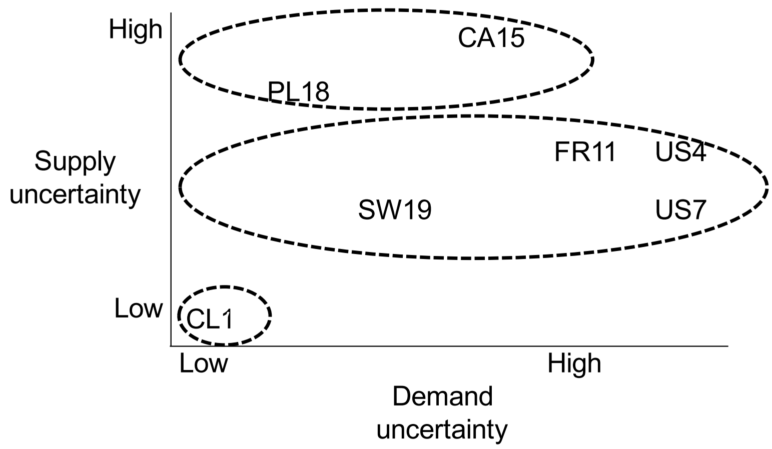


Figure 45: Clusters of cases with similar levels of supply uncertainty.

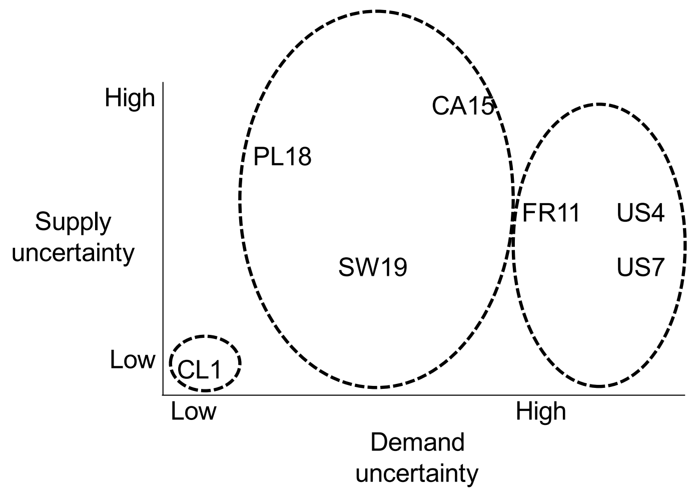


Figure 46: Clusters of cases with similar levels of demand uncertainty.

According to the general assumption in the literature on supply chain agility, an environment with high uncertainty calls for a supply chain with high agility capabilities. Thus, if we compare agility capabilities evaluated in the cases and those theoretically required according to the level of uncertainty, the case studies show a case (Chilean case 1) with high agility capabilities not required by the level of uncertainty, some cases where the uncertainty level calls for higher agility capabilities (French case 11, Canadian case 15 and Polish case 18 for the supply side) and, finally, cases with agility capabilities relatively well balanced with their uncertainty level (US case 4 and Swedish case 19).

Regarding other performance metrics (see Appendix 10 for examples of metrics), the literature on supply chain agility provides complementing results. The results are not uniform, but there is a convergence in the positive impact of supply chain agility on lead-time and service level and divergence in cost and quality. Moreover, while care must be taken to make sure that agility would not lead to lower quality and higger cost - which is reported to be a risk - the results shows that the positive impacts clearly outweigth the negative ones. Table 17 shows the impact of supply chain agility on standardised performance indicators according to several authors.

Table 17: Contribution of supply chain agility to performance indicators

Categories	Performance indicators	Supply chain agility impact		
		Positive impact	Neutral impact	Negative impact
Financial quantitative	Cost	1,4		2, 5
	Return on assets	3		
	Profit margin	3		
	Sales/employee	3		
Non-financial quantitative	Lead-time	2, 4, 5		
	Service level	2, 4, 5		
	New product introduction	4		
	Market share	3		
	Delivery speed	4		
Non-financial qualitative	Flexibility		1	
	Quality	4	1	2
	Customer satisfaction	4		

Legend: (1) Yusuf et al. (2004); (2) Agarwal et al. (2006); (3) Swafford et al. (2006); (4) Agarwal et al. (2007); (5) Carvalho et al. (2011)

5.5.2. Tailoring capabilities

Tailoring capabilities were first evaluated based on the location of the decoupling point(s) in each case. It is assumed that the closer the decoupling point is to the sourcing of standing timber, the easier the attributes of a value proposition (i.e. a product and logistics services in a WSC) can be personalised to a customer. For the tailoring capabilities of the product specifications, a crucial process in the material flow can be identified in the cases. This process is Merchandising at roadside landing for the FT method or harvesting in the CTL method.

Indeed, the process represents the main activity along the WSC where a felled tree is processed in one (FT method) or a set (CTL method) of specific products to deliver to the mills. Specialising the work-in-progress inventory into specific end products is a process designated as product differentiation activities (PDAs) in the concept of form postponement (Forza et al., 2008). Form postponement (also termed in the literature as late customisation, delayed product differentiation, postponed manufacturing or manufacturing postponement) consists of delaying one or more PDAs along the manufacturing and distribution process (Forza et al., 2008). The potential capabilities to tailor product specifications before a PDA are superior to the tailoring capabilities after a PDA. The localisation of the two main PDAs along the WSC is illustrated in Figure 47.

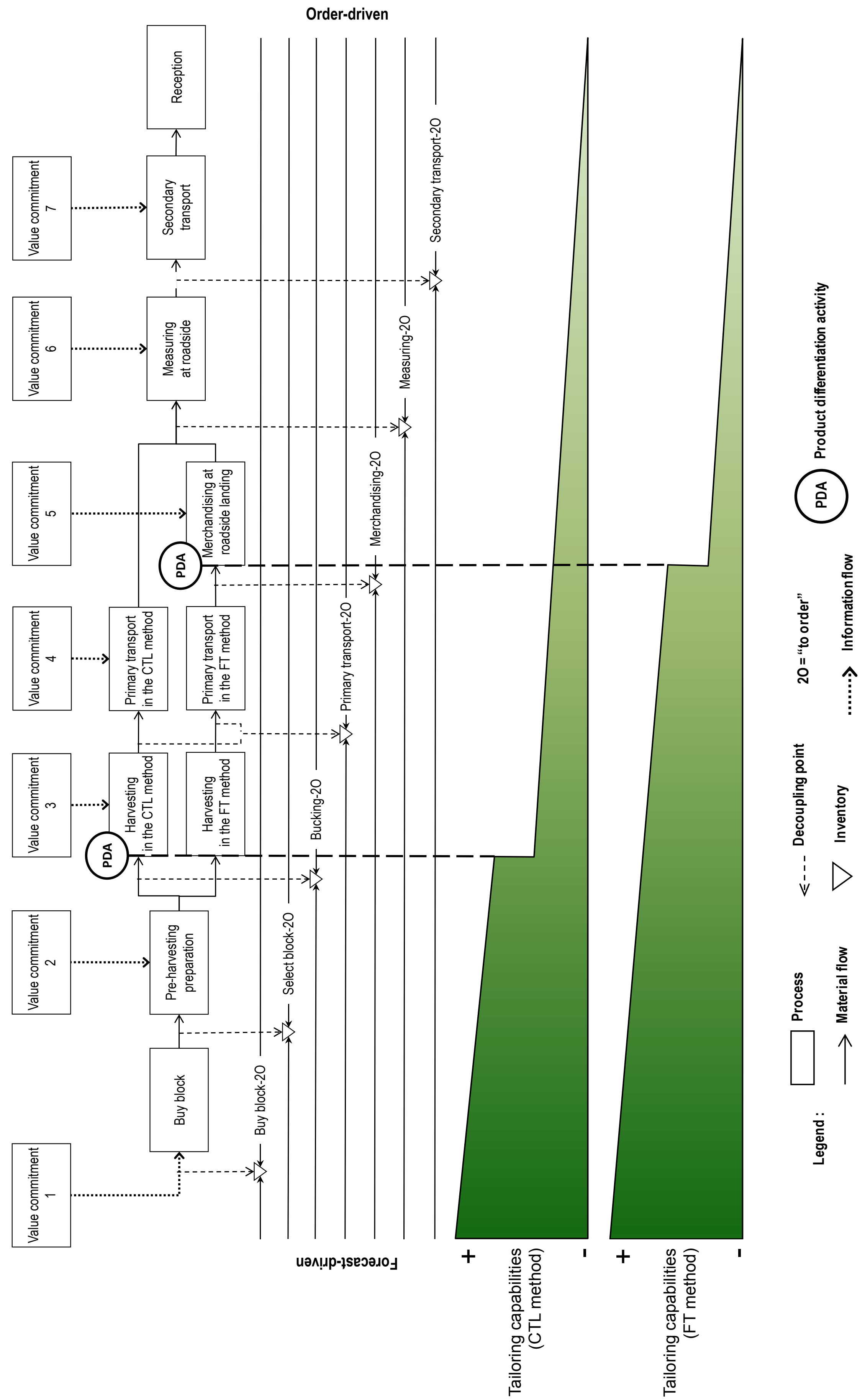


Figure 47: Location of the two main product differentiation activities.

In the CTL method, the tailoring capabilities of the first three decoupling points (i.e. Buy block-2O, Select block-2O and Bucking-2O) in the material flow are higher to the ones in the three last decoupling points (i.e. Primary transport-2O, Measuring-2O and Secondary transport-2O). In the FT method, the tailoring capabilities of the last two decoupling points (i.e. Measuring-2O and Secondary transport-2O) are lower to the ones in the first four decoupling points (i.e. Buy block-2O, Select block-2O, Primary transport-2O and Merchandising-2O).

According to the theoretical foundations of form postponement and the gains reported in the literature on case studies in different manufacturing contexts having implemented this concept, a WSC with a long order fulfilment cycle time, short term value commitment and/or short term change in the committed demand should gain from implementing form postponement. In the scope of the WSC study in this project (i.e. the scope ends at the mill yard), we observed the delaying of the PDA on a proportion of the wood flow in one case. In Chilean case 2, the bucking of a proportion of the harvested timber is performed at a bucking plant instead of at the harvesting sites (see 5.3.2.1). This delayed PDA is a key process in the overall procurement activities as it absorbs a large part of the production adjustments and thus avoids modification of the bucking/merchandising instructions at the harvesting sites. A similar approach is used by a New Zealand wood supplier where the delayed PDA is located in a terminal between the harvesting sites and the demand points. Thus, the bucking/merchandising instructions are adjusted more often at the terminal than at the harvesting sites (Visser, Rien, University of Canterbury, personal communication, July 2011).

As a baseline for deeper investigation, the fieldwork allows a first attempt at assortment typology according to the level of tailoring (here, designated as customisation) of its product specifications: the catalogue assortment based on a general set of product specifications (low customisation of product specifications) and the niche assortment based on product specifications personalised to a customer's requirements (high customisation of product specifications). In practice, only the length can be personalised to a customer's requirements in the catalogue assortment, while the other product specifications remain common among several customers. In the niche assortment, most specifications are personalised to a customer's requirements. Table 18 provides additional characteristics of the catalogue and niche assortments.

Table 18: Characteristics of the catalogue and niche assortment

Characteristics	Catalogue assortment	Niche assortment
Demand uncertainty	Highly-to-fairly predictable	Low-to-un- predictable
Demand volume	Medium to large volume but small volume is possible for high quality assortment.	Usually low volume but larger volume is possible
Price	Highly competitive price with low margin except for high quality assortment.	Usually command a premium price.
Product specifications	Customers choose among a general set of product specifications offered by the supplier.	Customers negotiate product specifications with the supplier.
Product specifications standardisation	Product specifications common to several customers.	Product specifications specific to one (or few) customer. Includes product specifications designed by the supplier according to customer's requirements.
Competitive business strategy and decoupling point	Cost leadership with harvest-to-order and transport-to-order	Differentiation with source-to-order and harvest-to-order
Obsolescence (perishable) risk of holding inventory	Low risk	High risk
Product one-way substitution[17]	Usually one-way substitution can be used straightforwardly in the same assortment group	One-way substitution impossible or costly to use

According to Fisher (1997) and the literature following his contribution [e.g. Vonderembse et al. (2006)], we could expect a long life-cycle in catalogue products and a shorter one for niche products. Such an observation has not been clearly seen in the fieldwork. However, we can suspect it to some degree. First, a wood buyer can aim to reduce his purchasing price and/or supply dependence by finding new wood suppliers. Second, other wood suppliers may want to supply more niche assortment that usually provides a premium price.

One aspect subject to deeper investigation is the correlation between the potential premium on the sale prices paid by wood buyers for products with a higher customisation level and the additional production costs incurred by the wood supplier to produce a set of products with, on average, a higher customisation level. For instance, if to produce this set of products the wood supplier increases the number of assortments, studies in the CTL method report production cost increases (Brunberg and Arlinger, 2001; Gingras and Favreau, 2005). In order to provide a financial incentive to the wood supplier to produce this set of products, wood buyers can pay a premium on the sale prices of customised products (see Figure 48). The minimum premium will compensate the increase in production costs, while higher premiums will provide superior margins and, in turn, a clear financial incentive. To implement such a financial incentive for the production of tailored products in practice, a potential approach is proposed in Andersson et al. (2011) - the wood price is increased according to

[17] One-way substitution assumes that the products are classified into different grades and that products with higher grades can be used to substitute products with lower grades (Huang et al., 2010)

'additional and not required' product specifications for which the buyer is willing to pay a bonus.

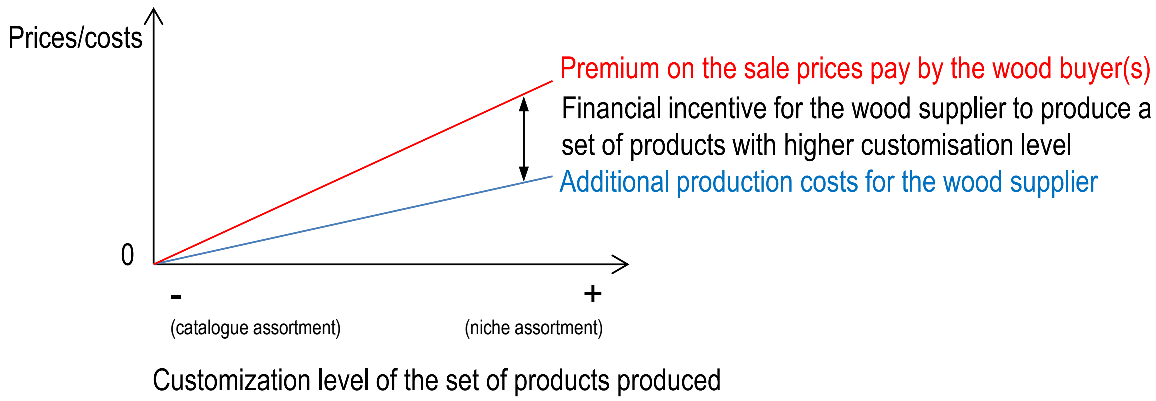


Figure 48: Potential correlation between the additional sale price and harvesting cost according to the tailoring level of a product

Tailoring is also linked to a time dimension: how long a customer must wait for an order with personalised attributes. Order fulfilment cycle time refers to the time from the placement of an order by a customer to the fulfilment of the order by the supplier, regardless if it includes only processing time or additional time, because the order was placed well in advance by the customer (Supply Chain Council, 2008). The SCOR model splits the Order fulfilment cycle time into two parts: order fulfilment process time (OFPT) and order fulfilment dwell time (OFDT).

OFPT is defined as the time from the first process to fulfil the demand to the fulfilment of the demand by the supplier. This time includes possible 'idle time' and 'non-value-added lead time' caused by inefficiencies in the organisation.

OFDT is defined as 'any lead time during the order fulfilment process where no activity takes place, which is imposed by customer requirements' (Supply Chain Council, 2008).

In the cases, we compute the OFDT according to how long in advance the customer places his demand before the first process to fulfil it takes place. Based on the available data on process lead time in the cases, we defined 'Harvesting in the FT (CTL) method' as the earliest first process to fulfil the demand. Thus, we exclude the lead time of potential processes before 'Harvesting in the FT (CTL) method' in the OFPT, while according to the aforementioned definition, such lead time should be included in the OFPT instead of the OFDT. Finally, we defined the process 'Reception' as the time the demand is fulfilled by the supplier, except in the Polish case, where the harvested timber is delivered at roadside instead of at a mill. In the Polish case, the process 'Measuring at roadside' is used as the time the demand is fulfilled by the supplier.

Self-reported and deducted data on order fulfilment cycle time were obtained for each case. Table 100 (see Appendix 20) details the OFPT and OFDT by value commitment process and also according to the three sections[18] along the WSC where the decoupling point(s) is

[18] Reminder: the seven decoupling points are located in one of the three sections along the wood supply chain: sourcing (i.e. Buy block-2O, Select block-2O), harvesting (i.e. Bucking-2O, Primary transport-2O, Merchandising-2O) and transportation (Measuring-2O, Secondary transport-2O).

located. Table 19 presents the OFPT and OFDT by case (ranked from the highest to the lowest agility capabilities) and according to the three sections[19].

Table 19: Order fulfilment cycle time in the cases.

		Sourcing		Harvesting		Transportation	
		OFPT	OFDT	OFPT	OFDT	OFPT	OFDT
+	US7	0.5-1.5 days	A few weeks to months	0.5-1.5 days	≥1 day(s) to a few weeks	n.a.	n.a.
	CL1	10 days	A few months	10 days	A few weeks to months	n.a.	n.a.
	US4	0.5-1.5 days	1-2 weeks	0.5-1.5 days	≥1 day(s)	n.a.	n.a.
Supply Chain Agility	SW19	≤1 month	A few weeks to months	<1 month	A few weeks	≤1 day	A few weeks
	CA15	3-4 weeks	Many weeks to a few months	3-4 weeks	A few weeks	≤1 day	A few weeks
-	FR11	n.a.	n.a.	3.5-7 days	2-3 days to a few months	≤1 day	1-3 day(s)
	PL18	n.a.	n.a.	3-9 days	A few weeks to two months	≤1 day	≥1 day(s) to a few weeks

The three cases with the highest agility capabilities did not present a decoupling point located at the end of the WSC (transportation section), while the two cases with the lowest agility capabilities did not present a decoupling point located at the beginning of the WSC (sourcing section). For the decoupling points located in the sourcing and harvesting sections, in general the higher the agility capabilities, the shorter is the average[20] fulfilment cycle time in the section. This is due basically to shorter times in the OFPT, while higher agility capabilities do not impact the OFPT for the decoupling points located in the transportation section. These results reinforce the convergence in the literature that supply chain agility is linked to shorter lead-time (see discussion and Table 17 in 5.5.1).

The contingency theory proposes that for an organisation to perform well, there must be a proper fit between its structure and the conditions of its external environment, assuming that there is no universal set of choices that is optimal for all organisations (Daft and Armstrong, 2009). In the proposed framework, the hypothesis emerging from this theory is that the low performance of a WSC - evaluated in this research project according to agility and tailoring capabilities - is the result of a weak alignment between the supply chain strategy, structure and implemented enablers on one hand and the level of uncertainty in the supply and demand on the other. The US cases are aligned with this hypothesis, showing high agility and tailoring capabilities (i.e. short order fulfilment cycle time and decoupling points located in the sourcing section of the WSC) in an environment with high uncertainty. The Canadian and French cases also are aligned with the hypothesis, but from the other way around. They present low agility and tailoring capabilities (i.e. long order fulfilment cycle time and, for the

[19] If a case has a different OFPT (OFDT) between two decoupling points located in the same section, the mimumum and maximum OFPT (OFDT) are reported in the table.

[20] It is important to note that in the French and Polish cases, even if the OFPT is shorter than a more agile case, the OFDT is generally longer.

French case, no decoupling point located in the sourcing section of the WSC) in an environment of high uncertainty. Therefore, the hypothesis proposes that the Canadian and French cases have supply chain strategies, structures and implemented enablers not fully aligned with the level of uncertainty in their supply and demand.

The level of uncertainty in the supply spans over three of the four main processes [i.e. sourcing timber (source), harvesting (make) and secondary transport (deliver secondary transportation)] along the WSC, while the level of uncertainty in the demand spans over one main process [i.e. sale of harvested timber (deliver value commitment)]. Thus, to capture the general uncertainty level of a case, the level of uncertainty in the supply is more representative than the level of uncertainty in the demand. The Polish case is in an environment with high uncertainty in supply and presents the lowest agility capabilities among the cases, as well as low tailoring capabilities (i.e. long order fulfilment cycle time and no decoupling point located in the sourcing section of the WSC). Therefore, the conclusion of the Canadian and French cases can also be proposed for the Polish case (i.e. not fully aligned).

The Swedish case is in an intermediary position with an environment not as uncertain as the Canadian and French cases, but with slightly better agility capabilities and roughly similar tailoring capabilities (i.e. longer order fulfilment cycle time but the presence of decoupling points located in the sourcing section of the WSC). Therefore, we propose that the Swedish case has a supply chain strategy, structure and implemented enablers well aligned with the level of uncertainty of their supply and demand.

The Chilean case is not aligned with the hypothesis, as it has agility capabilities at the opposite end of the requirements prescribed by an environment with very low uncertainty. We can explain this result by a qualitative evaluation of the agility capabilities in the developed assessment methodology. The Chilean case is characterised by high effectiveness and efficiency in procurement activities achieved by highly centralised planning and control of the execution. The implemented enablers and practices providing this operational excellence also provide a superior qualitative evaluation of their positive contribution to the four supply chain agility dimensions by Christopher (2000). Thus, the high agility capabilities are a consequence of operational excellence rather than a conscious choice made in response to the level of uncertainty in the environment. For the tailoring capabilities in the Chilean case, the hypothesis is confirmed by the long order fulfilment cycle times and by explaining the upstream localisations of the decoupling points by their higher efficiency (compared to downstream localisations) with stable supply and demand.

In this analysis, it was assumed that environmental uncertainty could not be changed. However, as mentioned by Porter (1998), an organisation (i.e. supply chain) should first try to overcome and mitigate the sources of uncertainty before developing alternative strategies to manage them. For instance, with the establishment of large private, genetically improved, mono-species and intensively managed plantations, many South America-based supply chains significantly reduced their uncertainty in the supply of homogenous raw material. However, some sources of uncertainty could not be changed (e.g. weather patterns impacting procurement activities). Thus, when it is not possible to overcome the source of uncertainty, alternative strategies should be developed. The alternative strategies proposed by Porter (1998) are: to tightly manage decentralisation, develop standard facilities that can be assembled or disassembled easily, increase the value added to the client, and specialise by product, customer, type of order or geographic area.

6. Conclusion

We have proposed a framework for describing WSCs. This framework uses a formalism that can be applied in a generic way to present different WSCs. It also allows an assessment to be made of their agility and tailoring capabilities. The framework consists of five main components: *1) external environment, 2) competitive business and supply chain strategies, 3) supply chain structure, 4) enablers and practices,* and *5) performance*. The content of each component is outlined in Figure 49. These fives components were detailed and analysed through a series of case studies. This led to the development of a set of interrelated templates to describe a WSC, including e.g. a description of the actors, their planning and execution processes, the decoupling points used, and the information, material and financial flows. Moreover, using the four dimensions of an agile supply chain proposed by Christopher (2000), the framework provides a novel assessment methodology of WSC agility capabilities. The developed methodology used a 0-4 scale to rate how well different enablers and practices identified along the main processes within a WSC contribute to each of these four dimensions. Furthermore, tailoring capabilities were assessed, based on the location of the decoupling points and their respective order fulfilment cycle time.

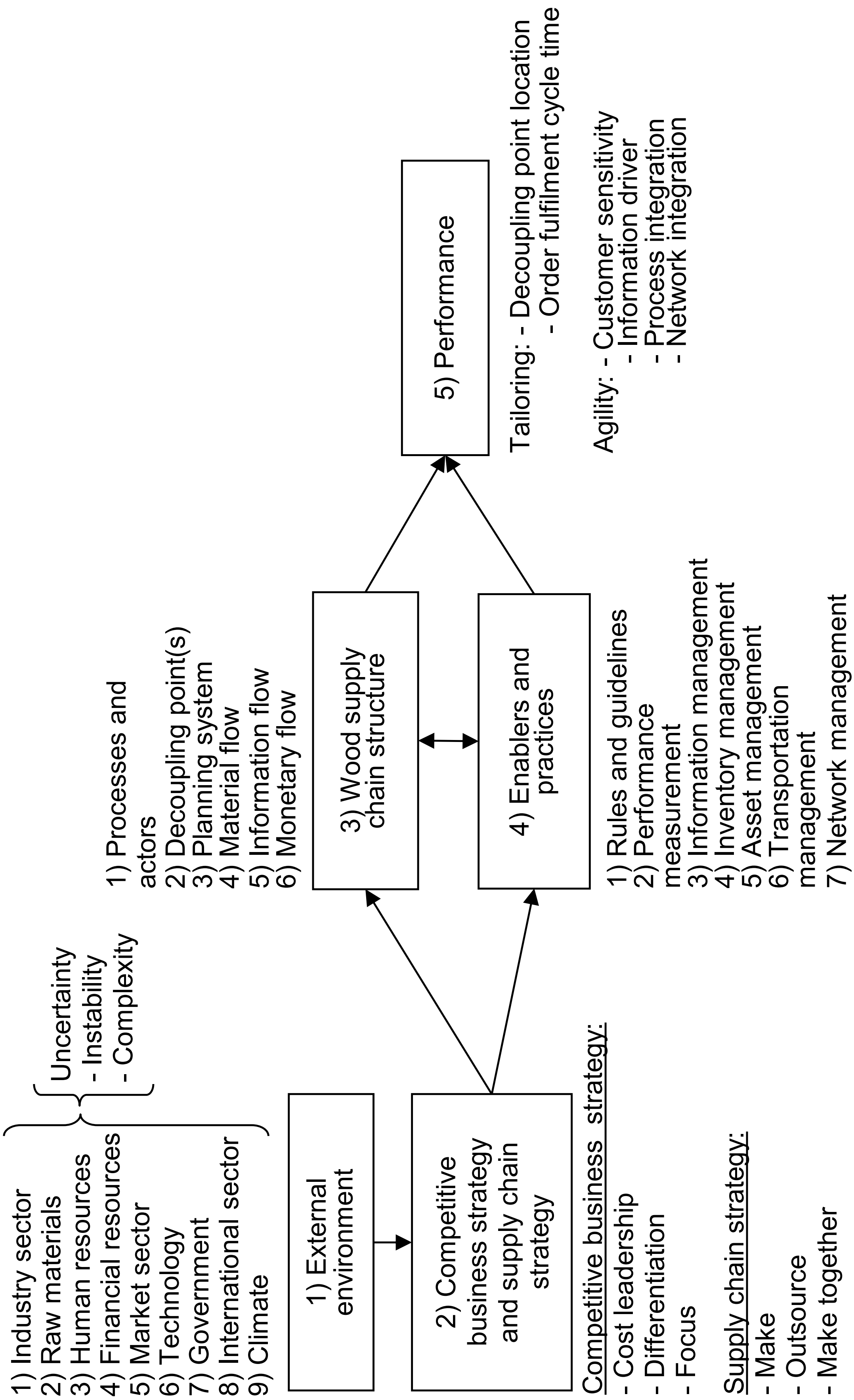


Figure 49: **A contingency framework for analysis of a wood supply chain.**

The proposed framework was applied to case studies in six countries (Canada, Chile, France, Poland, Sweden and USA) where fieldwork allowed information to be collected from 94 local actors and experts. The case studies allowed for a list of options (i.e. catalogues) to be generated for different descriptive elements within the framework. We generated catalogues of 16 types of actors involved in a WSC, seven locations of decoupling points, four types of value commitment process, eight standing timber and harvest timber pricing mechanisms and several payment methods for standing/harvested timber, harvesting and primary/secondary transportation. Furthermore, based on an adaptation of the Supply Chain Operations Reference (SCOR) model, we also developed 17 generic processes for any planning and execution activities within a WSC, as well as 13 generic planning decisions at the operational level. These catalogues could be used for further case studies and, although considerable numbers of options are already proposed, new ones can be added by the framework user.

Three basic designs of planning systems were identified: 1) integrated sourcing and harvesting planning (Canadian case 15, Polish case 18 and Swedish case 19), 2) integrated harvesting and transportation planning (US case 4 and US case 7), and 3) decoupled sourcing, harvesting and transportation planning (Chilean case 1 and French case 11). A decision matrix is provided for each of the three designs. We also identified six logistics techniques to adjust supply to demand and present the accountability option (i.e. perform planning/execution processes internally and/or outsource them) per macro-process in the cases.

We discussed the agility capabilities evaluated in the cases and those theoretically required according to the level of uncertainty in the supply and demand sides. Environments with high uncertainty require supply chains with high capabilities in agility. We did observe two cases with agility capabilities relatively well balanced with their uncertainty levels (US case 4 and Swedish case 19). The results also show a case (Chilean case 1) with high agility capabilities, while its level of uncertainty did not require it, whereas others had lower agility capabilities and experienced high uncertainty levels (French case 11, Canadian case 15 and Polish case 18 for the supply side). The evaluation of the agility capabilities in each case allowed us to create a database of several enablers and practices. Potential gains could be obtained in a case by the implementation of enablers and practices observed in other cases. Finally, when comparing the locations of the decoupling point, the agility capabilities and the average order fulfilment cycle time, it was possible to reinforce the results from the literature stating that supply chain agility is linked to shorter lead-time.

For the evaluation of the tailoring capabilities, two processes were identified where most of the product differentiation activities along a WSC occur: the harvesting in the CTL method and merchandising at roadside landing in the FT method. The capabilities to tailor product specifications are superior before rather than after one of these processes. Moreover, a typology of assortments according to the level of tailoring is provided as a baseline for further investigation. The financial incentive to produce a basket of assortments with a higher level of tailoring is discussed.

The framework is useful to public and private organisations interested in a describtion of their WSCs and the capacity to assess its agility and tailoring capabilities. A schematic and functional representation of the wood supply chain(s) to which an organisation belongs will make it easier to understand the constraints and objectives of each actor contributing to its processes. Moreover, such an exercise should ease the introduction of a new actor into the WSC. By assessing the tailoring and agility capabilities of a WSC, the framework can support an organisation in an exercise of self-diagnosis that leads to the identification of improvement opportunities to work on. Moreover, by assessing its WSC according to different scenarios (e.g. introduction of new technology, addition of a new value proposition for customer), an organisation can anticipate the impacts of changes.

Finally, the framework introduced a common vocabulary to be used by researchers and practitioners in different disciplines (e.g. forest engineering, management sciences, industrial engineering). It represents an original attempt to develop a reference model for future research on WSCs. Yet, to have significant impact, it needs to be further disseminated and tested within the respective communities.

We have identified several areas into which our contribution could be further developed. Eleven of those that we consider more important are presented below.

Expand the framework to tactical and strategical planning.

In accordance with the scope of the FlexWood project, the developed framework was restricted to planning and execution activities carried out at the operational level. As discussed in Appendix 1, planning activities also take place at strategic and tactical levels, which occur over a longer time horizon. The decisions from two consecutive planning time horizons are hierarchically integrated (i.e. the lower level planning activities enforce decisions from upper level planning activities). Integrating the description of the strategic/tactical level planning activities would be a natural extension for the framework. A broader perspective would help to identify potential inconsistencies in the planning system.

Expand the framework to upstream and downstream processes along the supply chain of the forest products industry.

The scope was also limited to the activities included from the selling agreements to the delivery of products at the mill yard. These procurement activities are a fraction of the whole supply chain of the forest products industry. Integrating a description of the activities upstream (e.g. silviculture) and downstream (e.g. transformation) is another possible extension to the framework. Such enhancements will increase the understanding of the objectives and constraints faced by the upstream/downstream activities that, in turn, can identify improvement opportunities in their integration with procurement activities. For instance, the description of the demand propagation along the supply chain can lead a wood supplier to modify his value proposition according to the expectations of the wood buyer's customers.

Study the impacts of different product chains and the benefits of supply chain segmentation.

Another property of a WSC that needs further investigation is related to the divergent nature of its material flow[21]. The same actors can therefore be part of different supply chains simultaneously (e.g. lumber, pulp and paper, energy), creating an effect of overlapping supply chains (Hertz, 2006) with particular opportunities and threats for economies of scale and scope. How this effect could be integrated in the proposed framework is therefore another area of development. The benefits of supply chain segmentation according to targeted customers segments could also investigated (see Thomas, 2012).

Increase the detail level in the planning processes description.

According to the level of detail aimed for in this research project, the proposed processes are an aggregation of the generic processes of the SCOR model. A disaggregated adaptation to the WSC of the generic processes in the SCOR model can be found in Schnetzler et al. (2009). Such an adaptation and the process mapping method proposed in Lindström and Fjeld (2011) can contribute to describe a WSC with a higher level of detail or to focus on specific activities.

Improve the supply chain agility assessment methodology with metrics.

Before developing the proposed methodology to measure supply chain agility, an attempt was made to use the agility metrics defined in the SCOR manual (see Table 4 in Appendix 2

[21] A mix of products can be obtained from the harvesting of a single standing timber and not all the harvested products necessarily have a current demand.

and the deleted questions in Appendix 3). We also considered the twelve statements for agility measurement by Li et al. (2008) (see Table 3 in Appendix 2). These methods proved impractical in the context of this project for various reasons (e.g. difficulty in explaining the concepts to the respondents, limited interview time, agility metrics not measured by the respondents). The proposed methodology to measure supply chain agility in a WSC proved better adapted, but could be criticised for being only qualitative. As understanding of the supply chain agility concept increases in the industry, we expect that more quantitative and objective evaluation could be attempted using financial or quantitative metrics[22], such as the inclusion of the metric 'order fulfilment cycle time' in the evaluation of tailoring capabilities.

Enhance the framework for scenario analysis, monitoring tools and benchmarking.

Including additional supply chain performance metrics is a possible extension to the framework. Doing so would improve the aforementioned uses of the framework to evaluate the impacts of a change in the WSC. Performance indicators would make it valuable as a monitoring tool (e.g. performance dashboard). Moreover, as with the supply chain benchmarking service based on the metrics of the SCOR model (see Section 2.1 in Appendix 2), such an extension can allow the framework to be used for benchmarking WSCs. Finally, the definition of the different Value commitment processes in a case study was essentially based on the length of the supply agreement or order. A definition including more parameters for the segmentation of customers (i.e. wood buyers) is a possible extension to the framework. Thus, if such criteria are assessed in an enhanced framework, the satisfaction or not of the criteria in each customer segment after a modification to the current WSC could be anticipated.

Deeper study on the tailoring capabilities in a WSC, especially the concept of form postponement.

The discussion on the tailoring capabilities in a WSC raises different issues and further work is required to study its meaning and benefits in WSCs.

Identify promising practices, enablers and adjustment techniques and evaluate their transferability to other cases.

Much remains to be done to better understand the enablers, practices and adjustment techniques that foster high performance in a specific case and how they can be transferred to other cases. However, we emphasise that there is not a 'one-size fits all' approach but only approaches best suited to the context of an organisation. Beaulieu and Landry (2012) illustrated such a principle with a case study on the development of the successful Hyundai Production System. With its history and context, Hyundai could not replicate the practices of the Toyota Production System and had to find its own production system. The work of appropriation and adaptation, rather than trying to transpose what is happening elsewhere, becomes crucial for this successful development.

Further develop the competitive business strategy in WSCs.

Porter's typology to address a competitive business strategy proved to be too general. In order to have deeper and more meaningful insights, an alternative approach could be to analyse the competitive business strategy by strategic goals, such as in Andren and Fjeld (2004). These strategic goals for the different actors could include, for instance: delivery flexibility, perfect order fulfilment, low quality rejects, low transport costs, stable inventory levels, precise delivery times and low purchasing costs. Moreover, based on an adaptation of

[22] A review of metrics to asses supply chain performance can be found in Appendix 10:, as well as the proposal, specifically for the FlexWood project, of a metric related to the capability of a WSC to use the optimal theoretical value in products within a harvesting block. Two of the ten metrics in the SCOR model (see Appendix 10:) were evaluated in the cases: 'cash-to-cash cycle time' and 'order fulfilment cycle time'.

the qualifier and order winner criteria by Hill (1995), the strategic goals could be classified as qualifiers or order winners. Further investigation by different market segments could also be made, since according to Hörte and Ylinenpää (1997), order winner and qualifier criteria work in different ways in different markets and with different customers.

Deeper study of the supply chain strategy in WSCs and the link to the competitive business strategy in WSCs.

Regarding the approach used to address supply chain strategy, an alternative methodology could be the one proposed by Schnetzler et al. (2007) or Perez-Franco (2010). According to Perez-Franco (2010), a supply chain strategy is not a “top-down” concept, but a convergence of core business strategy and strategic themes on one side, and functional and operational themes on the other. These themes are specific to each company or industry and can include, for instance: customer, market, operations, opportunity and product focus. This approach will have to be adapted, however, to a network context (such as found in a supply chain), composed of different companies.

Develop a taxonomy of WSCs.

Finally, another area to explore is the typologies and taxonomies of supply chain strategies or configurations. Typologies define conceptually “ideal types” of organisations developed theoretically, while taxonomies define them through empirical work (Martín-Peña and Días-Garrido, 2008). Table 101 (see Appendix 21) provides a review of general supply chain typologies and taxonomies. The framework can be used to identify taxonomies of WSCs and compare them with existing ones.

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Appendices

Please note that references in the appendices are detailed in Section 8, except at Appendix 5.

Appendix 1: List of generic decisions at operational level

The planning of wood procurement systems requires several steps and is commonly managed according to four time-perspective horizons: strategic, tactical, operational and real-time (i.e. during execution). Strategic decisions are related to long-term planning in forest management, logistics network design, terminal location, defining storage capacity, location of processing facilities, defining production capacity and wood procurement strategy (Marques et al., 2010). Tactical decisions deal with mid-term planning by providing rules, policies and resources for operational planning that leads to a budget and contracts with harvesting-related service providers. Operational decisions provide short-term exhaustive plans to be executed in anticipated harvesting and hauling activities, while real-time decisions adjust an operational plan according to the present situation. Operational decisions require highly detailed data to provide plans that are executable according to the anticipated situation, while real-time decisions require detailed data on the present situation in order to perform modifications that maintain the viability of the operational plan being carried out. Decisions from two consecutive planning time horizons are hierarchically integrated, with lower level planning problems being resolved within the context of decisions made to resolve upper level planning problems.

Different characteristics of the wood supply chain increase the complexity of planning procurement activities. We present three of them. First, the divergent nature of the material flow, where a different mix of products can be obtained from the harvesting of a single standing tree and where not all harvested products are in current demand. Second, the perishable and intrinsic variability of the natural raw material makes it difficult to standardise. Third, conducting procurement activities in an external and uncontrolled natural environment introduces many uncertainties along the wood supply chain. This, therefore, calls for planning strategies which manage the differences between what was planned and what must now be executed.

A combination of two aspects in the Planning matrix (i.e. decisions and time horizons) for a wood procurement system has been proposed in the literature: Frayret and LeBel (2003) for a wood procurement system in Quebec (Canada); Rönnqvist (2003) and Marques et al. (2010) for a generic wood procurement system with the cut-to-length method. A general discussion of the planning matrix for a supply chain can be found in Fleischmann et al. (2008).

Combining the aforementioned planning matrix and the tables reporting the main harvest/transportation planning decisions (i.e. Table 40 in Chilean case 1; Table 51 in US case 4; Table 64 in French case 11; Table 75 in Canadian case 15; Table 84 in Polish case 18; Table 92 in Swedish case 19), a list of 13 generic planning decisions at the operational level was identified. Table 20 details each of these decisions.

Table 20: Description of the generic planning decisions

Process	**Generic planning decision**	**Description**
Select/Buy block	Harvest units sourcing	Decisions related to determining harvest unit(s) to select or purchase.
Schedule harvesting	Harvest units scheduling	Decisions related to the time sequencing of harvest units.
	Assortments to produce per harvest unit and allocation to demand	Decisions related to determining the set of assortments to produce in a given harvest unit and which demands should be allocated their expected volume.
	Bucking/merchandising instructions and sorting rules per harvest unit	Decisions related to determining the bucking/merchandising instructions to be followed by the harvest unit and how to perform sorting at roadside.
	Harvest equipment selection per harvest unit	Decisions related to determining the type of harvesting method and type of equipment to use in each harvest unit.
	Harvest unit layout	Decisions related to the harvesting and primary transportation route within the harvesting unit and the number, localisation and capacity of the roadside inventory landing(s).
	Harvest unit assignment to contractors/teams	Decisions related to determining the contractor or harvesting team to assign to each harvest unit.
	Harvest crew scheduling	Decisions related to the definition of work shifts for the harvest crew and, in mechanised harvesting, the operator-equipment assignment.
Schedule secondary transportation	Assortments (re)allocation to the demand	Decisions related to determining the allocation of the harvested volume (by assortment and by harvest unit) to the demand.
	Transportation crew scheduling	Decisions related to the definition of work shifts for the transportation crew and operator-equipment assignment.
	Balance transportation with harvesting, inventory and reception	Decisions related to balancing the deliveries (demand) at reception points according to actual volume (inventory), future volume input (harvesting) and reception capacities over a time period.
	Assigning transportation quotas to contractors	Decisions related to determining which contractor to assign each volume (by assortment and by harvest unit) to be delivered to a specific demand.
	Transportation equipment routing and scheduling	Decisions related to determining which pickup and delivery route (truck) and loading/unloading tasks (loader) will be performed by the equipment, or their replanning according to the actual situation.

Appendix 2: Exploratory literature review

WP-5100 Alternative logistics concepts fitting different wood supply situations and markets

Exploratory literature review (Task 1)

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Preface

The redaction of this document fulfils an objective related to Task 1 of Working Package 5100 (WP-5100) in the research project *Flexible Wood Supply Chain* (FlexWood), a major European Union funded research initiative. Consequently, the diffusion of this document is restricted to the 14 FlexWood partners until the end of the FlexWood project. FlexWood begins with the assumption that wood supply chains in the forest products industry are not able to make full use of the real value of raw materials. The overall objective of FlexWood is therefore to build a novel logistics system that would provide value recovery and generation along the wood supply chain. FlexWood involves fourteen partners representing nine countries and is comprised of leading SMEs, universities and research centres and associations, which contribute complementary experience and expertise. For more details, see: http://www.flexwood-eu.org.

WP-5100 is led by the FORAC Research Consortium of Laval University (Canada) in partnership with Skogforsk – The Forestry Research Institute of Sweden (Sweden). The research is conducted under the supervision of Dr. Sophie D'Amours, professor in industrial engineering at Laval University and director of research and administration of FORAC Research Consortium, with the collaboration of Dr. Luc Lebel, professor in forest operations at Laval University and Dr Mikael Rönnqvist, professor in management science at the Norwegian School of Economics and Business Administration. The research team is completed by Karin Westlund, research professional in the logistics program at the Forestry Research Institute of Sweden (Skogforsk), Anna Furness-Lindén, research professional in the technology program at Skogforsk, and Jean-François Audy, doctoral student and research professional at the FORAC Research Consortium, Laval University. Jonathan Gaudreault, research professional at the FORAC Research Consortium, provides a link with other research projects at the FORAC Research Consortium.

Abstract
After a background introduction to supply chain management and logistics, this document provides an exploratory literature review structured in three sections. First, we review literature on performance measurement of supply chain and then, on the definition and assessment of the agility, the competitiveness and the customisation capacity of a supply chain. Second, we review reference models for supply chains and their management processes as well as typologies to characterise supply chain, value chain, service and collaborative planning in a supply chain. Third, we review the scarce literature on mapping supply chain in the forest products industry and various publications and concepts that could potentially contribute to WP-5100.

Introduction

We know that the configuration of Wood Supply Systems (WSS)[23] and their associated logistics concepts contribute greatly to the global performance of the forest products industry sector. We also know that the configuration and logistics concepts are motivated by precise contextual elements and adapted to fit precise needs and respond to various constraints applied by the operational environment. Sometimes, however, systems have inherited features and processes from past history. These features are often preserved without rationally scrutinizing their maintained relevance. We know that the context is changing more rapidly than ever before and that great potential lies in actively handling system adaptations.

The overall background of WP-5000 is an identified need to support the evaluation and design of innovative WSS for a better integration of the forest to mills within the supply chain of the forest products industry. Specifically for WP-5100, we have three objectives in our study which analyse alternative configurations and logistics concepts that fit different wood supply situations and markets. These objectives are:

> #1 - develop a framework to describe and represent any wood supply system in which the agility, competiveness and customisation capability of the system are highlighted;
>
> #2 - use the developed framework to study wood supply systems in different parts of the world;
>
> #3 - analyse and compare each studied wood supply system to identify basic designs of planning systems. Describe each of them with their logistics concepts and analyse their positive and negative impacts on agility, competiveness and customisation capability.

To provide a theoretical basis for the research works in WP 5100, an exploratory literature review was included in the WP-5100 detailed project plan (Audy et al., 2009). <u>We emphasise the qualifier 'exploratory' since the reviewed material could potentially contribute to WP-5100</u>. The review was structured according to four themes (see Table 1). For each of them, we explore existing research works and applications in the forest products industry and in other industries.

Table 1 : Themes in the literature review

i) Identify and describe the key features of a WSS.
ii) Find suitable key performance indicators (KPIs) tailored to measure the performance of WSS regarding the key features identified in (i).
iii) Summarise the theory on supply chain mapping, and identify generic methodologies that are used to represent and describe (i.e. map) supply chains.
iv) Review existing research aiming to measure and map supply chains in the forest products industry as well as other research that could provide input information (e.g. lists of actors, decisions and main constraints in WSS) in the development of our framework.

The document is structured as follows. In Section 0, we provide a background introduction to supply chain management and logistics. Section 2 includes the review on themes (i) and (ii) and Sections 3 and 4 are, the review on themes (iii) and (iv), respectively. Finally, a conclusion is provided.

[23] The WSS studied in WP-5100 spans from the measurement of the forest to the delivery of raw material at the mill gates and the focus is on short-term planning decisions and operations in the system. Thus, silvicultural and other pre-commercial operations as well as mid/long-term planning decisions are not explicitly targeted in the study, even though they will be indirectly discussed to capture their positive and negative impacts on the system.

1. Background on supply chain management and logistics

The Flexwood team benefits from 14 partners with expertise in various and complementary domains. The research works in WP-5100 are largely based on the research domain of supply chain management and logistics. Thus, in this section we provide a short background introduction to supply chain management and logistics. We also discuss about supply chain management and logistics in WSS.

The terms supply chain and supply chain management first appeared in 1982 (Kannegiesser, 2008) and since that time, various definitions of both terms have been proposed in the literature, see e.g. Stadler (2008) and Kannegiesser (2008) for more details.

A supply chain is a ''network of organisations that are involved, through upstream and downstream linkages [of, essentially, material, information and financial flows], in different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" Christopher (2005).

According to Kannegiesser (2008), there are two core ideas in the supply chain concept:

- a better collaboration between companies in the same supply chain will help to improve delivery service, better manage utilisation and save costs particularly for holding inventories (Alicke, 2005);

- individual businesses can no longer compete as solely autonomous entities, but rather as supply chains (Christopher, 2005) or, in other words by Lambert and Cooper (2000), ''one of the most significant paradigm shifts of modern business management is that individual organisations can no longer compete as solely autonomous entities, but rather as supply chains''.

Supply chain management is ''the task of integrating organisational units along a supply chain and coordinating material, information and financial flows in order to fulfil (ultimate) customer demand with the aim of improving the competitiveness of a supply chain as a whole'' (Stadler and Kilger, 2008). Thus, supply chain management ''encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.'' (CSCMP, 2010a).

Based on their review of SCM definitions, Mentzer et al. (2001) propose that SCM as a management philosophy has three main characteristics:

- a system approach viewing the supply chain as a whole with the total flow of goods inventory managed from the supplier to the ultimate customer;

- a strategic orientation toward cooperative efforts to synchronise and converge intra-firm and inter-firm operational and strategic capabilities into a unified whole;

- a customer focus to create unique and individualised sources of customer value, leading to customer satisfaction.

Logistics originated in the 1950s, motivated by the complexity in the coordination and management of material and personnel in the military sector (Kannegiesser, 2008). Logistics is "the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from their point of origin to point of consumption for the purpose of conforming to customer requirements" (Kannegiesser, 2008). ''Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flows and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements'' (CSCMP, 2010a).

A common understanding is that logistics is flows of goods, information and money within a defined system. When the system is defined as a factory, for example, the logistics is quite easy to visualize: goods will be processed and refined at stations inside the factory, customer demand will be translated into information on production plans, selling price will generate monetary flows into the factory for salaries, etc. However, nowadays, it's very rare (if it even exists at all) to have complete in-house industrial production. Over time, many comparative advantages, have led to increased trade along with industrialization and globalization. According to a study made with European companies (Soellner, 1997), the proportion of generated value from the supplier of the total value generated by the manufacture of a product is constantly increasing (see Figure 1). Following this trend, the discipline of supply chain management has inevitably evolved in the industrial world. Rather than proceed company by company, clusters of companies (i.e. supply chains) make up a meaningful unitary system that can be analyzed and managed when it comes to logistics.

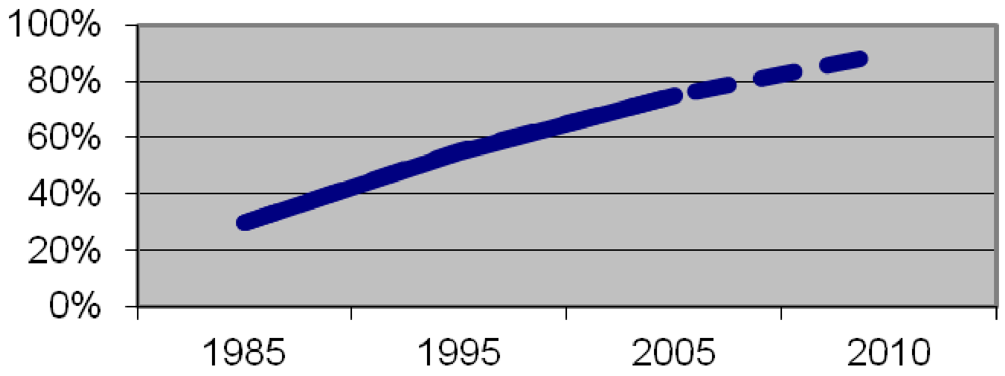

Figure 1: Share of supplier value of the total value of product produced (Soellner, 1997)

The literature on supply chain management is endless and there exist numerous suggestions and refined versions of the concept (e.g. demand chain management, supply chain engineering), but the common perception remains unchanged. The supply chain challenge is to manage and optimize the value creating flows of activities that ensue, and hence are interdependent on several legal units. In order to efficiently manage modern production processes, we need to manage supply chains.

Moreover, the forest industry has evolved in this general direction. In the old days in many forested countries, growing timber was the property of the company that owned the sawmill(s) and the pulp and paper mill(s). The timber was harvested and hauled to mill gate by employees. However, in most countries today, forestry consists of complex value chains with several independent actors that yet depend on each other and the competitiveness and profit of the supply chain as a whole. Contractors, carrying out logging, silviculture, planning, hauling and timber transportation are contracted by companies that either own the timberland and/or the mills. The primary and secondary markets for the mill products are of course spread worldwide. It makes great sense to apply general supply chain theory and knowledge to forestry processes.

2. Performance measurement, agility, competitiveness and customisation capacity of a supply chain

This section aims at providing an exploratory review of themes (i) and (ii), which are:

i) Identify and describe the key features of a WSS.

ii) Find suitable key performance indicators (KPIs) tailored to measure the performance of WSS regarding the key features identified in (i).

We consider themes (i) and (ii) together using research on supply chain performance measurement system. Performance measurement can be defined as "the process of quantifying the efficiency and effectiveness of an action" (Neely et al., 1995; Gunasekaran and Kobu, 2007). A performance measurement system can be defined as "the set of metrics used to quantify both the efficiency and effectiveness of actions'' (Neely et al., 1995). Here, metric refers to the definition of the measure, how it will be calculated, who will be performing the calculation, and from where the data will be obtained (Neely et al., 1995).

A review of the literature and discussions with different experts in forest operations (Glen Murphy, Oregon State University; Reino Pulkki, Lakehead University; Luc LeBel, Laval University; Jean Favreau, FPInnovations-Forest Operations, personal communications, March to May 2010) have resulted in a conclusion that there is an absence of publications on supply chain performance measurement applied to a WSS. However, we did find publications on performance measurement system for some business entities in the WSS and we summarise these.

Based on a wide survey of forest harvesting entrepreneurs (n = 336) in the province of Quebec (Canada), Drolet and LeBel (2009) report that forest harvesting entrepreneurs focus essentially on production metrics such as 'cubic metre per productive hour' or 'utilisation rate'. Moreover, a list of the 17 best performance metrics according to the 336 forest harvesting entrepreneurs in the survey is provided. Pomerleau (2003) provides a list of performance metrics that allow the procurement department of a forest company to manage the performance of three subcontracted operations: i) harvesting, ii) construction of first class's road and iii) construction of second class's road. For each operation, the metrics are classified in four categories: cost, quality, productivity and yield.

The EFORWOOD project (EFORWOOD, 2010) provides a set of sustainability indicators to assess the sustainability performance of a WSS. The sustainability indicators are regrouped in the three fundamental components that define the sustainable development: economic (e.g. investment and R&D, gross value added), social (e.g. education and training, innovation) and environmental (e.g. forest biodiversity, energy generation and use). A computerized decision-support tool, ToSIA, that embedded the calculation of these indicators for a specific scenario of WSS, has also been developed in this project.

The first level of the SCOR model version 9 (see Subsection 0 for a discussion on the SCOR model) provides a set of ten metrics on SC performance that, according to the Supply Chain Council, are generic for supply chain of any industrial sector (SCC, 2008). Table 2 summarises the ten metrics.

Table 2: Definition of the strategic performance metrics in the SCOR model version 9 (SCC, 2008)

Performance attribute	Definition	Metric of level 1
Supply chain reliability	The performance of a supply chain in delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Perfect order fulfilment
Supply chain responsiveness	The speed at which a supply chain provides products to the customer.	Order fulfilment cycle time
Supply chain agility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Upside supply chain flexibility
		Upside supply chain adaptability
		Downside supply chain adaptability
Supply chain costs	The costs associated with operating the supply chain.	Supply chain management cost
		Cost of goods sold
Supply chain asset management	The effectiveness of an organisation in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-cash cycle time
		Return on supply chain fixed assets
		Return on working capital

Metrics could also be found in survey and literature reviews on SC performance measurement (Neely et al., 1995; Gunasekaran et al., 2004; Shepherd and Günter (2006); Gunasekaran and Kobu, 2007; Arzu Akyuz and Erman Erkan, 2010; Payne, 2010), in levels 2 and 3 of the SCOR model (SCC, 2008) and in the Gartner Business Value Model (Smith et al., 2006). Beamon (1998) also report performance measures in supply chain modelling according to six perspectives: cost, customer, responsiveness, cost & customer responsiveness, cost & activity time, and, finally, flexibility.

In practice, many of the SC metrics are correlated and have a cause-effect relationship (Cai et al., 2009, Payne, 2010). For instance, a production department aims to maximize productivity with a long production program which entails inventories and late deliveries. Payne (2010) provides an example of a relationship map among a set of SC metrics (see Figure 2).

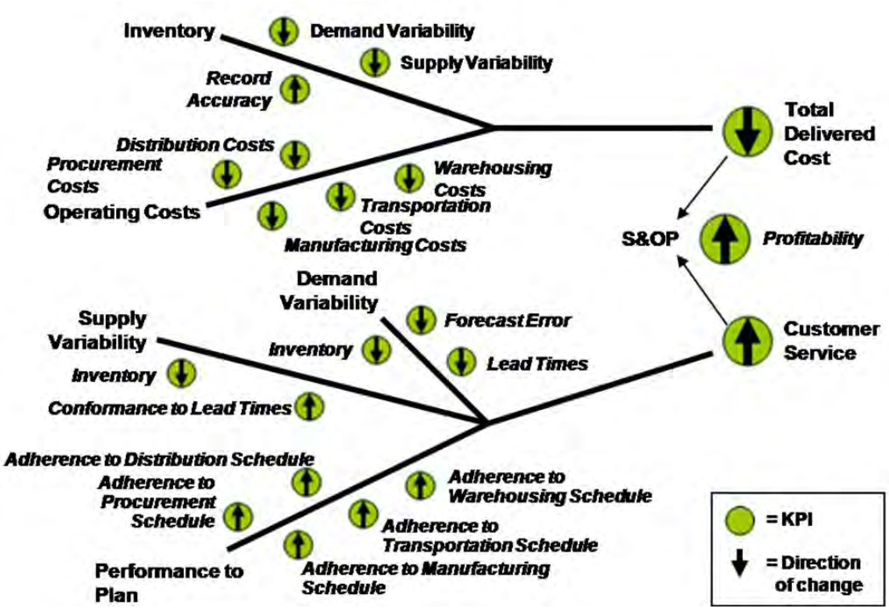

Figure 2: relationship map among a set of SC metrics (Payne, 2010)

According to Cai et al. (2009), pairs of metrics exist with a high correlation to each other. These pairs of metrics must be identified and the nature of their pair-wise relationships can be classified in three categories: parallel, coupled and sequential. A parallel relationship involves two metrics independent of each other (i.e. the efforts to accomplish them are not related), while the opposite is true for a coupled relationship. A sequential relationship usually implies a simple cause–effect relationship (i.e. the effort of accomplishing a metric result in extra cost to the other).

As mentioned in the WP-5100 description (Annex I - "Description of Work"), three attributes of wood supply chain planning systems will be specifically studied: agility, competitiveness and customisation (note: named as tailoring).

2.1 Agility

Based on a review of the several definitions proposed in the literature, Li et al. (2008) provide a unified definition of agility: ''An organisation's supply chain agility is the result of integrating the supply chain's alertness to changes (opportunities/challenges) – both internal and environmental – with the supply chain's capability to use resources in responding (proactively/reactively) to such changes, all in a timely and flexible manner.'' This unified definition of supply chain agility conceives agility in terms of two key dimensions (alertness and response capability), two directions (internal and environmental), two modes (reactive and proactive), and two measures of the degree of agility (timeliness and flexibility).

According to Li et al. (2008, 2009), there are two key components for agility: alertness to changes and response capability. Moreover, Li et al. (2008) divide agility into six dimensions: strategic alertness (SA), strategic response capability (SRC), operational alertness (OA), operational response capability (ORC), episodic alertness (EA) and episodic response capability (ERC). Including two items by dimension to evaluate with a five-point Likert-type scale (with 1 - low, 5 – high), Li et al. (2008) provide a list of 12 measurement items to assess supply chain agility (see Table 3).

Table 3 : Measurements of agility by Li et al. (2008)

SA 1- Detect strategic opportunities/challenges in a timely manner (e.g. new competitor movement, new economic tendency, new technology, and new market).
SA 2- Use many channels to keep aware of strategic opportunities/challenges.
SRC 1 – Reconfigure supply chain resources in a timely manner to respond to strategic opportunities/challenges.
SRC 2 – Reconfigure supply chain resources in a flexible manner to respond to strategic opportunities/challenges.
OA 1 – Detect changes in supply/demand in a timely manner.
OA 2 – Use many channels to keep aware of changes in supply/demand.
ORC 1 – Reconfigure supply chain resources in a timely manner to respond to changes in supply/demand.
ORC 2 - Reconfigure supply chain resources in a flexible manner to respond to changes in supply/demand.
EA 1 – Detect changes in supply chain daily execution in a timely manner.
EA 2 – Use many channels to keep aware of changes in supply chain daily execution.
ERC 1 - Reconfigure supply chain resources in a timely manner to respond to changes in daily supply chain execution.
ERC 2 - Reconfigure supply chain resources in a flexible manner to respond to changes in daily supply chain execution.
Legend: strategic alertness (SA), strategic response capability (SRC), operational alertness (OA), operational response capability (ORC), episodic alertness (EA) and episodic response capability (ERC)

In the SCOR model, the agility of an SC is one of the five performance attributes (see Table 2) and is about ''responding to marketplace changes to gain or maintain competitive advantage''. Three level 1 metrics are provided: Upside Supply Chain Flexibility (AG.1.1), Upside Supply Chain Adaptability (AG.1.2) and Downside Supply Chain Adaptability (AG.1.3) (see Table 4). A parameter value (i.e. number of day or percentage increase or decrease) must be set on each metrics according to the business context of the industry sector. We set this parameter value according to a recommendation by the Chief Technology Officer of the Supply Chain Council (Caspar Hunsche, personal communication, August 2010) and their mandated firm for benchmarking with the SCOR model (Erin Willians, personal communication, August 2010).

Table 4 : Three level 1 metrics of agility in the SCOR model

Metrics	Definition
Upside Supply Chain Flexibility	The number of days required to achieve an unplanned sustainable 20% increase in quantities delivered.
Upside Supply Chain Adaptability	The maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days.
Downside Supply Chain Adaptability	The percentage reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory or cost penalties.

To fit better with the two key components of agility according to Li et al. (2008, 2009), we should consider the 'SC Responsiveness' performance attribute in the SCOR model which is defined as ''the speed at which an SC provides products to the customer'' with one metric: Order Fulfilment Cycle Time. In the context of a WSS, we can use it as an average order fulfilment cycle time. For instance in a cut-to-length harvesting method with direct truck delivery, this average order fulfilment cycle time will be the summation of the average times: 1) between order received and harvesting equipment moved to the harvesting track; 2) after the moving of the equipment until harvesting begins; 3) in inventory on the ground in the harvesting track area; 4) forwarding to the roadside (considering the average forwarding distance of the track); 5) in inventory at the roadside; and 6) loading, transportation (considering the average[24] travelling distance to the delivery mills) and unloading at the mills. Of course, circumstances could require differentiating several average times (e.g. seasonality with distinct average order fulfilment cycle time during the year).

Also, for logical purposes, we will also add the 'SC reliability' performance attribute in the SCOR model which is defined as ''the performance of the supply chain in delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer'' with one metric: Perfect Order Fulfilment (in percentage). A differentiation by type of product could be required.

2.2 Competitiveness

Based on the recent work by Lee and Wilhelm (2010), we detail three main concepts to support our further evaluation of the competitiveness of a WSS: comparative advantage, sustained competitive advantage, and competitiveness at the firm/company level. We also discuss the competitive intensity in an industry and the typology for the competitive strategy of a supply chain.

2.2.1 Comparative advantage

Krugman and Obstfeld (2006) mention that ''a country has a comparative advantage in producing a good if the opportunity cost of producing that good in terms of other goods is lower in that country than it is in other countries''. We can adapt this definition to the aim of the project by changing 'country' to 'wood supply chain'. Also, the meaning of opportunity cost should be extended beyond the restrictive monetary aspect to consider, e.g. hours of labour required to harvest a specific quantity of cubic metres.

2.2.2 Sustained competitive advantage

Barney (1991) provided a widely accepted definition of competitive advantage relative to a company (Lee and Wilhelm, 2010): ''a firm is said to have a competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors.'' Li et al. (2006) described competitive advantage as ''the extent to which an organisation is able to create defensible position over its competitors'' and based on previous works, propose five dimensions of competitive advantage: price/cost, quality, delivery dependability, product innovation and time to market. Some authors (e.g. Tracey et al. (1999), Li et al. (2006), Cao and Zhang (2008), Lakhal (2009)) propose evaluating a set of statements on each dimension with a five-point Likert-type scale. We summarize them in Table 5.

Barney (1991) states that a firm is said to have a sustained competitive advantage when it has a competitive advantage and its competitors are unable to duplicate the benefits of its value creating strategy. Again, we can adapt these definitions to the aim of the project by changing 'firm/organisation' by 'wood supply chain'.

Lee and Wilhelm (2010) report many studies on how firms generate and sustain a competitive advantage through using innovative management skills and one of these skills is supply chain management practices. Indeed, Li et al. (2006) mention that ''effective supply chain management has become a potentially valuable way of securing competitive advantage and improving organisational performance since competition is no longer between organisations, but among supply chains.''

Moreover, we should note that the latter part of the citation of Li et al. (2006) is one of the many repetitions in the MS, OR & SCM literature (i.e., Management Sciences, Operations Research and Supply Chain Management) of the first core idea in the supply chain concept (see Section 1).

Table 5 : Statements on the five dimensions of competitive advantage

Price/cost: an organisation is capable of competing against major competitors based on low price.
We offer competitive prices.
We are able to compete based on our prices.

[24] An average distance that takes into account the proportion of the total volume delivery to each mill.

We are able to offer prices as low or lower than our competitors.
Quality: an organisation is capable of offering product quality and performance that creates higher value for customers
We are able to compete based on quality.
We offer products that are highly reliable.
We offer products that are very durable.
We offer high quality products to our customer.
Product innovation and Product line breadth: an organisation is capable of introducing new products and features in the marketplace
We respond well to changing customer preferences regarding products.
We respond well to changing customer preferences regarding accompanying services.
We provide customised products.
We alter our product offerings to meet client needs.
We respond well to customer demand for 'new' features.
Time to market: an organisation is capable of introducing new products faster than major competitors
We are first in the market in introducing new products
We have time-to-market lower than industry average.
We have fast product development.
Delivery dependability, frequency and flexibility: an organisation is capable of providing on time the type and volume of product required by customer(s).
We supply accurate projected shipping dates.
We supply accurate projected delivery dates.
We deliver customer order on time.
We provide dependable delivery.
Our customers are pleased with the frequency of our delivery.
We can alter our delivery schedule per each customer's requirements.
We are flexible in developing delivery schedules
We work with each customer to develop a delivery schedule that is acceptable.

2.2.3 Competitiveness at the firm/company level

Lee and Wilhelm (2010) mention that ''competitiveness has been a controversial notion and few agree on a precise definition (Ezeala-Harrison, 2005), although numerous definitions have been proposed''. Among the different definitions reported by Lee and Wilhelm (2010), we select the two definitions formulated at the firm/company level instead of industry or nation/country level. Thus, we can again adapt these definitions to the aim of the project by changing 'firm/company' to 'wood supply chain'.

Ambastha and Momaya (2004) defined competitiveness as ''the ability of a firm to design, produce and or market products superior to those offered by competitors, considering price and non-price qualities'' The TCI Network (2010) (former The Competitiveness Institute) defines competitiveness for a company as ''the ability to provide products and services as (or more) effectively and efficiently than relevant competitors''.

2.2.4 Competitive intensity in an industry

We refer to the competitive intensity inside an industry as an indicator of the level of the various pressures that force companies to continuously take action, both in terms of operational performance as well as strategic positioning, to stay competitive in its industry. Using a seven-point Likert scale, Hallgren and Olhager (2006) provide an evaluation in four statements of the competitive intensity of an industry (see Table 6).

Table 6 : Statements on the competitive intensity of an industry

We are in a highly competitive industry.
Our competitive pressures are extremely high.
Competitive moves in our market are slow and deliberate, with long time gaps between different companies' reactions (reverse coded).
We don't pay much attention to our competitors (reverse coded).

2.2.5 Competitive strategy

Competitive strategy addresses ''how an organisation chooses to compete in a market, particularly the issue of positioning the company relative to competitors with the aim of establishing a profitable and sustainable position'' (Hallgren and Olhager, 2006). Distinguishing among three major strategies to competitiveness (i.e. cost leadership, differentiation, and focus), the typology for competitive strategy of a company by Porter (1985) is probably the most well-known typology according to Hallgren and Olhager (2006). Cost-leadership means that the company takes the competition head on, offering a product that is equivalent to those offered by competitors, but more efficiently (e.g. cheaper price) than competitors. The differentiation is to avoid direct competition by differentiating the products and/or services offered to deliver higher customer value, making it possible to charge a premium price. The focus strategy is to target one or more market segments of the company's markets.

There are two opposing schools of thought concerning the typology by Porter, i.e. the first maintains that to perform, a company can have only one strategy, while the other maintains that a company can have many strategies (Yamin et al., 1997). Furthermore, as reported by Hallgren and Olhager (2006), several authors reduce the three strategies of Porter to two: cost leadership or differentiation strategies even in a focus strategy. Using a five-point Likert scale (from "absolutely crucial" to "least important"), Hallgren and Olhager (2006) propose identifying the importance of four goals (see Table 7) in order to evaluate to which strategy a company strives.

Table 7 : Strategy of a company according to four goals

Low price
Low manufacturing unit cost
Ability to rapidly change over product on short notice
Ability to vary volume of product produced on short notice

Treacy and Wiersema (1993) discriminated between strategies aiming for operational excellence, customer intimacy, and product leadership. Reimann et al. (2010) provide a set of statements to measure, each of them using a five-point Likert scale (see Table 8).

Table 8 : Statements on competitive strategy

Operational excellence
We continuously improve our processes in order to keep costs low
We constantly improve our operating efficiency.
We continuously strive for product cost reduction.
Product leadership
We continuously refine and improve existing products.
We have a high share of new products in our product portfolio.

We undertake new product development above the industry average.
The design and functionality of our products is crucial to our competitive positioning.
Our brand is different from other brands in terms of actual product attributes (features that can be physically identified by touch, smell, sight, taste etc.)
Our brand is different from other brands in terms of overall perceived quality (including non-tangible, psychological perceptions of the customer).
Customer intimacy
Our company's strategy to achieve competitive advantage is based on our thorough understanding of our customers' needs.
We design or produce our products to order.
Orders are packaged and shipped in a way appropriate to each customer.
Our employees are encouraged to focus on customer relationships.
We conduct advertising at a level above the industry average.
We conduct promotions at a level above the industry average.

2.3 Customisation

Customisation for a firm/company[25] refers to the design of its offers to the market, including the corresponding manufacturing or service capacities, based on a targeted segmentation of customers. In other words, '(...) when firms design their offers to the market, they decide on the appropriate combination of personalization levels in each market segment, in function of their capabilities, the market and client needs, and shareholder interests' (Poulin et al., 2006). As quoted from Montreuil and Poulin (2005), 'The goal with personalizing is to gradually develop the competitiveness of the firm by having an offer that closely matches the evolving personalized expectations of customers in the targeted segments and by having the [manufacturing] capability to profitably deliver the offer on a reliable basis'.
Poulin et al. (2006) propose a framework classifying customisation (called 'personalisation') in eight different alternatives: popularising, varietising, accessorising, parametering, tailoring, adjusting, monitoring and collaborating (see Table 9).

Table 9 : Customization framework by Poulin et al. (2006)

Customisation option	Characteristics
Popularising	Limited number of products to match a wide variety of customer needs, for those who want off-the-shelf products. Focus on evolving the popular product mix in line with evolving customer needs.
Varietising	Extensive mix of products to satisfy almost all customer needs. Retailers pick those they want to offer off-the-shelf and rely on quick delivery from the distribution network for fast delivery of the others.
Accessorising	A limited set of core products matched with a wide array of accessories. Final assembly of accessorised products performed to order either by the user, the retailer or a fulfilment centre.
Parametering	Customer defines the desired product through the setting of parameters and the selection of options. He is guided through the specification process. Manufacturing is strictly to order.
Tailoring	Product designed/engineered to customer needs. The customer is closely involved in the product realisation process.
Adjusting	Product adjusted to customer needs after usage. Distributed information systems capture customer feedback.
Monitoring	Product is replaced by more adequate product as the customer needs evolve, ensuring continually a best-fit product. This involves regular and interactive customer feedback.

[25] In WP-5100, we will focus at the WSS level rather than at the firm/company level.

Collaborating	Client is viewed as a collaborator with an open dialogue. Expert field systems interact with clients, seeking to continually optimise client return.

Poulin et al. (2006) applied their framework to a golf gear supply chain. Azouzi et al. (2009) use a simplification of this framework in a case study in the furniture industry. The framework by Poulin et al. (2006) has been developed according to a 'product industry' perspective. Consequently, we should expand the framework to handle the customisation alternative existing in the 'service industry' (e.g. harvesting, transportation) of the WSS.

A concept that is a close opposite to customisation is commoditisation. Matthyssens and Vandenbempt (2008) define commoditisation as ''a dynamic process that erodes the competitive differentiation potential and consequently deteriorates the financial position of any organisation''. The ''commoditisation of an industry describes an increase in similarity between the offerings of competitors in an industry, an increase in customer price sensitivity, a decrease in customer cost of switching from one to another supplier in an industry, and an increase in the stability of the competitive structure'' (Reinmann et al., 2010).

Reinmann et al. (2010) propose four dimensions for the commoditisation level of an industry: product homogeneity, price sensitivity, switching cost and industry stability. Reinmann et al. (2010) also propose evaluating a set of statements on each dimension with a five-point Likert scale (see Table 10)

Table 10 : Statements on industry commoditization level

Product homogeneity
In our industry, most products have no intrinsic differences from competing offerings.
In our industry, product offerings are highly standardised.
In our industry, homogeneity of technology and markets is high.
In our industry, many products are identical in quality and performance.
Price sensitivity
In our industry, customers check prices even for low-value products.
In our industry, customers buy the lowest-priced products that will suit their needs.
In our industry, customers rely heavily on price when it comes to choosing a product
Switching cost
In our industry, customers' costs in switching to another supplier (switching cost) are low.
In our industry, applying another supplier's product would be easy for the customer.
In our industry, the process of switching to a new supplier is quick and easy for the customer.
In our industry, switching to a new supplier does not bear risk for the customer.
Industry stability
In our industry, there are no frequent changes in customer preferences.
In our industry, there are no frequent changes in the product mix of suppliers
In our industry, technology changes are slow and predictable.
In our industry, product obsolescence is slow.

2.4 Other performance attributes in the SCOR model

The SCOR model considers a total of five SCM performance attributes of the SCOR model. We report the two performance attributes not previously considered (SCC, 2008):

- The costs associated with operating the supply chain. Two metrics: Supply Chain Management Cost and Cost of Goods Sold.

- The effectiveness of an organisation (note: we have no focal company, so we should use ''the effectiveness of the business entities in the wood supply chain'' instead of ''an organisation'') in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital. Three metrics: Cash-to-Cash Cycle Time, Return on Supply Chain Fixed Assets, Return on Working Capital.

3. Mapping of supply chains

This section aims to provide an exploratory review of themes (iii), which is:

iii) Summarise the theory on supply chain mapping, and identify generic methodologies that are used to represent and describe (i.e. map) supply chains.

In Subsection 0, we review six supply chain management reference models as well as two models of supply chain management processes. Then, in Subsection 0, we review typologies to characterise supply and value chain, a service and collaborative planning in a supply chain.

3.1 Models

Fettke et al. (2006) provide a survey and a classification scheme of business process reference models. They analyse 30 models based on several criteria such as: the origin of the model (e.g. science, practice), accessibility (i.e. open or closed), the application domain, the process modelling languages used, the size of the model and the construction method. One reference model has an application domain for supply chain management, the SCOR model, while another model has an application domain in production, planning and control system, the Aachen PPC model. We review both of them in the following subsections.

In a recent PhD Thesis, Blecken (2009) provides an overview of 26 reference models that fulfil the following criteria:

- the reference information model is the outcome of the construction of a modeller who declares information about universal elements of a system relevant for application system or organisation developers to solve a specific task at a given time in a given language in such a way that a point of reference for an information system is created;

- the reference model addresses either the tasks or activities of supply chain management and logistics or the reference model has a dedicated focus on business processes.

Based on its overview, Blecken (2009) provides a review of six reference models which fulfil the following criteria:

- the reference model addresses tasks and activities of supply chain management and logistics;

- the reference model provides some guidance with respect to business processes of supply chain management and logistics;

- the size and level of detail of the reference model are sufficient to provide concrete recommendations for organisations;

- the reference model has been evaluated through the application in practice or in case studies;

- the reference model employs a standardised (semi-) formal language.

In this subsection, we review the six supply chain management reference models that fulfil the criteria of Blecken (2009) as well as two models of supply chain management processes.

3.3.1 SCOR model version 9

The Supply Chain Operations Reference model (SCOR model) has been developed to describe the business activities associated with all phases of satisfying a customer's demand (SCC, 2008). The model focusses on one enterprise and spans from its supplier's supplier to its customer's customer. The SCOR model is organised around five processes types, see Table Table 11. By describing supply chains using these process building blocks, the SCOR model can be used to describe supply chains that are very simple or very complex using a common set of definitions (SCC, 2008). The SCOR model being a hierarchic model, the five processes types (level 1) then extend in two other levels: process categories (level 2) and process element (level 3). For the execution process types Source, Make and Deliver, Levels 2 and 3 then extend according to three supply chain configuration possibilities of the Customer Order Decoupling Point (see above for details on CODP): make-to-stock, make-to-order and engineer-to-order. The SCOR model also includes supply chain performance metrics, best practices and, for each process type, enables elements. Bolstorff and Rosenbaum (2007) provide a step-by-step methodology using the SCOR model version 8 to support managers in achieving improvement projects in their supply chain processes.

Table 11 : Processes types of the SCOR model (Bolstorff and Rosenbaum, 2007)

Generic process	Definition
Plan	Assess supply resources, aggregate and prioritise demand requirements, plan inventory for distribution, production, and material requirements, and plan rough-cut capacity for all products and channels.
Source	Obtain, receive, inspect, hold, issue, and authorise payment for raw materials and purchased finished goods
Make	Request and receive material, manufacture and test products, package, hold, and/or release products
Deliver	Execute order management process, generate quotations, configure product, create and maintain product/price database, manage accounts receivable, credits, collections, and invoicing, execute warehouse processes including pick, pack, and configure, create customer-specific packaging/labelling, consolidate orders, ship products, manage transportation processes and import/export, and verify performance;
Return	Defective [products], warranty, and excess return processing, including authorisation, scheduling, inspection, transfer, warranty administration, receiving and verifying defective products, disposal, and replacement

The SCOR model is still evolving. A preview of the new version 10 of the SCOR model was released online June 30, 2010 (SCC, 2010). The main novelty is the introduction in the SCOR model of standards definitions for workforce assets (i.e. the 'inventory' of skills in a supply chain), see Table 12. The SCOR model is silent on human resources and training in prior versions.

Table 12 : Workforce asset in SCOR model version 10 (SCC, 2010)

Workforce assets	Definition
HS-Skills	The capacity to deliver pre-determined results with the minimum input of time and energy.
HE-Experiences	The knowledge or skill acquired by observation or active participation over a period of time in a particular profession. Experience refers to know-how or procedural knowledge, rather than propositional knowledge: on-the-job training rather than book-learning.
HA-Aptitudes	A natural, acquired, learned or developed ability to do a certain kind of work at a certain level.
HT-Training	A particular skill or type of behavior learned through instruction over a period of time. Training refers to propositional knowledge, rather than know-how or procedural knowledge: book-learning and classroom-learning rather than on-the-job training.

3.3.2 ARIS House of Business Engineering model

A part of the review by Blecken (2009) is presented here, since the references on the ARIS House of Business Engineering model are available only in German:

''ARIS (Architecture of integrated information systems) provides a framework for the development, improvement, and implementation of integrated information and communication systems and aims to align enterprise information systems with all external and internal requirements. ARIS thus provides a framework which partitions the description of the model into perspectives and layers each with their own sets of modelling elements and languages.

ARIS provides several perspectives on an organisation, viz. the organisational view, data view, function view, control view, and output view. These perspectives are used as a means to reduce complexity of the overall system. Moreover, the redundant use of objects in the model is circumvented. The different perspectives can make use of different modelling techniques and languages. The organisational view denotes the class of organisational units and thus the organisational structure. Within the organisational structure, several task bearers are distinguished. The data view comprises all environmental data and messages which can trigger functions or which are created by the execution of functions. The function perspective illustrates all processes which transform input objects into output objects. Here, the notions of function, activity and process are used indiscriminately. Objectives of the organisation are also attributed to the function perspective since functions serve to pursue and are controlled by these objectives. The output view contains all material and immaterial input and output services including the financial flow. Lastly, the control or process view integrates all the latter perspectives and creates the framework for the systematic analysis of the bilateral relationships between the perspectives. The control view serves to model the control flow of the model, i.e. the temporal-logical sequence of the business process. While the first four perspectives describe the structure of the model, the latter process perspective portrays the dynamic, behavioural aspects of the business process flow.

ARIS foresees modelling the perspectives described before in a sequential and iterative process. The process models the three layers (functional) concept, data processing and implementation layer for each of the perspectives. The objective is to transform process-oriented models into information systems. In a first step, the functional concept is described independently of the applied information systems (requirements specification). Here, languages are chosen which are comprehensible from a business perspective but also formal enough that they can serve as the basis for an IT implementation. The data processing layer follows, in which it is defined how the contents of the functional concept layer can be implemented with information systems. Here, the requirements for the interfaces of implementation tools such as database systems or programming languages on the functional concepts are aligned (design specification). Lastly, the implementation layer is concerned with the construction of programming code and executable software.'' The entire ARIS model is displayed in Figure 3.

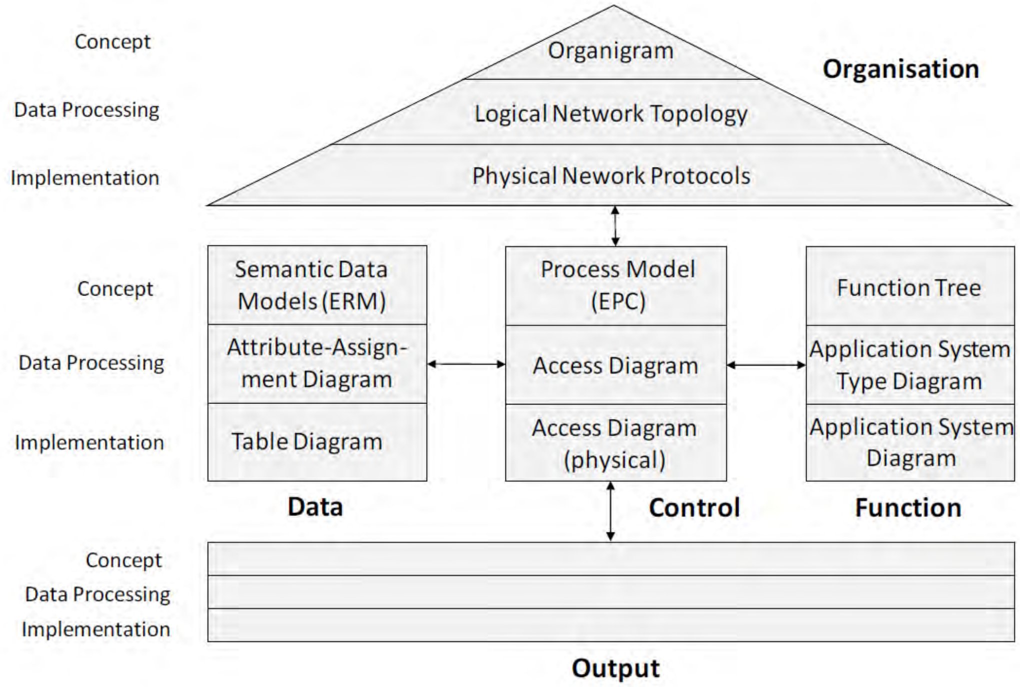

Figure 3 : ARIS House of Business Engineering model (Blecken, 2009)

3.3.3 R/3 model

A part of the review by Blecken (2009) is presented here, since the publication references on the R/3 model in English are scarce:

> ''The R/3 Reference Model is a comprehensive business process model that contains more than 4000 entity types in the data model and more than 1000 business processes and over 100 inter-organisational business scenarios in the process reference models. The R/3 Reference Model provides a comprehensive view of the main processes and business solutions available in the SAP R/3 system. It was developed based on SAP's empirical know-how of best practices in business processes of various industries. It is a tool that supports configuration of organisation-specific business processes. SAP has created a business blueprint which is a description of the R/3 Reference Model. The business blueprint has the objective to clarify what processes are decisive for supporting the organisations' activities and how these are linked. The R/3 Reference Model employs event-driven processes chains to provide templates for many different situations from "asset accounting" to "procurement" and "treasury".
>
> Five views are provided by the R/3 Reference Model: A Process view which displays the network event-driven process chains; a Function view which presents a summary of the business functions required for R/3; an Information flow-view which models the information flow between event-driven process chains; a Data view which clusters data structures required for the business processes; and an Organisation view illustrating the relationships between the organisational units of the enterprise.''

3.3.4 Retail-H model

A part of the review by Blecken (2009) is presented here, since the publication reference on the Retail-H (Becker and Schütte, 2006), is available in German only:

> ''Retail companies are the intermediaries of manufacturing companies and end consumers. They are characterised by a both temporal and spatial bridging function. Retail information systems are information systems which cover "not only merchandise tasks but also business administrative tasks as well as general controlling and company planning tasks." Retail information systems traditionally displayed certain weaknesses in terms of intra- and inter-company communication and coordination and legacy software architecture. The Retail-H was developed to address these shortcomings.

The Retail-H summarises the tasks of a retail company. The different views, function, data, and process, are distinguished similarly to the ARIS architecture. The function view lists all elementary functions of procurement, warehousing, distribution, administration, and strategic and tactical planning. The data view depicts the static structures in the form of ERMs. The process view determines the temporal-logical sequence of activities and combines functions and data together with the temporal aspect.

On the left side of the Retail-H [see Figure 4], the area of procurement is shown; the right side is composed of distribution and sales tasks. Warehousing is located in between these two and thus interconnects procurement and distribution. Procurement consists of contracting, purchasing, goods receipt, invoice verification, and creditor accounting. Distribution is comprised of marketing, sales, goods issue, billing and debtor accounting. The foundation of the model is composed of the functional areas general ledger and fixed-asset accounting, cost accounting and human resource management. Overarching the Retail-H are organisational tasks, viz. company planning, executive information systems and controlling. The information systems in the "roof" of the Retail-H aggregate data from the underlying layers to significant performance indicators which provide the basis for executive management decisions.''

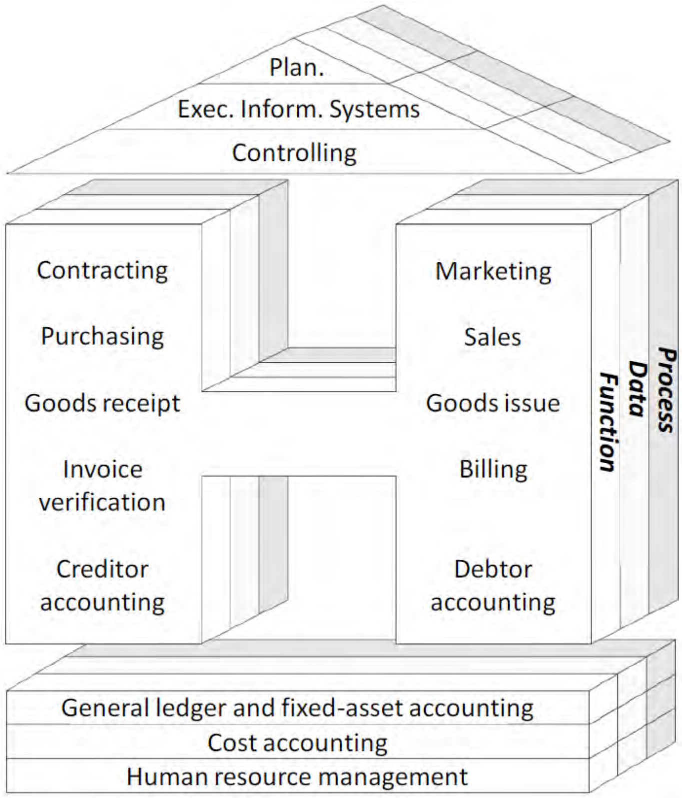

Figure 4 : The Retail-H model (Blecken, 2009)

3.3.5 Aachem PPC model

A part of the review by Blecken (2009) is presented here, since the publication reference on the Aachen PPC model (Schuh and Gierth, 2006), is available in German only:

''The Aachen Production Planning and Control model (Aachen PPC model) takes a holistic perspective on the production system. A company's and furthermore its suppliers' resources and processes need to be geared to create added-value and have to be aligned with the customers' requirements. The main objective is the optimisation of the production system. Thereby, a production system encompasses the entire production organisation including all concepts, methods, and tools. The interaction of these elements characterise the effectiveness and efficiency of the entire production flow. The Aachen PPC model has been developed to enable the implementation of projects focussing on the reorganisation of PPC as well as development, selection, and implementation of PPC concepts and systems.

Furthermore, the Aachen PPC model has the objective to describe production planning and control from different perspectives. Hence, reference views are created among which are the task view, process view, function view, and data view. There are a number of additional views such as the object-oriented view, the goal view, and others which are not elaborated here. The tasks view specifies and details the tasks of PPC in a hierarchical abstraction for the manufacturing company and its suppliers. Inter-company network tasks, intra-company core tasks and cross-sectional tasks are distinguished. The core tasks define the requirements for PPC from the manufacturing organisation. In the process view these tasks are extended by a temporal-logical sequence. Interfaces to other processes and external partners are defined. Several manufacturing-type dependent processes are available here which can be customised to the organisation at build-time. The function view serves to describe the requirements for IT systems for production planning and control. Reference functions are described in a flat hierarchy and are structured analogously to the task view in order to support rapid identification of functions necessary to support certain tasks. Finally, the data view delivers the required data. All data necessary to execute PPC systems are contained.

Similar to ARIS, a number of perspectives are used to enable the holistic modelling of a PPC system. Furthermore, detailed process descriptions, function catalogues and data structures are delivered with the model. While the model excels both in depth and application breadth, it remains strongly focussed on manufacturing tasks and does not address distribution and procurement tasks in a detailed manner.''

3.3.6 PRO-NET model

A part of the review by Blecken (2009) is presented here, since the publication reference on the PRO-NET model (Erzen, 2001) is available in German only:

''Erzen (2001) develops the reference model PRO-NET for textile supply chains focussing on improving the cooperation in these supply chains with respect to order planning and production control. In order to achieve this, Erzen combines elements of process and coordination management. The model can thus be integrated in an inter-organisational concept which includes design, planning and implementation of cooperation in textile supply chains.

Erzen's reference model can be classified as an organisational object model describing the behaviour of a system. It is intended for business process management and describes tasks and processes within its application domain. The focus is on the information flow rather than on the material flow. The reference model for order processing is complemented with a methodology for organisations to compare their processes to the reference processes and if needed adjust their processes according to the reference model and thus realise potentials for improvement. Object of the model is the description of cooperative customer-supplier relations with respect to order processing on the basis of framework orders, such as those typically found in textile supply chains. External and internal production as well as suppliers and customers are within the scope of the model.

Erzen presents his reference model with hierarchical flowcharts which capture all activities involved in order processing of textile supply chains. The model incorporates roles and responsibilities as well as objectives of supply chain partners and distinguishes between strategic, tactical and operational layers. Colours are used to point out to which layer activities are attributed. However, Erzen's reference model also suffers certain shortcomings: The lack of a formal language limits the modelling options and the possibility to extend the reference model and adapt it to order processing in other supply chains. Furthermore, the lack of a formal language also hampers the use of the model to support the implementation of IT systems or IT-supported workflow management. The reference model does not include data or function models which are needed when implementing IT systems to support order processing. Finally, the reference model does not support adaptation by use of build-time and runtime operators and thus the reusability of the model is reduced.''

3.3.7 GSGF model

According to Azevedo et al. (2009), two mains reference models are currently recognized when defining supply chain management processes: the Global Supply Chain Forum (GSCF) model of Ohio State University (Lambert, 2004; Lambert et al., 2005) and the previously discussed SCOR model of the Supply Chain Council (SCC, 2008). The GSCF model is organised around eight supply chain processes, see Table 13.

The GSCF model does not fulfil all the criteria of a reference model according to Blecken (2009), e.g. the model does not employ a standardised (semi-) formal language. Several related models on supply chain management processes are found in the literature. The interested reader is referred to the survey by Blecken (2009) that includes the well-known planning matrix for supply chain management of Fleischmann et al. (2008) and to the recent state-of-the art model on supply chain management processes proposed by Azevedo et al. (2009).

Table 13 : Processes of the Global Supply Chain Forum model (Lambert, 2004)

Process	Definition
Customer Relationship Management	Provides the structure for how relationships with customers are developed and maintained.
Customer Service Management	Represents the firm's face to the customer by providing information to the customer and administering the product and service agreements.
Demand Management	The process that balances customer requirements with supply chain capabilities with forecasting and by synchronising supply and demand, increasing flexibility and reducing variability.
Order Fulfilment	Includes all activities related to filling customer, defining customer requirements, designing a network and enabling the firm to meet customer requests while minimising the total delivery cost.
Manufacturing Flow Management	Includes all activities necessary to obtain, implement and manage manufacturing flexibility in the supply chain and move products through the plants.
Supplier Relationship Management	Provides the structure for how relationships with suppliers are developed and maintained.
Product Development and Commercialisation	Provides the structure for working with customers and suppliers to develop products and bring them to market.
Returns Management	The process by which activities associated with returns, reverse logistics, 'gatekeeping' and return avoidance are managed within the firm and across key members of the supply chain.

3.3.8 Azevedo et al. (2009) model

Mentzer et al. (2007) have proposed a three-category classification for a process: ''(i) *core processes* that are needed to attain business goals by enabling goods and services to reach an external customer; (ii) *support processes* that are needed to make the core processes work as well as possible, but which are not critical to the success of the company; (iii) *management processes* which are broader knowledge domains used to control and coordinate the core and support processes. Recently, Azevedo et al. (2009) justify the modification of the terminology 'management processes' for 'management competences'.

Recently, Azevedo et al. (2009) propose a state-of-the art model for the *core processes* in SCM (see Figure 5). WP-5100 aims the processes at the operational level, so we target the processes in 'Value Commitment', 'Order Fulfilment' and 'Inventory Replenishment'. Product development and product return are beyond the scope of the project, thus the processes in 'Product Return' and 'Value Development' are not covered.

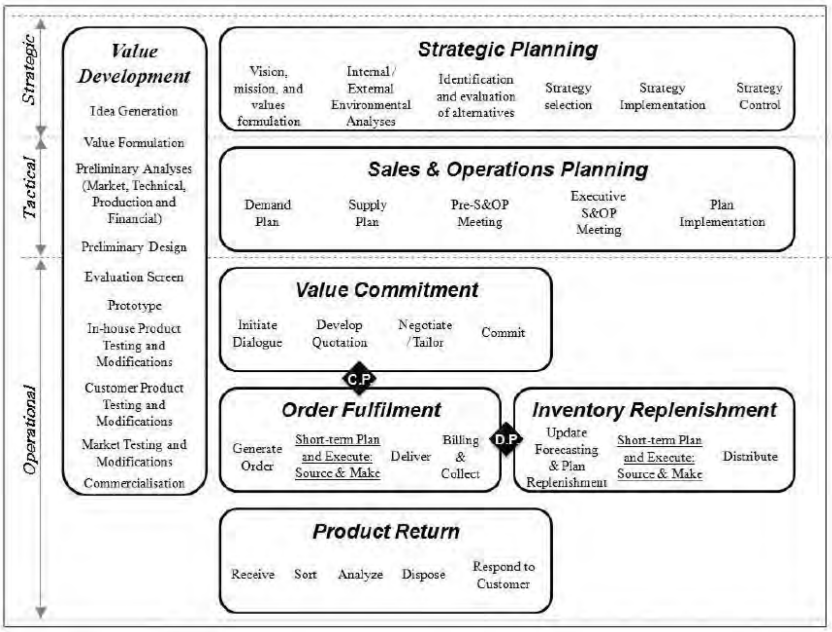

Figure 5 : Supply chain management core processes model by Azevedo et al., (2009) (Azevedo et al., 2009)

3.3.8.1 Commitment point and the decoupling point

Two key concepts are illustrated in above Figure 5:

- Designated by the black diamond C.P., the commitment point is defined by ''the stage where parties need to commit to the transaction or to a series of transactions (...), a decision with implications for both sides'' (Daniel et al., 2003).

- Designated by the black diamond D.P., the decoupling point or, the usual typology in the literature, the Customer Order Decoupling Point (CODP). Wikner and Rudberg (2005) provide the common definition of the CODP in the literature: ''(…) the point in the flow of goods where forecast driven production and customer order driven production are separated'' or, in other words by Rudberg and Wikner (2004), ''(…) the point in the value-adding material flow that separates decisions made under uncertainty from decisions made under certainty concerning customer demand (…)''. Four typologies of CODPs are traditionally defined in the literature: engineer-to-order, make-to-order, assemble-to-order and make-to-stock (Wikner and Rudberg, 2005). More typology of CODPs can be found, e.g. sale-to-order and deliver-to-order in Poulin et al. (2006). Rudberg and Wikner (2004) and Wikner and Rudberg (2005) also extend the traditional typology of CODPs to add an engineering dimension, e.g. engineer-to-stock.

The CODP is sometimes referred to as the order penetration point (Wikner and Rudberg, 2005). It can also be referred to as the postponement point or where the product is differentiated (Poulin et al., 2006). In its review on postponement (see also the review by Yang et al. (2004) and Boone et al. (2007)), van Hoek (2001) mention that ''postponement means delaying activities in the supply chain until customer orders are received with the intention of customising products, as opposed to performing those activities in anticipation of future orders.''

The CP and CODP concepts are tightly connected with the processes dealing with the customer, mainly the sales. However, the SCOR model doesn't address the sales to the customer while our framework should be able to capture sales done at the operational level. Based on the same structure of the SCOR model, the Supply Chain Council provides the Customer Chain Operations Reference model, CCOR model (SCC, 2004), to address sales. The CCOR model uses five basic processes: plan, relate, sell, contract and assist.

3.4 Typologies

Meyr and Stadler (2008) and Kannegiesser (2008) provide a typology to describe, respectively, a supply chain and a value chain, by a set of attributes relevant for decision-making. Attributes may have nominal properties (e.g. a product is storable or not), ordinal properties (e. g. an entity's power or impact on decision-making is regarded higher or lower than average) or cardinal properties (i. e. the attribute can be counted, like the number of legally separated entities within a supply chain) (Meyr and Stadler, 2008). The typology presented by Kannegiesser (2008) is an extension of the typology of Meyr and Stadler (2008). We report each of them in the following subsections.

3.4.1 Typology to characterise a supply chain

Meyr and Stadler (2008) discriminate between two groups of attributes: the functional attributes to be applied to each organisation, entity, member, or location of a supply chain as well as the structural attributes describing the relations among its entities. We report each set of attributes in Table 14 and Table 15. For the details of each characteristic and attribute, we refer to Meyr and Stadler (2008).

Table 14: Functional characteristics and attributes details (Adapted from Meyr and Stadler, 2008)

Type	Characteristics	Possible or range of attributes or definition
Procurement	Number of products procured	Few to many
	Type of product procured	Standard to highly specific product
	Sourcing type	Single sourcing, double sourcing, multiple sourcing
	Flexibility of suppliers	Flexible quantity, fixed quantity, minimum quantity, maximum quantity
	Supplier lead time	Short to long
	Supplier reliability	Reliable, unreliable
	Materials' life cycle	Short, middle, long
Production	Organisation of the production process	Flow shop, cellular, job shop, flow line
	Repetition of operations	Mass production, batch production, making one-of-a-kind product
	Changeover characteristics	Lower to higher setup time (or cost)
	Bottlenecks in production	Identification of the potential bottleneck(s) depending on the mix of demand
	Working time flexibility	Capability and lead times to adapt working time to changing demand pattern: low to high
Distribution	Distribution structure	One-stage, two-stage, three-stage
	Pattern of delivery	Cyclic, dynamic
	Deployment of transportation means	Standard routes, variable routes or capacity on individual link in the distribution network or cost function without capacity
	Loading restrictions	List of the requirement(s) (e.g. only full truckload)
Sales	Relation to customers	Contract to pure market
	Availability of future demand	Known (order), forecasted
	Demand curve	Static, sporadic, seasonal
	Products' life cycle	Short, middle, long or number (e.g. several years)
	Number of product types	Few to many or number (e.g. hundreds)
	Degree of customisation	Standard products to highly specific products
	Bill of materials	Serial structure, convergent structure, divergent structure, mixture of the three
	Portion of service operations	n.a.

Table 15 : Structural characteristics and attributes details (Adapted from Meyr and Stadler, 2008)

Type	Characteristics	Possible or range of attributes or definition
Topography of a supply chain	Network structure	Serial, convergent, divergent, or a mixture of the three
	Degree of	Single country to several continents

	globalisation	
	Location of decoupling point(s)	May differ between the product groups
	Major constraints	List of the main bottlenecks of the supply chain (as a whole) are
Integration and coordination	Legal position	Inter-organisational, Intra-organisational
	Balance of power	Focal firm to polycentric supply chain
	Direction of coordination	Purely vertical, purely horizontal, mixture of both
	Type of information exchanged	List of information exchanged.

3.4.2 Typology to characterise a value chain

Kannegiesser (2008) provides a typology to describe the characteristics of a value chain network in five sets of attributes: network, procurement, production, distribution and sales. The author applies this typology to the chemical industry, an industry that also produces mostly commodity products in as large volume as the forest product industry. We report each set of attributes in Table 16 to Table 20. For the details of each characteristic and attribute, we refer to Kannegiesser (2008).

Table 16 : Network characteristics and possible attributes (Kannegiesser, 2008)

Characteristic	Possible attributes
Geographical topography	Global, regional, local
Legal position	Intercompany, intracompany
Geographical configuration	Multinational, international, classic global, complex global
Spatial dispersion	Concentred, host-market, specialised, vertical integration
Value creation focus	Production, distribution
Value creation steps	Single-step, multi-stage

Table 17 : Procurement characteristics and possible attributes (Kannegiesser, 2008)

Characteristic		Possible attributes
Product	Type	Commodity, specialty
	Life cycle	Short, middle, long
	Number	Low, medium, high
	Customisation	Standard, variants, customer-specific
	Perishability	Fast, medium, not perishable
Market	constellation	Monopoly, oligopoly, polypoly
	Price mechanism	Exchange, auction, negotiation
Supplier	structure	Single, few, many
	Type	Internal, external
	relation	Contract, spot
Offer	Certainty	Forecasted, stochastic, unknown
	Volatility	Stable quantity, volatile quantity, stable price, volatile price
	Elasticity	Inelastic, relatively inelastic, unitary elastic, relatively elastic
Procurement	Flexibility	Flexible quantity, fixed quantity, flexible price, fixed price

Table 18: Production characteristics and possible attributes (Kannegiesser, 2008)

Characteristic	Possible attributes

Resource	Purpose	Single-purpose, multi-purpose
	Mode	Continuous, campaign, batch
	Throughput	Variable, static
Process	Method	Synthetic, analytic, regrouping, process
	Factors	Labour, assets, material, energy
	Change-overs	Flying, process, stop
Output products	Number	Single, few, many
	Factors	Static, variable
Input product	Number	Single, few, many
	factors	Static, variable

Table 19: Distribution characteristics and possible attributes (Kannegiesser, 2008)

Characteristic		Possible attributes
Inventory	Sourcing	Single-sourcing, multi-sourcing
	Stages	Single-stage, multi-stage
Transportation	Routes	Standard routes, variable routes
	Modes	Single, multiple dedicated, multiple alternatively
	Lead times	Single-period, multi-period

Table 20 : Sales characteristics and possible attributes (Kannegiesser, 2008)

Characteristic		Possible attributes
Product	Type	Commodity, specialty
	Life cycle	Short, middle, long
	Number	Low, medium, high
	Customisation	Standard, variants, customer-specific
	Perishability	Fast, medium, not perishable
Market	Constellation	Monopoly, oligopoly, polypoly
	Price mechanism	Exchange, auction, negotiation
Customer	Number	Single, few, many
	Type	Internal, external
	Relation	Contract, spot
Demand	Certainty	Forecasted, stochastic, unknown
	Volatility	Stable quantity, volatile quantity, stable price, volatile price
	Elasticity	Inelastic, relatively inelastic, unitary elastic, relatively elastic
Sales	Flexibility	Flexible quantity, fixed quantity, flexible price, fixed price
	Service	Standard, differentiating

3.4.3 Typology to characterise a service

The two previous typologies have been devoted to a products-based supply chain. An important service sector (e.g. harvesting, transportation) exists in the wood supply chain. Supported by e.g. the survey by Cook et al. (1999), the principal attributes to be considered in service management are identified by Gliatis and Minis (2007). The typology of service classification by Gliatis and Minis (2007) is grouped in six distinct service dimensions based on consideration for the customer, the service provider and their interaction:

- customer's buying motive: attributes related to the motives that direct customer's behaviour;

- customer's buying practices: attributes related to the way a customer practices its buying preferences;

- ways of service delivery: attributes related to the methods used by service organisations to deliver service offerings;

- ways of service production: operation related attributes;

- service output characteristics: attributes related to the nature of the end result of services;

- service management considerations: important attributes for management to consider while making decisions concerning service execution.

We report the characteristics of each dimension in Table 21 to Table 26.

Table 21 : Customer’s buying motive characteristics (Gliatis and Minis, 2007)

Characteristic	Definition
Type of customer	Institutions or individual customers. Institutions refer to non-individual customers that are likely to have more divergent needs and characteristics (e.g. larger quantities, more sophisticated services, etc)
Perceived risk	Perceived risk is the customer’s perception, rather than objective reality, that something may go wrong in an exchange. The dimensions of risk are: functional, physical, financial, psychological, social and time risk
Service importance	Importance is viewed as the level of customer’s interest in the service, the extent to which they think about it, the degree of importance it has to their everyday life, the amount of enjoyment it brings, their desire to keep informed on the particular service
Purchase effort	Purchase effort is the amount of money, time and energy that the buyer is willing to expend to acquire the service

Table 22 : Customer's buying practices characteristics (Gliatis and Minis, 2007)

Characteristic	Definition
Customer's commitment	The customer's ability to switch between competing offerings. If the customer’s power towards the service provider is low then it is likely to have a high degree of commitment
Necessity of customer's presence	Extent to which customers must be physically present with the service provider during service delivery
Demand fluctuations (patterns)	The extent of demand fluctuations (variations) over time. Two parameters are considered: the cycle periods of these demand fluctuations (predicted, random) and the underlying causes of them (customer habits or preferences, action by third parties, non-forecastable events, etc.)
Type of relationship	Whether the service organisation enters into a "membership" relationship with its customers (telephone subscriptions, banking etc) or there is "no formal" relationship (restaurants, car rental, etc)

Table 23 : Ways of service delivery characteristics (Gliatis and Minis, 2007)

Characteristic	Definition
Interaction between Customer and Service Organisation	Whether the customer goes to the service organisation, or the service organisation comes to the customer, or the customer and the service org. transact at arm’s length
Nature of Service Delivery	Continuous Delivery of Service, Discrete Transactions
Service Delivery Channel	The type and number (outlets) of the market channels used to deliver services
Priorities Serving rules	The rules used from the service organisation to serve customers under a certain priority as they enter the service system

Table 24 : Ways of service production characteristics (Gliatis and Minis, 2007)

Characteristic	Definition
Object processed	The object that is processed (people, materials, information) by the service organisation in order to deliver a specific service
Direct provider of the service (equip-ment vs. people)	Equipment-focussed services are those where the provision of certain equipment is the core element in the service delivery. People-focussed services are those where the provision of contact staff is the core element in service delivery
Extent of Customer Contact	The extent of customer contact in the creation of the service. Customer contact refers to the physical presence of the customer in the system, and creation of the service refers to the work process that is entailed in providing the service itself. Extent of contact here may be roughly defined as the percentage of time the customer must be in the system relative to the total time it takes to serve him
Customer's Influence	Degree to which the consumer by his/her presence, interaction and/or participation, in some way influences the service process. The customer can influence both the design and the delivery as well as the service content
Customisation /Routinisation	A high degree of customisation is where the service process can be adapted to suit the needs of individual customers (fluid). A low degree of customization is where there is non-varying standardized process (rigid); the customer may be offered several routes but the availability of routes is predetermined
Product / Process focus	A product-oriented service is where the emphasis is on what the customer buys. A process-oriented service is where the emphasis is on how the service is delivered to the customer
Personnel judgment	Extent to which personnel exercise judgment in meeting individual needs. A high degree of discretion is where front-office personnel can exercise judgment without referring to superiors. A low degree of discretion is where changes to service provision can be made only with authorisation from superiors
Value added, Back office / Front office	A back-office-oriented service is where the proportion of front-office staff to total staff is small. A front-office-oriented service is where the proportion of total office staff to total staff is large

Table 25 : Service output characteristics (Gliatis and Minis, 2007)

Characteristic	Definition
Degree of tangibility	The extent to which a service act contains Intangible or Tangible elements
Individual / Collective services	A collective service is provided whenever changes occur in the conditions of several persons, or of goods belonging to several economic units, as a result of the activity of a single economic unit, with the agreement of all concerned
Ownership	Owned goods services, Rented good services
Single service / Bundle of services	Bundle of services refers to additional services or elements that are added to facilitate successful completion of the primary transaction. The key advantage is that of 'one-stop-shopping' for an array of services
Timing and Duration of benefits	The length of time over which the change affected may normally be expected to persist

Table 26 : Service management considerations characteristics (Gliatis and Minis, 2007)

Characteristic	Definition

Extent to which supply is constrained	The extent to which peak demand can usually be met without a major delay or regularly exceeds capacity
Management's degree of control	Decisions that management makes regarding process design. How many controls the company has planted into the service delivery system and how many routes are available to deliver service offerings.
Perceived risk for the company	Perceived risk is the company's speculation that something may go wrong in an exchange that could lead to loss exposure
Production (& Transaction) cost	How much effort is required for a service to be produced by the service provider
Degree of regulation	The extent of regulations that influence the process delivery. Two parameters should be considered: the extent of regulations that influence the process and the degree of compliance with this regulations

3.4.4 Typology to characterise collaborative planning in a supply chain

A planning process in a supply chain exists within one business entity and also among two or more business entities. In the latter case, we refer to *collaborative planning* or, for a formal definition by Stadler (2009): ''a joint decision making process for aligning plans of individual SC members with the aim of achieving coordination in light of information asymmetry''. In a supply chain, one entity can be involved in collaborative planning both downstream (e.g. with customers) and upstream (e.g. with suppliers).

A *coordination scheme* is a ''procedure for aligning individuals' plans of two or more decision-making units'' while a *collaborative planning scheme* further requires that ''individuals' plans are adapted in an effort of joint decision making, i.e. a willingness to cooperate and to contribute to the generation of a plan which will be accepted by these SC members (which may well be a subset of the overall SC)'' (Stadler, 2009).

Stadler (2009) provides a typology to characterise a collaborative planning problem and scheme in a supply chain according to three broad categories:

1- the structure of the supply chain, the relationships among supply chain members and the requirements for the supply chain solution;

2- the decision situation facing each supply chain member;

3- the characteristics of the collaborative planning scheme;

We report the characteristics of each category in Table 27 to Table 29.

Table 27 : Characteristics for the structure, the relationships and the solution requirements (Stadler, 2009)

	Characteristics
Structure	Number of SC tiers
	Number of SC members on each tier
	Business functions SC members fulfil
Relationships	Power of each SC member
	Extent of self-interest governing an SC member's behaviour
	Learning effects
	Rolling schedules
Solution requirements	alignment of flows
	search for the SC optimum
	search for a fair solution

Table 28 : Characteristics for the decision situation (Stadler, 2009)

Decision models	Which decisions take place?
Phases of collaboration	When does collaboration take place?
Information status • Information hidden for each SC member • Information exchanged	What is the information status of each SC member? • Which information is hidden to the other party? • What is the type of information to be exchanged in the course of collaboration?
Degree of uncertainty	A deterministic or a stochastic situation?
Objective(s)	What are the objectives of the decision problem?

Table 29 : Characteristics of the collaborative scheme (Stadler, 2009)

Presence of a mediator
Initial solution • Number of plans exchanged • Number of rounds • Parallel offers • Total number of offers
Final results • Quality of the solution • Side-payments

The term *coordination/collaborative mechanism* instead of *coordination/collaborative scheme* is also used in the literature. Frayret et al. (2004b) propose seven classes of generic coordination mechanism:

1- by direct supervision with coordination by plan

2- by direct supervision with coordination during activities execution;

3- by mediation with coordination by plan;

4- by mediation with coordination during activities execution;

5- by mutual adjustment with coordination by plan;

6- by mutual adjustment with coordination during activities execution;

7- by standardisation.

Audy et al. (2010) extend three of these classes (i.e. 1, 3 and 5) to propose five collaborative mechanisms.

Coordination and collaborative planning involve the management of dependencies among activities occurring in the supply chain. Frayret et al. (2004b) review the various forms of interdependence between two or more activities and also review specific coordination mechanisms for each of them (see Table 30).

Table 30 : Type of interdependence and corresponding coordination mechanisms (Frayret et al., 2004b)

Type of interdependence	Characteristics	Coordination mechanisms
Pooled	• Involved in organisational resources sharing • Each part renders a discrete contribution to the whole and each is supported by the whole • Resource allocation problem	• Direct communication • Use of common staffs to support these activities • Rules-of-the-game to manage prescribed and forbidden actions • Market-based pricing and bidding mechanisms
Sequential	• Producer–consumer relationship • Links two activities for which the output of one is the input of the other • Three subtypes: Prerequisite constraint; Output/input transfer; Input usability	• Coordination by plan • Cross-activity programming • Notification, sequencing, tracking • Inventory management (e.g., JIT, EOQ) • Standardisation, ask users, participatory design, concurrent engineering
Reciprocal	• Links two activities for which their outputs are the • reciprocal inputs of the other	• Use of formalised contractual systems of both rules and supervisory hierarchical roles • Coordination by mutual adjustment
Intensive	• Related to the intrinsic sophistication of activity embeddedness	• Collaborative relationships involving one-to-one mutual adjustment
Task/subtask	• Involves top-down goal selection and decomposition, or bottom-up goal identification	• Goal selection • Task decomposition
Simultaneity	• Occurs when activities must be carried out, or not, at the same time	• Scheduling • Synchronisation

4. Mapping of supply chain in the forest product industry and other various works

The aim of this section is to provide an exploratory review of themes (iv), which is:

iv) Review existing research aiming to measure and map supply chains in the forest products industry as well as other research that could provide input information (e.g. lists of actors, decisions and main constraints in WSS) in the development of our framework.

Some publications on SC mapping in the forest products industry have been found. Using four of the five basic processes of the SCOR model (i.e. Plan, Source, Make and Deliver), Frayret et al. (2007) propose an agent-based planning system for a network of softwood sawmills. De Santa Eulalia (2009) presents a methodological framework to provide a uniform representation of distributed advanced planning and scheduling systems using agent technology and makes its proof-of-concept in a network of softwood sawmills. Using the Value Stream Mapping methodology, Jacques (2009) demonstrates its application to illustrate material flows in different production units of the forest products industry (i.e. a typical sawmill, chemical pulp mill, OSB mill and wood pallets mill), and also to illustrate the material flows in a generic value creation network of the forest product industry.

Publications to provide input information in the development of our framework can be classified in three categories:

i) Publication in Management Sciences, Operations Research and Supply Chain Management (MS, OR & SCM) applied to the wood supply chain, see literature review Rönnqvist (2003), Frayret et al. (2004a), Weintraub et al. (2007) and D'Amours et al. (2008).

ii) Glossary in forestry (Pulkki, 2010 and in MS, OR & SCM (Klappich, 2010; CSCMP, 2010b).

iii) Publication on MS, OR & SCM concepts to be potentially highlighted in our framework. We list them:

- different frameworks exist in the literature to assess the different dimensions, level or intensity of collaboration and integration in a supply chain, see e.g. Frayret et al., 2003 and Cruijssen et al., 2007 and, for a general discussion on several definitions of collaboration in the supply chain, Fugate et al. (2009).

- type of control architecture for planning systems, see five types by Frayret et al. (2004b): centralised, proper hierarchy, modified hierarchy, heterarchy and quasi-heterarchy.

- distinct between processor, product and process (from D'Amours et al., 2009)

> The abstract model used to represent a real complex network usually involves many components. To model a product transformation, three components are required: a processor, a product and a production process.
>
> The *processor* is the machine, the human being, the installation or the production line that is to perform the production / transformation work.
>
> The *product* may take different forms depending on its location along the production line or along the supply chain.
>
> The *production process* is what ties the processor to the product: it describes how the product will be transformed by the processor. It should be noted that a transformation on a product may involve not only a physical modification, but also a change of location. In that view, a truck may be a processor and the actual transportation can be seen as a process done on the product to be moved. Types of relationship to model a process are: one-to-one relationship (1 input, 1 output), one-to-many relationship (1 input, many outputs), many-to-many relationship (many inputs, many outputs).
>
> The processors are typically associated with a limited capacity (either in terms of throughput, hours available, batch size or time window availability) and an operating cost which can be a fixed cost, a cost per unit of time or a cost per batch. As for the product, it may influence some characteristics of the processes like the duration, the quantity of certain resources required and the resulting products, *co-products* (i.e. a valuable product that is created as a result of producing the main product) or *by-products* (i.e. low or zero value product deriving from a production process and that would be avoid if possible).

- Concepts of Available to Promise (ATP), Capable to Promise (CTP) and Profitable to Promise (PTP) (CSCMP, 2010b):

> Available to Promise (ATP): The quantity of a product which is or will be available to promise to a customer based on their required shipment date. ATP is typically 'time phased' to allow for promising delivery at a future date based on anticipated purchase or production receipts.
>
> Capable to Promise (CTP): A technique similar to Available-to-Promise, it uses the availability of individual components to determine if an end item can be configured and assembled by a customer-given request date and provides the ability of adjusting plans due to inaccurate delivery date promises. Capable to promise looks at both materials and labour/machine requirements.
>
> Profitable to Promise (PTP): This is effectively a promise to deliver a certain order on agreed terms, including price and delivery. Profitable-to-Promise (PTP) is the logical evolution of Available-to-Promise (ATP) and Capable-to-Promise (CTP). While the first two are necessary for profitability, they

are not sufficient. For enterprises to survive in a competitive environment, profit optimisation is a vital technology.

- three criteria that define how orders are won or lost (Hill, 1995):

  - order winners: criteria that win contracts on the marketplace;

  - qualifiers: criteria that qualify the company as a potential supplier;

  - order-losing: criteria that lose contracts on the marketplace, and most likely potential future orders, if the firm does not meet the necessary standards of such criteria;

The roles of order winners and qualifiers criteria are not stable: they change over time, they work in combinations, and they work in different ways on different markets and with different customers (Hörte and Ylinenpää, 1997).

- incoterm (international commercial terms), see e.g. Wikipedia (2010b).

- responsibility assignment matrix (RACI model, see Table 31) with its several extensions, see Table 32.

Table 31 : RACI model (Wikipedia, 2010a)

Key responsibility	Description
R - Responsible	Those who do the work to achieve the task. There is typically one role with a participation type *Responsible*, although others can be delegated to assist in the work required.
A - Accountable (also Approver or final Approving authority)	Those who are ultimately accountable for the correct and thorough completion of the deliverable or task, and the one to whom *Responsible* is accountable. In other words, an *Accountable* must sign off (Approve) on work that *Responsible* provides. There **must** be only one *Accountable* specified for each task or deliverable.
C - Consulted	Those whose opinions are sought; and with whom there is two-way communication.
I - Informed	Those who are kept up-to-date on progress, often only on completion of the task or deliverable; and with whom there is just one-way communication.

Table 32 : Extensions of the RACI model (Wikipedia, 2010a)

Model	Key responsibility	Description
RASCI (RASIC)	R - Responsible	Those who are responsible for the task, ensuring that it is done as per the Approver.
	S - Support	Resources allocated to *Responsible*. Unlike *Consulted*, who may provide input to the task, *Support* will assist in completing the task.
RACI-VS (VARISC)	V - Verifier	Those who check whether the product meets the acceptance criteria set forth in the product description.
	S - Signatory	Those who approve the *Verify* decision and authorise the product hands-off. It seems to make sense that the *Signatory* should be the party *Accountable* for its successor.
RACIO (CAIRO)	O - Out of the Loop (or Omitted)	Designating individuals or groups who are specifically not part of the task. Specifying that a resource does not participate can be as beneficial to a task's completion as specifying those who do participate.

One similar model of the responsibility assignment matrix could also contribute to the framework, see Table 33. The PACE model is used for ‘‘decision making process and supports reaching decisions faster while keeping all the actors informed, by reducing the "debate time" between the actors involved’’ (Wikipedia, 2010a).

Table 33 : PACE model (Wikipedia, 2010a)

Key responsibility	Description
Process Owner (or Process Leader)	One person has the Process Owner role to drive the decision making process on behalf of the Approver and is clear about that responsibility. The Process Owner is expected to bring well thought-out/researched options to the Approver who will make decisions regardless of consensus among all stakeholders.
Approver	The Approver decides by vetoing or choosing one of a series of well laid-out options presented by the Process Owner. The Approver is expected to possess the skills and experience to make decisions that will not be overturned, and helps to mentor/coach others until they gain requisite experience to become an Approver. Only the Approver may veto all options.
Consulted	Consulted people must not attempt to veto by going to the level above to overturn a decision.
Executers	Those who carry out the decision once made. Execution with excellence is expected regardless of intellectual buy-in.

- process management has been around for a long time and interest in the discipline remains high. Extensive literature furnishes several process management descriptions, but there doesn’t appear to be any really commonly known, widespread model. However, when discussing and analysing “processes”, it is important to define the “process” aimed at in the study. Process management for a single process within a supply chain will differ from process management within an entire production system, i.e. system management. This is a major challenge when striving towards portraying a “typical wood supply system of region X”. In order to be concrete when discussing and comparing different supply chains in terms of performance metrics, the need for a focal point within the supply chain evolves. Hence, the process management, rather than the system management view, is needed in order to achieve the study goals.

5 Conclusion

WP-5100 aims to develop a framework to describe and represent any wood supply system in which the agility, competitiveness and customisation capability of the system are highlighted. Next, WP-5100 seeks to use the developed framework to study wood supply systems in different parts of the world so that, by their analysis and comparison, basic designs of planning systems are identified. Finally, the aim is to describe each of these basic designs with their logistics concepts and analyse their positive and negative impacts on agility, competitiveness and customisation capability.

As outlined in the objective of Task 1 of WP-5100, this exploratory literature review includes a solid base of theories and concepts on four specific themes (see Table 1). The next step is to build our research work on that base with additional references to be integrated with future punctual needs.

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Appendix 3: Interview guideline

BACKGROUND

This research project is part of a major European Union funded research initiative: Flexwood (*Flexible Wood Supply Chain*). The concept for Flexwood originated with the problem that wood supply chains in the forest products industry are not able to make full use of the real value of raw materials. The overall objective of Flexwood is to build a novel logistics system that would provide value recovery along the wood supply chain. Flexwood involves fourteen partners representing nine countries and is comprised of leading SMEs, universities and research centres and associations, which contribute complementary experience and expertise. For more details, see: http://www.flexwood-eu.org.

This research project is led by the FORAC Research Consortium of Université Laval (Canada) in partnership with Skogforsk – The Forestry Research Institute of Sweden (Sweden). The research is conducted under the supervision of Dr. Sophie D'Amours, professor in industrial engineering at Université Laval and director of research and administration of the FORAC Research Consortium, with the collaboration of Dr. Luc Lebel, professor in forest operations at Université Laval and Dr. Mikael Rönnqvist, professor in management sciences at the Norwegian School of Economics and Business. The research team is completed by Karin Westlund, research professional in the logistics program at Skogforsk, Anna Furness-Lindén, research professional in the technology program at Skogforsk, and Jean-François Audy and Matheus Pinotti Moreira, doctoral students in industrial engineering at Université Laval.

SCOPE AND OBJECTIVES OF THE RESEARCH PROJECT

The *wood supply system* studied in this project spans from the measurement of the forest to the delivery of raw material at the mill gates and the focus is on short-term planning decisions and operations in the system. Thus, silvicultural and other pre-commercial operations, as well as mid/long-term planning decisions are not explicitly targeted in the study, even though they will be indirectly discussed to capture their positive and negative impacts on the system.

The objectives of the project are:
#1 – to develop a framework to describe and represent any wood supply system in which the agility and customisation capability of the system are highlighted;
#2 – to use such a framework to study wood supply systems in different parts of the world;
#3 – to analyze and compare each studied wood supply system to identify the basic designs of a planning system.

Your participation falls mainly in Objective #2, but it is also essential in the achievement of the two other objectives.

CONFIDENTIALITY IN THE RESEARCH PROJECT

The research team shall ensure adequate protection for the confidential character of the confidential information disclosed in this research project. Specifically, the following measures will be applied in the research project:

- participants' names will not appear in any research document (i.e., internal report, final report or any scientific publication or presentation produced by the research team);
- only a numeric code will appear in all research documents and only the project supervisor, Dr. Sophie D'Amours, will have a list of participants' names and codes;

- results from each studied wood supply system will be presented in a synthesized format in which no participant can be identified;
- under no circumstances will confidential information of any participant be disclosed to anyone.

BENEFIT OF YOUR PARTICIPATION

With your participation and the participation of the main entities in the wood supply system in which you are involved, the research project will provide a global understanding of ‘your’ system and highlight its agility and customization capability. Supported by this wider perspective of ‘your’ system, you could, for instance, initiate discussion with another entity on how you could together improve locally the performance of ‘your’ system, particularly with regard to agility and customization capability.

Also, ‘your’ wood supply system will be one of several systems (e.g. Canada, Chile, France, U.S., Poland and Sweden) that will be studied in this project. In the final report of the project that each participant will receive, the results of each studied system will be presented in the same synthesized format. Thus, you will be able to perform your own comparisons between ‘your’ system and the others in order, for instance, to identify the logistics concept or planning strategies used in another system that could potentially be valuable for ‘your’ system.

Finally, in addition to receiving an electronic version of the final report of this research project, you will also receive a hyperlink to access an electronic version of the final report of the entire Flexwood project. Thus, you will be able to access the results of more than 25 other research projects conducted by 13 research groups of various expertises. For more details see: http://www.flexwood-eu.org.

RISK OF YOUR PARTICIPATION

There is no known risk associated with your participation in this project.

OPEN-ENDED QUESTIONS

1. What is your role(s) and objective(s) in the wood supply system?
2. What is your business interaction with the other entities in the wood supply system?
3. For each business interaction, are there any material, information and/or financial flows? For each financial flow, what are the types of payment structure or agreement?
4. For each of your roles in the wood supply system, what is the planning process (i.e. Decision you should take) and/or execution process (i.e. Task you should do) you follow to achieve them?
5. Is there real time control and/or feedback (adherence to plan or possibility of improvement) in these planning and execution processes?
6. For each planning process, what are:
   - 6.1. the constraints you should respect (e.g. capacity, legal, environmental, policies, target);
   - 6.2. your planning objective(s);
   - 6.3. the input information you need and which is received from other entities;
   - 6.4. the output information you obtain and which is sent to other entities;
   - 6.5. the planning horizon (i.e. the time horizon in which you make your decision);
   - 6.6. the frozen horizon (i.e. the time horizon in which a decision you make now cannot be changed later);
   - 6.7. the tool you use;
   - 6.8. the planning process duration;
   - 6.9. the time interval between each consecutive planning process and the reason(s) that motivate redoing the previous planning;

7. What are the main issues in the wood supply system (e.g. Bottlenecks depending on the mix of demand, natural or business constraints)?
8. What is your knowledge of the demand (e.g. Market, sales structures, final customers, variability, forecast)?
9. What is your knowledge of the supply (e.g. Accessibility, timberland ownership structures, variability, estimation)?
10. Who are your main competitors (type of) and what are your competitive advantage(s)?
11. What is your market segmentation (e.g. by product, order winner criteria and qualifiers, type of agreement, type of price).
12. Upside Supply Chain Flexibility: the number of days required to achieve an unplanned sustainable 20% increase in quantities delivered. – CANCELLED QUESTION
13. Upside Supply Chain Adaptability: the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days. – CANCELLED QUESTION
14. Downside Supply Chain Adaptability: the percentage reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory or cost penalties. – CANCELLED QUESTION
15. Average Order Fulfilment Cycle Time: average time for all processes and inventory starting from the order commitment and ending with customer receipt of the order. (Note: may differ according to location of the decoupling point, customer segment, assortment quality grade, seasonality, etc.).
16. Average Perfect Order Fulfilment: the percentage of orders meeting delivery performance (right quantity, right time, right location and customer) with complete, accurate and on time documentation and in perfect condition (e.g. no delivery damage). (Note: may differ by customer segment, assortment quality grade, etc). – CANCELLED QUESTION
17. Can we send you, by email, a Likert-scale evaluation requiring less than 10 minutes to fill out consisting of a set of statements on five distinct subjects: supply chain agility, competitive advantage, competitive intensity, industry commoditization level and supply chain strategy? – CANCELLED QUESTION

Appendix 4: Case studies identified

Table 21 details the supply chain strategy in the 22 cases identified during the fieldwork by identified actor(s) (see Appendix 6 for the details of the types of actor) accountable for a given process. The three processes in Table 21 that are not detailed in Table 31 (see Appendix 7) have self identifying names (i.e. Chipping; Bucking and sorting at bucking plant, and Merchandising at intermediate yard).

Table 21: Supply chain strategy in the case studies identified in the fieldwork.

Country	Case	Deliver (value commitment)	Source			Make				
		Value commitment	**Select block**	**Buy block**	**Buy assortment**	**Schedule harvesting**	**Pre-harvesting preparation**	**Harvesting and Primary transport in the FT method**	**Merchandising at roadside landing**	**Harvesting and Primary transport in the CTL method**
Chile	1	Timberland-based wood procurement division	Timberland-based wood procurement division	Timberland-based wood procurement division	n.a.	Timberland-based wood procurement division	Harvesting contractors	Harvesting contractors	Harvesting contractors	Harvesting contractors
	2	Timberland-based wood procurement division	Timberland-based wood procurement division	Timberland-based wood procurement division	n.a.	Timberland-based wood procurement division	Harvesting contractors	Harvesting contractors	Harvesting contractors	Harvesting contractors
	3	Wood dealer / Timberland-based wood supplier	Wood dealer / Timberland-based wood supplier	Wood dealer / Timberland-based wood supplier	n.a.	Wood dealer / Timberland-based wood supplier	Harvesting contractors	n.a.	n.a.	Harvesting contractors
US	4	Wood dealer	n.a.	Wood dealer	n.a.	Wood dealer	Harvesting contractors	Harvesting contractors	Harvesting contractors	n.a.
	5	Timberland-based wood supplier	Timberland-based wood supplier	Timberland-based wood supplier	n.a.	Timberland-based wood supplier	Harvesting contractors	Harvesting contractors	Harvesting contractors	n.a.
	6	Wood	n.a.	Wood	n.a.	Wood	Harvesting	Harvesting	Harvesting	n.a.

Country	Case	Deliver (value commitment)	Source			Make				
		Value commitment	Select block	Buy block	Buy assortment	Schedule harvesting	Pre-harvesting preparation	Harvesting and Primary transport in the FT method	Merchandising at roadside landing	Harvesting and Primary transport in the CTL method
		procurement division		procurement division		procurement division	contractors	contractors	contractors	
	7	Timberland-based supplier	Timberland-based supplier	n.a.	n.a.	Timberland-based supplier	Harvesting contractors	Harvesting contractors	Harvesting contractors	n.a.
	8	Harvesting contractors	n.a.	Harvesting contractors	n.a.	Harvesting contractors	Harvesting contractors	Harvesting contractors	Harvesting contractors	n.a.
France	9	Wood procurement division	n.a.	Wood procurement division	n.a.	Wood procurement division	Harvesting contractors	n.a.	n.a.	Harvesting contractors
	10	Wood procurement division	n.a.	Wood procurement division	n.a.	Wood procurement division	Harvesting contractors / Wood procurement division	n.a.	n.a.	Harvesting contractors and Wood procurement division
	11	Harvesting contractor	n.a.	Harvesting contractor	n.a.	Harvesting contractor	Harvesting contractor	n.a.	n.a.	Harvesting contractor
	12	Cooperative of timberland owners	n.a.	Cooperative of timberland owners	n.a.	Cooperative of timberland owners	Harvesting contractor	n.a.	n.a.	Harvesting contractor
	13	Public organization	Public organization	n.a.	n.a.	Public organization	Harvesting contractor	n.a.	n.a.	Harvesting contractor
	14	Wood procurement division	n.a.	Wood procurement division	Wood procurement division	Wood procurement division	Harvesting contractor	n.a.	n.a.	Harvesting contractor
Canada	15	Wood procurement division	Wood procurement division	n.a.	Wood procurement division	Wood procurement division	Harvesting contractor	Harvesting contractor	Harvesting contractor	Harvesting contractor
	16	Wood	Wood	n.a.	Wood	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting

Country	Case	Deliver (value commitment)	Source			Make				
		Value commitment	Select block	Buy block	Buy assortment	Schedule harvesting	Pre-harvesting preparation	Harvesting and Primary transport in the FT method	Merchandising at roadside landing	Harvesting and Primary transport in the CTL method
		procurement division	procurement division		procurement division	contractor	contractor	contractor	contractor	contractor
	17	Syndicate of timberland owners	n.a.	n.a.	n.a.	Syndicate of timberland owners	Harvesting contractor / timberland owner	Harvesting contractor / timberland owner	Harvesting contractor / timberland owners	Harvesting contractor or timberland owner
Poland	18	Public timberland-based wood supplier	Public timberland-based wood supplier	n.a.	n.a.	Public timberland-based wood supplier	Harvesting contractor	Harvesting contractor	Harvesting contractor	Harvesting contractor
Sweden	19	Association of timberland owners	n.a.	Association of timberland owners	Association of timberland owners	Association of timberland owners	Harvesting contractor	n.a.	n.a.	Harvesting contractor
	20	Timberland-based wood procurement division	Timberland-based wood procurement division	Timberland-based wood procurement division	Timberland-based wood procurement division	Timberland-based wood procurement division	Harvesting contractor	n.a.	n.a.	Harvesting contractor
	21	Wood procurement division	Wood procurement division	Wood procurement division	Wood procurement division	Wood procurement division	Harvesting contractor	n.a.	n.a.	Harvesting contractor
	22	Public timberland-based wood procurement division	Public timberland-based wood procurement division	Public timberland-based wood procurement division	Public timberland-based wood procurement division	Public timberland-based wood procurement division	Harvesting contractor	n.a.	n.a.	Harvesting contractor

Table 21: Supply chain strategy in the case studies identified in the fieldwork. (continued)

Country	Case	Make	Deliver (secondary transport)					Make		
		Measuring at roadside	Schedule secondary transportation	Loading	Secondary transport	Measuring at the mill	Reception	Chipping	Bucking and sorting at bucking plant	Merchandising at intermediate yard
Chile	1	Harvesting contractors	Timberland-based wood procurement division	Transportation and loading contractors and, only in steep terrain, harvesting contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
	2	Harvesting contractors	Timberland-based wood procurement division	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
							Timberland-based wood procurement division (bucking plant)	n.a.	Timberland-based wood procurement division (bucking plant)	n.a.
	3	Harvesting contractors	Wood dealer / Timberland-based wood supplier	Transportation and loading contractors	Transportation and loading contractors	Mills	Chipping contractor	Chipping contractors	n.a.	n.a.
US	4	n.a.	Harvesting contractors	Harvesting contractors	Harvesting contractors	Mills	Mills	n.a.	n.a.	n.a.
	5	n.a.	Harvesting contractors	Harvesting contractors	Harvesting contractors	Mills	Mills	n.a.	n.a.	n.a.
	6	n.a.	Wood procurement division	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
	7	n.a.	Harvesting contractors	Harvesting contractors	Harvesting contractors	Mills	Mills	n.a.	n.a.	n.a.
	8	n.a.	Harvesting contractors	Harvesting contractors	Harvesting contractors	Mills	Mills	n.a.	n.a.	n.a.
France	9	Wood	Wood	Transportation	Transportation	Mills	Mills	n.a.	n.a.	n.a.

Country	Case	Make	Deliver (secondary transport)					Make		
		Measuring at roadside	Schedule secondary transportation	Loading	Secondary transport	Measuring at the mill	Reception	Chipping	Bucking and sorting at bucking plant	Merchandising at intermediate yard
		procurement division	procurement division	and loading contractors	and loading contractors					
	10	Wood procurement division	Wood procurement division	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
	11	Harvesting contractor	Harvesting contractor	Harvesting contractor	Harvesting contractor	Mills	Mills	n.a.	n.a.	n.a.
	12	Cooperative of timberland owners	Cooperative of timberland owners	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
	13	Public organization	Public organization	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
	14	Wood procurement division	Wood procurement division	Wood procurement division / Transportation contractors	Wood procurement division / Transportation contractors	Mills	Mills (internal customers)	n.a.	n.a.	n.a.
Canada	15	Harvesting contractor	Harvesting contractor	Harvesting contractor	Harvesting contractor	Mills	Mills	n.a.	n.a.	n.a.
	16	Harvesting contractor	Harvesting contractor	Harvesting contractor	Harvesting contractor	Mills	Mills	n.a.	n.a.	n.a.
	17	Harvesting contractor or timberland owner	Syndicate of timberland owners / Transportation and loading contractors	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
Poland	18	Public timberland-based wood supplier	Transportation and loading contractors	Transportation and loading contractors	Transportation and loading contractors	Mills	Mills	n.a.	n.a.	n.a.
Sweden	19	n.a.	Association of	Transportation	Transportation	Forestry	Mills	n.a.	n.a.	n.a.

Country	Case	Make	Deliver (secondary transport)					Make		
		Measuring at roadside	Schedule secondary transportation	Loading	Secondary transport	Measuring at the mill	Reception	Chipping	Bucking and sorting at bucking plant	Merchandising at intermediate yard
			timberland owners / Transportation contractor	contractor	contractor	and marketing service provider				
	20	n.a.	Timberland-based wood procurement division / Transportation contractor	Transportation contractor	Transportation contractor	Forestry and marketing service provider	Mills	n.a.	n.a.	n.a.
	21	n.a.	Wood procurement division / Transportation contractor	Transportation contractor	Transportation contractor	Forestry and marketing service provider	Mills	n.a.	n.a.	n.a.
	22	n.a.	Public timberland-based wood procurement division / Transportation contractor	Transportation contractor	Transportation contractor	Forestry and marketing service provider	Mills	n.a.	n.a.	n.a.

Table 21: Supply chain strategy in the case studies identified in the fieldwork. (continued)

		Deliver secondary transport)			
Country	**Case**	**Schedule secondary transportation**	**Loading**	**Secondary transport**	**Reception**
Chile	1	n.a.	n.a.	n.a.	n.a.
	2	n.a.	n.a.	n.a.	n.a.
		Timberland-based wood procurement division (bucking plant)	Timberland-based wood procurement division (bucking plant)	Timberland-based wood procurement division (bucking plant)	Mills (internal customers)
	3	Wood dealer / Timberland-based wood supplier	Transportation and loading contractors	Transportation and loading contractors	Seaport
US	4	n.a.	n.a.	n.a.	n.a.
	5	n.a.	n.a.	n.a.	n.a.
	6	n.a.	n.a.	n.a.	n.a.
	7	n.a.	n.a.	n.a.	n.a.
	8	n.a.	n.a.	n.a.	n.a.
France	9	n.a.	n.a.	n.a.	n.a.
	10	n.a.	n.a.	n.a.	n.a.
	11	n.a.	n.a.	n.a.	n.a.
	12	n.a.	n.a.	n.a.	n.a.
	13	n.a.	n.a.	n.a.	n.a.
	14	n.a.	n.a.	n.a.	n.a.
Canada	15	n.a.	n.a.	n.a.	n.a.
	16	n.a.	n.a.	n.a.	n.a.
	17	n.a.	n.a.	n.a.	n.a.
Poland	17	n.a.	n.a.	n.a.	n.a.
Sweden	19	n.a.	n.a.	n.a.	n.a.
	20	n.a.	n.a.	n.a.	n.a.
	21	n.a.	n.a.	n.a.	n.a.
	22	n.a.	n.a.	n.a.	n.a.

Appendix 5: Detailed literature review on each framework component

The development of the proposed framework is based on a literature review for each of the five components (see Figure 3 in Section 3). These literature reviews are presented in this annex.

Component 1: External environment

One of the first and most influential approaches for environmental analysis is Porter's strategic analysis based on five competitive forces (Porter, 1985), combined with the SCOR model by Di Martinelly et al. (2009). These forces are: the bargaining power of suppliers, the bargaining power of buyers, the threat of new entrants, the threat of substitute products or services, and the rivalry among existing firms. Additional forces may be added depending on the specificities of the sector studied, such as new technologies, social factors, government or other regulatory forces (Sharifi and Zhang, 1999; Di Martinelly et al., 2009). A more complete set of key elements for environmental analysis is presented by Daft and Armstrong (2009), which are translated to a WSC context in Table 22.

Table 22: Environmental elements for supply chain analysis. (Adapted from: Daft and Armstrong, 2009)

Environment element	General description	In WSC
1. Industry sector (internal)	Competitors, industry size and competitiveness, related industries.	Level of consolidation in the industry, number of companies, steel and concrete competition, electronic paper, etc.
2. Raw materials	Suppliers, manufacturers, real estate, services.	Wood variety and variability, land owners, machinery, fuel, road constructors, etc.
3. Human resources	Labour market, employment agencies, universities, training schools, employees in other companies, unionization.	Planners, drivers, sawyers, inspectors, consultants, buyers, sellers, etc.
4. Financial resources	Stock markets, banks, credit unions, private investors.	Liquidity and investment, public and private, availability to the industry.
5. Market sector	Customers, clients, potential users of products and services.	Sawmills, pulp and paper mills, bio-fuel refineries, wholesalers, retailers, construction industry, final customers, etc.
6. Technology	Techniques of production, science, computers, information technology, e-commerce.	Techniques and technologies used for planting, growing trees, planning, sawing, transporting, routing, stocking, etc.
7. Government	City, provincial, federal laws and regulations, taxes, services, court system, political processes.	Same as left.
8. International sector	Competition from and acquisition by foreign firms, entry into overseas markets, foreign customs, regulations, exchange rates.	Same as left.
9. Climate	New element.	Temperature and climate conditions varying in different seasons (spring, summer, autumn, winter).

A complementary environmental analysis is based on its uncertainty, or dynamism. Uncertainty is driven by changes in volume, variety and variability of any of the elements listed previously, increasing the unpredictability of demand or supply. It is a function of instability and complexity. The instability of an element is usually explained qualitatively using

2 levels: high or low (Stanley, 1993; Fynes et al., 2004; Fawcett et al., 2008; Germain et al., 2008). High instability in the wood industry can mean that some environmental element shifts abruptly and unexpectedly in a matter of days. Considering today's business world, if an element remains the same or highly predictable for weeks or months, it can then be considered stable (Daft and Armstrong, 2009).

The second dimension in classifying environmental uncertainty is complexity. Complexity means "the number or heterogeneity of external elements relevant to an organization's operations. The more external factors regularly influencing the organization and the greater the number of other organizations in the domain, the greater is the complexity" (Daft and Armstrong, 2009). It is important to know that as the environmental uncertainty of an industry increases, the greater is the need to develop an agile supply chain, to be able to forecast, detect and react quickly and effectively to changes (Christopher, 2000).
Porter (1998) also identified the importance of defining a company's strategy based on industry environment and presented five key contexts that require special attention for strategy formulation: fragmented industries, emerging industries, transition from rapid growth to maturity, declining industries and global industries. Two of these generic environments can be related to the current situation of a WSC, as they are fragmented and increasingly more global.

The definition of a fragmented industry environment is when "no firm has a significant market share and cannot strongly influence the industry outcome. Usually fragmented industries are populated by a large number of small- and medium-sized companies, many of them privately held" (Porter, 1998). A quantitative way to define whether an industry is fragmented is when the total market share of the top 4 firms is less than 40% (Porter, 1998). The reasons for industry fragmentation can be:

1. The existence of low overall entry barriers,
2. Absence of economies of scale or learning curve,
3. High transportation costs,
4. High inventory costs or erratic sales fluctuation,
5. No advantages of size in dealing with buyers or suppliers,
6. Diverse market needs,
7. High product differentiation,
8. Exit barriers,
9. Local regulation, and
10. Newness.

Some of these can be easily related to WSCs in general, such as low overall entry barriers, high transportation and logistics costs, high inventory due to erratic sales fluctuation and, in several countries, local regulation. The business and supply chain strategies should focus on overcoming these sources of fragmentation and uncertainty for a company to become a national or even global leader. A clear understanding of the environmental context helps in identifying the drivers for agility (Sharifi and Zhang, 1999; Lin *et al.*, 2006; Baramichai *et al.*, 2007) and in explaining strategic and operational choices.

Component 2: Competitive business strategy and supply chain strategy

The competitive business strategy addresses "how an organisation chooses to compete in a market, particularly the issue of positioning the company relative to competitors with the aim of establishing a profitable and sustainable position'' (Hallgren and Olhager, 2006). The dimensions describing a competitive strategy remain an open question and have been addressed by many authors and under different designations, such as competitive priority and competitive advantage (see Table 23).

Table 23: Dimensions of a competitive strategy/priority/advantage

Author	Dimensions of competitive strategy/priority/advantage
Porter (1998) (from Soni and Kodali, 2011)	Specialisation, brand identification, push vs pull, channel selection, product quality, technological leadership, vertical integration, cost position, service, price policy, leverage, relationship with parent company, relationship to home and host government
Krajewski et al. (2009) (from Soni and Kodali, 2011)	Cost (low cost operations), quality (top quality, consistent quality), time (delivery speed, on-time delivery, development speed) and flexibility (customisation, variety, volume flexibility)
Bozarth and Handfield (2006) (from Soni and Kodali, 2011)	Quality (performance, conformance, reliability), delivery (speed, reliability), cost and flexibility (mix, volume)
Flinch (2007) (from Soni and Kodali, 2011)	Cost, quality, dependability of delivery, flexibility and response time
Chase et al. (2003) (from Soni and Kodali, 2011)	Cost, product quality and reliability, delivery (speed, reliability) and flexibility (demand, new product)
Chase et al. (2006) (from Soni and Kodali, 2011) and Soni and Kodali (2011)	Cost, quality, delivery speed, delivery reliability, demand flexibility, new product flexibility
Gaither and Frazier (2007) (from Soni and Kodali, 2011)	Low production costs, delivery performance, high-quality product/services, customer service and flexibility
Mahadevan (2007) (from Soni and Kodali, 2011)	Cost, quality, value and flexibility
Heizer and Render (2007) (from Soni and Kodali, 2011)	Differentiation, cost leadership and response
Russell and Taylor (2003) (from Soni and Kodali, 2011)	Cost, quality, flexibility and speed
Buffa (2007) (from Soni and Kodali, 2011)	Overall cost leadership, differentiation and market segmentation
Chi et al. (2009) (from Soni and Kodali, 2011)	Low cost, quality, delivery performance and flexibility
Li et al. (2006), Cao and Zhang (2008), Lakhal (2009)	Price/cost, quality, delivery dependability, product innovation and time to market
Koufteros *et al* (1997) (from Lakhal, 2009)	Competitive pricing, premium pricing, value-to-customer quality, dependable delivery, and production innovation.
Mckone-Sweet and Lee (2009)	Low price, performance quality, fast delivery, on-time delivery and fast response to nonstandard orders
Tracey et al. (1999)	Price offered, quality of products, product line breadth, order fill rate, order cycle time, Order/Shipment information and frequency of delivery.
Miller and Roth (1994) (from Martin-Pena and Diaz-Garrido, 2008)	Cost, flexibility, quality, delivery, after-sales, service, advertisement, wide product distribution
Kathuria (2000) (from Martin-Pena and Diaz-Garrido, 2008)	Cost, quality, flexibility and delivery
Christiansen et al. (2003) (from Martin-Pena and Diaz-Garrido, 2008)	Price, quality conformance, delivery speed, delivery reliability, time to market, design, product features and variety, customisation
Diaz and Martin (2004) (from Martin-Pena and Diaz-Garrido, 2008)	Cost, quality, flexibility, delivery, after-sales, service and protection of the environment
Sum et al. (2004) (from Martin-Pena and Diaz-Garrido, 2008)	Cost, quality, delivery, and flexibility

Distinguishing among three major business strategies for competitiveness (i.e. cost leadership, differentiation and focus), the typology for the competitive strategy of a company by Porter (1985) is one of the most well-known and adopted typologies. It has already been used notably for strategy studies in the sawmilling and pulp and paper industry in Europe and North America (Niemelä and Smith, 1997; Roos et al., 2001; Hansen et al., 2006; Lähtinen, 2007).

There are two opposing schools of thought concerning this typology. The first maintains that to perform, a company can have only one strategy, while the second states that a company can combine strategies (Yamin et al., 1997). Furthermore, several authors reduce Porter's three strategies to two: cost leadership and differentiation, as a focus strategy is considered a "stuck in the middle" approach used by companies that are ineffective in concentrating on one strategy to implement it well (Porter, 1985; Davis et al., 2002; Hansen et al., 2006). This is the case, for instance, of small private sawmills in Sweden that focus on the local market and present neither a representative value-added offer nor a good productivity rate when compared to sawmills pursuing other strategies (Roos et al., 2002). We support and utilise the concept that a company can have many strategies, even if this choice is not reflected in major competitiveness or a higher performance level. More references on business strategies were identified by Audy et al. (2010) in Table 24, reinforcing the typology of "cost leadership-differentiation-focus".

Table 24: Business strategy typologies

Author	Business strategy typologies
Porter (1980)	- Cost leadership - Differentiation - Focus
Shapiro (1984)	- Product innovation (differentiation) - Customer service (differentiation) - Cost leadership
Treacy and Wiersema (1993), Reimann et al. (2010)	- Operational excellence - Customer intimacy (differentiation) - Product leadership (differentiation)
Niemelä and Smith (1997) Roos *et al.* (2001)	- Cost leadership - Differentiation - Focus - A combination of the options above
Davis *et al.* (2002) Hansen *et al.* (2006)	- Cost leadership - Differentiation by product, by service, by marketing channel
Yee and Platts (2006)	- Low price (cost leadership) - Low cost (cost leadership) - Customer accessibility (differentiation) - Service (differentiation)
Martin-Pena and Diaz-Garrido (2008)	- Cost leadership - Differentiation by service - Differentiation by product innovation - Combination of cost leadership and differentiation

Cost-leadership means that the company takes the competition head-on, offering a product that is equivalent to those offered by competitors, but more efficiently (e.g. cheaper price). The main drivers for the company are basically low unit cost, operational excellence and high productivity. It usually has a standard or limited catalogue of products and service attributes.

The differentiation strategy aims to avoid direct competition by differentiating the products and/or services offered to deliver higher customer value, making it possible to charge a premium price. The company is still concerned about costs, but these are not the primary drivers. The differentiation in a WSC can be achieved in mainly three different, but not self-excluding, ways (Hansen et al., 2006):

a) Services: a broad offer of personalized services, such as delivery windows, payment, packing, etc. Offer of additional services, such as maintenance, routing, planning, optimization, etc.
b) Product: products with higher quality, reliability or durability, frequent new product development, a high share of new products in the product portfolios and the implementation of value-added transformation activities by the company.
c) Marketing: differentiation is achieved through branding, control of distribution channels, exclusivity contracts and innovative marketing techniques.

These strategic choices apply to a single company. However, due to the general fragmentation level of the industry, among other factors, a WSC consists of several actors or companies, which frequently have different strategies. The literature describing and studying business strategies at a network level is very limited (Hofmann, 2010), concentrating mainly on the strategic choices in a relationship between two business partners (Blankenburg Holm *et al.*, 1999; Yee and Platts, 2006; Lefaix-Durand; 2008). These papers highlight the need to include a relationship dimension in any supply chain study.

Notably, Yee and Platts (2006) propose a practical approach to describe and analyse the interaction of firms in a supply network and how this links to business strategies. This method is called SNAP (Supply Network Analysis Process) and is an adaptation of the Strategic Charting technique from Cambridge's manufacturing group to a supply chain context.

It consists of describing, for each company in the network, the business strategy and the strategy approach. The strategy approach refers to how a firm is willing to implement a selected business strategy: in an offensive, defensive or diversifying way, and with an individual or cooperative approach. Table 25 describes each of these strategy approaches.

Table 25: Strategy approaches (Source: Yee and Platts, 2006).

Offensive-individual	A company seeks to capture more market-share at the expense of another firm(s) based on available resources that are internal to the firm.
Offensive-cooperative	A company seeks to capture more market-share at the expense of another firm(s) by utilising external resources from other network members.
Defensive-individual	A company seeks to maintain its current market-share based on available resources that are internal to the firm.
Defensive-cooperative	A company seeks to maintain its current market-share by utilising external resources from other network members.
Diversify-individual	A company seeks to explore new market segments based on available resources that are internal to the firm.
Diversify-cooperative	A company seeks to explore new market segments by utilising external resources from other network members.

Once the business strategy and strategy approach are identified, it is time to define the supply chain strategy. From a value creation network perspective, an effort has to be made to determine which of the processes should be executed and/or controlled by the organisation, and which should be undertaken by another enterprise. This is what we call the supply chain strategic options of make, not make, outsource or make together (see Table 26).

Table 26 : Supply chain strategic options (Source: D'Amours et al., 2010).

Strategic option	Impact on the organisation
Make	Own network The network does not necessarily have to change Some activities or operations could be optimized or adapted Some new activities or operations could also be executed The organisation can choose to acquire new business units
Outsource	External network Based on a relationship with a partner A new relationship can be created with an old partner A relationship can also be created with a new partner
Make together	Based on a relationship with a partner A new relationship can be created with an old partner A relationship can also be created with a new partner Some new activities or operations could also be executed
Not Make	Stop to process the operation Use resources for other activities

More precisely, enterprises need to identify their skills as well as the business processes they can efficiently conduct. If these activities are well executed, at a low cost and create value for the organisation, they should be classified as "make" operations. On the other hand, if activities are not necessarily executed economically or necessitate specific competencies that the organisation does not have, they should be outsourced (i.e. the use of an external network), executed with another organisation (i.e. development of network synergy) or not made.

Even if outsourcing or working with a partner can be very profitable, the enterprise cannot forget that this implies a lower level of control, the need to share some information, the need for metrics and, in the case of real partnerships, a share of the benefits. These strategic options guide the company in how the supply chain processes will be structured and coordinated to support the achievement of the business strategy (Ketata, 2003). The next two sections will describe in more detail the WSC structures and coordination mechanisms.

Component 3: Wood supply chain structure

One main question in describing a supply chain structure is determining the structural elements to be included in the description. The Supply Chain Operations Reference (SCOR) model was chosen to support the description of the WSC processes.

However, additional elements other than the processes should be part of the WSC structure. In a study of product personalisation options and its impacts on network design, Poulin et al. (2006) described six structural elements:

- Supply chain processes: the main steps related to product transformation.
- Personalisation option: the level of customisation allowed for a specific product.
- Point of customer involvement: specific process affected by a client's specifications.
- Material flow: direction of product movement from one supply chain process to another.
- Inventory: locations along the material flow where a considerable quantity of products waits for the next process to start and consume them.
- Decoupling point: inventory location in the supply chain allowing products to be differentiated according to a client's specification.

The importance of portraying the decoupling point and its relationship to the value proposition, including possibilities of postponement, were also identified by Forza et al. (2008) and Trentin et al. (2011). Wikner and Rudberg (2005) define the decoupling point, or order penetration point, as "the point in the flow of goods where forecast-driven production and customer order-driven production are separated" or, in other words, "the point in the value-adding material flow that separates decisions made under uncertainty from decisions made under certainty concerning customer demand (…)". Four typologies of a decoupling point are traditionally defined: engineer-to-order, make-to-order, assemble-to-order and make-to-stock.

In a supply chain structure, there exists, therefore, a relationship between the personalisation levels of the attributes of the value proposition, the processes and the decoupling point possibilities. In a WSC, it could be possible to assume the existence of at least four basic decoupling point possibilities: select block-to-order, harvest-to-order, primary transport-to-order, secondary transport-to-order. However, the nature of a WSC as a product-service system makes this assumption less obvious. This means that the main value proposition attributes that can be set or adjusted according to a client's demand in any process must be identified.

In addition to WSC processes, actors, value proposition attributes and decoupling points, another important feature to be captured, described and analysed as part of the structure is the planning system. For this, the decisions to be taken in each process, the actors responsible for them, the planning horizon, the planning period, update frequency, inputs and outputs also need to be captured. After describing the structure of the WSC, it is now time to describe its coordination mechanisms, other than the planning system, occurring through other practices and enabling mechanisms.

Component 4: Enablers and practices

The role of coordination mechanisms, also called enablers and practices, is to link the business strategy and the supply chain structure. The utilisation of adequate enablers can help the supply chain to achieve its business objectives by "preparing, maintaining, and managing information and relationships upon which planning, sourcing, making and delivering execution processes rely on" (Supply Chain Council, 2008). Enablers are the means to achieve expected end results.

In the literature on manufacturing and supply chain agility, enablers, providers, techniques, capabilities and practices appear as synonyms and the means to achieve and secure the required level of agility (Sharifi and Zhang, 1999; Mason-Jones et al., 2000; Van Hoek et al., 2001; Yusuf et al., 2004; Sun et al., 2005; Agarwal et al., 2006; Lin et al., 2006; Faisal et al., 2007; Baramichai et al., 2007).

After an extensive review on enablers of supply chain agility in scientific articles and the SCOR manual, more than 400 enablers were identified and listed (see Appendix 7). Following the SCOR structure, which includes not only the plan, source, make, deliver and return processes, but also a "pseudo" process called "Enable", a set of seven categories of enablers was identified. These categories are presented below with some examples of best practices.

1) Rules and guidelines for decision support: Collaborative Review and Agreement of Business Rules Prior to Contract Execution, Long Term Supplier Agreements/Partnerships, ABC Classification, Yield tables, growth models, simulations, sorting rules, practices, standards.

2) Performance measurement (internal and suppliers), including measures, targets and action plan: Reliable Continuous Improvement Process and Methodology, Supplier Performance Assessment System, Real Time

Performance Measurement Reporting Systems, productivity models for harvesting.

3) Information management, including data accuracy and granularity: Integrated Demand and Supply Planning, Automated Update of Supplier Performance Information, Customer Access to Online Tracking of Order Status and Shipping Information, Forest information systems, geographical information systems.

4) Inventory management (replenishment models, ownership, product mix, and stocking locations, both inter and intra company): Real Time Data on Current Status, Minimizing In-Process Product (WIP), Mapping of the stocks, inventory sampling, management of the logs, prognoses about the assortment of timber.

5) Asset management (defining capacity strategy and acquiring, maintaining and disposing an organization's capital assets): Total Preventative Maintenance Program, Supplier Managed Inventory of Parts, Standard Operating Procedures and Methodology.

6) Transportation management: transportation requirements (product, containerisation, vehicle, route, terminals, regulations, rates/tariffs and backhaul opportunity), and the management of transporters both inter and intra company: Transportation models, routing, Information to identify the felling area, Backhaul Trading Exchange.

7) Network management: Vendor Managed Inventory (VMI) Programs, Supplier certification programs, Management of the addresses of forest owners and parcels of land, Management of agreements made with forest owners (basic agreements, delivery conditions), standard contracts.

8) There is an eighth category called "Regulatory requirements and conformance", related to safety requirements, soil and vegetation protection, water pollution control, protected areas and customs formalities for timber import and export (Schnetzler et al., 2009), but it will not be used in this research project.

In the Flexwood framework, the enablers and practices identified in the case studies for the main steps of source, make and deliver must be described. The objective here is not to judge whether the practice is good or not, but rather to identify and describe what was observed. The evaluation of the pertinence and contribution of the practices is the objective of the next and final building component.

Component 5: Performance

Performance measurement can be defined as "the process of quantifying the efficiency and effectiveness of an action" (Neely et al., 1995; Gunasekaran and Kobu, 2007). A performance measurement system can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions. Here, metric refers to the definition of the measure, how it will be calculated, who will be performing the calculation, and the source of the data (Neely et al., 1995).

There are several literature reviews on supply chain performance measurement: Neely et al. (1995); Gunasekaran et al. (2004); Shepherd and Günter (2006); Gunasekaran and Kobu (2007); Arzu Akyuz and Erman Erkan (2010); Payne (2010); Carvalho et al. (2011)). Based on these reviews, three main types of supply chain performance measures can be identified:

financial quantitative measures, non-financial quantitative measures and non-financial qualitative measures. Non-financial qualitative metrics are understood as evaluations based generally on individual perception and open to a certain level of subjectivity, commonly measured with Likert scales and level of concordance with propositions. These measures are usually considered to positively impact other quantitative ones and, therefore, increase competitiveness.

Forthcoming Table 28 presents an excerpt of these metrics, classified as value chain-based and/or function-based (source, make, deliver). The metrics classified as “value chain-based” are process metrics and address a complete supply chain, such as cash-to-cash cycle time and supply chain response time. The ones classified as “function-based” are specific to sourcing, making or delivering activities and departments, such as inventory cost (of purchased parts, work-in-process and final products) and accuracy of scheduling (scheduling product reception, production scheduling, delivery scheduling). Some of the metrics can also be measured both as a value chain and at a functional level, such as overhead cost, delivery reliability and labour efficiency. These metrics can be further classified as the competitive priorities of the company, such as cost, quality, time and innovation (Shepherd and Günter, 2006).

A condensed view of a supply chain measurement system is proposed in the SCOR manual (Table 27), which provides a set of ten metrics on SC performance that are generic for the supply chain of any industrial sector, and covers costs, asset management, reliability, responsiveness and agility (SCC, 2008).

Table 27 : Definition of the strategic performance metrics in the SCOR model version 9 (Source: SCC, 2008)

Performance attribute	Definition	Metric
Supply chain costs	The costs associated with operating the supply chain.	Supply chain management cost
		Cost of goods sold
Supply chain asset management	The effectiveness of an organisation in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-cash cycle time
		Return on supply chain fixed assets
		Return on working capital
Supply chain reliability	The performance of a supply chain in delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Perfect order fulfilment
Supply chain responsiveness	The speed at which a supply chain provides products to the customer.	Order fulfilment cycle time
Supply chain agility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Upside supply chain flexibility
		Upside supply chain adaptability
		Downside supply chain adaptability

Some effort has been made to propose a measurement system based on the Balanced Score Card approach (Thakkar et al., 2009) and new trends and challenges in supply chain performance measurement include, notably, environmental measures, agility, and a more holistic scope covering more than one or two companies (Morgan, 2007). There is an absence of publications on supply chain performance measurement applied to a WSC.

However, we did find publications on performance measurement systems for some business entities in a WSC and we summarise these.

Based on a wide survey of forest harvesting entrepreneurs (n = 336) in the province of Quebec (Canada), Drolet and LeBel (2009) report that forest harvesting entrepreneurs focus essentially on production metrics such as 'cubic metre per productive hour' or 'utilisation rate'. Moreover, a list of the 17 best performance metrics according to the 336 forest harvesting entrepreneurs in the survey is provided. Pomerleau (2003) provides a list of performance metrics that allow the procurement department of a forestry company to manage the performance of three subcontracted operations: i) harvesting, ii) construction of first class roads and iii) construction of second class roads. For each operation, the metrics are classified into four categories: cost, quality, productivity and yield.

Table 28 : Supply chain performance metrics. Source: (1) Shepherd and Günter (2006), (2) Gunasekaran and Kobo (2007), (3) Supply Chain Council (2008), (4) Swafford et al. (2006).

Type	Metric	Value chain based	Function based	Authors
financial quantitative	Cash-to-cash cycle time	X		1, 3
	Inventory/WIP cost	X	X	1, 2
	Overhead cost	X	X	1, 2, 3
	Return on investment (fixed assets and working capital)	X	X	1, 2, 3
	Scrap/obsolescence cost		X	1, 2
	Selling price / cost of goods	X	X	1, 2, 3
non-financial quantitative	Accuracy of scheduling		X	1, 2
	Delivery reliability (Perfect Order Fulfilment)	X	X	1, 2, 3, 4
	Forecasting accuracy	X		1, 2
	Labor efficiency	X	X	1, 2
	Manufacturing lead time		X	1, 4
	Number of new products launched		X	1, 4
	Process cycle time (planned and real)	X	X	1, 2
	Procurement lead time		X	1, 2
	Product development cycle time		X	1, 2, 4
	Supply chain response time	X		1, 2, 3
non-financial qualitative	Autonomy of planning	X		1
	Buyer-supplier partnership level		X	1
	Customer satisfaction	X		4
	Customisation level	X		4
	Departmental relations	X		1
	Distribution of decision competences		X	1
	Downside adaptability	X	X	1, 3, 4
	Extent of mutual assistance in problem-solving		X	1
	Extent of mutual planning cooperation		X	1
	Horizon of business relationship	X		1
	Information accuracy and availability		X	1
	Mutual trust		X	1
	Quality and frequency of exchange of logistics information		X	1
	Supplier assistance in solving technical problems		X	1
	Upside adaptability	X	X	1, 3, 4

	Upside flexibility	X	X	1, 3, 4

The EFORWOOD project (EFORWOOD, 2010) provides a set of sustainability indicators to assess the sustainability performance of a WSC. The sustainability indicators are regrouped into the three fundamental components that define sustainable development: economic (e.g. investment and R&D, gross value added), social (e.g. education and training, innovation) and environmental (e.g. forest biodiversity, energy generation and use). A computerized decision-support tool, ToSIA, that embedded the calculation of these indicators for a specific scenario of a WSC, has also been developed in this project.

As mentioned in the WP-5100 description, three attributes of a WSC will be specifically studied: agility, competitiveness and customisation (also called tailoring). The fluid nature and definition of these attributes, the fragmentation of the industry, the diversity of the cases studied and the difficulty of accessing quantitative data make it more suitable to use non-financial qualitative metrics, assuming that agility and customisation positively impact the competitiveness of a WSC. Customisation will be evaluated based on the location of the decoupling point and there is a special section on agility measurement, as it is a very broad topic. This section remains, however, a reference for further research and applications of performance measurement systems in WSCs.

Measuring supply chain agility

The concept of organizational and manufacturing agility originated in the mid-1990's, and was spread and adapted to the supply chain field at the end of the 1990's (Li et al., 2008; Huang and Li, 2008). Although nearly 30,000 documents are available on the subject (Google Scholar, 2011), there are three main "structured schools" of thought identified on supply chain agility and its measurement.

The first and most relevant approach started with the article of Professor Christopher (2000), from Cranfield University in the United Kingdom. The framework for an agile supply chain proposed in this article is composed of four dimensions or capabilities: customer sensitivity, information drivers, process integration and network integration. It has been used as a reference since then for further studies in the United Kingdom, Benelux, India and Taiwan (Christopher and Towill, 2001; Van Hoek et al., 2001; Christopher et al., 2004; Yusuf et al., 2004; Agarwal et al., 2006; Lin et al., 2006; Agarwal et al., 2007; Faisal et al., 2007). It is a conceptual but strategy-oriented framework, already applied in different industries, such as clothing, manufacturing, retailing and electronics. It supposes the contextualisation and adaptation of enablers and practices to each study. A similar approach was also adopted in the context of humanitarian aid supply chains (Charles et al., 2010; Scholten et al, 2010).

When it comes to agility measurement, this is done indirectly for the four individual dimensions by the evaluation of enablers specific to each of them. Enablers are measured mainly by using self-evaluation questionnaires based on Likert scales or similar judgement scales, where the respondents identify their level of agreement on the utilisation of specified practices and enablers (Van Hoek et al., 2001; Yusuf et al., 2004; Lin et al., 2006; Faisal et al., 2007). A similar approach was used by Azouzi et al. (2009), who defined manufacturing technology agility by three capabilities and asked experts to rate the technology properties, the equivalent of enablers, of these capabilities. Other measurements used were pair-wise comparisons (Agarwal et al., 2006; Agarwal et al., 2007; Faisal et al., 2007) and importance weights assigned to enablers (Lin et al. 2006). The methods of data analysis used were arithmetical means (Van Hoek et al., 2001), percentage of answers by score (Yusuf et al., 2004), case studies (Christopher et al., 2004), analytic network process (ANP) (Agarwal et al., 2006), fuzzy logics (Lin et al., 2006) and interpretive structural modelling (ISM) (Agarwal et al., 2007; Faisal et al., 2007).

The second school is led by Professor Swafford, from the University of Texas in Arlington (Swafford et al., 2006; Swafford et al., 2007). Her framework defines supply chain agility as dependent on flexibility and IT integration in different functions (procurement, manufacturing and distribution). For each variable (SC agility, flexibility and IT integration), 4 to 8 practices were defined from the literature and, once again, a self-evaluation questionnaire based on Likert scales was used for surveys in the US manufacturing industry. Results were analysed using confirmatory factor analysis (CFA) and structural equation modelling (SEM).

The third school identified is based on the work of Professor Li, from Nicholls State University in Louisiana (Li et al., 2008; Li et al.; 2009). Her framework describes supply chain agility based on two dimensions - alertness and responsiveness to changes - in three different hierarchic levels of the organization. Two items for each dimension were measured with a Likert scale and the scores justified by the respondents. This conceptual and recent framework still has very limited application. These schools and their main elements and impact are portrayed in Figure 50, showing a detailed description of the SC agility measurement approaches.

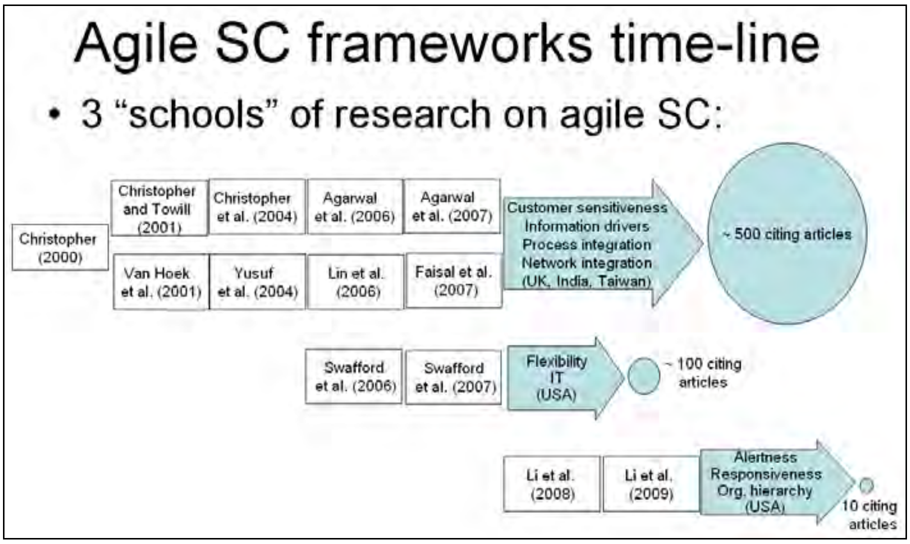

Figure 50 : Supply chain agility frameworks.

The SCOR manual proposes three supply chain agility metrics, defined as:

- Upside Supply Chain Flexibility: the number of days required to achieve an unplanned sustainable 20% increase in quantities delivered.
- Upside Supply Chain Adaptability: the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days.
- Downside Supply Chain Adaptability: the percentage reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory or cost penalties.

In a recent literature review on agility, Huang and Li (2009) also identified some minor efforts in supply chain agility measurement through simulation, case studies and surveys. Another observation is that some researchers measured agility as a finality in itself (Van Hoek et al., 2001; Swafford et al., 2006; Lin et al., 2006; Faisal et al., 2007), assuming an overall direct and positive contribution to competitiveness. Others also measured the perceived or expected effects of supply chain agility on the performance metrics of lead-time, product development, customization, customer satisfaction, service level and financial measures (Yusuf et al., 2004; Agarwal et al., 2006-2007; Swafford et al., 2007; Carvalho et al., 2011). The results are not uniform, but there is convergence on the positive impact of SC agility on lead-time and service level, with divergence on cost and quality. Table 30 lists the performance indicators used in the research, classified in the same categories specified in the last section and the impact of SC agility on them.

Table 29: Proposed supply chain agility measurement methods

Reference	Objective	SC Agility dimensions	What is measured	How it is measured	Data collection method	Data analysis method
Van Hoek et al. (2001)	Measure SC agility	Customer sensitivity	10 statements	5-point Likert scale	Survey followed by an interview of respondents from 88 European companies (40% response rate)	Arithmetical mean by dimension
		Virtual integration	3 statements			
		Process integration	5 statements			
		Network integration	6 statements			
Christopher et al. (2004)	Exemplify SC agility	Customer sensitivity	3 enablers	NA	Examples from the fashion industry	Conceptual paper
		Virtual integration	3 enablers			
		Process integration	3 enablers			
		Network integration	3 enablers			
Yusuf et al. (2004)	Measure SC practices and its impact on SC performance	Customer sensitivity	4 enablers	5-point Likert scale	Survey sent to 600 UK manufacturing companies (18,17% response rate)	% of answers by score Factor analysis
		Virtual integration				
		Process integration				
		Network integration				
		NA	1 Lean SC enabler			
		NA	2 Traditional SC enablers			
Agarwal et al. (2006)	Explore the relationship between SC agility enablers and SC performance	Market sensitiveness	3 enablers	Pair-wise comparison between enablers of the same dimension (1-9 scale)	Discussion with 5 SC experts to fill 117 pair-wise comparison matrices for the fast moving consumer goods industry	ANP - Analytic Network Process
		Process integration	3 enablers			
		Information driver	3 enablers			
		Flexibility	3 enablers			
Lin et al. (2006)	Develop an agility index	Customer sensitivity	7 enablers	Performance rating of each enabler in a 7-interval scale Importance weights of each enabler in a 7-interval scale	Workshops with 5 managers from a Taiwanese company	Fuzzy logic
		Information integration	4 enablers			
		Process integration	5 enablers			
		Collaborative relationships	8 enablers			
Agarwal et al. (2007)	Define SC agility development	Market sensitiveness	15 enablers	Pair-wise relationship between each enabler	Questionnaire sent to 760 OEM and their	Interpretive structural modeling
		Information driver				

Reference	Objective	SC Agility dimensions	What is measured	How it is measured	Data collection method	Data analysis method
	sequence and impacts on SC performance	Process integration			suppliers (23,55% response rate)	(ISM)
		Collaborative relationships				
Faisal et al. (2007)	Define the most important drivers of SC agility	Market sensitiveness	13 enablers	Pair-wise relationship between each enabler 0-10 rank value judgement for each enabler	Interviews with SC experts	Interpretive structural modeling (ISM) and Graph theoretic approach (GTA)
		Virtual integration				
		Process integration				
		Network integration				
Swafford (2006, 2007)	Measure SC agility and impact on SC performance	No specific dimensions, but SC flexibility and IT integration are considered antecedents of SC agility, measured in the same approach.	7 key agility measures	5-point Likert scale	Survey sent to high-ranking executives of 664 US manufacturing companies (19% response rate)	Confirmatory factor analysis (CFA) and Structural equation modeling (SEM)
			Speed in reducing development cycle time			
			Speed in increasing frequencies of new product introductions			
			Speed in increasing levels of product customisation.			
			Speed in adjusting delivery capability			
			Speed in improving customer service			
			Speed in improving delivery reliability			
			Speed in improving responsiveness to changing market needs.			
SCOR (2008)	Measure SC agility	Flexibility	Upside Supply Chain Flexibility	specific metrics	Not specified	Not specified
		Adaptability	Upside Supply Chain Adaptability	specific metrics		
			Downside Supply Chain Adaptability	specific metrics		
Li et al.	Create a construct	Strategic alertness	2 statements	5-point Likert scale	Interviews with SC	Confirmatory factor

Reference	Objective	SC Agility dimensions	What is measured	How it is measured	Data collection method	Data analysis method
(2008, 2009)	to measure SC agility	Strategic response capability	2 statements	Justification of the score given	executives or managers of 66 US manufacturing companies	analysis (CFA)
		Operational alertness	2 statements			
		Operational response capability	2 statements			
		Episodic alertness	2 statements			
		Episodic response capability	2 statements			
Carvalho et al. (2011)	Explore SC agility enablers and their impact on SC performance	NA	7 enablers	NA	NA	Conceptual paper

Table 30: Contribution of supply chain agility to performance indicators.

Categories	Performance indicators	SC agility contribution		
		Positive impact	Neutral impact	Negative impact
Financial quantitative	Cost	1,4		2, 5
	Return on assets	3		
	Profit margin	3		
	Sales/employee	3		
Non-financial quantitative	Lead-time	2, 4, 5		
	Service level	2, 4, 5		
	New product introduction	4		
	Market share	3		
	Delivery speed	4		
Non-financial qualitative	Flexibility		1	
	Quality	4	1	2
	Customer satisfaction	4		

Legend: (1) Yusuf et al. (2004); (2) Agarwal et al. (2006); (3) Swafford et al. (2006); (4) Agarwal et al. (2007); (5) Carvalho et al. (2011)

To summarise, the "state-of-the-art" of supply chain agility measurement uses the concept of agility in a supply chain scope measuring enablers and practices of dimensions (or capabilities) through rating techniques, eventually establishing a linkage to overall business performance metrics (Figure 51).

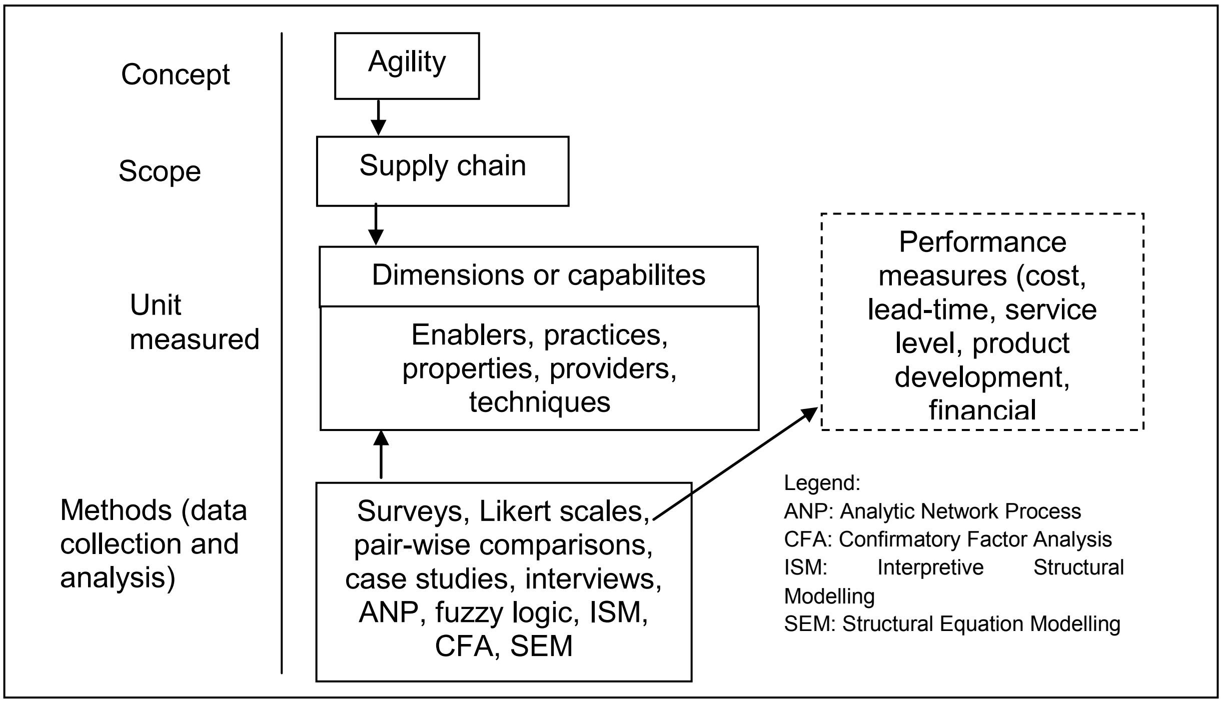

Figure 51: « State-of-the-art » supply chain agility assessment (Adapted from: Van Hoek et al., 2001).

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Appendix 6: Types of actor involved in the wood supply chain

A set of 16 types of actors was identified from the cases studied. Table 31 describes each of them. Not all the actors described below are discussed explicitly in the case studies.

Table 31: Description of actor type

Actor type	Definition
Timberland owner	Entity that owns timberland.
Structured group of timberland owners	Group of timberland owners structured in one of various types of organisations (e.g. cooperative, syndicate, association) acting as a timber supplier and/or forestry and marketing service provider.
Public and quasi-public organisation	State owned or controlled organisations (e.g. forest ministry, office of health and safety at work, environment agency).
Harvesting contractor	Harvesting service provider with internal harvesting capacity. When the harvesting contractor also performs transportation activities (see e.g. US case 4, Canadian case 15), two types of harvesting contractors can be differentiated: i) a turn-key harvesting contractor that has the internal resources to execute all activities from harvesting to secondary transport and ii) a ‘virtual’ turn-key harvesting contractor that is composed, at least, of one harvesting contractor and one transportation and loading contractor who act as a single entity with any supplier of harvested timber.
Transportation and loading contractor	Secondary transport and handling service provider with internal transportation/handling capacity. Can be a member of an association of transportation contractors working together. In some contexts (e.g. steep terrain), the handling service is offer by the harvesting contractor.
Road construction and maintenance contractor	Road construction and maintenance service provider with internal capacity. Can be a complementary service offered by a harvesting or transportation contractor.
Wood procurement division	Entity acting as a supplier of harvested timber and in corporate association with mill(s). Can have internal capacity but usually uses contractors.
Timberland-based wood supplier	Entity which owns timberland and acts as a supplier of harvested timber. It has no corporate ties with mill(s). Can have internal capacity but usually uses contractors.
Timberland-based wood procurement division	Entity acting as a supplier of harvested timber primarily based on own timberland and in corporate association with mill(s). Can have internal capacity but usually uses contractors.
Wood dealer	Entity acting as a supplier of harvested timber without timberland ownership and corporate association to mill. Can have internal capacity but usually uses contractors.
Customer / Mill	Entity buying harvested timber from supplier of harvested timber.
Forestry and marketing service provider	Entity providing forest management, silviculture, measurement and standing/harvested timber marketing services to timberland owners.
Logistics and information technology service provider	Entity providing planning and execution control services for logistics activities and information technology service to supplier of harvested timber and contractors.

Actor type	Definition
Research and development service provider	Entity providing research and development service to any actor in the WSC.
Equipment and maintenance service provider	Entity selling harvesting/transportation/handling equipment and providing maintenance to contractors and supplier of harvested timber with internal capacity.
Financial services provider	Entity providing financial services to any actor in the WSC.

Appendix 7: List of proposed processes within the wood supply chain

Table 32 describes the proposed processes in a WSC and their correspondence to the generic processes in the SCOR model. It presents a catalogue of processes, which could be further improved to include other activities not considered within the research project (e.g. road construction).

Table 32: Proposed planning and execution processes in a WSC.

Proposed process in a WSC	Macro-process	Generic processes in the SCOR model (Source: Supply Chain Council, 2008)
Select block: Selection of a specific block to be harvested.	Source	SX.1 Schedule Product Deliveries
		SX.3 Verify Product
		SX.5 Authorize Supplier Payment
Buy block: Purchase of the standing timber in a block.	Source	SX.1 Schedule Product Deliveries
		SX.3 Verify Product
		SX.5 Authorize Supplier Payment
Buy assortment: Purchase of a volume of harvested timber.	Source	SX.1 Schedule Product Deliveries
		SX.3 Verify Product
		SX.5 Authorize Supplier Payment
Schedule harvesting: Set of planning decisions related to harvesting activities (see Appendix 1 for the list of generic decisions). The process can be split among different actors.	Make	MX.1 Schedule Production Activities
Pre-harvesting preparation: Execution of all the activities to start harvesting a block (e.g. movement of equipment).	Make	MX.2 Issue Material
Harvesting in the FT or CTL method: Felling a tree with optional activities (e.g. bunching, delimbing, bucking) according to harvesting method and mechanisation level.	Make	MX.3 Produce and Test
		MX.4 Package
Primary transport in the FT or CTL method: Transportation of harvested timber from stumpage area to roadside landing with optional activities (e.g. sorting, piling at roadside) according to harvesting method.	Make	MX.5 Stage Product
		MX.6 Release Product to Deliver (if process 'Merchandising at roadside landing' or 'Measuring at roadside' is not required)
Merchandising at roadside landing: Delimbing, bucking (log or stem), sorting and piling at roadside.	Make	MX.3 Produce and Test
		MX.4 Package
		MX.6 Release Product to Deliver
Measuring at roadside: Measurement of harvested timber at roadside.	Make	MX.3 Produce and Test
		MX.6 Release Product to Deliver
Value commitment: Dialogue, quotation development, negotiation and commitment of harvested timber with a	Deliver	DX.1 Process Inquiry and Quote
		DX.2 Receive, Configure, Enter and Validate Order

Proposed process in a WSC	**Macro-process**	**Generic processes in the SCOR model (Source: Supply Chain Council, 2008)**
customer.		DX.3 Reserve Inventory and Determine Delivery Date
Schedule secondary transportation: Set of planning decisions related to transportation activities (see Appendix 1 for the list of generic decisions). The process can be split among different actors.	Deliver	DX.4 Consolidate Orders DX.5 Build Loads DX.6 Route Shipments DX.7 Select Carriers and Rate Shipments
Loading: Loading the harvested timber delivery into a vehicle.	Deliver	DX.11 Load Vehicle & Generate Shipping Docs
Secondary transport: Transportation of harvested timber from roadside (or intermediate site) to customer (or intermediate site). Usually includes loading the harvested timber delivery if not differentiated in the process 'Loading'.	Deliver	DX.9 Pick Product DX.11 Load Vehicle & Generate Shipping Docs (if 'Loading' process is not differentiated) DX.12 Ship Product
Measuring at the mill : Measurement of harvested timber at the mill.	Deliver	DX.13 Receive and Verify Product by Customer DX.15 Invoice
Reception: Unloading (if not a self-loading truck) and receipt of a delivery of harvested timber. Usually includes measurement of the harvested timber delivered if not differentiated in the process 'Measuring at the mill'.	Deliver	DX.13 Receive and Verify Product by Customer DX.15 Invoice

Legend: X = {1, 2, 3}; Source (S), Make (M); Deliver (D)

Appendix 8: Terminology used in the bucking/merchandising instructions

The bucking/merchandising instructions define how a felled tree must be processed to obtain one (stem in full-tree method) or a set of products (logs in cut-to-length method), while the sorting rules determine how each of the expected products must be separated in distinct inventory piles at roadside. The template of the bucking/merchandising instructions will change according to whether or not a mechanised processing head for the cross-cutting is used.

When a processing head is used, the bucking/merchandising instructions are provided through a price (or value) list of products specified in a two dimensional matrix of a diameter class and a length interval. The higher the price of a product, the more preferable it is to produce it, while a product with a null price indicates that its production is not allowed. The matrix is entered into the processing head's computer to optimise cross-cutting of the felled tree. A matrix is provided for each commercial species (or a group of species managed jointly). Moreover, for some products (i.e. here, a combination of diameter class and length), additional instructions on their specifications could be provided to the operator of the processing head. Such instructions are external criteria that the operator can easily observe on the felled tree, such as external defects. It is then the responsibility of the operator to validate or change the optimal bucking solution proposed by the computer before bucking is executed by the processing head.

For cross-cutting optimisation of the felled tree into products, the computer of the processing head runs a bucking problem. Two different bucking problems are discussed by Marshall (2007): the individual tree optimisation problem (buck-to-value problem) and the multiple trees with demand constraints problem (buck-to-order problem). The objective of the buck-to-value problem is to obtain the output in products from each individual stem that provides the maximum value according to the bucking price (or value) list. The objective of the buck-to-order problem is to obtain the output in products from a block (or a set of blocks) that provides the maximum value according to the bucking price list while meeting the demand and available input of trees.

Where no mechanised processing head is used, the bucking/merchandising instructions are usually called a cutting-list. A cutting-list consists of an ordered listing of products allowed to be produced. Each product is defined by a set of specifications, such as a species (or a group of species managed jointly), a length interval, diameter classes (big and small end) and a quality grade (that is, in turn, defined by external criteria that one could fairly easily observe on the felled tree). Thus, starting from the product at the top of the cutting-list, the first product that meets its requirements must be produced, and so on. Cutting-lists are used by different operators and at different locations along the WSC (e.g. a chainsaw operator at the stump, a loader and pull-through delimber operator at the landing site). Moreover, a cutting-list can include additional information, such as the sorting rules, the 'cut-and-haul' rate by product, the maximum (e.g. quotas) to produce by product or sorted product, the destination of the product and its delivery logistics instructions, etc.

Appendix 9: List of potential enablers and practices of supply chain agility

Based on a review of enablers and practices in supply chain management and agility, Table 33 and Table 34 list more than 400 potential enablers and practices of supply chain agility. These enablers and practices are classified by agility dimension (Table 33) or categories of enablers and practices (Table 34).

Table 33: List of potential enablers and practices of supply chain agility (Sources: Christopher, 2000; Van Hoek et al., 2001; Christopher et al., 2004; Yusuf et al., 2004; Agarwal et al., 2006; Lin et al., 2006; Agarwal et al., 2007; Faisal et al., 2007)

Dimension	Enabler	Christopher (2000)	Van Hoek et al. (2001)	Christopher et al. (2004)	Yusuf et al. (2004)	Agarwal et al. (2006)	Lin et al. (2006)	Agarwal et al. (2007)	Faisal et al. (2007)
Customer sensitivity	Delivery Speed					1		1	
	Capable of reading and responding to real demand (demand-driven x forecast-driven)	1	1					1	
	Capture data from POS/POU	1	1	1					
	Customer responsiveness		1	1		1			1
	Customer-based measures (service level improvement, lead time reduction, customer satisfaction)		1				1	1	1
	Product ready for use by individual customers						1		
	Customer-driven products						1		
	Retain and grow customer relationships						1		
	Products with substantial added value for customers						1		
	Agile benchmarking								1
	New product introduction					1		1	
	See opportunities to increase customer value (capture emerging trends)			1			1		
	Quick introduction of new products						1		1
Information driver	Electronic data interchange				1	1			
	Access of information and knowledge through internet				1	1			1
	Data accuracy				1	1		1	

Dimension	Enabler	Christopher (2000)	Van Hoek et al. (2001)	Christopher et al. (2004)	Yusuf et al. (2004)	Agarwal et al. (2006)	Lin et al. (2006)	Agarwal et al. (2007)	Faisal et al. (2007)
	Capture demand information immediately		1				1		1
	Information accessible supply chain-wide			1			1		1
	Prefer to keep information on file						1		
	Virtual connection						1		1
	Share demand data with with buyers and suppliers through IT/IS			1				1	
Network integration	Fluid clusters of network associates x long-term stable partnerships		1						
	Commitment to agile practices				1				1
	Focused on developing core competencies' through process excellence	1		1			1		
	Trust-based relationships with customers/suppliers	1					1	1	1
	Co-operation with competitors				1				
	Organised along functional lines						1		
	Team-based goals and measures						1		
	First choice partner						1		
	Actively share intellectual property with partners						1		
	Marketing information fluid cluster of network associates						1		
	Concurrent execution of activities throughout the supply chain						1		
	Leverage partners' capabilities			1					
	Act as network orchestrator			1					
	Minimise resistance to change							1	
Process integration	Facilitate rapid decision making (autonomy x standardisation)		1				1		
	Co-managed inventory			1					1
	Collaboration across each partner's core business process	1			1	1		1	
	Collaborative planning and joint strategy determination	1		1			1	1	1
	Source flexibility					1			

Dimension	Enabler	Christopher (2000)	Van Hoek et al. (2001)	Christopher et al. (2004)	Yusuf et al. (2004)	Agarwal et al. (2006)	Lin et al. (2006)	Agarwal et al. (2007)	Faisal et al. (2007)
	Make flexibility					1			
	Delivery flexibility					1			
	Infrastructure in place to encourage innovation within shortening time-frames						1		
	Pro-actively update the mix of available manufacturing processes in the SC network						1		
	Vertical integration						1		
	Joint cost minimisation programs							1	
	Quality improvement							1	
	Lead time reduction							1	
	Minimising uncertainty							1	
	Company specific issues on demand side				1	1			
	Company specific issues on supply side				1	1			
	Joint product development	1		1					1

Table 34: List of potential enablers and practices of supply chain agility (Sources: Supply Chain Council, 2008; Schnetzler et al., 2009; Frayret, 2011)

Categories of enablers and practices	Supply Chain Council (2008)	Schnetzler et al. (2009)	Frayret (2011)
1) Rules and guidelines	Integrated Business and Supply-Chain Planning Processes Where Cross-Functional Input is Leveraged to Set Business Rules Collaborative Review and Agreement of Business Rules Prior to Contract Execution Optimized Supply-Chain Processes, Optimized Supplier Count, Supplier and Part Rationalisation Enterprise Level Policies/Rules with Local Execution Enterprise Level Spend Analysis Long Term Supplier Agreements/Partnerships Automated Engineering Specifications Automated Links To Existing CAD & CAM Information Automatic Generation / Configuration Of Tooling / Set-Up Instructions Automatic Link to Recipe Management, PLC Program, CNC Program Systems, Etc., to Deliver New Manufacturing Documentation Automatic Notification When to Begin and When to Complete Design For Production On Line Access and Notification of Tooling and Equipment Information Document Control Electronic Documentation and Imaging Genealogy Tracking Pre-Defined Manufacturing Design Rules Storage and Configuration Management for Release and Revision Control of Final Documents Integrated Edit at Order Entry Time ABC Classification Incorporates leading practices such as ECR, CPFR, VMI and real time point of consumption reporting New Item Introductions Are part of the Sales and Operations Planning Process at the General Management Business Team Level.	Rules and guidelines (decision support): Yield tables, growth models, simulations, sorting rules, practices, standards Configuration of the planning: Bases for the configuration of the production network (integrated forest information system); stock lists, sorting models, workflow	Reduce perceived volatility: Forecasts End product markets (total demand and variability, market prices, trends, overseas markets, exchange rates, competition…) Supplied material markets (total availability and variability, market prices, seasonality…) Processes planning and smart information system Production and logistic process planning (new product introduction, variable servicing time -energy distribution-…) Buffer against variability: Time Order promising (allocate planned inventories and capacity in advance, available-to-promise -allocate planned inventories in advance-, capable-to-promise -allocate production capacity in advance-, profitable-to-promise -profitably allocate planned inventories or capacity in advance-…) Reduce inefficiencies: Process Operations planning (advanced planning and scheduling, robust optimization…) Manufacturing control (advanced scheduling/dispatching rules, production authorization card…) Life cycle management (new product introduction, engineer-to-order, design-to-order…)

Categories of enablers and practices	Supply Chain Council (2008)	Schnetzler et al. (2009)	Frayret (2011)
	SKU Rationalization. Use of Platform Teams in the New Product Development Process		Develop a culture of change (self-organising enterprise, strategy emergence…)
2) Performance measurement	Efficient and Effective Benchmarking Process Leveraging Cross Industry Metrics and Definitions Reliable Continuous Improvement Process and Methodology Sound Project Management Process and Methodology Comparative Analysis of Supplier Performance is Used in Sourcing Decisions Continuous Improvement and Development is Driven and Measured through the Performance Review Process Performance Expectations and Business Rules Are Clearly Communicated Prior to the Initiation of Business with the Supplier Supplier “Cost of Nonconformance” Data is Collected, Analyzed and Used in Performance Reporting Cost Reduction and or Cost Avoidance Opportunities Are Identified, Implemented and Measured on a Periodic Basis Supplier Performance Assessment System Attribute-Based Process Planning Standards and Measurements Aligned to Maximize Supply Chain Performance Periodic Review of Standards Real Time Performance Measurement Reporting Systems Customer Initiated Package Tracking Real Time Package Tracking	Performance measurement and improvement: Productivity models for harvesting, operational figures (productivity, utilization, costs etc.), benchmarking	Buffer against variability Time Lead times (decoupling point…)

Categories of enablers and practices	Supply Chain Council (2008)	Schnetzler et al. (2009)	Frayret (2011)
3) Information management	Integrated Demand and Supply Planning - Demand Planning, Supply Planning and especially the Supply Plan Execution Are no longer disconnected. All required planning and execution data is integrated and shared among all functional areas within an organization. Single Data Source for Decision Support and Business Rules Automated Update of Supplier Performance Information On Demand Access of Supplier/Source Data Data Accessibility across the Enterprise for Visibility by Discrete Business Units Utilize Enterprise Information Systems Continuous Improvement On-Demand Access of Production Information On-Demand Access to Available to Promise (ATP), Production Schedules and Inventory Status by Internal Operations and Customers Customer Access to Online Tracking of Order Status and Shipping Information Customer Service Data Validation Including Geo-Coding Online Real-Time Customer Entry and Edit Provide Single Source of Information on the Customer (Single Group/ Owner Responsible for Accuracy / Quality of Customer Data) Comprehensive History of Customer Interactions Including Order History, Claims, Problems, Etc. On-Line Rule Base	Information management: Forest information systems, geographical information systems	Process and information chain integration (value stream mapping, process mapping and reengineering, information technology, RIFD…) Flexible manufacturing system (computer controlled manufacturing systems - centrally coordinated CNCs-…)

Categories of enablers and practices	Supply Chain Council (2008)	Schnetzler et al. (2009)	Frayret (2011)
4) Inventory management	Capability to Run Multiple “Simulated” Full-Stream Supply/Demand Balancing Against Long-Term Capacity Plans and Scenarios. Periodic Review of Metrics and Strategy with Comparisons to Industry Benchmarks Real Time Data on Current Status Statistical Test Count In-Process Product (WIP) Handling Rules Dunnage Control Optimize Packing Minimizing In-Process Product (WIP) Minimum Product Handling	Warehouse management (Stocktaking, ware-house, inventory): Mapping of the stock, inventory sampling, management of the logs, prognoses about assortment of timber, cost-calculation	Buffer against variability: Inventory End product inventories (short delivery time, high customer service…) Work-in-process inventories (delayed differentiation, form postponement, transportation postponement…) Supplied material inventories (inventory management, consignment, Vendor-Managed Inventory…)
5) Asset management	Alignment of Strategic and Business Plans with Long-Term Capacity and Resource Planning Use of Cross Functional Teams to Execute the Process of Developing Long-Term Capacity and Resource Plans. Facility & Equipment Environment / Safety Audit System Changeover Reduction / Continuous Improvement Program Removal of Obsolete Capital Assets Total Preventative Maintenance Program Factory Floor Electronic Decision Making Information System Predictive Maintenance Monitoring (Heat, Noise, Lubrication Composition & Vibration) Systematic Disposition of Equipment Minimize Capital Assets Required and Maintenance Costs Supplier Managed Inventory of Parts Removal of Obsolete Stock Facility Master Plan Automated Data Entry Measure Customer Service Storage Location Zoning Standard Operating Procedures and Methodology	Infrastructure: Development, maintenance and repair of machines, facilities and buildings Management of commercial forests: Information to identify the felling area (maps of the selected stands and additional information)	Buffer against variability: Capacity Production rate (efficient equipment, use the right material with the right machine - in the right sequence, lean manufacturing…) Short setup times (SMED, fixture management, lot-size optimization…) Capacity availability (plan capacity to meet demand forecast, overtime, maintenance program, machine safeguarding…) Reduce inefficiencies: Process Eliminate waste (lean manufacturing, 5S, 6σ, quality control, ergonomics, SMED, just-in-time, kanban, CONWIP, poka-woke “fail-safing”…)

Categories of enablers and practices	Supply Chain Council (2008)	Schnetzler et al. (2009)	Frayret (2011)
6) Transportation management	Consideration of emissions in transportation decisions Capability to Run “Simulated” Full-Stream Supply/Demand Balancing for “What-If” Scenarios Reduce In-Process Product (WIP) Handling Short Move Paths Appointment Scheduling for Pickup and Delivery of Customer Shipments Backhaul Trading Exchange Electronic Manifest and Electronic Billing Integrated Order Management, Warehouse Management and Transportation Management Systems View for analysis of all orders and shipments with the following data: Logistics, Product, Cost, GL Charging Internet Pooling (Electronic brokerage of shipments) Measurement of Carrier Performance for On-time Delivery and Completeness Capture and Maintain Mode Specific Data Manage Information Across 100% of Shipments Real-Time Optimized Shipment Method Selection (Air Parcel, Ground Parcel, LTL, etc.) Based on Customer Service Requirements Real-Time Shipment Tracking, (via internet)	Transport management: Transportation models, routing	

Categories of enablers and practices	Supply Chain Council (2008)	Schnetzler et al. (2009)	Frayret (2011)
7) Network management	Internet Exchanges Identification of Suppliers Who Will Participate in Kanban Programs Identification of Suppliers Who Will Participate in Vendor Managed Inventory (VMI) Programs Create and Maintain Multiple Suppliers and Multiple Supplier Sites to Record Information about Individuals and Companies from Whom You Want to Purchase Catalogue Goods and Services Establishment of Criteria to Rank Suppliers Evaluate Supplier Network for Duplicates Identification of Suppliers Who Will Participate in Procurement Split (Two or More Suppliers Sharing Purchase Requirements) Programs Utilize Concurrent Engineering with Suppliers to Allow Them to Provide Engineering and Product Performance Test Data to Qualify as Part of Potential Supplier Network Supplier certification programs can reduce the cycle time to initially certify New Suppliers or Certify Existing Suppliers that Wish to Provide New Technologies Electronic Data Interchange Can Be Used To Send Requests and Technical Information to and from Potential Suppliers to Determine Supplier Capability to Fulfill Requirements So that They May Be Added to Supplier Network Electronic Sourcing and Negotiation Collaborative Planning/Scheduling JIT Environment Production Reporting/Status	Supplier management: Management of the addresses of forest owners and parcels of land Supplier contracts: Management of the agreements made with forest owners (basic agreements, delivery conditions), standard contracts Network for harvesting: Coordination of different harvesting units (e.g. lumberjacks)	Flexible network organizations Virtual organization (“Service-Oriented Architecture” - partners assembled on-demand-, symbiotic manufacturing network, coordination mechanisms, collaborative planning, objective alignment, auctions…) Resource pooling (trucks, pallets, storage, R&D, outsourcing, coopetition…) Information sharing and process integration (Collaborative Planning, Forecasting and Replenishment -CPFR-, Vendor-Managed Inventory -VMI-, category management, collaborative product design, collaborative life cycle management…) Benefit and risk sharing (incentives mechanisms…)

Appendix 10: List of supply chain performance metrics

We can identify three main types of supply chain performance measurements: financial quantitative measures, non-financial quantitative measures and non-financial qualitative measures. Based on four references ((1) Shepherd and Günter, 2006; (2) Gunasekaran and Kobo, 2007; (3) Supply Chain Council, 2008; (4) Swafford et al., 2006), examples of the metrics for each type can be found in Table 35. Moreover, Table 36 provides the definition of the strategic performance metrics in the SCOR model. Additional metrics can be found in these literature reviews on supply chain performance measurement: Neely et al. (1995); Gunasekaran et al. (2004); Arzu Akyuz and Erman Erkan (2010); Payne (2010) and Carvalho et al. (2011).

We propose a metric related to the capability of the WSC to use an optimal theoretical value of products (i.e. harvested timber) within a block. This metric is defined as the optimal value recovery percentage of a block and relies on a development made within the entire FlexWood project. With aerial/terrestrial laser scanning of the inventory in a block, it is possible to describe the standing timber on the basis of individual trees. It is possible to obtain a forecast[26] of the basket of products that could be obtained by harvesting the block with selected price list(s) by running a buck-to-value problem on each individual tree. Therefore, the optimal value of a block is obtained by selecting the price list(s) that result in the higher total value in products when a buck-to-value problem is run on each individual tree within the block. In practice, a different choice of price lists can be made, for example, to satisfy a specific set of committed demand. Therefore, the optimal value recovery percentage of a block is obtained by dividing the total value of the block obtained with the selected price list(s). An average optimal value recovery percentage can be obtained by computing previous metrics on a set of blocks instead to look each block individually.

[26] Such a forecast is ”(...) not as accurate as mill scanning equipment but but does show promise as a pre-harvest inventory tool for determining stand value and log product yields” in the case study reported by Murphy et al. (2011).

Table 35: List of supply chain performance metrics (Sources: (1) Shepherd and Günter, 2006; (2) Gunasekaran and Kobo, 2007; (3) Supply Chain Council, 2008; (4) Swafford et al., 2006).

Type of measurement	Metric	References
Financial quantitative	Asset turns	1
	Capital tie-up costs	1
	Cash-to-cash cycle time	1, 3
	Cost per operation hour	1
	Disposal costs	1
	Distribution costs	1
	Economic order quantity	1
	Incentive cost and subsidies	1
	Information carrying cost	1
	Inventory turnover	1
	Inventory/WIP cost	1, 2
	Manufacturing cost	1
	Net profit vs productivity ratio	1
	Overhead cost	1, 2, 3
	Percentage sales of new products	1
	Profit	1
	Return on investment (fixed assets and working capital)	1, 2, 3
	Scrap/obsolescence cost	1, 2
	Selling price / cost of goods	1, 2, 3
	Stock capacity	1
	Stock-out cost	2
	Storage costs per unit of volume	1
	Supplier cost-saving initiatives	1
	Total cost of resources	1
	Total logistics costs	1
	Total supply chain management costs	1
	Transportation cost	2
	Variations against budget	1
	Warehouse costs	1
	Warranty cost	2
Non-financial quantitative	Accuracy of scheduling	1, 2
	Average backorder level	1
	Bidding management cycle time	2
	Capacity utilisation	2
	Compliance to regulations	2
	Conformance to specifications	2
	Delivery reliability (Perfect Order Fulfilment)	1, 2, 3, 4
	Efficiency of purchase order cycle time	1
	Forecasting accuracy	1, 2
	Inventory accuracy	1
	Inventory days of supply	1
	Inventory utilisation	1
	Labor efficiency	1, 2
	Manufacturing lead time	1, 4
	Mix flexibility	1
	New product flexibility	1
	Number of backorders/stockouts	1

Type of measurement	Metric	References
	Number of items produced	1
	Number of new products launched	1, 4
	Number of tasks worker can perform	1
	Order flexibility	1
	Perceived value	2
	Percentage of late or wrong delivery	1
	Percentage of wrong products	1
	Process cycle time (planned and real)	1, 2
	Procurement lead time	1, 2
	Product & Service variety	2
	Product development cycle time	1, 2, 4
	Production flexibility	2
	Stockout probability	1
	Supplier lead time against industry norm	1
	Supplier rejection rate	1
	Supply chain response time	1, 2, 3
	Use of new technology	1
Non-financial qualitative	Autonomy of planning	1
	Buyer-supplier partnership level	1
	Customer satisfaction	4
	Customisation level	4
	Departmental relations	1
	Distribution of decision competencies	1
	Downside adaptability	1, 3, 4
	Extent of mutual assistance in problem-solving	1
	Extent of mutual planning cooperation	1
	Horizon of business relationship	1
	Information accuracy and availability	1
	Mutual trust	1
	Quality and frequency of exchange of logistics information	1
	Supplier assistance in solving technical problems	1
	Upside adaptability	1, 3, 4
	Upside flexibility	1, 3, 4

Table 36: Definition of the strategic performance metrics in the SCOR model (Adapted from Supply Chain Council, 2008).

Performance category	Definition	Metric
WSC costs	The costs associated with operating the WSC.	Total Supply chain management cost: "The sum of the costs associated with the SCOR Level 2 processes to Plan, Source, Deliver, and Return." (Supply Chain Council, 2008)
		Cost of goods sold: "The cost associated with buying raw materials and producing finished goods. This cost includes direct costs (labor, materials) and indirect costs (overhead)." (Supply Chain Council, 2008)
WSC asset management	The effectiveness of an organisation in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-cash cycle time: "The time it takes for an investment made to flow back into a company after it has been spent for raw materials. For services, this represents the time from the point where a company pays for the resources consumed in the performance of a service to the time that the company receives payment from the customer for those services." (Supply Chain Council, 2008)
		Return on supply chain fixed assets: "Return on Supply Chain Fixed Assets measures the return an organization receives on its invested capital in supply chain fixed assets. This includes the fixed assets used in Plan, Source, Make, Deliver, and Return." (Supply Chain Council, 2008)
		Return on working capital: "Return on working capital is a measurement which assesses the magnitude of investment relative to a company's working capital position verses the revenue generated from a supply chain." (Supply Chain Council, 2008)
WSC reliability	The performance of the WSC in delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Perfect order fulfilment: the percentage of orders meeting delivery performance (right quantity, right time, right location and customer) with complete, accurate and on time documentation and in perfect condition (e.g. no delivery damage). (Note: may differ by customer segment, assortment quality grade, etc).
WSC responsiveness	The speed with which the WSC provides products to the customer.	Order fulfilment cycle time: average time for all processes and inventory starting from the order commitment and ending with customer receipt of the order. (Note: may differ according to location of the decoupling point, customer segment, assortment quality grade, seasonality, etc).
WSC agility	The agility of the WSC in responding to marketplace changes to gain or maintain a competitive advantage.	Upside supply chain flexibility: the number of days required to achieve an unplanned sustainable 20% increase in quantities delivered.
		Upside supply chain adaptability: the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days.
		Downside supply chain adaptability: the percentage reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory or cost penalties.

Appendix 11: Pricing mechanisms and payment methods

Standing timber and harvested timber pricing mechanisms

Based on the standing timber pricing mechanisms discussed by Kant (2010), eight pricing mechanisms were reported in the cases studies for the sale and purchase of standing timber and/or harvested timber:

- Administered prices based on the residual value approach,
- Administered prices to supply internal markets within the enterprise itself so that it can capture the value-added from processing,
- Negotiated prices by bilateral negotiation,
- Negotiated prices in a supply contract,
- Transparent timer auctions with ascending prices,
- Transparent timer auctions with descending prices,
- First-price sealed-bid auction,
- Timber price at the mill (or an intermediate site) gate.

Kant (2010) mentions three other standing timber pricing mechanisms not reported in the case studies: second-price sealed-bid auctions, tenders based on market reference prices and tenders based on prices reflecting the cost of production and forest management.

Standing timber payment methods

- lump sum: the buyer and the seller agree to a fixed price for the standing timber. The sale price is not a function of the volume harvested.
- flat unit sale price (pay-as-cut): the buyer and the seller agree on a price by unit of volume (or weight). The buyer has to pay this price according to the volume (or weight) harvested.
- unit sale price by assortment: the buyer and seller agree on a price by unit of volume (or weight) by assortment. The buyer has to pay these prices according to the volume (or weight) harvested.
- shares contract (also designated profit share or cut-and-share): a buyer and seller agree on a percentage to split between them from the proceeds of the harvested volume sale.

Harvested timber payment methods

- flat unit sale price by origin zone (measured by e.g. volume or weight)
- unit sale price by assortment (measured by e.g. volume or weight).
- unit sale price by assortment (measured by e.g. volume or weight) and by origin zone. This method is usually applied when the seller is responsible for the secondary transport.

Harvesting payment methods

- flat unit rate [measured at roadside (e.g. volume) or at the demand site (e.g. volume or weight)] adjusted by productivity factors, such as e.g. type of commercial treatment, class of diameter at breast height mean, class of terrain and total number of assortments.
- unit rate by assortment [measured at roadside (e.g. volume) or at the demand site (e.g. volume or weight)] adjusted by productivity factors such as e.g. type of commercial treatment, class of diameter at breast height mean and class of terrain.

Primary transport payment methods

- flat unit rate [measured at roadside (e.g. volume) or at the demand site (e.g. volume or weight)] adjusted by productivity factors, such as e.g. class of primary transport distance mean, class of terrain and total number of assortments.

Loading (handling) payment methods

- flat unit rate
- flat hourly rate

Transportation payment methods

- flat unit rate adjusted by productivity factors, such as e.g. back-and-forth travelling time (estimated by class of road, mean distance from origin and geographic destination zones), thaw season load capacity reduction, need for a self-loader truck-trailer and minus the percentage discount subject to providing a backhaul load.
- flat truckload rate adjusted by productivity factors, such as e.g. back-and-forth travelling time, thaw season load capacity reduction, need for a self-loader truck-trailer and minus the percentage discount subject to providing a backhaul load.

Harvesting, primary and secondary transportation and handling integrated payment methods

- cut-and-haul rate: unit rate by destination adjusted by productivity factors, such as e.g. type of commercial treatment (harvesting), class of diameter at breast height mean (harvesting), class of terrain (harvesting and primary transport), class of primary transport distance mean (primary transport), back-and-forth travelling time by destination (secondary transport) and thaw season load capacity reduction (thaw season).
- cut-and-haul rate by assortment: unit rate by assortment and by destination adjusted according to productivity factors such as e.g. type of commercial treatment (harvesting), class of diameter at breast height mean (harvesting), class of terrain (harvesting and primary transport), class of primary transport distance mean (primary transport), back-and-forth travelling time by destination (secondary transport) and thaw season load capacity reduction (thaw season).

Appendix 12: Detailed information on Chilean case 1

Table 37: Environmental analysis of Chilean case 1.

Environment element	Description	Uncertainty
1. Industry sector (internal)	Higher consolidation	☐Unstable ☐Complex
2. Raw materials	Plantation Radiata pine Resource increase	☐Unstable ☐Complex
3. Human resources	Full year contractors	☐Unstable ☐Complex
4. Financial resources		☐Unstable ☐Complex
5. Market sector	International	☐Unstable ☐Complex
6. Technology	FT method OR applications Tree genetic improvement	☐Unstable ☐Complex
7. Government	Growing intervention	☒Unstable ☐Complex
8. International sector	Competition from neighbouring countries	☐Unstable ☐Complex
9. Climate	2 harvesting seasons Full year harvesting	☐Unstable ☐Complex

For each planning process in Chilean case 1, Table 38 lists the actor responsible for the planning process, the planning horizon (i.e. the time horizon during which decisions are made), the time period (i.e. the time bracket that splits the time horizon during which decisions are made) and the update frequency of the planning process (i.e. the delay for decisions made that are potentially modified by new planning), the decision(s) planned by the process, the planning objective and the tool used to support the actor, if any.
Instead of 15 days, a one month planning horizon is also used by the harvesting manager in some contexts (e.g. skyline tower harvesting team). A small percentage of the harvested volume comes from purchased blocks. The purchased blocks roughly follow the same planning and execution processes (with minimal road construction investment) and, for the sake of brevity, are not differentiated.

Table 38: Planning processes in Chilean case 1.

Planning process	Actor	Time: Planning horizon	Time: Time period	Time: Update frequency
Schedule harvesting 1.1	Timberland-based wood procurement division (Harvesting manager)	Done for each farm	n.a.	n.a.
Schedule harvesting 1	Timberland-based wood procurement division (Harvesting manager)	Season (winter or summer)	Month or 15 days	Rarely and for few harvesting teams Monthly with three months planning horizon
Value commitment 1	Timberland-based wood procurement division (Harvesting manager)	Variable (Season or less)	n.a.	n.a.
Schedule harvesting 2	For ground-based equipment type: Timberland-based wood procurement division (Harvesting manager and/or supervisors)	Done for each block, usually, after the construction of roads and roadside landing-inventory areas	n.a.	n.a.
	For air-based equipment type: Harvesting contractors	Done for each block, usually, after the construction of roads and roadside landing-inventory areas and assigning the harvesting in the blocks to ground equipment type	n.a.	n.a.
Schedule harvesting 3	Timberland-based wood procurement division (Harvesting manager)	15 days	3-5 day	15 days

Planning process	Actor	Time		
		Planning horizon	Time period	Update frequency
Schedule harvesting 3.1	Timberland-based wood procurement division (Harvesting manager and supervisors)	Less than 15 days	Day	Day (if required)
Schedule harvesting 4	Harvesting contractors	Variable (15 days to day)	unavailable	unavailable
Schedule secondary transportation 1	Timberland-based wood procurement division (Transportation manager)	15 days	One day to a few days	n.a.
Schedule secondary transportation 2	Timberland-based wood procurement division (Transportation manager)	Day/night shift	One minute or a few minutes	n.a. (Update by Schedule secondary transportation 2.1)
Schedule secondary transportation 2.1	Timberland-based wood procurement division (Fleet managers)	Current day/night shift	One minute or a few minutes	Real-time during the day/night shift when change to the work plan is required
Schedule secondary transportation 3	Transportation and loading contractors	15 days to day/night shift	unavailable	unavailable

Table 38: Planning processes in Chilean case 1. (continued)

Planning process	Decision	Objective	Planning tool
Schedule harvesting 1.1	- road design layout of the farm - block design layout of the farm - assigning type of air or ground equipment to each block - localisation of the roadside landing-inventory area(s) in each block (in a block with air equipment, a skyline tower is located at the landing area)	Maximise harvesting volume while minimising harvesting and road construction costs	OR based optimisation tool
Schedule harvesting 1	- blocks' harvesting sequence and production volume for each harvesting team - number of harvesting teams by farm (i.e. a set of blocks)	Maximise profit (sales revenue by product – transportation cost – harvesting cost – harvesting team moving cost) from the blocks to harvest during the PH	OR based optimisation tool

Planning process	Decision	Objective	Planning tool
	- production volume allocation to the demand points with or without supply agreements - modification of the sequence of a few blocks in the same farm (a few times a year by the harvesting supervisor) - stop harvesting in a farm to move the harvesting contractor in a new farm (one time a year by the harvesting supervisor)		
Value commitment 1	- attempt to convert the volume allocated for potential forecasted demand to confirmed demand by supply agreements	unavailable	Human skill (based on the volume allocation in Schedule harvesting 1)
Schedule harvesting 2	- harvesting and primary transport layout by block	Minimise harvesting and primary transport costs	Unavailable
	- skyline tower and support pillar(s) layout by block	Minimise skyline harvesting and set-up costs (OR based optimisation tool)	OR based optimisation tool
Schedule harvesting 3	- cutting-list with sorting rules for each harvesting team by TP - volume (from inventory and harvesting production) allocation to demand point by TP - overtime in harvesting	Maximise profit (sales revenue by product – transportation cost) from the volume to be harvested during the PH while satisfying the demand	OR based optimisation tool
Schedule harvesting 3.1	- update the daily cutting-list with sorting rules for each harvesting team by TP - volume (from inventory and harvesting production) allocation to demand point by TP	Tackle volume deviation between estimated and harvested production mix and/or volume change (increase or decrease) in a demand	Human skill (adjustment supported by an intranet system reporting inventories, production and transportation)
Schedule harvesting 4	- harvesting crew member schedule - transportation and accommodation plan for the harvesting crew members	Unavailable	Unavailable
Schedule secondary transportation 1	- spread of the volume to be delivered over the PH - estimation of truck fleet requirement over the PH - assignment of the loaders to the blocks where transportation activities will be held	Ensure the proper spread of forecasted deliveries at each demand point over the PH	Human skill (based on the harvest plan in Schedule harvesting 3)
Schedule secondary transportation 2	- routing and scheduling of the truck fleet - scheduling of the loaders at forest sites - update of the loaders' assignments	Minimise transportation and loading costs while satisfying the delivery priorities and respect the delivery logistics agreements	OR based optimisation tool

Planning process	Decision	Objective	Planning tool
Schedule secondary transportation 2.1	- update routing and scheduling of the truck fleet - update scheduling of the loaders at forest sites	Tackle deviations to the work plans	Human skill (supported by a real-time system)
Schedule secondary transportation 3	- crew member schedule for trucks and loaders	Unavailable	Unavailable

For each execution process in Chilean case 1, Table 39 lists the actor and the actions performed. Harvesting in the CTL method (excavator with processing head) and Primary transport in the CTL method (forwarder) are mechanised for the final cutting of Eucalyptus blocks, when there is only one product (i.e. logs of length 5 to 7 meters with a minimum end diameter of 5 centimetres and maximum 60 centimetres), except when more volume recovery is needed and two additional products are allowed (i.e. length of 1.22 or 2.44 meters with no or few centimetres minimum end diameter). Consequently, the price lists of the processing head are rarely updated compared to the possible daily update of the cutting-list in Harvesting in the CTL method (non-mechanised) and Merchandising at roadside landing (mechanised or non-mechanised) in Radiata pine blocks.

Table 39: Execution processes in Chilean case 1.

Execution process	Actor	Action
Pre-harvesting preparation	Harvesting contractors	- move equipment to the farm - set-up the support installations - delimit each block
Harvesting in the FT method	Harvesting contractors	- felling (non-mechanised and mechanised systems) and bunching (only mechanised system) the tree at the stumpage area
Primary transport in the FT method	Harvesting contractors	- primary transport of the trees from stumpage area to roadside landing
Merchandising at roadside landing	Harvesting contractors (processor operators)	- delimbing, bucking (according to the allowed product(s) in the daily cutting-list) and partial sorting
	Harvesting contractors (loader operators)	- sorting and piling at roadside
Harvesting in the CTL method	Harvesting contractors	- felling, delimbing, debarking (only for Eucalyptus), bucking and sorting in piles adjacent to the primary transport trail - update the price list of the processing head
Primary transport in the CTL method	Harvesting contractors	- primary transport of the logs from stumpage area to roadside landing - sorting and piling at roadside landing

Execution process	**Actor**	**Action**
Measuring at roadside	Harvesting contractor (scalers) For control and payment purposes, the timberland-based wood procurement division (harvesting supervisors) also scale volume at roadside twice a month	For pulp quality grade: - apparent volume measurement (i.e. metro ruma unit, which consists of a 1 meter x 1 meter x 2.44 meters) of the piles and recording on a slate tablet or a mobile handheld device (e.g. Forestruck) For other quality grades: - measurement of each log - paint marking the diameter class (range = 2 cm) and quality grade - recording on a slate tablet or a mobile handheld device (e.g. Forestruck) - if a log does not meet length specifications, a teammate with a chainsaw will be asked to fix it
Loading	Harvesting contractor	Only when the harvesting team requires transportation during the day (e.g. harvesting in steep terrain with narrow inventory space at roadside): - loading the trucks at roadside
Secondary transport	Transportation and loading contractors	- loading the trucks at roadside - secondary transport from roadside to demand points
Reception	Mills	- unloading the truck at the mill - scaling the truck

In Table 40, the main decision(s) made on the most relevant planning processes in Chilean case 1 are classified according to the four attributes characterising a harvest/transportation plan. Furthermore, generic planning decision(s) addressed in each planning process are presented in the last row.

Table 40: Description of the harvest/transportation plan attributes in Chilean case 1.

Planning process	Schedule harvesting 1.1	Schedule harvesting 1	Schedule harvesting 2		Schedule harvesting 3	Schedule harvesting 3.1
Actor	Timberland-based wood procurement division (Harvesting manager)	Timberland-based wood procurement division (Harvesting manager)	Timberland-based wood procurement division (Harvesting manager and/or supervisors)	Harvesting contractors	Timberland-based wood procurement division (Harvesting manager)	Timberland-based wood procurement division (Harvesting manager and supervisors)
Planning horizon	n.a.	Season	Done for each block	Done for each block	15 days	Less than 15 days
Harvesting or transportation resource	Air or ground type of harvesting equipment by block	Set of harvesting teams (include type of equipment and work shift template) for the season			If required, overtime by harvesting team	If required, daily update of the decision in Schedule harvesting 3
Input stock to harvest or transport	Design of the blocks in each farm to harvest in the season	Sequencing of blocks by harvesting team				
Harvesting or transportation instruction	Road design layout of the farm and localisation of the roadside landing-inventory area(s) in each block		Harvesting and primary transport layout of the block	Skyline tower and support pillar(s) layout of the block	Cutting-list with sorting rules by harvesting team and 3-5 days	
Allocation of the output stock		Monthly allocation of the volume by product to the demand			15 days to the demand	

Planning process	Schedule harvesting 1.1	Schedule harvesting 1	Schedule harvesting 2		Schedule harvesting 3	Schedule harvesting 3.1
Generic planning decision	- Harvest equipment selection by harvest unit	- Harvest equipment selection by harvest unit - Scheduling of harvest units - Assortments to produce by harvest unit and allocation to demand - Harvest unit assigned to contractors/teams	Harvest unit layout	Harvest unit layout	- Bucking/merchandising instructions and sorting rules by harvest unit	- Bucking/merchandising instructions and sorting rules by harvest unit

Table 40: Description of the harvest/transportation plan attributes in Chilean case 1. (continued)

Planning process	Schedule harvesting 4	Schedule secondary transportation 1	Schedule secondary transportation 2	Schedule secondary transportation 2.1	Schedule secondary transportation 3
Actor	Harvesting contractors	Timberland-based wood procurement division (Transportation manager)	Timberland-based wood procurement division (Transportation manager)	Timberland-based wood procurement division (Fleet manager)	Transportation and loading contractors
Planning horizon	Unavailable	15 days	Day/night shift	Current day/night shift	15 days to day/night shift
Harvesting or transportation resource	Harvesting crew work schedule	Estimation of transportation equipment required for the 15 days and assignment of loaders	Loaders and trucks schedule	If required, real-time update of the decisions in Schedule secondary transportation 2	Transportation crew work schedule
Input stock to harvest or transport		Spread of the volume to be delivered over the 15 days	Specific volume to load/transport by loader/truck		
Harvesting or transportation instruction	Transportation and accommodation plan for the harvesting crew members		Work schedule by loader (sequence of volume to load) and truck (route)		
Allocation of the output stock			No allocation decision in secondary transportation		
Generic planning	- Harvest crew	- Balance transportation	- Transportation	- Transportation	- Transportation

decision	scheduling	with harvesting, inventory and reception	equipment routing and scheduling	equipment routing and scheduling	crew scheduling

Table 41 describes, by attributes of a demand, whether the attribute of the demand in Chilean case 1 is fixed (i.e. planned) by the process or specified as an input to the process and also if the attribute of the demand is subject to future change. Not detailed in Table 41, the process «Value commitment 2 » represents the commitment in supply agreements for demand spanning the planning horizon of a single season. These demands to fulfil serve as input for the planning processes of a season.

Table 41: Description of the demand attributes in Chilean case 1.

Planning process	Value commitment 2	Schedule harvesting 1	Value commitment 1
Actor	Timberland-based wood procurement division (Harvesting manager)	Timberland-based wood procurement division (Harvesting manager)	Timberland-based wood procurement division (Harvesting manager)
Planning horizon	Variable (10 seasons to less)	Season	Variable (Season to less)
Product specifications	Fixed and no change in the future	Specified for demand from supply agreement [Value commitment (planned before the season)] and fixed for forecast demand	Fixed and no change in the future
Price and payment conditions	Fixed with adjustment policy	Specified for demand from the supply agreement (Value commitment 2) and fixed for forecast demand. Prices from the demand of internal and external customers are adjusted every three months.	Fixed with adjustment policy
Quantity and delivery conditions	Fixed by month and subject to monthly variation but total quantity by season not changed.	The planning allocates the quantity to the demand sites on a monthly basis subject to, for some sites, a quantity limit by the maximal processing capacity of the site	Fixed by month or 15 days and usually no change in the future

Table 41: Description of the demand attributes in Chilean case 1. (continued)

Planning process	Schedule harvesting 3	Schedule secondary transportation 1	Schedule secondary transportation 2
Actor	Timberland-based wood procurement division (Harvesting manager)	Timberland-based wood procurement division (Transportation manager)	Timberland-based wood procurement division (Transportation manager)
Planning horizon	15 days	15 days	Day/night shift
Product specifications	Specified	Specified	Specified
Price and payment conditions	Specified	n.a.	n.a.
Quantity and delivery conditions	Specified by a period of 15 days with various delivery conditions. If required, Schedule harvesting 3.1	Specified by a period of 15 days with various delivery conditions.	Specified by day/night shift (from Schedule secondary transportation 1). Specified to be delivered by priorities in

	can plan the quantity to be delivered by priorities in the next few days.		the next few days (from Schedule harvesting 3.1)

Table 42 and Table 43 list the information flow, in input and output, for the planning and execution processes respectively in Chilean case 1.

Table 42: Information flow in the planning processes in Chilean case 1.

Planning process	**Input**		
	From	**Tool**	**Information**
Schedule harvesting 1.1	Timberland-based wood procurement division (Harvesting manager)	- Geographic information system - LIDAR technology - Intranet system	- dendrometric and terrain data of the farm to be harvested - harvesting cost by air or ground equipment type - road transportation cost - available types of harvesting equipment
Schedule harvesting 1	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- demand from supply agreements - potential demand from forecasts - maximum processing capacity of some demand points (sawmills) in an hour by TP. - blocks to harvest (final cut or thinning) during the PH (include assignment of air or ground equipment type to each block) - estimation of volume by products in each block - available harvesting teams (under contract) by type of equipment and work shift template - harvesting cost (according to the interval of average diameter at breast height (DBP), type of equipment and work shift template), transportation cost and moving cost
Value commitment 1	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- volume allocation to potential forecasted demand
Schedule harvesting 2	Timberland-based wood procurement division (Harvesting manager)	- Geographic information system - LIDAR technology - Intranet system	- dendrometric and terrain data of the block - road design layout of the farm - roadside landing-inventory area(s) of the block - harvesting and primary transport costs
	Harvesting contractor	unavailable	- internal harvesting and set-up costs
Schedule harvesting 3	Timberland-based wood procurement division (Harvesting	Intranet system	- demand from the supply agreements - estimated productivity by harvesting team on each block to be harvested (final cut or thinning) during the PH (can include overtime in harvesting)

Planning process	Input		
	From	Tool	Information
	manager and supervisors)		- volume in inventory ready to be delivered - set of feasible cutting-lists by block
Schedule harvesting 3.1	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system	- demand from the supply agreements - estimated volume production by harvesting team on each block to be harvested (final cut or thinning) during the PH (can include overtime in harvesting) - volume in inventory ready to be delivered - set of feasible cutting-lists by block
	Transportation manager	Intranet system	- Volume of previous day's delivery
	Harvesting contractors	Intranet system	- Volume of previous day's production
Schedule harvesting 4	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system	- harvesting plan during the PH (can include requested overtime for harvesting) - daily cutting-list with sorting rules by harvesting team
Schedule secondary transportation 1	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system	- delivery logistics agreement by demand point (e.g. hourly truck arrival rate, reception hours) - volume of inventory ready to be delivered - harvesting supply plan during the PH - demand to satisfy during the PH - available trucks and work shift template (under contract) - available loaders and work shift template (under contract)
Schedule secondary transportation 2	Transportation and loading contractors	Intranet system	- available trucks and work shift template - available loaders and work shift template

Planning process	Input		
	From	Tool	Information
	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system	- delivery priorities in the next-few days - volume in inventory ready to be delivered - harvesting plan during the PH - demand to satisfy during the PH
	Timberland-based wood procurement division (Transportation manager)	Intranet system	- delivery logistics agreement by demand point (e.g. hourly trucks arrival rate, reception hours) - spread of the volume to be delivered over the PH
	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system partially based on mobile handheld devices with cellular communication	- required transportation during the day (mainly for the harvesting team in steep terrain with narrow inventory space at roadside): estimated volume production during the day and real volume production during the day
Schedule secondary transportation 2.1	Transportation and loading contractors (Transportation crew members)	- real-time system with GPS - text message/cellular	- Report or must answer to a deviation in the execution of the work schedule
Schedule secondary transportation 3	Timberland-based wood procurement division (Transportation manager)	Intranet system	- Daily work plan for their truck(s) - Daily work plan for their loader(s)

Table 42: Information flow in the planning processes in Chilean case 1. (continued)

Planning process	Output		
	To	Tool	Information
Schedule harvesting 1.1	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- blocks' design layout of the farm - air or ground equipment type assigned to each block - localisation of roadside landing-inventory area(s) in each block (in a block with air equipment, a skyline tower is located at the landing area)
	Road construction contractors	unavailable	- road design layout of the farm - localisation of the roadside landing-inventory areas

Planning process	**Output**		
	To	**Tool**	**Information**
Schedule harvesting 1	Mills (internal customers)	Intranet system	- finished wood products sale plan of internal processing facilities for the following month with a quarterly mobile horizon
	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- volume allocation to potential forecasted demand
	Harvesting contractors	Intranet system	- blocks' harvesting sequence and production volume for each harvesting team
	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system	- harvesting plan during the PH
Value commitment 1	Timberland-based wood procurement division (Harvesting and sale managers)	Intranet system	- supply agreements
Schedule harvesting 2	Harvesting contractors	Intranet system	- harvesting and primary transport layout by block
	Harvesting contractors	unavailable	- skyline tower and support pillar(s) layout by block
Schedule harvesting 3	Harvesting contractors	Intranet system	- cutting-list with sorting rules by harvesting team for the first TP - harvesting plan during the PH (can include requested overtime in harvesting)
	Timberland-based wood procurement division (Harvesting supervisors)	Intranet system	- harvesting plan during the PH (can include overtime in harvesting)

Planning process	Output		
	To	**Tool**	**Information**
	Timberland-based wood procurement division (Transportation manager)	Intranet system	- volume in inventory ready to be delivered - harvesting plan during the PH - demand to satisfy during the PH
Schedule harvesting 3.1	Harvesting contractors	Intranet system	- daily updated cutting-list with sorting rules by harvesting team
	Timberland-based wood procurement division (Transportation manager)	Intranet system	- delivery priorities in the next-few days - harvesting plan during the PH
Schedule harvesting 4	Harvesting contractors (Harvesting crew members)	Intranet system	- Work schedule for each crew member - transportation and accommodation plan for each crew member
Schedule secondary transportation 1	Timberland-based wood procurement division (Transportation manager)	Intranet system	- spread of the volume to be delivered over the PH
	Transportation and loading contractors	Intranet system	- their loader assignments
Schedule secondary transportation 2	Transportation and loading contractors	Intranet system	- Daily work plan for their truck(s) - Daily work plan for their loader(s)
	Harvesting manager and harvesting supervisors	Intranet system	- Report of the delivery volume - Report on compliance with the delivery logistics agreement by destination

Planning process	Output		
	To	**Tool**	**Information**
Schedule secondary transportation 2.1	Transportation and loading contractors (Transportation crew members)	- real-time system - text message/cellular	- Update of their work plan
Schedule secondary transportation 3	Transportation and loading contractors (Transportation crew members)	unavailable	- Work schedule for each crew member
	Timberland-based wood procurement division (Transportation manager)	unavailable	- Allocation of crew members to each daily truck/loader plan

Table 43: Information flow in the execution processes in Chilean case 1.

Execution process	Input		
	From	**Tool**	**Information**
Pre-harvesting preparation	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- the blocks' design layout of the farm - harvesting and primary transport layout by block
	Harvesting contractors	n.a.	- skyline tower and support pillar(s) layout by block
Harvesting in the FT method	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- harvesting layout by block
	Harvesting contractors	n.a.	- skyline tower and support pillar(s) layout by block
Merchandising at roadside landing	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- daily cutting-list with sorting rules by harvesting team
Harvesting in the CTL method	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- harvesting layout by block - daily cutting-list with sorting rules by harvesting team
Primary transport in the CTL method	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- primary transport layout by block - daily cutting-list with sorting rules by harvesting team
Measuring at roadside	Timberland-based wood procurement division (Harvesting manager)	Intranet system	- daily cutting-list with sorting rules for their harvesting team

Execution process	Input		
	From	Tool	Information
Loading	Timberland-based wood procurement division (Transportation manager)	Intranet system, text message, cellular	- Daily work plan for their loader(s) and potential update
Secondary transport	Timberland-based wood procurement division (Transportation manager)	Intranet system, text message, cellular	- Daily work plan for their truck(s) and potential update - Daily work plan for their loader(s) and potential update
Reception	Mills	n.a.	- demand with delivery instructions

Table 43: Information flow in the execution processes in Chilean case 1. (continued)

Execution process	Output		
	To	Tool	Information (tool)
Pre-harvesting preparation			
Harvesting in the FT method	Timberland-based wood procurement division (Harvesting manager)	Intranet system based, in mechanised harvesting, on reports from the equipment computer	- production KPI (intranet system)
Primary transport in the FT method	Timberland-based wood procurement division (Harvesting manager)	Intranet system based, in mechanised harvesting, on reports from the equipment computer	- production KPI

Execution process	Output		
	To	Tool	Information (tool)
Merchandising at roadside landing	Timberland-based wood procurement division (Harvesting manager)	Intranet system based, in mechanised harvesting, on reports from the equipment computer	- production KPI
Harvesting in the CTL method	Timberland-based wood procurement division (Harvesting manager)	Intranet system based, in mechanised harvesting, on reports from the equipment computer	- production KPI
Primary transport in the CTL method	Timberland-based wood procurement division (Harvesting manager)	Intranet system based, in mechanised harvesting, on reports from the equipment computer	- production KPI
Measuring at roadside	Timberland-based wood procurement division (Harvesting manager and supervisors)	Intranet system partially based on mobile handheld devices with cellular communication	- production volume (by product) scaled at roadside - roadside inventory update when there is night secondary transportation - required transportation during the day (mainly for harvesting team in steep terrain with narrow inventory space at roadside): estimated volume (by product) production during the day and real volume production (by product) during the day
Loading	Harvesting contractors	Intranet system	- Volume (by sorted product, by truck) loaded during the day/night shift
Secondary transport	Timberland-based wood procurement division (Transportation manager)	- Intranet system - Truck onboard GPS	- volume (by sorted product, by truck, by demand point) loaded, transported and delivered during the day/night shift - for each delivery, arrival and departure time (automatic measure by GPS in the truck)
Reception	Timberland-based wood procurement division (Transportation manager)	Intranet system based on scale database	- volume (by sorted product, by truck) unloaded and scaled during the day up to the month (depends on the mill) - for some mills, arrival and departure time for each delivery (automatic measure at the scale)

Table 44 lists the average inventory time of the material between consecutive pairs of processes in Chilean case 1. Shorter overall harvesting to reception time will apply when harvesting occurs in steep terrain.

Table 44: Average inventory time of the material between consecutive pairs of processes in Chilean case 1.

Consecutive pairs of processes		Material	Average inventory time	
Harvesting in the FT method	Primary transport in the FT method	Bunch of felled trees adjacent to the primary transport trail[27]	One to a few days	Average time of 10 days from harvesting to reception
Primary transport in the FT method	Merchandising at roadside landing	Piles of felled trees at the landing site	A few hours to a few days	
Merchandising at roadside landing. Note: only for material from harvesting and primary transport in the FT method	Measuring at roadside	Piles of sorted products at roadside	Less than a day (scaling by the harvesting contractor to report the daily production)	
Harvesting in the CTL method	Primary transport in the CTL method	Sorted (mechanised) or unsorted (non-mechanised) piles of logs adjacent to the primary transport trail	A few hours to 2 days	
Primary transport in the CTL method	Measuring at roadside	Sorted piles of logs at roadside	Less than a day (scaling by the harvesting contractor to report the daily production)	
Measuring at roadside	Reception	Sorted and measured piles of logs at roadside	One day to a few days except, only during the summer season and for Eucalyptus volume, 21 days (to reduce the weight by 10-15%)	

[27] A primary transport trail is the itinerary used by the harvesting equipment (e.g. forwarder) in the block.

Table 45 details by process(es) and payment methods, the main financial flows for the timberland-based wood procurement division in Chilean case 1. For the sake of brevity, the payments of internal human resources are not presented. The harvesting contractors and transportation and loading contractors pay a fixed salary by month to their operators/drivers with a volume-based productivity bonus. The harvesting and transportation pre-negotiated rates are adjusted on a monthly basis according to three main external factors: fluctuation of USD currency (contractors buy most of their supply (e.g. spare parts for the equipment) in USD), fuel index fluctuation and fluctuation of the national Consumer Price Index.

Table 45: Main monetary flows in Chilean case 1.

Process(es)	**Payment method(s)**	**Time**	**Monetary flow**
Harvesting in the FT/CTL method to Measuring at roadside	flat unit rate	Between 5-10 days after the month, subject to the provision of proof of payment of employees and other legal obligations by the harvesting contractor	Payment of the harvesting contractor for all the volume measured at roadside or at the mill during the month. Can also include a compensation cost for moving equipment from one farm to another.
		The 30th of the month, partial payment and then, within the next 15 days, complete payment	
Secondary transport to Reception	flat unit rate	Between 5-10 days after the month, subject to the provision of proof of payment to employees and other legal obligations by the transportation/loading contractor	Payment of the transportation/loading contractor for all the volume loaded/delivered during the month
Reception	unit sale price by assortment	Within 10 days of the end of the month	Payment by the internal customer for all the volume delivered during the month
		Within 10, 15 or 30 days of the end of the month	Payment by the external customer for all the volume delivered during the month

Table 46 details the enablers and practices by macro-process in Chilean case 1.

Table 46: Enablers and practices of Chilean case 1.

Category of enabler	Source
1) Rules and guidelines	
2) Performance measurement	
3) Information management	- GIS to support the management of the timberlands
4) Inventory management	- combination of pre-harvesting inventory and historic production data from a similar block (e.g. species, clone, quality site) to increase the forecast precision of volume by product in a block - silviculture flexibility in radiata pine plantation: time window of 2-4 years for thinning and 4 years for clear-cutting (24 years rotation). - silviculture flexibility in Globulus/Nitens eucalyptus plantation: time window of 4 years for clear-cutting (12-14 years rotation).
5) Asset management	- combination of LIDAR, pre-harvesting inventory and historic production data from similar blocks (e.g. species, clone, quality site) to increase the forecast precision of the productivity and costs models for the harvesting and primary transport of the block - GIS combined with yield tables, growth models and economic analysis (e.g. return on investment) to support the management of the timberlands - upcoming certification of the timberland - the management team of the timberland-based wood procurement division is supported by a planning team involving highly specialised competencies (e.g. industrial engineer, computer programming)
6) Network management	- business relationships with private timberland owners to purchase standing timber and slightly increase the harvested volume. - with some private timberland owners, 'rental' agreement by providing silviculture know-how to grow timber and offer the best price on the market at the time of harvesting - The planning team uses external resources, such as consultants, but also research centres and academic institutions (universities) to improve current planning tools or for prototype development.
7) Transportation management	

Table 46: Enablers and practices of Chilean case 1. (continued)

Category of enabler	Make
1) Rules and guidelines	- Mechanised harvesting contractors with 4-5 year contracts with stable production volume for each year. - Harvesting and primary transport pre-negotiated rates are adjusted by block according to productivity factors and by month according to external factors. - Compensation for moving equipment to a new farm. - Use several harvesting contractors, with several from local communities where the timberland is located (low dependence) - Standard documentation template, e.g. cutting-list with sorting rules by block - Harvesting contractors know in advance next season's blocks to effectively plan their activities - Productivity and cost models for the harvesting and primary transport - Contractors must comply with health and safety rules (specified by the timberland-based wood procurement division) in the transportation and accommodation of operators (independent audit). - Company-based basic soil and water protection measures - Volume-based productivity bonus to the salaries of operators (managed and paid by the harvesting contractor)
2) Performance measurement	- Performance monitoring system for harvesting contractors (by an intranet system) with daily data - For each block, an estimation of the volume percentage distribution by quality grade is provided to the harvesting contractor. This distribution is closely monitored and if deviations occur, the contractor must inform his supervisor.
3) Information management	- intranet system to manage most information exchanges between contractors and the harvesting manager/supervisors - the cutting-list with sorting rules of each harvesting team can be easily updated daily by an intranet system - inventory scaling recorded on mobile handheld devices to reduce transmission error and allow updates during the day
4) Inventory management	- intranet system to monitor the daily inventory level at roadside - scaling and control (product specifications) of the inventory at roadside by the contractor as they are produced (allow, if required, corrective measures of a product specification in the field) and fortnightly control scaling by the timberland-based wood procurement division - when needed in Eucalyptus, can increase volume recovery by using two additional assortments (shorter length product) - for Radiata pine, monitor for blue stain and beetle risks to reduce inventory deterioration
5) Asset management	- Preventive maintenance and repair services shared among harvesting contractors - Many human resource programs (e.g. education, security) and considerations in the planning (e.g. for operators that do not go home after their shift, work shift template design allows holidays to be spent at home) to reduce absenteeism/accidents and increase/secure work force competencies - use of OR based optimisation tools for harvesting planning, including harvesting and primary layout - use different types of equipment to fit the commercial treatment and block characteristics - overtime is possible - the possibility of using various scattered and 'pre-approved' accommodations for the harvesting crew allows high geographic flexibility in the allocation of block to the harvesting teams - if required, modify the harvesting sequence of a few blocks in the same farm or move the harvesting contractor in a new farm - the management team of the timberland-based wood procurement division is supported by a planning team involving highly specialised

Category of enabler	Make
	competencies (e.g. industrial engineer, computer programming)
6) Network management	- To allow several harvesting contractors to buy equipment, there is a company-based program responsible for part of the capital investment (usually, this involves having an exclusive or a first-choice priority work arrangement with the harvesting contractor) - notice of upcoming harvesting activities to the neighbourhood to maintain social acceptance - the planning team uses external resources such as consultants but also research centres and academic institutions (universities) to improve current planning tools or for prototype development.
7) Transportation management	- Invest in road construction on their timberlands to avoid interruption of harvesting activities during the rainy season

Table 46: Enablers and practices of Chilean case 1. (continued)

Category of enabler	Deliver (value commitment)
1) Rules and guidelines	- Pre-sale of the volume to be harvested (avoid make-to-stock) - Prices from internal customers must provide a higher margin than prices from external customers. Each 3 months, supported by the use of an OR based optimisation tool (volume allocation), internal prices can be adjusted to follow such a business rule.
2) Performance measurement	
3) Information management	- intranet system to monitor the gradual fulfilment of the demand
4) Inventory management	- paint marking of the diameter class and quality grade on each log (except for pulp quality grade) allows customers to virtually control each purchased log
5) Asset management	- the management team of the timberland-based wood procurement division is supported by a planning team with highly specialised competences (e.g. industrial engineer, computer programming)
6) Network management	- the planning team uses external resources such as consultants but also research centres and academic institutions (universities) to improve current planning tools or for prototype development.
7) Transportation management	- the supply agreement includes details of the delivery logistics conditions

Table 46: Enablers and practices of Chilean case 1. (continued)

Category of enabler	Deliver (secondary transport)
1) Rules and guidelines	- Contractors have a 4-5 year contract with a stable volume to delivery in each year. - Secondary transport and loading pre-negotiated rates are adjusted by a route model with productivity factors and by month according to external factors. - Use several transportation contractors, with several from local communities where the timberland is located to keep business dependence low - Productivity and cost models for the transportation and loading - contractors must comply with health and safety measures (specified by the timberland-based wood procurement division) in the field and at the accommodations. Compliance with the measures is enforced by an independent audit - productivity-based bonus to the salary of the drivers and loader operators (managed and paid by the contractor)
2) Performance measurement	- Performance monitoring system for transportation contractors (by an intranet system) with daily data - Performance monitoring system of the compliance level with logistics delivery conditions at the mill, specifically for supply agreements having a maximum hourly arrival rate at the mill
3) Information management	- truck fleet uses GPS for real-time localisation (in area with coverage) - provide information to the public data base for the maintenance of the public road network
4) Inventory management	
5) Asset management	- Many human resource programs (e.g. education, security) and considerations in the planning to reduce absenteeism/accidents and increase/secure work force competencies - the management team of the timberland-based wood procurement division is supported by a planning team with highly specialised competencies (e.g. engineer, computer programming)
6) Network management	- notify the neighbourhood of upcoming transportation activities and provide some audit on the sound level to maintain social acceptance - the planning team uses external resources such as consultants but also research centres and academic institutions (universities) to improve current planning tools or for prototype development.
7) Transportation management	- Agreement on a maximum hourly arrival rate at demand points between the transportation manager and some demand points to reduce truck queuing - Invest in road construction in their timberlands to avoid the interruption of transportation activities during the rainy season - use of an OR based optimisation tool for transportation (e.g. volume allocation, truck routing, loader scheduling) - use of an OR based optimisation tool with LIDAR technology for road construction planning - real-time system to control and adjust the execution of the transportation plan, including communication means with the drivers and loader operators - use of onboard scale by axle to maximise payload and respect weight limits - for Eucalyptus (pulp quality grade) use train in some contexts to reduce transportation costs - for Eucalyptus (pulp quality grade) during the summer season, delay secondary transport to keep inventory at roadside and reduce wood water content (10-15% weight reduction).

Table 47: Agility assessment by dimension and macro-process in Chilean case 1.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	2	3	2	4
	Some blocks scheduled for harvesting during the season are ‘push’ according to silviculture, economic and operational aspects but most of them are ‘pull’ according to supply agreements and demand forecasts.	The cutting-list with the sorting rules are planned and, if required, adjusted daily to fulfil the demand. All the volume harvested is pre-sale.	Internal customers receive priority for all the available supply volume (to commit) while external customers receive the residual volume. The large-scale of the supplier allows a high proportion of the entire demand for internal mills to be fulfilled.	Spread of the deliveries and, when required, delivery prioritisation of some volume allow the fulfilment of demand while complying with logistics delivery conditions at the mill
Information driver	3	3	3	4
	Homogeneity of the block (plantation) combined with historic data from similar blocks provide extremely high accuracy on the forecast volume by product by block. Information is then available for harvesting planning.	The intranet systems with its several applications for harvesting centralises information gathering, allowing frequent and accurate updates, and enabling all actors to access relevant information.	Demand to fulfil is reconfirmed with customers on a regular basis. With ‘connected’ customers, the demand fulfilment monitoring system (in the intranet system) is updated on a daily basis with accurate information (e.g. scale receipt) and relevant information is shared with most customers.	The intranet systems with its several applications for transportation centralises information gathering for planning.
Process integration	2	4	3	4
	Based partially on supply agreements and demand forecasts, blocks to harvest are selected for the entire season with no later opportunity to change. This does not support rapid decision-making.	The intranet system, with its several applications for harvesting, allows for interaction with transportation and demand fulfilment, and thus, supports rapid decision-making.	Sourcing, harvesting and transportation capacities, feasibility and profitability are validated for the committed volume. Supply agreements rely on a structured process, including an analysis of the most profitable wood allocation, facilitating rapid decision-making for supply agreement opportunities during the season.	Transportation planning and execution is centralised and allow rapid decision-making. Also, transportation is integrated with harvesting (inventory) and demand fulfilment.
Network	3	3	3	3

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
integration	Timberland is managed to supply internal customers with a long term, trust-based relationship. There are a few business relationships with private timberland owners (supplier of standing timber) and they appear to be a win-win situation. No obvious restrictions to change or to adopt new practices.	Even relationships with harvesting contractors are highly directive and structured, the overall objective is to improve their operational efficiency (this includes the adoption of new practices) to maintain a profitable margin and this contributes to trust-based relationships.	Demand fulfilment of internal and external customers is fundamental, reinforcing business relationships. Prices paid by internal customers must provide a higher margin than sales to external customers. Monitored on a three month basis, such a rule reinforces the competitive and trust-based relationships and fosters the adoption of new practices to maintain competitiveness and the margin.	Even relationships with transportation and loading contractors are highly directive and structured, the overall objective is to improve their operational efficiency (this includes the adoption of new practices) to maintain a profitable margin and this contributes to trust-based relationships. With some customers, the performance monitoring system on compliance with logistics delivery conditions at the mill enhance their trust-based relationships and in finding common solutions to possible transportation problems (e.g. queuing time).

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 13: Detailed information on US case 4

Table 48: Environmental analysis of US case 4.

Environment element	Description	Uncertainty
1. Industry sector (internal)	Fragmented Several actors	☐Unstable ☒Complex
2. Raw materials	Plantation of Southern yellow pines (loblolly) Stable volume	☐Unstable ☐Complex
3. Human resources	Full year and seasonal contractors	☐Unstable ☒Complex
4. Financial resources	Period of low investments	☐Unstable ☐Complex
5. Market sector	Local & National	☐Unstable ☒Complex
6. Technology	FT method Tree genetic improvement	☐Unstable ☐Complex
7. Government	Low intervention	☐Unstable ☐Complex
8. International sector	High competition from SA and Asia	☒Unstable ☒Complex
9. Climate	2 harvesting seasons Full year harvesting	☒Unstable ☐Complex

For each planning process in US case 4, Table 49 lists the actor responsible for the planning process, the planning horizon (i.e. the time horizon during which decisions are made), the time period (i.e. the time bracket that splits the time horizon during which decisions are made) and the update frequency of the planning process (i.e. the delay for decisions made that are potentially modified by new planning), the decision(s) planned by the process, the planning objective and the tool used to support the actor, if any.

Table 49: Planning processes in US case 4.

Planning process	Actor	Time		
		Planning horizon	**Time period**	**Update frequency**
Value commitment 1	Wood dealer	One to several weeks (according to the duration of the quota offer to auctions)	Week	No update possible after the quotas are obtained
Value commitment 2	Wood dealer	One to several weeks	Day to week	When the demand or harvesting changes
Buy block 1	Wood dealer	One to several weeks	n.a.	n.a.
Schedule harvesting 1 & Schedule secondary transportation 1	Wood dealer	One to several weeks	Week	n.a.
				Weekly and when the demand changes or during harvesting
Schedule harvesting 2 & Schedule secondary transportation 2	Harvesting contractors	One to several weeks (two processes done conjointly)	unavailable	unavailable
Schedule secondary transportation 3	Harvesting contractors (Loader and pull-through delimber operators)	Today	n.a.	Real-time adjustment during the day
Schedule secondary transportation 3.1	Harvesting contractors (Loader and pull-through delimber operators)	Tomorrow morning	n.a	n.a

Table 49: Planning processes in US case 4. (continued)

Planning process	Decision	Objective	Planning tool

Planning process	Decision	Objective	Planning tool
Value commitment 1	- Each Thursday evening, bid on transparent timer auctions with descending prices to obtain weekly quotas (weekly demand to satisfy) in the PH.	Maximise profit while maintaining business with harvest contractors by finding markets for production volume	Human skill
Value commitment 2	- Pre-sale (including gate wood) of the volume to be harvested that will not be used to satisfy weekly quotas.	Finding profitable markets for production volume not used to satisfy quotas	Human skill
Buy block 1	- Buy the block(s) required to satisfy weekly quotas through mainly first-price sealed-bid auction (managed by consulting forester) and negotiated prices by bilateral negotiation with timberland owners	Maximise profit while maintaining business with timberland owners having a regular business history with the company by purchasing their block	Human skill
Schedule harvesting 1 & Schedule secondary transportation 1	- by purchased block, sign and negotiate a harvesting contract with a harvesting contractor with a specific type of equipment. The harvesting contract includes the cut-and-haul payment for each product in the weekly cutting-list. - if needed, road design layout to access the block (can be already specified at block purchase) and assignment to a road construction contractor (could be a service offered by the harvesting contractor)	Maximise profit (sales revenue by product – costs from the cut-and-haul payments) for the block(s) to harvest while satisfying quotas and pre-sale demand	Human skill
	- weekly allocation of the volume to the demand by updating quotas and pre-sale demand in the weekly cutting-list of each harvesting team		
Schedule harvesting 2 & Schedule secondary transportation 2	- harvesting and primary transport layout by block - harvesting (including the loader and pull-through delimber) and transportation crew member allocation - if needed to satisfy the weekly quotas and pre-sale demand, overtime in harvesting, transportation and/or sub-contract for additional trucks	unavailable	Human skill
Schedule secondary transportation 3	- during the day, dispatch the truck fleet by allocated load when volume is produced at roadside - if required (e.g. to complete a truck-load), prioritise the production of the harvesting and primary transport for a specific product	Maximise the revenue from the cut-and-haul payments while satisfying the weekly cutting-list, its weekly quotas and pre-sale demand	Human skill
Schedule secondary transportation 3.1	- schedule the trucks to be loaded tomorrow morning	Load the trucks as early as possible while minimising wait time	Human skill

For each execution process in US case 4, Table 50 lists the actor and the actions performed.

Table 50: Execution processes in US case 4.

Execution process	Actor	Action
Pre-harvesting preparation	Harvesting contractors	- move equipment to the block - set-up the support installations
Harvesting in the FT method	Harvesting contractors	- felling and bunching the tree at the stumpage area
Primary transport in the FT method	Harvesting contractors	- primary transport of the trees from stumpage area to roadside landing - sometimes, partial delimbing using a gate delimber
Merchandising at roadside landing	Harvesting contractors (Loader and pull-through delimber operators)	- delimbing, grading, topping the tree and piling at roadside landing
Loading	Harvesting contractors (Loader and pull-through delimber operators)	- loading the trucks at roadside - recording on a paper tablet all trucks loaded (with the product loaded)
Secondary transport	Harvesting contractors and, subcontracted truckers when additional transportation capacity is required	- secondary transport from roadside to mill
Reception	Mills	- unloading the truck at the mill - scaling (payload) the truck

In Table 51, the main decision(s) made on the most relevant planning processes in US case 4 are classified according to the four attributes characterising a harvest/transportation plan. Furthermore, generic planning decision(s) addressed in each planning process are presented in the last row.

Table 51: Description of the harvest/transportation plan attributes in US case 4.

Planning process	Value commitment 1 and Value commitment 2	Buy block 1	Schedule harvesting 1& Schedule secondary transportation 1
Actor	Wood dealer	Wood dealer	Wood dealer
Planning horizon	One to several weeks	One to several weeks	One to several weeks
Harvesting or transportation resource	Desired harvesting team(s) to hire to satisfy the demand	- Type of equipment for the purchased block - Desired harvesting team to hire to harvest the purchased block	Set of hired harvesting teams
Input stock to harvest or transport	Desired block(s) to purchase to satisfy the demand	Purchase block	A block by harvesting team
Harvesting or transportation instruction		Desired cutting-list for the purchased block	Weekly cutting-list by harvesting team (including quotas and pre-sale demand)
Allocation of the output stock	Preliminary allocation of the volume from the desired block(s) to the demand	Preliminary allocation of the volume from the purchased block to the demand	Weekly allocation of the volume to quotas and pre-sale demand
Generic planning decision		- Harvest units sourcing - Harvest units scheduling - Assortments to produce by harvest unit and allocation to demand - Harvest equipment selection by harvest unit	- Harvest unit assignment to contractors/teams - Bucking/merchandising instructions and sorting rules by harvest unit - Balance transportation with harvesting, inventory and reception - Assign transportation quotas to contractors

Table 51: Description of the harvest/transportation plan attributes in US case 4. (continued)

Planning process	Schedule harvesting 2 & Schedule secondary transportation 2	Schedule secondary transportation 3	Schedule secondary transportation 3.1
Actor	Harvesting contractors	Harvesting contractors (Loader and pull-through delimber operators)	Harvesting contractors (Loader and pull-through delimber operators)

Planning process	Schedule harvesting 2 & Schedule secondary transportation 2	Schedule secondary transportation 3	Schedule secondary transportation 3.1
Planning horizon	One to several weeks	Today	Tomorrow morning
Harvesting or transportation resource	- Harvesting and transportation crew work schedule. - If required, overtime by harvesting team, truck and/or sub-contract additional trucks.		Trucks scheduled for tomorrow morning
Input stock to harvest or transport		- Volume to delivery	The few loads at roadside ready to be delivered
Harvesting or transportation instruction	Harvesting and primary transport layout of the block	- Dispatch the truck - If required (e.g. to complete a truckload), prioritise the production of the harvesting and primary transport of a specific product.	Arrival time for each truck to be loaded tomorrow morning
Allocation of the output stock	No allocation decision on secondary transportation		
Generic planning decision	- Harvest unit layout - Harvest crew scheduling - Transportation crew scheduling	- Transportation equipment routing and scheduling	- Transportation equipment routing and scheduling

Table 52 describes, by attributes of a demand, whether the attribute of the demand in US case 4 is fixed (i.e. planned) by the process or specified as an input to the process and also if the attribute of the demand is subject to future change.

Table 52: Description of the demand attributes in US case 4.

Planning process	Value commitment 1	Value commitment 2	Schedule harvesting 1 & Schedule secondary transportation 1
Actor	Wood dealer	Wood dealer	Wood dealer
Planning horizon	One to several weeks (according to the duration of the quotas offered to auctions)	One to several weeks	One to several weeks
Product specifications	Fixed and no change in the future	Fixed and usually no change in the future	Specified but subject to change in the demand of Value commitment 2
Price and payment conditions	Fixed and no change in the future	Fixed but subject to change, mainly for gate wood (timber price at the mill gate payment method)	Specified but subject to change in the demand of Value commitment 2
Quantity and delivery conditions	Fixed by week and no change in the future	Fixed by week or according to various delivery conditions (e.g. time windows by day to a few hours) but subject to change	Specified by week and other delivery conditions, but subject to change in the demand of Value commitment 2

Table 52: Description of the demand attributes in US case 4. (continued)

Planning process	Schedule harvesting 2 & Schedule secondary transportation 2	Schedule secondary transportation 3	Schedule secondary transportation 3.1
Actor	Harvesting contractors	Harvesting contractors (Loader and pull-through delimber operators)	Harvesting contractors (Loader and pull-through delimber operators)
Planning horizon	One to several weeks (two processes done conjointly)	Today's shift	Tomorrow morning
Product specifications	Specified but subject to change in the demand of Value commitment 2		
Price and payment conditions	n.a.		
Quantity and delivery conditions	Specified by week and other delivery conditions, but subject to change in the demand of Value commitment 2		

Table 53 and Table 54 list the information flow, in input and output, for the planning and execution processes respectively in US case 4.

Table 53: Information flow in the planning processes in US case 4.

Planning process	Input		
	From	**Tool**	**Information**
Value commitment 1	Mills	Internet-based auction platform	- quotas offered to auctions
	Wood dealers	n.a.	- potential block(s) for purchase with their expected buying costs and expected harvesting volume by product - expected available harvesting team(s) with their expected harvesting and transportation cost (cut-and-haul payment)
Value commitment 2	Wood dealer	n.a.	- volume to be harvested that will not be used to satisfy weekly quotas - potential demand (mills) with expected buying price
Buy block 1	Wood dealer	n.a.	- weekly quotas to satisfy - potential block(s) for purchase in the business network of local timberland owners
	Timberland owners	Telephone, meeting, on-site advertising...	- block offered for sale (mainly small private timberland owners, but some industrial timberland owners sell marginal blocks, e.g. small size)
	Forestry and marketing service provider (i.e. consulting foresters)	Mail, fax, email...	- block(s) offered for sale
Schedule harvesting 1 & Schedule secondary transportation 1	Wood dealer	n.a.	- weekly quotas and pre-sale demand - expected available harvesting team(s) with their expected costs for cut-and-haul payment
Schedule harvesting 2 & Schedule secondary transportation 2	Wood dealer	- Telephone, email, fax, visit with document - If quotas/pre-sale demand require paper delivery authorisation: email or visit	- harvesting contract - weekly cutting-list for each harvesting team (including the quotas and pre-sale demand with delivery logistics instructions)

Planning process	Input		
	From	Tool	Information
Schedule secondary transportation 3	Wood dealer	- Telephone, email, fax, visit with document	- weekly cutting-list for each harvesting team (including the quotas and pre-sale demand with the delivery logistics instructions) - delivery logistics instructions.
Schedule secondary transportation 3.1	Harvesting contractors (Loader and pull-through delimber operators)	n.a.	- a few loads at roadside ready to be delivered
	Wood dealer	- Telephone, email, fax...	- weekly cutting-list for each harvesting team (including quotas and pre-sale demand with delivery logistics instructions) - delivery logistics instructions.

Table 53: Information flow in the planning processes in US case 4. (continued)

Planning process	Output		
	To	Tool	Information
Value commitment 1	Wood dealer	n.a.	- quotas obtained and the price paid (fixed at the time of auction). The quotas specify a weekly quantity of a product to be delivered over one to several weeks at a specific demand point and according to specific delivery logistics instructions.
Value commitment 2	Wood dealer	n.a.	- pre-sale demand for the volume to be harvested that will not be used to satisfy quotas
Buy block 1	Wood dealer	n.a.	- block(s) purchased
Schedule harvesting 1 & Schedule secondary transportation 1	Harvesting contractors	- Telephone, email, fax, visit with document - If quotas/pre-sale demand require paper delivery authorisation: email or visit	- harvesting contract - weekly cutting-list for each harvesting team (including the quotas and pre-sale demand with delivery logistics instructions)
	Wood dealer	n.a.	- harvesting plan during the PH
	Road construction contractors (could be a service offered by the harvesting contractor)	Unavailable	- road design layout to access the block

Planning process	Output		
	To	**Tool**	**Information**
Schedule harvesting 2 & Schedule secondary transportation 2	Harvesting contractors (Harvesting and transportation crew members)	Unavailable	- Work plan for each crew member and potential sub-contracted truck
Schedule secondary transportation 3	Harvesting contractors (Transportation crew members)	- communication in person, CB radio, cellular, text message, email...	- next destination of their truck
	Harvesting contractors (Harvesting crew members)	- communication in person, CB radio, cellular, text message...	- if required, production priority for a specific product
Schedule secondary transportation 3.1	Harvesting contractors (Transportation crew members)	- communication in person, telephone, text message...	- schedule of the trucks to be loaded tomorrow morning

Table 54: Information flow in the execution processes in US case 4.

Execution process	Input		
	From	**Tool**	**Information**
Pre-harvesting preparation	Harvesting contractors	n.a.	- harvesting and primary transport layout by block
Harvesting in the FT method	Harvesting contractors	n.a.	- harvesting layout by block
	Harvesting contractors (loader and pull-through delimber operators)	- communication in person, CB radio, cellular, text message...	- if required (e.g. to complete a truck-load), specific product to prioritise in the harvesting
Primary transport in the FT method	Harvesting contractors	n.a.	- primary transport layout by block
	Harvesting contractors (loader and pull-through delimber operators)	- communication in person, CB radio, cellular, text message...	- if required (e.g. to complete a truck-load), specific product prioritised for the primary transport
Merchandising at roadside landing	Wood dealer	- Telephone, email, fax, visit with document	- weekly cutting-list (including quotas and pre-sale demand with delivery logistics instructions)
Loading	Wood dealer	- Telephone, email, fax, visit with document	- weekly cutting-list (including quotas and pre-sale demand with delivery logistics instructions)
Secondary transport	Harvesting contractors (loader and pull-through delimber operators)	- communication in person, CB radio, cellular, text message...	- next destination of their truck
Reception	Mills	n.a.	- weekly quotas or pre-sale demand at the mill

Table 54: Information flow in the execution processes in US case 4. (continued)

Execution process	Output		
	To	**Tool**	**Information (tool)**
Pre-harvesting preparation			
Harvesting in the FT method			

Execution process	Output		
	To	Tool	Information (tool)
Primary transport in the FT method			
Merchandising at roadside landing			
Loading	Wood dealer	- Telephone, email, fax, visit with document	- list of trucks loaded (with the loaded product) during the day to up to a week
Secondary transport	Wood dealer	- visit, post	- scale receipt for each delivery of the week
Reception	Harvesting contractors	- printer on-site	- issue a scale receipt at each delivery to each driver
	Wood dealer	- email, fax, post	- list of the truck (with product and payload) delivery during the week

Table 55 lists the average inventory time of the material between consecutive pairs of processes in US case 4.

Table 55: Average inventory time of the material between consecutive pairs of processes in US case 4.

Consecutive pairs of processes		Material	Average inventory time	
Buy block	Harvesting in the CTL method	Standing timber	A few days to a few weeks	
Harvesting in the FT method	Primary transport in the FT method	Bunch of felled trees adjacent to the primary transport trail	One to a few hours	Average time of 0.5-1.5 days from harvesting to reception
Primary transport in the FT method	Merchandising at roadside landing	Bunch of felled trees adjacent to the loader and pull-through delimber	A few minutes	
Merchandising at roadside landing	Secondary transport	Pile of sorted products adjacent to the loader and pull-through delimber	One to a few hours	

From the process of Buy block to the process of Reception, Table 56 details, by process(es) and payment methods, the main financial flows for the wood dealer in US case 4 and also for the other case studies in the US. For the sake of brevity, the payments of internal human resources are not represented.

Table 56: Main monetary flows in US case 4.

Process(es)	Payment method(s)	Time	Monetary flow
Buy block	lump sum	Purchasing time	Full payment to timberland owner and, sometimes, a good practices security deposit (refunded after harvesting and transportation if the good practices have been met)
	unit sale price by assortment	Purchasing time	Usually, payment of an advance to the timberland owner
		With a delay (specified at purchase) after the harvesting volume has been measured at the mill(s)	Payment to the timberland owner
Harvesting in the FT method to Reception	Cut-and-haul rate	At the end of the week or within the next week	Payment of the harvesting contractor for all the volume delivered during the week (no payment for the possible few loads harvested but not delivered)
Harvesting in the FT method to Primary transport in the FT method	unit rate by assortment	At the end of the week or within the next week	Payment of the harvesting contractor for all the volume delivered during the week (no payment for the loads harvested but not delivered)
Secondary transport to Reception	flat unit rate	At the end of the week or within the next week	Payment of the transportation contractor for all the volume delivered during the week
Reception	unit sale price by assortment	Within 7-10 days after the week or the two last weeks	Payment by the customer for all the volume delivered during the week or the two last weeks

Table 57 details the enablers and practices by macro-process in US case 4.

Table 57: Enablers and practices of US case 4.

Category of enabler	Source
1) Rules and guidelines	- Blocks are purchased with all or most of the demand attributes that are fixed and cannot be modified, reducing the risk of loss - prevention of abuse in standing timber purchases by legislation protecting forest owners
2) Performance measurement	- low fixed cost and small-scale supplier organisation allow a niche for the purchase of marginal and low margin blocks usually neglected by large-scale supplier organisations
3) Information management	- tacit knowledge of timberland owners in the region, harvesting contractors and customers
4) Inventory management	- combination of pre-purchasing cruise and lengthy experience to increase the forecast precision of volume by product in a block
5) Asset management	- combination of pre-purchasing cruise and lengthy experience to increase the forecast precision of productivity and expected rates for the harvesting and primary transport - silviculture flexibility in loblolly pine plantations: time window of a maximum of 3 years to perform the first thinning (12-15 years) and 9 years for clear-cutting (26-35 years)
6) Network management	- long term (up to the preceding generation) business relationships with private timberland owners to access standing timber not advertised for purchase or by being contacted directly by the timberland owner - receive purchase proposition of standing timber directly from timberland owners due to local knowledge of its business - in business contact with different consulting foresters to receive the documentation on the block for sale
7) Transportation management	- if road construction is needed, road design layout to access the block can be specified at purchase and will reduce the purchasing cost

Table 57: Enablers and practices of US case 4. (continued)

Category of enabler	Make
1) Rules and guidelines	- general contractual agreement with few regular harvesting contractors with pre-negotiated conditions and legal eligibility for a future harvesting contract on a block - specialised and preferable harvesting contractor to work with according to the commercial treatment (i.e. specialised in thinning or in clear-cutting) - with regular harvesting contractors, 'cut-and-haul' base rate pre-negotiated and adjusted by block according to productivity factors in harvesting and secondary transport, as well as fuel index fluctuation - harvesting contractors must have the Best Management Practices accreditation - volume-based productivity bonus provided to the salary of the operators (managed and paid by the harvesting contractor) - water, soil and air pollution protection measures - notice to local authority of upcoming harvesting activities and, sometimes, requiring the payment of a security deposit (refunded after harvesting and transportation if the public infrastructure has not been damaged)
2) Performance measurement	- tacit knowledge of productivity and cost models from harvesting to secondary transport - with the cut-and-haul rates, the descending structure of the product rate from the higher value product to the lower value product provide a financial incentive to the harvesting contractor to merchandise the most valuable product.
3) Information management	- the cutting-list with sorting rules of each harvesting team can be updated at virtually any time with a telephone call
4) Inventory management	- if required to satisfy an urgent demand (or match production with restrictive quotas), can temporarily increase the specification requirements of non-urgent (or with no quota) products to merchandise the urgent product (or products with quotas) - cut-and-haul payment based on scaled weight at delivery site fosters short inventory time between felling and delivery -short inventory time between felling and delivery avoids virtually all inventory deterioration risks (e.g. blue stain)
5) Asset management	- possibility of using various scattered accommodations for the harvesting crew give harvesting contractors high geographic flexibility - overtime is possible - relatively low capital investment needed for FT harvesting equipment enables harvesting contractors to be profitable despite the seasonality pattern of reduced work days
6) Network management	
7) Transportation management	- to maximise trucking capacity, a few truckloads at the end of day 'n' are produced and stocked to allow the loading of a few trucks at sunrise on day 'n+1'. - to complete a truckload of a specific product or to fulfil an urgent demand, specific trees that will foster the merchandising of the needed product are felled (and then primary transported)

Table 57: Enablers and practices of US case 4. (continued)

Category of enabler	**Deliver (value commitment)**
1) Rules and guidelines	- based on tacit knowledge of available block(s) to purchase (and estimated purchase cost) and available harvesting contractor(s) to hire (and estimated cut-and-haul rate for the block), a positive margin is estimated before committing to a demand. - high supplier penalty is charged if quotas are not fulfilled - some customers can require that harvesting contracts have the Best Management Practices accreditation and/or that the delivery volume comes from a Sustainable Forestry Initiative (SFI) certified block
2) Performance measurement	- small-scale supplier organisation allows for a niche in the supply of low volume mills, usually neglected by large-scale supplier organisations
3) Information management	- part of the demand is obtained through internet-based auctions
4) Inventory management	
5) Asset management	
6) Network management	- good history allows privileged business relationship with some mills
7) Transportation management	- quotas and pre-sale demand include the details of the delivery logistics conditions

Table 57: Enablers and practices of US case 4. (continued)

Category of enabler	Deliver (secondary transport)
1) Rules and guidelines	- productivity-based bonus to the salaries of drivers and loader operators (managed and paid by the harvesting contractor) - notice to local authority of upcoming transportation activities and, sometimes, required payment of a security deposit (refunded after the harvesting and transportation if public infrastructure has not been damaged) - no secondary transport (loaded truck) at night - local authority can decrease the weight limit on local roads
2) Performance measurement	- tacit knowledge of productivity and cost models from harvesting to secondary transport
3) Information management	
4) Inventory management	
5) Asset management	
6) Network management	- harvesting contractors have access to punctual sub-contracting trucker(s) when internal transportation capacity is insufficient (note: with a cut-and-haul payment method, harvesting contractor are also responsible for secondary transport)
7) Transportation management	- reduce handling by loading a truck where the merchandising takes place - some pre-sale demand reserve delivery time windows to reduce truck queuing time - to maximise trucking capacity, a truck can stay loaded overnight (i.e. pick-up at the end of day ‘n’ and delivery at the beginning of day ‘n+1’) or first pickup is scheduled at sunrise.

Table 58: Agility assessment by dimension and macro-process in US case 4.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	3	3	2	3
	Blocks are purchased according to confirmed demand for all or most of the volume to be harvested in the block. The small-scale of the supplier limits purchasing (e.g. cash-flow, production capacities). Source can identify the standing timber (to be sold) with a profitable volume for specific mills and proactively propose this.	Virtually no volume is harvested without a demand. The cutting-list with sorting rules can be adjusted at virtually any time by a telephone call according to e.g. a change in the need of the mills. If a production problem occurs, small-scale operations do not allow the redistribution of the missing production among the set of harvesting teams.	Demand will be committed only if a positive margin is estimated (except for by-products that could be sold at a loss with a positive global margin for the block). Small-scale of the supplier also forces the organisation to be more aware and receptive to any requirements of the mill which, in turn, makes it easier to identify new market opportunities. The small-scale of the supplier does not allow it to fulfil the entire demand of a mill.	Capacity of the secondary transport to fulfil the logistics of delivery conditions of the demand or new opportunity for the demand is highly dependent on the harvesting (no stock at roadside to act as a buffer).
Information driver	1	2	2	3
	Mostly tacit knowledge of the blocks available for purchase but also receives purchase offers directly from timberland owners or through intermediaries (e.g. consulting foresters). Accuracy of the inventory included in purchase offers is variable, thus requiring one's own cruise. Overall, accessibility of sourcing information tends to be limited with competition among buyers.	Information exchanges are frequent and fairly accurate with harvesting contractors, but the sharing of information remains limited to a short-time horizon.	Some demand is accessible to any accredited supplier through an Internet-based auction while accessibility to other demand is more or less limited to a supplier already in a business relationship according to a seasonal pattern. The frequency and accuracy of the information on the available demand is variable by customer and according to the level of the business relationship.	Same as in Make. The frequency and accuracy of the information on the demand fulfilment is variable by customer.
Process	2	4	4	4

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
integration	Purchasing is based on demand buying prices and estimated cut-and-haul rates for the block with the potentially available harvesting contractors for hire. Timberland owners are prompted to sell their block when standing timber prices are high, which it is not necessarily only linked to high demand. Purchasing is connected to the sellers using different means that, overall, facilitate rapid decision-making but can be impacted by an imposed delay (e.g. solicitation time in a sealed-bid auction sale).	Harvesting is jointly planned and executed with secondary transport and based on the demand (expressed by the cutting-list with quotas/pre-sale volume by the mill), leading to rapid decision-making locally.	Based on tacit knowledge of available block(s) for purchase (and estimated purchase cost) and available harvesting contractor(s) for hire (and estimated cut-and-haul rate for the block), a positive margin is estimated before committing to a demand. When a block is purchased and the residual volume is left to sell, the global positive margin is checked before commitment. The short term horizon in the demand commitment by the mill facilitates rapid decision-making.	Same as in Make.
Network integration	2	2	1	2
	Many long-term business relationships with timberland owners, local-level knowledge of its business practices by timberland owners and business relations with intermediaries (e.g. consulting foresters) foster good business reputation in the block purchase. Traditional model to sell/buy block is conservative and hesitant to change and adopt new practices.	The use of a general contractual agreement for the harvesting contracts by block reinforces a trust-based relationship while the cut-and-haul rate allows operational flexibility to the harvesting contractor to adopt new practices (but only limited to his activities) by himself.	Business relationships through Internet-based auctions or gate wood deliveries do not reinforce trust-based supplier-mill relationship (but can impose at a given level the adoption of new practices to be more competitive), while other traditional relationships (bilateral negotiation) reinforce trust-based relationships, but this only happens for a small number of contracts.	Same as Make, but cut-and-haul rate by block makes it difficult to adopt back-hauling and other logistics practices reducing empty distance, which are based on collaboration among many blocks.

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 14: Detailed information on partial US case 7

Table 59 details the enablers and practices by macro-process in US case 7.

Table 59: Enablers and practices of US case 7.

Category of enabler	Source
1) Rules and guidelines	
2) Performance measurement	- timberland managed to generate value not only from forestry (e.g. gravel rock)
3) Information management	- geographic information system to support the management of the timberlands
4) Inventory management	- combination of inventory cruise and experience to increase the forecast precision of volume by product in a block
5) Asset management	- combination of inventory cruise and experience to increase the forecast precision of productivity and expected rates for the harvesting and primary transport - sell the standing timber of a block of a small size and low margin estimation - geographic information system combined with yield tables, growth models and economic analysis (e.g. return on investment) to support the management of the timberlands - silviculture flexibility in loblolly pine plantations: time window of a maximum of 3 years to perform the first thinning (12-15 years) and 9 years for clear-cutting (26-35 years) - a small logistics team is dedicated to support the decisions of the top and regional managers (of the large timberland-based wood supplier) involved in this macro-process.
6) Network management	- to improve the activities involved in this macro-process, the timberland-based wood supplier uses external resources, such as consultants but also research centres and academic institutions (universities).
7) Transportation management	

Table 59: Enablers and practices of US case 7. (continued)

Category of enabler	Make
1) Rules and guidelines	- general contractual agreement with regular harvesting contractors to pre-negotiate the conditions and legal eligibility for a future harvesting contract for a block - three levels of preferable classification of harvesting contractors to work with (and according to the fit of their type of equipment and the commercial treatment and block characteristics) used to absorb production fluctuation - try to keep harvesting contractors with one or few harvesting teams to e.g. keep owner in the field, avoid negotiating power increase, keep business dependence low - with regular harvesting contractors, 'cut-and-haul' base rate pre-negotiated and adjusted by block according to productivity factors in harvesting and secondary transport, as well as fuel index fluctuation - harvesting contracts must have the Best Management Practices accreditation - volume-based productivity bonus provided to the salary of operators (managed and paid by the harvesting contractor) - water, soil and air pollution protection measures - notice to local authority of upcoming harvesting activities and, sometimes, required payment of a security deposit (refunded after the harvesting and transportation if public infrastructure has not been damaged). The large timberland-based wood supplier has the cash-flow to pay this deposit, which could be a problem for some harvesting contractors.
2) Performance measurement	- tacit knowledge of productivity and cost models from harvesting to secondary transport - can harvest a block at two different times when e.g. the market goes down - with cut-and-haul rates, the descending structure of the product rate from the higher value product to the lower value product provides a financial incentive to the harvesting contractor to merchandise the most valuable product - in fixing the cut-and-haul rate by product on a block, the margin on each product allows the production to be validated and thus, some potential products with distant customer(s) are not produced (and included in lower quality grade, i.e. degrading) because their superior selling price does not cover the extra transportation cost
3) Information management	- the cutting-list with sorting rules of each harvesting team can be updated at virtually any time with a telephone call.
4) Inventory management	- cut-and-haul payment based on scaled weight at delivery site fosters short inventory time between felling and delivery - short inventory time between felling and delivery avoids virtually all risk of blue stain deterioration
5) Asset management	- operators trained to perform thinning operations without tree marking (thinning quality is controlled after the procedure by the wood supplier) - use different types of equipment to fit the commercial treatment and block characteristics - harvesting crew has wide geographic flexibility (e.g. affordable accommodations are virtually available anywhere) - if a production problem occurs with the current equipment (or more punctual production is required), some harvesting contractors keep old but well maintained harvesting equipment ready to be used and have already moved it to the block (or a closer location than the contractor's home base) - if a harvesting contractor faces production problems, the timberland-based supplier can reallocate his quotas among several other harvesting contractors to guarantee the fulfilment of the quotas - if a block has more high quality grade products than estimated, a harvesting contractor can obtain additional quotas in high quality grade products by reallocating the quotas among several harvesting contractors - overtime is possible - the relatively low capital investment needed in FT harvesting equipment allows harvesting contractors to be profitable despite the seasonality pattern reducing the number of work days - at the timberland-based supplier, a management position is dedicated to increasing the business competencies of the regular harvesting contractors - bad weather patterns tend to be localised (Grace et al., 2010), thus, when a bad weather pattern requires a harvesting contractor to stop for few days,

Category of enabler	**Make**
	he can be moved to other available blocks allowing the loss in a production day to be minimised - blocks with good draining soils are kept for winter season harvesting - a small logistics team is dedicated to supporting the decisions of top and regional managers (of the timberland-based wood supplier) involved in this macro-process.
6) Network management	- to improve the activities involved in this macro-process, the timberland-based wood supplier uses external resources such as consultants, but also research centres and academic institutions (universities).
7) Transportation management	- to maximise trucking capacity, a few truckloads are produced and stocked at the end of day ‘n’ to allow the loading of a few trucks at sunrise on day ‘n+1’. - to complete a truckload of a specific product or to fulfil an urgent demand, felling (and then primary transport) of specific trees that should foster the merchandising of the needed product is performed - better quality roads are built in their timberlands to avoid excessive road damage during high rainfall periods that can lead to interruptions in harvesting and transportation activities

Table 59: Enablers and practices of US case 7. (continued)

Category of enabler	**Deliver (value commitment)**
1) Rules and guidelines	- total volume under medium-long term supply agreements is limited to 65-75% of the total harvested volume in order to guarantee operational flexibility while complying with these supply agreements - long term supply agreements (i.e. up to 25 years) down to daily (i.e. 1 to a few truckloads) supply agreements - sales management is regionally decentralised for ‘regional’ customers while regional sales managers act together for customers present in many regions to e.g. increase negotiating power and avoid internal competition/cannibalisation - some customers can require that harvesting contractors have the Best Management Practices accreditation and/or that the delivered volume comes from a Sustainable Forestry Initiative (SFI) certified block
2) Performance measurement	- being a timberland-owning and large-scale supplier represents a competitive advantage in becoming a first-level supplier - customers under contract that solicit additional volume on short notice can usually be supplied, but a premium price is generally charged on this additional volume - to maximise the selling price of the harvested volume, the wood supplier is in continuous contact with current and potential customers to develop/adjust merchandising and sorting rules to extract more valuable products.
3) Information management	- supply agreements rely on a structured process ensuring that their requirements are well diffused among the relevant actors in the short term
4) Inventory management	
5) Asset management	- to support sales managers in the value commitment process, an OR based optimisation tool is used to allocate volume from hundreds of blocks to the most profitable customers over a wide supply area - a small logistics team is dedicated to supporting the decisions of top and regional managers (of the large timberland-based wood supplier) involved in this macro-process.
6) Network management	- maintain business relationships with most of the main customers in the region in order to secure several regional markets for their products
7) Transportation management	- supply agreement includes details of the delivery logistics conditions

Table 59: Enablers and practices of US case 7. (continued)

Category of enabler	Deliver (secondary transport)
1) Rules and guidelines	- continuous monitoring of the credit limit of each customer before delivery to reduce the risk of loss - productivity-based bonus provided to the salaries of drivers and loader operators (managed and paid by the harvesting contractor) - notice to local authority of upcoming transportation activities and, sometimes, required payment of a security deposit (refunded after the harvesting and transportation if the public infrastructure has not been damaged) - local authority can decrease weight limit on local roads - no secondary transport (loaded truck) at night
2) Performance measurement	- tacit knowledge of productivity and cost models from harvesting to secondary transport
3) Information management	
4) Inventory management	
5) Asset management	- a small logistics team is dedicated to supporting the decisions of top and regional managers (of the large timberland-based wood supplier) involved in this macro-process.
6) Network management	- harvesting contractors have access to punctual sub-contracting trucker(s) when internal transportation capacity is insufficient (note: with the cut-and-haul payment method, harvesting contractor are also responsible for secondary transport) - to improve the activities involved in this macro-process, the timberland-based wood supplier uses external resources, such as consultants but also research centres and academic institutions (universities).
7) Transportation management	- reduce handling by loading a truck as the merchandising takes place - some volume in supply agreement reserve delivery time windows to reduce truck queuing time. - to maximise trucking capacity, a truck can stay loaded overnight (i.e. pick-up at the end of day ‘n’ and delivery at the beginning of day ‘n+1’) or first pickup is scheduled at sunrise. - better quality roads are built in their timberlands to avoid excessive road damage during high rainfall periods that can lead to interruptions in harvesting and transportation activities. - pilot project to improve transportation by reducing the empty distance through back-hauling among harvesting contractors.

Table 60: Agility assessment by dimension and macro-process in US case 7.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	3	4	3	4
	The geographic spread and importance of its timberlands allows the identification of standing timber to be harvested with a profit for virtually any demand. For long term supply agreements, timberland is managed to ensure its most profitable fulfilment.	Virtually no volume is harvested without a demand. The cutting-list with the sorting rules can be adjusted at virtually any time by a telephone call. If a production problem occurs locally, large scale activities with many harvesting teams allow harvesting manager(s) to redistribute the missing production required to fulfil the demand.	To reduce dependence, mills tend to diversify their network of suppliers and restrict the volume from each supplier to a given limit. The large-scale of the timberland-based wood supplier allows this limit to be fulfilled for any customer, but better profitability with other mill(s) will usually restrict the volume delivered. Identification of opportunities to increase customer value is subject to additional value for the wood supplier.	Capacity of the secondary transport to fulfil the demand of logistics delivery conditions is highly dependent on the harvesting (no stock at roadside to act as a buffer). If a production or transportation problem occurs locally, large scale activities with many harvesting teams allow the delivery of the demand in compliance with the logistics delivery conditions.
Information driver	3	2	3	2
	Homogeneity of the timberland (plantation) combined with an inventory cruise provides accurate sourcing information that is then available/diffused for the value commitment and harvesting planning.	Information exchanges are frequent and fairly accurate with harvesting contractors and among the harvesting managers but information sharing remains limited to a short-time horizon.	Long-to-daily supply agreements are accurate and they follow a well documented process. Supply agreements are frequently revised/renegotiated with mills and their requirements are well diffused among relevant actors.	Same as in Make. The frequency and accuracy of the information on the demand fulfilment varies by customer.
	3	4	4	4

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Process integration	Combined with process value commitment, knowledge on the inventories (in standing timber) allows volumes to be identified that will be harvested (or must be harvested according to silviculture, economic and operation aspects) that could be reallocated (or need to be allocated) to a mill providing a higher margin. Knowledge on the available inventory (in standing timber) supports rapid decision-making.	Harvesting is jointly planned and executed with secondary transport and based on the demand (expressed by the cutting-list with quotas/pre-sale volume by mill), leading to rapid decision making locally. At the level of the harvesting managers, centralised planning of what should be delivered regionally and by each of them during the week is then used in the execution of the plan to facilitate rapid decision-making when changes occur during the week.	Feasibility of sourcing and harvesting/transportation capacities is evaluated earlier to commit to volume. Supply agreements rely on a structured process, including an analysis of the most profitable wood allocation, facilitating rapid decision-making in short term supply agreement opportunities.	Same as in Make.
Network	3	4	3	3

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
integration	For mills with a long term supply agreement, sourcing and timberland are managed to ensure their most profitable fulfilment, requiring a trust-based relationship and the adoption of new practices to maintain/improve the competitiveness of the business relationship. For other mills, sourcing and timberland are managed to maximise margin and thus, will lead to reinforce the trust-based relationship essentially with the more profitable mill.	The use of a general contractual agreement for harvesting contracts by block, a manager dedicated to business competencies improvement, a three level harvesting contractor classification and other practices reinforce a trust-based relationship with the first level harvesting contractors, but also with other level contractors as they know what to expect when the globally required production capacity decreases. Cut-and-haul rates provide the harvesting contractor with the operational flexibility to adopt new practices (but only limited to his activities) by himself. In addition, the timberland-based wood supplier provides managers to support harvesting contractors in the adoption of new practices.	Compliance with supply agreement and some flexibility to supply additional volume on short notice foster trust-based relationships with mills. Mostly in medium-long term supply agreements, bilateral negotiation on price adjustments tends to foster the adoption of new practices to maintain/improve the competitiveness of the business relationship.	Same as Make and also a pilot project is operating to improve transportation by reducing empty distance with back-hauling among harvesting contractors.

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 15: Detailed information on French case 11

Table 61: Environmental analysis of French case 11.

Environment element	Description	Uncertainty
1. Industry sector (internal)	Fragmented Several actors	☐Unstable ☒Complex
2. Raw materials	Plantation of Maritime pine Resource scarcity	☒Unstable ☐Complex
3. Human resources	Full year contractors	☐Unstable ☐Complex
4. Financial resources	Period of low investments	☐Unstable ☐Complex
5. Market sector	Local & Continental	☐Unstable ☒Complex
6. Technology	CTL method Tree genetic improvement	☐Unstable ☐Complex
7. Government	Higher regulation level	☐Unstable ☐Complex
8. International sector	Competition from eastern Europe and Scandinavia	☒Unstable ☒Complex
9. Climate	Full year harvesting	☐Unstable ☐Complex

For each planning process in French case 11, Table 62 lists lists the actor responsible for the planning process, the planning horizon (i.e. the time horizon during which decisions are made), the time period (i.e. the time bracket that splits the time horizon during which decisions are made) and the update frequency of the planning process (i.e. the delay for decisions made that are potentially modified by new planning), the decision(s) planned by the process, the planning objective and the tool used to support the actor, if any.

Table 62: Planning processes in French case 11.

Planning process	Actor	Time		
		Planning horizon	**Time period**	**Update frequency**
Value commitment 1	Harvesting contractor	Month	Week	Week (if change in the demand)
Value commitment 2	Harvesting contractor	Week	Day	Day (if change in the demand)
Value commitment 3	Harvesting contractor	Day	AM and PM	Less than a day (if change in the demand)
Buy block 1	Harvesting contractor	Twice a year purchase for public timberland blocks and continuous purchase for private timberland blocks	n.a.	n.a.
Schedule harvesting 1	Harvesting contractor	Done for each block	n.a.	n.a.
Schedule harvesting 2	Harvesting contractor	Continuous harvesting scheduling	n.a.	n.a.
Schedule secondary transportation 1	Harvesting contractor	Day	A few minutes	Updated by Schedule of secondary transportation 1.1
Schedule secondary transportation 1.1	Harvesting contractor	Today	A few minutes	Real-time when a work plan change is required

Table 62: Planning processes in French case 11. (continued)

Planning process	Decision	Objective	Planning tool

Planning process	Decision	Objective	Planning tool
Value commitment 1	- Each end of the month and for each customer with an annual supply agreement, confirm the next month's quantity by product fixed in the annual supply agreements, the delivery conditions (weekly to daily time period quotas) and the pre-negotiated price (at roadside or delivery at the mill)	Confirm profitable demand for the volume in inventory and to be harvested	Human skill (supported by a centralised paper agenda)
Value commitment 2	- Each Thursday/Friday (for most customers), accept, refuse or negotiate a spot demand for the next week. A spot demand is a quantity of a product, a price and strict delivery conditions (per day up to daily time period quotas). A spot demand can involve volume to be delivered for a few consecutive weeks.	Accept profitable demand while maintaining business with spot demand	Human skill (supported by a centralised paper agenda)
Value commitment 3	- Each afternoon and for each customer with a regular business history, confirm the next day's quantity by product, the delivery conditions (AM and PM quotas) and the price.	Confirm profitable demand for the volume in the inventory	Human skill (supported by a centralised paper agenda)
Buy block 1	Public timberland: - Twice a year, bid on first-price sealed-bid auction during the sale of blocks by the ONF (Office National des Forêts) Private timberland: - Negotiated prices through bilateral negotiation with timberland owners - Bid in transparent timer auctions with descending prices during the sale of blocks by consulting foresters	- Buy a portfolio of blocks to secure the satisfaction of supply agreements and maintain additional supply for profitable spot demand. - Increase purchase when the block prices are 'good' (i.e. expectation to maximise future profit). - Maintain purchase with timberland owners having a regular business history with the company.	Human skill (supported by an ERP)
Schedule harvesting 1	- harvesting and primary transport layout - type of harvesting equipment for preferable assignment - estimated production volume by product	Minimise harvesting and primary transport costs	Human skill (supported by an ERP)

Planning process	Decision	Objective	Planning tool
Schedule harvesting 2	- scheduling of the next block to harvest in the portfolio of blocks - harvesting team assignment by block and crew member allocation (include overtime if required) - list of products allowed for production in each block (note: the list is used by the harvester operator to update the price list of the harvester's computer) and the sorting rules - partial and short-term preliminary allocation of the volume (in inventory and to be harvest) to the demand - if required to satisfy a demand, block(s) where specific products in the primary transport are prioritised	Minimise costs (harvesting + primary transport + secondary transport) while satisfying the demand	Human skill (supported by an ERP)
Schedule secondary transportation 1	- routing and scheduling of the truck fleet - scheduling of the loaders - allocation of the volume (in inventory) to the demand to fulfil during the day - if required to satisfy a demand to fulfil during the day, selection of inventory for one way product substitution or product sorting during truck loading	Minimise transportation costs while satisfying the demand	Human skill (supported by an ERP)
Schedule secondary transportation 1.1	- update of routing and scheduling of the truck fleet - update of the loader scheduling - update of the allocation of the volume (in inventory) to the demand to fulfil during the day - if required to satisfy a demand to fulfil during the day, selection of inventory for one way production substitution or product re-sorting during truck loading	Address deviations to the work plans	Human skill

For each execution process in French case 11, Table 63 lists the actor and the actions performed.

Table 63: Execution processes in French case 11.

Execution process	Actor	Action
Pre-harvesting preparation	Harvesting contractor	- move equipment to the block - set up the support installations
Harvesting in the CTL method	Harvesting contractor	- update the values list of the harvester according to the list of products allowed for production in the block - felling, delimbing, bucking and sorting in piles adjacent to the primary transport trail
Primary transport in the CTL method	Harvesting contractor	- primary transport of the logs from stumpage area to roadside landing - sorting and piling at roadside landing
Measuring at roadside	Harvesting contractor (harvesting supervisors)	- apparent volume measurement (i.e. stere unit, which consists of 1 meter x 1 meter x 1 meter) of the piles
Secondary transport	Harvesting contractor	- loading the trucks at roadside (can load other truck(s) without crane) - secondary transport from roadside to mill
Reception	Mills	- unloading of the truck at the mill (or done by the trucker for mills without a loader) - scaling (payload) of the truck (or done at the scale station of the harvesting contractor for mills without scale)

In Table 64, the main decision(s) made on the most relevant planning processes in French case 11 are classified according to the four attributes characterising a harvest/transportation plan. Furthermore, generic planning decision(s) addressed in each planning process are presented in the last row.

Table 64: Description of the harvest/transportation plan attributes in French case 11.

Planning process	**Schedule harvesting 1**	**Schedule harvesting 2**	**Schedule secondary transportation 1**	**Schedule secondary transportation 1.1**
Actor	Harvesting contractor	Harvesting contractor	Harvesting contractor	Harvesting contractor
Planning horizon	Done for each block	Continuous harvesting scheduling	Day	Today
Harvesting or transportation resource	Desired type of harvesting equipment to assign to the purchased block	- Harvesting team assigned by block - Harvesting crew member work schedule (if required, includes overtime)	- Loaders and trucks scheduled - Transportation crew work schedule	If required, real-time update of decisions in Secondary transportation scheduling 1
Input stock to harvest or transport	Purchased block	Next block to harvest in the portfolio of blocks	Specific volume to load/transport by loader/truck	
Harvesting or transportation instruction	Harvesting and primary transport layout of the purchased block	- List of products allowed for production in each block and sorting rules - If required, the block where specific products are prioritised for primary transport	- Work schedule by loader (sequence of volume to load) and truck (route) - if required to satisfy a demand to fulfil during the day, selection of inventory for one way production substitution or product sorting during truck loading	
Allocation of the output stock		Partial and short-term preliminary allocation of the volume (in the inventory and to be harvested) to the demand	Allocation of the volume (in inventory) to the demand to fulfil during the day	

Planning process	Schedule harvesting 1	Schedule harvesting 2	Schedule secondary transportation 1	Schedule secondary transportation 1.1
Generic planning decision	- Harvest equipment selection by harvest unit - Harvest unit layout	- Harvest units scheduling - Assortments to produce by harvest unit and allocation to demand - Bucking/merchandising instructions and sorting rules by harvest unit - Harvest unit assignment to contractors/teams - Harvest crew scheduling	- Assortments (re)allocation to demand - Transportation crew scheduling - Transportation equipment routing and scheduling	- Transportation equipment routing and scheduling

Table 65 describes, by attributes of a demand, whether the attribute of the demand in French case 11 is fixed (i.e. planned) by the process or specified as an input to the process and also if the attribute of the demand is subject to future change.

Table 65: Description of the demand attributes in French case 11.

Planning process	Value commitment 1	Value commitment 2	Value commitment 3
Actor	Harvesting contractor	Harvesting contractor	Harvesting contractor
Planning horizon	Month	Week	Next day
Product specifications	Fixed by month (from a set of product specifications fixed in the annual supply agreement) but subject to rare changes (to other product specifications in the set)	Fixed but subject to rare change	Fixed and no change in the future
Price and payment conditions	Fixed in the annual supply agreement but subject to change 3-4 times/year	Fixed and no change in the future	Fixed and no change in the future
Quantity and delivery conditions	Fixed by week or according to various delivery conditions (e.g. by a day to a few hour time windows) and subject to change	Fixed but subject to change	Fixed but subject to rare change in the strict delivery conditions

Table 65: Description of the demand attributes in French case 11. (continued)

Planning process	Schedule harvesting 2	Schedule secondary transportation 1
Actor	Harvesting contractor	Harvesting contractor
Planning horizon	Continuous harvesting scheduling	Next day
Product specifications	Specified for all demands and subject to change for demand in Value commitment 1 and 2.	
Price and payment conditions	Specified for all demands and subject to change for demand from Value commitment 1	
Quantity and delivery conditions	Specified and subject to change for all demands	

Table 66 and Table 67 list the information flow, in input and output, for the planning and execution processes respectively in French case 11.

Table 66: Information flow in the planning processes in French case 11.

Planning process	Input		
	From	**Tool**	**Information**
Value commitment 1	Harvesting contractor	n.a.	- demand from the annual supply agreements and previously accepted spot demand - volume in inventory (roadside and inventory yard) ready to be delivered - according to harvesting and transportation capacities and blocks currently/available in/for harvesting, volume that could be delivered during the PH
	Mill	Email, intranet system, fax, telephone	- monthly demand by product, delivery conditions and pre-negotiated prices
Value commitment 2	Harvesting contractor	n.a.	- according to harvesting and transportation capacities and blocks currently being harvested, the volume that could be delivered during the PH and that will not be used to satisfy previous supply agreements - volume in inventory (roadside and inventory yard) ready to be delivered and that will not be used to satisfy previous supply agreements
Value commitment 3	A few mills	Email, intranet system, fax or telephone	- confirmation of the next day's quotas
	Blocks currently being harvested: harvesting supervisors and primary transport operators. Blocks where harvesting is finished and at inventory yard: trucker with the last pick-up at the site	Cellular, text message...	- volume of inventory (roadside and inventory yard) ready to be delivered and that will not be used to satisfy previous supply agreements
Buy block 1	Harvesting contractor	n.a.	- demand from supply agreements - potential demand from spot demand (forecast)
	Timberland owner	Telephone, meeting, on-site advertising...	- block offered for sale (from small private timberland owners to silviculture societies)
	Public organisation (i.e. Office National des Forêts)	Semiannual auction document	- blocks offered for sale

Planning process	Input		
	From	Tool	Information
	Consulting forester	Mail, fax, email...	- block offered for sale
Schedule harvesting 1	Harvesting contractor	n.a.	- dendrometric and terrain data of the block (obtained during the purchase of the block) - available type of harvesting equipment - harvesting and primary transport costs by type of harvesting equipment
Schedule harvesting 2	Harvesting contractor	n.a.	- demand from the annual supply agreements (monthly quantity divided into weekly quantity), accepted spot demand and forecasts of spot demand with delivery conditions - available harvesting teams (equipment and crew) - available transportation capacities - blocks currently being harvested / available for harvesting - estimation of short-term volume production by harvesting team for each block - harvesting and primary transport layout for each block - type of preferred harvesting equipment to assign to each block
	Blocks currently being harvested: harvesting supervisors and primary transport operators. Blocks where harvesting is finished and at inventory yard: trucker with the last pick-up at the site	ERP, cellular, text message...	- volume in inventory (roadside and inventory yard) ready to be delivered
Schedule secondary transportation 1	Harvesting contractor	n.a.	- available trucks, loaders and operators - volume in inventory (roadside and inventory yard) ready to be delivered - short-term preliminary allocation of the volume (in inventory) to the demand and delivery conditions
Schedule secondary transportation 1.1	Harvesting contractor	n.a.	- volume in inventory (roadside and inventory yard) ready to be delivered - short-term preliminary allocation of the volume (in inventory) to the demand and delivery conditions
	Harvesting contractors (Transportation crew members)	Cellular, text message...	- Report on deviations in the execution of the work schedule
	Mill	Telephone, email, intranet	- change in delivery conditions

Planning process	Input		
	From	Tool	Information
		system ...	

Table 66: Information flow in the planning processes in French case 11. (continued)

Planning process	Output		
	To	Tool	Information
Value commitment 1	Harvesting contractor	Centralised paper agenda	- monthly quantity by product, delivery conditions and prices
Value commitment 2	Harvesting contractor	Centralised paper agenda	- next week's quantity by product, delivery conditions and prices
Value commitment 3	Harvesting contractor	Centralised paper agenda	- tomorrow's quantity by product, delivery conditions and prices
Buy block 1	Harvesting contractor	ERP	- block(s) purchased - current purchase offers
Schedule harvesting 1	Harvesting contractor	n.a.	- harvesting and primary transport layout - type of preferred harvesting equipment to assign - estimated production volume by product
Schedule harvesting 2	Harvesting contractors (Harvesting crew members)	Paper document, communication in person, cellular...	- harvesting and primary transport layout of the block - list of products allowed for production in the block and the sorting rules
	Harvesting contractors (Harvesting crew members)	Paper document, communication in person, cellular...	- work plan for each crew member and sub-contractor
	Harvesting contractor	n.a.	- short-term preliminary allocation of the volume (in inventory) to the demand and delivery conditions - if required to satisfy a demand, selection of block(s) to prioritise specific products in the primary transport, selection of inventory for one way production substitution or product sorting during truck loading
Schedule secondary transportation 1	Harvesting contractors (Transportation crew members)	ERP, paper document, communication in person, cellular...	- Daily work plan for each crew member (including printed delivery tickets for some mills)
Schedule secondary transportation 1.1	Harvesting contractors (Transportation crew	Cellular, text message...	- Update of their work plan

Planning process	Output		
	To	**Tool**	**Information**
	members)		

Table 67: Information flow in the execution processes in French case 11.

Execution process	Input		
	From	**Tool**	**Information**
Pre-harvesting preparation	Harvesting contractor (harvesting and transportation managers)	Paper document, communication in person, cellular...	- harvesting and primary transport layout
Harvesting in the CTL method	Harvesting contractor (harvesting and transportation managers)	Paper document, communication in person, cellular...	- harvesting layout by block - list of products allowed for production in the block - sorting rules for the block
Primary transport in the CTL method	Harvesting contractor (harvesting and transportation managers)	Paper document, communication in person, cellular...	- primary transport layout by block
Measuring at roadside			
Secondary transport	Harvesting contractor (harvesting and transportation managers)	ERP, paper document, communication in person, cellular...	- daily work plan by trucker (including the printed delivery tickets for some mills)
Reception			

Table 67: Information flow in the execution processes in French case 11. (continued)

Execution process	Output		
	To	**Tool**	**Information (tool)**
Pre-harvesting preparation			
Harvesting in the CTL method	Harvesting contractor (harvesting and transportation managers)		- production KPI
Primary transport in the CTL method	Harvesting contractor (harvesting and transportation managers)	Cellular, text message...	- volume of inventory at roadside (for block currently being harvested) - production KPI

Execution process	**Output**		
	To	**Tool**	**Information (tool)**
Measuring at roadside	Harvesting contractor (harvesting and transportation managers)	ERP, cellular, text message...	- volume in inventory at roadside (for block currently being harvested)
Secondary transport	Harvesting contractor (harvesting and transportation managers)	- Paper document - Cellular, text message...	- scale receipt for each delivery - volume in inventory at roadside (for block where harvesting is finished and in the inventory yard)
Reception	Harvesting contractor (driver)	- printer on-site	- issued for each driver, a scale receipt at each delivery
	Harvesting contractor (harvesting and transportation managers)	Mail, email, fax, intranet system	- for some customers, list of the deliveries (with product and payload) during the month and, with the intranet system, follow-up of the deliveries during the month

Table 68 lists the average inventory time of the material between consecutive pairs of processes in French case 11.

Table 68: Average inventory time of the material between consecutive pairs of processes in French case 11.

Consecutive pairs of processes		Material	Average inventory time	
Buy block	Harvesting in the CTL method	Standing timber	From few months to less than one year	
Harvesting in the CTL method	Primary transport in the CTL method	Sorted piles of logs adjacent to the primary transport trail	2-3 days	Average time of 5-7 days from harvesting to reception
Primary transport in the CTL method	Measuring at roadside (for the volume where measuring is required for the payment method)	Sorted and measured piles of logs at roadside	Within 3-4 days (scaling by the harvesting supervisor during his control visits of the block)	
Primary transport in the CTL method	Secondary transport	Sorted and, for some volume, measured piles of logs at roadside	3-4 days	

From the process of Buy block to the process of Reception, Table 69 details, by process(es) and payment methods, the main financial flows for the harvesting contractor in French case 11 and for the other case studies in France. For the sake of brevity, the payments of internal human resources are not represented, but they are (usually) paid on a monthly basis.

Table 69: Main monetary flows in French case 11.

Process(es)	Payment method(s)	Time	Monetary flow
Buy block	lump sum	Purchasing time	First payment to the timberland owner
		3 months later	Second payment to the timberland owner
		6 months later	Third and final payment to the timberland owner
		The payments can be made in installments and at different times or paid entirely at the time of purchase usually with a price discount for the buyer	
	unit sale price by assortment	60 days after all harvesting volume has been scaled at roadside or at the mill (according to the agreed upon scaling method)	Single payment to the timberland owner
		For blocks being harvested over several months, within 30 days of the end of the month	Monthly payments to the timberland owner for the total volume scaled at roadside or the mill (according to the agreed upon scaling method) during the month
Buy assortment to Reception	unit sale price by assortment or unit sale price by assortment and origin zone (i.e. transportation zone)	Within 30 days of the end of the month	Payment to the supplier for the volume delivered during the month
Harvesting in the CTL method to Measuring at roadside or Reception	flat unit rate (measured at roadside or the mill)	Within 30 days of the end of the month	Payment of the harvesting contractor for all of the volume scaled at roadside during the month (no payment for volume harvested but not at roadside)
Secondary transport to Reception	flat unit rate or flat truckload rate	Within 30 days of the end of the month	Payment of the transportation contractor for all of the volume delivered during the month
Reception	unit sale price by assortment or unit sale price by assortment and origin zone (i.e. transportation zone)	Within 30 days of the end of the month	Payment by the external customer for all of the volume delivered during the month
		Within 60 days of the end of the month	Payment by the internal customer for all of the volume delivered during the month

Table 70 details the enablers and practices by macro-process in French case 11.

Table 70: Enablers and practices of French case 11.

Category of enabler	Source
1) Rules and guidelines	- Blocks are purchased to build a portfolio of blocks to secure the satisfaction of the supply agreements and have additional supply for profitable spot demand - Purchase increased when block prices are ‘good’ (i.e. expect to maximise future profit). - Purchase is maintained with timberland owners having a regular business history with the company.
2) Performance measurement	- ERP used as a database to record purchase prices and thus support the performance assessment by block before or after volume delivery
3) Information management	
4) Inventory management	- combination of pre-purchasing cruise and experience to increase the forecast precision of volume by product in a block - silviculture flexibility in maritime pine plantation: time window of 4-5 years for thinning and 10 to 15 years for clear-cutting (45-60 years). - ERP to record all purchase offers and purchased blocks
5) Asset management	- combination of pre-purchasing cruise and experience to increase the forecast precision of productivity and expected costs for the harvesting and primary transport
6) Network management	- receive purchase proposition of standing timber directly from timberland owners as the result of long term business relationships with private timberland owners and regional-level knowledge of the harvesting contractor - accredited purchaser for the semiannual auction sales of blocks by the ONF - in business contact with consulting foresters and silviculture societies to receive purchase propositions of blocks
7) Transportation management	- economically preferable to increase the primary transportation distance (and provide compensation if a primary transport subcontractor is used) rather than perform short road construction. - if road construction is needed, road design layout to access the block can be specified at the purchase

Table 70: Enablers and practices of French case 11. (continued)

Category of enabler	**Make**
1) Rules and guidelines	- volume-based productivity bonus provided to the salary of the operators - general contractual agreement with regular primary transportation subcontractors with pre-negotiated conditions and legal eligibility for a future harvesting contract for the block - with primary transportation subcontractors, base rate pre-negotiated and adjusted by block according to productivity factors - water, soil and air pollution prevention measures - notice to local authority at the start and end of harvesting activities
2) Performance measurement	- tacit knowledge of productivity and cost models from harvesting to secondary transport - ERP used as a database to record all costs and productivity KPI and thus supports a performance assessment by block before or after volume delivery
3) Information management	- ability to update the list of products allowed for production in each block and the sorting rules at virtually any time with a telephone call
4) Inventory management	- monitoring the risk of blue stain deterioration - ERP to record scaling volume at roadside and to monitor inventories along the wood supply chain
5) Asset management	- monthly performance monitoring of the harvesters - full-time internal staff for equipment maintenance - harvesting crews have fairly wide geographic flexibility - punctual overtime is possible during the evening and/or weekend - operator flexibility with several able to operate more than one type of harvesting equipment/commercial treatment and some able to drive a truck (tacit knowledge) - three types of specialised harvesters according to block characteristics and commercial treatment (e.g. clear-cutting or thinning, small or large block, small or large average tree DHP)
6) Network management	- harvesting contractor uses sub-contracted primary transport operator(s) and equipment to complete internal capacity - to improve the planning and execution processes involved in this macro-process, the harvesting contractor collaborates with a research centre on research projects - investment support program by the government to foster harvesting mechanisation
7) Transportation management	

Table 70: Enablers and practices of French case 11. (continued)

Category of enabler	Deliver (value commitment)
1) Rules and guidelines	- annual supply agreement down to daily sale
2) Performance measurement	- a supplier with a considerable scale of procurement activities acquires a competitive advantage to become a privileged supplier
3) Information management	- with some customers, an intranet system is used to obtain confirmed demand and delivery tickets - centralised paper agenda of the demand - excel spreadsheet used to record the demand history of some customers
4) Inventory management	- offer a scaling service for customers without a scale
5) Asset management	
6) Network management	
7) Transportation management	- supply agreement includes details of the delivery logistics conditions - for some customers, the intranet system allows them to follow the monthly demand fulfilment

Table 70: Enablers and practices of French case 11. (continued)

Category of enabler	**Deliver (secondary transport)**
1) Rules and guidelines	- productivity-based bonus provided to the salaries of drivers and loader operators - notice to the local authority at the start and end of transportation activities
2) Performance measurement	- tacit knowledge of productivity and cost models from harvesting to secondary transport - ERP used as a database to record all costs and productivity KPI and thus support the performance assessment by block before or after volume delivery
3) Information management	
4) Inventory management	- control of product specifications by the driver/loader operator during truck loading to avoid truckload delivery rejection or penalty - use of one way product substitution (i.e. the supplier substitutes a higher value product for a lower value product that is not in the inventory, see e.g. Routroy et al., 2011) or product sorting during truck loading to satisfy an urgent demand or to find a new market for a volume already produced but reduced/cancelled by the original customer. - ERP to record planned deliveries and validate them with executed deliveries in order to monitor inventories along the wood supply chain
5) Asset management	- operator flexibility with several able to operate more than one type of harvesting equipment and some of them are able to drive a truck - when it is economically more efficient (e.g. block with small volume), avoid loader utilisation by e.g. using a forwarder for loading or schedule the pick-up of a self-loading truck with a non-self loading truck on a site without loading equipment
6) Network management	- to improve the planning and execution processes involved in this macro-process, the harvesting contractors collaborate with a research centre on research projects.
7) Transportation management	- for inventory of products requiring a short delivery lead time by customers (e.g. next day morning), use of place postponement (see van Hoek, 2001) by moving distant roadside stock to an inventory yard close to potential demand points - some volume in the supply agreement reserve delivery time windows to reduce truck queuing time. - flexibility for a mill to change (mainly delay) on short notice the delivery time of a truck and even change the destination of the truck when it is already on the road.

Table 71: Agility assessment by dimension and macro-process in French case 11.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	2	1	3	3
	Blocks are purchased according to a general picture of supply agreements and demand forecasts (as well as other considerations) but, at purchasing time, no explicit link is made between an estimated volume in the block and a specific confirmed demand. This link will happen later, at earliest during harvesting planning. Thus, the portfolio of purchased blocks (or inventory of product) provides the capacity to fulfil demand and this could limit/delay the sourcing of short term opportunities.	Volume to be harvested is not explicitly linked to a demand but the list of products allowed for production in a block is set according to a preliminary allocation: confirmed demand to a rough estimation of volume to be harvested. All harvested volumes in the inventory are then allocated to the confirmed demand.	Pre-negotiated price of supply agreement and demand will be committed only if a positive margin is estimated (except for by-products that could be sold at a loss with a globally positive margin for the block). Medium-scale of the supplier fosters greater awareness and receptivity by the organisation of any requirements of the mill which, in turn, makes identification of new market opportunities easier. The medium-scale of the supplier and the inventories usually allow any demand to be fulfilled.	Capacity of the secondary transport to fulfil the demand (committed or new opportunities) while meeting logistics delivery conditions is based on inventory at roadside and logistics techniques, such as one way product substitution and product resorting during truck loading.
Information	1	1	2	2

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
driver	Mix of tacit knowledge and ‘public-to-limited’ information for the blocks available for purchase with variable frequency according to the business relationship with the timberland owner or the seller-intermediary. Accuracy of the inventory for the purchase offers is variable, thus own cruise required, but even in plantations, historic perturbation(s) and tree geometry reduce accuracy. Overall accessibility of available blocks for purchase tends to be limited with competition among the buyers, while information on the block portfolio is internally accessible.	Information exchanges are frequent and fairly accurate with harvesting operators but the monitoring of the production and the inventories before their scaling at roadside is imprecise and their diffusion is limited to the company level. The inventories' scaling at roadside is precise and diffused at the company level.	The awareness of potential demand is more or less limited to suppliers already in a business relationship. Committed demand is documented and updated reactively (i.e. as the mills ask for a change or precise parameters). Information on committed demand information is diffused to relevant actors but restricted to a short term horizon.	Precision and company-level diffusion about inventory levels along the wood supply chain decrease as time nears to harvesting. Information exchanges are frequent and fairly accurate with drivers. The frequency and accuracy of the information on demand fulfilment varies by customer.
Process integration	1	1	2	1
	Blocks are purchased with a general picture of the demand (committed and forecast) and a few operational considerations (e.g. localisation), while blocks selected from the portfolio meet short term operational considerations (e.g. type of equipment of the available harvesting team) and provide a less general picture of the demand (confirmed and forecast). Purchasing is connected to sellers using different means that more or less facilitate rapid decision-making.	Volume to be harvested is not explicitly linked to the value commitment but harvesting is adjusted (virtually at any time by a telephone call) to produce inventories that will fulfil demand after their scaling at roadside. A delay in decision-making can occur since inventories are monitored at roadside.	For weekly to shorter time demand, volume is committed according to an approximate feasibility evaluation based on an approximate inventory level and average harvesting/transportation capacities. When a more robust evaluation is required, delay to gather more precise information is required and thus, this delays decision-making.	Transportation is managed in the short term to fulfil current demand using mainly inventory at roadside. There is little anticipation of upcoming inventory from harvesting. Demand fulfilment is well monitored with a good record of delivery volume, but precision on inventory level along the wood supply chain decreases as harvesting time nears and thus, a delay in decision-making can occur.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
	2	3	2	2
Network integration	Many long-term business relationships with timberland owners, local-level knowledge of the business by the timberland owners and business relations with intermediaries (e.g. consulting foresters) foster good business reputation in the block purchase that, in turn, reinforces a trust-based relationship. The traditional model to sell/buy a block is conservative and hesitant to change and adopt new practices.	The use of a general contractual agreement for primary transportation subcontracts by block reinforces a trust-based relationship and can foster change and the adoption of new practices.	Compliance with supply agreements and flexibility for changes in confirmed demand on a short term notice foster trust-based relationships with mills. Bilateral negotiations on price setting or adjustment tends to foster the adoption of new practices to maintain/improve the competitiveness of the business relationship.	Compliance with agreed logistics delivery conditions fosters trust-based relationships with mills, in addition to the flexibility to change delivery time on short notice by a mill and can foster the adoption of new practices.

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 16: Detailed information on Canadian case 15

Table 72: Environmental analysis of Canadian case 15.

Environment element	Description	Uncertainty
1. Industry sector (internal)	Fragmented Several actors	☐Unstable ☒Complex
2. Raw materials	Natural forest 7 different species (high wood variability). Boreal forest: 1.25 m3/year by ha	☒Unstable ☒Complex
3. Human resources	Full year contractors Intermediary harvest and transport contractors subcontracting with smaller ones	☐Unstable ☒Complex
4. Financial resources	Period of low investments Some investments in diversification strategy Quite frequent mergers & acquisitions increase complexity	☐Unstable ☐Complex
5. Market sector	Local and regional (North America)	☒Unstable ☐Complex
6. Technology	CTL and FT methods New integrated weight measurement system with finance reporting	☐Unstable ☐Complex
7. Government	Higher regulation level New regulation will be in place in 2013, uncertainty regarding forest management Different constraints: environmental, social, first nation, leisure, hunting, etc.	☒Unstable ☒Complex
8. International sector	Some competition from NA and Asia (not applicable for case studied)	☐Unstable ☐Complex
9. Climate	Full year harvesting 6-8 weeks transport stoppage during spring "thaw" (March-May) Fire risks	☒Unstable ☐Complex

For each planning process in Canadian case 15, Table 73 lists lists the actor responsible for the planning process, the planning horizon (i.e. the time horizon during which decisions are made), the time period (i.e. the time bracket that splits the time horizon during which decisions are made) and the update frequency of the planning process (i.e. the delay for decisions made that are potentially modified by new planning), the decision(s) planned by the process, the planning objective and the tool used to support the actor, if any.

Table 73: Planning processes in Canadian case 15.

Planning process	Actor	Time		
		Planning horizon	**Time period**	**Update frequency**
Value commitment 1	Wood procurement division (Harvesting manager)	Remaining year	Month	Month (or when required by a customer)
Value commitment 2	Wood procurement division (Harvesting manager)	Weeks to months	Week to month	n.a.
Value commitment 3	Wood procurement division (Harvesting manager)	Weeks	Week	n.a.
Schedule harvesting 1 & Select block 1 & Buy assortment 1	Wood procurement division (Harvesting manager)	Remaining year	Month	Month (or when required by a Value commitment process)
Schedule harvesting 2	Harvesting contractors	Month(s)	Week (to month)	unavailable
Schedule secondary transportation 1	Wood procurement division (Harvesting manager)	Month	Week	Week
Schedule secondary transportation 2	Harvesting contractors	Week to day	unavailable	unavailable

Table 73: Planning processes in Canadian case 15. (continued)

Planning process	Decision	Objective	Planning tool
Value commitment 1	The monthly quantity by product fixed in the annual supply agreements, delivery conditions and pre-negotiated price are confirmed at each end of the month 'n' and for each customer with an annual supply agreement at month 'n+2'.	Confirm profitable demand for the volume to be harvested according to the remaining annual harvest plan	Human skill based on annual supply agreement
Value commitment 2	Commit new demand to replace cancelled demand in Value commitment 1 or to capture a business opportunity (e.g. new demand from a customer).	Replace demand to maintain the remaining annual harvest plan or capture new profitable demand to improve the profitability of the remaining annual harvest plan	Human skill
Value commitment 3	Commit new demand for harvested volume not sold in previous Value commitment 1 and 2.	Find a profitable (or less of a loss) demand for the volume	Human skill
Schedule harvesting 1 & Select block 1 & Buy assortment 1	Revise the remaining annual harvesting plan: - harvesting sequence of the selected blocks and/or source new blocks; - purchase assortment (less than 3%); - assign harvesting contractors (including decisions on the type of equipment and work shift template) to harvest areas (i.e. set of blocks); - assortments to produce in each block and volume allocation to customer and then update list of products allowed for production in each block and sorting instructions by block; - harvesting and primary transport layout by block	Satisfy the committed volumes in Value commitment 1 and 2 at the lowest cost in order to reach a profitable annual harvest plan	Human skill supported by tools (e.g. GIS, home-made excel spreadsheet, scenario simulation modules, such as FPInterface)
Schedule harvesting 2	- Harvesting equipment and crew scheduling (including machine movement planning) - Transportation and accommodation plan for harvesting crew members - If required, overtime by harvesting team - Subcontract additional harvesting contractors (optional)	Minimise internal costs and maximise productivity	Human skill

Planning process	Decision	Objective	Planning tool
Schedule secondary transportation 1	- Preliminary planning of monthly delivery quotas to fulfil the demand - Assign harvesting contractors weekly delivery quotas from specific harvest areas to specific customers and specify delivery conditions	Deliver committed volumes in Value commitment 1-3 at the lowest costs	Human skill supported by internal tools (e.g. GIS, home-made excel spreadsheet)
Schedule secondary transportation 2	- Routing and scheduling of their truck fleet - Transportation equipment and crew scheduling - Subcontract additional secondary transportation contractors (optional)	Primarily satisfy weekly delivery quotas and then minimise empty travelling distance.	Unavailable

For each execution process in Canadian case 15, Table 74 lists the actor and the actions performed.

Table 74: Execution processes in Canadian case 15.

Execution process	Actor	Action
Pre-harvesting preparation	Harvesting contractor	- move equipment to the block - set-up the support installations
Harvesting in the CTL method	Harvesting contractor	- update the values list of the harvester - felling, delimbing, bucking and sorting in piles adjacent to the primary transport trail
Primary transport in the CTL method	Harvesting contractor	- primary transport of the logs from stumpage area to roadside landing - sorting and piling at roadside landing
Harvesting in the FT method	Harvesting contractors	- felling the trees at stumpage area
Primary transport in the FT method	Harvesting contractors	- primary transport of the trees from stumpage area to roadside landing
Merchandising at roadside landing	Harvesting contractors	- delimbing, bucking, sorting and piling at roadside landing
Secondary transport	Harvesting contractors	- loading the trucks at roadside - secondary transport from roadside to mill
Reception	Mills	- unloading the truck at the mill - scaling the truck

In Table 75, the main decision(s) made on the most relevant planning processes in Canadian case 15 are classified according to the four attributes characterising a harvest/transportation plan. Furthermore, generic planning decision(s) addressed in each planning process are presented in the last row.

Table 75: Description of the harvest/transportation plan attributes in Canadian case 15.

Planning process	**Schedule harvesting 1 & Select block 1 & Buy assortment 1**	**Schedule harvesting 2**	**Schedule secondary transportation 1**	**Schedule secondary transportation 2**
Actor	Wood procurement division (Harvesting manager)	Harvesting contractors	Wood procurement division (Harvesting manager)	Harvesting contractors
Planning horizon	Remaining year	Month(s)	Month	Week to day
Harvesting or transportation resource	- Assignment of harvesting contractors (include type of equipment and work shift template) to harvest areas	- Harvesting crew work schedule - If required, overtime by harvesting team - Subcontract additional harvesting contractors (optional)		- Loaders, trucks and crew schedule - Subcontract additional secondary transportation contractors (optional)
Input stock to harvest or transport	- Harvest area (i.e. set of blocks) to harvest and harvesting sequence of the blocks in each area		Weekly delivery quotas are from specific harvest areas to specific customers	Specific volume to load/transport by loader/truck
Harvesting or transportation instruction	- Harvesting and primary transport layout of the block - List of products allowed for production in each block and the sorting rules	- Transportation and accommodation plan for harvesting crew members	Assign harvesting contractors weekly delivery quotas and specify delivery conditions	Work schedule by loader (sequence of volume to load) and truck (route)
Allocation of the output stock	- Allocation of the volume by product to the demand		No allocation decision in secondary transportation	

Planning process	**Schedule harvesting 1 & Select block 1 & Buy assortment 1**	**Schedule harvesting 2**	**Schedule secondary transportation 1**	**Schedule secondary transportation 2**
Generic planning decision	- Harvest units sourcing - Harvest units scheduling - Assortments to produce by harvest unit and allocation to demand - Harvest equipment selection by harvest unit - Harvest unit assignment to contractors/teams - Harvest unit layout - Bucking/merchandising instructions and sorting rules by harvest unit	Harvest crew scheduling	- Balance transportation with harvesting, inventory and reception - Transportation quotas assignment to contractors	- Transportation crew scheduling - Transportation equipment routing and scheduling

Table 76 describes, by attributes of a demand, whether the attribute of the demand in Canadian case 15 is fixed (i.e. planned) by the process or specified as an input to the process and also if the attribute of the demand is subject to future change.

Table 76: Description of the demand attributes in Canadian case 15.

Planning process	Value commitment 1	Value commitment 2	Value commitment 3
Actor	Wood procurement division (Harvesting manager)	Wood procurement division (Harvesting manager)	Wood procurement division (Harvesting manager)
Planning horizon	Remaining year	Weeks to months	Weeks
Product specifications	Fixed based on an annual supply agreement but subject to rare changes within the month	Fixed but subject to rare changes	Specified and no change is possible
Price and payment conditions	Fixed based on an annual supply agreement but subject to change during the month	Fixed but subject to change	Fixed and usually no change in the future
Quantity and delivery conditions	Fixed by month based on an annual supply agreement but subject to change	Fixed according to various delivery conditions and subject to change	Fixed according to various delivery conditions and subject to change

Table 76: Description of the demand attributes in Canadian case 15. (continued)

Planning process	Schedule harvesting 1 & Select block 1 & Buy assortment 1	Schedule secondary transportation 2
Actor	Wood procurement division (Harvesting manager)	Harvesting contractors
Planning horizon	Remaining year	Week to day
Product specifications	Specified for all demands and subject to change for demand in Value commitments 1 and 2	Specified
Price and payment conditions	Specified for all demands and subject to change	n.a.
Quantity and delivery conditions	Specified for all demands and subject to change	Specified by week with various delivery conditions

Table 77 lists the average inventory time of the material between consecutive pairs of processes in Canadian case 15.

Table 77: Average inventory time of the material between consecutive pairs of processes in Canadian case 15.

Consecutive pairs of processes		**Material**	**Average inventory time**	
Harvesting in the CTL method	Primary transport in the CTL method	Sorted piles of logs adjacent to the primary transport trail	2-3 days (less during high snowfall)	Average time of 3-4 weeks from harvesting to reception
Harvesting in the FT method	Primary transport in the FT method	Bunch of felled trees adjacent to the primary transport trail	2-3 days (less during high snowfall)	
Primary transport in the FT method	Merchandising at roadside landing	Piles of felled trees at the landing site	Few hours	
Primary transport in the CTL method or Merchandising at roadside landing	Reception	Sorted piles of logs or stems at roadside	2-3 weeks (1-1.5 months between the start of harvesting and the start of transporting)	

Table 78 details, by process(es) and payment methods, the main financial flows for the wood procurement division in Canadian case 15. For the sake of brevity, payments of internal human resources are not represented.

Table 78: Main monetary flows in Canadian case 15.

Process(es)	Payment method(s)	Time	Monetary flow
Harvesting in the FT/CTL method to Reception	Cut-and-haul rate	Two weeks after a two week period.	Payment of the harvesting contractor for all his harvested volume delivered to the mill during the two week period.
		3 months after the end of the year.	Payment (or, rarely, reimbursement) of the harvesting contractor of the volume adjustment (according to a revised weight/volume ratio) for the total harvested volume delivered to the mill during the year. This adjustment can represent up to 10% of the annual payment.
Reception	Unit sale price by assortment and origin zone (i.e. cutting sectors)	Within two weeks after a 15 day period.	Payment by an external customer for all the volume delivered during a 15 day period.
		Within two weeks after a 15 day period.	Payment by an internal customer for all the volume delivered during a 15 day period.
Reception	Flat unit sale price by origin zone (i.e. pricing zone)	Within 30 days after the period of a week (delivery volume) or at each three month period for volume at roadside.	Payment of the harvested volume to the government for all of the volume delivered during the week or brought to roadside during the last three month period.

Table 79 details the enablers and practices by macro-process in Canadian case 15.

Table 79: Enablers and practices of Canadian case 15.

Category of enabler	Source
1) Rules and guidelines	- only blocks planned in the annual harvest plan can be selected for harvesting; for a derogation (with an average 15 day delay), the government must be asked to select other blocks. - maintain a set of blocks for which, when required, derogation can be requested from the government. These blocks usually do not require (or require little) road construction. - government provides the forest management rules that frame the selection of a block in the annual harvest plan; these rules must be complied with in order to harvest the block - different ISO certifications for the wood procurement division to support this macro-process - blocks selected for harvesting are subject to agreement with other wood buyers having a contract with the government, as well as other stakeholders of public timberland (e.g. first nation, outfitter)
2) Performance measurement	
3) Information management	- geographic information system to support the management of the timberland under contract with the government
4) Inventory management	- government responsible for providing GIS inventory database of its timberland; companies must do pre-harvesting inventory to increase the forecast precision of volume by product in a block - silviculture flexibility in black spruce blocks: time window of 15 years for thinning and virtually no limit for clear-cutting.
5) Asset management	- pre-harvesting inventory and historic production data from similar blocks to increase the forecast precision of productivity and cost models for the harvesting and primary transport of the block - some timberland under certification - investment analysis for building and localisation of forest camps (accommodations for internal and contractors' human resources)
6) Network management	- Business relationships and some supply agreements (e.g. pricing, expected volume) with syndicates of private timberland owners to purchase additional volume - Business relationships and some supply agreements (e.g. pricing, expected volume) with large private timberland owners to purchase additional volume - significant effort in maintaining/improving relationships with other stakeholders of public timberland (e.g. first nation, outfitter) to make required collaboration easier in the sourcing planning and to maintain social acceptance
7) Transportation management	

Table 79: Enablers and practices of Canadian case 15. (continued)

Category of enabler	Make
1) Rules and guidelines	- Harvesting contractors with a one year contract with stable production volume for each year. - Annual harvesting planning with monthly update - Government enforces strict rules on harvesting and primary transport on its timberland - for harvesting and primary transport, cut-and-haul pre-negotiated rates are adjusted by block according to productivity factors and fuel index variation - standard documentation template used to send information to harvesting contractors - harvesting contractors know in advance their harvesting areas for the next months to give them the time to effectively plan their activities - different ISO certifications for the wood procurement division to support this macro-process - Compensation for equipment movement between two harvesting areas - Productivity and cost models for the harvesting and primary transport - specialised and preferable harvesting teams to work with according to the commercial treatment (i.e. specialised in thinning or in clear-cutting) - Harvesting permits by harvest area - contractors must respect health and safety measures (from a third party organisation) in the field, the transportation of operators and the accommodations location. Compliance with these measures is enforced by an independent audit
2) Performance measurement	
3) Information management	- internal inventory system to follow the inventory, by assortment and customer, at roadside and delivery on a weekly basis. - government manages a geographic information system to gather silviculture history (including harvesting) on its timberland - the bucking/merchandising instructions and sorting rules of each harvesting team can be updated daily, but not used in practice
4) Inventory management	- Wood procurement division controls inventory at roadside every two weeks while harvesting contractors are responsible for providing weekly inventory - Seasonality (2x more volume in autumn than summer) - Starting in autumn (e.g. two times more inventory at roadside in autumn than in the middle of summer) up to before spring, inventories are built up at the mill (e.g. three times more inventory than during the summer) to cover procurement to industry
5) Asset management	- Equipment maintenance is the contractor's responsibility (e.g. on average, two hours daily per machine) - Outsourcing the maintenance and daily operation of forest camps - Human resource programs (e.g. formation, security) and considerations in the planning (e.g. work shift template designed to allow holidays at their homes) to reduce absenteeism/accident and increase/secure work force competencies - overtime is possible - use different types of equipment to fit the commercial treatment and block characteristics
6) Network management	- Keep a catalogue of potential contractors in order to stimulate competition and service quality based on annual contract tendering - Foster medium to large scale turn-key harvesting contractors to sign annual contracts in order to maintain rates and guarantee high levels of services

Category of enabler	**Make**
	- Bonus system for small businesses and penalties for large (based on wood cut) - to improve current planning methods and harvesting practices, the wood procurement division uses external resources, such as consultants, but also research centres and academic institutions (universities) - significant effort is made in maintaining/improving relationships with other stakeholders of the public timberland (e.g. first nation, outfitter) to make the required collaboration easier in harvesting planning and to maintain social acceptance
7) Transportation management	

Table 79: Enablers and practices of Canadian case 15. (continued)

Category of enabler	Deliver (value commitment)
1) Rules and guidelines	- Annual supply agreements with monthly updates are committed based on an annual harvesting plan that must provide a positive margin - government determines harvested timber price by geographical pricing zone - during each value commitment process, the wood procurement division and its wood buyers negotiate together how the wood procurement cost will be shared - annual supply agreement includes a cost adjustment according to a fuel index variation and penalties for the buyers and the wood procurement division in case of non-compliance with committed volume - monitoring of the credit limit of each customer to reduce the risk of loss
2) Performance measurement	- internal financial monitoring system for all procurement activities with internal and external customers for a monthly follow-up of profitability by the wood procurement division
3) Information management	
4) Inventory management	
5) Asset management	
6) Network management	
7) Transportation management	- agreement includes details of the delivery logistics conditions

Table 79: Enablers and practices of Canadian case 15. (continued)

Category of enabler	**Deliver (secondary transport)**
1) Rules and guidelines	- Harvesting contractor (does transportation) with a one year contract - Productivity and cost models for the transportation and loading - For secondary transport, cut-and-haul pre-negotiated rates are adjusted by harvesting areas according to productivity factors and the fuel index variation - transportation is managed by weekly delivery quotas assigned to harvesting contractors - contractors must comply with health and safety measures (from a third party organisation) in the field and the accommodations location Compliance with the measures is enforced by an independent audit
2) Performance measurement	
3) Information management	- government manages a geographic information system to gather data on road network development in its timberland - internal inventory system to follow the inventory, by assortment and customer, at roadside and delivery on a weekly basis - Some infrastructure (mainly roads and bridges) is subject to a utilisation fee and a central database monitors fee payments and charges
4) Inventory management	- Scaling at the mill's yard - Seasonality (3x more inventory in winter than summer): preparation for thawing period - Most mills use the same scaling system and thus, the exchange of delivery volume is facilitated
5) Asset management	- Monitoring system for the maintenance of the forest road network - Equipment maintenance is the contractor's responsibility (e.g. on average, two hours daily per machine)
6) Network management	- Maintain a catalogue of potential contractors in order to stimulate competition and service quality based on annual contract tendering - Foster medium to large scale turn-key harvesting contractors to sign annual contracts in order to maintain rates and guarantee high levels of services - harvesting contractors have access to punctual sub-contracting trucker(s) when internal transportation capacity is insufficient (note: with the cut-and-haul payment method, harvesting contractors are also responsible for secondary transport)
7) Transportation management	- Build winter roads to lower road construction investment - Public programme to support road construction/repair cost - some trucks equipped with onboard scale on axles to maximise payload and comply with weight limit - some trucks equipped with a tire pressure control system that allows the driver to adjust tire pressure while the truck is in motion to e.g. get more traction or extend access to roads closed during thawing or in heavy rains

Table 80: Agility assessment by dimension and macro-process in Canadian case 15.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	1	2	2	2
	Blocks sourced annually with limited flexibility for change during the year, whereas committed/forecasted demand can change. The sourcing is also subject to governmental norms, agreements between companies with supply rights and agreements with local stakeholders.	The bucking/merchandising instructions and the sorting rules are adjusted to fulfil the annual or newly committed demand. Most of the volume harvested is pre-sold.	Annual demand is committed according to supply rights and annual allowable cut provided by the government, whereas new demand is mostly based on new, profitable opportunities in supply.	The capacity of the secondary transport to fulfil the committed demand of the logistics delivery conditions is based on inventory at roadside. All adjustments from demand changes are made in the harvesting scheduling, limiting the capture of new demand opportunities, with the exception of the sale of make-to-stock volume at roadside. Transport planning only adjusted to the harvesting schedule (indirect answer to changes in demand).
Information driver	1	2	2	2
	Accuracy on available volume by block is highly variable and pre-harvesting inventories are mandatory. Internal centralised database for forest management of timberland with supply rights is partially accessible to the entire supply chain (to meet legal requirements).	Information about harvested volumes is updated on a weekly basis (and controlled twice a month) by each contractor and moderately accurate. Sharing of key information over the short to mid-term is variable among the contractors, while it is limited with customers.	Annual and newly committed demands are updated on, at least, a monthly basis but subject to change during the month. The diffusion of information on a change in demand is well supported from harvesting to secondary transport but limited with customers.	Information about delivery volumes is updated on a weekly basis by each contractor and accurate since it is based on measurement results at the mills. Contractors' information is validated with measurement results received from the mills. Sharing of key information over the short- to mid-term and during transportation execution is variable among contractors and subject to communication limits (e.g. coverage).
Process	2	2	3	2

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
integration	Sourcing is performed according to annual committed demand with aggregated operational considerations (e.g. localisation, weather conditions). However, imposed annual sourcing and delays for new sourcing do not facilitate rapid decision-marking.	Volumes to be harvested are largely linked to committed demand. Weekly monitoring of harvested inventories and considerations regarding demand fulfilment and secondary transport allows reasonably rapid decision-making to adjust harvesting.	In general, committed demand is the input to follow in harvesting and secondary transportation planning but changes (in demand or imposed by available sourcing) are common. Enablers to face such a context allow reasonably rapid decision-making.	Secondary transportation is conducted according to the committed demand and based on input from harvesting while harvest planning is performed with little consideration of later secondary transportation. Rapid decision-making in the execution of secondary transportation is subject to communication limits (e.g. coverage).
Network integration	2	3	2	2
	Sourcing is subject to several norms and involves many actors making complex changes and adoption of new practices, but even they involve delay. Support programs and initiatives exist and are used. In general, the high level of regulation in this sourcing context imposes trust-based relationships, but a degree of mistrusts remains.	Even relationships with contractors are directive; the overall objective is to improve their operational efficiency (this includes the adoption of new practices) to maintain a profitable margin and, with the effort to develop medium to large scale turn-key harvesting contractors, this contributes to trust-based relationships.	Demand fulfilment of internal and external customers is conditional to maintaining a profitable margin. This fosters the adoption of new practices to maintain the margin but too frequent modifications (for the supplier or buyer) do not reinforce trust-based relationships.	Even relationships with contractors are directive; the overall objective is to improve their operational efficiency (this includes the adoption of new practices) to maintain a profitable margin and, with the effort to develop medium to large scale turn-key harvesting contractors, this contributes to trust-based relationships. However, delivery schedules and truck queuing remain problematic with some customers and this does not contribute to trust-based relationships with them and increases resistance to the adoption of new practices.

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 17: Detailed information on Polish case 18

Table 81: Environmental analysis of Polish case 18.

Environment element	Description	Uncertainty
1. Industry sector (internal)	Depends on auctions for raw material, even though annual volumes are stable. Two auctions for the actors.	☐ Unstable ☒ Complex
2. Raw materials	The same auctions every year (stable). Only one supplier: 85% of timberland belongs to a public organisation. Natural forests plus "extensive" plantations of pine (reforestation).	☐ Unstable ☒ Complex
3. Human resources	13% unemployment	☐ Unstable ☐ Complex
4. Financial resources	Low investments due to unreliable wood supply allocation (maximum 1 year agreement with harvesting contractors)	☐ Unstable ☐ Complex
5. Market sector	Mostly national	☐ Unstable ☐ Complex
6. Technology	CTL + full stem method Frequent use of manual harvesting Internet based auctions IT applications used by the public organisation (GIS for forest management) Very different technological levels in the processes	☐ Unstable ☐ Complex
7. Government	"Strategic" level forest operations are regulated by the National State Forest Act (but there is no explicit strategy). The Act is open to different interpretations and there is low awareness of the Act by the actors.	☐ Unstable ☒ Complex
8. International sector	German competitors (biofuel) at the auctions	☐ Unstable ☐ Complex
9. Climate	Harvesting all year round	☐ Unstable ☐ Complex

For each planning process in Polish case 18, Table 82 lists lists the actor responsible for the planning process, the planning horizon (i.e. the time horizon during which decisions are made), the time period (i.e. the time bracket that splits the time horizon during which decisions are made) and the update frequency of the planning process (i.e. the delay for decisions made that are potentially modified by new planning), the decision(s) planned by the process, the planning objective and the tool used to support the actor, if any.

Table 82: Planning processes in Polish case 18.

Planning process	**Actor**	**Time**		
		Planning horizon	**Time period**	**Update frequency**
Select block 1 & Schedule harvesting 1	Public timberland-based wood supplier	Year	unavailable	6 months
Value commitment 1 & Schedule harvesting 2	Public timberland-based wood supplier	6 months (December to May or June to November)	Unavailable	No update possible after the sale with some exceptions (see **Erreur ! Source du renvoi introuvable.**)
Value commitment 2	Public timberland-based wood supplier	Day to weeks	Day to week	No update possible after the sale with some exceptions (see **Erreur ! Source du renvoi introuvable.**)
Schedule harvesting 3	Public timberland-based wood supplier	Remaining 6 months (December to May or June to November)	unavailable	Unavailable. When a customer asks for a change (e.g. in product specifications)
Value commitment 3	Public timberland-based wood supplier	Day to weeks	Day to week	No update possible after the sale
Value commitment 4	Public timberland-based wood supplier	Day to weeks	Day to week	No update possible after the sale
Schedule harvesting 4	Public timberland-based wood supplier	unavailable	unavailable	unavailable
Schedule harvesting 5	Harvesting contractors	unavailable	unavailable	unavailable
Schedule secondary transportation 1	Mills	unavailable	unavailable	unavailable

Planning process	Actor	Time		
		Planning horizon	Time period	Update frequency
Schedule secondary transportation 2	Transportation and loading contractors	unavailable	unavailable	unavailable

Table 82: Planning processes in Polish case 18. (continued)

Planning process	Decision	Objective	Planning tool
Source timberland 1 & Schedule harvesting 1	- select and sequence blocks (with respect to the harvesting time windows in the forest management plan) in a preliminary annual harvesting plan	Generate an annual harvesting plan that more or less satisfies the MAAH by assortment and the harvesting time window restrictions in the forest management plan	Human skill supported by internal tools (e.g. GIS)
Value commitment 1 & Schedule harvesting 2	- Based on half of the preliminary annual harvesting plan, twice a year (October and April) and using a two phase internet-based auction system (using the 'transparent timer auctions with ascending prices' pricing mechanism), sale of unharvested volume by assortment from a specific forest district (i.e. set of farms in the same geographic area) and to be delivered (at roadside) during the PH in several negotiated time windows. - Adjust half of the preliminary annual harvesting plan according to negotiation	Maximise the sale profit	Two phase internet-based auction system
Value commitment 2	Continuous throughout the year, using an internet-based auction system (using the 'transparent timer auctions with ascending prices' pricing mechanism), sale: - unharvested volume by assortment from specific forest district not sold in previous Value commitment 1; - harvested or unharvested volume by assortment from specific block(s). These volumes must be delivered (at roadside) according to a negotiated time window(s).	Maximise the sale profit and find a market for the volume not sold in Value commitment 1	Internet-based auction system

Planning process	Decision	Objective	Planning tool
Schedule harvesting 3	- Select or revise bucking price list or cutting-list and sorting rules by block - Assign harvested or unharvested volume by assortment from specific block(s) to each committed demand supply at the district level - harvesting and primary transport layout by block	Satisfy the committed volume in processes Value commitment 1 and 2 while minimising harvesting costs	Human skill supported by internal tools (e.g. GIS, local to central daily follow-up of inventories at roadside)
Value commitment 3	Continuous throughout the year, using on-site auctions (using the 'transparent timer auctions with ascending prices' pricing mechanism), sale of harvested assortment with high value (e.g. veneer log).	Maximise the sale profit	Auction and human skill
Value commitment 4	Continuous throughout the year, using bilateral negotiation and retail channels, sale of harvested volume not sold in previous value commitment processes	Find a market for the volume not sold in other value commitment processes	Human skill
Schedule harvesting 4	- Harvest equipment selection by block(s) - From the list of harvesting contractors with an annual volume agreement (obtained using an internet-based auction system (using the 'transparent timer auctions with descending prices' pricing mechanism), select a harvesting contractor(s) for one or a set of block(s) and sign a harvesting contract. If no harvesting contractors with an annual volume agreement are available, find a new one and sign a harvesting contract.	Minimise the harvesting rate	unavailable
Schedule harvesting 5	- Harvesting crew work schedule - Subcontract additional harvesting contractors (optional)	unavailable	unavailable
Schedule secondary transportation 1	Assign a transportation contractor to each purchased volume and specify delivery conditions	unavailable	unavailable
Schedule secondary transportation 2	- Routing and scheduling of the truck fleet and synchronisation with a scaler from the public timberland-based wood supplier for each loading at roadside - Transportation crew work schedule	unavailable	unavailable

For each execution process in Polish case 18, Table 83 lists the actor and the actions performed.

Table 83: Execution processes in Polish case 18.

Execution process	Actor	Action
Pre-harvesting preparation	Harvesting contractor	- move equipment to the block - set-up the support installations
Harvesting in the CTL method	Harvesting contractor	- update the bucking values list of the harvester according to the cutting-list - felling, delimbing, bucking and sorting in piles adjacent to the primary transport trail
Primary transport in the CTL method	Harvesting contractor	- primary transport of the logs from stumpage area to roadside landing - sorting and piling at roadside landing
Harvesting in the FT method	Harvesting contractors	- felling (not mechanised and mechanised system) the tree at stumpage area
Primary transport in the FT method	Harvesting contractors	- primary transport of the trees from stumpage area to roadside landing
Merchandising at roadside landing	Harvesting contractors	- delimbing, bucking, sorting and piling at roadside landing
Measuring at roadside	Public timberland-based wood supplier	- measurement during loading (note: after the fieldwork, we obtained different information (i.e. measurement after primary transport well before loading) but we decided to keep the information collected during the fieldwork)
Secondary transport	Transportation and loadings contractors	- loading the trucks at roadside - secondary transport from roadside to mill
Reception	Mills	- unloading the truck at the mill

In Table 84, the main decision(s) made on the most relevant planning processes in Polish case 18 are classified according to the four attributes characterising a harvest/transportation plan. Furthermore, generic planning decision(s) addressed in each planning process are presented in the last row.

Table 84: Description of the harvest/transportation plan attributes in Polish case 18.

Planning process	Select block 1 & Schedule harvesting 1	Value commitment 1 & Schedule harvesting 2	Schedule harvesting 3	Schedule harvesting 4
Actor	Public timberland-based wood supplier	Public timberland-based wood supplier	Public timberland-based wood supplier	Public timberland-based wood supplier
Planning horizon	Year	6 months (December to May or June to November)	Remaining 6 months (December to May or June to November)	unavailable
Harvesting or transportation resource				- Harvest equipment selection by block(s) - Harvesting contractor assigned by block(s)
Input stock to harvest or transport	Selection and sequence of blocks	- Revised sequence of blocks		Specific block(s) to harvest by transportation contractor
Harvesting or transportation instruction			- Select/revise cutting-list with sorting rules by block - Harvesting and primary transport layout by block	
Allocation of the output stock		Assign unharvested volume by assortment from specific forest district to a customer	- Assign harvested or unharvested volume by assortment from specific block(s) to each committed demand supply at the district level	
Generic planning decision	- Harvest units sourcing - Harvest units scheduling	- Assortments to produce by harvest unit and allocation to demand - Harvest units scheduling	- Assortments to produce by harvest unit and allocation to demand - Bucking/merchandising instructions and sorting rules by harvest unit - Harvest unit layout	- Harvest equipment selection by harvest unit - Harvest unit assignment to contractors

Table 84: Description of the harvest/transportation plan attributes in Polish case 18. (continued)

Planning process	Schedule harvesting 5	Schedule secondary transportation 1	Schedule secondary transportation 2
Actor	Harvesting contractors	Mills	Transportation and loading contractors
Planning horizon	unavailable	unavailable	unavailable
Harvesting or transportation resource	- Harvesting crew work schedule - Subcontract additional harvesting contractors (optional)	Assign a transportation contractor to each purchased volume	- Truck schedule subject to synchronisation with a scaler from the public timberland-based wood supplier for each loading at roadside - Transportation crew work schedule
Input stock to harvest or transport		Specific volume to transport by transportation contractor	
Harvesting or transportation instruction		Delivery conditions for each transportation contactor	Truck routing
Allocation of the output stock			
Generic planning decision	- Harvest crew scheduling	- Transportation quotas assignment to contractors	- Transportation crew scheduling - Transportation equipment routing and scheduling

Table 85 describes, by attributes of a demand, whether the attribute of the demand in Polish case 18 is fixed (i.e. planned) by the process or specified as an input to the process and also if the attribute of the demand is subject to future change.

Table 85: Description of the demand attributes in Polish case 18.

Planning process	Value commitment 1 & Schedule harvesting 2	Value commitment 2	Schedule harvesting 3	Value commitment 3-4
Actor	Public timberland-based wood supplier	Public timberland-based wood supplier	Public timberland-based wood supplier	Public timberland-based wood supplier
Planning horizon	6 months (December to May or June to November)	Day to weeks	Remaining 6 months (December to May or June to November)	Day to weeks
Product specifications	Fixed and change is possible but conditioned by the public timberland-based wood supplier's approval and results in a cost to the customer	For volume sold before harvesting: fixed and change is possible but conditioned by the public timberland-based wood supplier's approval and results in a cost to the customer. For volume sold after harvesting: specified and no change is possible	Specified/fixed for volume sold before/after harvesting. Subject to change for volume sold before harvesting in Value commitment 1 and 2 processes	Specified and no change is possible
Price and payment conditions	Fixed and no change possible (except to cover additional harvesting cost when a customer asks for a change in product specifications)	Fixed and no change possible (except to cover additional harvesting cost when a customer asks for a change in product specifications)	Specified for volume sold before harvesting.	Fixed and no change possible
Quantity and delivery conditions	Fixed but, in practice, delivery time windows (at roadside) are subject to change by the public timberland-based wood supplier (if so, penalty cost incurred by the supplier).	Fixed but, in practice, delivery time windows (at roadside) are subject to change by the public timberland-based wood supplier (if so, penalty cost incurred by the supplier).	Specified for volume sold before harvesting but, in practice, delivery time windows (at roadside) are subject to change by the public timberland-based wood supplier (if so, penalty cost incurred by the supplier)	Fixed but, in practice, delivery time windows (at roadside) are subject to change by the public timberland-based wood supplier (if so, penalty cost incurred by the supplier).

Table 85: Description of the demand attributes in Polish case 18. (continued)

Planning process	Schedule harvesting 5	Schedule secondary transportation 1	Schedule secondary transportation 2
Actor	Harvesting contractor	Mills	Transportation and loading contractors
Planning horizon	Unavailable	Unavailable	Unavailable
Product specifications	Specified but subject to change	Specified	Specified
Price and payment conditions	n.a.	Specified	n.a.
Quantity and delivery conditions	n.a.	Specified but, in practice, delivery time windows (at roadside) are subject to change by the public timberland-based wood supplier (if so, penalty cost incurred by the supplier). The mills can fix shorter delivery time windows for the transportation contractors to e.g. satisfy urgent demand at the mill	Specified by the mills but delivery time windows at roadside are subject to change according to the availability of a scaler from the public timberland-based wood supplier (required for each loading at roadside).

In Polish case 18, limited information was available on the average inventory time of the material between consecutive pairs of processes (see Table 86).

Table 86: Average inventory time of the material between consecutive pairs of processes in Polish case 18.

Consecutive pair of process		Material	Average inventory time	
Harvesting in the CTL or FT method	Primary transport in the CTL or FT method	Sorted piles of logs adjacent to the primary transport trail or felled trees adjacent to the primary transport trail	1-2 days	Average time of 3-9 days from harvesting to reception
Primary transport in the CTL or FT method	Measuring at roadside and Secondary transport	Sorted piles of products (logs or stem) at roadside	1 day to a few days	

Table 87 details the enablers and practices by macro-process in Polish case 18.

Table 87: Enablers and practices of Polish case 18.

Category of enabler	**Source**
1) Rules and guidelines	
2) Performance measurement	
3) Information management	- GIS - Annual plan
4) Inventory management	- Database (bank) of sites - Physical evaluation
5) Asset management	
6) Network management	
7) Transportation management	

Table 87: Enablers and practices of Polish case 18. (continued)

Category of enabler	**Make**
1) Rules and guidelines	- Selection of contractors through an auction system with annual volume agreements, including a general contractual agreement with pre-negotiated conditions for a future harvesting contract and pre-negotiated rates and adjustments according to productivity factors - Agreements and payments based on cost/m3.
2) Performance measurement	- cost per m3
3) Information management	- Basically telephone to exchange information on harvesting each week
4) Inventory management	- Forwarded and harvested volumes appointed daily by harvesting contractors and/or scalers and inventory data are gathered locally in a centralised database shared among forest districts to follow-up the inventories at roadside.
5) Asset management	- Mainly manual chainsaw and farming tractors (only the few existing large companies have harvesting machines)
6) Network management	- Some organisations of harvesting contractors for lobbying
7) Transportation management	- Responsibility of harvesting contractor through full agreement contracts

Table 87: Enablers and practices of Polish case 18. (continued)

Category of enabler	**Deliver (value commitment)**
1) Rules and guidelines	- Four types of sale mechanisms, including two internet-based auction systems - Selling volumes depending on records. - Sales price is determined at the auctions; delivery date and quantity are settled in contracts. - Different forms of purchase security (e.g. bank warranty, insurance, bails, prepayments)
2) Performance measurement	- forecasts of harvesting costs (rates) and sales prices made by the public timberland-based wood supplier - forecast of transport costs (rate) made by the wood buyer
3) Information management	
4) Inventory management	
5) Asset management	
6) Network management	- Steady selling systems. - Good records from customers.
7) Transportation management	

Table 87: Enablers and practices of Polish case 18. (continued)

Category of enabler	**Deliver (secondary transport)**
1) Rules and guidelines	- Contracted by customer. - Companies try to schedule transports. - Bottleneck: measurement at roadside only during office hours (7 AM-3 PM from Monday to Friday) using the scaler of the public timberland-based wood supplier - Monetary penalty if the public timberland-based wood supplier or the buyer does not comply with the agreed pick-up time windows.
2) Performance measurement	- cost per km
3) Information management	- Telephone - truck GPS
4) Inventory management	- Wood stays at roadside until customer provides transport at the time determined in the agreement
5) Asset management	
6) Network management	
7) Transportation management	

Table 88: Agility assessment by dimension and macro-process in Polish case 18.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	0	1	1	1
	Blocks scheduled for sale are 'push' according to silviculture aspects with few demand considerations.	Even though most activities are manual or conducted without special equipment, most harvesting is linked to auction results that include some conditional flexibility for the customer to modify the product specifications (after purchasing time up to harvesting), helping to identify emerging trends.	Volume by generic assortments is pushed to the market mainly by auctions that allow some flexibility for the customer to modify the product specifications at purchasing time, helping to identify emerging trends. Also, between the auctions, there are other selling channels for customers requiring more volume.	One week transport windows give some flexibility in transport for the customer.
Information driver	2	0	2	0
	Information on available blocks is relatively accurate and inventory is frequently updated but, for business considerations, only accessible to the public timberland-based wood supplier.	Manual reports provided by harvesting contractors with unclear frequency. Volumes are confirmed only by the scaler according to auctioned volumes.	Information on block/volume to sale is accurate and frequently updated but diffusion is limited to some potential customers, while the residual block/volume (if any) is then advertised to all potential customers.	Date when wood will be available is set in the auction. Public timberland-based wood supplier communicates only if there is a delay and incurs some penalties. Information is available only to the buyer.
Process integration	1	2	1	1
	Sourcing occurs with limited harvesting considerations.	No real collaboration, but the high unemployment level forces harvesting contractors to make decisions rapidly (e.g. harvesting sites can be anywhere in the country).	Sale conducted according to silviculture considerations with limited harvesting considerations (e.g. no harvesting capacity limit). Purchase is independent of transportation capacity.	No real collaboration, but the high unemployment level forces trucking contractors to make decisions rapidly (e.g. origin and destination sites can be anywhere in the country). Transportation contractor schedules a meeting with scaler when wood is available and plans transport the same day by phone.
Network	0	0	1	0

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
integration	Timberlands are managed according to traditional silviculture and economic considerations with no link to customers or demand forecasts. Traditional silviculture and economic considerations are conservative and, in turn, hesitant to change and adopt new practices.	Cost is the only driver in harvesting; no incentives for improvement.	Purchasing price is the primary driver in the sale system but direct negotiation can occur in the first auction. However, after the first auction, there can be different sale channels for customers requiring more volume and this can help to reduce the low effort in building trust-based relationship with customers by the public timberland-based wood supplier. The dominant wood supplier position of the public timberland-based wood supplier allows it to impose new practices in sales.	Cost is the only driver in secondary transportation; no incentive for improvement.

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 18: Detailed information on Swedish case 19

Table 89: Environmental analysis of Swedish case 19.

Environment element	Description	Uncertainty
1. Industry sector (internal)	Fragmented, several actors	☐Unstable ☒Complex
2. Raw materials	3 commercial species, natural forest/plantation	☐Unstable ☐Complex
3. Human resources	Full year contractor with good educational level	☐Unstable ☒Complex
4. Financial resources		☐Unstable ☐Complex
5. Market sector	National and international	☐Unstable ☐Complex
6. Technology	CTL only, fully mechanised, computer aided; decision support tool, GIS, laser scanning	☐Unstable ☒Complex
7. Government	Authority; nature preservation/protection/regulations/ production	☐Unstable ☐Complex
8. International sector		☐Unstable ☐Complex
9. Climate	Harvesting all year round	☐Unstable ☐Complex

For each planning process in Swedish case 19, Table 90 lists lists the actor responsible for the planning process, the planning horizon (i.e. the time horizon during which decisions are made), the time period (i.e. the time bracket that splits the time horizon during which decisions are made) and the update frequency of the planning process (i.e. the delay for decisions made that are potentially modified by new planning), the decision(s) planned by the process, the planning objective and the tool used to support the actor, if any.

Table 90: Planning processes in Swedish case 19.

Planning process	Actor	Time		
		Planning horizon	**Time period**	**Update frequency**
Value commitment 1	Association of timberland owners (Harvest manager)	Remaining year	Month	Month (or when required by a customer)
Value commitment 2	Association of timberland owners (Harvest manager)	Week to months	Week to month	n.a.
Value commitment 3	Association of timberland owners (Harvest manager)	Weeks	Week	n.a.
Buy block 1	Association of timberland owners (Forester)	Continuously	n.a.	n.a.
Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1	Association of timberland owners (Harvest manager)	Remaining year	Month	Month (or when required by a Value commitment process)
Schedule harvesting 2	Harvesting contractors	Month(s)	Week (to month)	unavailable
Schedule secondary transportation 1	Association of timberland owners (Transportation manager)	Month	Week	Week
Schedule secondary transportation 2	Transport and loading contractors (member or not of a trucking association)	Month to day	unavailable	unavailable
Schedule secondary transportation 3	Association of timberland owners (Transportation manager)	Day	A few minutes	Day

Planning process	Actor	Time		
		Planning horizon	Time period	Update frequency
Schedule secondary transportation 4	Transport and loading contractors (Transportation managers in trucking associations)	Day	A few minutes	Day
Schedule secondary transportation 5	Transport and loading contractors (drivers)	Shift	A few minutes	Real-time when required

Table 90: Planning processes in Swedish case 19. (continued)

Planning process	Decision	Objective	Planning tool
Value commitment 1	Each end of the month and for each customer with an annual supply agreement, the next month's quantity by product fixed in the annual supply agreements, delivery conditions and pre-negotiated price are confirmed.	Confirm profitable demand for the volume to be harvested according to the remaining annual harvest plan	Human skill based on annual supply agreement
Value commitment 2	Commit new demand to replace the reduction in demand from Value commitment 1 or to capture a new demand from a customer in Value commitment 1.	Replace demand to maintain the remaining annual harvest plan or capture new profitable demand to improve the profitability of the remaining annual harvest plan	Human skill
Value commitment 3	Commit new demand for harvested volume not sold in previous Value commitments 1 and 2.	Find a profitable (or with less of a loss) demand for the volume	Human skill
Buy block 1	- Purchase block with (limited) negotiation with timberland owners that are members of the association	- Buy a portfolio of blocks to secure the satisfaction of the supply agreements. - Maintain purchase with timberland owners having a regular business history with the association. - Increase purchases when the product price is good (i.e. expectation of maximising future profits for the association).	Human skill supported by GIS-based members timberland data base (includes silviculture)

Planning process	**Decision**	**Objective**	**Planning tool**
Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1	Revise the remaining annual harvesting plan: - harvesting sequence of previously purchased blocks; - select specific block to purchase; - purchase assortment; - wood bartering of same or different assortment; - assignment of harvesting contractors (including decision on the type of equipment and work shift template) to send to block(s); - assortments to produce in each block and volume allocation to customer and then update bucking price list and sorting instructions by block; - harvesting and primary transport layout by block	Fulfil the committed demand, minimise harvesting and transportation costs and try to change as little as possible in the remaining annual harvest plan	Optimisation based decision support system aided by e.g. GIS
Schedule harvesting 2	- Harvesting equipment and crew scheduling (include machine movement planning) - Subcontract additional harvesting contractors (optional)	Minimise internal costs and maximise productivity	Human skill based potential for home-made tools (e.g. excel)
Schedule secondary transportation 1	- Revise the volume allocation to customer based on the remaining annual harvesting plan, the inventory and the committed volumes in Value commitments 1 and 2, - Then, for the regions where the planning and execution of secondary transportation is outsourced to a trucking association (i.e. a set of transport and loading contractors): assign to each trucking association monthly delivery quotas from specific blocks to specific customers and specify delivery conditions	Minimise transportation costs while satisfying the demand and building inventory for e.g. the thaw period	Optimisation based decision support system aided by e.g. GIS
Schedule secondary transportation 2	- Transportation equipment and crew scheduling - Subcontract additional secondary transportation contractors (optional)	unavailable	Unavailable
Schedule secondary transportation 3	For region where secondary transportation planning is not outsourced to a trucking association: - routing and scheduling of the truck fleet	Delivery at the lowest cost for the committed demand	Optimisation based decision support system aided by e.g. GIS
Schedule secondary transportation 4	- Routing and scheduling of the truck fleet	Primarily satisfy the monthly quotas and then minimise empty travelling distance.	Optimisation based decision support system aided by e.g. GIS

Planning process	Decision	Objective	Planning tool
Schedule secondary transportation 5	- Change their routing and scheduling plan by exchanging loads with other drivers and exchanging information about real-time events	Be more efficient by delivering more loads	Human skill supported by information exchange tools

For each execution process in Swedish case 19, Table 91 lists the actor and the actions performed.

Table 91: Execution processes in Swedish case 19.

Execution process	Actor	Action
Pre-harvesting preparation	Harvesting contractor	- move equipment to the block - set-up the support installations
Harvesting in the CTL method	Harvesting contractor	- update the bucking price list of the harvester - felling, delimbing, bucking and sorting in piles adjacent to the primary transport trail
Primary transport in the CTL method	Harvesting contractor	- primary transport of the logs from stumpage area to roadside landing - sorting and piling at roadside landing
Secondary transport	Transport contractors	- loading the trucks at roadside (can load other truck(s) without a crane) - secondary transport from roadside to mill
Measuring at the mill	Forestry and marketing service provider (i.e. SDC)	- measurement: pulp log by apparent volume, other assortments by log
Reception	Mills	- unloading the truck at the mill (or done by the trucker for mills without a loader)

In Table 92, the main decision(s) made on the most relevant planning processes in Swedish case 19 are classified according to the four attributes characterising a harvest/transportation plan. Furthermore, generic planning decision(s) addressed in each planning process are presented in the last row.

Table 92: Description of the harvest/transportation plan attributes in Swedish case 19.

Planning process	**Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1**	**Schedule harvesting 2**	**Schedule secondary transportation 1**	**Schedule secondary transportation 2**
Actor	Association of timberland owners (Harvest manager)	Harvesting contractors	Association of timberland owners (Transportation manager)	Transport and loading contractors (member or not of a trucking association)
Planning horizon	Remaining year	Month(s)	Month	Month to day
Harvesting or transportation resource	- Assignment of harvesting contractors (include type of equipment and work shift template) to harvest block(s)	- Harvesting crew work schedule - Subcontract additional harvesting contractors (optional)		- Transportation equipment and crew scheduling - Subcontract additional secondary transportation contractors (optional)
Input stock to harvest or transport	- Selection and sequencing of blocks to harvest		Monthly delivery quotas for specific blocks to specific customers	
Harvesting or transportation instruction	- Harvesting and primary transport layout of the block - Bucking price list and sorting rules by block		Assign monthly delivery quotas and specify delivery conditions to the trucking association	
Allocation of the output stock	- Allocation of the volume by product to the demand			

Planning process	**Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1**	**Schedule harvesting 2**	**Schedule secondary transportation 1**	**Schedule secondary transportation 2**
Generic planning decision	- Harvest units sourcing - Harvest units scheduling - Assortments to produce by harvest unit and allocation to demand - Harvest equipment selection by harvest unit - Harvest unit assignment to contractors/teams - Harvest unit layout - Bucking/merchandising instructions and sorting rules by harvest unit	- Harvest crew scheduling	- Assortment reallocation to demand - Balance transportation with harvesting, inventory and reception - Transportation quotas assignment to contractors	- Transportation crew scheduling

Table 92: Description of the harvest/transportation plan attributes in Swedish case 19. (continued)

Planning process	Schedule secondary transportation 3	Schedule secondary transportation 4	Schedule secondary transportation 5
Actor	Association of timberland owners (Transportation manager)	Transport and loading contractors (Transportation managers at the trucking associations)	Transport and loading contractors (drivers)
Planning horizon	Day	Day	Shift
Harvesting or transportation resource	- Loaders and trucks scheduled	- Loaders, trucks and crew scheduled	If required, adjustment of the decisions in Schedule of secondary transportation 3 and 4
Input stock to harvest or transport	- Specific volume to load/transport by loader/truck	- Specific volume to load/transport by loader/truck	
Harvesting or transportation instruction	- Work schedule by loader (sequence of volume to load) and truck (route)	- Work schedule by loader (sequence of volume to load) and truck (route)	
Allocation of the output stock			

Planning process	Schedule secondary transportation 3	Schedule secondary transportation 4	Schedule secondary transportation 5
Generic planning decision	- Transportation equipment routing and scheduling	- Transportation crew scheduling - Transportation equipment routing and scheduling	- Transportation equipment routing and scheduling

Table 93 describes, by attributes of a demand, whether the attribute of the demand in Swedish case 19 is fixed (i.e. planned) by the process or specified as an input to the process and also if the attribute of the demand is subject to future change.

Table 93: Description of the demand attributes in Swedish case 19.

Planning process	Value commitment 1	Value commitment 2	Value commitment 3
Actor	Association of timberland owners (Harvest manager)	Association of timberland owners (Harvest manager)	Association of timberland owners (Harvest manager)
Planning horizon	Remaining year	Week to months	Weeks
Product specifications	Fixed based on annual agreement but subject to rare changes within the month	Fixed but subject to rare changes	Specified and no change is possible
Price and payment conditions	Fixed based on the annual supply agreement but subject to change	Fixed but subject to change	Fixed and usually no change in the future
Quantity and delivery conditions	Fixed by month based on the annual supply agreement but subject to change	Fixed according to various delivery conditions and subject to change	Fixed according to various delivery conditions and subject to change

Table 93: Description of the demand attributes in Swedish case 19. (continued)

Planning process	Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1	Schedule secondary transportation 4
Actor	Association of timberland owners (Harvest manager)	Transport and loading contractors (Transportation managers at the trucking associations)
Planning horizon	Remaining year	Day
Product specifications	Specified but subject to change	Specified
Price and payment conditions	Specified but subject to change	n.a.
Quantity and delivery conditions	Specified but subject to change	Specified by month with various delivery conditions and usually no change

Table 94 and Table 95 lists the information flow, in input and output, for the planning and execution processes respectively in Swedish case 19.

Table 94: Information flow in the planning processes in Swedish case 19.

Planning process	Input		
	From	**Tool**	**Information**
Value commitment 1	Association of timberland owners (Harvest manager)	- GIS - Site database - Manual inspection - Delivery plan/contract	- Stand figures (volume, quality, species, etc.) - Forwarding distance, e.g. cost - Road conditions - Transport distance - Demanded assortments to be planned for the mills - Contract with land owner
Value commitment 2	Association of timberland owners (Harvest manager)	- GIS - Site database - Manual inspection - Delivery plan/contract - Replanning of harvesting machines - New contracts - Wood bartering	- Stand figures (volume, quality, species, etc.) on contracted sites and sites with suitable road conditions expected to be contracted, transport distance, quality and volume characteristics - Road conditions - Transport distance - -Roadside inventory - - New contracts with land owner who has the "right" stands - - Replanning of available harvesting teams - Physical planning meetings
Value commitment 3	Association of timberland owners (Harvest manager)	- GIS - Site database - Manual inspection - Delivery plan/contract - Replanning of harvesting machines - New contracts - Wood bartering	- Stand figures (volume, quality, species, etc.) on contracted sites and expected sites with suitable road conditions expected to be contracted, transport distance, quality and volume characteristics - Road conditions - Transport distance - Roadside inventory - New contracts with land owner who has the "right" stands - Replanning of available harvesting teams - Physical planning meetings - Better quality can replace a lack of demanded qualities in order to fulfil the demand.
Buy block 1	Association of timberland owners (Buying manager)	- GIS - Site database - Manual inspection - Delivery plan/contract	- Stand figures (volume, quality, species, etc.) - Forwarding distance, e.g. cost - Road conditions - Transport distance - Demanded assortments to be planned for the mills - Contract with land owner

Planning process	**Input**		
	From	**Tool**	**Information**
Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1	Association of timberland owners (Harvest manager)	- GIS - Site database - Manual inspection - Delivery plan/contract	- Stand figures (volume, quality, species, etc.) - Forwarding distance, e.g. cost - Road conditions - Transport distance - Demanded assortments to be planned for the mills - Contract with land owner
Schedule harvesting 2	Association of timberland owners (Harvest manager)	Same as in previous process	Same as in previous process
Schedule secondary transportation 1	Association of timberland owners (Transportation manager)	- Own systems developed to follow and administer transport order - Telephone - SDC system (Viol data)	- System for listing available wood at roadside - Connection to the SDC system where harvested and forwarded volumes in many cases are registered daily. In the SDC system, measured volumes by the industry are also registered, which makes it possible to estimate the remining roadside inventory on a daily basis. - Physical planning of the transports, with the list of available volumes and quotas, is done by the transport company/team.
Schedule secondary transportation 2	Transport and loading contractors (member or not of a trucking association)	Same as in previous process	Same as in previous process
Schedule secondary transportation 3	Association of timberland owner suppliers (Transportation manager)	Same as in previous process	Same as in previous process
Schedule secondary transportation 4	Transport and loading contractors (Transportation managers in the trucking associations)	Same as in previous process	Same as in previous process
Schedule secondary transportation 5	Transport and loading contractors (drivers)	Same as in previous process	Same as in previous process

Table 94: Information flow in the planning processes in Swedish case 19. (continued)

Planning process	Output		
	To	**Tool**	**Information**
Value commitment 1	Association of timberland owners (Harvest manager)	- SDC system (Viol – harvesting and forwarding reports) - SDC system – following quotas at mill - Measured volumes and quantities (Viol)	- Harvester and forwarder data (Viol system) - Information about quotas and inventory at mill site - Receipt from truck drivers who have released the load at the measurement station and are issued a receipt. - Internal system follows own mills and the Viol system follows the inventory at roadside or measured (from a given site) at the mill. - Telephone contact among truck drivers to exchange loads and to plan how to fulfil demand quotas.
Value commitment 2	Association of timberland owners (Harvest and planning managers)	- SDC system (Viol – harvesting and forwarding reports) - SDC system – following quotas at mill - Measured volumes and quantities (Viol) - Planning meeting between the managers and contact with harvesting manager	- Harvester and forwarder data (Viol system) - Information about quotas and inventory at mill site - Receipt from truck drivers who have released the load at the measurement station and are issued a receipt. - Internal system follows own mills and the Viol system follows the inventory at roadside or measured (from a given site) at the mill. - Direct contact with truck companies to replan transports. Daily replanning of transports is done by the trucking companies themselves to fulfil VC2 and VC3. - Direct contact with harvesting companies to reallocate harvesting.
Value commitment 3	Association of timberland owners (Harvest and planning managers)	- SDC system (Viol – harvesting and forwarding reports) - SDV system – following quotas at mill - Measured volumes and quantities (Viol) - Planning meeting between the managers and contact with harvesting manager	- Harvester and forwarder data (Viol system) - Information about quotas and inventory at mill site - Receipt from truck drivers who have released the load at the measurement station and are issued a receipt. - Internal system follows own mills and the Viol system follows the inventory at roadside or measured (from a given site) at the mill. - Direct contact with truck companies to replan transports. Daily replanning of transports is done by the trucking companies themselves to fulfil VC2 and VC3. - Direct contact with harvesting companies to reallocate harvesting.
Buy block 1	Association of timberland owners (Harvest and planning managers)	- Internal system - Wood order in Viol system (SDC) - Planning meeting	- Contracted volumes and sites are fed into the site database. - New wood orders (contracts) are updated in Viol

Planning process	Output		
	To	Tool	Information
Schedule harvesting 1 & Select block 1 & Buy block 2 & Buy assortment 1	Harvesting contractor	- Directive for the site in paper format or sent by mobile broadband	- Site directive includes i. Volumes and expected assortments (price list) ii. Map with different boundaries and coordinates (environmental, landowner, etc.) iii. Breast height diameter (basis for payment)
Schedule harvesting 2	Same as in previous process	Same as in previous process	Same as in previous process
Schedule secondary transportation 1	Association of timberland owners (Transportation manager) and Forestry and marketing service provider (i.e. SDC)	- Internal system - Report to Viol from measurement station	- Reloaded loads, volumes and assortments - Collected volumes at roadside.
Schedule secondary transportation 2	Same as in previous process	Same as in previous process	Same as in previous process
Schedule secondary transportation 3	Same as in previous process	Same as in previous process	Same as in previous process
Schedule secondary transportation 4	Same as in previous process	Same as in previous process	Same as in previous process
Schedule secondary transportation 5	Same as in previous process	Same as in previous process	Same as in previous process

Table 95: Information flow in the execution processes in Swedish case 19.

Execution process	Input		
	From	**Tool**	**Information**
Pre-harvesting preparation	Association of timberland owners (Harvest manager)	- Site database - Contract - Price list	- Manually collected site information or from the site database - The contract will also stipulate information about what is bought and when and how to harvest.
Harvesting in the CTL method	Harvesting contractor	- GIS in the machines - Site directive from manager	- Site directive includes i. Volumes and expected assortments (price list) ii. Map with different boundaries and coordinates (environmental, landowner, etc.) iii. Breast height diameter (basis for payment). - GIS system supports the above and maps the site.
Primary transport in the CTL method	Harvesting contractor		
Secondary transport	Association of timberland owners (Transportation manager) Transport and loading contractors Harvesting contractor	- Internal transport system - Transport GIS	- Internal planning system includes information on site, coordinates, volume inventory, etc. - Direct contact with truck companies to replan transports. Daily replanning of transports is done by the trucking companies themselves to fulfil VC2 and VC3.
Measuring at the mill	Transport and loading contractors (driver)	- Viol	- Receipt for what is reloaded at the mill. Sometimes reloaded at measurement station and is measured immediately.
Reception	Same as previous	- Site database - Contract - Price list	- Manually collected site information or from the site database - The contract will also stipulate information about what is bought and when and how to harvest.

Table 95: Information flow in the execution processes in Swedish case 19. (continued)

Execution process	Output		
	To	**Tool**	**Information (tool)**
Pre-harvesting preparation	Association of timberland owners (Harvest manager) Harvesting contractor	- Site database - Wood order in Viol - Paper format maps - Digital site directive	- Viol – wood order and fed into the system. Coordinates, landings, volumes, assortment, etc. are available to the harvesting manager. - Site directive (digital or paper format) includes: i. Volumes and expected assortments (price list) ii. Map with different boundaries and coordinates (environmental, landowner, etc.) iii. Breast height diameter (basis for payment). GIS system supports the above and maps the site.
Harvesting in the CTL method	Association of timberland owners (Transportation manager) Transport and loading contractors	HPR and PRD files reported to Viol	The production files are sent to the Viol system. In some cases, when the landings are overfilled, the harvesting manager also calls the managers in the district as well as the truck drivers. Roadside inventory is available daily for the association's transport planner.
Primary transport in the CTL method			
Secondary transport	Association of timberland owners (Transportation manager)	- Viol - Internal transport system	Loaded and reloaded volumes, where and when they are collected, information about remaining loads and road conditions are reported in the internal system.
Measuring at the mill	Association of timberland owners (Transportation manager) Forestry and marketing service provider (i.e. SDC)	- Viol	Information on what is measured (reloaded) from a specific site and the truck driver (information from notes about the piles) are reported in the Viol system for the association and landowner so that payments can be cleared. This also enables adjustments to be made to forwarded volumes and already paid assortment volumes after forwarding and (in some cases) pre-payment to the landowners.
Reception			

Table 96 lists the average inventory time of the material between consecutive pairs of processes in Swedish case 19.

Table 96: Average inventory time of the material between consecutive pairs of processes in Swedish case 19.

Consecutive pairs of processes		Material	Average inventory time	
Buy block	Harvesting in the CTL method	Standing timber	From few months to less than two years	
Harvesting in the CTL method	Primary transport in the CTL method	Sorted piles of logs adjacent to the primary transport trail	1-3 days	Average time of one month from harvesting to reception. This could increase up to a few months when high inventory levels are building (following the inventory management policy).
Primary transport in the CTL method	Secondary transport	Sorted piles of logs at roadside	One week to a few months according to the inventory management policy for the time of the year	
Measuring at the mill	Reception	Logs loaded in a truck	At reception time or a few weeks/months later according to the inventory management policy for the time of the year	

From the process of Buy block to the process of Reception, Table 97 details, by process(es) and payment methods, the main financial flows for the harvesting contractor in Swedish case 19 and for the other case studies in Sweden. For the sake of brevity, the payments of internal human resources are not represented but they are (usually) paid on a monthly basis.

Table 97: Main monetary flows in Swedish case 19.

Process(es)	Payment method(s)	Time	Monetary flow
Buy block	unit sale price by assortment Note: flat unit sale price and lump sum are also used but unit sale price by assortment is the most common.	A few days after the last harvested volume is measured at the mill.	Payment(s) of the timberland owner by the association based on the internal price list by assortment. Harvesting and primary costs are withdrawn from the payment received by the timberland owner.
Harvesting in the CTL method	flat unit rate	Within 1-2 weeks for all the harvested volume during the week (or less).	Payment of the harvesting contractors for all the volume harvested during the week (or less). Harvested volumes are based on harvester production files and validated by measurements done by a third party at the mill. A final payment adjustment is made when all the timber from a block has been measured.
Secondary transport	flat unit rate	Within 1-2 weeks for all the volume delivered during the week (or less).	Payment of the transportation contractors for all the volume delivered during the week (or less). Delivered volume is based on the measured volume at the mill, with measurements done by a third party.
Reception	unit sale price by assortment	Within 30 days after receipt of an invoice from the association based on the measurement at the end of the month.	Payment by the customer for the delivered and measured volume.

Table 98 details the enablers and practices by macro-process in Swedish case 19.

Table 98: Enablers and practices of Swedish case 19.

Category of enabler	Source
1) Rules and guidelines	- site database - internal purchasing price list by assortment - purchasing contracts of, usually, 2 years - Legislation on harvesting and silviculture enforced by authorities - Forest practices certification (e.g. FSC, PEFC)
2) Performance measurement	- forecast of m3/ha to be harvested
3) Information management	- combination of pre-purchasing cruise and experience to increase the forecast precision of volume by product in a block, a few also use the laser scanning technique - central database at the association to manage the volume forecast by assortment - central database at a third party of the road network (e.g. distance from block to mill)
4) Inventory management	- GIS-based timberland members database for forest management and silviculture follow-up
5) Asset management	- Prediction of annual volumes affects pricing on block purchasing - Building of new land or train terminals according to inventory management - silviculture flexibility for Norwegian spruce and Scottish pine blocks: time window of 5 years for thinning and virtually no limit for clear-cutting (75 year rotation).
6) Network management	- Business and personal relationships with the actors of private forests. - Informal knowledge of new potential members for the association. - Local and national lobbying - to obtain inventory level according to targeted volume by assortment, the association barters wood with other associations and suppliers of harvested timber (a trust-based relationship among the managers is a key issue). The exchange can also be delayed to allow the association to satisfy a present volume need with a promise of the later delivery of a volume in the same or different assortment.
7) Transportation management	

Table 98: Enablers and practices of Swedish case 19. (continued)

Category of enabler	Make
1) Rules and guidelines	- Annual harvesting planning with monthly updates - Site database of available blocks to harvest - directives to contractors - considerations related to the natural environment - defined jointly by contractors and companies, standard general contractual agreement on how the harvesting and primary transport service agreements are reached - harvesting contractors with annual contracts but usually a business history of stable annual production volume with the association. - harvesting contractors know in advance their assigned blocks for the next month, providing them with the time to effectively plan their activities - Health and safety regulations - Harvesting and primary transport legislation
2) Performance measurement	- pre-harvesting evaluation of expected productivity to be profitable and meet production quotas - assortments based on quality classes - payment is based on e.g. roughness of the terrain, transport distance, machine system and harvesting rate; requires a good level of productivity to be profitable
3) Information management	- Harvesting and primary transport reports (roadside inventory) to SDC and/or association on a daily basis
4) Inventory management	- Primary transport operators report to truck drivers when roadside inventory overfills - Primary transport reports (roadside inventory) to SDC, then SDC reports to the association
5) Asset management	- Machine maintenance performed by contractors
6) Network management	- harvesting and primary transport contractors association to improve the business of contractors - Association maintains good relationships with employed contractors - to improve the planning and execution processes involved in this macro-process, the association awards research mandates to research centres/consulting firms and supports harvesting contractors involvement in the mandates
7) Transportation management	- Primary transport operators report to truck drivers when roadside inventory overfills

Table 98: Enablers and practices of Swedish case 19. (continued)

Category of enabler	Deliver (value commitment)
1) Rules and guidelines	- Annual supply agreement with monthly updates - Prices subject to renegotiation
2) Performance measurement	- Analysis conducted to find the most profitable customers and wood allocations (according to quantity, quality and transportation distance)
3) Information management	- procurement position supported by an internal system to follow-up the gradual fulfilment of the supply agreement
4) Inventory management	- usually, between harvesting and secondary transport (roadside or from a terminal), bartering of loads of the same assortment can take place with other associations/companies to e.g. reduce one-way travelling distance, maintain good business relationships by supporting a 'partner'.
5) Asset management	
6) Network management	- record demand history of some customers
7) Transportation management	- supply agreements include details of the delivery logistics conditions

Table 98: Enablers and practices of Swedish case 19. (continued)

Category of enabler	Deliver (secondary transport)
1) Rules and guidelines	- annual and monthly delivery quotas by mill - Transportation contractors with annual contracts but usually have a business history of stable annual hauling volume with the association. - Maximum working/driving hours for drivers - Tons per axle - Allowed roads
2) Performance measurement	- payment based on agreed travelling distances (not from one area to another) and measured volume at delivery - transportation rates require a good level of backhauling to be profitable
3) Information management	- updates on inventory at roadside are based on measurement reports from unloading truck drivers - Truck drivers/local government report road conditions to SDC, which in turn reports it to the association - measuring at reception is done by a third party and measurement is used as the basis of payment for all actors (except harvesting and primary transport)
4) Inventory management	- different kind of terminals (e.g. train terminal, intermediate land terminal) are used as a buffer to balance procurement and address the thawing period - Inventory building before the thawing period - Control of inventory along the wood supply chain is managed with company specific follow-up tools - Truck drivers exchange information amongst themselves and with the fleet manager about the inventory at roadside and whether the estimations of roadside inventories are inaccurate - not common, but the drivers can barter loads (of the same assortment) to improve their efficiency
5) Asset management	
6) Network management	- Trucking associations and clusters of carriers allow offers to be made for a good level of service to the association (can include transport routing and scheduling) - Many exchanges among drivers - to improve the planning and execution processes involved in this macro-process, the association/trucking association awards research mandates to research centres/consulting firms and supports the involvement of transportation contractors in the mandates. - to reduce empty travelling distance, the association barter wood of similar assortments with other associations and suppliers of harvested timber (a trust-based relationship between the managers is a key issue)
7) Transportation management	- the secondary transport activities of many harvesting managers is centralised to one transportation manager in order to avoid sub-optimal local allocation decisions. - the planning and execution of a proportion of the secondary transport is outsourced to a trucking association. Because of its large scale hauling activities serving several shippers, the trucking association is able to capture opportunities by reducing empty travelling distances and can offer competitive transportation rates to the shipper while maintaining a good margin.

Table 99: Agility assessment by dimension and macro-process in Swedish case 19.

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
Customer sensitivity	2	2	3	2
	Most blocks are bought according to annual supply agreements. Internal forest management system allows the rapid identification of additional blocks to purchase when required but this is not commonly used. Sourcing is limited to the blocks of the association's members and continuous efforts are made to connect available supply to potential/committed demand.	The bucking instructions and sorting rules are planned and, if required, adjusted monthly to fulfil the demand. Most of the volume harvested is pre-sale.	Demands are committed according to the sourcing capacity of the association and extensive analyses are made to connect available supply to the most profitable potential demand.	Capacity of the secondary transport to fulfil the committed demand of logistics delivery conditions is based on inventory at roadside and in buffers (e.g. train terminal). All adjustments resulting from demand changes are made in the harvesting scheduling, limiting the capture of new demand opportunity, except for the sale of make-to-stock volume at roadside/buffer. Transport planning only adjusts to the harvesting schedule (indirect answer to changes in demand).
Information driver	2	3	2	3
	Accurate and frequent updates to the centralised database for forest management (provides the potential blocks for purchase) and the data on blocks to purchase are available to harvesting managers. This database is not accessible to the entire supply chain (confidential information).	Information about harvested and forwarded volumes updated at least daily and fairly accurate. Information on harvested and forwarded volume available to the association but not shared with customers.	Committed demand is updated on a monthly basis but subject to change during the month. The diffusion of a change in demand is well supported from harvesting to secondary transport but limited to customers.	Delivery inventory information is accurate and updated daily from the measurement station, but available only to the association. Information flow in cases of unplanned events is possible depending on the level of the personal relationship between the transportation contractor-driver and the association.
Process	2	2	3	2

Dimension of agility	Source	Make	Deliver (value commitment)	Deliver (secondary transport)
integration	Blocks are purchased both with a general picture of the demand (confirmed and forecasted) and aggregated operational considerations (e.g. localisation, weather conditions). Database of available blocks to purchase allows rapid decision-making for sourcing.	Volumes to be harvested are largely linked to committed demand. Bucking instructions can be updated daily but usually this occurs about 10 times a year. Harvested and primary transported inventories are monitored on a daily basis, allowing rapid decision-making for harvesting as well as for secondary transportation planning and demand fulfilment.	At the operational level, committed demand is an input followed in sourcing, harvesting and secondary transportation. Potential changes in the demand create difficulties in decision-making.	Secondary transportation decisions depend on committed demand and are based on input from harvesting, while harvest planning occurs with little consideration of later secondary transportation (e.g. infinite transportation capacity). Rapid decision-making in response to unplanned events (e.g. downtimes or stoppages at mills) is possible depending on the personal relationship level between the transportation contractor-driver and the association.
Network integration	4	3	2	2
	Lengthy and personal relationships with private forest landowners. Rare exchanges between association and companies due to legislation (e.g. anti-trust law). Different methods (e.g. events, publications) foster the adoption of new practices among members.	Lengthy relationships with harvesting contractors, but less important than with members. Different programs (including research mandates) to foster the adoption of best practices among harvesting contractors and raise interest in the harvesting business among young people.	Association must maintain good trust-based business relationships with internal and external mills to secure markets for the wood of their members but price is the main driver for the mills. In general, mills have a dominant position, allowing them to impose more or less the rules of the supply agreement and, perhaps, accept/impose new practices.	High customer-driven/service-driven mindset, but transport companies do not really trust the transport scheduling of the transportation manager. Different programs (including research mandates) to foster the adoption of best practices among transportation contractors/drivers, but even if they are open to new practices, adoption is difficult if they do not see a value in it.

Legend: 0: no contribution, 1: small contribution, 2: medium contribution, 3: high contribution, 4 = extremely high contribution

Appendix 19: Agility capability by case within dimensions in the Make, Deliver (value commitment) and Deliver (secondary transport) macro-processes

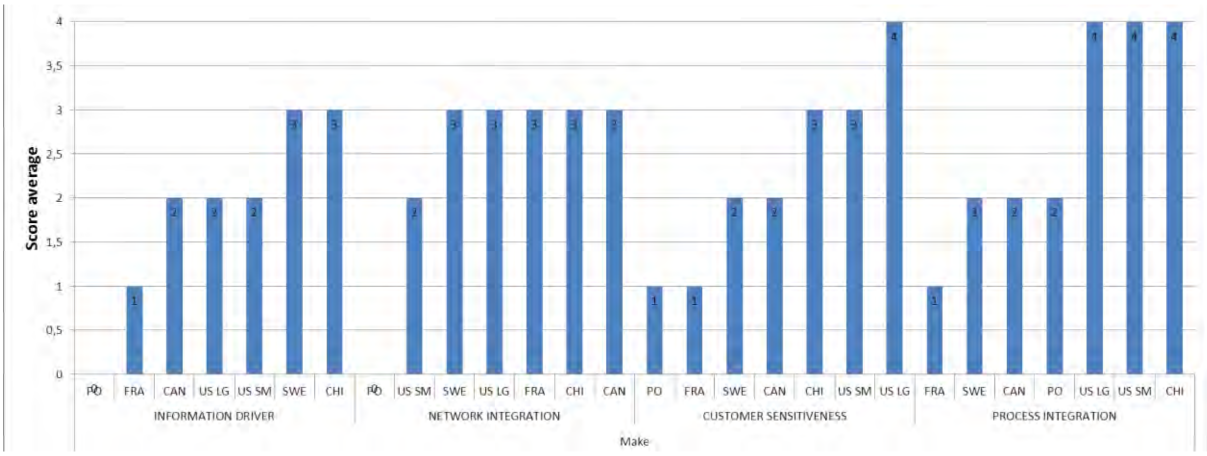

Figure 52: Agility capability by case within dimensions in the Make macro-process.

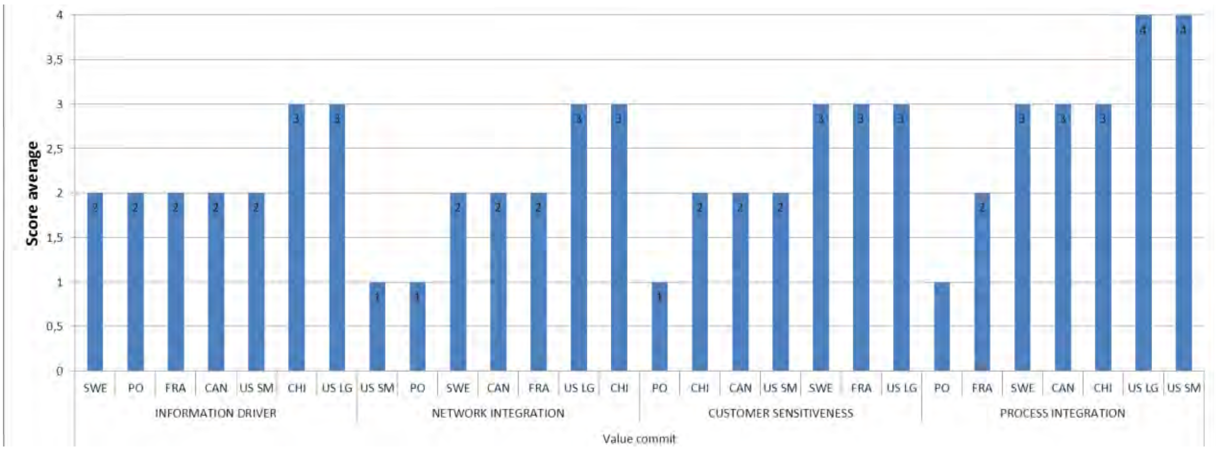

Figure 53: Agility capability by case within dimensions in the Deliver (value commitment) macro-process.

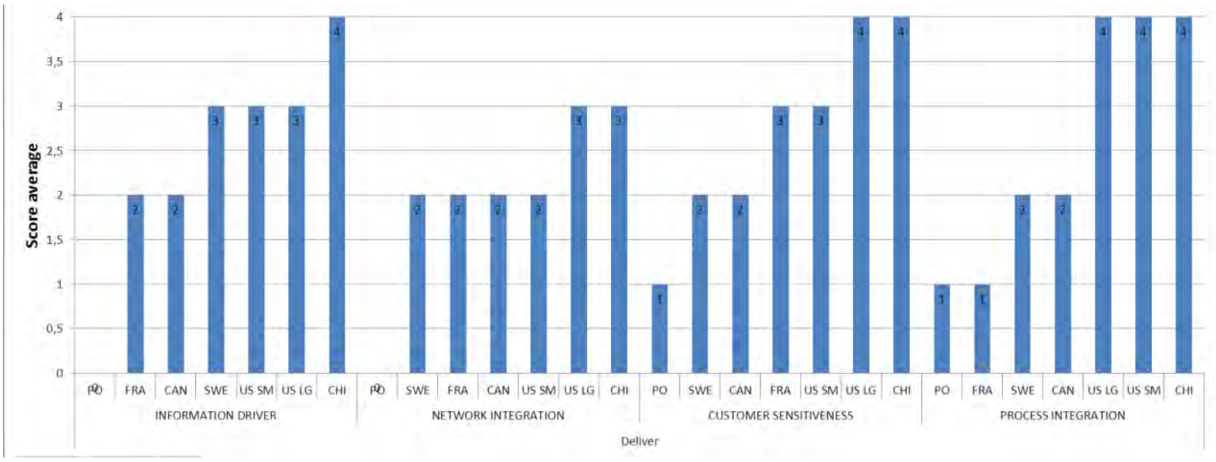

Figure 54: Agility capability by case within dimensions in the Deliver (secondary transport) macro-process.

Appendix 20: Order fulfilment process/dwell time per value commitment in each case

Table 100: Order fulfilment process/dwell time per value commitment in each case.

Case	VC	Sourcing		Harvesting			Transportation		Order fulfilment process time	Order fulfilment dwell time
		Buy block-2O	Select block-2O	Bucking-2O	Primary transport-2O	Merchandising-2O	Measuring-2O	Secondary transport-2O		
CL1	VC1			+		+			10 days	A few weeks to months in advance for an order within a supply agreement during a 4-8 month period or less
CL1	VC2		+++						10 days	A few months in advance for an order within a supply agreement during more than a 4-8 month period
US4	VC1	++							0.5-1.5 days	1-2 weeks in advance for an order within a supply agreement during one to a few weeks
US4	VC2	++							0.5-1.5 days	1-2 weeks in advance for an order during one to a few weeks
US4	VC2					+			0.5-1.5 days	≥1 day in advance for an order during one day to a few weeks
US7	VC1		++						0.5-1.5 days	A few months in advance for an order within a supply agreement during one to many years
US7	VC2		++						0.5-1.5 days	A few weeks in advance for an order within or lacking a supply agreement during one week to a few months
US7	VC2					+			0.5-1.5 days	≥1 day to a few weeks in advance for an order during one day to a few weeks
FR11	VC1			++					5-7 days	A few months in advance for an order within a supply agreement during one year

Case	VC	Sourcing		Harvesting			Transportation		Order fulfilment process time	Order fulfilment dwell time
		Buy block-2O	Select block-2O	Bucking-2O	Primary transport-2O	Merchandising-2O	Measuring-2O	Secondary transport-2O		
	VC2				+				3.5-4.5 days	2-3 days in advance for an order during one week
								++	≤1 day	2-3 days in advance for an order during one week
	VC3							+	≤1 day	≥1 day in advance for an order during one day
CA15	VC1		+++						3-4 weeks	A few months in advance for an order within a supply agreement during one year
	VC2		+						3-4 weeks	Many weeks in advance for an order within a supply agreement during a few weeks-months
				++		++			3-4 weeks	A few weeks in advance for an order during a few weeks-months
	VC3							+	≤1 day	A few weeks in advance for an order during a few weeks
PL18	VC1			+++		+++			3-9 days	Two months in advance for an order within a supply agreement during a 6 month period
	VC2			++		++			3-9 days	A few weeks in advance for an order within a supply agreement during a 6 month period or less or ≥1 day to a few weeks in advance for an order during one to several weeks
							+		≤1 day	≥1 day to a few weeks in advance for an order during one to several weeks
	VC3						+		≤1 day	≥1 day in advance for an order during one to a few days
	VC4						+		≤1 day	≥1 day in advance for an order during one to a few days
SW19	VC1	+	+++						1 month	A few months in advance for an order within a supply agreement during one year
	VC2	+	+						<1 month	Many weeks in advance for an order within a supply agreement during a few weeks

Case	VC	Sourcing		Harvesting			Transportation		Order fulfilment process time	Order fulfilment dwell time
		Buy block-2O	Select block-2O	Bucking-2O	Primary transport-2O	Merchandising-2O	Measuring-2O	Secondary transport-2O		
				+					<1 month	A few weeks in advance for an order during a few weeks
	VC3							+	≤1 day	A few weeks in advance for an order during a few weeks

Legend: Chilean case 1 (CL1); US case 4 (US4); US case 7 (US7); French case 11 (FR11); Canadian case 15 (CA15); Polish case 18 (PL18) and Swedish case 19 (SW19); large part of the demand (+++); medium part of the part of the demand (++); small part of the demand (+); Value commitment (VC); to-order (2O)

Appendix 21: Typologies and taxonomies of supply chain strategies or configurations.

Table 101: Typologies and taxonomies of supply chain strategies or configurations.

Author	Dimensions/attributes	Supply chain strategies/configurations typologies and taxonomies
Fisher (1997) (from Neher, 2005)	- uncertainty of demand - product	- Physically efficient process - Market responsive process
Tan et al. (2000) (from Neher, 2005)	- uncertainty of demand - product	- Physically efficient process - Market responsive process for a customisable product - Market responsive process for an innovative product
Christopher (2000)	- variety/variability - volume	- Lean - Agile
Mason-Jones et al. (2000)	- product standardisation, variety and life cycle - demand predictability - market winners - profit margin - dominant stock - stockout penalties - purchasing policy - information enrichment - forecasting mechanism	- Lean - Agile - Leagile
Lee (2002)	- uncertainty of demand - uncertainty of supply	- Efficient supply chain - Responsive supply chain - Risk-hedging supply chain - Agile supply chain
Corsten and Gabriel (2002)	- uncertainty of demand - product structure	- Lean supply chain - Connected supply chain - Agile supply chain - Speed supply chain
Klass (2003) (from Neher, 2005)	- forecast or order driven - cost or flexibility orientation	- Tight logistics segment - Agile logistics segment - Modular logistics segment - Individual logistics segment
Cigolini et al. (2004)	- product life cycle (PLC) phase - product complexity - variable versus fixed cost ratio - manufacturing flexibility - elasticity of demand to price - main market winner criteria	- Efficient supply chain - Lean supply chain - Quick supply chain
Gereffi et al. (2005)	- complexity of transactions - ability to codify transactions - capabilities in the supply base - degree of coordination	- Market - Modular - Relational - Captive - Hierarchical
Neher (2005)	- uncertainty - volume - business strategy (cost or differentiation)	- Lean - Agile - Leagile
Christopher et al. (2006)	- supply lead time - demand predictability	- Lean based on continuous replenishment - Agile based on quick response - Lean based on efficient planning and execution

Author	Dimensions/attributes	Supply chain strategies/configurations typologies and taxonomies
		- Leagile based on production/logistics postponement
Martínez-Olvera and Shunk (2006)	Six main dimensions, each with a set of supply chain structural elements: - business - supplier - manufacturing - planning - marketing - customer	- Engineer to order - Make to order - Make to order and Assemble to order - Assemble to order - Make to stock - Make to forecast
Vonderembse et al. (2006)	- goal - manufacturing techniques - product variety and production strategy - alliance with suppliers and customers - internal and external integration - product life cycle - markets - organisational structure - suppliers selection strategy - demand patterns - inventory strategy - lead time focus - manufacturing focus - product design strategy - human resources polyvalence	- Lean supply chain - Agile supply chain - Hybrid (leagile) supply chain
Jüttner et al., (2006)	- customer segmentation - demand variability - volume - product value and standardisation	- Continuous replenishment supply strategy - Quick response supply strategy - Quick response and continuous replenishment supply strategy
Narasimhan et al. (2008)	- Corporate supply chain management initiatives - Supply chain functional initiatives	- Six supply chain strategies, each based on a subset of corporate SCM and functional initiatives
Mckone-Sweet and Lee (2009)	- Organisational capabilities - Information technology capabilities	- Three supply chain strategies, each based on a subset of capabilities
Carvalho et al. (2011)	- goal - manufacturing strategy - alliance and integration with suppliers and customers - organisational structure - suppliers selection strategy - inventory strategy - transportation and production lead time - product design strategy - product variety - market	- Lean supply chain - Agile supply chain - Resilient supply chain - Green supply chain
Gattorna (2011)	- customer buying behaviours	- Collaborative - Efficient - Dynamic - Innovative solutions