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An innovative framework for enhancing inter-firm collaboration in forest based supply chain

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by

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Resumo

A importância da colaboração entre os agentes envolvidos na gestão da cadeia de abastecimentos (CA) e em especial, na área florestal, é bem percebida. No entanto exemplos de implementação de colaboração bem sucedida em CA florestal ainda são raros, devido em parte à falta de conhecimento e orientação que incentiva os agentes para colaborar. Este facto, sugere a necessidade de novas abordagens metodológicas que possam efetivamente planear e implementar a colaboração na prática. *Frameworks* existentes não conseguiram fornecer ferramentas para a identificação das oportunidades de colaboração dentro da cadeia de abastecimentos e como proceder para implementar estratégias colaborativas. Este estudo propõe um *framework* inovador para projetar a colaboração inter-empresas em CA florestal (FSCC), abrangendo as etapas para definir a estratégia de colaboração apropriada e as técnicas necessárias para a colocar em prática. O estudo discute ainda como se podem identificar oportunidades para novas colaborações, entre as empresas da mesma cadeia de abastecimento ou entre empresas de diferentes cadeias mas desenvolvendo a mesma atividade. O estudo foi construído sobre uma revisão de literatura e também sobre os resultados de dois *workshops* com agentes de diferentes CA florestal em Portugal. Os resultados preliminares da aplicação do *framework* proposto para uma colaboração vertical entre uma indústria de pasta e papel Português e seus fornecedores, também são relatados.

Palavras-chave: Colaboração da cadeia de abastecimentos, estratégia colaborativa, cadeia de abastecimento florestal, colaboração inter-empresas

Abstract

The importance of collaboration among the agents involved in supply chain management (SCM) and in particular in forestry, is well perceived. Nevertheless examples of implementation of successful collaboration in forest based SC are still rare due in part to lack of knowledge and guidance that motivate agents to collaborate. This fact, suggests the need of new methodology approaches that may effectively plan and implement collaboration in practice. Existing frameworks fail to provide tools to identify opportunities within the supply chain and how to proceed to implement collaborative strategies. This study proposes an innovative framework to design inter-firm collaboration in forest based SCs (FSCC) by encompassing the steps to define the appropriated collaborative strategy and the needed techniques to put in practice. The study further discusses how to identify opportunities where collaboration might be formed, among companies of the same supply chain or companies of different SC that develop the same activity. This study has been built on a thorough literature review and also on the results of two workshops with agents of different FSCs in Portugal. Preliminary results of the application of the proposed framework to a vertical collaboration between a Portuguese pulp mill and its suppliers are also reported.

Keywords: Supply chain collaboration, collaborative strategy, forest-based supply chain, inter-firm collaboration

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Introduction

At the global level in 2006, the forestry sector employed 13.7 million people, generated USD 468 billion in value-added and exported products with a total value of USD 291 billion (FAO, 2008). According to this report, forest sector includes commercial activities that are dependent on the production of wood activities (i.e., production of industrial roundwood, woodfuel and charcoal; sawnwood and wood based panels; pulp and paper; and wooden furniture), production and processing of non-wood forest products (NWFP) and economic activities related to production of forest services. The contribution of forest sector to national economies is around 1% of the GDP, however the trend has been decreasing during the period 1990-2006 and likely still now due to higher rate of growth in other sectors and significant fall in some major economies such as United Kingdom, France, Italy, and Spain (FAO, 2008). Forest sector faces special challenges regarding cost efficiency, adaptation to new technology progress and uncertainty in market prices and requirements. In addition, risk of natural disasters, such as forest fires, pest, diseases or wind and snow storms are stochastic events that might affect significantly the final wood production.

Dealing with this situation is becoming a high priority not only for the governments but also at international level. Thus, over the last years, European Union is enhancing and supporting new research projects that address the different issues impacting in the valorisation of forest resources particularly through less costs and increased efficiency in operations of the forest-based supply chains (FSCs). This is the case of the research project FOCUS (Advances in Forestry Control and Automation System) in the area of FSCs control and planning. The goal of FOCUS is to improve sustainability, productivity, and product marketability of forest-based value chains through an innovative technological platform for integrated planning and control of the whole tree-to-product operations, used by forest-producers to industry players. For this purpose, FOCUS brings together leading SMEs, experts and organizations in the fields of precision forestry, sensors, automation and software development. Case studies will be set in Finland, Belgium, Switzerland, Austria and Portugal covering the four main forest-based value chains in Europe (lumber, pulpwood, biomass, cork), from forest planning and monitoring forest growth, harvesting, wood transportation and industrial processing (www.focusnet.eu).

The present study has been carried out under the scope of the project FOCUS and in particular this research forms part of the 5th objective of the project *"Explore new business models for fostering collaboration among the future users of the FOCUS platform"*.

The FSC as is perceived in this European project is structured in procurement (forest production, storage and transportation and manufacturing supply), production (transformation of woody material in the various intermediate and end products), distribution to the markets and sales networks. It involves a sequence of activities of wood transformation from forest to customer performed by different entities (e.g., forest owners, harvest companies, wood carriers, and forest product processing industry). Complex interdependences arise from the interactions between these independent agents, mainly motivated by their own interests. In this context, Supply Chain Collaboration (SCC) is seen as a potential approach to overcome difficulties coming from the interdependences among the agents involved as well as to take competitive advantage from potential synergies. Cao and Zhang (2011) define SCC as a "partnership process where two or more autonomous firms work closely to plan and execute supply chain operations toward common goals and mutual benefits". Working jointly might provide members of the collaboration with new opportunities to improve profitability of their business that are not possible to obtain individually.

The benefits obtained from collaborative partnerships are documented in the literature, cost reduction and improvements in supply chain performance and service level are the most mentioned (Leitner et al., 2011; Lei et al., 2008; Cao and Zhang, 2011; Holweg et al., 2005; Agarwal and Ergun, 2010; Ramanathan, 2014; Cruijssen et al., 2007; Pomponi et al., 2013). Despite these advantages, studies about successful implementation of collaboration in FSCs in practise are still few and mainly focused on the transportation stage while other stages and opportunities within the SC are poorly addressed.

Hence, there is a research gap in practical and simple to use methodological approaches that enable entities to design and implement collaboration according to their needs and capabilities. Audy et al. (2012a) provide a comprehensive review of factors to be considered in forest collaborative logistics. Naesens et al. (2009) propose a framework focus on addressing the issue of trust and strategic fit to assure that the coalition is feasible. Bahinipati and Deshmukh (2012) propose a framework for collaboration in semiconductor industry. They note that the main issues to manage collaboration are connected to partner selection, motivation, resources allocation, information sharing and coordination. Verstrepen et al. (2009) provide 4 phases framework to implement and manage horizontal cooperation for logistics service providers.

The objective of this research is to enhance collaboration in FSCs by providing a common understanding on concept and techniques and providing an innovative framework that facilitates entities to establish collaborative relationships and allows them to take advantage of the synergies to improve profitability. This might be a “critical factor to remain competitive” as is suggested by Naesens et al. (2007). The research further aims at establishing a new framework, extending the work of Audy et al. (2012a). The proposal was built upon the findings of a thorough literature review and from the results of two workshops organized to collect information about requirements from agents of different forest-based supply chains which. Furthermore, the application of the proposed framework to the collaboration between a Portuguese pulp mill and its suppliers was validated through a questionnaire whose results are also presented.

This thesis is structured as follow: in Chapter 1 the Literature on supply chain collaboration and particularly in forestry, is reviewed. In Chapter 2 the Methodology of this research work is explained. Chapter 3, 4, 5 and 6 present the results. Particularly in chapter 3 the Conceptualization and systematization of the collaboration domain, in chapter 4 Focus group requirements are reported, in chapter 5 a Framework for inter-firm collaboration in forest-based supply chain (FSCC) is proposed and chapter 6 presents the framework application and validation. In chapter 7 conclusions and further research are presented.

Chapter 1

Literature review

It is well acknowledged the importance of collaboration in increasing the efficiency of supply chain planning and decision-making processes, particularly in a multi-firm context.

> Collaboration occurs when two or more entities form a coalition and exchanges or share resources (including information), with the goal of making decisions or realizing activities that will generate benefits that they cannot (or only partially) generate individually (Audy et al., 2012a).

Examples of collaboration in logistics are abundant, in particular in transportation services, carriers or shipper companies collaborate by pooling their needs, requests and/or resources and obtain significant cost reduction as well as new opportunities to extend market or improve delivery times. Examples of collaboration between client and supplier have also been documented. Collaborative strategies proposed in the literature for this case, Vendor management inventory (VMI) or collaborative forecasting where Collaborative planning, forecasting and replenishment (CPFR) is the more evolved strategy. These strategies are usually based on information exchange and joint decisions for efficient inventory management and accurate forecasts. The most cited benefits obtained are significant inventory cost reduction and mitigation of the bullwhip effect. This effect is defined by Rubiano and Crespo

(2003) as “the disruption that results from dramatic, sudden changes in forecasted demand which is amplified as it travels up through the SC”. Examples of these strategies are found in Pasandideh et al. (2010), Rubiano and Crespo (2003), De Toni and Zamolo (2005), Southard and Swenseth (2008), Danese (2006). However other stages of the SC are poorly addressed despite the potential advantages of developing new business models encompassing collaborative actions.

To carry out collaborative strategies different techniques has been used, where Operational Research (OR) plays an important role. Thus, optimization techniques have been proved to be adequate to optimal integrated planning, i.e., developing plans that take into account the restrictions and goals of all the integrated agents leading to synchronized activities and overall cost reductions (see for example Gunnarsson (2007) and Philpott and Everett (2001)). Simulation techniques have also been used to enhance supply chain collaboration. Ramanathan (2014) suggests this technique to assess variables such as optimum number of partners, investment and duration of partnership in potential collaborations.

More recently, a new concern is attracting attention increasingly which is the fact of how these savings as well as other quantitative or qualitative benefits are shared. As Lehoux et al. (2011) report it might be that the total profit of the activity under collaboration is higher than the traditional manner since cost reduction are provided but it is only beneficial for one of the partners. Nevertheless, the collaboration will be feasible only if all the partners see their profit improved. In other words, partners need to have an incentive to be part of the collaboration and behave according to the common interest otherwise they will prefer to leave the coalition.

To start up a collaboration requires time, efforts and sometimes costs to be implemented. Hence, the benefits obtained have to be enough to motivate members. In this regard, different techniques have been studied such as incentives previously agreed among the partners (e.g., discounts and payments) or cost/savings allocation mechanism based on economic models where the total cost or the total benefit of the coalition activity is computed and distributed according to criteria such as equal distribution or proportional distribution. Examples of these techniques are found in Agarwal and Ergun (2010), Dai and Chen (2012) and Lozano et al. (2013).

Examples of collaborations where both kind of techniques, OR and sharing benefits techniques, are implemented are still few particularly in forest sector, although the results are significant and the implementation more promising. For example, Lozano et al. (2013) propose a mixed integer programming to compute the cost saving under collaboration between 4 shippers that merge their transportation needs and reduce the collective transportation cost. The problem is analysed with different coalitions in order to identify potential partners when sharing capacities can be an opportunity to reduce costs. Cost allocation methods are also assessed to address the profit distribution. Agarwal and Ergun (2010), define a mechanism to deal with the optimization planning problem and also the incentives to assure members stay in the coalition. The collaboration consists of an alliance among different carriers that pool their ships and integrate their networks to obtain maximum profit of the alliance. They note that the saving obtained from the alliance is not enough for motivating members to behave in the best way. To deal with this, they add a cost of the capacity exchange as a new incentive where partners receive cash each time they share their capacity with others.

Other researchers go one step further and design computerized tool to effectively implement the collaboration. Thus, Schönberger and Kopfer (2011) propose a DSS to address the unexpected events (i.e., additional requests) by adding incentives or penalties previously agreed. They propose an on-line optimization models for planning. Dahl and Derigs (2011) design a real-time decision support system to propose order exchanges between partners of a Cooperative Logistic Network in Germany. Collaboration is enhanced through a compensation scheme previously agreed.

Collaboration in forest based supply chain

The forestry literature revels the use of collaboration in forest logistics since significant cost reduction in transportation has been computed as well as higher efficiency. As Audy et al. (2012a) note in FSC, transportation cost might reach up to a third part of the total raw material cost. Optimization techniques have been used to support optimal collaboration planning and different collaborative incentives have been tested to support logistic collaboration. Most of the studies propose strategies based on pooling transportation needs of several companies and obtain an optimal and common plan for all. They consider the use of backhauling to obtain the maximum advantage of each trip, reduce distances and consequently the global cost. For example, Carlsson and Rönnqvist (2007) show significant transportation cost savings (around 5%) by using backhauling. Other benefits are also identified such as reduction in unloaded driving and fuel consumption, need for maintenance of road network, less emissions of pollutants. This strategy provides a global cost savings in transportation but the benefits distribution issue is not addressed. Frisk et al. (2010) propose a new mechanism to deal with the problem of savings distribution (Equal Profit Method, EPM) which provides a more equal distribution among the companies. The collaboration takes place among 8 forest companies in Sweden with the goal of improving transportation planning efficiency. The optimization problem is solved by using a DSS, called FlowOpt (Forsberg et al., 2005) where backhauling and bartering (or wood exchange) are included as opportunities to reduce transportation cost. Almost 15% of savings are reported. Marques et al. (2014) present a DSS for optimal planning and dispatching of raw material at the mills. The main aim is to minimize the waiting time at the mill to reduce reception cost and total delivery time. The collaboration is formed among a Portuguese pulp mill and its 10 main suppliers. Decisions about arrival time planning are made jointly and a system based on priorities allocation allows to distribute the waiting times to each truck. Both the arrival time schedule and the priorities allocation is previously agreed among the partners through a negotiation process. Beaudoin et al. (2010) propose a negotiation based planning to coordinate activities and agree on wood allocation and transactional cost which motivate forest companies to exchange procurement services in order to increase local and total profitability. Audy and D'Amours (2008) present 4 different collaborative scenarios where 4 furniture companies jointly plan and execute their shipments from Canada to USA. The benefits reported from collaboration are cost and delivery time reduction and increase on markets coverage. The cost/savings distribution issue is addressed by Audy et al. (2011). They propose a modified EPM proposed by Frisk et al. (2010) and a modified Alternative Cost-Avoided Allocation method.

Finally, examples of collaborative strategies to reduce inventory costs, improve customer satisfaction and activities synchronization based on demand information exchange in FSC are rare. Examples are found in Lehoux et al. (2007) where the CPFR strategy is modelled as an integration of producer and retailer in pulp and paper industry and is compared to other strategies such as VMI and CR. CPFR strategy presents the highest cost reduction. However, they do not address the savings distribution issue. Lehoux et al. (2011) present the collaboration between a pulp and paper producer and one of its buyers and compare the traditional manner with the CPFR method. Results report that the latter generates the greatest total profit. They also address the benefit distribution issue by comparing 3 incentives based on bonus, sharing the transportation costs and quantity discounts. They demonstrate that sharing properly the total profit of the collaboration among the entities involved, individual profits are also possible.

Regarding computerize tools to implement successful collaboration, examples in forest sector are Marques et al. (2014), Audy et al. (2007) and Forsberg et al. (2005) although the two latter do not addresses the benefits sharing issue. These tools allow users to obtain optimal plans at tactical or operational level and in some cases to react to unexpected events at real time. Further information about these DSS is provided in chapter 5.

The contribution of this research is twofold. First, a concept harmonization of the collaboration domain has been carried out since no consensus in terminology exists which can be an impediment for successfully designing collaborations (chapter 3). Second, our research aims at contributing to this literature by providing an innovative framework to enhance collaborations in FSC (chapter 5). This framework grounded in the work of Audy et al. (2012a) intends to go one step further, that is, not only setting up the collaborative strategies and other key issues for building collaboration but also to gathers the techniques for the effective implementation and maintenance of collaboration. Special focus on forest sector is given since as it was already noted, many agents are involved and synergies may results in higher profitability.

Chapter 2

Methodology

Research was built on a thorough literature review and the analysis of requirements from focus groups gathered in thematic workshops where content analysis techniques were used. Afterwards, a conceptualization of this knowledge domain and its systematization was done to propose a framework for enhancing inter-firm collaboration in forest-based supply chain (FSCC). Finally, the validation of the framework was conducted with its application to a case study and an end-users questionnaire. This methodology is shown in figure 1.

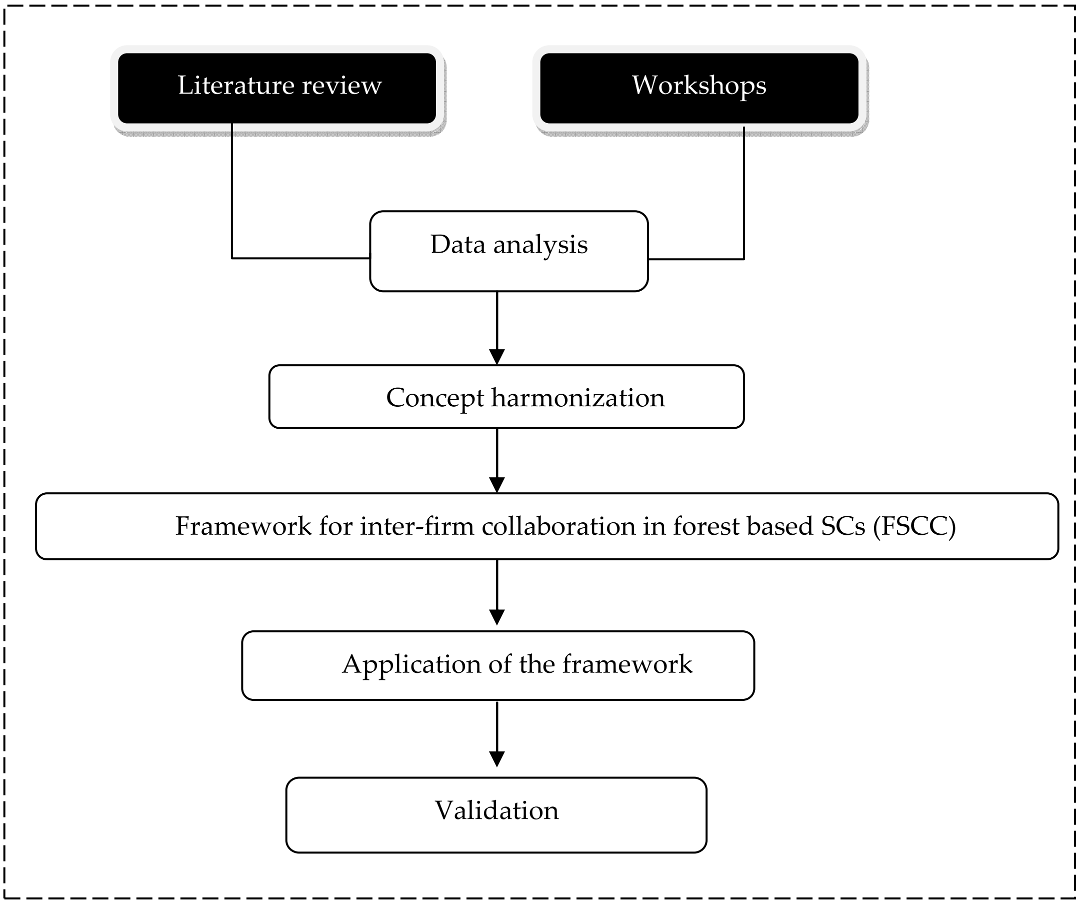

Figure 1. Methodology

1. Literature review methodology

The objectives of the literature review are (1) to provide a critical review of the state of art on collaboration in supply chain context by identifying both reliable strategies and techniques and research gaps to be fill (2) the conceptualization on collaboration in forest-based supply chain to provide a better understanding on this field and (3) to systematize the knowledge about concepts, strategies and techniques from the literature into an innovative framework that enable forest entities to plan and to implement collaborative strategies and consequently to improve their activities' profitability.

The different phases of the applied method are similar to the stages required for a systematic review (SR) widely used in medical sciences (see for example Rosenfeld (1996) and Tranfield et al., 2003). However, SR method relies on rigorous inclusion criteria and peer-review journals which is not our case because this is an exploratory study for qualitative findings including not only peer-reviewed articles but also conference proceedings papers and working papers since this topic is relatively new and relevant studies are still to be submitted or published.

Concerning the article collection process, different electronic databases were i.e., Web of Science (WOS), ScienceDirect, Google Scholar. The review focused on collaboration in forest-based supply chain literature.

In the first phase the key words search applied were "Forest" and "Collaboration" and "Supply chain". The search was conducted on WOS. The results were 15 papers, including peer-reviewed articles and conference proceedings papers.

The second phase consisted on the review of abstracts and findings. The inclusion criteria to select the relevant papers were (i) to be related to planning and control of forest supply chain activities such as harvesting, transportation, industry reception and/or sales, (ii) to be recent (up to 15 years) and (iii) English or exceptionally French languages. After the review only 6 papers were selected as relevant according to the criteria. The rest of studies were rejected since they deal more with forest management and natural resources management which are out of the scope of this study.

The third phase was to collect relevant papers from the references of the first 6 studies. In particular, Audy et al., 2012a was of special interest. Authors identified the main issues to implement collaboration in forest logistics and useful concepts and theories are identified which has been key to develop the proposed framework in the present study. Jean-Francois Audy who is an expert in this domain, took part in this research by guiding the literature review process and contributing for the definition of the framework later presented in this study. As a result of this collaboration the proposed Framework for enhancing inter-firm collaboration in FSC will be submitted to the Canadian Journal of Forest Research this year 2014.

2. Requirements from FSC agents

Different workshops were organized to collect information directly from agents involved in forest-based supply chains where focus group method was used. This method is widely used to collect large amount of information in short time (see for example Lam et al. (2013) and Upham and Roberts (2011)). It consists of discussion groups where there is a moderator who supplies the topic and guides the discussion. It also provides interesting information from the interaction among the participants unlike with other methods such as individual interviews.

In this research two workshops were organized. The first workshop aimed at identifying problems and requirements regarding forest planning and control and the second workshop aimed at identifying potential collaborative opportunities.

Focus group 1

In the first workshop the participants were split in 4 groups, randomly mixing IT developers and end-users. Cork and pulp and paper industry agents were the majority of participants.

The topic to discuss was the identification of main problems and expectations, information and functionalities under the perspective of each group member. The post-It method was used to carry out the discussion. This method is usually used to solve problems that have many possible solutions or to collect many ideas about a particular question. Examples of this method are found in Marques et al. (2013) and Gill (2003).

It consisted of three phases: (1) participants wrote down 4-5 items per supply chain stage (i.e., planning, harvesting, logistics and industry) on single 2-colour post-its: green: problems, orange: information, (2) each participant hangs out these post-its on a board, providing a brief explanation to the others and finally (3) when all group members finished the exercise, moderator clustered the post-its and established the main conclusions of the group.

After the session, the post-Its were collected and were transcribed into four tables, one per group. Thirteen post-its were dismissed for being unreadable, incomprehensible or out of context and thirty-four post-its were re-categorized due to misconception about problem/information concepts. The data analysis was conducted by three members of exercise board by means of Content Analysis. This is an analytical tool that allows to reduce the volume of information into smaller groups and thus more manageable. Moreover, frequencies of each group (in this case "problem" or "need") are computed and it allows to identify the main focus or concern of the participants group. Examples of this method are found in different domains such as marketing (Vitouladiti, 2014), social sciences (Harun et al., 2014), educational (İşlek and Hürsen, 2014) and often used to analyse research trends or determining authorship (Stemler, 2001).

Proposed clusters were discussed and validated by the moderators of all the groups.

Focus group 2

Aiming at finding opportunities to increase energy and resources-efficiency, a second workshop took place. Members of a furniture industry and members of a wood panels company were the focus group.

At the beginning of the session, the moderator suggested to participants a discussion about needs and opportunities. During the session each participant proposed some initiatives where collaboration is absolutely necessary or might help and explain what they expected to obtain. Finally, a set of collaborative opportunities were identified and ranked according to the priority. The systematization of the results was done during the workshop. Each opportunity was described by the main benefit and by type of agents involved.

The results of the two focus groups are presented in Chapter 4 and the primary data of workshop 1 in the Annex I.

3. Concept harmonization

Once the studies were selected from the literature review and as their analysis was carried out, the conceptualization on collaboration in FSC was also conducted. To do this, conceptual mapping method was used. This technique allows to represent graphically the knowledge (Novak and Cañas, 2008) and the existing inter-connection among the concepts. This is especially useful when the relationships are not clear or there are many cross-connections that can lead to confusion. The software used to develop the conceptual map has been Cmap Tools (www.ihmc.us/cmaptools.php) where the squares are concepts and lines are the connections between two concepts. These lines also contain words-links to specify the type of connection.

In addition, this method has also helped to solve the lack of consensus in the terminology about collaboration that has been identified from the literature review. On the other hand, the presented conceptual map provides a systematization of concepts, benefits, barriers and techniques which has been further presented in chapter 3 and 5.

4. Framework for inter-firm collaboration in FSC

Existing frameworks have in common the purpose of providing general procedures that later on are tailored to different cases. For example, the supply chain operations (SCOR 2006) , the Process Classification Framework (APQC 2006) and the Pulp and Paper Supply Chain Process Framework (Marques et al., 2011). Our framework provides the systematization of the collaborative domains on three decision levels (i) decision about the identification of potential partners and collaborative opportunity, (ii) decisions about collaborative strategy and (ii) decision on techniques to implement the collaboration.

Each level encompasses a set of steps which might be tailored to apply in each case. The framework is intended to provide the knowledge from the literature review into each step in such a way that for every step, examples of existing strategies, critical issues to be considered and recommended methods are provided.

5. Application and validation of the framework

The framework is validated by means of its application to a case study presented in Marques et al. (2012) where a Wood Delivery System prototype is applied to plan the reception of 120 pulpwood deliveries at the mill. This Decision Support system (DSS) provides optimal arrivals planning that provides significant reception cost reduction by reducing the need for queues at the mill. Moreover, the system also provides the dynamic allocation of each truck to a time slot available at the moment it arrives at the mill. The waiting time of the trucks is minimize and thus its total delivery time.

The contribution of this research was to provide the needed adaptation of the proposed system to assure that this process meet the requirements to be collaborative. To do so, the proposed framework was applied and some adjustments were needed as is presented in chapter 6.

Moreover, a questionnaire was used to collect information from end-users were researchers, professors, students, developers of DSS, and forest planners participated. The questionnaire was launched after a workshop session in which the system was presented and the simulation program SIMIO was used to show how the process would work from the arrival of the trucks to their departure.

The questionnaire was structured in 2 section; DSS impact in decision making and DSS architecture. Both sections encompassed a series of closed questions with four options assessing the level of importance (scale ranging from not important to very important with a "don't know" additional option). Additionally, two open questions were included at the bottom end of the questionnaire. The data from the questionnaires were analyzed by computing responses frequency of each question. The results concerning this research are presented in Chapter 6 and the questionnaire in the annex 2. These results allowed us to validate not only the DSS as a computerized tool to support planning and dispatching of wood deliveries but also the usefulness of the framework to plan collaborative opportunities as well as to identify the interest of end-users in this kind of collaboration

Chapter 3

Conceptualization and systematization of collaboration domain

1. Literature review remarks

The number of papers included in the literature review is 62 from 38 different journals. The main journals identified are International Journal of Production Economics by 16.13 % and European Journal of Operational Research by 11.29% followed by Computers and Industrial Engineering, Decision Support Systems and Logistics and Transportation Review by 4.84% each one. The period between 2001 and 2014 encompasses all papers. An increasing trend in the number of articles is observed over this period, especially from 2008 denoting a growing interest in the collaboration domain.

An in-depth review of Supply Chain Collaboration concepts, strategies and techniques presented in the literature (Chapter 1) put in evidence some important remarks that guide the work in the next chapters.

1. There is no consensus on the terminology about collaboration. In addition, the lack of connections among concepts makes difficult to

apply existing methods to new opportunities. A conceptual map to deal with this issue is proposed in section 2 of this chapter.

2. Potential benefits and barriers of collaboration in supply chain have been identified which are presented in the following sections of this chapter, section 3 benefits and 4 barriers.
3. Despite the potential benefits, collaboration in the forest sector is still in its infancy since not many examples have been reported so far.
4. Most of the research focuses on logistics and in particular on transportation while other stages of the supply chain are poorly addressed.
5. Information exchange and perceptions of fair distribution of savings are the main critical factors to start up collaboration. It refers to trust among partners and motivation to be part of the coalition and behave according to the common objective. Without dealing with these issues and the selection of proper techniques, collaborations might fail.
6. Examples of OR techniques for improving planning are documented but few of them address also the benefit sharing issue which leads to lack of incentives to collaborate.

2. Concepts harmonization proposal

The first intended contribution of this research is a concept harmonization of collaboration on supply chain management that provides a full understanding of concepts and theories and allows entities to take maximum advantage of the already existing studies and findings. With this in mind, a conceptual map is presented next. Here, it is intended to form a basis for future research and practical applications.

Studies refers the same concept by using different terms e.g., to refer collaboration, some authors use collaboration (Holweg et al., 2005) others cooperation (Cruijssen et al., 2007; Lozano et al., 2013; Leitner et al., 2011) or coordination (Zhang et al., 2012; Schönberger and Kopfer, 2011). In this study it is accepted the definition and wording provided by Audy et al. (2012a). Thus, "collaboration occurs when two or more entities form a coalition and exchanges or share resources, with the goal of making decisions or realizing activities that will generate benefits that they cannot generate individually". According to this definition different types of collaboration can be formed depending on the nature of the entities involved, the resources to share/exchange, the decisions making process and the benefits to achieve. These factors influence the *collaborative strategy* to apply. Authors usually describe the applied strategy without any specific definition and using different characteristics to define it (see for example Carlsson and Rönnqvist, 2005). From our view, the collaborative strategy needs to be clearly defined and should encompasses information about who are the partners, which are the resources, at which level to collaborate, how the decisions are made and how entities coordinate their activities. These aspects are described in detail in chapter 5.

Collaboration might take place at different intensity levels. Researchers suggest different approaches to classify the level of collaboration e.g., Frayret et al. (2003) propose increasing levels according to which, information sharing becomes more complex. They go from transactional relationship to co-evolution [1]. This approach is shared by Audy et al. (2012a) and Lehoux et al. (2009). Leitner et al. (2011) distinguish 4 levels of increasing intensity from individual

[1] "This level involves the co-evolution of business partners at the alignment and the definition of their business strategy. Here, business partners attach to the highest point for their business by leveraging each other on the strategic choices of the other" (Frayret et al. 2003)

transport planning to lateral supply chain cooperation. In this case, the potential of consolidation increases with the levels. Other authors distinguish from operational to tactical and strategic levels and suggest starting at the lowest level and increase the intensity of collaboration gradually (Pomponi et al., 2013; Verstrepen et al., 2009).

In this study it is proposed a classification of 4 increasing levels of collaboration; *Information exchange, Joint decision, Joint planning and Joint execution*. The higher the level is, the higher the complexity but also the higher the benefits that are feasible to reach. Under this perspective each level includes the previous ones, being information exchange essential in all of them. Examples of each level are reported in chapter 5.

According to its scope, collaboration may take place within the same entity i.e., intra-collaboration, or among different entities which is known as inter-collaboration. In this study the first form is not addressed since it is out of its scope. However, its application is seen as desired requirement to form successful inter-firms collaboration (Beaudoin et al., 2010; Muckstadt et al., 2001; Ramanathan, 2014) which can be formed by entities of the same supply chain (upstream or downstream) called vertical collaboration or by entities of different supply chains that develop the same activity, which is called horizontal collaboration.

Other authors propose coordination mechanisms to systematize how the strategies are to be carried out (Frayret et al., 2004; Audy et al., 2012a; Marques et al., 2014). According to Frayret et al. (2004), coordination may take place during the execution of the activities or by plan, yet this research focus mainly on the latter, coordination by plan. These mechanisms enable entities to actually know how to carry out the agreed strategy. Information, decisions and financial flows should be defined in such a way that all partners know what and how to do at every moment.

These mechanisms encompass the planning process supported by optimization and/or simulation techniques and the benefit sharing issue based on economic models or different financial incentives. Finally, computerized tools that rely on those techniques are used to implement the defined solution where Decision Support Systems (DSS) play an important role.

All these concepts and their inter-connections are presented in the figure 2.

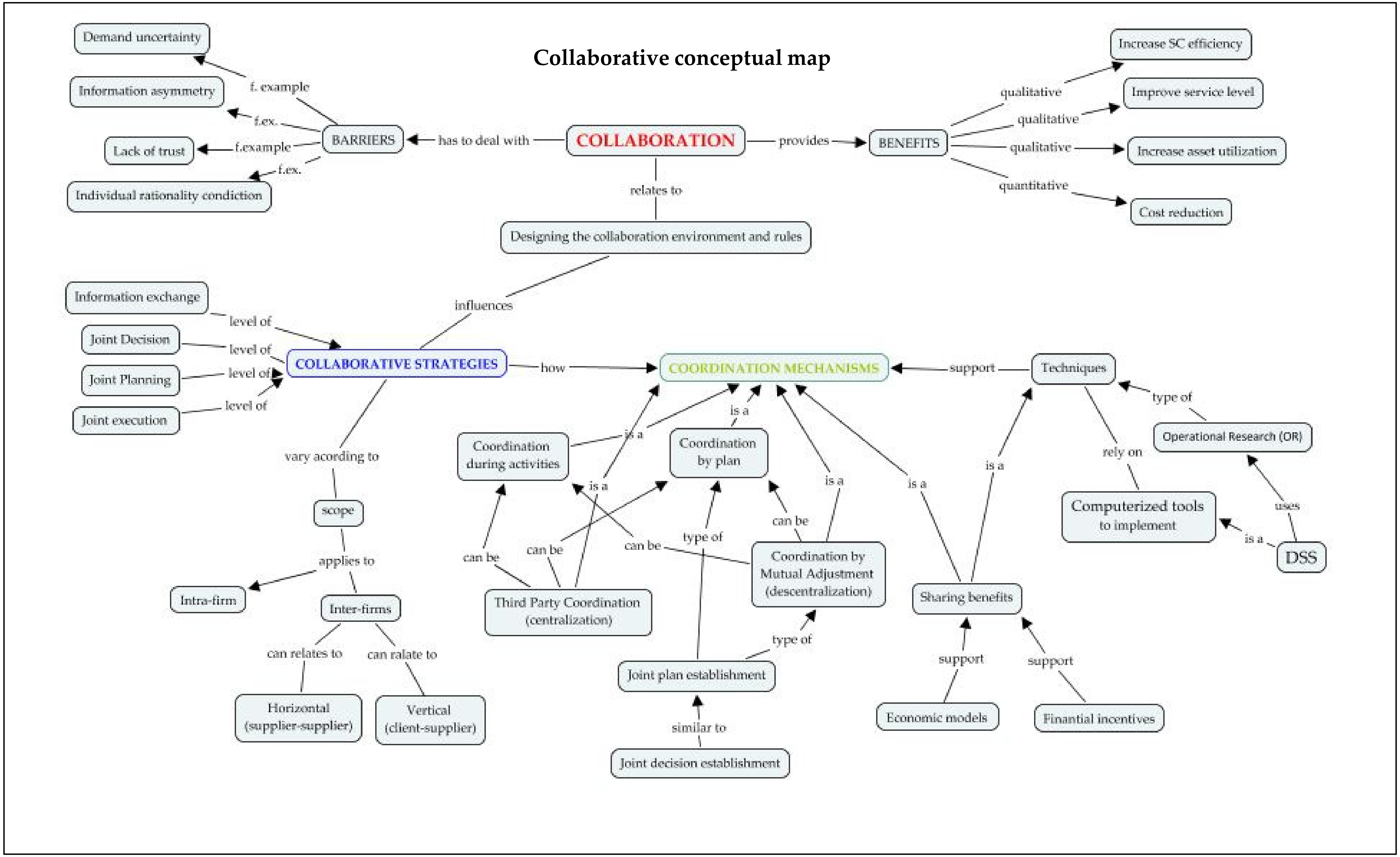

Figure 2: Collaborative conceptual map

3. Benefits

Different benefits have been identified in the literature when collaboration takes place. Yet, most of them are qualitative, and not quantified. Concerning qualitative benefits, the most often cited are increase of supply chain efficiency which is directly or indirectly obtained, service level improvement, increase of asset utilization and performance improvement. These benefits might be obtained from different collaborative strategies. More specific benefits are also identified e.g., flexibility, customer satisfaction, market geographic coverage increase or bullwhip effect mitigation which depends on the particular collaboration carried out.

Regarding quantitative benefits authors compute cost savings or profit increasing. However, due to the lack of valorisation of qualitative ones the global advantage of managing supply chain activities in a collaborative manner is usually underestimated.

In the table 1 the benefits documented in the literature are presented.

QUALITATIVE BENEFITS	Agarwal and Ergun, 2010	Audy and D'Amour, 2008	Bahinipati et al 2012	Beaudoin et al. 2010	Cao and Zhang, 2011	Holweg et al. 2005	Lei et al. 2008	Lozano et a. 2013	Muckstadt et al., 2001	Ramanathan, 2014	Marques et al. 2014
Increase negotiation power		x						x			
Increase asset/capacity utilization	x					x	x		x	x	
Higher frequency services	x						x				
Allow economies of scale	x						x	x			
Improve services levels	x				x	x	x				
Reduce excess inventory (cost)					x	x					
Bullwhip effect mitigation					x	x					
Extend markets geographic coverage	x	x					x				
New markets	x										
Improve performance	x				x				x	x	
Reduce uncertainty/more accurate forecast									x	x	
Increase visibility and avoid asymmetric information											
Improve appointment scheduling											x
Better market response						x					
Delivery time reduction		x									
Positive environment al impact		x									
Customer satisfaction			x							x	
Improve inventory management			x								
Better coordination				x							
Increase profitability				x							
Increase flexibility (fast response to changes)					x				x		
Improve production lead time										x	
Enchance innovation					x					x	
Increase supply chain efficiency	x	x	x	x	x	x	x	x	x	x	x
QUANTITATIVE BENEFITS											
Cost saving (transaction, transportation, inventory, ...)	x	x	x	x	x	x	x	x	x	x	x

Table 1. Benefits from collaboration in supply chain

4. Barriers

Authors report different barriers to create forms of collaboration and/or to maintain them. The reasons pointed out are of different nature, from economic aspects to social issues. Here it is provided a classification of barriers in planning, implementation, social and economic nature. These barriers should be understood as considerations to take into account when designing collaborations. In principle, avoiding all these constraints the likelihood to succeed is higher. Some of the exposed issues are really hard to control and avoid. In these cases, any mechanism to mitigate the effect would be of help.

Barriers in planning

- When different interest, business, priorities, capacities etc. between partners optimization problem becomes hard (Lei et al., 2008)

- Planning and decision making becomes much more complex (Frisk et al., 2010)

- Demand uncertainty (Muckstadt et al., 2001)

- Need for taking into account stochastic events (Beaudoin et al., 2007; Bahinipati and Deshmukh, 2012; Marques et al., 2014).

Barriers in implementation (start up and/or maintain)

- Low internal efficiency (Muckstadt et al., 2001; Ramanathan, 2014)

- Lack of knowledge about how to use the available information (Holweg et al., 2005)

- Risk of opportunistic behaviour (Naesens et al., 2007; Bahinipati and Deshmukh, 2012; Audy et al, 2012b) especially when one of the members has higher negotiation power or is the leader of the coalition. Centralized collaboration where one of the partners acts as the mediator or coordinator has higher risk of this behaviour.

- Information asymmetry, when one of the members is better informed than others. It might produce mistrust and avoid optimal savings scenario (Lehoux et al., 2011; Hsieh et al., 2008)
- Need for information and communication technology (Cruijssen et al., 2007; Ramanathan, 2014; Danese, 2006; Verstrepen et al., 2009)
- Partner selection process needs to be carefully considered (Audy et al., 2012b; Pompoi et al., 2013; Cruijssen et al., 2007; Naesens et al., 2007).
- Coalition size (Lozano et al., 2013; Cruijssen et al., 2007).
- Specific limitations of backhauling: geographical distribution
- Specific limitations of bartering: need for equal wood requirements

<u>Barriers of social nature</u>

- Social issues such as trust, commitment, power, etc. A high level of trust is the basic fundamental to enable the building of a long-term collaborative strategy (Wu et al., 2014; Naesens et al., 2009)
- Need for awareness about collaboration advantages and opportunities
- Need for willingness to exchange crucial information and behave collaboratively
- Lack of transparency
- Unequal negotiation power (Cruijssen et al., 2007)

<u>Barriers of economic nature</u>

- Need for fair distribution of profits mechanism (Audy et al., 2012b; Cruijssen et al., 2007). Common definition of fairness (Dai and Chen, 2012)
- Need for individual rationality condition (i.e., all members need to be better off under collaboration) (Dai and Chen, 2012; Audy et al., 2012b; Yilmaz and Savasaneril, 2012)
- Need for enough collaborative incentive in each case. Sometimes, savings obtained in a coalition is not enough to assure member are satisfied (Agarwal and Ergun, 2010)
- Cost transaction and establishment cost (Audy et al., 2012b)

Chapter 4

Focus group requirements

1. Focus group 1

After the end-users workshop 1, the total collected post-Its were 170, 114 were problems and 56 were information needs. The total amount of problems was clustered into 8 main problems (codes) by means of Content analysis as is explained in chapter 2. The results are presented next in table 2 and in figure 3.

Problem	Frequency (%)
I. Lack of proper technological tools for planning and control	48
II. Difficulties in technology uptake by end-users	7
III. Low interest in forest management	2
IV. Difficulty in accessing information	6
V. Better data quality	11
VI. Need for traceability of products across the chain	10
VII. Hard to reach solutions which fit all cases	4
VIII. Need for fostering collaboration among partners of the supply chain	12

Table 2. Main problems in Forest planning and control

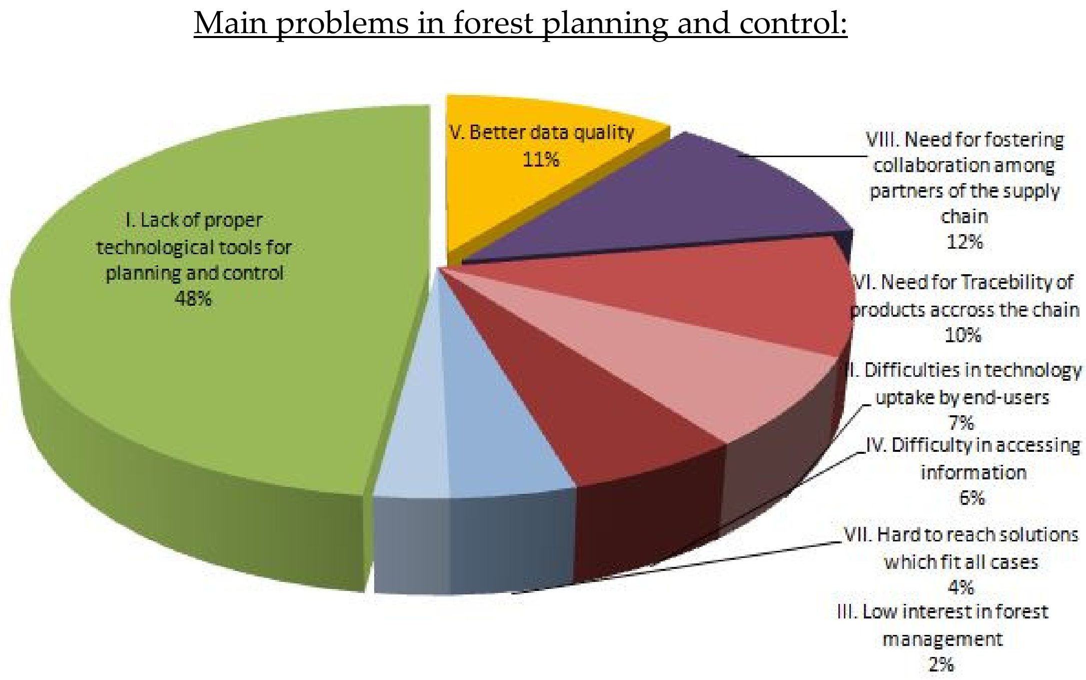

Figure 3. % of post-its with respect to the main problems in FSC

The nature of the problems is different although there is a significant difference between the first problem and the rest of the problems since the 48% of the post-its are related to lack of proper technological tools for planning and control. Nevertheless, this issue is out of the scope of our study and therefore not addressed. In this research we address the second main problem identified by 12% of participants, in this case clearly related to collaboration; **"Need for fostering collaboration among partners of the supply chain"**. This problem encompasses: (i) lack of transparency, (ii) how to collaborate? (iii) models, incentives, and gains, (iv) fair cost-benefit distribution, (v) foster collaboration for better planning and better communication. This information put in evidence the need for enhancing collaboration in forest-based supply chain and for the identification of tools to enable entities to carry out these collaborations.

Regarding information needs, users mostly stated their need for information on raw materials properties (i.e., quality, humidity, thickness, diseases, price and volume) by 42% of the post-its, and site and stand Information (soil structure, stand composition and ownership boundaries) by 17%. Relevant information for planning and control further include: Road characteristics (accessibility, distances travelled), wood demand, wood stock and wood flows, overall information for monitoring plans execution, existing IT solutions and infrastructure of the parties involved in the supply chain. Information specifically related to collaboration was not identified at this stage.

2. Focus group 2

Concerning the focus group 2 with members of a furniture industry and members of a wood panels company, 8 collaborative initiatives were highlighted which were gathered in two main objectives; efficient use of forest resources and energy optimization. The latter is not analysed in this research since it is out of its scope. Within the first group, two initiatives respond to the need for traceability of the product, two initiatives are related to reduce waste and re-work and two opportunities were pointed out to improve by-product valorisation. These results are shown in table 3.

Efficient use of forest resources			
Priority	**Collaborative opportunity**	**Expectations**	**Agents**
1	Apply to the product the same tag	Traceability of the product	Furniture company and wood panels company
2	Application of RFID technology		Furniture company and wood panels company
3	Customized products from panel company to furniture company instead	Reduce waste and re-work	Furniture company and wood panels company
4	SPC (Statistical Process Control)		Intra-collaboration in Furniture company
5	Use wastes from the furniture company to panel company	To improve by-product valorisation	Furniture company and wood panels company
6	Re-sell to other producers of panels		Furniture company and other panels companies

Table 3. Collaborative opportunities between a furniture company and a wood panel company in Portugal

In our research special attention deserves the latter, to our knowledge not addressed yet in the literature; it refers to the possibility of using the wastes from the furniture company as raw material for the panel company. Thus, the profit from sale would increases, since currently this waste is used for energy production only, the inputs costs to build panels would be also reduced since the company takes advantage of the way back of their trucks.

These results remark how participants are interested in collaborating when they perceive that significant advantages can be achieved by working jointly.

Chapter 5

A proposed framework for inter-firm collaboration in forest-based supply chain (FSCC)

This proposed framework extends the work of Audy et al. (2012a) by addressing the main decisions undertaken by an agent that wishes to start implementing a successful collaboration with others of its supply chain or of different supply chain. This framework will be subject to publication to the Canadian Journal of Forest Research (Olmo et. al., 2014).

This framework consists of 3 interdependent decision levels: collaborative opportunities, collaborative strategy and implementation (Fig. 4). Each level encompasses a number of steps that have to be followed when designing a desired collaboration. The development of the framework is presented next from the perspective of an agent, hereafter called key-partner, who has the initiative to collaborate with the purpose of improving the profitability of his/her activity.

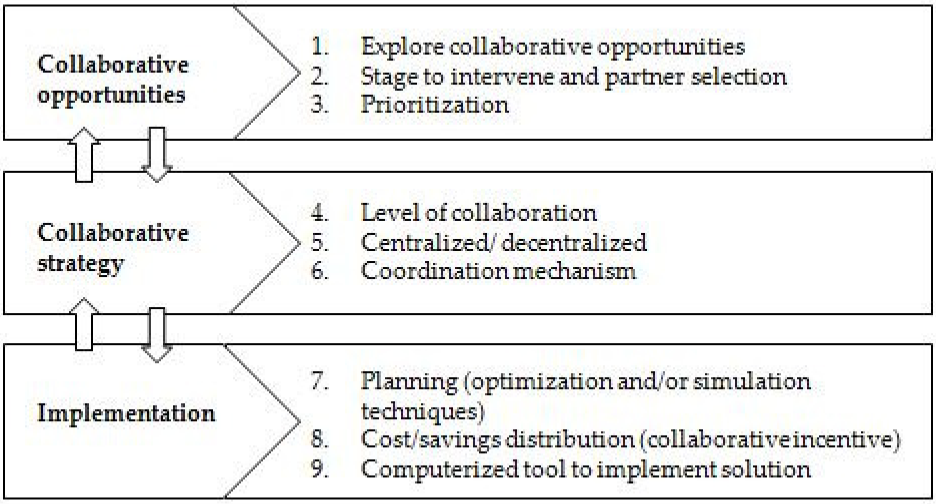

Figure 4: Framework for inter-firm collaboration in Forest-based supply chain (FSCC)

1. Collaborative opportunities

In this initial phase the key-partner identifies the inefficiencies or weaknesses of his/her own process that could be addressed through collaboration with other partners. According to the review of literature the main objectives aimed at with collaboration are efficiency increase and cost reduction. Yet, many other benefits can be also obtained as has been shown in Chapter 3. Most of them are qualitative but at the end higher profitability and/or cost reduction are somehow reached. Table 1 presented in Chapter 3 might help the key-partner to identify specific objectives where collaboration might help and define the collaborative opportunities.

In order to select the adequate collaborative opportunity, all the potential partners should participate in the process from the beginning. Thus, it is suggested to organize a workshop involving potential partners to discuss the expectations of all participants and explore feasible opportunities for implementation. In the first place, the key partner has to select the potential partners to participate. To do so, it is suggested to build up a matrix where all the agents of the given SC are represented, vertically and horizontally. As is noted by Bahinipati and Deshmukh (2012) to choose proper partners to form the collaboration is a critical stage for the success of collaboration. During the workshop the partners expose individual goals and constraints as well as expectations regarding the objectives from the collaboration. Finally a table may be filled up with all the identified opportunities, expectations and agents involved of the supply chain that may participate in each collaboration (table 4). Different workshops could be organized for horizontal and vertical collaboration to avoid revealing confidential information to competitors.

Priority	Collaborative opportunity	Expected benefits	Agents
1	e.g., collaborative transportation plan	transport cost reduction/delivery time reduction	Transportation companies (horizontal)
(…)	-	-	-
n	-	-	-

Table 4. Collaborative opportunities

A prioritization on the collaborative strategy will be carried out taking into account 2 aspects, the expected benefits and the compatibility among the entities. The later criterion concerns to company characteristics, size and strategy. This is an important phase since collaboration is not always feasible and special requirements can lead to the rejection of optimal cost savings scenarios as it is reported by Audy and D'Amours (2008). Naesens et al. (2009) also highlight the influence of having compatibility among the companies to get successful collaboration.

Another issue referred to in the literature as important at this phase for successful collaboration relationships is cooperation leadership as is reported by Cruijssen et al. (2007).

The size of the coalition is also an important decision to make. In general, cost savings increase with the size of the coalition (i.e., number of partners) but, on the other hand, time consumption, operational complexity and likelihood of forming sub-coalitions increase as well (Agarwal and Ergun, 2010; Audy et al., 2012b). Cost saving increases with the number partners but with diminishing importance, therefore, there is a moment when it is not worth to increase further complexity adding new partners (Lozano et al., 2013).

At the next Implementation Phase, techniques to compute and distribute savings among partners will be developed and tested previously to the actual implementation. According to these preliminary results partners will be able to decide definitively if they accept or not the conditions of the collaboration. It means that final size and partner composition will be definitively decided after the last stage of the collaboration plan. Hence, the proposed framework allows to return iteratively to the previous steps and to redefine the strategy or select a different opportunity.

2. Collaborative strategy

At this phase, the collaborative strategy is to be settled by deciding about the level of collaboration and how the coordination among the agents will take place. Studies report that higher levels of collaboration lead to higher operational complexity although more benefits can be obtained. Thus a trade-off needs to be sorted out between operational complexity and benefits. Leitner et al. (2011) note that as the intensity of the collaboration increases the benefits also increase. Muckstadt et al. (2001) point out that collaboration is not only transferring data between partners but also planning jointly and executing the activities, maintaining the collaboration throughout the process.

In this study four increasing levels of collaboration are proposed (figure 5) as it was already mentioned in section 2 of chapter 3: information exchange, joint decision, joint planning and joint execution.

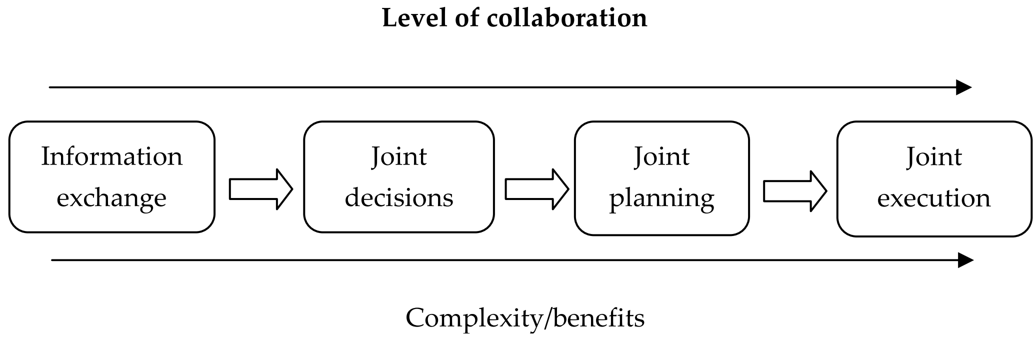

Figure 5: Levels of collaboration

Information exchange is the first level of collaboration. Different information must be shared according to the scope of the collaboration envisaged. Information might refer to demand, inventory, capacity, business strategies, needs, operations plan, schedules, routes or resources. According to Simatupang and Sridharan (2004) information sharing allows to identify and communicate crucial information to support decision making processes on supply chain planning. As it is noted by Rubiano and Crespo (2003) greater sharing of information leads to improve SC performance. Yet, results on collaborations show how companies not always share proper information. This may be even detrimental. Choi et al. (2013) reveal “harmful forecast updating with bad information”. Other research point out that sharing confidential information might increase the risk of opportunistic behaviour (Pomponi et al., 2013).

Examples of strategies are mainly connected to demand information exchange. For example, Vendor Managed Inventory (VMI), where besides the traditional supply chain information and material flows, the supplier controls the retailer's inventory level so as to ensure that desirable customer service levels are maintained (Pasandideh et al., 2010). Several benefits have been reported when VMI is implemented, the most often cited is the reduction of the bullwhip effect (see for example Disney and Towill, 2003). However, this advantage is not often taken by the supplier to improve its own planning and inventory process as it is reported by Holweg et al. (2005). They go one step further and describe a Synchronize Supply (SS) strategy where the supplier besides managing the inventory to satisfy the customer, takes advantage of the information exchanged to plan his operations. Studies in forestry are rare, yet Carlsson and Rönnqvist (2005) present the results of a questionnaire where more than 50% of customers show interest in collaborating by sharing demand information in exchange of managing the stock in the entire supply chain.

Joint decision arises usually when coordination among members is needed. According to Jaber and Osman (2006) reaching agreements on quantities, prices and other aspects of business, requires coordination to make decisions together. At this stage, members of the coalition develop individual plans despite sharing key information on their plans to make decisions jointly.

An example of collaborative strategy at this level is collaborative forecasting where Collaborative Planning, Forecast and Replenishment (CPFR) is seen as the most evolved strategy. Here both customer and supplier try to link their plans for better demand forecast. Holweg et al. (2005), describe this strategy under Information Exchange. However joint decisions are also placed since the result of exchanging information at high level of detail implies making decisions jointly. Studies on this kind of strategies in forestry are found in Lehoux et al. (2007) where CPFR is modelled as an integration of producer and retailer and is compared to other strategies such as VMI and CR. CPFR presents the highest cost reduction of all. Another example is provided by Marques et al.

(2014) where a mill and its suppliers agreed upon decisions related to arrival times and priorities in order to minimize the waiting time at the mill. Significant reductions of reception cost (around 56%) and delivery time (an average of 54 %) are also reported (more details in chapter 6).

The *Joint planning* level takes place when the agents involved in the collaboration agree on the operation plan, this is the so-called coordination by plan (Frayret et al., 2004). A suitable example of this level in forestry is found in Beaudoin et al. (2010). They extend the work of Frayret at al. (2004) by focusing on the coordination mechanism of joint plan establishment, poorly addressed in the literature. This mechanism is prevalent among the firms involved in wood procurement planning in eastern Canada.

The Joint *execution* level occurs when the strategies of the members are also pooled. They are usually based on exchanging requests and demands and share vehicles capacities. Research focuses on shipper (buyer) collaboration or carrier (seller) collaboration (Yilmaz and Savasaneril, 2012) with the goal of minimize transportation cost. In the first case, the literature gives examples of carriers who merge their requests and thus solve the problem of optimal allocation of requests to maximize the total profit of the coalition (Dai and Chen, 2012). Regarding shippers' alliances, further examples can be found. For example, Lozano et al. (2013), Yilmaz and Savasaneril (2012) and Audy et al. (2011) where shipper companies merge their transportation needs reducing the collective transportation cost. Opportunities to use larger vehicles and backhauling allow reductions on delivery time and increase service levels and frequencies.

Backhauling is when a truck carrying a load from one point to another, transport another load on its return (Frisk et al., 2010). However, examples of joint activities execution in other stages of the supply chain such as harvesting, despite of being an interesting issue to probe, are still poorly addressed in the literature.

Another decision to make at the collaborative strategy stage is connected to the need for a third party to intervene in the coordination concerning the decisions and the activities, i.e., centralized or if the coordination will take place by mutual adjustment between the agents involved without any external participation, i.e., decentralized. Advantages and disadvantages have been identified in the literature about centralized/decentralized forms. Actually depending on the objectives and complexity of the coalition both need to be assessed to decide which the appropriated form in each case is. Authors agree that centralized forms does not assure the equity among firms (Beaudoin et al., 2010) although centralized collaborations provide higher profit in alliances. While decentralized forms can be more realistic, have less cost of implementation and less risk of opportunistic behaviour.

Once this is set up, the coordination among the entities has to be clearly defined. To do so, it is suggested the use of proper c*oordination mechanisms.* As Agarwal and Ergun (2010) note, these mechanisms are crucial to manage the interactions and distribute the benefits and costs among the agents involved. The questions to be answered when a coordination mechanism is applied for a specific collaboration are: what information is needed, how it is going to be exchanged, which decisions, how to make them and by whom, how the savings will be distributed.

There is not a standard coordination mechanism, rather it is something to be decided jointly by the entities involved. Yet, research has made an effort to identify some general coordination mechanisms e.g., Frayret et al. (2004) present different mechanisms where information and decision flows are represented. Audy et al. (2012a) extend this by presenting different coordination mechanisms. In this case, the financial flow is also included. Recent research proposes the design and the implementation of a new coordination mechanism tailored to a specific vertical collaboration between a mill and its suppliers (Marques et al., 2014).

3. Collaboration Implementation

To implement collaborative strategies, three techniques are needed: (i) techniques to improve efficiency in forest operations planning, (ii) techniques to compute and distribute costs or benefits among partners and (iii) tools to implement the chosen solutions. These techniques are instrumental to make the collaboration efficient, profitable and implementable, respectively. That is, to ensure that collaboration will be both feasible and stable.

Despite this, many authors focus on optimization techniques to improve planning often by integrating partners' activities but few authors address the savings distribution issue and even take into account computerized tools. By doing so, optimal planning can be reached but partners will not be fully aware of their benefits and then they will not be motivated to participate. Consequently collaboration will not take place. As Narayanan and Raman (2004) note, to manage the supply chain properly the incentives of the agents involved must be fairly aligned and recognized by all the coalition. Similarly, well defined strategies without tools to support real time information, communication and decision making processes, will hardly be carried out.

Concerning the benefits to be shared, even though qualitative benefits have been recognized, usually quantitative benefits are needed to encourage entities to decide if the proposal is convenient or not. The main goal of any company is to realize the activities at the minimum cost possible, although other purposes are also considered. Under collaboration new opportunities to reduce that cost arise. The new goal is to realize the activities of all the agents at the minimum cost for the entire coalition.

For that purpose Operational Research has been widely used for forest planning in multi-agent context (D'Amours et al., 2008) although without making explicitly basic collaboration issues such as benefits distribution. Optimization and simulation techniques support optimal planning by achieving minimum cost or maximum profits when resources and needs are pooled. Such techniques compute the total cost savings from collaborative planning. Examples in logistic collaboration are available in Lei et al., 2008; Dai and Chen, 2011; Yilmaz and Savasaneril, 2012; Cruijssen et al., 2010; Lozano et al., 2013; Dahl and Derigs, 2011; Agarwal and Ergun, 2010 and in particular in forest sector; Forsberg et al., 2005; Carlsson and Rönnqvist, 2005; Audy et al., 2007; Frisk et al., 2010; Audy and D'Amours, 2008.

Complementarily, incentive methods are used to allocate/share cost or saving among the collaborative partners. These techniques should provide *collaborative incentives* (i.e., profits) to make partners willing to participate and behave in favour of the collaboration. In vertical collaboration usually incentives consist of price agreement, quantity discount, flexible return policies, revenue sharing contracts where negotiation is needed. These agreements should be fixed as contract clauses. Examples of these techniques are provided in table 5.

In horizontal collaboration, cost/saving allocation methods based on economic models, are more often used (Frisk et al., 2010; Audy et al., 2012b; Audy et al., 2011). Examples of applied methods are inspired on Cooperative Game Theory (CGT) where some properties (i.e., conditions) are defined from which the different feasible methods are derived. The properties used most frequently for feasible methods selection are: (i) efficiency, i.e., common cost/saving must be split among the collaborative partners (CP), (ii) individual rationality, i.e., all the members need to be better off, (iii) cross monotonic, i.e., the pay off of a CP does not decrease when the coalition grows with a new agreement and the fact that non CP can receive a nil pay off. Examples of application of these techniques are provided in table 5.

Other mechanisms for horizontal collaboration when resources, orders or services are exchanged or shared are proposed by Agarwal and Ergun (2010) and Dahl and Derigs (2011). These authors propose to add payments for the exchange. That is, for example, every time a resource is shared or exchanged within the collaboration a payment exists as the cost to be paid by the agent using this resource. It acts as an extra incentive since agents involved in the collaboration already receive other benefits. Beaudoin et al. (2010) provide a negotiation protocol to get agreements on wood procurement areas and exchange procurement services by transaction price agreement.

At this stage, partners can decide if form or not a coalition according to the results. Hence the framework allows to return through the previous steps if the results are not satisfactory.

Contract agreements			
Technique	**Description**	**Scope**	**References**
Price agreement	Negotiation price	Fair price	Beaudoing et al., 2010
Quantity discount	Price discount per increased unit	Compensation	Jaber and Goyal, 2008
Return policies	Unsold products are return to upstream firms	Profit sharing	Ding and Chen, 2008
Revenue sharing	Optimal order quantity and price	Profit sharing	Zhang et al., 2012
Cost/savings allocation methods			
Technique	**Description**	**Scope**	**References**
Weighted cost	The proportional part of each entity's cost with respect to the sum of all entities' costs is calculated. Then this weighted measure is applied to the global cost of the coalition that is different from the latter	Cost allocation	Frisk et al., 2010; Audy and D'Amours, 2008
Separable/non-separable cost	Marginal cost (separable cost) is allocated to each entity and according to how the difference between the sum of entities' costs and the overall cost of the coalition (the non-separable cost) is distributed, different methods are applied such as equal charge and alterative cost avoided method (ACAM) (D'Amours and Rönnqvist, 2013)	Cost allocation	Frisk et al., 2010; modified ACAM (Audy et al., 2011)

Shapley value	Since the marginal cost of each entity is affected by the order in which it enters, this method compute the average marginal cost in case the entry order is random	Cost allocation	Frisk et al., 2010; modified SV (Dai and Chen, 2012)
Shadow prices	It is applied in transportation services. The total cost of each company in a coalition takes into account separately its contribution to the total supply and demand nodes' cost	Cost allocation	Frisk et al., 2010
Equal Profit Method (EPM)	The total saving from the collaboration is distributed equally among the involved agents	Savings distribution	Frisk et al., 2011; modified EPM (Audy et al., 2011)
Nucleolus	This technique identifies the worst cost allocation from which some agent might be not satisfied	Cost allocation	Frisk et al., 2010; Lozano et al., 2013
Others			
Technique	**Description**	**Scope**	**References**
Payment	Payment in the form of a exchange cost	Incentive for exchanging capacities or orders	Agarwal and Ergun, 2010; Dahl and Derigs, 2011
Negotiation protocol	The protocol guides to get agreements	Activities coordination	Beaudoing et al., 2010

Table nº 5. Sharing benefits techniques

Finally, the collaborative strategy needs to be efficiently put in practice where computerize tools play an important role. Computerized-tools that go beyond information exchange and actually support inter-firm collaboration in forest logistics and supply chain planning are poorly addressed in the literature (Marques et al. 2014). "Decision support tools have been found to have the ability to offer greater transparency to the chain" (Carlsson and Rönnqvist, 2005).

Implementing tools should be dynamic and capable of supporting real time communication as well as facing unexpected events. Examples of DSS that address unexpected events are found in Schönberger and Kopfer (2011) and Dahl and Derigs (2011). In particular, in forest sector for transportation planning at tactical level, Forsberg et al. (2005) present the FlowOpt system that provides users with alternatives routes where bartering (wood exchange) and backhauling are included in the analysis since significant cost reductions can be achieved through these collaborative operations. Audy et al. (2007), present a Virtual Transportation Management (VTM), a web-based DSS supporting collaborative route planning based on optimization planning at operational and real time level. Visibility data, optimal planning and easy of usage make this DSS a useful example of computerized tool for collaboration. The weakness of these DSS is the lack of addressing the savings distribution issue. In this regard, Marques el al. (2014) present a Material Delivery System (MDS) to support the raw material delivery planning and handling where collaborative incentives are provided for all the partners involved. This case is described in detail in Chapter 6.

Chapter 6

Framework application and validation

1. Case study description

As Marques et al. (2012) note “transportation and reception of the raw materials at the mills are key problems of the inbound logistics in most of the industries that transform natural resources”. These problems are particularly important in forest sector since the material (i.e., wood) cannot be long time piled next to the forest once it has been harvested. Risk of natural disasters, such as forest fires, and degradation of the wood are significant issues requiring urgent transportation. As said in chapter 2, this case study was presented in Marques et al. (2012) where the reception of wood at a Portuguese pulp mill was addressed.

Currently the delivery of wood is not planned in advance and consequently many trucks arrive simultaneously in some pick hour. It leads to congestion and queuing of the trucks increasing the duration and cost of the service. Moreover, the wood is temporarily stockpiled in unloading locations until it is moved to the line production. Thus, there are 2 times where trucks wait, the entrance mill and the unloading locations. Consequently, the total time for completing the delivery service becomes huge. In addition, inefficiencies are identified when the material is often shifted. Finally, the needed space for both trucks and stockyards increases also the total cost of the mill.

This situation evidences the need for improving the entire reception process, which would be beneficial for both, the mill and the suppliers. In this context, collaboration might help to develop a better reception planning where all partners should be engaged from the beginning. The aim of this study is to apply the proposed framework in the particular case of a pulp Portuguese mill and its 10 major suppliers. Moreover, a survey is carried out to validate not only the proposed methodology but also the hypothesis on the role of collaboration in improving profitability in forest-based supply chains.

Input data to model the delivery planning is provided by the mill. It is assumed that the mill is the main client of the suppliers and that those suppliers are responsible for most of the mill's raw material supplies. The "key partner" in this collaboration case is the mill.

2. Framework application

As it was noted before, this research focuses on applying the proposed framework to the already presented case study in Marques et al. (2012). Thus some modifications have been proposed with the goal of guarantee the success of the collaboration. For example, the deliveries schedule did not take into account the suppliers' opinion before this application, while now the input information of the system is consensual among the mill and the suppliers. In addition, the proposed system did not foresee the need for specifying the incentives to motivate suppliers to be part of the collaboration, to deal with this a negotiation protocol has been provided to ensure the collaborative incentives for the mill and suppliers. Finally a new coordination mechanism has been design to support the information, decisions and financial flows. These improvements are presented in following sections.

2.1 Collaborative opportunities

As it has been exposed before, the key partner (i.e., the mill) realizes that the reception process is not optimal and wants to improve it by reducing reception time and cost. Thus, the collaborative opportunity in this case consists of a collaborative planning to reduce queuing time and total reception cost at the mill with mill and suppliers agreeing on the delivery schedule.

2.2 Collaborative strategy

The proposed and modeled collaboration corresponds to the joint decision level referred to earlier (Chapter 5, section 2). Partners exchange information weekly (week as the planning time horizon) on arrival times and agree on a delivery schedule. Afterwards, each partner develops each own plan. There is not need for third party, therefore the collaboration is decentralized.

In this study, a new coordination mechanism is proposed called "Joint shared decisions establishment". It is a variant of Joint plan establishment (Frayret et al., 2004) and encompasses information, decisions and financial flows for a complete definition of the collaborative strategy.

This mechanism consists of seven steps. The first one regards to the information about expected arrival times, in this study called "expected deliveries times". It is the input for the planning function (i.e., the proposed system) which later on provides a proposal schedule to support the decision made by the mill and its suppliers (agreed upon decision). The final schedule is called in this study "planned delivery times".

Next steps are out of the system but are still part of the collaboration. They refer to the development of individual plans, one by partner, the individual decisions concerning their resources and communication and financial flows.

Communication flow takes place during the delivery day, as truck arrives to the mill, the planner allocate a time slot equal to the planned if the truck is on time and different to the planned if it is late. Finally, payment for the service is provided to the suppliers who manage their own resources costs.

Below in the figure 6 and table 6, the scheme is described in detail.

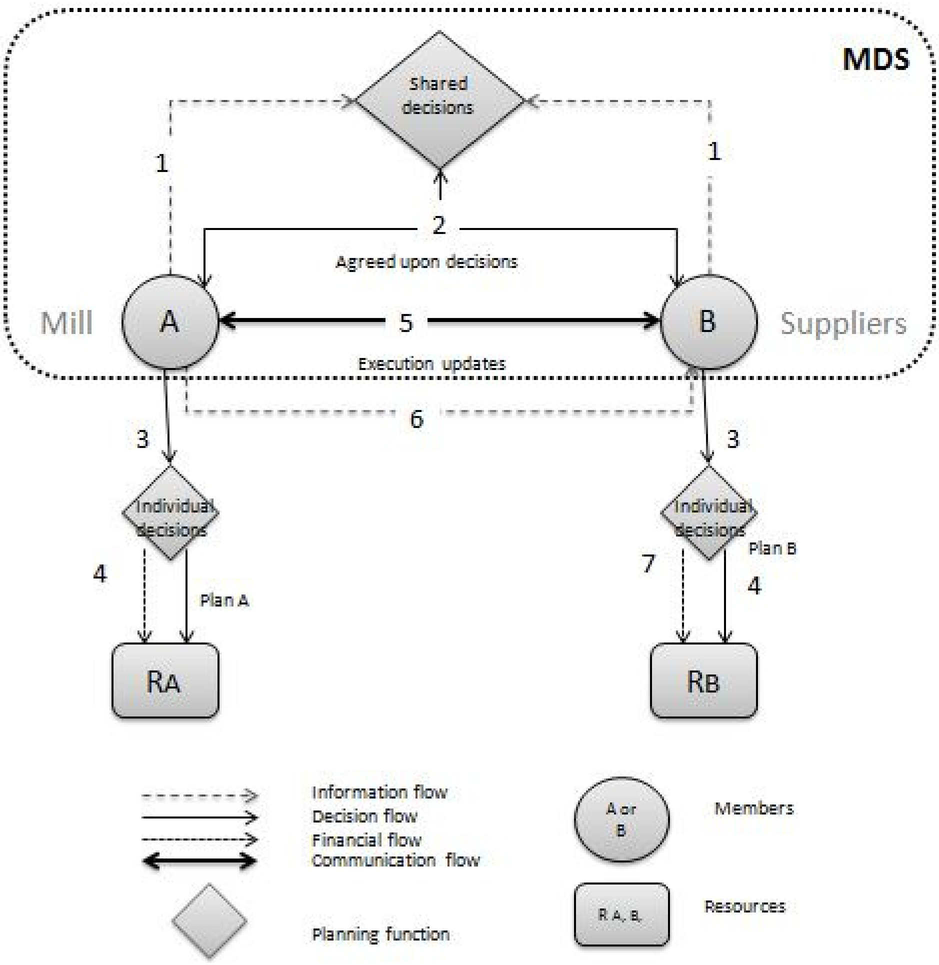

Figure 6: Joint shared decisions establishment

Step	Activity
1	**Information flow** • Suppliers inform about their expected arrivals • Mill informs about its needs
2	**Agreed upon decisions (feedback flow)** • Planner runs the model that makes a proposal of arrival time to each supplier • Suppliers accept or enter into negotiation • Decisions are about time and priorities allocation • Incentive is based on waiting time reduction • A compensation could be taken in case the agents do not agree in the arrival time of a truck and time reduction is not enough for motivating the supplier. It consists of an increase in the priority for future deliveries
3	**Individual decisions** • Taking the agreed decision from (2), each member develops its individual plan
4	**Decision flow** • Decision (through the plan) and payments are assigned to the resources of the mill. • Decisions about the resources of the supplier are made
5	**Communication flow** • Real time communication in dispatching process
6	**Financial flow (mill-supplier)** • Payment for the service
7	**Financial flow (supplier resources)** • Payment for the trucks

Table 6. Coordination mechanism process

The negotiation process

The negotiation process aims at achieving a consensus between the mill and suppliers on the anticipated schedule for a given week. The decision function considers the expected arrival time of each truck in such a way that, if planned and expected arrival times coincide, agreement is reached.

Similarly, if planned arrival time is higher (i.e., truck should arrive later) than the expected time but the departure time is lower (i.e., it departs earlier), the agreement is also reached. Moreover, same arrival time cannot produce higher departure time than the expected since the system assures a reduction of waiting time compare to the current situation.

Finally, it can be the case that both, planned arrival and departure times exceed the expected times. In this case, even though the waiting time at the mill is still reduced, a compensation can be provided to the truck in the form of a higher priority in future deliveries. Higher priority means then lower unloading queuing time.

The negotiation process is shown in table 7.

	A_v = A_v ^plan	A_v < A_v ^plan
B_v = B_v ^plan	Agreed	Agreed
B_v < B_v ^plan	Agreed	Compensation
B_v > B_v ^plan	No possible	Agreed

Where B refers to departure time (plan = planned or v = expected) and A refers to arrival time (plan = planned or v = expected).

Table 7. Negotiation process

For example:

The expected arrival time (A_v) of a given truck is at 8:00 and taking into account the current situation, the departure time (B_v) might be at 10:00. With the proposed collaboration and the applied optimization model, the proposed or planned arrival time (A_v ^plan) is 8:20 and the departure time (B_v ^plan) is 9:24. Since (B_v) is higher than (B_v ^plan) the agreement should be reached despite the arrival times are different.

<u>Benefit distribution</u>

The main benefit for the suppliers is the possibility to reduce the total delivery time by reducing waiting time at the mill. Additional benefits are better organization of their services, higher extent of services fulfilled in a given day and lower drivers' working hours per service.

The distribution of savings among suppliers is represented by time reduction which depends on the allocated priority to each truck. The priority is allocated as a function of historical behaviour of the carriers, its next scheduled trips for the same day and the freight/truck specific characteristics. Due to the fact that the most weighted criterion is the historical behaviour of carriers the distribution of savings is supposed to be fair.

Concerning the benefits for the mill, the improved reception planning allows to improve the stockyard operation planning (Marques et al., 2012), to improve production planning efficiency, to better asset utilization and fast response to unexpected or delayed deliveries. All these benefits might lead to a significant reception cost reduction.

2.3 Collaboration Implementation

In this study, a combination of optimization and simulation techniques has been implemented. The optimization problem addressed consists of ordering the trucks arriving at the mill and establishing the best unloading location for each truck while assuring continuous supply to the production lines (Marques et al., 2012). This problem is called the Raw Material Reception Problem (RMRP) firstly introduced by Marques et al. (2012). Simulation techniques are useful to visualize the process and thus to identify possible problems which might be avoid before the system is implemented. Moreover, the proposal addresses the savings distribution issue by providing a proper collaborative incentive that motivates drivers to arrive at the planned time as it was already explained in previous section.

The propose collaboration is applied to plan and dispatch 120 daily pulpwood deliveries. The results report more than 50% of reception cost reduction and an average of 54% of delivery time reduction with respect to the current situation.

In the next table 8 the results of delivery time reduction by supplier are shown. The numerical results correspond to the average of the delivery time taking into account the number of deliveries of each supplier.

Supplier	Deliveries	Current Delivery Time (min.)	Optimized Delivery Time (min.)	Time reduction (min.)
1	9	89,3	50,2	39,1
2	14	98,5	53,0	45,5
3	12	70,1	29,0	41,0
4	13	60,5	47,7	12,8
5	20	57,7	28,9	28,9
6	10	91,3	23,9	67,3
7	9	64,7	13,8	50,9
8	9	76,7	19,2	57,5
9	6	52,9	36,3	16,6
10	18	72,9	38,8	34,0
	Average	**73,5**	**34,1**	**39,4**

Table 8. Current delivery time, optimized delivery time and time reduction by supplier's delivery.

To provide these results, on time deliveries, delayed deliveries and unexpected deliveries have been considered in the model with the objective of being as much realistic as possible. In other word, the results represent a real situation in which not all the deliveries arrive according to the plan with the aim of simulate a more real situation.

The optimal planning process and dispatching is supported by the system Material Delivery System (MDS). This is a DSS which also provides real-time information and time slot allocation under arrivals uncertainty. Thus, the system acts as the implementing tool for the collaboration.

3. Empirical validation

In this section the information from the responses concerning collaboration issues is analyzed where this research has taken part. The corresponding questions are mainly in section 1.2 of the questionnaire available in the annex 2. Results regarding DSS architecture and its characteristics are out of the scope of this research and will be available in the paper to be submitted to the Decision Support System journal, this year 2014. The reference of this paper is Marques et al., 2014.

Answers to section 1.2 of the questionnaire are shown in figure 7. The question regards to the potential benefits that may be obtained through the implementation of the proposed system.

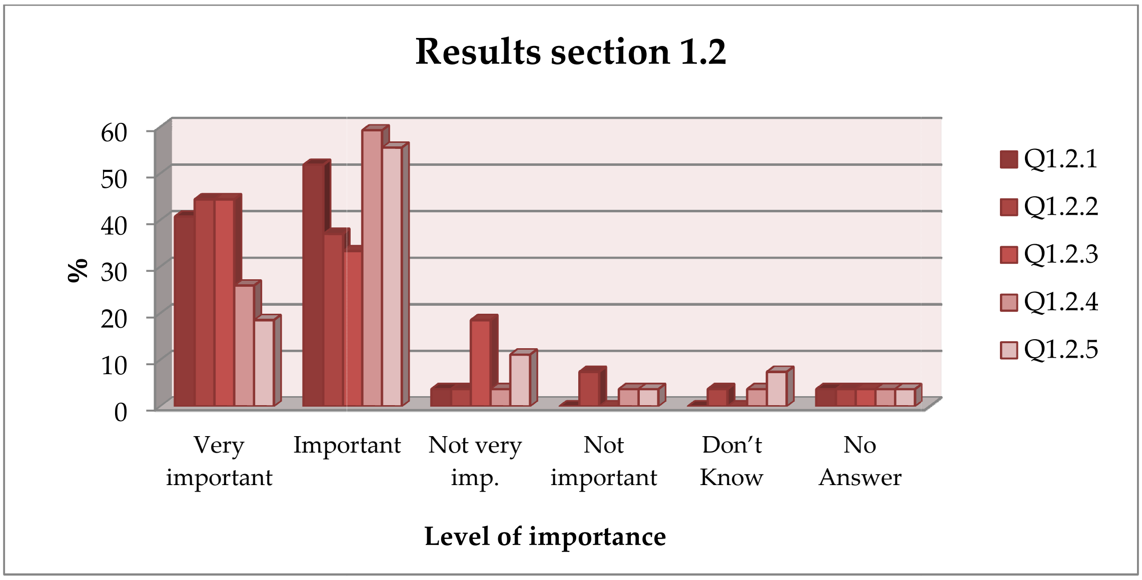

Figure 7. % of answers with respect to the importance level. Section 1.2

According to the participant' responses more than 40% of the participants consider the MDS very important with respect to the performance improvement for both, the mill and suppliers (40 and 44% respectively). Therefore, respondents tend strongly to believe that MDS is important for all the agents involved.

Participants also believe that productivity and collaboration might improve through the MDS by more than 55% of answers allocated to "important". It validates the hypothesis about the positive impact of collaboration in profitability and the importance of having proper techniques to carry out the planned collaborative strategy.

In general, the results validate first, the capability and potential of the presented MDS to support the proposed collaborative strategy. Secondly, it also validates the framework since the commitment of all the steps has allowed to build properly the collaboration, being feasible its implementation. The collaboration addresses all the identified issues; improves profitability, provides benefits for all the partners, supports implementation and real-time communication. Moreover, it enables re-schedule as a response of unexpected events and enhances trust and transparency. Developers, researchers and general users of DSS agree on the importance and completeness of the proposed tool to improve the reception problem at the mill.

Regarding the open questions about the main issues, advantages and disadvantages of the implementation of the proposed system, advantages such as friendly interface and the possibility to face unexpected situation at real time were identified by the participants. Lack of collaborative negotiation and lack of real time information for drivers were identified as the main issues of the proposed system. In this regard, the present work has dealt with the first issue since a negotiation protocol has been proposed as presented in section 2.2 of this chapter.

Finally, other issues might be dealt with, such as the application in more real cases or the implementation of a communication tool that allow drivers to know the situation at the mill or inform of any delay in advance. These issues are suggested for further research.

Chapter 7

Conclusions and further research

1. Conclusion

Collaboration in supply chain context may play an important role to become the forest sector more competitive. This study proposes a FSCC to support decisions upon collaborative strategies and to facilitate collaboration in practice. The framework consists of 3 phases that encompass the needed steps and decisions to design collaboration with the aim of improving SC efficiency and reducing costs. From the literature has been noted that examples of collaboration in forestry are scarce. Moreover, research is focused on horizontal collaboration to reduce transportation costs while other stages are poorly addressed. It is reported how complexity increases with the level and the size of the collaboration. Yet, significant advantages can be reached. According to the willingness to work jointly with others and the objective to achieve, higher levels such as joint planning may lead not only to reduce costs but also to open new market opportunities. From the workshops with end-users, collaboration has been identified as a possible solution to deal with existing problems in supply chain context and in particular in forestry (e.g., lack of transparency, better planning and better communication, higher resources efficiency). Companies are becoming aware of the advantages that collaboration can provide and are willing to participate. Yet, lack of common understanding of the concepts and methodological approaches to support collaboration in practice, makes hard for users to carry out with the implementation. This research aims also at solving this issue by proposing a conceptualization of collaboration concepts.

On the other hand, savings distribution has been identified as a key issue to implement collaborations among different entities. Motivation and fairness need to be clearly defined and accepted by all the members, otherwise the risk of failure rises. Previous research suggests the cooperative game theory to develop different cost/savings allocation methods that provide a suitable solution in each case. According to the characteristics of the collaboration, different properties can be applied such as individual rationality, efficiency, symmetric or additive. There is not an only mechanism to distribute savings, each case requires specific study to determine the most appropriated strategy and collaborative incentive that assures the feasibility and stability of the collaboration. The cost/saving allocation methods must be agreed by all the companies before the coalition is formed.

The last steps of the proposed framework refer to the implementation. In this regard, operational research has been used, although without making explicitly basic collaboration issues such as benefits distribution. Previous work has focused on developing integrated models to come up with a common solution for two or more activities within a supply chain. Yet, each agent needs to see their own profits improved. Computerized tools to implement final solutions are also necessary. The contribution of our research is twofold since first a conceptual map that provides common understanding of collaboration concepts is presented and, second a framework as a procedure to implement collaboration where the main issues are identified, is provided. Finally the application of the framework is presented to a vertical collaboration among a Portuguese mill and its suppliers. The three needed techniques are provided for planning, distribution of benefits and implementation. The latter is carried out through a DSS that encompasses the optimization process and the real-time schedule that enables fast responds to unexpected events. The system has been validated through a questionnaire. Results support the quality and usefulness of the system not only to improve deliveries planning but also to support the collaboration in place.

2. Further research

To reinforce the good results obtained in this study, further research for fostering collaboration in forest-based supply chain can be an opportunity to improve existing methodologies and/or implement collaborations in more field works. Some research opportunities are:

- Application of the proposed framework to different case studies. The proposed framework facilitates and encourages new research in this topic by applying in different cases.
- Explore different collaborative opportunities in other stages such as harvesting.
- Another interesting research to our knowledge not addressed yet in the literature is the issue of how to measure qualitative benefits. Research focuses on quantitative benefits which finally determine if the collaboration is accepted by agents or not, however a set of qualitative benefits are not measurable and could have an important impact.

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Annex

Annex I. Primary data of workshop 1

GROUP 1

Forest Planning		Harvesting		Wood logistic		Industrial processing		General	
Problems	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**
Input data from suppliers	Quality evaluation in tree before harvest	Lack of technology to automize and collect harvest data	Humidity percentage in raw material	Logistics of planks (cork)	Transport volumes(wl)	End-proc-cork; traceability; food contract (security of consumers)	Understand if there are alternative tools, cost effective, but high performants to do a specific task	How to collaborate?	Indicators (monitoring); activities; outcomes
Lack of Forest Planning and Control for Cork oak trees	Expedit forest inventory data	Temporary job (not invest in something for few days)	Traceability per product	wood trucks have other rules in the countries	Control wood flows		Need to acquire and collect data (temperature, raw material provenance, humidity, thickness, internal profile and quality, ?, tomography?	Changing requirements to the user interface/dash board application	How may test the data provide us for the dashboard????
Lack of sustainable harvest planning		Difficult equipment not damage tree	The owner from the harvester/forwarder must work transparently (for saw industry)	Trucks queuing	Control wood flows (wl)		Stock rotation (ip)		Indicators; objectives; tradeoffs
Abcenteeism lead by cork prices following		Workers don't even use telephone			Crews work (starting, ending)				
Profitability of forest cork		Resistance of workers to change							
Traceability of cork (all chain)		Traceability of the final product (one raw material---multipleproducts)							
Diseases of trees are not identified (cork)		Harvesting security and safe (of workers) cork							
Forest owners want advanced technology in their fields?		Theft of cork/wood in pile							
Lack of qualifications from people who work in Forest		Wood piles control							
Type of Forest		Lack of transparency part of the game							
Structure of the forest (mountains)		The same CAN-ID's for the data							

GROUP 2

Forest Planning		Harvesting		Wood logistic		Industrial processing		General	
Problems	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**
Owner structures	Communication	Cost-benefit, who pays, who gains (*)	Weather data (*)	Cost-benefit, who pays, who gains (*)	Weather data(*)	Dynamic models specifications (*)	What data is needed/useful to collect		
Society		Weather conditions (*)	Soil structure	Weather conditions (*)	Log pile app	Available data (*)	Dynamic modelling: available data, type of data, variables measures,…		
Knowledge of objects				Position of log piles	Road condition	Identification of suppliers			
Information about the current state				Forest road accessibility (curve radious, weight capacity)	Road network information + conditions				
				Lack of information from forest owners					
				Dynamic models specifications (*)					
				Available data (*)					

(*) Across themes

GROUP 3

Forest Planning		Harvesting		Wood logistic		Industrial processing		General	
Problems	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**
Need for more precise and detailed stand level data	Single tree information (Quality)	Piles management	Boundaries of stand for harvester operator	Not enough collaboration and standardization in logistics	Corks crop (extraction, quality,price,productivity)	Product mix (1 cork = 2500 product)	Cost calculation	Supply chain as a whole	Info on the current status of operations
Harmonization and integration of different time/space data	Distance to mill	Need for more precise and detailed stand level data		From which location came the wood received at the mill		Information flow for payment		Collaboration (Information exchange; Sharing problems, sharing solutions; sharing decisions	Assessing existing IT solutions
Collaborative planning in order to meet demand (medium term, long term)		Precise ecological data (soil, humidity) for operational machine planning		Lack of integration with different Supply Chain within the same plan (Wood products/non wood products)		Material requirements, e.g. moisture		Makes it possible to apply optimal solutions within the whole supply chain	
Connectivity between stategic-tactical and operational planning		Suitable Interfaces. Combining production data and bookkeeping		Unexpected events because of the weather conditions and natural disasters				Integration of small forest owners in the supply chain	
Restrictions, e.g.m project framework		Where are the harvesters		Network instead of a single line. Many small enterprises work for several mills and buy wood from different forest owners and from different areas				Qualification of the users (operators)	
Yield Forecast (crop =9 years)(1st chop =35 years)		What is the hourly productivity of a harvester		How to control wood flow to avoid queue at wood yard reception				Emergency/unexpected events management	
Uncertainty in demand		GSM availability		Long value chain = 2 years (what/how to buy cork)				Lack/gaps in communication	
What stands to cut (year1--year3)		GPS precision		How much wood is ready to transport in each stand? (and where)				GSM availability	
		Lack of integration of biological and technical production		GSM availability				Information sharing	
		Qualification of the operator		Inter-modality information				Data privacy vs supply chain collaboration	
		In small size forest, machinery for increasing productivity is too expensive - costs to be competitive ; costs of good technology		No flexibility in the plans/schedules (logistics)					
		Mechanization; today= specialized short on Herman R.							
		Quality of ????							
		Information about quality							

GROUP 4

Forest Planning		Harvesting		Wood logistic		Industrial processing		General	
Problems	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**	**Problems**	**Information**
Initial state of forest stands	Reliable and updated forest inventory data	soil damage and compaction	Volume, mass, grade...	Finding the piles/stocks	Right collection points and optimized routes	Production process (some steps of it) destroy tags (used 4 traceability); high temperatures/pressure	Traceability inside the factory (pulp production)	include considerations about risk and uncertainty	
Maximisation of potential profits while sustainably monitor the stands	Long, medium and short term planning possibilities	Automate processes	Real time status (wip, ...)	Information on forest road conditions not available (curve radius, weight limit, seasonal accessibility)	Reduction of empty runs of trucks	Shortage of data from former processes	Traceability for wood origin	Propagation of errors throughout the supply chain and impact on decisions	
Long time horizons; cause— effect	Multiple objectives; productivity, sustainability, ecosystem services	Data on log piles not electron available (place, volume, assortments) ???	Use of earth observation (remote sensing) to assess exploration rate (large assess)	Influence of weather conditions (humidity and temperature) on the wood (transportation, storage)	Amount of material to be collected in net	Wood place of origin is decisive on the full production process (quality, o&M costs, ...)	Quality parameters		
	Use of earth observation (remote sensing) as a cost-effective data source	Data Fusion (multidimensional sources of data)	Traceability	Allocation of wood to plants (space-time)	Wood truck schedules and forest navigation bases on different objectives (max.load, least emergy conditions, emissions, ??	Obtain data on available stocks and prices to optimise the supply of the raw material	Mathematical models to predict pulp quality and adjust O&M accordingly		
	Pulp and paper industry feedback onfo??? could improve planning	Cost effective technology (e.g. Sensoring)	Place of origin (to be furworded in the process, ...)	Finding smarter ways to optimise stocks)	Historical data for temperature and humidity	Data correlation with lots of process variables –data mining (pulp industry)	Individually associated data for wood		
		Linking harvesting to planning, logistic and demand for the stands	Real time information on soil status, ...)				Residue management		
		Quantity and evaluate quality	Early quality information on the harvested stands						
		Information on loggings residues (as a by-product of round wood loggings); not available (amount, place)	Quality assessment						

Annex II Questionnaire

Empirical validation of the MDS Material Delivery Decision Support System

Your profile:					
What is your main working activity?	☐ Researcher/Professor ☐ Forest/ Wood supply planner	☐ Forest-based industry ☐ Wood carrier			
	☐ Other:_ ______ ______ ______ ______ ____				
Country?					
Do you regularly use DSS or other computerized-tools in your working activities?	☐ No ☐ Yes, please state which tools and type of utilization:				
How familiar are you with the process of delivering wood to the mill?	++	+	-	--	Don't know
	☐	☐	☐	☐	☐

DSS impact in decision-making:	++	+	-	--	Don't know (DK)
How important is this DSS for improving the <u>process</u> of delivery planning and decision making in respect to...					
... better understand the decision problem (goals, inputs, outputs)?	☐	☐	☐	☐	☐
... better understand the decision alternatives addressed as scenarios?	☐	☐	☐	☐	☐
... help to evaluate new alternatives and reaching to a better decision?	☐	☐	☐	☐	☐
... help all the parties involved in implementing the best solution?	☐	☐	☐	☐	☐
... support the evaluation of the implemented solution and make changes if necessary?	☐	☐	☐	☐	☐
How important is this DSS for improving the <u>outcome</u> of delivery planning and decision making in respect to...					
... improve performance of the mill (better resource utilization, decrease wood handling cost,...)	☐	☐	☐	☐	☐
... improve performance of the supplier (decrease the truck's waiting time at the mill, improve level of service and satisfaction,...)	☐	☐	☐	☐	☐
... reduce time needed for planning and improve real-time response?	☐	☐	☐	☐	☐
... improve productivity, knowledge and maturity of planners?	☐	☐	☐	☐	☐
... better collaboration environment (trust, transparency, accountability)?	☐	☐	☐	☐	☐

DSS architecture:	Importance	Complete								

		n e ss								
	++	+	-	--	DK	++	+	-	--	DK
How important and how good is the current implementation of the following DSS characteristics:										
Graphical User interfaces for inputting data and consult results: informative, simple and easy to understand?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Web-based application, built upon open-source technologies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Optimization module for providing optimal delivery schedules: provides quick and accurate results?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Workflow for automatically handling the deliveries lifecycle	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Capable to provide support to distinct roles (planner, carrier, receptionist), enable data exchange and foster collaboration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Integration with simulation software for anticipating the performance of the delivery process during plan execution	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Enable "what-if" analysis (i.e. making hypothetical change to problem data and observing impact on the results)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Support real-time monitoring of the operations execution	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Automatic and instant messaging to users (by e-mail, SMS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Open to integration with the companies' systems (ERP, GIS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Possibility to include other optimization modules for planner and suppliers (e.g. routing, wood procurement planning)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DSS help, and user support material	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Can you enumerate the 6 major issues that may affect the uptake of this DSS by practitioners?

Open Question: What are your general comments about the advantages and disadvantages of this DSS and its practical impact?

Date:

Thank you for your valuable opinion!
If you are interested in updates about this work, please provide your **name** and **e-mail:**

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