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BUSINESS MODELS FOR COLLABORATIVE PLANNING IN TRANSPORTATION: AN APPLICATION TO WOOD PRODUCTS

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Transportation is an important part of the wood fibre flow chain in forestry. There are often several forest companies operating in the same region and co-ordination between two or more companies is however rare. Lately, the interest in collaborative transportation planning to support co-ordination has risen since important potential savings have been identified. Even though substantial savings can be realized, it seems that companies' willingness to collaborate is tightly linked to a business model driven by one or many leaders. In this paper, we study a specific business model where one company leads the development of the coalition. The impact of different behaviours of the leading company (i.e. altruistic, opportunistic) is illustrated using an industrial case study of eight forest companies.

1 INTRODUCTION

Transportation is an important part of the wood fibre flow chain in forestry. Large volumes and relatively long transport distances together with rising fuel prices and environmental concerns raise the need for improved transportation planning.

Typically, several forest companies operate in the same region. Harvest areas supply mills that transform the round wood into a basket of end-products (e.g. lumber, veneer) as well as by-products (e.g. chips, sawdust). All of these are then shipped to other mills for further transformation (e.g. engineered wood products or pulp and paper). However, co-ordination between two or more companies is rare, even when supply, demand and mills are evenly dispersed geographically within a region.

Lately, the interest in collaborative transportation planning to support the co-ordination of the wood fibre flow has risen, since important potential savings have been identified, often in the range of 4-7%. Examples of such collaborative

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transportation planning that have improved transportation efficiency are found in (Forsberg et al., 2005). In many of the case studies, the savings are defined as the difference between the cost of the collaborative plan (i.e. all companies together) compared with the sum of the cost of each individual plan (i.e. each company alone).

Even though collaboration can provide substantial savings, it seems that companies' willingness to collaborate is tightly linked to the business model driven by one or many leaders. These leaders aim at building the coalition (participants and savings sharing model) that will provide them with the best returns.

In this paper, we first present a general framework for collaborative transportation planning. We discuss how the leadership of the coalition can be assumed, how the participants in a coalition are selected and how the savings are shared. The core of the paper refers to a set of specific business models where one forest company leads the development of the coalition. The impacts of different savings sharing approaches (i.e. altruistic, opportunistic) on the coalition are illustrated using an industrial case study of eight Swedish forest companies.

2 TRANSPORTATION PLANNING

Transportation planning in forestry is done in several steps and is commonly managed according to four time perspective horizons: strategic, tactical, operational and real-time. Decisions at the strategic level often deal with silviculture (defining prescriptions), wood procurement and road upgrade/building/maintenance considerations. Tactical decisions mainly address planning issues from one week to one year. On an annual basis, transportation is often integrated with harvesting planning, deciding on the catchments areas to supply the mills with the right wood assortments (depending on e.g. species and dimensions). A problem which often ranges from one to several weeks is deciding the destination of logs, that is, which supply point(s) should deliver to which demand point(s) in what volume. Operational decisions concern the planning of the entire route schedule for each individual truck for one or many days. Real-time decisions concern the planning of the next route of one truck in the present situation (i.e. when a truck completes a route) instead of the predicted one.

In the case study used below, we will focus on a tactical problem [TP] that deals with transportation of logs from harvest areas/terminals (supply points) to mills/ terminals (demand points). A complete description of this problem and its linear programming (LP) formulation is found in (Frisk et al, 2006). In this problem, the savings from collaborative planning derives from two co-ordination opportunities: wood bartering and backhauling. In wood bartering, volumes of some supply points are exchanged between the companies to reduce the total travel distance. Backhauling is used to find better routes by combining transport orders of different companies. The use of backhaulage tours can decrease the transportation cost, savings between 2% and 6% are reported in different case studies, see (Carlsson and Rönnqvist, 1998) and (Gingras et al., 2006).

3 TRANSPORTATION COLLABORATION FRAMEWORK

3.1 Leaders of the coalition

We denote by coalition a set of stakeholders, customer(s) or/and carrier(s), disposed to co-ordinate their wood flow by collaborative planning. We denote by player each of these stakeholders and, consequently, a coalition must include at least two players. To implement the collaborative planning between these players, we need to build a coalition. From a business point of view, one or a set of the players will lead in the creation of the coalition. We identify here six different types of leadership:

#1 A customer leads the coalition: it aims to minimize its transport costs by finding other customers that can provide a good equilibrium (geographical, volume and time) between supply and demand. An example of this, are the forest companies Holmen Skog (HS) and Norra Skogsägarna (NS), who are using the decision support system ÅkarWeb (Eriksson and Rönnqvist, 2003). Via some carriers of the NS player, the leading player, HS, takes advantage of certain backhaulage tours.

#2 A carrier or 3PL leads the coalition: it aims to maximize its profit by a better usage of its carrying capacity. An example is the Swedish forest product carrier Skogsåkarna or the worldwide transporter Ryder in general freight transport.

#3 A fourth party logistics provider, 4PL, leads the coalition: its aims to minimize/maximize the cost/profit of these customers/carriers by finding for each of these customer/carrier the more "compatible" carrier(s)/customer(s). An example of a typical service offered by a 4PL is the e-marketplace of a Nistevo network.

#4 Customers share the leadership of the coalition: they aim to minimize their transportation costs. An example is the regional wood log buyer network of the Canadian wood log supplier Groupe Transforêt, using the decision support system VTM prototype, see (Audy et al., 2006). Another example is the Swedish company Sydved who organizes the purchase and the transport of logs for its owners, the forest companies Stora Enso and Munksjö.

#5 Carriers share the leadership of the coalition: they aim to maximize their profit by a better usage of their carrying capacity. An example is the Canadian TransForce Income Fund that invests in independent carriers and uses its capacities of analysis to implement transport synergies between the carriers. Another example is the Swedish logging and transportation company VSV who collaborates in its transport operations with other carriers.

#6 Carrier(s) and customer(s) share the leadership of the coalition: they aim to minimize their transportation costs by using the carrying capacity of the carriers. No example of this can be found at this present time.

3.2 Building the coalition

If we disregard external business considerations, the basic rule of adding a player p to a coalition c is if the player p increases the *benefit* of the current coalition c. The *benefit* of a coalition *c*, denoted B^c, is defined as the difference between the value of the collaborative plan including all players in the coalition *c*, V^c, compared to the sum of the values of the individual plan of each player *p* in the coalition *c*, $\sum_{p\in N} V_p$ where *N* is the set of the players in the coalition *c*. In a minimization objective context, the benefit refers generally to the savings whereas in a maximization context they refer to a profit. The tactical problem [TP] used in the case study of this paper is in a minimization context, therefore, the values of collaborative and individual plans are defined as costs while the coalition benefit is defined as a saving.

Coalition *c'* will be created if more benefit can be generated by adding player *p'* to coalition *c*. Let's denote $M^c_{p'}$ the marginal increase of the benefit of coalition *c* when player *p'* is added to form coalition *c'*. On the other hand, any player *p* already in a coalition *c* who does not contribute to the benefit of this coalition *c*, should be removed. Let's denote C^c_p the *contribution* of player *p* to the benefit of coalition *c*.

Although the addition of a player to a coalition can provide a benefit, it seems that the players' willingness for the collaboration is tightly linked to the business model of the coalition that is driven by one or several leading players. These leading players aim at building the coalition in such a way that they will maximize their returns while providing enough incentives to the others to keep them in the coalition. Let's denote this return by I^c_p, the *incentive* of player *p* and set the benefit of a coalition as the summation of all its players' incentives.

In this paper, the add/remove rules are therefore based on the benefit to the leading players of the coalition *c*, BL^c, as opposed to other approaches which could base the rules on the contribution to the benefit of the total coalition B^c. With that perspective, let's denote $ML^c_{p'}$ as the marginal increase of the leaders' benefit when player *p'* is added to coalition *c* to form coalition *c'*. Also, let's denote CL^c_p the *contribution* of player *p* to the benefit of the leading players in the coalition *c*.

There remains an exception. Thus, a player who contributes to the benefit of the coalition but not to the benefit of the leading players will be kept in the coalition if and only if its removal reduces the incentive of at least one of the leading players.

3.3 Sharing the benefit of the coalition

Collaboration raises the following question. How should the benefit of a coalition be shared between its players? As suggested by (Frisk et al., 2006), this issue could also be addressed by using a *cost allocation approach* instead of a *saving allocation approach*. In other words, instead of splitting the coalition's benefit (i.e. the saving in the case study used below) among the players, the value of the coalition's collaborative plan (i.e. the cost in the case study) could be split between the players. Thus, the incentive of a player to remain in a coalition is the difference between the player stand alone cost and its allocated cost when a cost allocation approach is used, and the allocated saving when a saving allocation approach is preferred.

The core of this paper refers to the study of a series of business models in which one player, a customer, leads the creation of the coalition. The leader decides, one by one, which player should enter the coalition and when. The leader proposes a method to share the benefits of the coalition among the participants.

In this paper, we explore two different sharing methods for both the cost and savings allocation approaches and show how coalitions may differ, one from another. Thus, in the two allocation approaches, a sharing method is adapted to imitate the altruistic and opportunistic behaviour of the leading player. First, an altruistic behaviour is simulated. For the cost allocation method, the leader shares among all the players the coalition benefit of the new coalition obtained by adding a new player. For the saving allocation method, the leader shares among all the players only the marginal benefit obtained by adding a new player. Secondly, an opportunistic behaviour is simulated. In this case, for both the cost and the saving allocation methods, the leader shares the marginal benefit obtained by adding a new player with the new player only.

In the four sharing methods tested, the cost/saving allocation is based on the stand alone weighted cost of each player in the coalition. This allocation method is easy to understand and to compute. Several cost/saving allocation methods exist in literature, mainly under the term cost allocation methods. An extensive list of literature papers on cost allocation methods based on game theory can be found in (Tijs and Driessen, 1986). The computing and analyze of some cost allocation methods on the case study used below is presented in (Frisk et al., 2006). A new method that allows a proportionally equal incentive to each player is also proposed in (Frisk et al., 2006).

In contrast with these papers, the aim in this paper is to demonstrate through a simple allocation method how under a coalition leader's behavior it can affect the cost/save allocation among the players as well as the development and the size of the coalition. Thus, the cost/saving allocated to a player depends on the business model as well as on the cost/saving allocation method. The same exercise could be achieved with more advanced allocation methods.

3.3.1 Business model 1: altruistic cost allocation method

In this model, each time a new player p' is added to the coalition, the new coalition cost is reallocated to each player of the new coalition. The coalition cost is spilt according to the proportion of the player's stand alone cost on the sum of all the players' stand alone cost in the new coalition. This means that the incentive of the players in the coalition changes as new players enter.

3.3.2 Business model 2: opportunistic cost allocation method

In this model, each time a new player p' is added to the coalition, the cost allocated to the leading players is recomputed. In contrast with the previous model, the cost allocated to a non leading player is computed only once, that is, when it is added to the coalition. This means that, once a non leading player is in the coalition, its incentive remains constant even with the addition of new players.

For each new coalition, the cost allocation is computed in three steps. First, the part of the new coalition' cost that is allocated to the new player p' is computed according to the proportion of the player's p' stand alone cost on the sum of all players stand alone cost in the new coalition. Second, the remaining part of the new coalition cost is calculated by withdrawing the part of the new coalition cost allocated to the new player in the first phase and also all the parts of coalition cost allocated to the non leading players in the previous coalitions. This remaining cost is then divided among the leaders according to the proportion of the leading player alone cost on the sum of all the leading players stand alone cost.

3.3.3 Business model 3: altruistic saving allocation method

In this business model and the following one, instead of using a cost allocation approach as in the two previous business models, we adopt a saving allocation approach. Thus, it is the marginal increase in the benefit (i.e. the saving in the case study used below) of coalition c when player p' is added that is divided among all the players, leader or not, in this new coalition c'. This means that, once a player is in the coalition, its incentive increases each time a new player is added to the coalition. The split of the marginal benefit is computed according to the proportion of player's p' stand alone cost on the sum of all the players' stand alone.

3.3.4 Business model 4: opportunistic saving allocation method

In this business model, the marginal increase in the benefit of coalition c when player p' is added is split between the leading players and the new player p' only. Similar to business model 2, this means that, once a non leading player is in the coalition, its incentive remains constant even with the addition of new players.

The split of the marginal benefit is computed in three steps. First, the part of the marginal benefit given to the new player p' is computed according to the proportion of the player's p' stand alone cost on the sum of all players, including player's p' stand alone cost. Second, the remaining part of the marginal benefit is computed by withdrawing the part given to the new player p'. Finally, this remaining part of the marginal benefit is divided among the leaders according to the proportion of the leading player alone cost on the sum of all the leading players stand alone cost.

4 FORMING SUSTAINABLE COALITION

One of the key issues for the leading players of a coalition is the development of a coalition that will provide the greatest return. In order to study this issue we address the development of a coalition as a step-by-step process where one player at a time is added to the coalition. In this process, it is assumed that all players have the opportunity to join and collaborate in the coalition but it is the leading players who decide which player should be added at which step. Also, it assumes that once a player is in the coalition, it is the leading players only who can decide to remove the player and only one coalition can be created. This step-by-step process allows us to evaluate, for the four business models described above, the impact on the leading players' incentive of the sequence in which the non leading players are added to the coalition.

The leader can develop its coalition in various ways. However, in practice, evaluation of the potential for collaboration is often realized between two companies at one time only (e.g. wood bartering). Each company uses its internal planning system to anticipate the potential benefit of the collaboration without revealing it to the other company and to negotiate a possible collaboration agreement. The main reasons why the information about the potential benefits are not shared are that the information may include sensitive business information and provide insights that could substantially affect the cost/save allocation. It appears realistic to suppose that collaboration with another company can also be evaluated on a "two companies basis" while considering the collaborating companies as one. Then, all the companies can negotiate a new collaboration agreement with the new company with or without modifying the previous collaboration agreements.

We can formulate the development of a coalition as a longest path problem (LPP). Given a network of oriented vectors from node *i* to node *j* with each a length value, the objective of the LPP is to find the longest path in the network to reach a sink node *0** starting by a source node *0*. The indexes, sets, parameters and decision variables used in the linear programming formulation are defined in Table 1.

Table 1: Indexes, sets, parameters and decision variables

Indexes	
i	: an arrangement of coalition i
j	: an arrangement of coalition j
0	: the pseudo-player source
0^*	: the pseudo-player sink
Sets	
I	: set of all arrangements of coalition without the pseudo-player sink
J	: set of all arrangements of coalition
Parameters	
$M_{i,j}$	: marginal incentive increase of the leader(s) from coalition i to j
Decision variables	
$X_{i,j}$	: 1 if we develop coalition j from coalition i, 0 otherwise

The problem can be formulated as a LP model :

$$[\text{P}] \quad \text{MAX} \sum_{i\in I}\sum_{j\in J} X_{i,j} M_{i,j}$$

s.t.

$$X_{i,j} - \sum_{j'\in J} X_{i=j,j'} = 0 \quad \forall i \in I, \forall j \in J \tag{1}$$

$$\sum_{j\in J} X_{0,j} = 1 \tag{2}$$

$$\sum_{i\in I} X_{i,0^*} = 1 \tag{3}$$

$$X_{i,j} \in \{0,1\} \quad \forall i \in I, \forall j \in J$$

In this context, a node represents an "ordered" coalition, e.g. the coalition "1,2" is different from the coalition "2,1" even if they have the same set N of players. The sequence in which the players are added to the coalition refers to an arrangement. The vector value represents the marginal increase in the incentive of the leading players to develop a new coalition c' by adding a new player p' in the coalition c. The value of the vector is computed according to a specific business model. All vectors starting from the pseudo-player source or arriving at the pseudo-player sink have a null marginal incentive increase. The objective is to find the coalition arrangement that allows the total maximal incentive to the leading players. The leaders' incentive is the sum of each of the vector values of the path traversed in the network from the pseudo-player source to the pseudo-player sink. The constraints (1) ensure that the development of the coalition is made by adding players to the coalition one by one. The constraints (2) and (3) ensure that only one coalition is created.

5 NUMERICAL RESULTS

The data used has been taken from a case study done by the Forestry Research Institute of Sweden for eight participating forest companies. The case represents a total of 898 supply points, 101 demand points and 12 wood assortments (depending on e.g. species and dimensions). The companies are uneven in volume transported.

For all the *combinations* of coalition of 2 to 8, the tactical problem [TP] has been solved. In contrast to an arrangement, in a *combination* the order of the players in the coalition has no importance. Thus, we obtain the cost (V^c) of 247 combinations of coalitions. To define the stand alone cost (V_p) of each player, the tactical problem [TP] was solved for each company solely. Then, the values of B^c, M_p^c and C_p^c have been computed for each of the potential coalitions.

For the four business models, the values of BL^c, CL_p^c, I_p^c and ML_p^c have been computed for all the 109 592 possible arrangements of the 247 combinations. This case study is smaller however, since it focusses only on the context where company 2 leads the creation of the coalition. Consequently, the number of combinations considered is 120 while the number of arrangements is 13692.

In business model 1, it is the presence of the player in the coalition which will enable it to have a positive incentive. For business model 1, the leader best coalition brings together all players, except player 1. Thus, by driving the selection of the players in the coalition to its own advantage, the leader obtain an incentive of 9,5% (i.e. a reduction of 9,5% on its stand alone cost, a saving of $1,400,518.81). Player 1 is the big loser of business model 1 even if its addition to the coalition would increase the coalition benefit by 7%. However, it was not chosen because its addition would reduce by 2,2% the incentives of the other players, more specifically player 2 would loose $30,731.89. In a situation in which the excluded player 1 has, for any reason, a strong influence on the leading player 2, it is highly plausible that player 1 will use its influence to join the coalition. To maintain its incentive, the player 2 must negotiate with player 1 by allowing it an incentive equal or smaller to the marginal increase of the coalition benefit. By accepting an incentive equal to the marginal increase of the coalition, the player 1 obtains 76,2% (a loss of 80,819.99$) of the incentive that he would have obtained without the leadership of the coalition by player 2.

In opposition to business model 1, the order in which the players are added in the coalition have an influence on the players' incentive for business models 2, 3 and 4. Thus, the leader best coalition for these models is the arrangement providing the highest incentive for the leader. In order to show the impact of the arrangement, the leader best coalition is compared to the leader worst coalition. The leader worst coalition regroups the same set N of players that found in the leader best coalition but in a different arrangement which results in a lowest incentive for the leader.

Using business model 2, the leader best and worst coalitions have been computed. By following the best coalition arrangement (i.e. player 1, 5, 8, 4, 6, 7 and 3) instead of the worst one (i.e. 3, 7, 8, 4, 1, 6 and 5), the leader obtain an additional saving of 4,5% ($668,752.06) on a total saving of 16,2% ($2,383,787.82). In comparison to the leader altruistic behavior of model 1, the leader opportunistic behavior in model 2 allows the leader to obtain an additional saving of 6,7% ($983,269.01).

In business model 3, the leader best and worst coalitions have been computed. By following the best coalition arrangement (i.e. 3, 7, 8, 4, 6, 5 and 1) instead of the worst one (i.e. 5, 1, 6, 8, 4, 7 and 3), the leader obtain an additional saving of 2,9% ($426,256.47) on a total saving of 15% ($2,201,067.33). In business model 4, the best coalition arrangement (i.e. 4, 1, 6, 3, 8, 7 and 5), instead of the worst one (i.e. 3, 5, 6, 7, 4, 1 and 8), allows the leader to obtain an additional saving of 1,1% ($161,355.49) on a total saving of 22,3% ($3,282,559.05). In comparison to the leader altruistic behaviour of model 3, the leader opportunistic behaviour of model 4 allows the leader to gain an additional saving of 7,4% ($1,081,491.72). In all the tested models, business model 4 is the more lucrative for the leader: he obtain an incentive equal to 83,3% ($3,282,559.05) of the higher coalition benefit which could be obtained by a eight players coalition.

6 CONCLUDING REMARKS

It has been shown that collaboration in transportation can provide savings. There exist decision support systems that can establish the collaborative transportation plans. These systems however raise the question of how to share the obtained benefit? Several business models for the implementation of collaborative planning in transportation were considered in this paper. The leader role for building the coalition is discussed and six different leading approaches are described. Using a case study of eight companies, four specific business models, all driven by one leading company, are tested and numerical results are discussed. The impact of two different behaviours of the leader is studied under two approaches of benefit sharing. The first one is based on the allocation of costs while the second is based on the sharing of the savings.

The business model approach allows the integration of practical considerations (e.g. the leadership position of some players compared to others and their behaviours) in defining the cost/saving allocation method as well as the coalition creation process (e.g. development and size). However, it was shown that in a group of stakeholders, a business model could lead to coalition who is not catching all the economical potential of the group. More research works must be achieved on different coalition building process and business models to study their influence on the leaders' incentive and the achievable of all possible saves. Also, the sustainability of the coalition must be studied taking into consideration the risk for the leaders that one player leave the coalition. Another issue to be addressed relates to temporal aspects and their impact on the development of the coalitions. Finally, the advantage for a company to join more than one coalition by splitting its demand/supply should be investigated.

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