54

IMPACT OF BENEFIT SHARING AMONG COMPANIES IN THE IMPLANTATION OF A COLLABORATIVE TRANSPORTATION SYSTEM - AN APPLICATION IN THE FURNITURE INDUSTRY

Jean-François Audy[1] and Sophie D'Amours[2]

1 Doctoral Student, Department of Mechanical Engineering, CIRRELT, FORAC Research Consortium, Laval University, CANADA, jean-francois.audy@cirrelt.ca

2 Professor, Department of Mechanical Engineering, CIRRELT, FORAC Research Consortium, Laval University, CANADA, sophie.damours@forac.ulaval.ca

Transportation has become an increasingly important part of the Canadian furniture industry supply chain. Even when different furniture companies ship to the same regions, the same cities and/or the same furniture retailers, coordination between two or more companies is rare. Recently, interest in collaborative transportation planning to support coordination has intensified as important potential benefits (e.g. cost and delivery time reductions) have been identified. Even though substantial benefits can be realized, the methods for sharing benefits among companies as well as the leadership of the collaboration implementation are key issues in deciding on a logistics scenario for the collaboration. In this paper, the impacts of these two key issues are illustrated using an industrial case study of four Canadian furniture companies shipping to the United-States.

1. INTRODUCTION

With 95-96% of the total export value over the last decades (IC, 2008), the main export market of the Canadian furniture industry is the United States. As neighbouring countries, most deliveries are done by truck over long distances. In 2006, the exportation value was $CDN 3.9 billion, a decrease of 6.9% of the historical peak in 2000, while the total export value of furniture in US rose by 173% (ITA, 2008). Increased competition from countries with low production costs, mainly China, together with escalating fuel prices and environmental concerns have created the need to improve transportation efficiency.

Last year's appreciation of the Canadian dollar against the US dollar as well as the request of furniture retailers to reduce delivery time have also added extra pressure on the Canadian furniture industry supply chain. Efficiency, velocity and flexibility of transportation operations form part of the essential elements in attaining the characteristics of the furniture manufacturer of the future described by (Archambault *et al.,* 2006).

However, even when different furniture companies located in the same region ship to the same market regions, the same cities and/or the same furniture retailers,

Please use the following format when citing this chapter:

Audy, J.-F. and D'Amours, S., 2008, in IFIP International Federation for Information Processing, Volume 283; *Pervasive Collaborative Networks*; Luis M. Camarinha-Matos, Willy Picard; (Boston: Springer), pp. 519–532.

coordination in the transportation operations between two or more companies is rare. In the furniture industry of the Canadian province of Quebec, which employs a third of the work force in the furniture industry in Canada (MEDIE, 2007), the interest in transportation operations coordination by collaborative planning has heightened as significant potential benefits have been identified in two recent internal studies (Audy, 2007) and (Audy *et al.*, 2008).

By exploring different logistics scenarios allowing collaborative transportation planning among a group of furniture companies, cost and delivery time reductions have been identified as well as gain in market geographic coverage. Even though a logistics scenario of collaboration can provide substantial benefits for the group, each company will evaluate a scenario in regard of its own benefits. Some benefits are computed according to a sharing rule which divide among the companies the group benefit, therefore using a given rule instead of another have an impact on the appreciation level of each scenario by each company. Consequently, the implementation of the collaborative transportation planning implies both, a decision on the logistics scenario as well as a decision on the sharing rule(s). In this paper, we study a set of situations in which the leadership of the collaboration is assumes by only one company.

In this paper, we first introduce in section 2 the transportation planning problem studied in the context of the Canadian furniture industry. Then, in section 3, we present a general framework for collaborative transportation planning. We discuss the benefits of collaborative transportation planning and how they can be shared. We also present a set of four logistics scenarios allowing an implementation of collaborative transportation planning in an industrial case study of four furniture companies. In section 4, the numerical results obtained on each of the logistics scenarios are presented. The core of this paper refers to Section 5 in which the impact of different benefit sharing methods as well as the implementation leadership is illustrated and discussed using the case study. Finally, concluding remarks are provided.

2. TRANSPORTATION PLANNING

In the Quebec's furniture industry, most customer orders are less-than-truckload size shipments and are delivered by truck to the furniture retailers. Some companies' ship palletized disassembled furniture while others, such as the companies in the case study, ship assembled furniture inside cardboard boxes. For the latter, the volume of the trailer is the capacity limit rather than the weight. The maximum volume is variable depending on the assorted boxes' dimensions and the skill of the loading staff. In the case study, the limit has been fixed around a conservative volume of 2900 cubic feet and all cardboard boxes of an order must be carried together in order to visit the customer only once.

Even when the furniture company is make-to-stock or make-to-order, furniture companies realize their transportation by a carrier operating mainly according to one of the two following modes.

The first mode is multiple-stop truckload (TL) operations. The TL carrier delivers a trailer to the shipping dock of the furniture company who loads the trailer with many shipments. Occasionally, only one shipment will fill the trailer but, on average, 9 to 21 shipments are needed to do so. Soon after the trailer is loaded, a driver of the TL carrier will leave for the destination of its first customer delivery. Since the shipments are not handled again before their delivery to the customer, the loading of the trailer must respect the 'First In, Last Out' constraint: the sequence of the deliveries of the shipments is the reverse of the sequence of the loading of the shipments in the trailer.

Thus the loading decisions are tightly linked to the truck routing decisions. Efficient planning is a key issue for short delivery time and reduced cost. This planning is commonly done on a weekly basis by the furniture company. Each planned route must respect operational constraints such as the driver's hours of service regulations (i.e. working/driving time daily limits and minimum daily rest time) and the business hours of the customers. The cost of a route is proportional to the total one-way traveling distance (i.e. from the dock of the company to the last customer delivery including all intermediate stops) with specific traveling distance rates by destination zone (i.e. the states of the last customer delivery). A cost by intermediate stop, a cost for customs documentation preparation and a fuel surcharge is also charged on each route.

The second mode is less-than-truckload (LTL) operations. The LTL carrier always keeps a trailer at the furniture company in order to allow the company to load its shipment as it is ready. Each day or so, the carrier comes with a new trailer and leaves with the previous one to collect these shipments and bring them to its terminal. The LTL carrier handles these transportation/consolidation operations with many furniture companies in order to consolidate a large number of shipments at its terminal and in order to achieve truck routing planning several times a week and dispatch drivers regularly. After a shipment has been collected at the company, the LTL carrier guarantees its delivery inside a specific time range by destination zone. The increase of potential damage due to additional orders handled is a disadvantage of the LTL mode.

Without being concerned with the planning, the furniture company is charged on each of its shipments rather than on a route basis. The cost is proportional to the shipment volume, with specific rates by volume range and destination zone. The cost of shipment is subject to a minimum charge in addition to a fuel surcharge. The rate table structure of LTL carrier enables computing the cost of a shipment to the advantage or the disadvantage of the shipper, see e.g. (Klincewicz and Rosenwein, 1997) and (Caputo *et al.*, 2005). The first is applied in the case study as this is the present situation for one of the companies.

When it is really cost-effective and the customer allows it, a furniture company operating with the first mode could use a regional LTL carrier. In this case, rather than planning the shipment delivery up to customer location, the delivery is planned up to one of the regional LTL carrier terminals who offers the service to the customer (e.g. within a radius of 200-300 Km). In the case study, the regional terminals network of the North American carrier USF (www.usfc.com) has been used as a base. The cost charged by a regional LTL carrier is usually proportional to the shipment weight and subject to a minimum charge in addition to a fuel surcharge.

3. TRANSPORTATION PLANNING

Actually, the companies in the case study realize their transportation operations with the carrier/mode they judge to be more beneficial for them. (Caputo *et al.*, 2005) report that although different criteria may influence the selection of a carrier, such as quality of service, schedule reliability (both for pickup and delivery), possibility of negotiating terms and conditions, geographic location and cost, the latter is often the most important as is the case for the four companies. Therefore, the case study focuses on the cost reduction benefit although delivery time is also measured. Meeting delivery time is a critical additional criterion for the companies as well as special requirements related to the handling of assembled furniture (e.g. air ride suspension trailer, careful handling staff).

According to (Cruijssen *et al.*, 2007a), identifying and exploiting win-win situations among companies at the same level of the supply chain in order to increase their performance is about *horizontal cooperation*. We can consider this case study as an example of horizontal cooperation. The literature provides interesting case studies of horizontal cooperation among companies which report cost-savings opportunities, see e.g. (Bahrami, 2002), (Frisk *et al.*, 2006), (le Blanc *et al.*, 2007), (Cruijssen *et al.*, 2007b) and (Ergun *et al.*, 2007). In this paper, when the companies accomplish collaborative planning, cost-savings derive from two coordination opportunities: improved delivery routes and better transportation rates.

By planning together the delivery routes of the four companies' shipments, efficiency improvements could be achieved, such as reduction in traveling distance and increase in the loading rate of the trailer. A savings of 5% by such improved efficiencies with multi-stop delivery routes among half a dozen manufacturing plants are reported by (Brown and Ronen, 1997).

By negotiating their transportation rates together with the carrier rather than individually, the companies obtain at least the better transportation rates of the actual rates of the four companies. (Kuo and Soflarsky, 2003) report discounts in the ranges of 20-45% by negotiate with several carriers, with up to 70% discount from some large firms. The existence of these discounts, but in lower percentages, has been confirmed in our case study by a comparison of the actual rates of the four companies as well as a current quotation study by a consulting firm among the LTL and TL carriers of assembled furniture operating in Quebec (QFMA, 2008).

Along with shipping a greater volume, the companies can more easily use several carriers and therefore, as reported by (Caputo *et al.*, 2005), take advantage of the backhauling practice of the carriers, i.e. usually in a destination zone, a specific carrier will have better rates because he has a significant number of customers inside this zone who allows him to be loaded during the return trip. For the companies in the case study, taking advantages of this practice is more pertinent than ever before. Indeed, the last years' raise in the trucking flow imbalance between Canada and United-States increase the opportunities for the carriers to realize backhauling from United-States to Canada (NATSD, 2008).

3.1 Sharing the benefits of the collaboration

Collaboration brings up the following question. How should the benefits gained through collaborative transportation planning among a group of companies be shared between the companies? First, you have to determine if the benefits can be divided or not among the companies. In the case study, cost-saving can be divided while reduction in delivery time cannot. The total delivery time of each player in the collaboration is computed according to the delivery date of each of its shipments which is already determined by the transportation plan in the logistics scenario. To address the sharing problem, cooperative game theory provides a natural framework.

In cooperative game theory, a situation in which a group of companies can obtain through cooperation a certain benefit (such as a cost-savings) which can be divided without loss between them, can be described in a *n-person game with transferable utility*. Moreover, in such game, a company is named a *player* and a group of companies a *coalition*. As mentioned by (Hadjdukavá, 2006), there are two fundamental questions that need to be answered in such game: (1) which coalitions can be expected to be formed? and (2) How will the players of coalitions that are actually formed apportion their join benefit?

By studying a set of situations in which the decision to implement a logistics scenario is taken by a leading company, we address the first question in a very restrictive way. Indeed, in each situation, we limit to one the number of coalition that can be formed. Specifically, if we disregard external business considerations and focus on cost reduction, the leading company will choose the logistics scenario (including one sharing rule) that will provide it the greatest savings. However, in order to be able to implement the chosen logistics scenario, the leading players must provide enough savings to the other players. How much is enough to convince a player to join the coalition? At the least, the cost allocated to a player must be less than its stand alone cost. However, in practice this issue is much more complex and it is based on negotiation between the companies which goes beyond the scope of this paper, see (Nagarajan and Sošić, 2008) for a review of cooperative bargaining models in supply chain management. (Frisk *et al.*, 2006) address the second question by using a cost allocation method instead of a saving allocation method. In other words, instead of splitting the savings of the coalition among the players, the cost of the collaborative planning is split between the players. Several cost allocation methods exist in literature, an extensive list of papers on cost allocation methods, which are partly based on cooperative game theory such as the *Shapely value* and the *nucleolus*, can be found in (Tijs and Driessen, 1986) and in the literature survey by (Young, 1994). The computing and analysis of some cost allocation methods on a case study in forest transportation with eight companies is presented in (Frisk *et al.*, 2006) as well as a new method called *equal profit method* that provides an as equal relative profit as possible among the players. For the purpose of illustrating the impacts of different cost allocation methods on the leader's collaboration implementation decision, only three cost allocation methods were computed. They are described below.

M1 Proportional equal savings: the cost is allocated in order that each player obtains the same percentage of savings. For the leading player(s), the fairness of the method is the main argument favoring this method. It should however be noted, that the leading player do not always play fair as discussed in (Audy *et al.*, 2007).

M2 Weighted volume: the cost is allocated according to the proportion of the player's shipping volume of the total volume shipped by the coalition. Because transportation costs are often charged on a volume basis, this method was instinctively suggested by the companies and was unanimous. This method is also easy to understand and implement.

M3 Weighted volume according to the transportation plan: this method is similar to method M2 with the difference that the transportation plan is explicitly taken into account in the cost allocation. In this case, for each delivery route, the cost is spread between the furniture companies using the route accordingly to the volume ratio of their shipments to the total volume shipped on the route. Also, for the consolidation operations, a cost is charge to each furniture company for each of their shipments. This method is based on the principle of 'user-pays' that appears, in the present quotation study (QFMA, 2008), to be a standard in the industry.

3.2 Implementation of the collaboration

In the case study, collaborative planning has been explored under four different logistics scenarios.

#1 LTL mode: in this scenario, the coalition outsources to a common LTL carrier the operations of consolidation-warehousing and transportation, upstream and downstream from the terminal. This offers from an asset-based company of multiple and bundled services, rather than just single and isolated transportation or warehousing service refers in the literature to a third party logistics (3PL) provider, see (Selviaridis and Spring, 2007) for a review.

#2 TL mode with terminal at company #1: in this scenario, the coalition outsources to company #1 the operations of consolidation-warehousing at the terminal, which is located at company #1. To avoid possible conflict of interest, the truck routing at the terminal is done by a computer application and company #1 must follow pre-agreed rules in its consolidation-warehousing operations. In a discussion on inter-organizational system, (Kumar and van Dissel, 1996) identify possible risks of conflict and strategies for minimizing the likehood of such conflict. In practice, possible conflict of interest or the appearance of such still remains. Companies #2-4 must accept this risk since in this scenario the company #1 must be consider as a 3PL just as the LTL carrier in scenario #1 but a 3PL without transportation asset. Transportation operations upstream and downstream from the terminal are outsourced by the coalition to a common TL carrier. The shipments of companies' #2-4 are delivered to the terminal during the week using only full truckload delivery except when a partial delivery is necessary on Friday afternoons to clear the shipments inventory at a company. Consolidation is done during the weekends as well as the start of the trip. As the 3PL of the consolidation-warehousing and logistics planning services, company #1 charges companies' #2-4 a cubic foot flat rate on their total shipping volume.

#3 Hybrid TL/LTL mode with terminal at location i: in this scenario, the coalition outsources to a common LTL carrier the operations of consolidation-warehousing and transportation upstream from the terminal, which is at location *i*. The transportation operations downstream from the terminal are outsourced to a common TL carrier. As company #1 in scenario #2, the LTL carrier charges a cubic foot flat rate for its consolidation-warehousing and logistics planning services.

#4 Hybrid TL/LTL mode with terminal at location ii: this scenario is similar to scenario #3 but the terminal is at location *ii* rather than at location *i*.

Figure 1 illustrates the scenarios in a diagram where the numbered squares represent each company, the circle the terminal, and the arrows the oriented flows of furniture. The line at the top of each diagram identifies the service provider (i.e. company #1, LTL or TL carrier) to which the coalition outsources the operations of i) transportation upstream the terminal, ii) consolidation-warehousing at the terminal, and iii) transportation downstream the terminal.

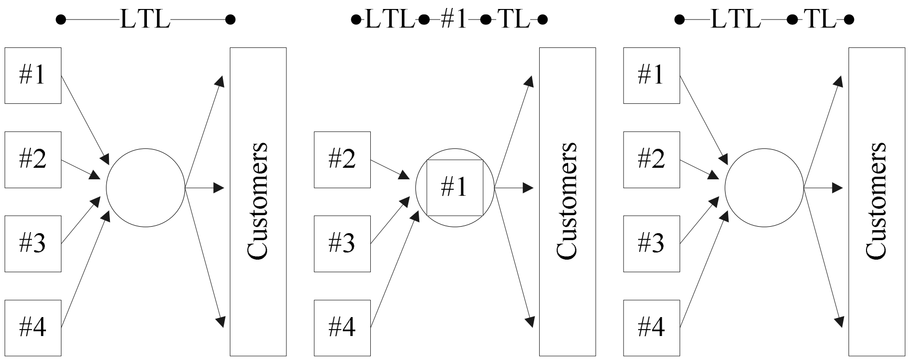

Figure 1 - Diagrams of the logistics scenario #1 (left), #2 (centre) and #3-4 (right)

These scenarios are based on the available realistic option of collaboration implementation for the four companies. The locations of the terminals in scenario #3 and #4 are in the two areas where terminals already exist. The existing terminals belong to LTL carriers meeting the minimum requirements of the companies and therefore, permitting collaboration. Aware of the difficulties of launching a new terminal, e.g. (Heliane Martins de Souza Hilário, 2007), the option to build or rent a terminal has not been considered. In our study, the high investment requirement has been the decisive factor of not acquiring a new terminal. On the other hand, it is the low investment requirement that made scenario #1. In scenario #2, company #1 has enough warehousing capacity and reception/shipping docks to carry out the consolidation. In fact, in the first half of the years 2000, the volume consolidated and shipped by company #1 was greater than the total actual volume of all companies.

Moreover, the common LTL/TL carrier in the scenario should not be considered only as a service provider operating alone. The carrier could belong to a group of collaborating carriers such as World Wide Logistics, an ongoing founding organization of six specialized furniture carriers (Thomas, 2008). With customers across the United-States of America, the coalition could be forced to outsourced several carriers according to exclusive geographic area or to designate a lead logistics provider (LLP). LLP manages on behalf of its customer (here, the coalition) the complex relationships involving multiple providers (Lieb and Miller, 2002). In the literature, the term fourth party logistics (4PL) provider is also use to designate such provider having this coordination capability, see e.g. (van Hoek and Chong, 2001).

4. NUMERICAL RESULTS

The data used in the case study has been collected in the billing system of the four furniture companies on a weekly basis during four consecutive weeks, earlier in the fall. The results are thus based on a comparison of the stand alone cost (delivery time) of each company. Specifically, the cost (delivery time) reduction/loss of each logistics scenario are defined by the difference between the sum of the stand alone cost (delivery time) of each company compared with the cost (delivery time) of the collaborative transportation plan of the logistics scenario. Moreover, the cost-savings of each player is the difference between the player's stand alone cost and its allocated cost (according to one of the three cost allocation methods) in the logistics scenario.

In accordance with the priorities of the four furniture companies and the deployment of the Quebec road network, two regions of the United States have been targeted for the collaborative planning of their shipments. First, all the states on the West Coast and second, the states surrounding the Great Lakes. Figure 2 shows the volume shipped during the four weeks in each ZIP code. The bigger the circle, the more volume was shipped. The different circle colours refer to the four companies (i.e. red: #1; yellow: #2; blue: #3 and green: #4).

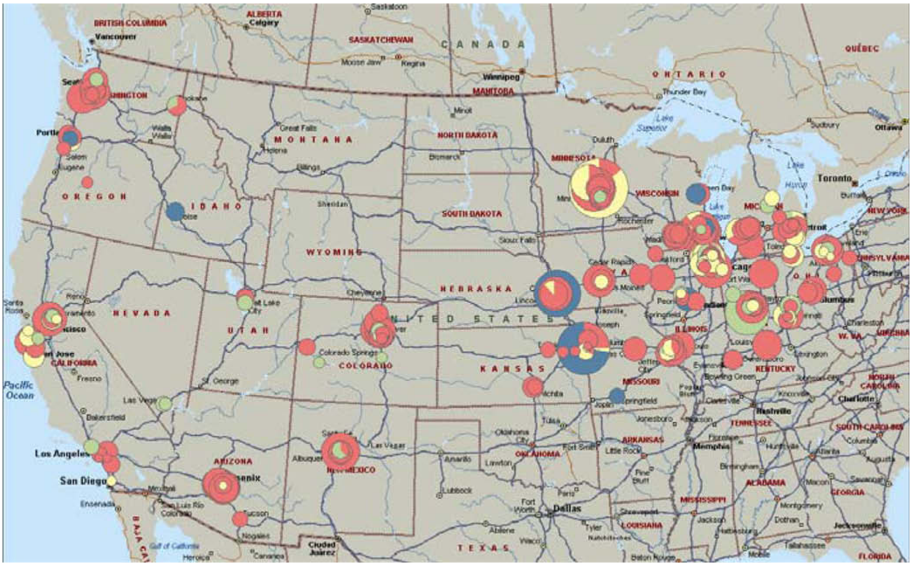

Figure 2 - Shipping volume per companies during the four weeks

The western region is characterized by a wide territory, a small density road network and clustered customers. The Great Lakes region is characterized by a high density road network and scattered customers. The case represents a total of 363 shipments to 256 different customers for a percentage of 44.6% of the total volume shipped in the United States by the companies during these four weeks. No volume was shipping in Montana, Wyoming, South and North Dakota. The representation of the volume shipped during the four weeks compared to the rest of the year has been confirmed by a comparison with the volume shipped during four periods of five weeks distributed in the year 2006-2007.

The furniture companies are uneven in volume shipping. Company #1-4 shipped, respectively, 66.6%, 17.5%, 9.3% and 6.7%, of the total volume shipped while the distribution of the stand alone cost is 59.7%, 21.8%, 10.4% and 8.2%. A significant difference between the two percentages of a company suggests that some companies are more cost-efficient than others.

4.1 Result for all companies

For each of the four weeks, collaborative planning was done for the four scenarios. Table 1 shows the results, in percentages of cost-savings and delivery time, per week and total. The scenario with the higher cost-savings is #2 while scenario #1 is the only one that generates loss. The reason for the loss in scenario #1 is discussed in Section 4.2. The fact that no transportation operations upstream from the terminal are required for company #1, who in addition is the highest volume shipper in the coalition, mainly explains the superior savings of scenario #2 versus scenarios #3-4.

Table 1 - Result in cost-saving and delivery time reduction per scenario

	Cost-savings				Delivery time	
	Scenario				Scenario	
Week	1	2	3	4	1	2 to 4
1	-17,3%	14,3%	9,7%	11,7%	35,3%	22,7%
2	10,9%	26,7%	28,0%	29,4%	12,6%	11,0%
3	-8,1%	17,0%	12,8%	14,3%	33,0%	6,0%
4	-13,9%	-2,8%	-3,7%	-3,0%	14,8%	-6,1%
1 to 4	-9,0%	14,9%	11,8%	13,4%	29,6%	11,6%

All scenarios generated a loss during the fourth week while all scenarios generated a savings in the second week. The weekly variation in scenario #2-4 illustrates the impact of the shipping volume and its geographical distribution on the efficiency improvement that can be obtained in collaborative planning.

All scenarios cut the total delivery time. Scenario #1 has the higher reduction which is very predictable. In scenario 1, several consolidation operations happen during the weeks, allowing gradual departure of trucks for faster delivery, while in scenarios #2-4, consolidation operations are performed only during the weekend, thus delaying the delivery of shipments already at the terminal. This weekend consolidation and the weekend closure of the customers as well as the proportionally short distances between the terminals as regards the average distance to reach the customers, explains why the three terminals have the same performance in delivery time. There is enough ‘dead’ time to allow a truck starting from the farthest terminal to reach the first customer at the same time as a truck starting from the closer terminal.

4.2 Result per company

Table 2 shows the results in percentage of delivery time reduction per company. Even if globally we have a reduction of the delivery time in all the scenarios, we see that company #2 increases its delivery time in all scenarios and also company #3 in scenarios #2-4. The average increase by shipment is less than 1 day for company #2 in scenario #1 (+0.66 day/shipment) and company #3 in scenarios #2-4 (+0.25day/shipment). Since these two companies have actual delivery performance meeting, and generally bellow, the requirement of their customers, these small increases should not have a significant impact among their customers. However, by extending the delivery time of 3.1 days by shipment on average, the increase in scenarios #2-4 for company #2 is significant. Indeed, for this company who is production-to-order, this increase would likely have an impact among its customers and thus, scenario #1 represents less incertitude and risk than scenarios #2-4.

Table 2 - Result in delivery time reduction per company

	Scenario	
Company	1	2 to 4
1	37,0%	27,0%
2	-15,4%	-72,5%
3	29,5%	-3,4%
4	40,6%	27,6%

Table 3 shows the results, in percentage of cost-savings per company for each of the cost allocation methods. Note that as transportation and consolidation operations are charged individually on each shipment according to the rate table of the LTL carrier, no allocation method has been necessary for logistics scenario 1. Also, note that the absence of shipping volume by some companies during certain weeks explains why the cost-savings percentage is not identical for all companies in each scenario with the cost-allocation method M1. Indeed, as for collaborative planning, the cost allocation methods are computed each week.

Table 3 - Result in cost-saving per company

	Scenario and cost allocation method			
	1	2		
Company	*n.a.*	M1	M2	M3
1	-29,3%	14,5%	4,7%	6,8%
2	19,2%	12,5%	30,0%	28,0%
3	27,7%	22,1%	26,2%	20,7%
4	17,3%	15,2%	34,3%	31,6%

	3			4		
Company	M1	M2	M3	M1	M2	M3
1	10,9%	0,9%	-1,9%	12,4%	2,6%	0,02%
2	10,6%	28,7%	33,4%	11,9%	29,7%	34,2%
3	21,1%	24,9%	25,8%	22,6%	26,3%	27,6%
4	10,7%	30,8%	37,4%	12,5%	32,3%	37,6%

Except for the two losses for company #1 (i.e. -29.3% and -1.9%), all scenarios and cost allocation methods provide a cost-savings to each company. Moreover, the significant loss of company #1 in scenario #1 is the reason behind the global loss of this scenario (i.e. -9.0% in Table1) even if the three other companies obtain a saving. Indeed, among the companies, company #1 is the only one who actually operates using the TL mode. We can see that with high shipping volumes such as company #1, the TL mode is more cost-efficient than LTL mode even with the better transportations rates of scenario #1.

5. DECISION ON THE LOGISTICS SCENARIO BY EACH COMPANY

According to the previous results, we can study all the four situations in which each of the four companies sets the decision on the logistics scenario (including the choice of the sharing rule) to implement.

If the leadership of the collaboration is assumed by company #1, he will implement scenario #2 with the cost allocation method M1. Indeed, this choice provides the greatest cost-saving to company #1 (i.e. 14.5%) and the three other companies obtain interesting cost-savings. However, if company #2 considers the impact of scenario #2 on its delivery time too important, he will not join the coalition. The result of scenario #2 without company #2 must be evaluated by company #1. Scenario #2 demands a high degree of involvement and operation changes for company #1. Therefore, if the result of scenario #2 without company #2 is not considerably profitable for company #1 (e.g. more than 2% savings), it is likely that company #1 will not go along with any collaboration implementation.

There are two alternatives if the leadership of the collaboration is assumed by company #2. If company #2 considers the impact of scenarios #2-4 on its delivery time too great, then scenario #1 will be preferred. In scenario #1, the savings/loss for a company derives from the better/worse transportation rates of the coalition. With a loss in scenario #1, this implementation must be done without company #1. Without the shipping volume of company #1 in the coalition, the transportation rates discount allowed by the LTL carrier will likely be less. However, cost-saving will still be obtained with the high savings of companies #2-4 (i.e. 19.2%, 27.7% and 17.3% respectively).

If company #2 can do with the increase of its delivery times in scenarios #2-4, scenario #4 with method M3 will be implemented as if the leadership is assumed by company #3 or #4. This decision leads to a situation where it is a sub-optimal scenario which is implemented, i.e. optimal scenario #2 generates 1.5% more cost-savings than sub-optimal scenario #4.

However, in a coalition, mainly with few players as in the case study, it is likely that the companies with the greater shipping volume will have a stronger position in a negotiation (Frisk *et al.*, 2006). Therefore, with only 0.02% of savings in scenario #4 with method M3, company #1 will certainly use its stronger position to negotiate a larger part of the cost saving. This larger part could be obtained by modifying the scenario and/or allocation method decision or by using another allocation method which may include the payment to company #1 of a compensation out of the savings of the other companies. Of course, if the negotiation ends with a saving for the leader less than in scenario #1, the leader will decide to implement scenario #1 without company #2. The notion of compensation of a specific player could also be used in other situations by the leader(s), e.g. convince company #2 to join a coalition in scenarios #2-4 even if its delivery time increases. Aware of this business consideration of an uneven negotiating position between the players, it is to the advantage of companies #2-4 to either together or as a pair, take the leadership to increase their position regarding company #2 and thus limit the additional savings to give to company #1 so it will participate in the coalition.

For each company, the cost-savings difference between computing of cost allocation according to the transport plan (i.e. method M3) rather than the total cost (i.e. method M2) as more common cost allocation methods was significant (i.e. difference of 2% or more except for company #2 in scenarios #3-4). Since the principle of 'user-pays' as in method M3 appears to be a prerequisite in the industry for any cost allocation method, it is necessary to think ahead to avoid a situation where a sub-optimal scenario is implemented as in the case study.

6. CONCLUDING REMARKS

It has been demonstrated that collaboration in transportation can provide different benefits. Some of these benefits can be divided among the companies and others not. Using a case study of four Canadian furniture companies shipping to the United-States, it has been shown that the benefits divided among the company as well as the leadership of the collaboration impact the implementation decisions. Some leading company and sharing methods could lead to the implementation of a sub-optimal logistics scenario that does not capture all the potential benefits. Also, even with impressive benefits, if the implementation of a logistics scenario generates only one very significant benefit loss, then a leading company could reject it.

As future research work is concerned, different issues should be studied. New logistics scenarios integrating both the LTL mode and the TL mode should be considered. (Caputo *et al.*, 2005) report attractive savings by using both modes, especially when LTL mode is used to deliver to marginal customers. Considering different types of benefit in the cost allocation methods would also be a challenging problem. In the case study, considerable coverage benefit could be achieved through the coalition, raising the question of how much this is worth.

Typically, the decision on the benefits sharing among the companies is determined simultaneously that the decision on which coalitions can be expected to form (Greenberg, 1994). Few approaches address at once these two issues and they should be investigated, see (Hadjdukavá, 2006) for some approaches. Moreover, in the paper the approach chosen to address these two issues is static, i.e. the coalition is formed according to the leading company best solution and remains unchanged. This approach is justifiable considering the high transaction costs to implement such collaboration. (Macho-Stadler *et al.*, 2006) note that the transaction costs seem much higher the more companies are involved. However, these two issues should be addressed using a more dynamic approach allowing modifications to the coalition as time goes by. Finally, the issues of the optimal size of the coalition, when should one stop adding new company in the coalition? Economics do provide a rich understanding of the fundamentals behind these issues, the next step is to validate the knowledge in fieldwork.

Acknowledgments
The authors wish to thank Philippe Marier of FORAC Research Consortium, Charles Doucet of the Quebec Furniture Manufacturers Association and the project leaders in the four furniture companies of the case study for their contribution to this work. Also, the authors wish to acknowledge the financial support of the Natural Sciences and Engineering Research Council of Canada and the private and public partners of the FORAC Research Consortium.

7. REFERENCES

1. Archambault, G., Carle, D., Caron. M. and R. Vézina, 2006. The furniture manufacturer of the future - executive summary [In French]. FPInnovations – Forintek, Quebec: FPInnovations-Forintek.
2. Audy, J.-F., 2007. Feasibility study for a transportation collaboration project in a network of companies in the furniture industry [In French]. FORAC Research Consortium, Quebec Furniture Manufacturers Association research mandate No. 1. Quebec: FORAC Research Consortium.
3. Audy, J.-F., D'Amours, S. and M. Rönnqvist, 2007. Business models for collaborative planning in transportation: an application to wood products. In: Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C., eds. IFIP International Federation for Information Processing, Volume 243, Establishing the Foundation of Collaborative Networks. Boston: Springer, 667-676.
4. Audy, J.-F., D'Amours, S. and P. Marier, 2008. Project on the simulation of a collaborative transportation planning in a network of companies in the furniture industry [In French]. FORAC Research Consortium, Quebec Furniture Manufacturers Association research mandate No. 2. Quebec: FORAC Research Consortium.
5. Bahrami, K., 2002. Improving supply chain productivity through horizonal cooperation – the case of cusumer goods manufacturers. In: Seuring, S., Goldbach, M., eds. Cost Management in Supply Chains. New York: Physica Verlag, 213-232.
6. Brown, G.G. and D. Ronen, 1997. Consolidation of customer orders into truckloads at a large manufacturer, The Journal of the Operational Research Society, 48 (8), 779-785.
7. Caputo, A.C., Fratocchi, L. and P.M. Pelagagge, 2005. A framework for analyzing long-range direct shipping logistics, Industrial Management and Data Systems, 105 (7), 876-899.
8. Cruijssen, F., Dullaert, W. and H. Fleuren, 2007a. Horizontal cooperation in transport and logistics: a literature review. Transportation Journal, 46 (3), 22-39
9. Cruijssen, F., Bräysy, O., Dullaeert, W., Fleuren, H. and M. Salomon, 2007b. Joint route planning under varying market conditions. International Journal of Physical Distribution and Logistics Management, 37 (4), 287-304.
10. Ergun, O., Kuyzu, G., and M. Savelsbergh, 2007. Reducing truckload transportation costs through collaboration. Transportation Science, 41 (2), 206-221.
11. Frisk, M., Jörnsten, K., Göthe-Lundgren, M. and M. Rönnqvist, 2006. Cost allocation in collaborative forest transportation. Norwegian School of Economics and Business Administration, Discussion paper No. 15. Bergen: NHH Department of Finance and Management Science.
12. Greenberg, J. 1994. Coalition structures. In: Aumann, R.J., Hart, S., eds., Handbook of Game Theory with Economic Applications. Amsterdam: North-Holland, 1305-1337.
13. Hadjdukavá, J., 2006. Coalition formation games: a survey. International Game Theory Review, 8 (4), 613-641.
14. Heliane Martins de Souza Hilário, 2007. Personal communication through a portugese speaking collegue, Matheus Pinotti Moreira, 30 January 2007, Ms. Martins de Souza Hilário was the manager of the Intersind Central de Fretes
15. IC, 2008. Trade Data Online, requests on NAICS based code #337, data available from 1997 to 2006 [online]. Industry Canada, Government of Canada. Available from: http://www.ic.gc.ca/ [Accessed 25 January 2008]

16. ITA, 2008. TradeStats Express, requests on NAICS based code #337, data from 1997 to 2006 [online]. International Trade Administration, Department of Commerce, United States of America. Available from: http://trade.gov/index.asp [Accessed 25 January 2008]
17. Klincewicz, J.G. and M.B. Rosenwein, 1997. Planning and Consolidating Shipments from a Warehouse. The Journal of the Operational Research Society, 48 (3), 241-246.
18. Kuo, C.-C. and F. Soflarsky, 2003. An automated system for motor carrier selection, Industrial Management and Data Systems, 103 (7), 533-539.
19. le Blanc, H. M., Cruijssen, F., Fleuren, H. A. and M.B.M. de Koster, 2007. Factory gate pricing: an analysis of the Dutch retail distribution. European Journal of Operational Research, 174 (3), 1950-1967.
20. Lieb, R. and J. Miller, 2002. The use of third-party logistics services by large US manufacturers, the 2000 survey. International Journal of Logistics Research and Applications, 5(1), 1-12.
21. Macho-Stadler, I., Pérez-Castrillo, D. and N. Porteiro, 2006. Sequential formation of coalitions through bilateral agreements in a Cournot setting. International Journal of Game Theory, 34 (2), 207-228.
22. MEDIE, 2007. Profile of the Quebec furniture industry [In French]. Ministry of Economic Development, Innovation and Exportation, Government of Quebec. Quebec: Government of Quebec.
23. Nagarajan, M. and G. Sošić, 2008. Game-theoretic analysis of cooperation among supply chain agents: review and extensions. European Journal of Operational Research, 187 (3), 719-745.
24. NATSD, 2008. Tables in section 6: North American Merchandise Trade [online]. North American Transportation Statistics Database. Available from: http://nats.sct.gob.mx/ [Accessed 25 January 2008]
25. QFMA, 2008. [forthcoming]. Consulting firm Logistique CAF, Quebec Furniture Manufacturers Association mandate.
26. Young, H.P., 1994. Cost allocation. In: Aumann, R.J., Hart, S., eds., Handbook of Game Theory with Economic Applications. Amsterdam: North-Holland, 1193-1235.
27. Selviaridis, K. and M. Spring, 2007. Third party logistics: a literature review and research agenda. International Journal of Logistics Management, 18 (1), 125-150.
28. Thomas, L., 2008. Six furniture trucking firms to merge [online]. Furniture Today. Available from: http://www.furnituretoday.com/ [Accessed 30 April 2008]
29. Tijs, S. H. and T. S. H. Driessen, 1986. Game theory and cost allocation problems. Management Science, 32 (8), 1015-1058.
30. van Hoek, R.I. and I. Chong, 2001. Epilogue: UPS Logistics – practical approaches to the e-supply chain. International Journal of Physical Distribution and Logistics Management, 31 (6), 436-468.