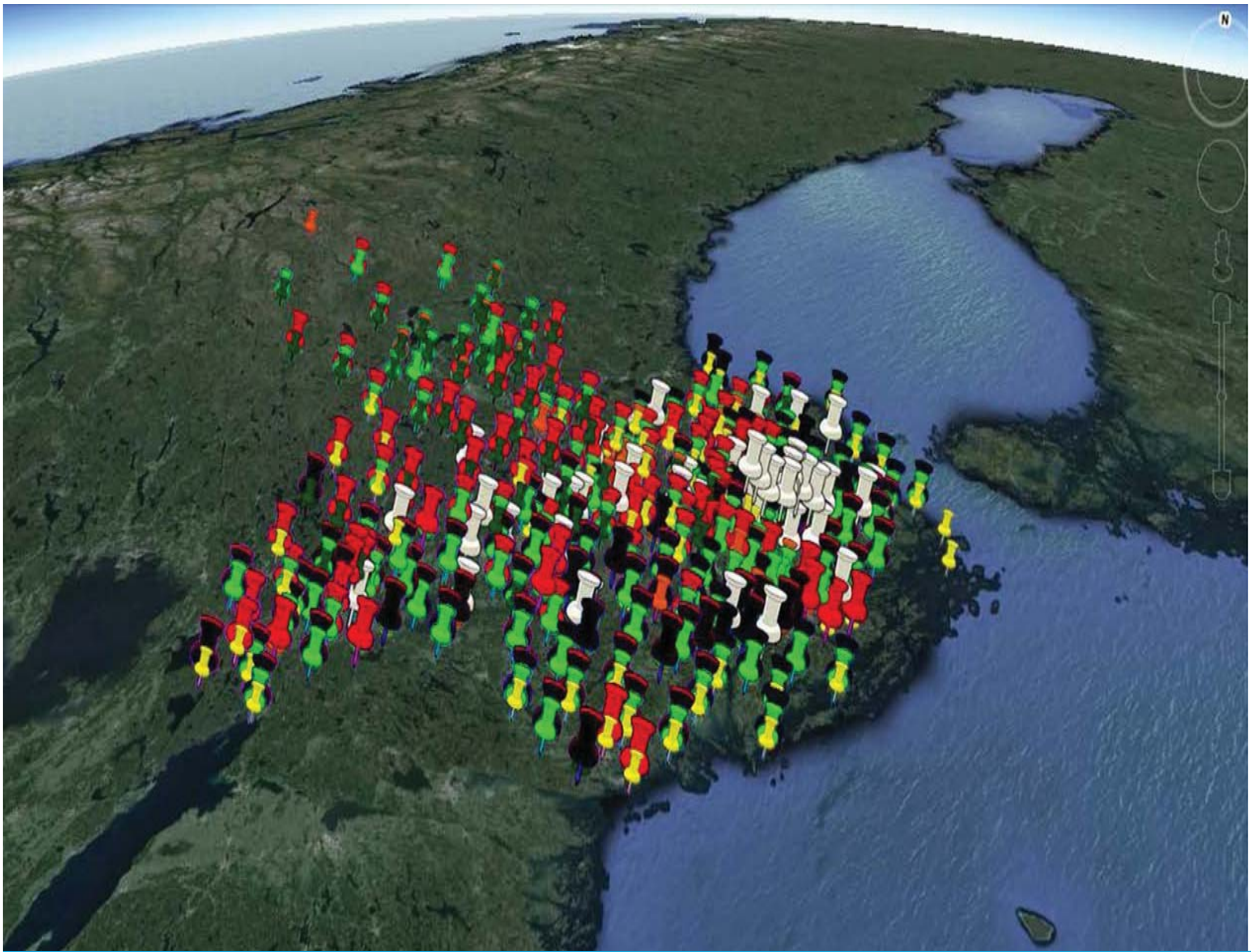

Arbetsrapport

Från Skogforsk nr. 849–2014

Location barter may reduce forest fuel transportation cost

Destinering och lägesbyten för att effektivisera transporterna av skogsflis

Petrus Jönsson, Lars Eliasson och Rolf Björheden

Arbetsrapport

Från Skogforsk nr. 849–2014

The Arbetsrapport series comprises background material, descriptions of methods, results, analyses and conclusions relating to both current and completed research.

Titel:

Destination and location exchange will reduce transportation distance.

Destinering och lägesbyten för att effektivisera transporterna av skogsflis.

Bildtext:

White pins are representing thermal power stations. The other pin colures are representing the landings for the wood chip's.

Ämnesord:

Exchange, chips, simulation, optimisation, transport.

Byten, flis, simulering, optimering, transport.

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Abstract

Several studies of the possibilities for hauliers from various industries in the transport sector to exchange landing locations and destinations show that such exchanges have potential to reduce transport distances. It is relatively common for forestry companies to exchange landing locations for pulpwood and timber. Many companies are also trying to coordinate transport, so that return haulage to the home location is planned at the same time as the outward journey. This reduces empty haulage transports that otherwise could be up to 50 percent of transports and provide no revenue.

In the Mälardalen region, an area with a large number of heating plants and numerous fuel producers with overlapping activity areas, effi ciency of wood chip shipments could be improved by 12–15 percent if hauliers exchanged biofuel volumes with each other.

This report shows the potential for reducing transport distances with one-to-one exchange. This means that it is only the trades that reduce distances for both parties that are interesting. The analysis has been carried out with the simulation tool, ExtendSim.

Contents

Sammanfattning

Flera analyser av möjligheterna i lägesbyten mellan befraktare, från olika branscher inom transportsektorn, visar att det finns potentialer i att minska transportsträckorna. Lägesbyten av volymer på massaved och timmer mellan skogsbolag är relativt vanligt förekommande. Många av skogsbolagen försöker även samordna så att returtransporter till hemmaort planeras då lastbilarna vet var deras destination är. På detta sätt minskas tomkörningen som annars skulle uppgå till 50 procent och inte ge någon vinst.

Denna rapport visar på vilken potential det finns i att minska transportsträckorna med rena byten. Med ”rena byten” menas att det är bara de transportsträckor som minskar sträckorna gemensamt för bägge parter. Analysen har genomförts med simuleringsverktyget ExtendSim.

Sett över hela året kan mellan 9–24 procent av transporterna bytas. Nivån är beroende på bolag och att minskningen i medeltransportsträcka uppgår till 3–15 procent.

Introduction

The objective of this study was to estimate potential transport savings through biomass barter (location exchanges) between suppliers as a means to reduce transport distance.

Much of the biomass burnt in Swedish heating and combined heat and power (CHP) plants is primary forest fuels in the form of chipped (or hogged) fuel from tops and branches from final felling sites, small-diameter wood from early thinnings, and defective roundwood from all kinds of logging operations. While defective wood is often transported to terminals by the ordinary fleet of timber trucks, logging residues and small-diameter wood is normally chipped at the landing to improve handling properties and increase density and, consequently, transport economy. Fuel chips are mainly transported from the landing to the customer by truck – bulk cargo chip trucks or container trucks that are loaded with chipped material, or chipper trucks, equipped with a chipper that chips material into its own cargo hull.

According to Brunberg (2014), transportation accounts for 20–30 per cent of the supply cost. As the demand for forest chips is determined by the need for heat and electricity, there is great seasonal volatility in demand. The uncertainty in demand is strongly linked to the prevailing temperature. In some months demand is less than predicted, but since the demand is higher than predicted in other months annual demand is fairly stable, though temperature dependent. This uncertainty makes planning difficult, increasing the risk of inefficient transport compared to a more controlled environment such as roundwood deliveries to pulpmills.

Several analyses of the possibilities for timber trading between sellers of wood in order to improve logistics, a.k.a. location exchange, show that such barter has a potential to reduce transport distances. In a location exchange, a volume of wood in one location is traded for the same volume of wood in another location closer to the customer of the company. Location barter of pulpwood and timber between forestry companies is relatively common. Many forest companies also try coordinating return transports as soon as the trucks reach their first destinations. This could reduce empty haulage, which otherwise would be up to 50 per cent.

In a previous analysis of location barter of roundwood, involving eight participating haulage companies, a possible 18 percent reduction of average transport distance was found (Frisk 2005, Transportanalys SYD). The results included the return flows when calculating the relative reduction. By optimising the transport distance of the entire flow, a global optimum was obtained, minimising the total transport distance for the eight participating companies.

Hauliers that handle large volumes and have many transports are likely to benefit from location exchanges, but there is a risk that small haulage companies with small quantities and few transports would lose out. The overall profits are significant, but these have to be distributed among all companies to motivate participation. This problem is resolved through cost sharing. Cost sharing aims to provide a fair distribution of profits and costs. In general, it is often weighted against the relative contribution of the various parties to the total.

Among the experiences gained through location barter of roundwood is that hauliers are somewhat sceptical about exchanges that could result in longer distances for some of the individual companies. Profit sharing will involve financial transactions between the companies to compensate what the companies ‘lost’ on the location exchanges. To avoid this, only ‘one-to-one’ exchanges that will benefit both parties are implemented in the present study. The potential savings of such trading are lower, but no cost-sharing is needed to motivate participants.

The Swedish Transport Administration has examined trends in freight transport in Sweden, and found a growing proportion of long-distance transport, i.e. transports over 100 km. The proportion of biofuels in these transports is not reported, but Brunberg (2014) reported that substantial volumes are transported in excess of 100 km. This development, coupled to the fact that the biofuel industry does not have a tradition of barter, indicates that there is potential to cut transportation costs through location exchange.

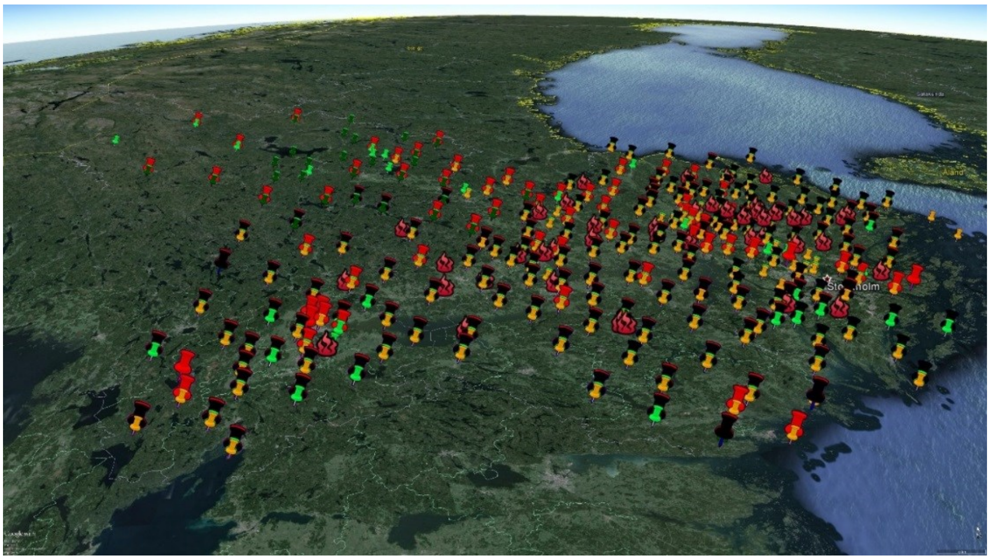

Figure 1.
4 500 landings were included in the study. The colours of the pins show the locations of the five suppliers. The 42 thermal power stations are marked by red flame symbols.

MATERIAL & METHODS

Historical flows in the Mälaren region for the five companies that delivered wood chips to a number of heating plants in 2010 is shown in Table 1. An attempt has been made to filter out and exclude volumes from railway terminals, corresponding to approximately 7000 of the 25,822 truckloads in the material. The remaining 18,824 truckloads were included in the simulation data set.

Table 1.
Total number of transports and average transport distance for each of the five haulage companies over one year. This data was included in the study.

Haulier ID	No of loads	Average transport distance, km
A	7 543	54.5
B	3 350	54.7
C	7 694	56.6
D	8 72	48.4
E	734	82.8

Volumes are given in m^3 loose volume. Assuming a conversion factor of 0.43 odt (oven dry tonnes) per m^3, and a moisture content of 40%, this results in 0.72 odt per m^3.

The data contains information about available biomass, divided by owner and parish. Biomass location is set at parish centre (LKF). The LKFid is used to calculate the transport distance from a landing to each of the heating plants. ID is a unique number for the specific LKF or heating plant. All LKFs and heating plants in the material have GPS coordinates.

Table 2.
Structure and explanation of how data is used. Each parish (LKF) has an ID, with a corresponding GPS coordinate and analogy for the bioenergy plant. Each haulier has an ID, haulage distance from specific LKF to a heating plant, and a volume for the actual transport.

LKF		Bioenergy plant		Haulier	
ID	Num.	ID	Num.	ID	Num.
X Coordinate	RT90	X Coordinate	RT90	Haul	Km
Y Coordinate	RT90	Y Coordinate	RT90	Volume	Tonne

Data from SDC (forest industry's IT company) usually contains time-stamped flows providing information about when in the year the volumes were transported. Data retrieved from a third party lacks time-stamped flows, so this data has not has been used in this analysis.

The analysis was carried out with the simulation tool, ExtendSim. Simulation is used to model the supply process and to test various alternatives and solutions in order to improve decision making in the development, modification and improvement phase. Instead of conducting full-scale tests in reality, studies are made in a data model that replicates the real world, but only involve processes that are necessary for analysing the studied hypotheses. Building a model where the activity becomes predictable makes it easy to understand the relationships between parts and the whole process. The data model incorporates aspects of the real world that give important information for developing a model that gives a holistic picture. Simulation models are also used to develop and evaluate new businesses by building a model of the planned activities and processes.

LOCATION BARTER

The simulation model is designed to search for possible location barter options based on the possible destinations for a volume of biofuel from a given landing. In order for a candidate to be nominated, transport distance must be reduced by at least 10 percent by sending it to an alternative destination. Landings within a 10 km radius from the intended customer will not be available for location exchanges. The requirement of 10 percent reduction in transport distance was set up as a base-line level in order to make barter profitable. Location barter introduces a risk for the companies, and necessitates administration that must be financed.

The principle of location exchanges can be illustrated as follows: which alternative heating plant X $X\in \{x\_1, x\_2, x\_3 \cdots x\_42\}$ is it closer for company A to transport to from landings Y, $Y\in \{y\_1, y\_2, y\_3 \cdots y\_4680\}$? If a location exchange is to take place, company A's changed destination (the candidate) is compensated by company B or C if a heating plant is found that can accommodate the equivalent volume as that of A.

For example, suppose we find a possible replacement for company A, marked with green pin 2 A for the landing and green line to heating plant A (see Figure 2). We swap this transport (candidate) with Company B, marked with yellow pin 1 C for the landing and yellow line to heating plant C. This type of location switching benefits both parties.

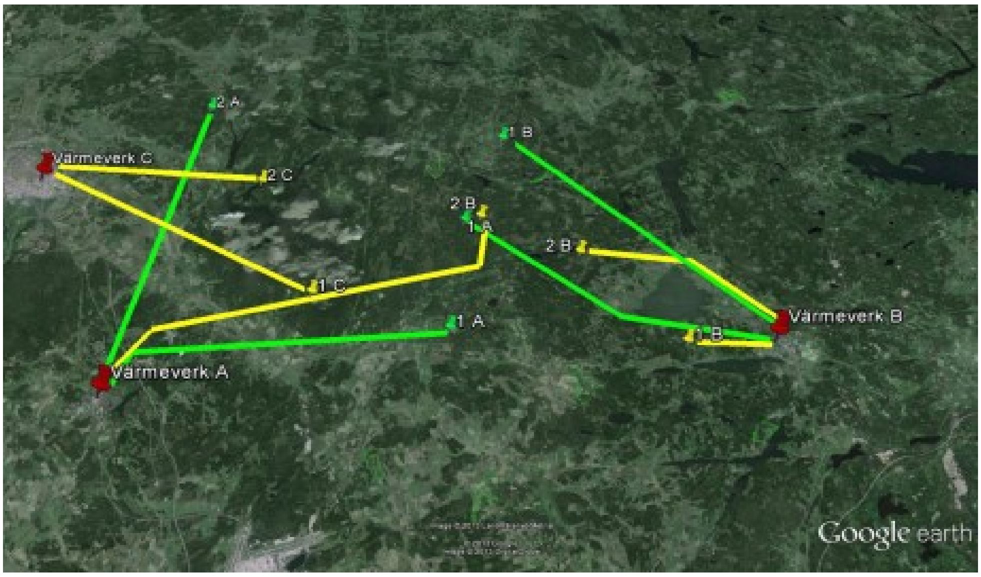

Figure 2.
Schematic picture of how exchanges are made between hauliers in the model. The map also shows three bio-energy plants, A, B and C. These plants are supplied by two companies, yellow and green. By studying the flow from landings to plants, some of the transport seems to be running in the opposite direction.

The model is executed in four different variants in order to determine potential benefit of exchanges. The options are described below;

i) Result calculated on the basis of actual transports for the investigated year. This result is used to quantify the rationalisation potential of the following variants.

ii) Location barter where the company is allowed to exchange landings and destinations within the company (internal destination) and with other companies (external destination).

iii) Exchanges where the companies can swap positions with each other but do not exchange within their own company (internal destination).

iv) This option is similar to II and III, but instead of searching for the globally 'best' candidate, the model finds the 'first acceptable'.

The two different search criteria, 'best' and 'first acceptable', are two different ways to find candidates for location barter in the database. 'Best' is the best candidate available for reducing transport distance. 'First acceptable' chooses the first candidate found in the database that meets the requirement for shortening transportation distance by at least 10 percent. The search function is restricted to only investigating storage locations that are more than 10 km from the customer's plant, since it was not considered reasonable to change destination for such short transports.

Results

The historical flows during 2010 in the Mälaren region for the five suppliers of wood chips to bioenergy plants are displayed in table format in Table 1. The changes that are tested in the model can then be compared against this table and so the benefits of an action can be analysed.

Location barter with internal destination

When the analysis of the potential for location exchanges is applied to historical data, positive effects of both improved internal and external destination are possible due to information about all the transports. An important point here is that potential for improved destination is not as high in reality as that shown by the model. In reality transports are scheduled according to prevailing demand and available landings, and there is limited knowledge about the situation six months ahead.

Table 3.
Proportion of bartered volumes when applying 'Best' and 'First acceptable' search criteria respectively. Companies are allowed to barter locations within their own company.

Supplier ID	Search criterion	Share of exchanges, %	Average transport distance in km	Actual transport distance in km
A	Best	19	48.2	54.5
	First acceptable	24	49.2	
B	Best	16	49.7	54.7
	First acceptable	20	50.4	
C	Best	17	51.8	56.6
	First acceptable	18	52.4	
D	Best	15	43.9	48.4
	First acceptable	18	44.2	
E	Best	7	81.7	82.8
	First acceptable	7	81.7	

Compared with actual transports in 2010 (Table 1), and the transports using the best destinations (Table 3), allowing changes of destination may reduce average transport distance by up to 12 percent. A maximum reduction of 10–12 percent is available for company A. The different suppliers demonstrate great variations in the proportion of material that can be bartered in order to reduce transport distance. Only 7 per cent of company E's transports were redirected to other destinations while up to 24 per cent of company A's transport are allocated new destinations. There were no major differences in resulting average transport distance between the search criteria.

The overall percentage reduction in transport distance for criteria 'best' is 9.3 % and for 'first acceptable' the reduction is 8.2 %.

EXTERNAL LOCATION BARTER

In this alternative, the model is not allowed to barter locations within a company; the exchange must be with the other four companies. This causes large changes in individual companies' share of exchanges. For companies A, C and D, the share of exchanges is reduced, while for B and E their share is increased (Table 4).

Table 4.
Results when only external barter is allowed.

Haulier ID	Search criterion	Share of exchanges, %	Average transport distance in km	Actual transport distance in km
A	Best	14	51	54.5
	First acceptable	15	51.3	
B	Best	24	47.5	54.7
	First acceptable	28	48.7	
C	Best	10	53.8	56.6
	First acceptable	10	54.2	
D	Best	13	44	48.4
	First acceptable	13	44.7	
E	Best	9	80.4	82.8
	First acceptable	12	80.4	

Only allowing external barter will only marginally affect the reduction of average transport. Company B has the largest reduction in average transport distances (11–13 percent shorter). As in the previous solution, there are no major differences between the different search criteria.

The results in the different search criteria are probably cancelled out because the percentage changes that will be made available increase as the first acceptable replacement candidate is chosen, but the reduction in transport distances are slightly lower.

The average reduction of transport distance for criteria 'best' was 7.4% and for 'first acceptable' 6.4%

Discussion

The analysis shows significant potential for location barter. The total transport distance can be reduced by over 7 percent if hauliers are willing to barter or trade biofuel volumes with each other. Some suppliers could also reduce transport distance by changing destination of their own material. Some of the potential will probably never be realised, as not all landings are accessible for the whole year, and because some of the transports are dependent on the chipping of the material by contractors that move their equipment between landings. As it is costly to relocate chippers over longer distances, contractors prefer to move in a 'nearest-is-next pattern'. This also has advantages from a road maintenance perspective as it minimises the time during which a road has to be kept open for chip transport, thereby reducing maintenance costs, such as for snow clearance.

The potential for location barter shown for the Mälaren region is probably high, as the region is geographically favourable. With many biofuel plants distributed over the area and several suppliers operating throughout the area, the possibilities of finding a 'better fit' through location barter is high. Consequently, the potential found in this report is likely to be higher than the average potential for Sweden in general.

We also asked four forest companies operating in central Sweden for their views on trading forest fuel with each other. It turned out that three of them had already tried some form of trading – not as regular exchanges but rather through buying materials from each other when needed. Some of the trading is done in order to reduce transport distances, i.e. a form of location barter.

There are two arrangements for location exchanges:

i) A competitor buys the fuel at the landing and transports it from there.

ii) The selling company's haulier delivers on another company's contract to the customer, i.e. the material is sold to the other company at mill gate.

In the first case, there may be problems if the landowner dislikes the arrangement, and the second case normally requires customer approval. Most forest companies who commented on the prospects for exchanging forest fuel said that they favoured delivering on other companies' contracts. Both variants have occurred.

A major concern of all the surveyed companies is the risk involved in barter. As the product and its quality is poorly defined, and only a general description of the material at the landing is available, it is hard to evaluate whether materials of equal value and quality are being bartered. Furthermore, unlike pulpwood, there is no fixed price for forest chips, which increases the risk involved in the transaction.

The simulation presented in this study was based on historical biomass transports. There is always considerable uncertainty concerning parameters and values. The model must reflect reality sufficiently well to illustrate this uncertainty. The current model has no stochastic elements, as the objective of the study would be overshadowed by the need to determine the correct probability distribution for each activity. This would severely increase the effort required to solve the task of finding the barter candidates, while adding only marginal value to the model.

A refined simulation model would provide better guidelines on how to implement location barter, but to make such a development worthwhile, a number of interested companies should be included and committed. Under such conditions, a method could be developed based on a combination of simulation and optimisation, incorporated in an iterative process.

The starting point is flows, activities and processes that are modelled in a simulation tool. In the activities and processes where there is some kind of uncertainty, probability distributions are determined and used to calculate the expected value for a flow that has passed through a variety of processes. At a predetermined time or event, the simulation will pause and the values from the decision variables are sent to an optimisation model, which provides an answer as to which decision is best. The best alternative is sent back to the simulation model to evaluate and test how the choice will affect the overall flow. This method would provide an optimal policy option that is also evaluated on the basis of a variety of uncertainties. In other words, this method would provide the best location exchanges in each time step, while allowing evaluation of uncertainty in a full-scale implementation.

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