Prospects and Challenges of Timber Trucking in a Changing Operational Environment in Finland

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Abstract

The objective was to study how entrepreneurs taking care of the transport of wood perceive the current challenges in the operating environment and reflect these challenges in the changing climate. The data was collected in spring 2012 by mail questionnaire, which was answered by a total of 86 entrepreneurs giving a response rate of 19.1%. According to the respondents, the most debilitating factors in the changing infrastructure in future will be the challenges of the low volume road network, especially winter maintenance including removing snow and ice and preventing slippery conditions. The entrepreneurs were concerned about labour costs caused by a possible shortage of skilled drivers. The main problem concerning Information and Communication Technology (ICT) in timber trucking logistics is the inability to use one ICT system for two or more clients, which leads to problems in handling multiple clients. Almost all respondents agreed that timber trucking enterprises are too dependent on clients' ICT systems.

Keywords: Wood procurement, wood transport, ICT, business environment, profitability

1. Introduction

In Finland, 76% of roundwood used by the forest industry is transported to the mill by 1 700 trucks (Finnish statistical... 2012). The remaining 24% is transported to the mill either by train or waterways, although this includes timber trucking at the beginning of the transportation chain, 50 km on average. In general, timber trucking is a flexible transportation method in circumstances where the starting point of transportation is continuously changing, and the extent of value added is low. Thus, timber trucking is the most important transportation method for the raw material supply of the Finnish forest industry.

A typical roundwood truck in Finland operating in the Nordic cut-to-length system is a three-axle truck pulling a four-axle trailer. The maximum weight, including payload, of the vehicle was limited to 60 t, but on Oct. 1, 2013, the maximum permitted weight of the vehicles was increased to 76 t. Regardless of the high load, the trucks are designed to operate on public roads and to work under demanding conditions on narrow and sometimes inadequate forest roads. The trucks are equipped with removable roundwood cranes and separate loaders are seldom used.

Roundwood trucks are typically owned by family enterprises situated in the countryside, where the entrepreneur participates actively in production work. There are about 900 timber trucking entrepreneurs employing 2 600 truck drivers, and the average number of trucks per enterprise is less than two (Rieppo 2010). At the same time, customers are concentrated; the share of the three largest customers is about 90%. This, with specialised trucks incapable of competing in other markets, has produced strong dependency between timber trucking entrepreneurs and the Finnish forest industry.

Timber trucking in Finnish conditions has been considered relatively competitive compared to other countries (Högnäs 2001). In 2000, about 2/3 of the timber trucking enterprises were considered to be profitable with a positive net income and over 15% return on invested capital (Högnäs 2001). In the period 2001

– 2006, timber trucking enterprises grew by about 10% per year. The profitability of the smallest companies with a turnover under € 1 million clearly benefited from the growth, whereas € 1 – 1.5 million seems to be the most efficient size for a timber trucking enterprise (Soirinsuo and Mäkinen 2010). The competitiveness of Finnish timber trucking is based on long term development work, investments in information and communication (ICT), optimisation systems and high net carrying loads. Although timber trucking has been a cost effective transportation method, there are some threats to be faced. The rising price of fuel, environmental impact, changing regulations and taxes and changes caused by climate change may have an effect on the operational environment of timber trucking.

In the changing operating environment, the forest industry is attempting to improve its cost effectiveness by offering extended entrepreneurship agreements that increase the responsibilities of timber trucking entrepreneurs (Palander et al. 2006). In a typical regional entrepreneurship application, the wood procurement organisation signs haulage contracts with fewer entrepreneurs, each responsible for a larger area (Palander et al. 2012). These contracts include tasks, which are larger and more diverse including more responsibilities than in conventional contracts, and thus the requirements for entrepreneurs are growing, as well their degree of freedom for organising the work.

Roundwood logistics in Finland is controlled by ICT systems owned by wood procurement companies. Each company has its own ICT system, which is delivered to the timber trucking entrepreneur. If the timber trucking entrepreneur has multiple clients, the onboard computer, or at least the hard drive, has to be changed. This has complicated operations with multiple clients since the optimisation of the routes and timetables is more difficult, preventing the chance of carrying payload during backhaul instead of driving empty (Palander and Väätäinen 2005). Additionally, drivers have to master several different ICT systems. However, recently an integrated ICT system, the LogForce, for timber trucking enterprises has been developed, and at least two of the three largest wood procurement companies are planning to use it. According to final report of the investigation of roundwood trade by the Finnish Ministry of Employment and Economy (Puumarkkinoiden… 2009), the extended use of integrated roundwood transportation logistics ICT systems will promote more efficient timber trucking, especially enhancing the operational environment and cost effectiveness of timber trucking enterprises.

In the changing business environment of timber trucking entrepreneurs, the management of cost structure and price setting is becoming more demanding. The margins are low and small mistakes in pricing may steer the enterprise to a situation where the price does not cover expenses. For assigning logistic costs to roundwood assortment and lots, Nurminen et al. (2009) introduced an activity based cost (ABC) management system for cut-to-length roundwood harvesting and trucking. In the system, costs are traced to individual stands and to roundwood assortment lots from a stand. Palander et al. (2012) have also suggested planning systems based on the dynamic activity based costing (DABC), which can be used for the determination of certain costs and their sources in the comparative work studies of time dependent work processes. These systems would promote development of a more efficient and plausible ICT system for timber trucking organisations.

Finnish industry, with the forest industry at the forefront, has been demanding higher loads for trucking. Although gross weights for trucks are already at the top of the European scale (Permissible… 2012), both Finland and Sweden are pushing towards higher gross weights. In Finland, the maximum weight of the trucks has been increased to 76 t for vehicles equipped with four axles on the truck and five on the trailer (Korpilahti 2013), and the first experimental permit for the 80 t truck has been given. In Sweden, research project 'ETT, Modular System for Timber Transport' has run vehicles with a gross weight of up to 90 t on public roads. In Sweden, the argument for an increase in gross weights has been supported by lower fuel consumption and therefore lower emissions of environmental contaminants and lower transport costs (ETT, Modular System… 2013). In Finland, the primary argument has been the global economy, especially the effect of the EU's sulphur directive on Finnish industry. The sulphur directive restricts the sulphur content of fuel used in the shipping industry to 0.1% in the Baltic Sea, which is classified as a Sulphur Emission Control Area under the directive, meaning stricter limits than for waters in southern Europe. Furthermore, in Finland, the increase in gross weight has been justified by the smaller stress on the road caused by the increased number of axles and better road safety caused by the improved weight ratio between truck and trailer.

Recently in Finland, some experiments have been done in Metsähallitus (Finnish state run enterprise managing state forests) with central tyre inflation (CTI) systems, which have been used more frequently, for example in Canada. In the CTI system, the vehicle operator can change the tyre inflation pressure while the vehicle is moving. The results have been promising. Unpublished findings correspond to the findings of Woodrooffe and Burns (1998) and Vuorimies et al. (2009), who discovered that lower tyre inflation pressure reduces road wear and improves vehicle performance in traction, braking, ride quality and vehicle maintenance. However, return on investment in CTI-systems has been questioned by timber trucking entrepreneurs but, due to costs saved in road maintenance and heavier gross weights of trucks, it is more likely that the renewal of contracts demands roundwood trucks with CTI-systems.

In Nordic countries such as Finland, weather conditions mean that the operating environment is often challenging. There are three major weather factors that affect road transport (Saarelainen and Makkonen 2007): temperature, rain and wind. Low (or high) temperature, rainstorms, increasing average rainfall and violent winds cause disturbance in road transport, damage road infrastructure and complicate road maintenance. Some weather conditions have direct implications for road maintenance and transportation. Roads must be cleared of snow and slippery ice needs anti-icing or gritting.

The Finnish climate is characterised by large variation between years. On the basis of climate change models, the mean temperature is expected to rise and precipitation will increase, particularly in winter time. These changes will affect timber trucking. Some of the effects of climate change will be favourable, but some will be unfavourable (Tiehallinto 2009). Climate change will affect different parts of Finland differently. For instance, anti-icing and de-icing will decrease in Southern Finland, but increase in Central Finland and Northern Finland. Nevertheless, climate change is expected to increase the total costs of road maintenance to some extent.

The aim of the study was to see how timber trucking entrepreneurs experience the operating environment of timber trucking and what they feel about the ICT systems of roundwood logistics used in operational management, and to consider the results in the future operating environment as climate changes. The infrastructure and logistic chain as a whole are under consideration.

2. Material and Methods

The study data was collected in spring 2012 using a 5 page questionnaire sent by mail to Finnish timber trucking entrepreneurs, of which 410 belonged to the Finnish Association of Forest Road Carriers. This association represents companies offering road timber trucking services for forestry. The sample was complemented with 40 entrepreneurs not belonging to the association, making a total of 450. Answering the questionnaire was estimated to take approximately 20 minutes. In total, 86 entrepreneurs returned the questionnaire giving a response rate of 19.1%.

The questionnaire was divided into five parts. The first part asked entrepreneurs about their current situation and obtained other background information. The second part considered the infrastructure of timber trucking and the availability of manpower. The third part considered opinions about the ICT systems of logistics used in operational management. The fourth part examined the overall operational environment of timber trucking and the last part examined the operations of particular enterprises. Most of the questions were composed using a five point Likert scale.

The respondents were divided into three groups with the number of trucks as the indicator of the size of a respondent's operations. Out of 86 respondents, 40 had only one truck (»small company«), 18 had two trucks (»medium company«) and 28 had more than two trucks (»large company«). The biggest company had 14 trucks. The average weekly number of working hours of entrepreneurs varied greatly between respondents. The average number was 62.5 hours per week, the least being 4 hours per week and the greatest 105 hours. There were no statistically significant differences in the number of weekly working hours between entrepreneurs of different sizes.

The relationships between questionnaire variables were examined using principal component analysis (PCA). PCA is a statistical technique where correlated variables are transformed into a smaller set of uncorrelated, composite variables called principal components (PCs). The use of PCA with a dataset as small as this ($n < 100$) is questionable, but because of the item ratio (over 20:1), the critical use of PCA was enabled (Osborne and Costello 2004).

PCA involves calculating the eigenvalue decomposition of a data covariance matrix and the results are usually discussed in terms of PC loadings. In this study, PC loadings smaller than 0.40 were considered insignificant, and they were removed from the PCs. The variables ($n = 21$) depicting the operational environment of timber trucking were reduced to three PCs. Both the Kaiser-Meyer-Olkin measure of sampling adequacy (0.763) and Barlett's test of sphericity (< 0.00) show that the data is appropriate for this type of analysis. Since the PCs were correlated with many variables, the varimax rotated factor matrix was computed. By rotating the factor, we would like each factor to have non zero or significant loadings for only some variables. Rotation does not affect the communalities and the percentage of total variance explained.

In the analysis of the background information and the attitude results, non-parametric analysis of variance (the Kruskal-Wallis test) and the Mann-Whithey *U*-test were utilised. The tests were selected because the values of answers did not show a normal distribution. The statistical significance level of $p < 0.05$ was used for all results.

3. Results

3.1 Profitability of timber trucking enterprises

Almost half of the respondents felt that in recent years the profitability of timber trucking in their enterprise had decreased greatly (22.6%) or to some extent (23.8%). One-third (33.3%) answered that the prof-

Table 1 Attitudes of entrepreneurs towards the infrastructure of timber trucking by the geographical location of their enterprise. 1 »Not at all influential«; 2 »Slightly influential«; 3 »Somewhat influential«; 4 »Very influential«; 5 »Extremely influential«

	Northern Finland (A)		Western Finland (B)		Eastern Finland (C)		Southern Finland (D)		Average	
	av	σ	av	σ	av	σ	av	σ	av	σ
Winter maintenance (incl. removing of snow and ice and slip prevention)	4.6	0.7	4.3	1.0	4.4	0.9	4.4	0.6	4.44	0.85
Dimensions and condition of storage areas and intersections (B – C*)	4.0	0.8	4.3	0.8	3.9	0.7	4.2	0.7	4.05	0.80
Condition and sizing of passing points and turning places (C – D*)	4.1	0.9	4.1	0.9	3.7	0.8	4.3	0.8	4.01	0.89
Bearing capacity of roads (year – around)	3.9	0.7	4.1	0.8	4.0	1.0	4.0	1.0	3.99	0.86
Proportion of multi-source loads	3.7	1.2	4.0	1.2	3.8	0.9	4.2	0.9	3.89	1.06
Frost-damaged roads (incl. spring and autumn damages)	3.9	0.7	3.9	0.8	3.9	1.1	3.8	0.9	3.88	0.89
Condition of road surface	3.7	0.7	3.8	1.0	3.9	1.0	3.7	0.9	3.80	0.91
Grading of road surface	3.7	1.4	3.8	1.1	3.8	1.3	3.8	1.3	3.78	1.25
Terminal operations at pulp and paper mills	3.9	0.9	3.7	1.0	3.8	0.9	3.7	0.9	3.76	0.90
Terminal operations at sawmills	3.9	1.2	3.7	0.9	3.6	1.1	3.6	1.0	3.71	1.06
Roundwood stacks and loading conditions	3.7	1.1	3.7	1.1	3.3	1.1	3.6	0.6	3.56	1.03
Slopes and curves at forest roads	3.3	1.1	3.3	1.2	3.6	0.9	4.0	1.1	3.52	1.08
Condition of bridges, tunnels and pipe culverts (C – D*)	3.4	1.0	3.5	1.1	3.3	0.9	4.0	1.1	3.48	1.02
Proportion of driving empty (B – D**)	3.3	1.2	3.6	1.1	3.3	1.1	3.8	1.1	3.46	1.14
Particularly small roundwood lots	3.5	0.9	3.1	0.9	3.5	1.0	3.9	0.8	3.45	0.95
Other road maintenance (removing of stones, repairs of damages)	3.3	1.0	3.5	1.0	3.4	0.8	3.6	1.1	3.42	0.93
Sizing of terminals and loading points for short-term storing (A – D*, B – C*, C – D**)	3.5	0.9	3.0	1.2	3.8	1.0	2.6	1.1	3.37	1.10
Possibilities for intermediate storage of roundwood	3.4	1.1	3.1	1.2	3.4	1.0	3.0	0.8	3.25	1.04
Hot shot hauling of roundwood by truck to trailer (A – D*)	3.0	1.1	3.1	1.1	3.3	1.2	3.9	0.9	3.24	1.11
Clearing of roadside coppice (A – B*)	2.7	0.9	3.5	1.2	3.0	1.1	3.3	1.4	3.09	1.13
Parking and rest areas	3.0	1.1	2.5	1.2	3.0	1.1	2.8	1.2	2.84	1.15
Terminal operations for railway transportation (A – D**)	3.2	1.0	2.6	1.1	2.8	1.3	2.1	0.8	2.76	1.16
Other terminal operations (A – D*, B – D*, C – D*)	2.8	1.0	2.7	1.1	3.0	1.2	1.9	0.8	2.70	1.12
Roundwood rafting terminals (A – B*, A – D*, B – C**, C – D*)	2.2	1.3	1.6	1.1	2.5	1.2	1.2	0.6	2.01	1.21

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, Mann-Whitney *U*-test

itability of their enterprise was unchanged, and the rest answered that their profitability had increased to some extent (16.7%) or greatly (3.6%). The size of the enterprise or geographical location did not have any statistical significance on profitability. The prospects for the future were similar. Four out of ten felt that their profitability had decreased, half of them greatly (20.2%) and other half (19.0%) felt that it had decreased to some extent and would continue to do so. The same number of respondent (39.3%) believed that their profitability would continue on a similar level, whereas the rest felt that they had increased profitability to some extent (20.2%) or greatly (1.2%).

3.2 Infrastructure of timber trucking

The respondents' opinion of the infrastructure of timber trucking was examined by 24 questions. The questions were prepared using the Likert-scale, where:

1 »Not at all influential«,
2 »Slightly influential«,
3 »Somewhat influential«,
4 »Very influential«,
5 »Extremely influential«.

All variables within the twelve most important variables were considered to have a great effect on the operating environment of timber trucking (Table 1).

Table 2 Varimax rotated factor matrix for the PCA of the variables depicting the attitudes of entrepreneurs towards the infrastructure of timber trucking

	PC1	PC2	PC3
Winter maintenance (incl. removing of snow and ice and slippery prevention)	.728	–	–
Condition of bridges, tunnels and pipe culverts	.717	–	–
Dimensions and condition of storage areas and intersections	.707	–	–
Grading of road surface	.681	–	–
Condition of road surface	.662	–	–
Bearing capacity of roads (year-around)	.631	–	–
Other road maintenance (removing of stones, repairs of damages)	.617	–	–
Condition and sizing of passing points and turning places	.566	–	–
Slopes and curves at forest roads	.547	–	–
Frost-damaged roads (incl. spring and autumn damages)	.539	–	–
Roundwood rafting terminals	–	.765	–
Sizing of terminals and loading points for short-term storing	–	.716	–
Terminal operations for railway transportation	–	.681	–
Parking and rest areas	.488	.638	–
Terminal operations at pulp and paper mills	–	.594	–
Terminal operations at sawmills	–	.586	–
Possibilities for intermediate storage of roundwood	.445	.566	–
Particularly small roundwood lots	–	–	.809
Hot shot hauling of roundwood by truck to trailer	–	–	.787
Proportion of multi-source loads	–	–	.606
Roundwood stacks and loading conditions	–	–	.586
Extraction sums of squared loadings	5.672	2.362	2.176
Coefficient of determination (%)	31.54	13.12	12.08
Cronbach's alpha	0.83	0.839	0.746

The most influential infrastructure factor affecting timber trucking was winter maintenance, including removing snow and ice and anti-slip measures. There were no statistically significant differences between different geographical regions in Finland, although winter maintenance was most influential in Northern Finland where the winter is longest and the amount of snowfall the largest. The second influential infrastructure factor was dimensions and the condition of storage areas and intersections. This, as well as the third influential factor, the condition and sizing of passing points and turning places, was a greater problem in densely populated areas in Southern and Western Finland than in rural areas in Eastern and Northern Finland.

The infrastructure of timber trucking was analysed by PCA, which converts a set of correlated variables into a set of linearly uncorrelated variables, PCs. In the study, 21 original variables were transformed into three PCs (Table 2), which were named according to variables included in the PCs. PC1 included variables depicting the condition and usability of the road network, hence PC1 was named »low volume roads«. The extraction sums of squared loadings was high (5.7), and PC1 explained almost one third of the variation. The internal consistency depicted by Cronbach's alpha value (0.83) was also high. PC2 was named »Loading and terminal operations« due to variables included in PC2. The extraction sums of squared loadings were 2.4, and Cronbach's alpha 0.84. PC3 included variables depicting load specific factors and was named »Stand specific factors«. The extraction sum of squared loadings for the third PCI was 2.2, and Cronbach's alpha 0.75.

3.3 Availability of manpower

The attitudes of timber trucking entrepreneurs towards factors depicting the availability of manpower were studied by nine questions prepared using the Likert scale. The most important factor was a possible increase in drivers' salaries, and consequently, an increase in timber trucking costs caused by a possible labour shortage (Table 3). This is mostly caused by the second important factor: most of the current drivers are retiring in the next few years. However, especially in large companies, the entrepreneurs felt that the drivers were committed to the enterprise and timber trucking business. At the same time, they felt that the means to prevent a labour shortage are not working properly: strengthened operations and larger enterprises will not prevent a labour shortage, young persons are not interested in timber trucking as a profession and the co-operation between timber trucking enterprises and learning institutes is not working properly.

3.4 ICT systems of logistics used in operational management

The entrepreneurs responded to 18 claims concerning the ICT systems of logistics in operational management. Attitudes were neutral towards most of the claims, especially towards claims concerning the op-

Table 3 Attitudes of entrepreneurs towards variables describing the availability of manpower by the size of the company. 1 »Not at all influential«; 2 »Slightly influential«; 3 »Somewhat influential«; 4 »Very influential«; 5 »Extremely influential«

	Small company A		Medium company B		Large company C		Average	
	av	σ	av	σ	av	σ	av	σ
Possible labour shortage increases salary and transportation costs	4.2	0.7	3.9	1.1	4.0	1.0	4.1	0.9
Most of the current drivers are retiring in the next few years (A – C*)	4.1	0.9	3.6	1.1	3.4	1.2	3.7	1.1
Employees are committed to the enterprise and timber trucking (A – C**)	3.3	1.0	3.1	0.9	3.9	0.7	3.4	0.9
I'm aware of how the process of succession is conducted	3.2	1.5	3.4	1.5	2.8	1.5	3.1	1.5
Induction for new employees is a planned process in my enterprise	2.9	1.1	2.9	0.8	3.1	0.8	3.0	1.0
Succession will be topical in the coming years	2.8	1.7	2.7	1.7	2.4	1.4	2.6	1.6
Co-operation between enterprises and learning institutions is working well (A – -C*)	2.6	0.7	2.2	0.7	2.2	0.9	2.4	0.8
Young persons are interested in timber trucking	2.4	0.9	2.1	0.9	2.4	1.1	2.3	1.0
Strengthened operations and larger size enterprises will help labour shortage	2.3	0.9	2.2	1.0	2.2	0.9	2.2	0.9

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ Mann-Whitney *U*-test

erational function of current ICT systems (Table 4). The strongest agreement was towards the claim »entrepreneurs are completely dependent on clients' ICT systems«, and the strongest disagreement towards the claim »ICT systems are compatible with different operations«.

4. Discussion

The main objective of the study was to investigate what timber trucking entrepreneurs feel about the operating environment of timber trucking and the ICT systems of roundwood logistics used in operational management. The main concern regarding the operating environment was the low volume roads. Winter maintenance including removing snow and ice and anti-slip measures especially caused concern. Winter maintenance has a large impact not only on the logistics of timber trucking, but also road safety. Although the dimensions and condition of low volume roads and seasonal problems such as year-around bearing capacity and frost-damaged road were raised, winter maintenance was clearly a greater cause for concern than other problems in low-volume roads.

Although the climate is changing due to increased CO_2 levels caused by human actions, the importance of winter maintenance in timber trucking will not be reduced. According to the Finnish Road Administration (Tiehallinto 2009), increasingly mild winters are expected to mean fewer days of sub-zero temperatures in Southern Finland, reducing the need for winter maintenance in southern parts of the country. However, the need for slip prevention is likely to increase in Central Finland and Northern Finland, and the focus of winter road maintenance will shift further north. The likelihood of freezing rain, which creates treacherous road conditions, is expected to decrease in Southern and Central Finland. However, freezing rain is expected to become slightly more common in the northernmost parts of Finland, as temperatures around zero degrees become more common. Short-lived snowstorms, when a lot of snow falls at once

Table 4 Attitudes of entrepreneurs towards ICT systems of logistics used in operational management by the size of the company. 1 »Strongly disagree«, 2 »Disagree«, 3 »Neither agree or disagree«, 4 »Agree«, 5 »Strongly agree«

	Small company A		Medium company B		Large company C		Average	
	av	σ	av	σ	av	σ	av	σ
Entrepreneurs are completely dependent on clients' ICT systems	4.2	1.0	4.2	0.8	4.0	1.0	4.2	1.0
ICT has improved possibilities to serve customers (B – C*)	3.8	1.0	3.5	0.9	4.1	0.9	3.8	1.0
ICT has improved the management and execution of timber trucking (B – C*)	3.6	0.8	3.2	0.9	3.8	1.0	3.5	0.9
Employees demand more education regarding ICT systems	3.6	0.9	3.2	1.1	3.4	1.0	3.5	1.0
Profitability of ICT system investments includes uncertainty	3.5	1.1	3.8	1.1	3.4	0.8	3.5	1.0
ICT systems overly dominating the drivers' work	3.2	1.2	3.4	1.3	3.4	1.0	3.3	1.1
ICT supports extended responsibility of entrepreneurship	3.2	0.9	3.6	0.9	3.2	0.8	3.3	0.9
Current ICT systems are adequate for the required working efficiency	3.3	1.0	3.4	1.0	3.1	1.0	3.3	1.0
Helpdesk operations help me when needed	3.1	1.3	3.1	1.1	3.3	1.1	3.2	1.2
Management of operations works well with current ICT systems	3.2	1.1	3.1	1.2	3.0	1.0	3.1	1.1
Information exchange routes between prime- and subcontractors are sufficient	3.1	0.8	2.9	1.0	3.0	0.8	3.0	0.8
ICT has decreased the number of human mistakes (A – B*)	3.2	1.0	2.7	0.8	3.0	1.0	3.0	0.9
Current ICT systems are adequate for different clients	2.8	1.1	2.9	1.2	3.2	1.0	2.9	1.1
Tailored ICT systems are available	2.8	0.9	2.8	1.0	2.9	0.9	2.8	0.9
The ICT system used by my enterprise is insufficient	2.6	1.1	2.5	1.3	2.7	1.0	2.6	1.1
ICT has reduced the costs	2.7	1.2	2.4	1.1	2.6	0.9	2.6	1.1
I demand more ICT for my everyday routines	2.1	0.9	1.9	0.8	2.1	1.0	2.1	0.9
ICT systems are compatible with different operators	2.2	1.1	1.9	0.8	2.1	1.1	2.1	1.0

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ Mann-Whitney *U*-test

causing disruptions to timber trucking, are likely to increase. All in all, the need for snow removal is likely to remain relatively unchanged or to decrease, because the period of snow cover will become shorter, and the need for slip prevention will shift further north (Tiehallinto 2009). This will not help timber trucking in Northern Finland, where winter maintenance is already a greater problem than in southern regions.

The year-around bearing capacity was the fourth most important factor affecting timber trucking. The bearing capacity of the road is dependent on the subsoil, drainage and structure of the road framework. In wintertime, ground frost helps the bearing capacity and some of the roads are so called winter roads, which are designed to access harvesting sites in locations where it is not profitable to build a summer road, or the construction and use of a summer road is not feasible for reasons of conservation. Climate change may affect the likelihood of ground frost in two ways. On the one hand, higher average temperatures limit frost formation, and frost may not penetrate as deep into the ground as before. On the other hand, the thinner snowpack may counteract this: frost penetrates deeper into the ground if temperatures drop below freezing when there is no protective layer of snow. The likelihood of frost is nevertheless expected to decrease on the whole, and this will have negative implications on roundwood and energy wood harvesting and hauling since ground and forest roads will no longer be able to support the weight of forest machinery and roundwood trucks as well as before, so there will be problems for roundwood and energy wood logistics (Marttila et al. 2005, Tiehallinto 2009). At the same time, the timber trucking environment is going through two changes affecting to bearing capacity of roads. CTI systems will reduce the ground pressure allowing transportation on roads, which would not otherwise permit the load of roundwood trucks. On the other hand, realized higher gross weights in Finland from the current 60 tonnes to up to 76 tonnes demand more from the road network. In conclusion concerning the impact of climate change on Finnish timber trucking, Southern and Western Finland will have fewer problems with winter maintenance, but more problems with year-around bearing capacity and the condition of the road surface. The problems with winter maintenance will increase in Northern Finland, whereas the operating environment in Eastern Finland will remain the same.

According to the respondents of the study, the sizing and condition of storage areas, intersections, passing points and turning places was a great problem especially in Western and Southern Finland. The unsatisfactory sizing and condition of forest roads is a well-known problem for all parties in timber logistics. However, the problem is diverse and more connected to deserted rural areas. To reduce the problems of forest roads, co-operation between forest owners, government and forest industry must be enhanced.

The results of the study emphasised concern over the availability of manpower in timber trucking. Consequently, timber trucking entrepreneurs were worried about labour costs caused by a shortage of skilled drivers. According to Solakivi et al. (2012), there is a need to ensure adequate supplies of labour, skills and expertise, and first rate training and research to sustain competitiveness in the hauling business. Although the problem of labour availability and commitment to timber trucking business was a larger problem in small companies, the respondents of the study did not feel that being larger helped the problem.

The main problem concerning ICT in timber trucking logistics is the inability to use one ICT system with two or more clients causing problems in handling multiple clients. Almost all respondents agreed that timber trucking enterprises are too dependent on the clients' ICT systems. However, recent development towards global transaction standards for paper and forest supply chains (PapiNet 2013) and an integrated ICT system (LogForce) for timber trucking enterprises may enhance the possibilities to handle multiple clients.

5. Conclusion

The results of the present study indicated that timber trucking entrepreneurs felt that the changing environment, low-volume roads and the availability of skilled labour were major complications for their business. The condition and maintenance of low volume roads, especially in winter time, is one of the crucial factors in successful roundwood supply in Finland. However, due to tight financial circumstances, it is unlikely that the budget for road maintenance will increase as demand increases. To facilitate roundwood supply for the Finnish forest industry, research will need to develop new concepts for timber trucking. As a start, in spring 2013, Metsäteho Oy, a Finnish research company, awarded a €10 000 prize for the completion of 'new innovations in timber trucking'. The winning entry included several innovations for adapting roundwood trucks according the hauling task.

The timber trucking operating environment is changing due to enhancement in ICT technology, climate change and increasingly fierce global competition. To enhance the hauling environment, entrepreneurs are willing to participate in planning a timber trucking logistic chain together with their clients. Entrepreneurs also want ICT systems that can be used with multiple clients. According to Pajuoja and Hämäläinen (2012), roundwood logistics is demanding new operating models for roundwood harvesting and hauling, wood procurement and the whole forest cluster. Development is towards co-operational models between timber trucking entrepreneurs, including joint venture and subcontracting as mechanisms for extending their responsibilities. To facilitate the development, of co-operation, the objectives for ICT systems should be determined quickly.

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