EVALUATION OF A NOVEL LOGISTICS SOLUTION FOR ROUNDWOOD IMPORT

Ekku Heljanko*

Olli-Pekka Hilmola*

*Lappeenranta University of Technology, School of Business and Management, Kouvola Unit, E-mail: Ekku.Haljanko@student.lut.fi, Olli-Pekka.Hilmola@lut.fi

Heljanko, Ekku & Olli-Pekka Hilmola (2017). Evaluation of a novel logistics solution for roundwood import. NOFOMA 2017 - Proceedings of the 29th Annual Nordic Logistics Research Network Conference (Lund, Sweden), pp. 266-281. ISBN: 978-91-7753-337-5

ABSTRACT

Purpose

Investment analysis on a novel logistics concept for timber transportation in South-Eastern Finland is presented. Concept utilizes longer freight train units, efficient terminal operations and multimodality based on High-Capacity Transport (HCT) trucks. This is compared to a current state of relying on shorter, but direct train transportation to factories. Primary interest is on Russian birch wood import (used in pulp manufacturing).

Design / methodology / approach

Research uses Cost-Benefit Analysis (CBA) in evaluation of wider societal effects. Financial and economic costs are estimated for a 33-year period using Discounted Cash Flow (DCF).

Findings

Analysis reveals that the modeled logistics concept is feasible. Taking the time-value of money into account, in the long-term this alternative method has lower overall costs compared to the currently used one. Possibility for intermodal container backhauling provides potential for synergy benefits. Synergies could also be accessed from the joint use of terminal by number of near-by factories.

Research limitations / implications

Regulations on train lengths and maximum truck weight have a major impact on results, and these vary among different European countries.

Practical implications

Although investment seems to be profitable, sensitivity analysis on the most crucial parameters should draw attention. Model is particularly sensitive on rolling stock turnaround difference and benefits could be gained in much shorter time period and larger economic scale, if environment is feasible (simultaneous changes in key parameters).

Originality / value

Analysis provides practical guidance for multiple interest groups. Model built for this research can be used with modifications in other locations.

Keywords: wood transports, railways, road, terminal, investment appraisal

1. INTRODUCTION

A high concentration of pulp production capacity is located in South-Eastern Finland. Three pulp mills in region of Kymenlaakso and three in region of South Karelia use large quantities of wood as a raw material on their processes. The demand highly outweighs local supply of fiber timber in both regions. Thus, transports from nearby regions and imports are required. Majority of timber imported to Finland is Russian birch fiber (Finnish Forest Research Institute, 2014). A need for this particular timber type is forecasted to sharply rise in both Kymenlaakso and South Karelia, while its national supply is unlikely to grow significantly (Räsänen et al., 2016; Natural Resources Institute Finland, 2016a & 2016b). Therefore, the rise in birch fiber demand is most likely to be met on Russian imports. Railways play a key role on these transports due to long transportation distances on Russian side and regulations that considerably limit maximum truck mass on Russian roads (Saranen, 2009). In long-term, regulation has been forced at mill level e.g. for environmental issues, while sourcing of wood and keeping up the forestry resources has received smaller role (Bergquist & Keskitalo, 2016). However, sourcing wood from Russia has not been problem-free as wood tariffs increased in period of 2006-2008, and affected many factories and continuity of their operations (Palander & Vesa, 2011).

Kouvola in Northern Kymenlaakso is located alongside the core Trans-European Transport Network (TEN-T). Its railroad terminal is the only one in Finland classified as top priority on TEN-T. Logistics are already an important economic driver in the city and based on this competence a public development project for a new Kouvola Rail-Road Terminal (RRT) was launched. Although the primary focus on RRT is to provide enhanced intermodal container logistics, other types of freight, such as timber, could also be handled and stored at the terminal.

A change in regulation has offered Finnish transport companies (similarly like in Sweden, Ye et al., 2014) a possibility to field test High-Capacity Transport -trucks (HCT). These vehicles exceed the standard legal limitations in maximum length (25.25 meters) or mass (76 tons). Five of such vehicles are currently used for timber transportation in Finland. Currently every HCT operator must participate in public research and development project to reveal, if these vehicles are as safe as standard trucks and gather insight on their cost efficiency (e.g. fuel consumption throughout the year in different situations). Depending on the results of these studies, it is possible that Finnish standard for maximum truck length and mass could be raised or a license to operate a HCT could become easier and more common in the future.

Based on these three standpoints, this research focuses on evaluating a novel logistics concept for timber transportation in South-Eastern Finland. Primary interest is on birch fiber timber imports from Russia. Analysis covers the whole logistics chain from Russian border to pulp mill(s). Costs connected to the required returns of empty stanchion wagons back to the border station are also included in the analysis. Investment appraisal is carried out by comparing costs of the current method of transporting timber relying solely on trains to those of the alternative concept, which consists of three phases: 1) Considerably longer freight train units from the border to RRT; 2) Efficient terminal logistics at the RRT for both railway wagons and timber; and 3) Transporting the timber from RRT to a factory with a HCT on road. Proposed logistics chain also provides a possibility for intermodal container backhauling from factory to RRT with the same HCT used for timber transportation. Synergy benefits arising from this possibility are taken into account in separate calculations. To enable these synergies in practice, the technological aspects must be paid attention before the investment in a purpose-built HCT is made. Prior research on railway transportation has proven that combining timber and intermodal freight can enhance supply chain efficiency (Saranen, 2009). Similarly, new concepts on railway transportation of timber has been shown to enable significant cost savings (Saranen & Hilmola, 2007).

Terminal facilities at the RRT are central in the novel logistics solution studied. Costs to build these facilities are major in comparison to annual costs of roundwood and container transportation. Therefore, the interest in investment evaluation is whether the terminal investment should be initiated or not. Logistics terminals are considered to be infrastructure investments, to which long duration, illiquidity and high capital intensity are common characteristics (Grimsey & Lewis, 2002). In most infrastructure projects public sector is involved in one way or another. For member states of the European Union it is possible to apply for union wide public finance for some of these projects. To secure this finance, appropriate analysis is required. According to European Commission (2014) guidelines, both financial and economic costs have to be taken into consideration. This can be done through Cost-Benefit Analysis (CBA), in which Discounted Cash Flow (DCF) is highly recommended on financial costs, whereas economic costs can be analyzed in multiple ways. The numerous alternative methods to carry out a CBA on infrastructure investment projects seem to be divided roughly on two different groups. Econometric approach rely on sophisticated tools such as general equilibrium models (for example: Bröcker et al., 2010; Calthrop et al., 2010; Verhoef et al., 2010). This approach is theoretically sound, but requires significant expertise and is perhaps better suited for situations in which majority or all benefits are not financial. That is, for example a public road that does not directly accrue any money to government, but brings time or cost saving benefits to those who use it. The second approach utilizes simulation-based methods (for example: De Palma et al., 2010; Saranen & Hilmola, 2009). Here analysis models can be built piece by piece and the situation around a proposed project be modelled precisely enough to represent reality without a set of complicated functions.

While not a simulation-based model per se, the analysis model used in this research builds more on this approach on CBA than on the econometric one. Estimated costs are thus strictly limited to those directly caused by the terminal and required transportation of roundwood and containers. Interest leans more on financial profitability of the terminal project and all considered externalities are negative, caused mainly on freight transportation via road or rails. Five types of external costs are recognized and measured in this research: congestion, accidents, air pollution, noise, and climate change. To match both financial and economic costs in the analysis, both are analyzed in a DCF manner, and in monetary terms (euros). Net Present Value (NPV) is considered as the most important investment criteria. It is widely considered to be the single best and most theoretically sound investment criteria, although other commonly used criteria could prove to be useful as well (Brealey et al., 2008; Copeland et al., 2005; Ross et al., 2008). Other measures calculated are Internal Rate of Return (IRR), Profitability Index (PI), Discounted Payback Period (DPP), and Payback Period (PP). These provide supporting information on the feasibility of the novel logistic concept as an alternative supply chain with regards to the currently used method relying solely on direct railway transports of Russian timber from the border to a factory with short train units.

This research is structured as follows: In Section 2 we shall introduce analysis model further, and will portray most important differing issues between current state and suggested novel logistics solution. Data on timber flows, investment and operating costs of the supply chain, and external costs are covered in Section 3. These are followed by analysis results in Section 4. Discussion concerning the implications of research and sustainability of results is provided in Section 5. Finally, in Section 6 we conclude our study.

2. ANALYSIS MODEL

The analysis model utilized on this research was built on spreadsheet software. Financial savings and external cost estimations are carried out individually on separate sheets and results on these are brought together on a CBA-sheet that provides evaluation on the overall economic effects the use of proposed novel logistics concept would have. An additional sheet was included for the results of the sensitivity analysis. For each table the parameter values were listed separately, allowing sensitivity analysis and alternative scenarios to be run easily. This feature also enables easy conversion of the model to be used to represent timber terminal in other locations than the one of RRT. Critical variables such as terminal investment cost, wagon cycle times, timber volumes and final destinations can be varied to see their effect on the profitability of the novel logistics concept. Each cost class under financial and external costs is calculated on its own row under total cost for train transports, HCT transports, terminal set up and operation, and material handler. This allows a clear view to compare, which cost classes are the most significant under the two alternative timber supply chains compared.

Analysis is carried out in annual precision for a total of 33 years, first three years representing the set up period on terminal infrastructure and the rest 30 years actual operations on the supply chain. Each year of operations was assumed to be similar to each other. While this might not be the case in practice, this choice was done to handle the uncertainty around multiple variables in their long term development. For the same reason real values were used in cash flow estimations instead of inflated ones. This is taken into consideration on the discount rates used. Following the European Commission (2014) recommendations, financial discount rate was set to 4% p.a. and economical discount rate to 5% p.a.

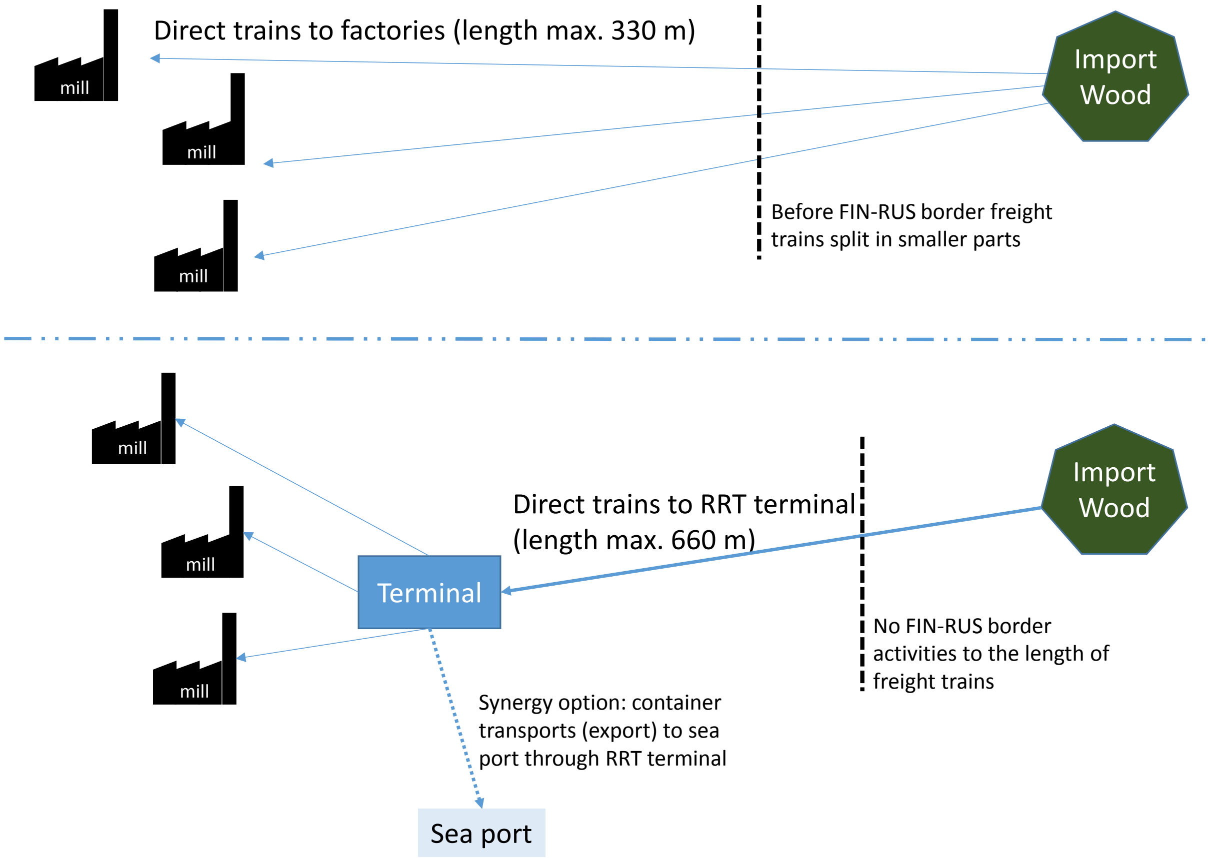

Figure 2.1 Illustration of two different alternatives analyzed for wood import, where in upper part wood arrives in smaller trains and batches to different factories directly, while in lower part, longer trains and larger batches are sent to terminal to be further processed by HCT trucks to factories (with option of container export).

A major difference in the model between the novel logistics concept and direct train transports is the length of a single train unit. This was assumed to be 330 meters / 22 wagons on currently used direct railway transports due to the limitations on pulp mill railway facilities. The RRT can accept considerably longer train units, which were set to 660 meters / 44 wagons in this research. This significantly reduces costs related to locomotive changes at the border. Another difference between the two alternative supply chains is the number of required changes or handling times for a single stanchion wagon on its way from the border to pulp mill / RRT and back. On direct train transports, this was estimated to be four (Iikkanen, 2013). Due to the enhanced planning and more efficient logistics at the RRT, this number was assumed to be one on the novel logistics concept. Through savings on these costs and reduced wagon rent costs due to faster turnaround, the novel logistics concept can provide savings on overall logistics cost on Russian timber imports. The present values of these savings are compared to those of required investments to evaluate, if the proposed alternative supply chain should be taken in use. It should be emphasized that the point of view here is on costs for the whole supply chain and in practice it would most likely require more than one operator to carry out railway and HCT transports as well as terminal logistics at the timber section of the RRT. Figure 2.1 illustrates our research environment and novel logistics solution further.

3. DATA

Data on timber supply, demand and imports (sub-section 3.1.) was used in primary analysis to find out, which timber classes and freight routes should be taken into consideration in the analysis model. Information used in the analysis of financial costs is divided in the five sub-sections by cost drivers. These are: 3.2. Terminal investment and operation; 3.3. Train transportation; 3.4. HCT transportation; 3.5. Material handler; and 3.6. Shipping container backhauling. Data used to widen the analysis perspective and include economic costs in monetary terms is presented in sub-chapter 3.7. Externalities costs.

3.1. Timber supply, demand and imports

Statistics from Natural Resources Institute Finland's database (2016a; 2016b) were used to draw a picture on the balance between timber supply and demand in South-Eastern Finland. Here harvests in Kymenlaakso and South Karelia represent the supply and timber used by forestry industry on these regions represents demand. A total of six timber classes were analyzed on annual precision. Three species were considered: pine, spruce and hardwood (mostly birch). Types considered were logs (sawmill industry) and fiber (pulp manufacturing). Financial crisis caused a sharp decline in both supply and demand of timber in 2009, after which the situation has stabilized. Therefore a five year average between 2010 and 2014 was used to represent the situation as it stands today. Estimations for 2020 were collected from scenario 2 in Metsäteho report 238 (Räsänen et al., 2016), which assumes the total annual timber imports to Finland rise by three million m^3 from current levels. Analysis reveals that there is a significant deficit in both Kymenlaakso and South Karelia for all three species in fiber type timber. This situation is due to the high concentration of major pulp mills on the area. For 2020 this deficit on hardwood fiber is projected to rise remarkably, whereas there are no major changes on the balance of other timber classes. This indicates a growing need for hardwood fiber transports to South-Eastern Finland from outside its two regions.

Timber imports to Finland were inspected by the six timber classes described above and by country of origin from statistics by Natural Resource Institute Finland (2016c). Conclusions on these timber flows are rather clear. After the disruptions of financial crisis majority of timber imports have been hardwood fiber and by far the most significant source for it has been Russia. The situation with regards to timber imports has remained rather steady from 2010 onwards.

As the local harvest are by no means sufficient to meet the demand for fiber timber in either of the regions in South-Eastern Finland, large quantities of all the three species has to be transported to factories in Kymenlaakso and South Karelia from elsewhere in Finland and abroad. Projected investments in pulp production capacity are to further escalate this logistic problem. This is especially the case with hardwood fiber. Its national supply is limited on a situation in which its demand is sharply on a rise. Most of the future imports are likely to be from Russia as has been the case so far. For these transports trains are superior to road traffic due to low maximum mass for trucks on Russian road network (International Transport Forum, 2015). Based on these premises, Russian birch fiber imports via railways to Kymenlaakso were chosen to be the primary interest on this research.

3.2. Terminal investment and operation costs

Investment costs on the timber terminal section of the RRT can be divided to two classes: 1) RRT infrastructure costs allocated to the timber terminal, and 2) costs specific to building the timber terminal. Common infrastructure for all users of the RRT includes rails, switches, roads, fencing and buildings. These, and required planning, supervision and permits, account a total estimated cost of 2 211 000 € to be allocated on the timber section of the RRT. The investment costs specific to the timber section cover gravel field, transport and protection of land masses, ditches, runoff and waste water sewers, water and electricity connections, lights as well as planning, supervision and permits needed to complete the fore mentioned. These are estimated to be 2 072 840 € in total. Annual operation costs of the timber terminal include land rent, 33 000 €, and terminal maintenance, services and utilities, 21 000 €.

On the DCF-calculations the investment costs, in total approximately 4.3 million €, are divided equally for the first three years to represent the building period. Operation costs are assumed to stay constant throughout the years. Estimations on investment and operation costs of the timber terminal are based on three expert interviews of company (consultation and/or engineering) representatives working on the Kouvola RRT development project.

3.3. Railway transportation costs

Finnish Transport Agency report on railway traffic cost models was used as a basis to determine train transport costs on timber freight (Iikkanen, 2013). Both data on costs and main parts for the structure of cost modelling with regards to railway transports were gathered from this document. For the timber terminal case examined, a total of eight cost types are recognized. Time based costs, distance based costs, railway payments and fuel taxes are presented on Table 3.1. Cost for changing or handling wagons in a rail yard is 19 €/wagon and locomotive change cost at the Russian border is 146 €/change. Overhead costs account for 15% out of the total costs on the five types mentioned above. These costs cover management, planning, marketing and sales, real estate upkeep and insurance. In addition to these costs, wagon rent costs and cost of capital employed are included in the DCF calculations.

Table 3.1 Timber freight train transportation costs in Finland

	Time based cost, €/h	Distance based cost, €/km	Railway payments and fuel taxes
Electric locomotive, 1st	235	1.39	0.15

Electric locomotive, 2nd & 3rd	122	1.39	0.15
Wagon	2.05	0.10	0.10

As the interest is mainly on imported Russian timber, wagons are assumed to be Russian. Based on a review of rental prices for these wagons, daily rent for one was set to 900 rubles (ЭРВК, 2016). For the last few years ruble-euro –exchange rate has been rather volatile (Thomson Reuters, 2016). For the analysis, this rate was set on a constant level of 50 RUB/€. This is very close to the average rate between 1/2010 – 6/2016. On these standpoints, rent for a stanchion wagon dedicated to timber transportation is expected to be 18 €/day.

Making the total wagon cycle time shorter was recognized to be one of the main drivers to achieve costs savings by using the novel logistics concept. Gate-to-gate lead time on timber wagons was used on the model to represent the degree of efficiency on wagon utilization. This factor covers the stanchion wagons entire round trip from Vainikkala at the Russian border to the RRT/pulp mill and back. For the time this round trip takes, rent has to be paid on Russian wagons used to import timber. Gate-to-gate lead times are following for the four factories included in the model (based on short interviews with two major producers): UPM Kymi – 5 days; Stora Enso Anjala – 5 days; Metsä Group Äänekoski – 5 days; UPM Kaukas – 3 days. These are estimations on average lead times, which in practice may vary. Operations at the RRT are to be coordinated in a manner to enable straightforward and efficient railway logistics. This is most likely not the primary interest at the pulp mills where multiple in- and outbound logistics chains need to be optimized to meet various goals set by company management. Due to this difference between the RRT and factories, the gate-to-gate lead time for timber wagons at the RRT is assumed to be 1.5 days on average.

Cost of capital employed in timber was calculated by multiplying the expected rolling stock (on the solution relying on terminal, also average stock at the terminal field was considered), import timber value and cost of capital. The average rolling stock is dependent on wagon cycle times as well as the timber volume transported through the terminal on an annual level. Average stocking time for timber at the RRT was set to be four days. Import timber value was assumed to be 36 €/ton (Natural Resources Institute Finland, 2016c). For cost of capital, estimation on UPM WACC was used. In the summer of 2016 this was estimated to be approximately 7.6% p.a. (UPM, 2016; Nasdaq, 2016; Bank of Finland, 2016; Yahoo Finance, 2016a & 2016b).

Google Maps route service was utilized to find distances between the locations of interest in this model. To simplify the already rather complex model, same distances were used for both road and rail between two points for most routes. From the RRT (Google Maps, 2016) the distances are following: Vainikkala (station at Russian border) – 91 km; UPM Kymi – 17 km; Stora Enso Anjala – 24 km; Metsä Group Äänekoski – 236 km; UPM Kaukas – 87 km; and Kotka harbor – 57 km. Distances via rail from Vainikkala to two factories are listed separately. These are: Metsä Group Äänekoski – 402 km; and UPM Kaukas – 64 km. To these two locations direct train transports do not run through RRT.

3.4. HCT transportation costs

A total of six cost types were recognized for transporting timber via road on a HCT-vehicle: investment, diesel, AdBlue, tire, salary and other. In addition to estimation of these costs, the annual operating hours were calculated. This was done to determine whether a one or two vehicles would be needed. It was assumed that the HCT could be driven in shifts and its schedule extended to weekends and nights if required.

Investment cost for a purpose-built HCT is 311 000 € (Venäläinen & Korpilahti, 2015). This does not cover tires, which are set to be a variable cost in the model dependent on distance travelled. Tire cost is 0.1276 €/km. Estimations on tire costs, AdBlue consumption, factors taken into account on salary costs and the degree of other relevant costs are based on Kurki's (2013) Master's thesis and adjusted to appropriately represent the costs of a HCT. Technical life of the HCT was assumed to be 15 years, after which it would have no salvage value and needs be replaced with a similar vehicle. Freight capacity of a HCT used in the modelling has a maximum freight capacity of 66 tons of roundwood or two FEU intermodal containers.

Diesel price was assumed to be 1.10 €/liter (without value added tax) and AdBlue 0.35 €/liter (Statistics Finland, 2016). Diesel consumption was estimated to be as follows: 34 l/100 km without freight and 67 l/100 km on maximum freight. A formula presented by Immanen (2009) was used for this estimation. He proposes a following mass-based method to estimate freight truck diesel consumption: *Diesel consumption (l/100 km) = total mass (ton) / 2 + 20.* AdBlue consumption is assumed to be 5% out of the diesel consumption.

Salary cost cover all the costs of employing the driver(s) for HCT. A base wage is 14.90 €/hour and a HCT bonus 1 €/hour (AKT, 2016). The bonus was taken into consideration, because the HCT requires a more experienced staff compared to a standard truck. Indirect wage costs are expected to be 68% of the total wage paid for drivers. This covers all the payments employer is responsible to do in behalf of its workforce according to Finnish law, such as pension, unemployment insurance, social security and regulatory holidays (and related payments). Maintenance, breaks and rest was set to be 9% out of total work time.

Other costs consist of maintenance, insurance, vehicle tax and other payments to the government, management and upkeep of the HCT. These were estimated to be 35 350 €/year.

3.5. Material handler costs

Five cost types were recognized for a material handler used to lift and move timber at the terminal field. These costs cover investment, diesel, AdBlue, salary and other. In addition to these costs, the required annual operating hours were calculated.

Investment cost for a material handler is 100 000 €. A slightly used machine was used for a reference point in here and it was assumed to last for 15 years. After this a repurchase of a similar material handler would had to be made. Diesel consumption of a material handler is 18 liters/hour, AdBlue consumption 0.9 liters/hour and the efficient handling capacity was estimated to be 540 tons/hour. Other costs on material handler cover insurance, management, maintenance and upkeep. Annually these account for 7 900 €.

An assumption was made, that 25% of the timber incoming to the terminal would be directly lifted from the railway wagons to the HCT. The remaining 75% would have to be lifted twice on their way to the factory. First down from the train on the terminal field, and second up from the field and on the HCT.

3.6. Shipping container backhauling costs

Shipping container backhauling costs cover of HCT transports back from the factory to the RRT, container handling and rent, and train transportation to the export harbor. The purpose of studying these costs is to estimate potential of synergy benefits the purpose-built HCT vehicle and RRT would provide. Just like with import timber transportation, this alternative logistics chain is compared to direct train transports. In this case the interest is on final product heading out from the factory. Destination for all containers in the model is Kotka sea port, which is the most important port in Finland in terms of intermodal containers (Finnish Port Association, 2017). RRT and two of the pulp mills included in the analysis, UPM Kymi and Stora Enso Anjala, are located in close proximity to this port. This secures the supply of free containers to be used in outwards supply chains of end products for export on these factories. For pulp mills located far away from major container flows this could, however, be an issue and could prove to be problematic for Metsä Group Äänekoski on the framework of this research.

In order to capture the benefits of container backhauling possibility, technical factors need to be paid attention before making an investment to a HCT vehicle. A purpose built vehicle on this route would have to be able to transport both timber and intermodal containers. The transition between these two rather different freight types needs to be made quick and easy. Concepts that meet this description exist already on a research and development phase.

Costs for HCT transportation of containers include diesel, AdBlue and salaries additional to those of the timber supply chain. Without the possibility for container backhauling the HCT would have to be driven empty from the factory and back to the RRT. Costs caused by this idle drive are already taken into consideration on timber transport HCT costs. The additional diesel and AdBlue costs are caused by the higher consumption due to hauling a container instead of idle drive. Time required for a single container lift on or off the truck was estimated to be 15 minutes.

Container rent was set to 7.50 €/day. Wagon rent is expected to be 22 €/day, due to the fact that these are required to be Finnish. Container handling costs for its loading/unloading is 35 €/lift (Henttu & Multaharju, 2011). As the purpose of this part of the analysis is to study synergy benefits, investment costs of a container terminal area at the RRT or lift truck are not taken into consideration on this research.

An assumption was made, that 25% of the containers incoming to the terminal would be directly lifted from the HCT to a train. The remaining 75% would have to be lifted twice. First down from the HCT on the terminal field, and second up from the field on a train.

For train transportation of containers, five cost types are considered in addition to wagon and container rents. These costs are time based, distance based, wagon change and handling, taxes and payments, and overhead. Values for all these costs are the same as presented in sub-section 3.3. Train transportation costs. Size for a train departing from the RRT was fixed to 50 FEU platforms and gate-to-gate lead time on its wagons and containers was assumed to be 1.5 days on average. On direct train transports from a factory these variables are 22 FEU platforms and 4 days, correspondingly. Total number of transported containers is set for 2 600 FEU annually.

3.7. External costs

European Commission (2014) guidelines were used on estimating the external costs for a novel logistics solution and direct train transports to factory. These were then compared to each other similarly as with the financial costs and benefits. Five types of external costs were considered: congestion, accidents, air pollution, noise and climate change. Primary measure used in estimation was vehicle kilometers (vkm). On rail transports tonnekilometers (tkm) were used instead in congestion, air pollution and climate change estimations. Considering the novel logistics solution, annual diesel consumption estimates of HCT and material handler were used to come up with an appropriate measure on climate change cost instead of vkm. Values used on this analysis were drawn from two handbooks providing guidance and data on estimation of external costs on transportation sector (Maibach et al., 2008; DG MOVE, 2014).

From external cost tables at Maibach et al. (2008) and DG MOVE (2014), articulated heavy goods vehicle (HGV) was chosen to represent trucks used on road transportation of timber. Mass class of 50-60 tonnes was used on HCT, because this was the heaviest one listed. For

Russian standard trucks this gross mass class was 34-40 tonnes. All trucks were assumed to meet the EURO IV –emission standards. Whenever an environment type had to be considered, while choosing the appropriate external cost values, a rural or non-urban was chosen due to the fact that majority of the roads and railways included in the model exist on countryside. Similarly day was used as a point of time and thin as a type of traffic to represent the realistic circumstances most timber freight is likely to be transported on. Table 3.2 presents the values used on the external cost analysis for diesel and electric freight trains as well as for HCT and Russian standard trucks.

Table 3.2 External costs on freight transport via railway and road (where unit is left blank, value is same for all trains regardless of power source or truck regardless of max mass)

	Freight train, Diesel	Freight train, Electric	HCT	Russian standard truck
Congestion	0.2 €/1000 tkm	-	0.168 €/vkm	-
Accident	0.2 €/1000 vkm	-	0.005 €/vkm	-
Air pollution	0.0060 €/tkm	0.0008 €/tkm	0.095 €/vkm	0.069 €/vkm
Noise	57.8 €/1000 vkm	-	1.5 €/1000 vkm	-
Climate change	0.0026 €/tkm	0.0008 €/tkm	0.081 €/vkm	-

On climate change costs representing primarily CO2-emissions, a conversion factor was required to have an appropriate value also on electric freight train. LIPASTO (2009) statistics on Finnish railway transports report an average CO2-emission of 7.2 grams/tkm on electric freight train and 24.0 grams/tkm diesel one. Based on this data, climate change costs of an electric freight train were assumed to be 30% of those caused by a comparable diesel train. Climate change cost for a diesel used in trucks and material handler is 0.243 €/liter. This includes the external costs caused by emissions of CO2, CH2 and N2O.

4. RESULTS

4.1. Base scenario

In the base scenario all timber is transported to UPM Kymi pulp mill and the annual volume of roundwood transported is 300 000 tonnes. Results on analysis of the base scenario suggest that the novel logistics solution studied is financially profitable in the long run. This is the case with and without the estimated synergy benefits taken into account. Table 4.1 presents the key results of the analysis on base scenario by investment criteria in cases both with and without the synergy benefits that could be captured on container backhauling. Although the degree of estimated savings captured by container backhauling is not as significant as with the timber transports, these synergies play a major role in determining the profitability of this investment possibility. The NPV for the solution studied more than triples when synergies are considered. However, the payback period is considerably long even in this case.

Table 4.1 Key results of the analysis by investment criteria, with and without synergies

	With synergies	Without synergies
NPV	**1 769 953 €**	**564 384 €**
IRR	6.7 %	4.9 %
PI	1.4	1.1
DPP	20 (years)	27 (years)
PP	14 (years)	18 (years)

The fact that majority of the investments have to be made before the novel logistics solution can be operated, and the benefits accumulate over a long period of time, significantly increases the risk of this project. Many parameter values used in this analysis are likely to fluctuate, which could lead to smaller annual savings than estimated here. To illustrate this risk, shortening the analysis period to 20 years of operations would bring NPV of the base scenario down to 358 607 € with synergies and far below zero without them.

4.2. Sensitivity analysis and alternative scenarios

Sensitivity analysis was carried out on four of the most important variables in the model in terms of profitability. These are terminal investment cost, gate-to-gate lead time for wagons on direct train transports, total volume of annually transported timber, and RUB/€ -exchange rate. For each variable its estimated value was altered for better and worse to find out the effect this has on solution's NPV. This was done for one variable at a time as the other crucial variables remained constant and had same values as in base scenario analysis (all transports to/from UPM Kymi, annually transported roundwood volume 300 000 tonnes). Increments used were: 1 000 000 € - terminal investment cost; one day – gate-to-gate lead times; 50 000 tonnes – annual timber volumes; and 10 RUB/€ - RUB/€ -exchange rate. Situations with and without synergies were analyzed separately.

Synergies taken into account, profitability of the novel logistics solution is rather sensitive for changes in all of the four crucial variables studied. This goes both ways, towards negative and positive directions. As in the base scenario NPV is positive and thus suggests to take the novel logistics solution in use, interest of a potential investor is most likely to be more on the negative side of the risk. Turns out, that the novel logistics solution can take somewhat remarkable downward hits in all of the four variables, before the NPV of a base scenario turns negative.

Without synergies the novel logistic solution is a lot more risky to end up being unprofitable in the long run. Although on this case the NPV is positive on base scenario with most likely values on critical variables, the situation turns around if any of these is worse than expected. If any of the studied variables turn out to be one increment less beneficial for the novel logistics solution, the NPV is negative. This underlines the importance of synergy benefits the RRT can provide.

While carrying out the sensitivity analysis and multiple alternative scenarios, it was found out that also fifth factor has remarkable effect on the NPV of the project. This is the distance between a factory and the RRT. Based on the experiments run on the model, the novel logistics solution is applicable on transports heading to pulp mills relatively close by the RRT. In this case this means UPM Kymi (17 km) and Stora Enso Anjala (24 km). On transports further away direct train was found out to be more efficient. The novel solution utilization on timber flow towards Metsä Group Äänekoski (236 km) and UPM Kaukas (87 km) were not found to be positive NPV no matter how favorable the variable values were set.

In addition to sensitivity analysis on the base scenario, two alternative scenarios were studied to demonstrate the upside potential this novel logistics solution holds. For both of these, synergies were taken into account while calculating investment criteria. First alternative scenario has higher volumes of timber flowing through the terminal due to two destinations for timber instead of just one in the base scenario. With 50% of the timber transport heading to UPM Kymi and another 50% to Stora Enso Anjala, and 500 000 tonnes of timber a year, the NPV for novel logistics solution is 6 335 542 €. This is more than three and a half times greater compared to the NPV of the base scenario with synergies. The second alternative scenario holds other values equal, but has a lower cost of 20 €/lift on container handling instead of the 35 €/lift on the base scenario. NPV on this scenario is 2 861 097 €. This clearly reveals the significance of synergy benefits for the solution's profitability, as NPV almost doubles by just assuming lower cost on container handling at the RRT. Such development is realistic, if the container terminal at the RRT expand rapidly. In such a case, higher volumes of containers handled at the site are likely to bring down the unit cost for a single lift.

4.3. External costs

When the externalities are included in the CBA, results are not as positive and promising as on the financial side of the analysis. On annual level the economic costs for the novel solution logistics solution exceed those of the operation model utilized today by slightly over 350 000 €. This brings the ENPV for the novel logistics solution including both financial and economic costs and benefits on the final CBA down to -3 116 552 €. From environmental and social perspectives railways are generally preferred over road for transportation whenever this is possible due to lower external costs. In this case direct train transports have lower external costs on all of the five categories taken into account when compared to solution combining train and HCT transports. The difference is most remarkable on congestion, air pollution and climate change.

An alternative point of view can be taken on when studying the externalities cost. If the combined train and HCT transports are not compared to utilization of direct trains as in financial analysis, but on Russian standard trucks, the results are strikingly different to those described above. Due to the facts that these trucks have a much lower allowance on maximum mass and all the transports from the border onwards are driven on road, external costs for this method of timber transportation are significantly higher than those of the novel logistics solution. On annual level this difference is more than 500 000 €. Financial costs for timber transports on Russian trucks were not estimated as this alternative is not desired to be taken in use as long as other cost effective means exist. However, with Russian timber imports likely to be on a rise and limited capacities to accept railway transports at some pulp factories, this scenario is possible to occur, if the proposed novel solution is not utilized.

The results on CBA taking in account also economic costs do not indicate that the novel solution studied should not be taken in use. The fact that the financial NPV is positive does not change due to this result and after all the financial profitability is the factor private companies base their decisions on with regards to investments and operating models. The negative external effects connected to the novel solution might make it considerably more difficult to apply for public financing on national or EU level programs on either for the timber terminal itself or for other parts of the proposed logistics chain.

5. DISCUSSION

The NPV for utilizing the proposed novel logistics solution on timber transports through Kouvola RRT is positive in the base scenario and withstands some uncertainty when the potential of synergy benefits in container backhauling are taken into account. However, the payback period on this solution after required investments is long. Therefore, it is notable that significant amount of risk is included on these investments should this solution be taken in use. In the model real values without inflation are used and every year of operations is expected to be similar to each other. Realistically the variable values are likely to change year by year and price changes on different cost classes can vary significantly. In a 33 year period these developments can be major and unexpected. Risks on this novel solution opportunity studied are not only downwards. The calculations made were kept conservative and the goal in this research was to seek objective information on the matter. It could also be so that positive effects take place simultaneously – think about wagon lead times of eight to ten days (could be the situation in worst case) and then terminal wood handling volumes of being 0.5 mill. tons. In this situation, novel solution could offer NPV of more than 10 mill. EUR (even without container synergies), and in the case of strong ruble NPV of more than 20 mill. EUR is possible (payback times are correspondingly very short). Would the investments be made and the novel solution proven to provide no significant savings in practice, divestments of the equipment and the terminal field are possible. Machinery can be sold to be used in other operations, if the timber handling operations are ceased in the RRT (making downsize risk much smaller).

As the results of this study are somewhat promising, it would be worthwhile to extend the scope of this research to other potential timber terminal locations. Keeping the interest in Russian imports and South-Eastern Finland one such location of interest is Mustola harbor terminal in Lappeenranta, South Karelia. This site has been used before to accept Russian timber imports transported on waterway via Saimaa Channel. At the moment Mustola has plenty of idle terminal field suitable for timber handling and temporary warehousing. It is located nearby two major mills and has a direct connection to a main road already utilized in timber transports with HCT. Railway link to the terminal could use imports from two border crossing points. Presented novel logistics solution implementation in Mustola requires only investments in HCT and material handler.

Timber supply chain very similar to the one modelled here has been in use for 25 years in northern Sweden. Gimonäs terminal in Umeå collects timber transported on rails from Västerbotten region. In this terminal a material handler lifts the timber from stanchion wagons to trucks, which haul it to Obbola paper mill 15 km away. The size, basic characteristics and annual timber volume on Gimonäs terminal are very close to those used in our analysis. As Swedish standard trucks (64 tonnes) are used in road transports, more trucks and personnel are required compared to our model relying on HCT.

6. CONCLUSIONS

In this research, a novel logistic solution on roundwood imports was introduced and the analysis model was used to evaluate its feasibility as an alternative to the currently approach. Significant amount of data had to be collected in order to carry out this research and the most crucial points of it is introduced. Results of the analysis carried out suggest that in the long run the proposed novel logistics solution is profitable as it provides savings that outweigh the investments required to take this concept in use. However, the payback period of these investments is long and this considerably increases risk. Sensitivity analysis reveals that profitability of the logistics concept studied is particularly sensitive to rolling stock turnaround difference (with or without changes in other parameter values) between this novel solution and the traditional operating model. Although the financial NPV seems promising, including the external costs in the CBA is not favorable to the novel concept and in fact brings the economic NPV down below zero. As a conclusion it could be stated that the novel logistics concept might be an attractive option for the major forestry industry companies operating pulp mills close to the Kouvola RRT, but publicly funded subsidies could prove difficult to obtain due to the negative effect on external costs. The research made on this topic so far provides valuable information to multiple interest groups in the region including forestry industry, city council, and logistics service providers. Model built for this research can be adjusted to study profitability of the proposed novel logistics solution in different locations. One such promising location might be Mustola harbor area in Lappeenranta.

This study was completed from the perspective of local regional development with respect of mill wood imports. These mills do also need distribution and export solutions, and one potential alternative was introduced in this research as bringing further synergy. However, it would be interesting to repeat same study from HCT truck investment perspective. It could be e.g. better to develop a system, where raw materials are transported from external terminal (like RRT) to mills, however, thereafter these trucks could serve as direct delivery of containers to sea port(s), and eventually returning to terminal area to serve wood import. This system could have better possibility for higher utilization of fleet, and better overall cost efficiency.

REFERENCES

AKT (2016). Collective agreement on trucking labor terms between Trucking employers' union and Truckers' labor union 1.2.2014 – 31.1.2017 (original text in Finnish). Available at URL: https://www.akt.fi/site/assets/files/1683/kuorma-autoalan_tyoehtosopimus_2014-2016.pdf Retrieved: July 2016.

Bank of Finland (2016). Interests on Finnish government loans *(*original document in Finnish). Available at URL: https://www.suomenpankki.fi/fi/Tilastot/korot/taulukot2/korot_taulukot/viitelainojen_korot_fi/ Retrieved: July 2016.

Bergquist, A-K. & Keskitalo, E.C.H. (2016). Regulation versus deregulation. Policy divergence between Swedish forestry and the Swedish pulp and paper industry after the 1990s. *Forestry Policy and Economics*, 73, pp. 10-17.

Brealey, R.A., Myers, S.C. & Allen, F. (2008). *Principles of Corporate Finance*, 9th edition. McGraw-Hill/Irwin, New York, United States.

Bröcker, J., Korzhenevych, A. & Schürmann, C. (2010). Assessing spatial equity and efficiency impacts of transport infrastructure projects. *Transportation Research Part B*, 44, pp. 795-811.

Calthrop, E., De Borger, B. & Proost, S. (2010). Cost-benefit analysis of transport investments in distorted economies. *Transportation Research Part B*, 44, pp. 850-869.

Copeland, T.E., Weston, J.F. & Shastri, K. (2005). *Financial Theory and Corporate Policy*, 4th edition. Pearson Education.

De Palma, A., Proost, S. & van der Loo, S. (2010). Assessing transport investments – Towards a multi-purpose tool. *Transportation Research Part B*, 44, pp. 834-849.

DG MOVE (2014). *Update of the Handbook on External Costs of Transport.* Report for the European Commission. Ricardo-AEA, London, United Kingdom.

ЭРВК (2016). Current offers (original text in Russian). Available at URL: http://ervk.ru/klientam/tekushchie-predlozheniya/ Retrieved: June 2016.

European Commission (2014). *Guide to Cost-Benefit Analysis of Investment Projects.* Economic appraisal tool for Cohesion Policy 2014-2020. Directorate-General for Regional and Urban policy, Brussels, Belgium.

Finnish Forest Research Institute (2014). *Finnish Statistical Yearbook of Forestry 2014*. Finnish Forest Research Institute, Vantaa, Finland.

Finnish Port Association (2017). Monthly statistics, Rolling 12 months, Carriage of containers. Available at URL: http://www.finnports.com/eng/statistics/monthly-statistics/?stats=monthly&changes=rolling&T=2&year=2017&month=1&sort=2&dir=desc Retrieved: April 2017.

Google Maps (2016). Kullaskalliontie 58, 45200 Kouvola, Finland. Planned location for the Kouvola RRT. Available at URL: https://www.google.fi/maps/place/Kullaskalliontie+58,+45200+Kouvola/@60.8737747,26.7269442,13z/data=!4m5!3m4!1s0x4691ad6097750327:0x853be9fefdf4f2e!8m2!3d60.8725264!4d26.8031438 Retrieved: July 2016.

Grimsey, D. & Lewis, M.K. (2002). Evaluating the risks of public private partnerships for infrastructure projects. *International Journal of Project Management*, 20:2, pp. 107-118.

Henttu, V. & Multaharju, S. (2011). *Transshipment Costs of Intermodal Transport in Finnish Context*. Research Report 234. Lappeenranta University of Technology, Faculty of Technology Management, Department of Industrial Management, Kouvola, Finland.

Iikkanen, P. (2013). *Railway Traffic Operating Cost Models in Finland* (original text in Finnish). Finnish Transport Agency, Transport Planning, 15/2013. Helsinki, Finland.

Immanen, M. (2009). *Enterprise economy and transportation technology* (original text in Finnish). SKAL Kustannus Oy, Helsinki, Finland.

International Transport Forum (2015). Permissible maximum weights of lorries in Europe (in tonnes). Available at URL: http://www.itf-oecd.org/sites/default/files/docs/weights_0.pdf Retrieved: February 2017.

Kurki, T. (2013). *Combining of Freight Streams to one Cost-Effective Haulage in Agricultural Related Product Categories* (original text in Finnish). Master's thesis, Lappeenranta University of Technology, Faculty of Industrial Management. Lappeenranta, Finland.

LIPASTO (2009). Average emissions of railway traffic in Finland per ton-kilometer in 2007. Available at URL: http://lipasto.vtt.fi/yksikkopaastot/tavaraliikennee/raideliikennee/junat_tavarae.htm Retrieved: June 2016.

Maibach, M., Schreyer, C., Sutter, D., van Essen, H.P., Boon, B.H., Smokers, R., Schroten, A., Doll, C., Pawlowska, B. & Bak, M. (2008). *Handbook on estimation of external costs in the transport sector.* CE-publications, Delft, Netherlands.

Nasdaq (2016). UPM-Kymmene Oyj, Mkt Cap for 12.7.2016. Available at URL: http://www.nasdaqomxnordic.com/aktier/microsite?Instrument=HEX24386&name=UPM-Kymmene Retrieved: July 2016.

Natural Resources Institute Finland (2016a). Roundwood removals and drain of the growing stock. Available at URL: http://statdb.luke.fi/PXWeb/pxweb/en/LUKE/LUKE__04%20Metsa__02%20Rakenne%20ja%20tuotanto__10%20Hakkuukertyma%20ja%20puuston%20poistuma/01_Hakkuukertyma.px/?rxid=dc711a9e-de6d-454b-82c2-74ff79a3a5e0 Retrieved: June 2016.

Natural Resources Institute Finland (2016b). Forest industries' wood consumption by region 1989-2014 (1 000 m³). Available at URL: http://statdb.luke.fi/PXWeb/pxweb/en/LUKE/LUKE__04%20Metsa__04%20Talous__08%20

Metsateollisuuden%20puunkaytto/01_metsateol_puunk_aluiettain.px/?rxid=dc711a9e-de6d-454b-82c2-74ff79a3a5e0 Retrieved: June 2016.

Natural Resources Institute Finland (2016c). Imports of roundwood and wood residues by month and by country of origin. Available at URL: http://statdb.luke.fi/PXWeb/pxweb/en/LUKE/LUKE__04%20Metsa__04%20Talous__06%20Metsateollisuuden%20ulkomaankauppa/01_Puun_tuonti_maittain_kuukausittain.px/?rxid=001bc7da-70f4-47c4-a6c2-c9100d8b50db Retrieved: June 2016.

Palander, T. & Vesa, L. (2011). Potential methods of adjustment to declining imports of Russian roundwood for the Finnish pulp and paper industry. *International Journal of Logistics Management*, 22:2, pp. 222-241.

Ross, S.A., Westerfield, R.W. & Jaffe, J.F. (2008) *Corporate Finance*, 8th edition. McGraw-Hill/Irwin, New York, United States.

Räsänen, T., Sirkiä, A. & Venäläinen, P. (2016). *Scenarios on roundwood transportation for 2020* (original text in Finnish). Metsäteho report 238. Available at URL: http://www.metsateho.fi/wp-content/uploads/Raportti_238_Ainespuukuljetusten_skenaariot_2020.pdf Retrieved: July 2016.

Saranen, J. & Hilmola, O-P. (2007). Evaluating the competitiveness of rail-ways in timber transports with discrete event simulation. *World Review of Intermodal Transportation Research*, 1:4, 445-458.

Saranen, J. & Hilmola O-P (2009). The role of freight transport in railway network investment evaluation. *International Journal of Industrial and Systems Engineering*, 4:4, pp. 455-470.

Saranen, J. (2009). Enhancing the efficiency of railways by multi-use of wagons. *International Journal of Management and Enterprise Development*, 7:2, pp. 215-233.

Statistics Finland (2016). Consumer prices on gasoline, diesel and fuel oils (original document in Finnish). Available at URL: http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehi/040_ehi_tau_104_fi.px/?rxid=dc522e2a-7b8f-4ba4-830d-8c9da70bfcec Retrieved: August 2016.

Thomson Reuters (2016). Datastream: Exchange rate for ruble, Russia – euro, monthly, 1.1.2000 – 1.7.2016. Retrieved: July 2016.

UPM (2016). Annual Report 2015. Available at URL: https://user-fudicvo.cld.bz/UPM-annual-report-2015 Retrieved: July 2016.

Venäläinen, P. & Korpilahti, A. (2015). *Effect of HCT-vehicles in improving timber transportation efficiency* (original text in Finnish). Ministry of Employment and the Economy Publications, 30/2015. Available at URL: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/75029/TEMjul_30_2015_web_23042015.pdf?sequence=1 Retrieved: July 2016.

Verhoef, E.T., Koh, A. & Shepherd, S. (2010). Pricing, capacity and long-run cost functions for first-best and second-best network problems. *Transportation Research Part B*, 44, pp. 870-885.

Yahoo Finance (2016a). UPM-Kymmene Oyj, Historical Data. Available at URL: https://finance.yahoo.com/quote/UPM1V.HE/history?p=UPM1V.HE Retrieved: July 2016.

Yahoo Finance (2016b). OMX Helsinki 25, Historical Data. Available at URL: https://finance.yahoo.com/quote/%5EOMXH25/history?p=^OMXH25 Retrieved: July 2016.

Ye, Y., Shen, J. & Bergqvist, R. (2014). High-capacity transport associated with pre- and post-haulage in intermodal road-rail transport. *Journal of Transportation Technologies*, 4:3, pp. 289-301.