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Supply Chain Management Applications for Forest Fuel Procurement – Cost or Benefit?

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It is commonly agreed that logistics is very demanding in forest fuel business. Even though logistics and supply chain management (SCM) tools already have found their way into forestry business, for example, in roundwood operations, they are not yet very widespread in the field of forest fuel procurement. The present study investigates if modern supply chain management applications are capable of increasing the profitability of forest fuel procurement operations. Since margins are low, decreasing the provision costs could boost wood-based bioenergy business. The study is based on the investigation of two Finnish forest owners associations (FOA) involved in forest fuel procurement using a modern SCM tool. The investigation is done by cost-benefit analysis (CBA) using the net present value (NPV) methodology to determine the profitability.

According to the estimates made by the staff, which are based on data such as work time records and delivery notes from before and after introduction of the new system, in both FOAs, the benefits far outweigh the costs over a considered timespan of ten years. However, the amount of the NPV varied significantly. For FOA1, with an annual chip production of 150 000 loose m^3, the NPV is 212 739 €, while for FOA2, with an annual chip production of 37 000 loose m^3, the NPV is 969 841 €.

Even if the NPV of FOA2 seems to be very high, the profitability of SCM tools in forest fuel procurement is clearly demonstrated. Additionally, the results indicate that a considerable cost saving potential in forest fuel procurement is attainable through improving work flows and thus reduce the work input.

Keywords forest fuel, logistics, supply chain management, cost-benefit analysis
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1 Introduction

The international efforts to mitigate climate change have led to an increased demand for more environmentally friendly energy sources. Forest biomass for energy production is considered to potentially play a considerable role in lowering the output of greenhouse gases by replacing fossil fuels (COM 1997, 2005, 2006, IPCC 2007). Its large potential in Europe has been demonstrated in studies by Alakangas et al. (2007) and Asikainen et al. (2008). However, these studies also highlighted a large gap between current utilisation and the technically harvestable potential of forest energy.

It has been shown that a major reason for the low actual utilisation is the gap between technically harvestable and economically available potential of forest fuel resources due to the high procurement costs and low value of the material (Malinen et al. 2001, Nord-Larsen and Talbot 2004, Ahtikoski et al. 2007, Heikkilä et al. 2009). Closing the gap involves great challenges for the participants in forest fuel business, especially in consideration of the ambitious goals set by the EU in their so called 20-20-20 targets (European Commission 2009). Achieving these goals will strongly depend on efficient logistics to lower procurement costs and, thereby, increase profits in the wood-based bioenergy business.

The challenge of designing and managing supply chains and logistics in forest fuel procurement in a profitable way is indicated previously particularly by studies in Scandinavia (Johansson et al. 2006, Ranta and Sinne 2006, Nurmi 2007) and Central Europe (Wittkopf 2005, Gronalt and Rauch 2007, Kühmaier et al. 2007, Kanzian et al. 2009). These studies indicate that there is no universal solution for designing an efficient forest fuel supply chain due to the numerous factors which have to be considered. Nevertheless, the approach of optimising the interplay of the single participants and process steps to increase efficiency and, thus, profitability can be applied to each supply chain.

Modern logistics and supply chain management (SCM) computer applications already have found their ways into forestry. In particular in roundwood procurement they are commonly used in Finland and Sweden and recently they are also becoming more popular in Central Europe. Several studies have revealed their cost saving potential and their potential to increase efficiency in wood procurement operations (Linnainmaa et al. 1996, Bodelschwingh 2005, Lemm et al. 2006). Sikanen et al. (2005) investigated the topic regarding forest fuel procurement. As their study indicates, efficiency in forest fuel supply chains can be improved by using modern supply chain management software. Different to earlier systems which were based on Excel sheets and communication via phone calls, such modern tools use computer technologies to control and monitor procurement operations. Data collection and exchange is done by portable computers or mobile phones. Digital map material and Global Positioning System (GPS) data are used for navigation. The communication between the members of the supply chain takes place via internet and Short Message Service (SMS).

For assessing the value of projects and investments, cost-benefit analysis (CBA) has been shown to be a practical and effective tool. In the Dictionary of Finance and Investment Terms (Downes and Goodman 2006) CBA is defined as a "method of measuring the benefits expected from a decision, calculating the cost of the decision, then determining whether the benefits outweigh the costs." As such it has been chosen to investigate whether a supply chain management tool can increase the profit of participants in the bioenergy business because, according to Levy and Sarnat (1994), involved firms are "continuously confronted by the problem of deciding if a proposed use of resources is worthwhile in terms of prospective benefits".

The aim of the present study is to investigate if modern supply chain management systems have the potential to increase the profitability of forest fuel procurement operations, this will involve investigating cost and benefit factors, and calculate the potential surplus that can be gained.

2 Material and Methods

2.1 Concept of the Supply Chain Management Tool

The investigated SCM tool acts as a link and data distribution channel between the different functional units of the supply chain. Fig. 1 gives an overview of the procedures within the system and which tasks the single functional units of the supply chain fulfil. The application is server-based and provides a central data management system which distributes and forwards the available information to all participants. That means that as soon as one of the participants inputs data into the system, it is available for the others. Thus, the information and data flow is greatly accelerated. All functional units are in the loop regarding the status of the operation, which work steps have to be done at a certain time and which tasks have already been carried out, thereby simplifying the contractors process planning. Additionally, the application creates multiple reports providing information about status of storage places, chipper performance, etc. The data exchange and communication between the system and the participants is done using the internet, SMS, email, mobile phone, and, if needed, paper print outs. Also interfaces to

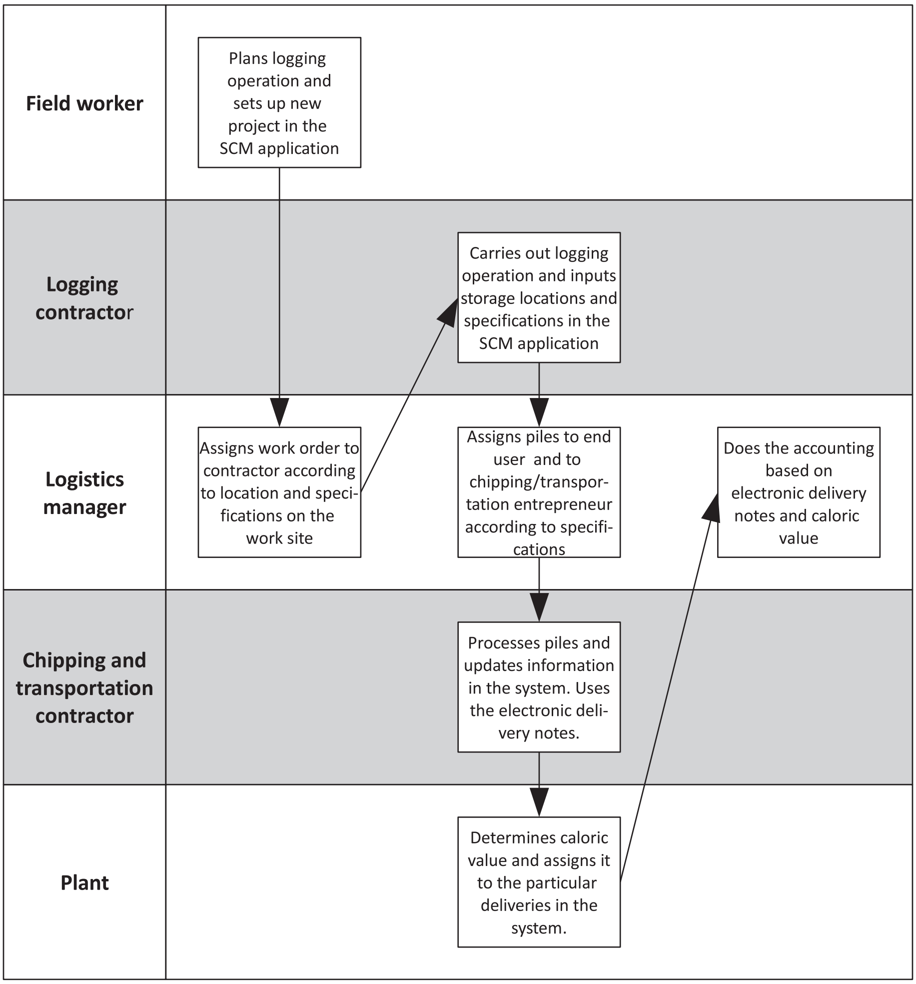

Fig. 1. Process SCM within the SCM application.

different third-party applications can be integrated into the system, for example, to truck scales or enterprise resource planning systems.

2.2 Research Material and Processing

Two different forest owners associations (FOAs) in Finland were investigated. As part of their core business, both supply forest fuel on a medium to large scale and are experienced users of the SCM application. The costs were defined by real expenses, while the benefits were identified according to estimations of staff. The persons giving the estimations were professionals who were involved in establishing and in using the system and who are in charge of monitoring its benefits. In FOA1, the managing director and the forest fuel logistics manager were interviewed. The managing director had been involved with the application of the system continuously. The advisor is the person who uses the system in practice. In FOA2, the managing director was interviewed who was involved with the implementation and application of the system. Since the staff has been working in this field for several years, both, before

Table 1. Cost and benefit factors for FOA1.

Factor	Composition of factor	Occurrence	Basic amount	Annual change
Costs				
Purchasing			0 €	
License fees	80 €/license/month 5 persons	Annually	4800 €	3%
Phone costs	20 €/person/month 5 persons	Annually	1200 €	0%
Starting training	0 €/consultation days 5 days 1 person 300 €/day/person	Implementation	1500 €	
Update training	1500 €/consult day 1 day 5 persons 300 €/day/person	Annually	3000 €	3%
Portable computers	4 pieces 4 years lifetime 1500 €/computer	Every 4th year	6000 €	–10%
Other costs		Annually	1000 €	2%
Benefits				
Work time savings	0.5 man years 65 000 €/man year	Annually	32 500 €	3%
Transportation savings	15% 11 500 km 0.6 €/km	Annually	6750 €	7%

and after implementation of the SCM tool, they were able to monitor its effects in great detail.

The CBA covers a time span of 10 years. The single cost and benefit factors which are shown in Table 1 do not remain unchanged during this period of time. The costs of labour and transportation expenses, for instance, will more than likely increase, while costs for portable computers are likely to become lower. For this reason, corresponding factors were included in the calculations for adjusting the costs and benefits every year. The annual change (%) of the costs of labour are based on statistics about cost of labour in the Eurozone by Eurostat (2010). The same percentage was also used for the license fees and the consultation days, as real data on the rate of price increase of such applications does not exist. License fees must be paid by each user of the system while the consultation days apply for trainings when a consultant from the software company visits the FOA and ensures a proper and efficient use of the system. The price decrease for portable computers is based on information from the web page of Statistics Finland (2010b) which says that laptop computers decreased in price by 49.6% from June 2005 to June 2010 which means an annual decrease of about 12.8%. For the following calculation it is assumed that the annual decrease does not remain so high over the whole ten year period. Therefore, an average annual decrease of 10% is taken as a basis. Other costs as well as the additional profit because of the decrease in moisture content, are adjusted based on the inflation rate in the Eurozone which has been fairly stable during the past ten years (Eurostat 2009). The fact that mobile phone costs have an annual change rate of 0% practically means a decrease in price by the inflation rate of 2% annually. This is verified by the statistics on communication costs from Eurostat (2009). The increase rate for transportation distance savings is based on the price trend of diesel oil in Finland over the last 10 years (Statistics Finland 2010a). The price has increased by 50% during this period, this means an annual increase of 4 %. In the present study it is assumed that due to the progressive scarcity of oil, the price of liquid fossil fuels will increase significantly faster in the coming years. For this reason the annual increase rate for the transportation cost and the benefits, consequently, is set at 7%.

For the NPV calculations a range of interest rates of 4, 6, 10, and 15% was chosen in order to cover different options for reinvesting the profits.

The different cost and benefit factors which occur in FOA1 are listed in Table 1. Because FOA1 was involved in the development of the SCM tool, it gets some reductions, which have to be taken into account: Firstly, they did not have to purchase the application. Secondly, they did not have to pay the five consultation days for starting training which usually cost 1500 € per day. The additional phone costs originate from the SMS system that is used for the data exchange between operators and other field staff and the SCM application. Each data-SMS costs about 0.6 €. The overall expenses for using this service are more than 20 € per month. Nonetheless, using the application decreases the general demand for communicating via mobile phones. For this reason, the increase of the average monthly phone costs does not exceed 20 €. At a yearly wood chip volume of 150 000 loose m^3, FOA1 gains benefits of 0.5 man years of working time and 15% transportation distance saving. At an average annual transportation distance of 75 000 km, before implementation of the tool, the saving of driven kilometres amounts to 11 500 km per year.

The composition of the cost and benefit factors of FOA2 is slightly different, as Table 2 shows. In contrast to FOA1, costs for the purchase and the consultation days for the training have to be taken into consideration, since FOA2 is a regular user. Even though, no additional phone costs occur, the overall costs are significantly higher than for FOA1. At a comparatively low chip volume of 37 000 loose m^3 per year, the staff of FOA2 estimates very high work time savings of two man years. Labour costs (salary and social contributions) were 65 000 € in the first year, that means a saving of 130 000 €. Before implementation of the SCM tool the annual transportation distance was 40 000 km. At a saving percentage of 10%, this means a decrease of 4000 km per year. In addition to these factors, FOA2 achieves a 5% decrease of the moisture content of the raw material by means of the storage management function of the application. At a 0.24 € higher selling price, FOA2 receives an annual profit of 8880 €.

The single cost factors occur at different points in time. At which points in time they have to be included in the calculation is shown in Table 3.

Table 2. Cost and benefit factors for FOA2.

Factor	Composition of factor	Occurrence	Basic amount	Annual change
Costs				
Purchasing		Implementation	2000 €	
License fees	80 €/license/month 5 persons	Annually	4800 €	3%
Starting training	1500 €/consult day 3 days 5 persons 300 €/day/person	Implementation	9000 €	
Update training	1500 €/consultation days 2 consultation days 5 persons 300 €/day/person	Annually	6000 €	3%
Portable computers	5 pieces 4 years lifetime 1500 €/computer	Every 4th year	7500 €	–10%
Other costs		Annually	1000 €	2%
Benefits				
Working time savings	2 man years 65 000 €/man year	Annually	130 000 €	3%
Transportation savings	10% 4000 km 0.6 €/km	Annually	2400 €	7%
Moisture decrease	5% 0.24 €/loose m³/year	Annually	8880 €	2%

After year 4 and 8 the portable computers have to be replaced due to their limited lifespan. After four years they are either damaged or no longer state of the art.

Since the staff of both FOAs stated that they needed one year to get fully familiar with the system and to use its potential, correction factors for the first three years are involved in the cost-benefit calculation, which represent a learning curve for the use of the application. For the first year the benefit is assumed to be 0. In years two and three the benefits are reduced by factors 0.5 and 0.7, respectively. The full amount is reached from year four onwards.

2.3 Data Analysis

For calculating the profitability of using the SCM application, the method of net present value (NPV) was chosen as it was found to meet all study's requirements. The following formula, as mentioned by Levy and Sarnat (1994), was used for the calculations.

Table 3. Expenses at different points in time.

Type	FOA1	FOA2
Initial outlay	Starting training Mobile computers	Purchase Starting training Mobile computers
First year costs	License fees Phone costs Other costs	License fees Other costs
Normal year costs	License fees Phone costs Update training Other costs	License fees Update training Other costs
Costs in year 4 and 8	License fees Phone costs Mobile computers Other costs Update training	License fees Update training Mobile computers Other costs

$$\text{NPV} = \sum_{t=1}^{n} \frac{S_t}{(1+k)^t} - I_0 \quad (1)$$

S_t = the expected net cash receipt at the end of year t
I_0 = the initial investment outlay
k = the discount rate, i.e., the required minimum annual rate of return on new investments
n = the project's duration in years

To reliably calculate the NPV, two figures must be known: the future cash flows and the cost of capital (discount rate). The result can simply be interpreted: If the NPV is positive, the project is profitable. If the NPV is negative, the project will yield losses.

In order to evaluate their influence on the total benefit, the growth over time of the single benefit factors was investigated. Then the growth was compared to the change of their percentage in the overall benefit.

3 Results

3.1 Cost-Benefit Analysis of FOA1

The investigation of the undiscounted net benefits (undiscounted gross benefits minus undiscounted gross costs) for each year shows that due to the annual change in the rate of the cost and benefit factors the annual net benefit increases significantly (Fig. 2). As a result of the simulated learning curve, the benefits are comparatively low in the first three years. In year one the costs are 14 500 €, this includes the costs for a normal year plus the initial outlay. In years four and eight the purchase of new portable computers obviously reduces the benefits. In year ten the net benefit reaches the highest value of 42 242 €. The distribution of net benefit per m^3 for each year can be seen in Fig. 3. After expenses of 0.097 €/m^3 in the first year, the benefit in the second year amounts to 0.067 €/m^3. Over the considered timespan it increases up to 0.282 € in year ten.

Through the use of the undiscounted net benefit for each year the NPV over a timespan of 10 years for different rates of return can easily be determined. The results of the corresponding calculations can be seen in Figs. 4 and 5. While the NPV at an interest rate of 4% amounts to 204 674 €, it strongly decreases if the enterprise assumes that it is able to reinvest the surplus at higher return rates. If the enterprise takes an interest rate of 15% as a basis, the NPV decreases to 103 234 €. Due to the simulated learning curve, the NPV needs two years to turn positive, regardless of the underlying rate of return.

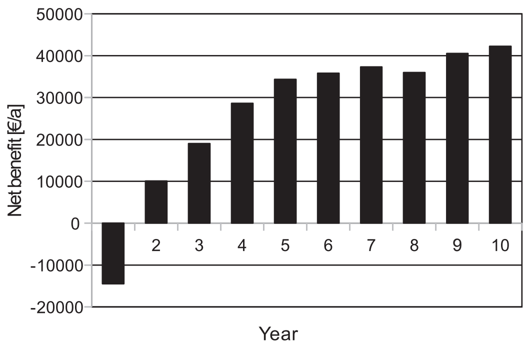

Fig. 2. Net benefits for each year in FOA1.

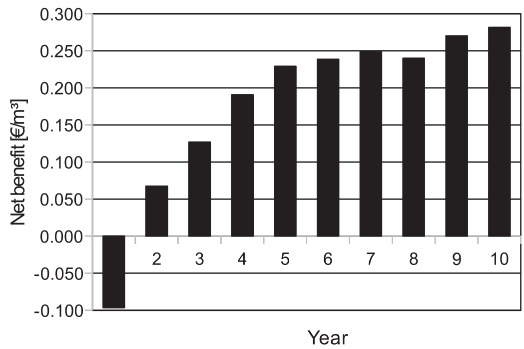

Fig. 3. Net benefit per loose m^3 for each year in FOA1.

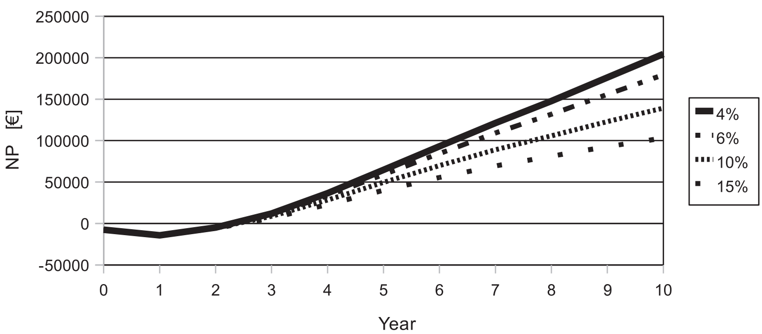

Fig. 4. NPV for FOA1 considering different rates of return over a period of 10 years.

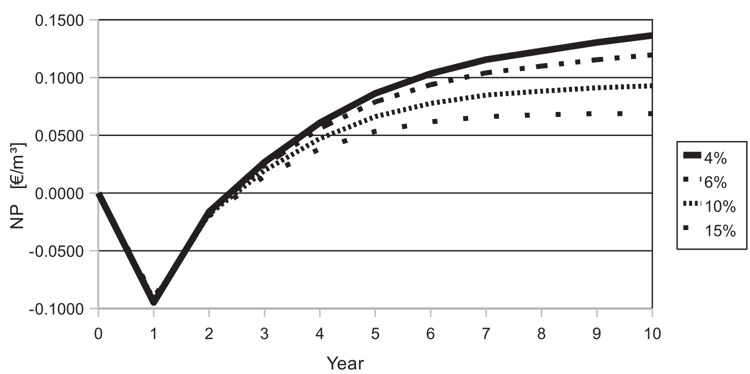

Fig. 5. NPV in €/m^3 for FOA1 involving different rates of return and a period of 10 years.

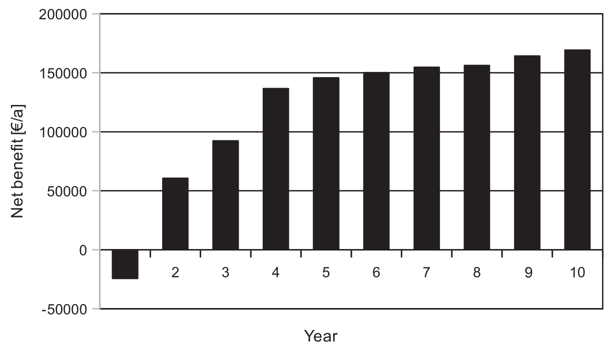

Fig. 6. Net benefit for each year in FOA2.

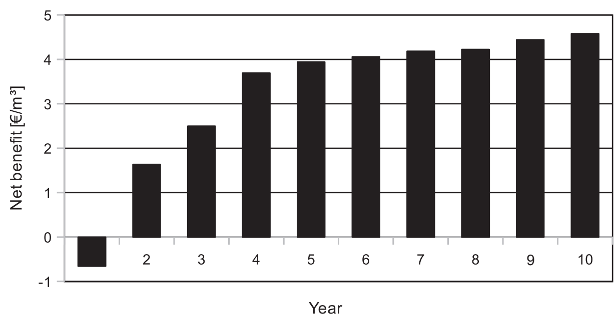

Fig. 7. Net benefit per loose m^3 for each year in FOA2.

3.2 Cost-Benefit Analysis of FOA2

The undiscounted net benefits for FOA2 for each year show a picture very similar to the one for FOA1, as can be seen in Fig. 6. The values, however, are obviously much higher. Again, the simulated learning curve lowers the benefits for the first three years, so that costs of 24 300 €, including cost for a normal year plus the initial outlay, appear in the first year. The influence of the purchase of new portable computers in years four and eight become apparent in this case as well. Due to the high estimation of savings in FOA2, the undiscounted net benefits reach their maximum of 169 359 € in year ten. Consequently, the undiscounted net benefits per loose m^3 in Fig. 7 show a comparable distribution. In the first year expenses of 0.66 €/loose m^3 are necessary in order to implement the system. In the second year the benefits reach 1.64 €/loose m^3 and increase up to their maximum of 4.58 €/loose m^3 in year ten.

Due to the high benefits, the NPV turns positive already after year two, despite the correction factors. The range of NPVs regarding different rates of return varies between 931 269 € at a rate of 4% and 496 524 € at 15% (Figs. 8 and 9).

3.3 Sensitivity Analysis

As the list of the benefit factors of the two FOAs in Table 1 and Table 2 already indicate, the share of the working time savings in the benefits is very large. This becomes even more obvious if one takes a look at the development of these factors over the entire study period. In Fig. 10 it can be seen that due to the different annual change rates, the value of transportation and working time savings increases unevenly. The final values of the working time savings have increased by 30.48%

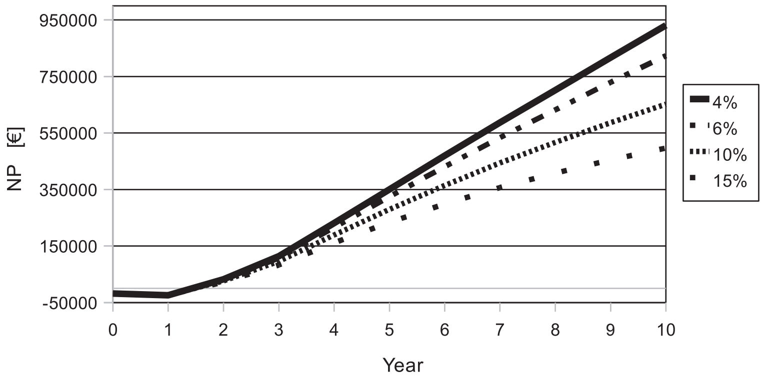

Fig. 8. NPV for FOA2 considering different rates of return over a period of 10 years.

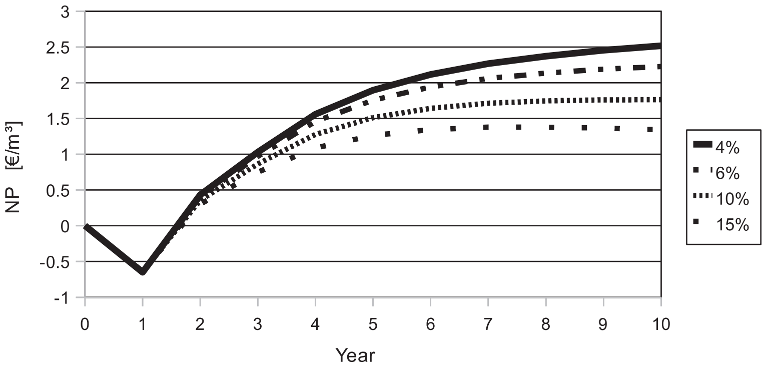

Fig. 9. NPV in €/m^3 for FOA2 involving different rates of return and a period of 10 years.

by end of year ten, while the transportation savings have increased by 83.85% compared to the values of the first year. However, the share of the transportation savings in the gross benefits has increased only marginally from 17.20% to 22.46% in FOA1. Due to the high working time savings in FOA2 the increase of the share of transportation savings in the gross benefits is even lower. Within ten years it increases only by 0.69% from 1.70% to 2.39%. The share of additional incomes through the reduction in the moisture content of the raw material even decreases from 6.29% to 5.75%. That clearly demonstrates that even though the transportation savings have almost doubled over the ten year period, their effect on the total savings remains comparatively small. This emphasises the clear importance of the factor working time saving and how low the influence of the other factors on the overall benefits is in the present cases.

4 Discussion

The cost-benefit analysis is based on estimations of staff members from the two different FOAs. The cost factors collection and verification of cost factors was a relatively straightforward task. The benefit estimations have been made by carefully selected experts and, hence, also have to be considered reliable. However, an exception is the working time saving estimation in FOA2. The staff members stated that they saved two man

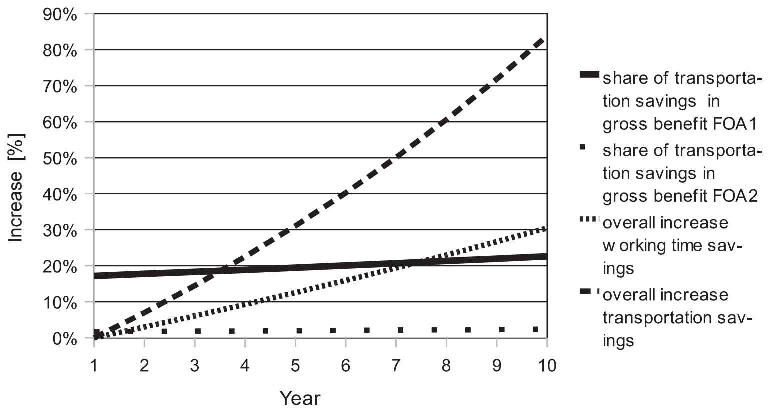

Fig. 10. Overall increase of different factors and their share in the gross benefit.

years. This estimation, in itself, is very high. But if it is taken into consideration that the annual chip volume supplied by FOA2 is only 37 000 loose m³, the stated working time saving had to be overestimated. The saving of 0.5 man years at an annual volume of 150 000 loose m³ estimated by FOA1 seems to be more realistic and confirms the assumption that the estimation of FOA2 is too high. More reliable data would be necessary to confirm the high estimations, though unfortunately are not available. Additionally, the cost-benefit analysis does not consider the working time and cost saving potential of the contractors which should be included in subsequent studies since it is a major cost saving. A detailed determination of working time savings could be done within the scope of a case study in cooperation with one of the FOAs comparing the time consumptions for work organisation; first using their old system and then using the SCM tool.

The simulated learning curve involved in the calculations for the first three years is the consequence of a conservative approach which was used to avoid an overestimation of the achieved benefits during the familiarisation phase in the CBA. Depending on the people involved, supply chains will most likely be able to achieve full benefits much earlier in real life situations.

The annual change factors are based on statistical data of the past ten years and not on predictions on future developments. An exception is the increase of the transportation savings and the cost for portable computers. As mentioned above, recent developments make an increased rise in costs for transportation services very likely. For this reason a fairly high annual inflation of 7% was chosen. Even if one considers this factor as being too high, its effect on the overall benefit is not large enough to raise a doubt on the results, as demonstrated by the sensitivity analysis. In case of the portable computers a decrease of 12.8% per year would reduce the prices by 71.8% over ten years. This is a fairly high value, in particular if it is taken into consideration that during this time period more expensive new developments continuously will replace outdated technology. A factor of 10% still means a price reduction of 61.3% over 10 years. Since for using the SCM hardware with comparatively moderate performance is sufficient, such a price decrease is adequate.

For a business operation interest rates of 4 and 6% might seem to be very low. Forest owners associations, however, will most likely first and foremost invest in forest related businesses. Since forests tend to grow rather slowly and margins are low, especially in forest fuel business, 4 and 6% are adequate rates of return for forest related operations.

The results of the sensitivity analysis indicate the strong influence of working time savings on the cost-benefit calculation. Consequently, that demonstrates the large effect the possible overestimations of working time savings in FOA2 have on the overall results. Furthermore it demonstrates that the transportation savings have a comparatively low effect on the cost saving potential.

Linnainmaa et al. (1996) estimated the cost saving potential of the EPO (Finnish abbreviation for Enson Puunhankinnan Ohjaus) wood procurement management system in the large scaled wood procurement chains of Stora Enso to be at least several million USD. Large scale in this context means involving several tens of millions m³ of roundwood. Bodelschwingh (2005) examined the potential efficiency increase by using new procedures and tools for supply chain management in forestry operations in Germany. His results show a significant increment of efficiency. Simply by improving the planning and using electronic data exchange, the pass-through time could be reduced by one third. Lemm et al. (2006) examined the SCM tool POLVER which is designed for roundwood procurement and is used in Switzerland. The study shows a working time saving potential and, hence, a cost saving potential of 40% along the supply chain. These studies are similar to our results that using logistics and SCM tools in forestry business provides substantial advantages. Since working steps and conditions differ remarkably in roundwood operations, the results of these studies can not be applied directly to forest fuel procurement. Nevertheless, they set a trend by proving increment of efficiency by SCM tools, and benefits can be assumed to also appear in other branches of forestry business. Hence, they confirm the results of the present study.

Among others Wittkopf (2004) and Kühmaier et al. (2007) also emphasise that logistics in forest fuel procurement is a great challenge which strengthens the benefit assumptions of using tools for optimisation of logistics and supply chain management. Sikanen et al. (2005) investigated the Finnish SCM tool Arbonaut Fleet Manager modified for forest fuel procurement and demonstrated a cost saving potential, however, the main focus of their study was not cost-benefit or profitability analysis and it was limited to a supply chain consisting of only one chipper unit and one chip truck. Their study indicates that in more complex forest fuel procurement operations the saving potential most likely is considerably higher. This confirms the results of the present study, especially since it has investigated medium and large scale forest fuel suppliers.

5 Conclusions

The study has been successful in proving that supply chain management applications can improve efficiency and profitability of forestry in the fast growing field of forest fuel procurement. Unfortunately, the overall potential could not be assessed. The results match with several other studies. But obviously this is a large field of research given, and the need for further and follow-up studies has been clearly demonstrated. Nonetheless, the results of the cost-benefit analysis are valuable since they prove that SCM systems can help to boost forest energy business. In particular it shows that internet based supply chain management systems can be low-cost alternatives to gain more efficiency for the supply chain. Even if benefits would be lower than estimated, investments seem to be safe. In both studied cases, supplied volumes of forest fuels are expected to grow in the future. This can also increase the relative benefits when the scale of the operations gets too demanding to be controlled by traditional methods. Another important result of the present study is the indication that a large potential for cost reduction in this branch of forestry is in improving work flows and thus reduce the work input. Recent research on cost reduction in wood-based bionenergy business is very focused on transport costs and application of new machinery (Jylhä et al. 2006, Ranta and Sinne 2006, Jylhä and Laitila 2007, Möller and Nielsen 2007, Laitila 2008). It, however, seems to be reasonable to do further research on optimisation of work flows as well.

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Total of 32 references