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ECONOMIC BENEFITS OF LONG TERM FORESTRY MACHINE DATA CAPTURE: AUSTRIAN FEDERAL FOREST CASE STUDY

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Abstract: *Operating forest machines is not only expensive but accurate monitoring of economic variables can be very difficult. Detailed machine data capture of economic variables within a forest enterprise can be used to decision support processes, especially accurate costing for new investments. The objectives of this study were to analyze economic variables of forest machinery based on long-term recorded data from one of the Austrian federal state forest machinery workshops.*
The study used data from the enterprise's resource planning system over the period 2004 to 2008. In total 28 cable yarders, 19 skidders, 12 harvesters and 18 forwarders where analyzed for annual utilization, repair costs, fuel consumption and lubrication costs. The average annual utilization of all skidders was approximately 1,150 productive machine hours (PMH) per year. Fuel consumption ranged between 5.1 and 9.4 liters/PMH. Repair costs range between 9.5 and 15.4 €/PMH. For the fully mechanized harvesting system the forwarders achieved 2,070 PMH/year and the harvesters 2,040 PMH/year. The annual utilization of cable yarding systems is between 560 PMH and 1,500 PMH.

1. Introduction

In 2009, the Austrian annual timber harvest was 16.9 Mio m³. The extraction of timber from the stand to the forest road side is split with 20 % being carried out with cable yarding equipment, 49 % with skidders and 26% with forwarders and 5% with other means. Due to difficult mountainous terrain only 16 % is felled and processed with harvesters (Holzeinschlagsmeldung 2009). In addition to technical machine limitations, as well as social and environmental compatibility, a main decision criteria in terms of what system to use is cost-effectiveness.

The Austrian Federal Forestry company represents 15% of the forest area, is managed like a private company and harvests approximately 1.8 Mio m3. Within its organisation it operates two technical divisions that carry out forest operations such as planning, road construction and timber harvesting. These divisions also offers consulting work on private forests. Data acquisition can support strategic and operational decision making processes within a company; especially accurate costing for new investments.

In Austria machine cost calculations for timber harvesting is normally based on the FAO-Scheme, combined and adapted with company related data and conditions. One of the most important factors influencing machine cost calculation is the annual use and utilization of forest machinery. Annual utilisation is the ratio of productive to scheduled machine hours. Machine utilisation is affected by different factors such as technical reliability of the machines, weather and road conditions, logistics, proportion of set-up time, and the workers.

The machine rate is usually divided into ownership costs, operating costs, and labour costs (Sessions, 1992). Operating costs include maintenance and repair costs, fuel and lubricant costs, tire, track, chain and cable replacement. Maintenance and repair may include everything from simple maintenance items to the periodic overhaul of engine, transmission, clutch, brakes, and other major equipment components (Bushman et al., 1988).

The goal of this paper is to analyse long term machine information from the Austrian Federal Forest Company to improve data used for cost calculations. Harvesters, skidders, forwarders and tower yarders are included in this project.

2. Material and Method

2.1 Data

The study used data from the enterprise's resource planning system over the period 2004 to 2008. In total 28 cable yarders, 19 skidders, 12 harvesters and 18 forwarders where analyzed for annual utilization, repair costs and fuel consumption. Table 1 shows the number of machines, and number of models of each machine type, included in this study.

Table 1. Study layout for long-term machine utilization analysis

Machine type	Harvester	Cable yarder	Skidder	Forwarder
Number of studied machines	12	28	19	18
Number of models	4	7	6	6

For each machine categorized information was recorded. This included time elements, fuel quantities and repair and maintenance costs. Both productive and scheduled time was recorded on a daily basis. Scheduled hours include all normal working hours, but excludes holidays and sick-days. Productive time was defined as all machine operating hours including breaks less than 15 minutes in duration (PMH_{15}). Relocation and set-up times are not included in productive machine hours.

A spreadsheet-based data base was developed to combine and prepare the data. Based on this data-base relevant variables of different forest machineries are filtered and analyzed. The data was analysed using the SPSS statistical program.

3. Results and Discussion

3.1 Harvesters

The average annual machine use for harvesters was 2042 productive machine hours (Table 2). The maximum annual use of a harvester was 3120 PMH_{15} was recorded when operating multi-shifts in wind-throw in Sweden. Fuel consumption ranged from 10.2 to 24.3 litres per PMH_{15}. The average repair cost was 21 Euros per PMH_{15}.

Table 2. Descriptive statistics for the harvesters

Attributes	Min.	Average	Max.
Cumulative operating time [h]	1,742.0	13,280.0	31,579.0
Productive time [h/year]	938.0	2,042.0	3,120.0
Repair cost [€/h]	8.3	21.2	48.8
Fuel consumption [liter/h]	10.2	15.6	24.3
Fuel cost [€/h]	8.4	13.7	24.9

The average scheduled machine hours in Austria for a harvester in single shift is 1650 PMH_{15}. Figure 1, which shows the annual machine use for different harvester types, is considerably higher than the average. The reason is that the Austrian Federal Forestry company uses a special work shift model. This system uses two workers and results in the machines being used seven days a week. Using this work shift model the scheduled machine hours is 3300. Therefore, this results in an average machine utilisation rate for all harvesters of 62%.

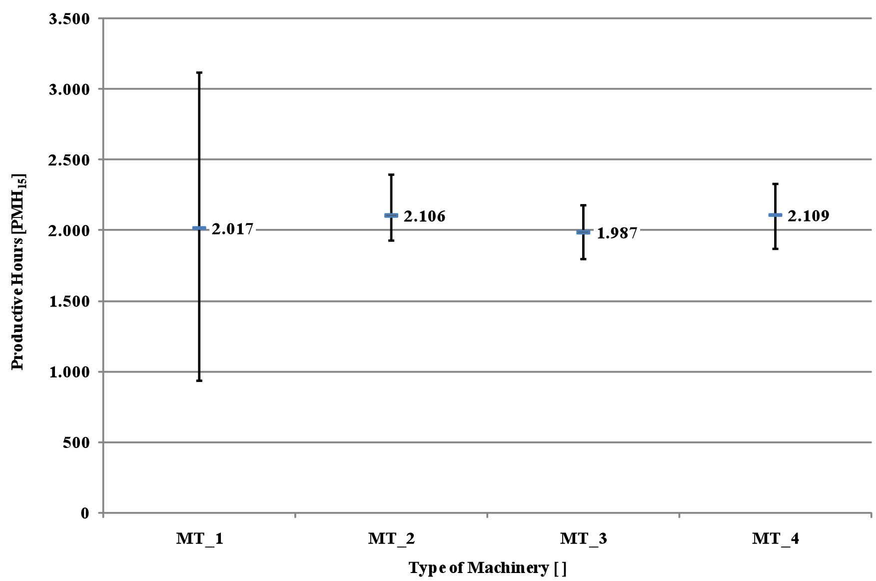

Figure 1. Productive hours per year for different types of harvesters

3.2 Forwarders

Forwarders have the largest average productive hours per year with 2,068 PMH_{15} among the investigated machines. They work the same shift model as the harvesters. The variability in the hours is greater than that of the harvesters, as forwarders are also used after motor-manual felling. The calculations yielded average repair costs of 11.8 €/h and average fuel consumption of 11.1 litres/h (Table 3).

In Finland the repair and maintenance costs for harvester and forwarder averaged 9.66 €/h and 5.06 €/h respectively. The fuel consumption for harvester and forwarders were about 12.79 litres/h and 10.76 litres/h. They classified the oil consumption in three categories; motor oil, transmission oil, hydraulic and chainsaw (for harvesting head of harvester) (Nurminen et al. 2009).

Repair and service costs (classified variable costs) of a logging contractor with a harvester-forwarder in Finland was studied by Väätäinen et al. (2006) and covered 6.2% of total costs. Maintenance costs defined fixed costs consisted of 5.3% of total costs.

Table 3. Descriptive statistics of machine utilization for Forwarders

Attributes	Min.	Average	Max.
Cumulative operating time [h]	2,539.0	12,478.0	33,599.0
Productive time [h/year]	787.0	2,068.0	4,254.0
Repair cost [€/h]	2.4	11.8	39.7
Fuel consumption [litre/h]	1.4	11.1	20.5
Fuel cost [€/h]	1.2	9.7	20.8

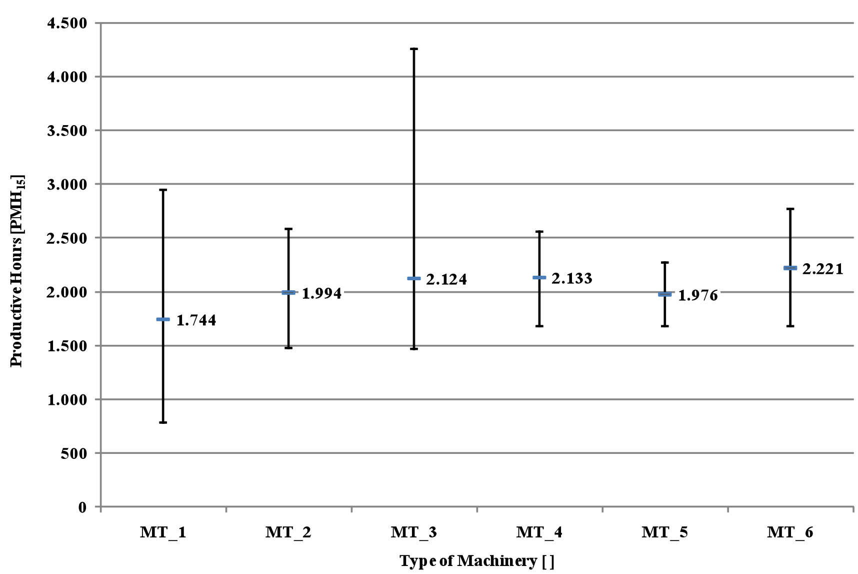

Figure 2. Productive hours per year for different types of forwarders

The forwarders have the same annual scheduled machine hours as the harvesters, being 3300 hours. This results in a slightly higher machine utilisation rate of 63%.

3.3 Skidders

Skidder use shows a clear seasonal effect with higher use in winter time (Figure 3). Because of this effect productive machine hours ranged from 355 to 1619, and averaged 1,151 PMH_{15} per year (Table 4). Repair costs and fuel consumptions averaged 11.9 €/h and 7.3 litres/h respectively.

Table 4. Descriptive statistics of machine utilization for Skidders

Attributes	Min.	Average	Max.
Cumulative operating time [h]	374.0	3,312.0	7,102.0
Productive time [h/year]	355.0	1,151.0	1,619.0
Repair cost [€/h]	1.5	11.9	46.2
Fuel consumption [litre/h]	3.6	7.3	11.3
Fuel cost [€/h]	2.8	5.7	11.2

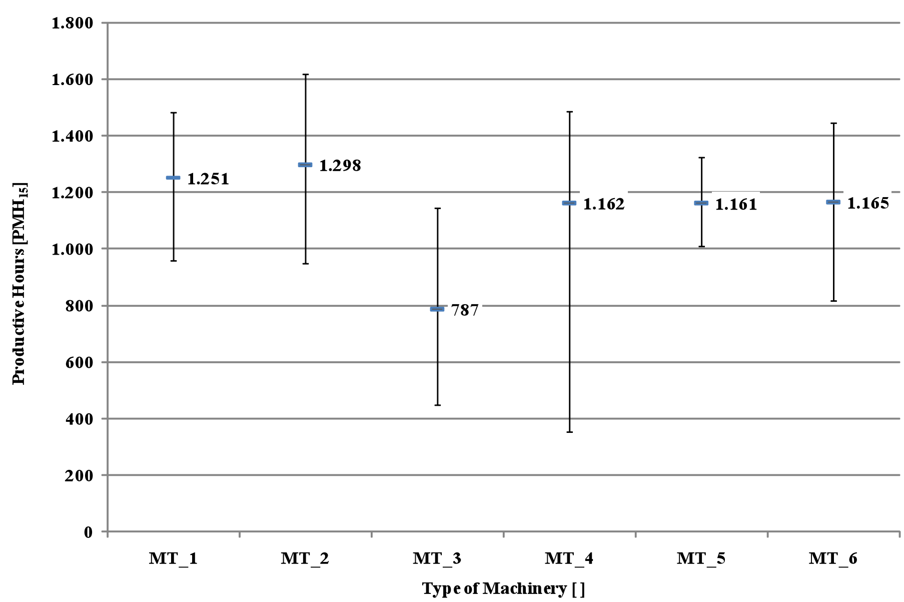

Figure 3. Productive hours per year for different types of Skidders

The annual scheduled machine hours for a skidder is 1650 hours. This results in a machine utilisation rate of 70%.

3.4 Tower yarders

The productive hours averaged 1,074 PMH_{15}/year and the repair costs averaged 29.3 €/h (Table 5). In Figure 4 machine type 1-4 represent towers yarders manufactured in-house, whereby machine type 5-7 are modern tower yarders. The difference in annual use is clearly visible.

Table 5. Descriptive statistics of machine utilization for cable yarders

Attributes	Min.	Average	Max.
Cumulative operating time [h]	541.0	4,365.0	14,821.0
Productive time [h/year]	361.0	1,074.0	1,531.0
Repair cost [€/h]	6.0	29.3	71.5
Fuel consumption [litre/h]	5.3	16.0	24.8
Fuel cost [€/h]	3.3	13.3	24.0

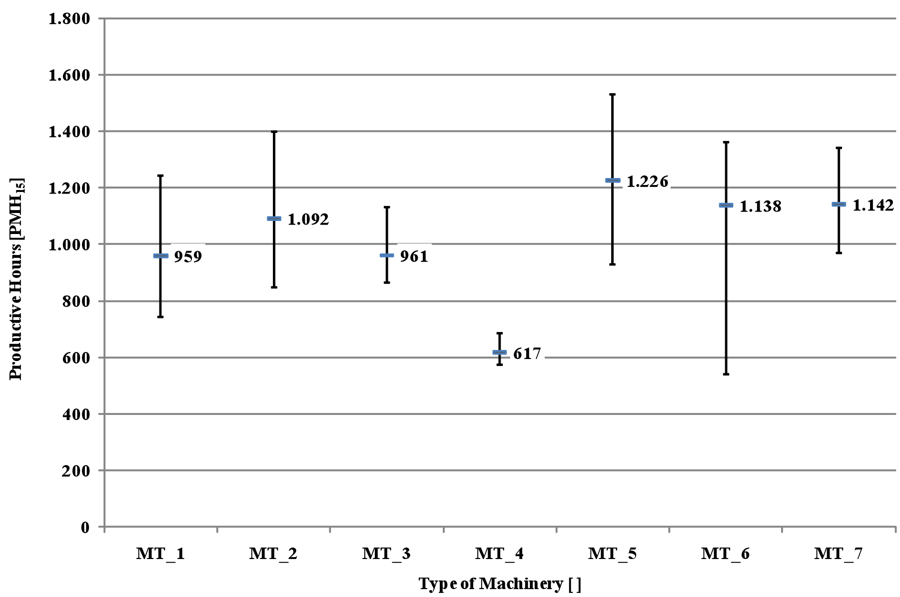

Figure 4. Productive hours per year for different types of cable yarders

The annual scheduled machine hours for a cable yarder is 1650 hours. This results in a machine utilisation rate of 65%.

3.5 Repair Costs

The analyses shows a surprisingly light increase in repair costs over the operating time (cumulative productive machine hours). A clear example of this is shown in Figure 5. Repair costs where corrected with the annual consumer price index based on the year 2004. Although a clear increasing trend of repair cost per hour is visible for new machines, this does not appear to continue with the average costs remaining relatively constant beyond 7,000 cumulative operating hours. The repair cost variability for both new and old machines is high, and it is considered to be combination effect of machine and worker.

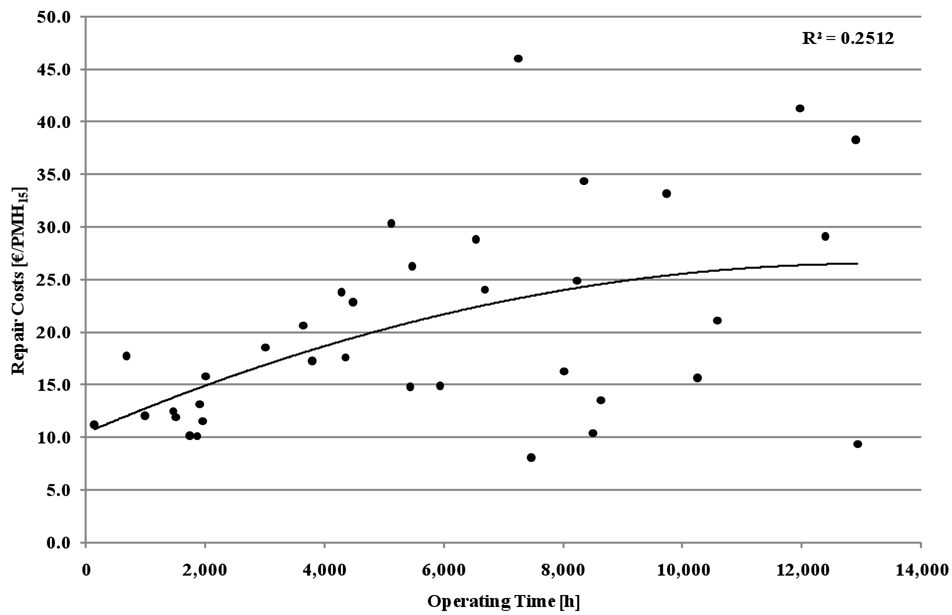

Figure 5. Repair costs of harvesters according to the accumulative operating time of the machine

4. Conclusion

Information regarding machine utilization and repair costs gives forest engineers a useful tool for timber harvesting planning and cost-evaluation for logging operations. This study used long term machine data captured by the Austrian Federal Forestry for 4 different machines categories, and each category included multiple machines for a total of 23 machines. The data used was from 2004-2008.

Average annual machine use is reported for all machines. Average utilisation rates ranged from a low of 62% for the harvesters up to a high of 70% for skidders. The new working shift model used by the Austrian Federal Forestry Company for their harvesters and forwarders shows a clear increase in the annual machine use in comparison to the skidder and cable yarder. Repair costs showed a high variability between machine types and with the cumulative operating time.

In future data availability and calculation of results could be automated with defined interfaces between costing and enterprise's resource planning system. Further work could also include investigating parameters influencing the repair costs of forest machines. The results of this paper can be also applied as basic information in life cycle assessment.

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