Determining the economic efficiency of operating modern forestry machines

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Abstract. The necessary measures to support the timber industry complex of the Russian Federation in the conditions of the new economic reality are given, experimental data are given on the performance of a forwarder based on snow and swamp-going equipment TROM 20 in the conditions of development of hard-to-reach logging sites in the Russian Federation in real natural and production conditions of the rental base of enterprises. The performance of the KS TROM 20 machine under various operating conditions was determined. An economic justification for the use of the KS TROM 20 forwarder in conditions of hard-to-reach logging sites based on theoretical calculations is presented. Based on the data obtained as a result of operation, the annual current effect and net present value of the theoretical option, the profitability index of discounted investments were calculated, and as a result, the payback period of the implemented equipment was obtained.

1 Introduction

Under the conditions of the new economic reality in the forestry cluster (FC) industry of the Russian Federation [1-9], the following measures should be implemented in the short term to develop and support FC and attract investments into the industry:

1. Regulation of export tariffs, including the abolition of exchange rate export duties on paper and a two-year moratorium on export customs duties, as well as the resumption of transportation subsidies for shipments through the ports of the North-Western Federal District (NWFD) of the Russian Federation, which will lead to the removal of excessive transportation load from the eastern direction;
2. Introduction of a three-year moratorium on changing approaches to calculating the rent for forest use and on increasing the rates of payment above the annual deflator coefficient; this will allow for a full analysis of the structure of revenues and expenditures for all components of the forest complex, not only forestry;
3. Improvement of the mechanism for concluding lease agreements for forest areas for a new term without tenders with bona fide tenants (establishment of clear and precise criteria for the state authority to make a positive decision on the extension of the lease agreement);

4. Improvement of mechanisms for the implementation of priority investment projects (PIP) for 2024-2025 (at the moment, companies spend a considerable amount of time on adjusting plans, for example, for the purchase of logging, forestry, road-building machinery or timber processing equipment, and the approval period is much longer than the normative one; however, this need is dictated by the withdrawal of a number of manufacturers from the Russian market, which entails the replacement of the previously agreed nomenclature; a similar approach is needed for the implementation of PIP.
5. Granting the lessees of forest areas the right to use, within the boundaries of the leased area, commonly occurring minerals for the creation and maintenance of forest roads;
6. Elimination of excessive requirements to issue quarantine certificates when moving forest products within the region and cases of unreasonable fragmentation of the quarantine phytosanitary zone;
7. Supporting domestic demand by increasing the volume of housing and infrastructure construction;
8. Expansion of the program of modernization of existing boiler houses operating on coal and fuel oil and construction of new ones operating on environmentally friendly fuel;
9. Revision of the rules for calculating the environmental fee for the utilization of waste from paper and cardboard packaging.

At the same time, according to the trend of comprehensive import substitution, various domestic solutions are known for the comprehensive increase of productivity and development of harvesting areas [10-16].

It is worth noting the trend of digitalization and digitalization not only of equipment, but also of trade relations. Thus, the Federal Forestry Agency (Rosleskhoz) declares its intention to develop a methodology for calculating the initial value of timber for timber exchange trading at the Saint-Petersburg International Mercantile Exchange (SPIMEX), i.e., to create a trading standard in 2024, which will become the basis for the further use of effective exchange mechanisms in the timber industry and will provide industry enterprises with additional opportunities for the development of their business.

There is also a clear tendency for state agencies to join timber trading on SPIMEX. St. Petersburg became the 44th region of the Russian Federation, whose state institutions are engaged in timber exchange trading in 2024. The leaders among the constituent entities of the Russian Federation in terms of the volume of timber traded on SPIMEX are Krasnoyarsk Krai, Sverdlovsk, Irkutsk and Tver regions, and the Udmurt Republic. In total, more than 3,500 companies from 57 regions of Russia use the relevant instruments. In the first seven months of 2024, more than 3,000,000 m³ of timber was sold on SPIMEX. On an annualized basis, the indicator added 43%. The turnover of exchange trading doubled to almost 5.5 billion rubles.

These indicators clearly demonstrate the strengthening of the role of state regulation over timber turnover. This is also evidenced by the analytics of the Federal Forestry Agency, according to which in the first half of 2024 in some regions of the Far Eastern Federal District (FEFD) illegal logging decreased by 2-3 times, as well as the area of illegal logging and the number of detected cases. Thus, in January-June, 58 facts of illegal logging were registered in the FEFD, which indicates that in annual terms the number of detected offenses decreased by 23%. The area of illegal logging decreased by 65% to about 82 hectares, the volume decreased by 43% to 6,400 m³. In Khabarovsk Krai, three cases of illegal logging were detected during the reporting period, which is 2.3 times lower than in the first half of last year. The area of illegal logging halved, from 12.7 to 6.6 hectares, and the volume decreased 2.6 times, from 1,300 to 482 m³. In the Republic of Buryatia in January-June 2024, 29 facts of illegal logging were revealed, which is half as much as last year's figure. The area decreased 5.6 times, from 139 to 25 hectares, the volume of illegally harvested timber - five times, from 7,800 to 1,600 m³. In Zabaikalsky Krai by the results of the first half of 2024, 1

fact of illegal logging was recorded, a year earlier the figure amounted to 3 pieces. The area of illegal logging decreased over the year from 2.7 to one hectare, the volume - by half, from 840 to 402 m³.

It is crucial to consider not only the necessity of implementing these solutions and monitoring them but also the economic efficiency of modern forest machine operations.

2 Materials and methods

To determine the cost of services, it is necessary to calculate the current costs. The cost of production includes the following cost items:

- Labor costs of the main workers.
- Insurance premiums (IP) to non-budgetary funds - 20% and insurance of production risks - 5%, i.e., IP =20 + 5 = 25%.
- Expenses for maintenance and operation of equipment,
- Overheads.

Determination of labor costs of the operator (Dc) of the domestic wheeled forwarder (KS) TROM is calculated according to formula 1, rubles:

$$D_c = W_r \cdot C_{inc} \cdot C_r \cdot C_{ad} = W_r \cdot C_{tar} \quad (1)$$

where DC – labor costs per person-day, rubles; Wr – daily wage rate, rubles; Cind – coefficient taking into account incentive and compensation payments (Cinc = 1.3); Cr – regional coefficient (Cr = 1); Cad – coefficient taking into account additional salary and long-service remuneration (Cad = 1.7), Ctar defines the transition coefficient from tariff salary to total salary (Ctar = 2.2).

In this case, the daily wage rate (Wr) is calculated according to formula 2, rub.:

$$W_r = \frac{LW \cdot C_{ind} \cdot C_{tar}}{WT_h} \cdot t_{st} \quad (2)$$

where LW is living wage in the region (applied for the month preceding the current quarter – 15,826 rubles for 2024 in the North-Western Federal District (NWFD) of the Russian Federation); Cind – industry coefficient, taking into account the specifics of the industry (Cind = 1.4); Ctar is tariff coefficient (Ctar = 1.8 for grade 6); WTh – hourly working time on average per month (253.98 hours (6-day workweek of 61.2 hours per week)); tst – shift duration, hour.

As a result of calculations, we obtain the following values of parameters Dc and Wr:

$$D_c = 1601.67 \cdot 1.3 \cdot 1 \cdot 1.7 = 3539.69 \text{ rubles/person/day}$$

$$W_r = \frac{15826 \cdot 1.4 \cdot 1.8}{253.98} \cdot 10.2 = 1601.67 \text{ rubles/person/day}$$

Labor costs of the main workers per 1 person-day are 2 persons: wheeled forwarder operator (KS) tractor driver of the 6th category and amount to 3539.69 rubles per person-day for 2024.This value refers both to the basic and the implemented variants.

Expenses for labor remuneration (Elr) per 1 m3 will be according to formula 3, rubles:

$$Elr = Wr / Lst \quad (3)$$

As a result of calculations, we obtain the following values of Elr parameters:

Elr = 3539.69/44.74 = 79.11 rub/m3.

As a result of calculations, we get insurance premiums (IP) to non-budgetary funds, rubles:

IP = 79.11 · (0.2 + 0.05) = 19.78 rub / m3.

Next, the costs of maintenance and operation of equipment are determined.

Wages of auxiliary workers and service personnel performing daily maintenance of the forwarder - 6th tariff grade (Eaux) taking into account typical values of coefficients as a result of calculations is calculated according to formula 4, rubles:

$$Eaux = 0.34 \cdot Elr \cdot Ctar \cdot 5IP \quad (4)$$

As a result of calculations, we obtain the following values of parameters Eaux:

Eaux = 0.34 · 3539.69 · 1.8 · 1.25 = 2707.86 rubles per 1 machine per shift

Insurance premiums (IP) as a result of calculations are equal to:

IP = 2707.86 · 0.25 = 676.97 rubles.

Fuel and lubricants costing is then determined as follows:

Fuel expenses (Ef) and lubricants (El) are determined by the consumption rates for 1 hour of work and current prices according to the expression 5, rubles:

$$Ef\,(El) = Rc \cdot tst \cdot P \cdot Cdc \quad (5)$$

here Rc defines fuel (lubricants) consumption rate, kg/h; tst - shift duration, h; P is price of fuel (lubricants), rubles/kg; Cdc – coefficient that takes into account fuel delivery costs (Cdc = 1.2).

Diesel fuel expenses (Ef (El)) as a result of calculations are equal to:

Ef (El) = 11 · 10.2 · 62.21 · 1.2 = 8375.95 rubles/shift.

Engine oil, gear oil, grease costs (Ef+gc), are 15% of fuel costs, rubles.

Costs for diesel fuel and costs for lubricants are equal according to formula 6, rubles:

$$Ef+gc = Ef\,(El) + 0.15 \cdot Ef\,(El) \quad (6)$$

As a result of the calculations, diesel fuel costs and lubricant costs are as follows Ef+gc are equal to:

Ef+gc = 8375.95 + (0.15 · 8375.95) = 9632.34 rubles/shift.

Depreciation and amortization charges (A) are determined by formula 7, rubles:

$$A = \frac{B_v \cdot \frac{R_a}{100}}{N_{st}} \quad (7)$$

where Bv is book value of wheeled forwarder (KS) or forwarder, rubles, we take the value of KS TROM as Bv = 25 000 000 rubles; Ra – amortization rate, we take 20%; Nst – number of working shifts per year, we take Nst = 315. KS TROM has a useful life of 5 years.

As a result of calculations, depreciation charges are equal to:

$$A = \frac{25\,000\,000 \cdot 0.2}{315} = 15873.02\ rubles$$

Expenses for technical works and maintenance (TW and M) KS TROM (Etw and m) are taken as the amount of 12.5% of the book value and determined by the formula 8.

$$E_{tw\ and\ m} = \frac{B_v \cdot 0.125}{N_{st}}, \text{rubles} \quad (8)$$

As a result of calculations expenses for technical works and maintenance of KS TROM are equal to:

$$E_{tw\ and\ m} = \frac{25\,000\,000 \cdot 0.125}{315} = 9920.63 \text{ rubles} \quad (9)$$

Other expenses (Eother) are taken in the amount of 5% of the sum of costs on previous expenditure headings and amount to 1,940.54 ruble, taking into account the calculation of the sum of previous expenditure headings.

Conclusions and recommendations. The final calculation of the cost of maintenance and operation of ΣE KS TROM 20 is summarized in Table 1.

Table 1. Calculation of the cost of maintenance and operation

no.	Expenditure headings	Expenditure amount
	1	2
1	Salaries of auxiliary workers and service personnel, E_{aux}, rubles	2 707.86
2	Insurance premiums, IP (20+5= 25%), rubles	676.97
3	Fuel and lubricants, E_{f+gc}, rubles	9 632.34
4	Amortization, A, rubles	15 873.02
5	Routine repair and maintenance, $E_{tw\ and\ m}$, rubles	9 920.64
6	Other expenses, E_{other}, rubles	1 940.54
7	Total per 1 vehicle shift, ΣE, rubles	40 751.37
8	Capacity per machine shift, L_{st}, m^3	45.62
9	Expenses for 1 m^3, E_{1m3}, m^3	893.28

Traditionally, it is worth considering in the calculation of logging operations in the timber industry of the Russian Federation that overhead costs include part of shop, general economic and commercial expenses of the organization. In accordance with the structure of the cost of logging products, they account for an average of 30% of the direct costs in the Russian Federation.

The cost of timber harvesting service KS TROM is defined in Table 2 "Calculation of the cost of timber harvesting services". Costs for all papers except for the paper "Overheads" are transferred to "Costing of wood skidding services" from Table 1.

KS TROM 20 overhead costs also include a part of shop, general and commercial expenses of the organization and in accordance with the structure of the cost of timber production in the Russian Federation they make up on average 30% of the sum of direct costing.

Table 2. Calculation of the cost of wood skidding services

no.	Indicators	KS TROM 20 value	
	1	2	
1	Annual production volume, Q, m^3	9 295.91	
2	Expenses, E, rubles	per 1 m^3	Total thousand rubles
3	Labor expenses of main workers, E_m, rubles	79.11	735.40
4	Insurance premiums (25%), IP, rubles	19.78	183.85
5	Equipment maintenance and operating expenses, E_{eq}, rubles	893.28	8 303.84
6	Of them - amortization, A, rubles	198.43	1 844.62
7	Overhead expenses, O_{exp}, rubles	297.65	2 766.93
8	Full cost, C_f, rubles	3483.09	32 378.47

The next parameter, which shows how profitable a given KS TROM 20 technique option is over the reporting period (year), is the balance of the flow (annualized current effect). The annual current effect (Eft) is equal to the difference (balance) between cash inflow and cash outflow. Calculation of cash flow from operating activities for logging of assortments is performed and is shown in Table 3.

Table 3. Cash flow from production (operating) activities for the procurement of grades

no.	Indicator	Unit designation	Calculation formula	Indicator value, thousand rubles
	1	2	3	4
1	Revenue from profit	PR	$P_{cond} \cdot P_г$	40 473.09

2	Service cost	E_s	Table	32 378.47
3	Amortization	A	Table	1 844.62
4	Total profit	P_{tot}	PR – E_{cur}	8 094.62
5	Income tax (20%)	T	P_{in}·20/100	1 618.92
6	Net income	I_n	P_{in} – R	6 475.69
7	Flow balance (annualized current effect)	Ef_t	P_h + A	8 320.31

Service price (P_{serv}) for KS TROM 20 is determined by formula 9, ruble:

$$P_{serv} = C_{av} + C_{av} \cdot R_c/100 \quad (10)$$

where C_{av} — average cost of logging of assortments, rubles/m ^{3}; R_c – profit margin as a % of C_{av}, is set by the organization independently, taking into account the demand, R_c= 25 %.

As a result of calculations, the price of service (P_{serv}) for KS TROM 20 is equal to:

$$C_{serv} = 3483.09 \text{ rubles / m}^3$$

$$P_{serv} = 3483.09 + 3483.09 \cdot 0.25 = 4353.86 \text{ rubles / m}^3$$

To determine the theoretical payback period of the forwarder KS TROM, we need to calculate the net discounted income (hereinafter - NDI), this indicator is traditionally fundamental for making decisions about investment in a particular forestry equipment decision maker in the timber industry in Russia.

Traditionally, the calculation period (T) is equal to the useful life of forwarders (5 years), the calculation step is 1 year, discount rate E = 10%. Production (operating) activity starts from the 1st year of the calculation period, i.e., from zero step.

The calculation of the NDI KS TROM 20 is presented in Table 4.

Table 4. Net discounted income of the forwarder TROM 20, thousand rubles.

Step number of the calculation period (t)	K_t*O_t	E_t	a_t	E_t*a_t	NDI, total flow	NDI, accumulated flow
1	2	3	4	5	6	7
0	25 000	0	1	0	– 25 000	– 25 000
1	–	8 320.31	0.909	7 563.16	7 563.16	– 17 436.84
2	–	8 320.31	0.826	6 872.58	6 872.58	– 10 564.26
3	–	8 320.31	0.751	6 248.55	6 248.55	– 4 315.71
4	–	8 320.31	0.683	5 682.77	5 682.77	1 367.07
5	–	8 320.31	0.621	5 166.91	5 166.91	6 533.98
Totally	25 000	8 320.31	–	31 533.98	6 533.98	-

Table 4 shows that as a result of the calculations the net discounted income of the forwarder KS TROM 20 is equal to 6 533.98 thousand rubles

At the same time, the discounted investment return index (DIR) is equal to:

$$DIR = Et \cdot at / Kt \cdot Ot = 31\,533.98 / 25\,000 = 1.26$$

Investment payback period including discounting is Tpb. It is known that the payback moment lies inside step 3, because NDI3 ≤ 0, NDI4 ≥ 0. To clarify the position of the payback moment, the “distance x” from the beginning of the step to the payback moment is calculated:

$$X = \text{NDI Step 3} / \text{NDI Step 4} = 4\,315.71 / 5682.77 = 0.76$$

As a result of the calculations, the calculated payback period of KS TROM 20 is as follows:

$$\text{Tpb} = 1 + 1 + 1 + 0.76 = 3.76 \text{ years.}$$

Thus, as a result of the calculation it should be concluded that the investment project KS TROM 20 is effective, because the net discounted income NDI ≥ 0, discounted investment return index DIR ≥ 1, payback period Tpb = 5 years.

3 Conclusion

According to the theoretical variant the calculation of economic efficiency of wheeled forwarder TROM 20 is made, according to which the calculation period (T) is equal to the useful life of forwarder (Tpb) and is 5 years. The main parameter for calculations is the balance of flow (annual current effect), which shows how profitable this variant of machinery is for the reporting period.

Net discounted income (NDI) amounted to 6,533.98 thousand rubles, while the discounted investment return index (DIR) is 1.26. The resulting payback period is less than the period of useful life of the forwarder and amounts to 3.76 years. This in turn means that the machine will be profitable until the end of its useful life. Accordingly, the introduction of KS TROM 20 forwarder into similar technological processes of logging in the Russian Federation can be called economically efficient because the net discounted income NDI ≥ 0, the index of return on discounted investments DIR ≥ 1.

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