Economic Analysis of Construction Equipment in Public Projects in Jordan

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ABSTRACT: Escalating project costs in Jordan is a great challenge for public project managers and decision-makers. This research aims to calculate the financial feasibility of owning versus renting heavy equipment. Real data were collected from 12 public construction governorates in Jordan. The data covered rental and ownership costs of construction equipment over two years 2021& 2022. Present worth analysis over a 10-year service life showed that The ownership option is found economically feasible over the year-long rental option at a monetary saving of 30,000 JD per equipment per year. The cumulative curve for the year-long rental breaks even with the equipment ownership curve in the eighth year. After eight years of life, the ownership option becomes economically favored over the year-long rental option. On the other hand, the on-call rental option is found economically feasible compared to the ownership option with over 120,000 JD savings per equipment per year. Finally, research conclusions provide insight for government decision-makers to save substantial costs from the public project budget.

KEYWORDS: Heavy Equipment, Year-long Rental Cost, Ownership Cost, On-call Rental Cost, Economic Analysis.

1. **INTRODUCTION**

The trends in successive governments in Jordan aimed at reducing capital expenses due to the severe conditions of the local economy. These have considerably lowered the share of most public construction agencies from the general financial budget.

Among the tasks of public construction directorates in Jordan is to link population and economic communities in cities and villages to neighboring countries with a network of high-quality infrastructure. Duties of the sector are constantly increasing due to the expansion of the services, serviced road networks, and the diversity of construction projects throughout the country. This study is an effort to study available alternatives and solutions to cope with public resource shortage. In the past, the public construction directorates owned a sufficient fleet of heavy machinery, due to the upgrading of infrastructure throughout the country and the expansion of the areas served by the road networks, the need for additional heavy construction equipment emerged. Many construction equipment have expired beyond their economic service lives, heavy equipment became a financial burden on the public construction directorates in terms of escalated operating and maintenance costs. The need emerged to provide an alternative to keep pace with the change, the alternative of renting machinery from contractors became viable instead of buying them.

Equipment ownership versus renting is considered a controversial issue. Decision-makers were split into two directions one of them adopted the lease option because it required the payment of small amounts of money over a period that might be long; the other opinion followed the saying ‘‘Why rent when you can buy?’’. Disagreement among analysts and regulatory authorities about the economic feasibility of renting machines instead of owning them implies searching for a solution or an informed decision-making process that is based on actual financial data. Such a solution would yield substantial savings to the public construction budgets [1] [2].

Available literature in construction equipment economics is concerned with the decision to rent or own equipment. Many factors control the work of the public sector and their impact on the decision-making process that vastly differ from factors affecting private business. Equipment cost data differs for the case of public construction compared to private construction. Moreover, Literature covers many topics related to construction equipment cost prediction to arrive at informed economic decisions [3] [4] [5].

In public infrastructure projects, equipment is the driving resource of construction. Equipment economics entails weighing their associated costs against their periodic production throughput, calculation of economic service life for replacement and retention decisions, or the calculation of equipment capital recovery [6] [7].

The most obvious factor to consider is whether the directorate affords the required capital to buy or lease out a better option at a time when the equipment is needed. However, the study must consider the life-cycle costs over the useful life of each machine to reach accurate results [8].

Although the purchase may be a larger one-time capital expense; however, the cost of rental might be increasing rapidly; thus, becomes infeasible over a long time as it might end up exceeding the capital cost. Considering at the same time that the equipment is not efficiently utilized throughout the entire rental period. Unlike other fields, when it comes to financial returns at the end of use, government agencies do not sell the equipment at the end of its life [9] [10].

Literature also covered a variety of methods for estimating repair costs which covers major overhaul work for the engine, and replacement of certain components due to wear and tear during operation; however, repair or maintenance cost doesn't include oiling, greasing, or fuel since they are considered part of the operational costs. Most importantly, repair cost doesn't include the cost of wheel replacement due to wear and tear during operation. Due to their substantial cost, wheel cost is considered part of the ownership cost [11].

Each type of construction equipment, make, or brand has a manufacturer-specified total operating hour in thousands of hours of use, service, or useful life is computed in years by dividing the total operating hours by average work hours per day by the number of work days per year. Many factors affect the deterioration rate of an equipment for example: operator skills, tough work conditions, severely high or low temperature, preventive maintenance, machine make or quality [12].

Construction equipment economics inputs include the collection of costs associated with the equipment under consideration. Costs are incurred on a fixed or variable basis, they are split into capital, operational, or maintenance types. Economic study inputs include the service life in years for each piece of equipment (which is computed from the manufacturer-specified operational hours) and interest rate. Thus, the study shall include all lifecycle costs associated with each equipment [13] [14].

2. APPROACH

This study relies on data collected from 12 public construction directorates in Jordan through personal visits and structured interviews with decision-makers and administrators whose work nature involves heavy machinery.

In various directorates, two types of renting approaches are available. The first is the year-long rental, such as the rental of heavy machinery for long-term projects for periodic and recurring works. The other rental approach is renting on demand to deal with temporary works such as earth collapse the occurrence of disasters or any weather conditions such as snow accumulations, soil embankment drifts, or sandstorms. Often in both types, there is a need for two types of heavy machinery, motor grader and wheel loader For ease of analysis, The analysis is based on the costs of both heavy equipment at 12 directorates of the Jordan government.

Data were collected during two years, 2021 and 2022. Data included ownership and rental costs incurred at each government directorate. The costs included annual operating costs and maintenance costs for machines owned by the Ministry and were compared with the annual costs of renting similar machines by calculating the annual cumulative cost of both types and finding the point of intersection of these values In addition to calculating the present worth (PW) value for each option

3. ANALYSIS& RESULTS

Table 1 depicts the actual data of full-year rental costs at the 12 directorates

Table 1: Year-long rental data for the years 2021& 2022.

Governorate	Number of (rented heavy equ 2021	cost (JD)	Number of (rented heavy equi 2022	cost (JD)
Main Governorate #1	3	92101	4	50163
Governorate # 2	4	85059	3	59812
Governorate # 3	2	49920	2	41881
Governorate # 4	3	56442	3	56442
Governorate # 5	2	43997	1	14092
Governorate # 6	3	42332	3	42332
Governorate # 7	3	51127	3	37127
Governorate # 8	0	0	1	19210
Governorate # 9	2	37980	2	39980
Governorate # 10	1	15650	0	0
Governorate # 11	2	11096	1	11096
Governorate # 12	1	14103	3	49219
∑	26	499807	26	421354

3.1. Equipment Cost Analysis For A Year-Long Rental

Starting with the first type of lease the year-long rental, let's take C_A: machinery yearly rental cost, N: number of rented equipment which equals 26+26= 52, from Table 1 data, C_M: cost of single machinery which equals 499807+421354= 921161 JDs.

Then the average annual cost of a single machine becomes [6]:

$$average\ C_{M\,n1-n2} = \sum C_A / \sum N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$average\ C_{M2021-2022} = 921161/52 = 17715 \text{ JD per year}$$

Therefore, the cost of a year-long rental of a single heavy machine is about 17715 JDs.

We conducted several interviews with the owners of heavy machinery stores to obtain an approximate price for the machines and concluded that: The price of the wheel loader ranges from (120,000 to 140,000) JD, and the price of the settlement machine from (110,000 to 130,000) JD, to simplify the calculations. We considered that the average price is 125,000 JD's for both.

When buying new equipment, management assumes relatively little maintenance costs since the equipment has just started consuming its life span, to be more realistic, heavy machinery works endure a great deal of tough conditions; therefore, the equipment from the first day of operation might be exposed to circumstances that mandate maintenance. Table 2 includes cost data for equipment of varying ages showing the annual periodic maintenance expenses and operational costs in terms of fuel expenses that the engine consumes in addition to the costs of transporting the machine between different work sites in case the machine requires a Lowboy Trailer.

Table 2: Ownership maintenance& operational costs of heavy equipment.

Governorate	Average *maintenance* costs per year (JD)	Average *operational* costs per year (JD)
Main Governorate #1	1190	849
Governorate # 2	1783	998
Governorate # 3	1121	1008
Governorate # 4	1992	918
Governorate # 5	1302	1102
Governorate # 6	1178	922
Governorate # 7	1090	1004
Governorate # 8	1010	887
Governorate # 9	1209	973
Governorate # 10	1984	977
Governorate # 11	1772	930
Governorate # 12	1886	944
	1459.75	959.33
Total annual ownership cost	2420 JD	

Table 2 includes the annual ownership maintenance and operating (M&O) cost data at the 12 directorates. The total shown at the bottom of Table 2 is the estimated cost of owning a single heavy machine which is equal to the sum of *the average maintenance cost* and *the average operational cost* (operational cost without including the operator wages) at 2420 JDs per year. The average initial cost for all equipment is estimated at 125000 JD.

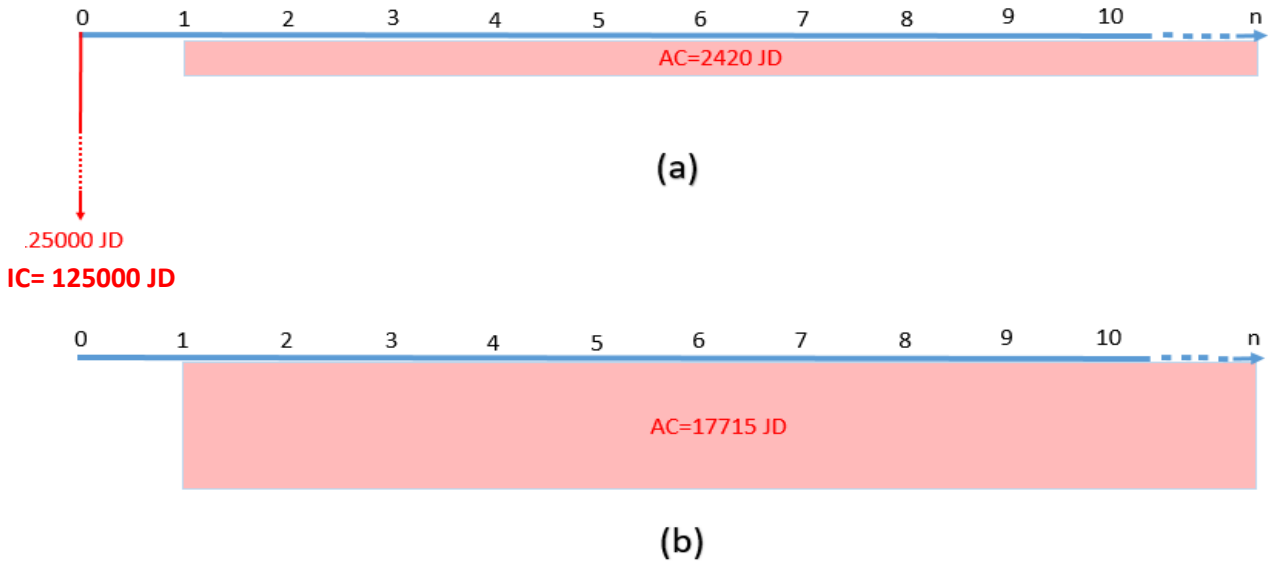

Figure 1: (a): Equipment "*owning*" cash flow, (B): Equipment "*renting*" cash flow.

The next step is to use time-value-of-money equations to compute the present worth (PW) for both ownership and on-call rental costs using the information in Figure 1. The interest rate is assumed 3%. The number of years (n) is assumed 10-year planning horizon since most construction equipment has a service life between 10-12 years [15].

$$PW = -IC - A \times (P/A, i, n) \quad \text{..... (2)}$$

$$\mathrm{PW}_{owning} = -125000 - 2420 \times (P/A, 3\%, 10)$$

$$= -125000 - 2420 \times (8.5302) = -145643.084$$

$$\mathrm{PW}_{renting} = -17715 \times (P/A, 3\%, 10)$$

$$= -17715 \times (8.5302) = -151112.493$$

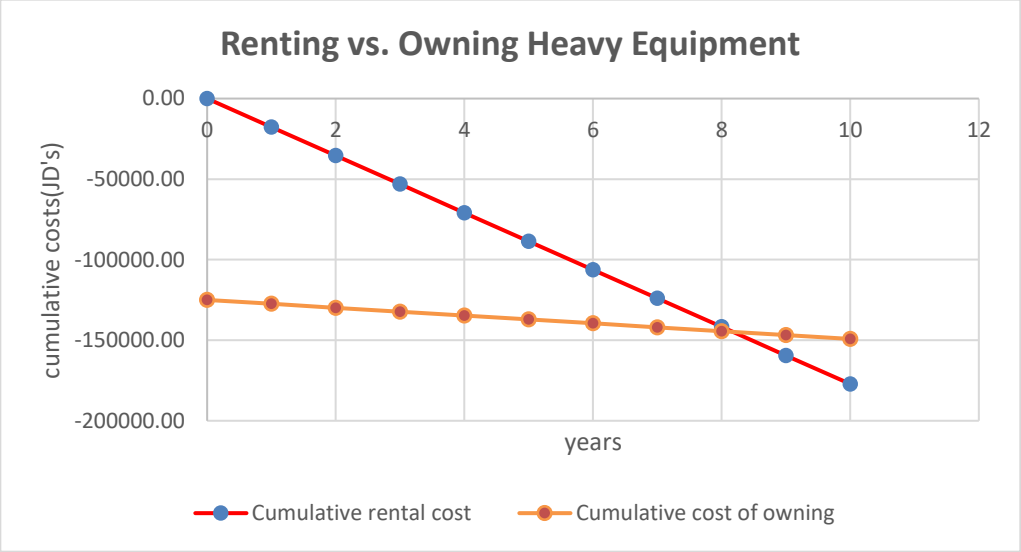

Figure 2: Cumulative year-long rental cost versus ownership cost.

Figure 2 depicts the 10-year cumulative comparison between year-long rental versus ownership cost. During the first eight years, the year-long rental remains appealing to decision-makers to select it over the equipment ownership option. However, after the breakeven point in year # 8, the ownership option becomes feasible over the year-long rental option for the two remaining years of the 10-year planning horizon, after which the useful life of the heavy equipment expires. Overall, the ownership option is economically feasible over the year-long rental at a monetary savings of 30,000 JD.

3.2. Equipment Cost Analysis For On-Call Rental

The second type of renting is the on-call rental. Several factors and circumstances control on-call rental, which makes it difficult to predict the amount of expenses. For example, there is no specific directorate that can predict the occurrence of snowfall, rockslides, or heavy rain based on weather forecasts. However, data were collected financial data related to the temporary lease, one of the topics of our research is shown in Table No. (3)

Table 3: On-call rental costs.

Governorate	Number of rented heavy equipment 2021	cost (JD)	Number of rented heavy equipme in 2022	cost (JD)
Main Governorate #1	9	27384	6	19561
Governorate # 2	10	20100	7	22255
Governorate # 3	7	23008	6	16152
Governorate # 4	9	19557	7	20119
Governorate # 5	3	9119	0	0
Governorate # 6	8	17080	5	11771
Governorate # 7	8	19101	5	14762
Governorate # 8	0	0	0	0
Governorate # 9	5	12989	4	13918
Governorate # 10	4	9928	4	7201
Governorate # 11	3	10031	3	8910
Governorate # 12	4	7702	5	17502
∑	70	175999	52	152151

Take C_T: Temporary machinery rental cost in one year, N: number of rented machinery, C_M: cost of single machinery [1].

$$\text{Then } average\ C_M = \sum C_T / \sum N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Then $average\ C_{M2021-2022} = \sum C_T / \sum N = 2720$ JD

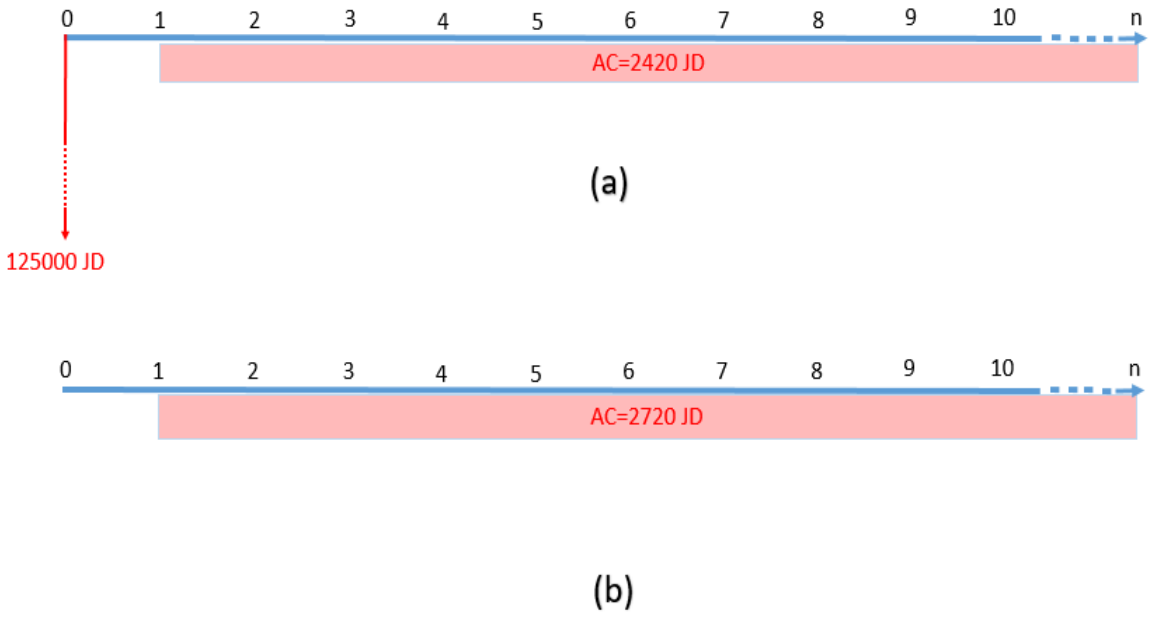

Figure 3: (a) Equipment owning cash flow (B) Equipment on-call renting cash flow.

Calculating the present worth for the on-call rental costs and projecting for a 10-year useful life [15].

$$PW = -IC - A \times (P/A, i, n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\mathrm{PW}_{owning} = -125000 - 2420 \times (P/A, 3\%, 10)$$

$$= -125000 - 2420 \times (8.5302) = -145643.084$$

$$\mathrm{PW}_{(on-call)renting} = -2720 \times (P/A, 3\%, 10)$$

$$= -2720 \times (8.5302) = -23202.144$$

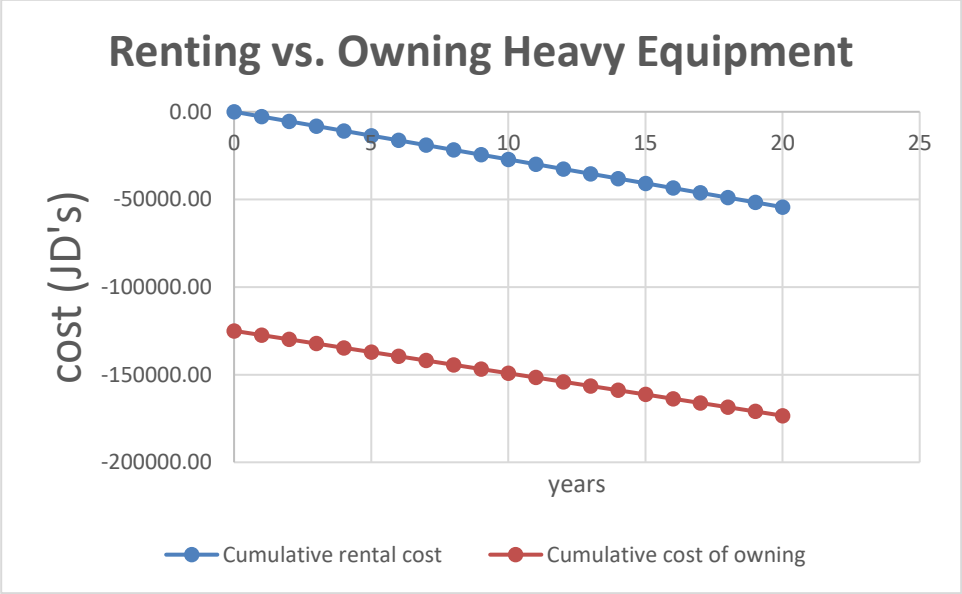

Figure 4: Cumulative cost of on-call rental versus ownership for a single machine projected over a 20-year horizon.

Figure 4 shows the cumulative cost of on-call rental versus ownership for a single machine projected over a 20-year horizon. Figure 4 proves that on-call rental is found economically feasible over the ownership option of heavy construction equipment regardless of the intended acquisition period of the equipment. The two curves run in parallel through the years of acquisition.

CONCLUSIONS

The results of this study were based on realistic data that express the economic reality of heavy machinery owned or rented by a major government body in Jordan. Government ministries/ departments which deal with construction can benefit from the research outcomes. This research provides insight for making informed decisions regarding the acquisition of heavy construction equipment relevant to the project's nature, limitations, and circumstances. Such informed decisions would save millions from the government budget and be able to sustain the challenges of depleted resources and exploited local economies.

The following two major results obtained from the analysis in the previous section with underlying conclusions are in support of the objectives of the study.

Result# 1: The ownership option is found economically feasible over the year-long rental option at a monetary savings of 30,000 JD (See Figure 2)

Conclusion# 1: in case the acquisition period of the heavy equipment is over eight years. Therefore, for an acquisition period shorter than eight years, it's better to choose the year-long rental as the ownership costs remain excessive; hence, not feasible.

Conclusion# 2: It was found that owning equipment is the most economical option when the directorate needs to operate for long periods of the year. That is when the ownership option is less than the year-long renting option, which the government frequently resorts to.

Conclusion# 3: The value of the cumulative costs of owning equipment breaks even with the costs for year-long rental in the eighth year; that is, the ministry pays the market value of the equipment every eight years of year-long rental; in return, for the ownership option is resorted to, the equipment in many cases continues to operate beyond the assumed 10-year service life for at least for another 8 to 12 years.

Result# 2: The on-call rental option is found economically feasible over the ownership option at a monetary savings of approximately 125,000 JD/year per a single piece of equipment (See Figure 4).

Conclusion# 4: Heavy construction equipment operates for limited time intervals during the year and does not incur excessive costs making on-call rental economically feasible over equipment ownership.

Conclusion# 5: On-call rentals, in other words, renting equipment only when they are needed, and only for the period they are needed is found feasible over the year-long rental option and equipment ownership option, as well.

The government might have a profound intention to shift from renting to ownership gradually to get rid of exploitation by contractors or to have more control over productivity; however, such a decision entails negative economic consequences.

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