Article

Life Cycle Approaches to Physical Assets: Assessing Purchasing, Leasing, and Renting Options

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ABSTRACT

Purpose: The sustainability of physical assets is a major strategic concern for many companies, because they need to enhance their decision-making processes in order to achieve their strategic sustainability goals. The performance of an organisation and the production of value are based on its physical assets. The choice of whether to buy, lease, or rent these assets has a big impact on financial risk, operational flexibility, Total Cost of Ownership (TCO) and, obviously, when maximizing the life cycle of physical assets, it corresponds to withdrawal later and, by consequence, to increase sustainability. This study examines life cycle models for physical assets, emphasising the strategic, technical, and financial ramifications of the three main sourcing approaches of purchasing, leasing, and renting. Investing in a physical asset by Purchase or using it through contracts like Leasing or Renting is, day after day, a more pertinent question and decision, namely regarding organizations sustainability. Then, it is necessary to evaluate the most pertinent decision based on a rigorous assessment of the several hypothesis and market proposals, aiming to maximize the value for money. Obviously, any decision of this type must be always supported in a relation win-win between investor and supplier, with the objective to supply the best service to the client. This is the main subject discussed in this paper where there are proposed new Leasing/Renting models and compared with the traditional acquisition, through a life cycle investment simulation approach, the financial implications of different forms of possession—namely purchasing, leasing, and renting—taking into account costs, returns, and asset recovery mechanisms over time. The models presented here help to achieve the Sustainable Development Goals (SDGs), specifically Goal 9 (Innovation and Industry Infrastructure). *Research Question*: Which is the best possession form for a Physical Asset towards sustainability? *Methods*: This paper uses a simulation quantitative method for different life cycles to evaluate different forms of possession aiming to support the decision about the most adequate option for each situation. *Results and Discussion*: After analysing the simulations, as expected there is not one possession form more adequate than others; it depends on the situation, business, global economic situation of each country, among other variables. But the models proposed help strongly to decide, in a quantitative way, the best option for each specific economic environment helping the organization to meet its sustainability goals. *Conclusions*: The math models developed prove to be robust enough to support the decision about the most adequate form of possession for physical life cycles that organization needs.

KEYWORDS: physical assets; life cycle models; leasing; renting; Fisher's equation; apparent rate; sustainability

INTRODUCTION

Sustainability has been more and more crucial in the last few decades. The environment, the economy, and society are the three domains in which it is typically discussed [1–3].

Waas et al. (2014) [4] emphasise the importance of using methods for decision-making that promote sustainable development. Martin (2015) [5] suggests techniques for openly integrating values into sustainability decisions, and Zavadskas et al. (2016) [6] evokes that the general sustainability of businesses and organisations can be enhanced by using formal decision-making techniques. Other authors, such as Kamari et al. (2017) [7], Dizdaroglu (2017) [8], Davidson & Venning (2011) [9], reinforce the need to use decision criteria in order to make decisions concerning the sustainability of organizations.

In the context of rising financial constraints, rapid technological obsolescence, and increasing pressure for efficiency in asset-intensive sectors such as healthcare, industry, and public infrastructure, decision-makers face complex choices regarding the acquisition and management of physical assets [10]. These challenges are particularly evident in public health systems, where budget rationality must coexist with the need for continuous technological renewal.

As a result, there is growing interest in alternative financing and asset management models—such as leasing and renting—that allow organizations to ensure operational continuity without heavy upfront capital expenditures. These models must be analysed not only from an accounting or legal perspective, but also in terms of their long-term economic performance, risk exposure, and strategic flexibility.

Although traditional cost-benefit analyses are commonly used in physical assets possession planning, they often fail to incorporate the full financial and operational implications of the asset lifecycle. Furthermore, there is limited comparative research that simulates the long-term outcomes of acquisition, leasing, and renting decisions based on lifecycle models tailored to organizational needs. This study aims to address this gap through quantitative simulation and lifecycle investment modelling.

Framework

For the best possible value and greater sustainability realisation, physical assets must be managed throughout their life cycle.

Businesses must choose between buying physical assets or possessing them by leasing or renting for a certain period of time. The planning, possession, operation, maintenance, and disposal phases of the life cycle are all affected differently by each method [11].

The main concepts used in this paper are the followings (Figure 1): Renting is a financial arrangement where a person (the tenant or renter) pays another person or company (the owner or landlord) to use a Physical Asset (such as a house, apartment, car, or equipment) for a short or flexible period of time, usually for a shorter period compared to Leasing, and often on a month-to-month basis—the renter never owns the asset and must return it after the rental period ends—the owner is typically responsible for maintenance and repairs (especially in property rentals)—Renting has as advantages its maximum flexibility, low commitment, and fast deployment, and as disadvantage a highest per-use cost, limited availability, and less control; Leasing is a financial arrangement where one party (the lessee) pays another party (the lessor) to use an asset—such as a car, equipment, or property, for a specified period of time—Instead of buying the asset outright, the lessee pays regular instalments (usually monthly) to use it—In a Leasing contract, the lessor retains ownership of the asset during the lease term—Leasing typically have a fixed term (e.g., 2–5 years)—At the end of Leasing time, the lessee may: Return the Physical Asset; Renew the Lease; or Purchase the Physical Asset (It is common for organizations to lease physical assets and then purchase them later [12]. In these lease-to-own arrangements, a physical asset is originally accounted as a right to use the physical asset, and, subsequently treated as a fixed physical asset; The transaction is similar to a financed purchase in that one large cash outlay is not required, but rather a series of cash payments over time. This arrangement may be structured as a leasing with a title transfer at the end of the leasing period or with a purchase option that organization intends to make; Usually, the maintenance procedures during the leasing time is of the owner of the physical asset; Leasing as advantages to need reduced capital expenditure, access to newer technologies, off-balance-sheet financing, and as disadvantages to have high long-term costs, contract rigidity, limited customization.

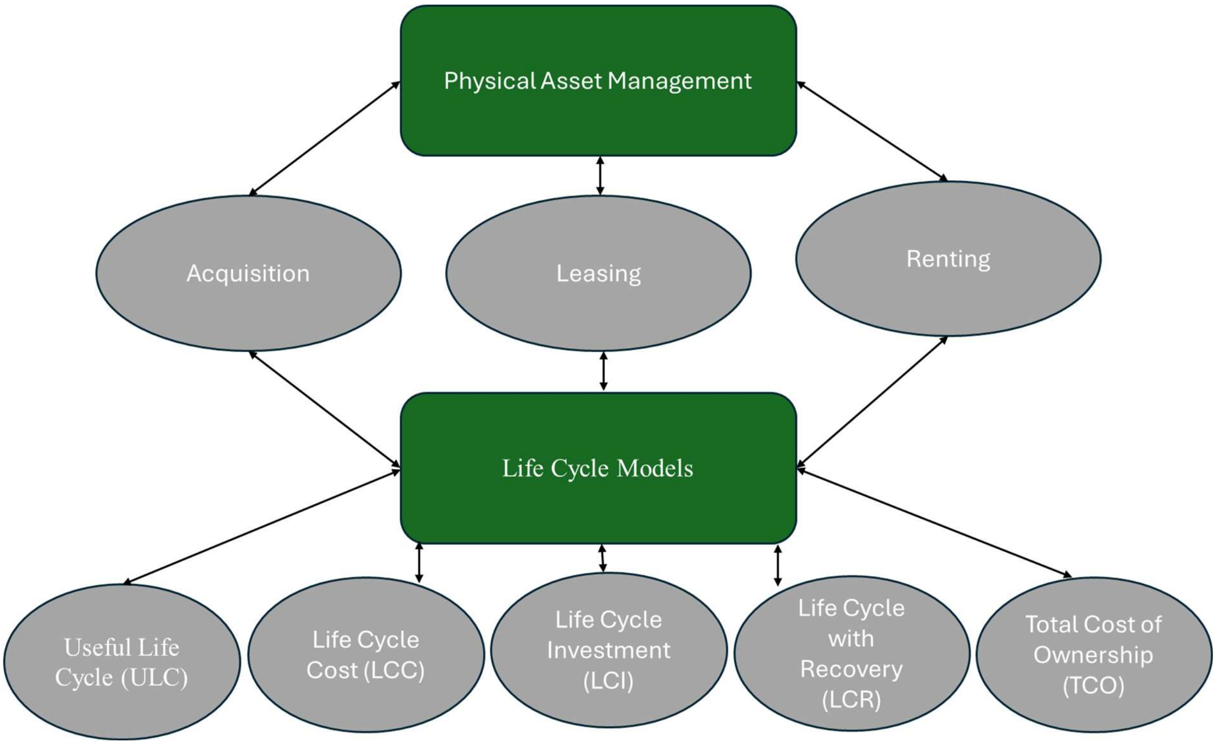

Figure 1. Asset Management versus Life Cycles Model.

To manage the several options of possession, being the acquisition, renting, leasing or any other, the concepts of Life Cycle help a lot. The Life Cycle concepts used in this paper are: Useful Life Cycle (ULC)—Defines that the life of a physical asset ends when its maintenance costs exceed the maintenance costs plus the capital amortization of an equivalent new equipment; Life Cycle Cost (LCC)—Is a concept that aggregates all costs that an organization will incur over the life of the physical asset. It includes the initial investment (non-recurring expense) and any further investment, such as operating costs, maintenance, and upgrades (recurring expenses); Life Cycle Investment (LCI)—Is a concept that permits to evaluate the Life Cycle of Physical Assets from the point of view of investment, costs, profits, and the global return (Life Cycle with Recovery (LCR)—It is a concept that considers, like LCI, expenses and profits—LCR may correspond to what is usually called Sensitivity Analysis; however, it adds an evaluation about the money that must be earned annually to reinvest in a new Physical Asset to replace the old one; Total Cost of Ownership (TCO)—Is a thorough financial estimate designed to assist owners and purchasers in figuring out the direct and indirect expenses of a system or product over the course of its whole life cycle. TCO is a crucial instrument for supporting strategic choices regarding acquisition, leasing, or renting in the context of physical asset management.

Research Question

The main problem discussed in this paper can be synthetized in the next Research Question:

Which is the best possession form for a Physical Asset towards sustainability?

The answer to this Research Question is made through evaluating the life cycle of physical asset based on the several possession models, based on quantitative simulation methods, from which result the financial implications of each model—purchasing, leasing, or renting—taking into account costs, profits, and asset recovery mechanisms over time.

Structure of the Paper

This paper is organized as follow:

- Section "Theoretical Framework" presents a theoretical framework;
- Section "Life Cycles Models Framework" presents a life cycles models framework;
- Section "Base Case and Sensitivity Analysis" presents life cycles models simulation;
- Last Section offers the conclusion.

THEORETICAL FRAMEWORK

The life cycle of physical assets encompasses all stages from acquisition to disposal, including planning, operation, maintenance, and renewal.

ISO 55000:2024 provides a comprehensive overview of asset management, defining its principles, concepts and terminology. ISO 55001:2024 establishes the requirement for designing, implementing, maintaining and improving an asset management system. The updated ISO 55001:2024 edition places greater focus on integrating knowledge management into asset strategies, enhancing decision-making framework, and aligning organisational goals with the dynamic challenges of global industries. ISO 55002:2024 provides guidelines for applying ISO 55001 in practical contexts [13]. New standards linked to the ISO 5500X family have been written and published, such as:

- ISO 55010:2024—Asset Management—Guidance on the Alignment of Financial and Non-Financial Functions in Asset Management;
- ISO 55011:2014—Asset Management—Guidance for the Development of Public Policy to Enable Asset Management;
- ISO 55012:2024—Asset Management Guidance on People Involvement and Competence;
- ISO 55013:2024—Asset Management—Guidance on the Management of Data Assets;
- ISO/AWI TS 55014—Guidance for Asset Management Decision Making.

According to the ISO 55000 standard, life cycle management aims to optimize performance, cost, and risks associated with assets over time, ensuring that they continue to deliver value aligned with organizational objectives. ISO 55001:2024 drives asset management aligned with sustainability, promoting innovative and resilient practices that enable organizations to anticipate future challenges.

Almeida Pais et al. (2021) present a case study to apply new methods of econometric models to the Life Cycle Assessment (LCA) of physical assets, by integrating investments, such as maintenance, technology, sustainability, and technological upgrades, and to propose a means to evaluate the Life Cycle Investment (LCI), with emphasis on sustainability.

Sustainability is a recurrent theme of existing studies and will be a concern in coming decades. As a result, equipment with a smaller environmental footprint is being continually developed. This paper presents a method to evaluate asset depreciation with emphasis on maintenance investment, technology depreciation, sustainability depreciation, and technological upgrade investment.

Farinha (2025) [14] presents a general view of Leasing and Renting, as well as the main Terms of Reference for Leasing and Renting.

Raposo et al. (2024) [15] emphasize that life cycle of physical assets analysis is a tool of great importance for asset management and of great use to managers, namely hospital facilities and equipment managers. Furthermore, this is an essential issue in the current macroeconomic economy, being its assertiveness preponderant for the success of any investment. This paper aims to emphasize the importance of investment analysis in the decision-making strategy of any organization, intertwined with the life cycle of the physical asset analysis, framed in a structuring approach of certification by the ISO 55001 standard. For an efficient physical assets management, in general, and within the health sector, in particular, optimizing their maintenance and determining the optimal moment for their withdrawal from operation, or their renewal, are fundamental aspects for its profitability and quality of service to users.

In this context, the selection of an acquisition model—whether outright purchase, leasing, or renting—is a critical strategic decision that significantly impacts both financial planning and operational flexibility.

Asset-intensive sectors, such as healthcare and industrial manufacturing, often rely on life cycle models to guide decisions regarding the most appropriate method of asset acquisition and utilization. Amadi-Echendu et al. (2010) [16] emphasize that managing assets across their life cycle is essential to ensuring that they operate efficiently and economically. This perspective is particularly relevant when dealing with technologically sensitive equipment, where the pace of innovation and the risk of obsolescence must be weighed against cost and functionality.

When evaluating acquisition versus leasing or renting solutions, decision-makers frequently resort to financial methodologies such as Total Cost of Ownership (TCO) and Net Present Value (NPV) to compare long-term implications. Brealey (2022) [17] highlights that direct acquisition is generally more cost-effective in the long term for assets with extended useful lives and high utilization rates. Conversely, leasing and renting arrangements tend to be more advantageous in environments characterized by high uncertainty or rapid technological change, as they require lower upfront capital and provide greater flexibility.

Recent approaches have expanded traditional life cycle cost models by incorporating investment recovery perspectives. Concepts such as Life Cycle Investment (LCI) and the sensitivity analysis through the Life Cycle with Recovery (LCR) allow decision-makers not only assess cost accumulation and depreciation but also model reinvestment strategies for asset renewal. These models are particularly relevant when the financial sustainability of asset replacement is critical to service continuity, as in the case of public healthcare infrastructures.

Tlili et al. (2024) [18] propose a planned maintenance strategy to be adopted by the lessor during the lease period. They also refer that the greater the quantity of consumables used by the customer, the more the equipment will deteriorate. They add that the objective is to determine, for a given customer with an estimated consumption rate profile of consumables, the optimal values of these decision variables; so, the lessor can maximize their profit. As an example, these authors refer the X-ray machines. In some countries, this equipment is provided with free of charge to healthcare institutions on the condition that they purchase a predetermined minimum quantity of certain films during the lease period.

From an accounting perspective, the International Financial Reporting Standard IFRS 16 (https://www.ifrs.org/issued-standards/list-of-standards/ifrs-16-leases/, accessed on 2025 May 16) has reshaped how organizations record leasing obligations, reducing the distinction between finance and operating leases. This shift underscores the need for decision-making models that incorporate both financial and regulatory implications.

To navigate the complexity inherent in evaluating such models—where multiple qualitative and quantitative factors must be considered—researchers have increasingly adopted fuzzy logic and other soft computing techniques. Zimmermann (2001) [19] notes that fuzzy set theory enables the modelling of linguistic variables and imprecise data, thereby supporting structured decision-making in scenarios where uncertainty is significant. Kahraman et al. (2003) [20] demonstrate that fuzzy logic is particularly effective when applied to Multi-Criteria Decision-Making (MCDM) problems involving supplier selection, a framework that can be extrapolated to leasing and acquisition decisions, especially when factors such as service quality, technological obsolescence, and maintenance requirements are considered.

While NPV and TCO remain central to acquisition analysis, their applicability is constrained when qualitative factors, such as supplier reliability, technological interoperability, or strategic alignment, are pivotal. In such cases, hybrid approaches combining soft computing (e.g., fuzzy logic) with financial modelling provide a more accurate representation of real-world complexity.

Within the healthcare industry, the application of simulation and optimization models further supports the lease-versus-buy decision process. According to Leite et al. (2020) [21], simulation models applied to healthcare asset management demonstrate that leasing strategies can facilitate the adoption of advanced technologies without large upfront investments. This approach is particularly effective in environments characterized by budgetary restrictions and constant technological evolution.

Thus, the theoretical framework underscores that asset acquisition decisions should not rely solely on cost-minimization principles. Instead, they must integrate long-term strategic, operational, and contextual variables, including technological renewal cycles, organizational mission, and sustainability objectives.

In summary, theoretical models of asset life cycle management offer a multidimensional lens through which organizations can evaluate acquisition strategies. By integrating financial analyses with qualitative decision-support systems such as fuzzy logic, these models facilitate comprehensive, context-aware decision-making that aligns operational needs with long-term strategic goals.

LIFE CYCLES MODELS FRAMEWORK

In his book, Farinha (2025) [14] are presented several models to analyses the life cycle of physical assets. Some of the most relevant concepts presented are summarized in the next sections.

This paper focuses on the assessment of the purchasing, leasing, and renting options what adds value to the cited previous publications.

Fisher Equation

It is important to define the way the Apparent Rate (i_A) is calculated and influences the results of the models, because it is used in all of the models. In this paper, not only was the Real Interest Rate, Inflation Rate and Profit Rate introduced but also the Risk Rate. The relationship among these rates is described using Fisher's equation (Equation (1)) [14]:

$$(1 + i_A) = (1 + r) \times (1 + h) \times (1 + R) \tag{1}$$

where:

i_A = Nominal interest rate;
r = Real interest Rate;
h = Expected inflation rate;
R = Risk Premium.

Life Cycle Investment

The Life Cycle Investment Method not only considers expenses and taxes but also profits. This method allows for an evaluation of the right time as to when an investment does not return a positive value. Equation (2) defines this approach:

$$GR_n = \sum_{j=0}^{n} \frac{B_j}{(1+i_A)^j} - \sum_{j=0}^{n} \frac{F_j}{(1+i_A)^j} - \sum_{j=0}^{n} \frac{M_j}{(1+i_A)^j} \quad (2)$$

where:

GR = Global Result from expenses and benefits in year n;
i_A = Apparent Rate;
B_j = Value of Benefits in year j;
F_j = Cost of Functioning in year j;
M_j = Cost of Maintenance in year j.

Life Cycle of Physical Assets with Recovery

The value of the Physical Asset over time may be seen from two perspectives: Devaluation, taking into account the Apparent Rate; and the value of a new asset, taking into account the Apparent Rate.

For many companies, it is important to create financial reserves that aim to be financially available to renew a physical asset or buy a new one at the end of its economic life cycle. Because of this, it is important to know when these two lifecycle times occur.

The preceding perspectives are opposites and are evaluated as follows:

The devaluation of the Physical Asset, taking into account the Apparent Rate is given by Equation (3):

$$C_{0D}^{t} = C_{0D}^{t-1} \times i_A \quad (3)$$

where,

C_{0D}^{t} = Value of the Physical Asset at time t;
C_{0D}^{t-1} = Value of the Physical Asset at time $t – 1$;
i_A = Apparent Rate.

The value of a new Physical Asset, taking into account the Apparent Rate (Equation (4)):

$$C_{0N}^{t} = C_{0N}^{t-1}/(1 + i_A)^i \quad (4)$$

where,

C_{0N}^{t} = Value of the new Physical Asset at time t;
C_{0N}^{t-1} = Value of the new Physical Asset at time $t – 1$;
i_A = Apparent Rate.

The Total NPV, considering the devaluation of the Physical Asset and taking into account the Apparent Rate, is given in Equation (5):

$$NPV_{TD} = NPV_{FpD} + NPV_{Fe} \quad (5)$$

where,

NPV_{TD} = Total Net Present Value considering Physical Asset Devaluation;
NPV_{FpD} = Total Net Present Value considering Physical Asset Devaluation;
NPV_{Fe} = Net Present Value of the Financial Expenses movement.

The Total NPV, considering the value of a new Physical Asset and taking into account the Apparent Rate, is given in Equation (6):

$$NPV_{TN} = NPV_{FpN} + NPV_{Fe} \tag{6}$$

where,

NPV_{TN} = Total Net Present Value considering a New Physical Asset;
NPV_{FpN} = Net Present Value of the Financial Production movement;
NPV_{Fe} = Net Present Value of the Financial Expenses movement.

Leasing and Renting Models

By evolving the models presented in the previous sections, new Leasing/Renting models can be developed, as will be seen below.

The new Leasing/Renting models are proposed through Equation (7):

$$Rt_n = \frac{Rt_i}{(1+i_A)^i} \tag{7}$$

where,

Rt_n = Rent in the year n;
Rt_i = Rent in the year i;
i_A = Apparent Rate.

Leasing Considering a New Physical Asset

If it was considered the acquisition of a new asset after the leasing/renting time, it must be considered an additional amount to be possible to save money for that time. With this objective, below will be presented a model to support this objective.

It can be considered, in a first step, to make a Leasing/Renting and, after accumulating the necessary budget, to buy the Physical Asset. Equation (8) gives the way to calculate the Rent to reach this objective:

$$Rt_n = \sum_{i=1}^{n} \left(\frac{Rt_i}{(1+i_A)^i} * Inc\right) \tag{8}$$

where,

Rt_n = Rent in the year n;
Rt_i = Rent in the year i;
i_A = Apparent Rate;
Inc = percentage amount to be saved annually for the purchase of new Asset.

Return On Investment with and without a New Physical Asset

It is very relevant to know when the Return On Investment (ROI) happens. Equation (9) presents the most usual way to evaluate the Return On Investment (ROI):

$$ROI = \frac{\sum_{j=1}^{n} CF_j}{II} \tag{9}$$

where,

ROI = Return On Investment;
CF_j = Positive and Negative monetary fluxes in the year i;
II = Initial Investment.

However, the ROI can be evaluated considering the accumulation of a budget to by a New Physical Asset; this new approach can be done through Equation (10):

$$ROI_N = \frac{\sum_{j=1}^{n} CF_j}{(II_{NPV} + II_N)} \quad (10)$$

where,

ROI_N = Return On Investment with New Physical Asset;
CF_j = Positive and Negative monetary fluxes in the year i;
II_{NPV} = Initial Investment reduced to Net Present Value;
II_N = Initial Investment for a New Physical Asset.

BASE CASE AND SENSITIVITY ANALYSIS

The simulation models developed in this study and presented in this section are directly grounded in the theoretical foundations discussed in Section “Theoretical Framework”. Financial indicators such as Net Present Value (NPV), Return on Investment (ROI), and Total Cost of Ownership (TCO) were applied to compare acquisition, leasing, and renting strategies over a 25-year horizon. Moreover, the simulation incorporates life cycle investment principles (LCI and LCR), allowing the quantification of asset recovery strategies and replacement planning.

The values inside the Table 1 are all theoretically; however, in real analysis there are main general indicators that may be used, like the following:

- Leasing = 1%–4% of purchase price per month;
- Renting = 4%–10% of purchase price per month;
- Leasing is cheaper because it’s long-term and lower risk.

About Renting by activity sector, some general indicators are the following:

- Heavy construction equipment: 5–10% of purchase cost - Excavators, loaders, cranes;
- Industrial equipment: 4%–8%—Compressors, generators;
- IT/office equipment: 3%–6%—Servers, photocopiers;
- Medical equipment: 2%–5%—High-value devices;
- Vehicles (fleet): 1.5%–3%—Long useful life.

About Leasing by activity sector, some general indicators are the following:

- Vehicles (operating leases): 1%–2.5%—Very common in fleets;
- Industrial & production equipment: 2%–4%—CNCs, fabrication machines;
- Construction equipment: 2%–3.5%—Excavators, loaders, cranes;
- IT & office equipment: 2%–4%—Servers, printers, telecom;
- Medical equipment: 1.5%–3%—Long life, high residual value.

Usually, *lato sensu*, the values for Renting varies between 1.5% and 10%, depending on the type of Physical Asset to rent: Heavy construction equipment, between 5% and 10% of purchase cost (Excavators, loaders, cranes); Industrial equipment, between 4% and 8% (Compressors, generators); IT/office equipment between 3% and 6% (Servers, photocopiers); Medical equipment, between 2% and 5% (High-value devices usually have a lower %); Vehicles (fleet), between 1.5% and 3% (Long useful life with lower rate).

The simulations presented next are based on the following data, to which must be added the annual values inside Table 1:

- Real interest rate (1 + r): 1.01;
- Expected inflation rate (1 + h): 1.02;
- Risk Premium (R): 0.05;
- Annual Increase to buy a New Asset II: 0.1;
- MTBF: 500;
- MTTR: 50;
- Initial Investment (II): 500.000 Monetary Units (MU);
- Rent: 25.000 MU;
- Production: 120.000 MU;
- Total Functioning Costs: 10.700 MU.

It is important to emphasize the relation between production and the Availability of the Physical Assets, through the MTBF and MTTR and the Equation (11).

$$A = \frac{MTBF}{MTBF + MTTR} \tag{11}$$

Table 1 shows the simulated data relating to the accumulated financial results over the life cycle of the asset, considering different acquisition and recovery strategies. The negative values mean expenses; the positive values mean positive incomes.

Figure 2 shows the cumulative evolution of total positive and negative flows over 25 years, with Sensitivity Analysis:

- The light grey line presents the Total Results Accumulated, reduced to NPV;
- The green line represents the Global Result with Rent (NPV) without considering the Initial Investment;
- The dark grey represents the Total Production Accumulated, reduced to NPV;
- The brown line represents the Global Result with II (NPV), including the Rent.

Table 1. Values for life cycle models simulation.

Time (t)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
r: real interest rate *(1 + r)*		1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
h: expected inflation rate *(1 + h)*		1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
i: money rate (nominal interest rate)		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
i: Apparent Rate with Risk Premium		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
1/((1 + *i*)^t))		0.92	0.85	0.79	0.73	0.68	0.62	0.58	0.53	0.49	0.46	0.42	0.39	0.36	0.33	0.31	0.28	0.26	0.24	0.22	0.21	0.19	0.18	0.16	0.15	0.14
Initial Investment (II)	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000	−500 000
Initial Investment (II) (NPV)	−500 000	−462 231	−427 315	−395 037	−365 197	−337 610	−312 108	−288 532	−266 737	−246 588	−227 962	−210 742	−194 823	−180 106	−166 502	−153 924	−142 297	−131 548	−121 612	−112 425	−103 933	−960 82	−888 24	−821 15	−759 12	−701 78
Initial Investment (II) Considering NEW Asset (NPV Inverse)	−500 000	−540 855	−585 048	−632 853	−684 563	−740 499	−801 005	−866 455	−937 253	−101 3836	−109 6676	−118 6286	−128 3217	−138 8069	−150 1488	−162 4174	−175 6886	−190 0441	−205 5726	−222 3699	−240 5398	−260 1943	−281 4548	−304 4524	−329 3292	−356 2387
Rent	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00	−250 00
Rent (NPV Inverse)	−250 00	−270 43	−292 52	−316 43	−342 28	−370 25	−400 50	−433 23	−468 63	−506 92	−548 34	−593 14	−641 61	−694 03	−750 74	−812 09	−878 44	−950 22	−102 786	−111 185	−120 270	−130 097	−140 727	−152 226	−164 665	−178 119
Rent (NPV Inverse) Accumulated	−250 00	−270 43	−562 95	−879 38	−122 166	−159 191	−199 241	−242 564	−289 426	−340 118	−394 952	−454 266	−518 427	−587 831	−662 905	−744 114	−831 958	−926 980	−102 9766	−114 0951	−126 1221	−139 1318	−153 2046	−168 4272	−184 8937	−202 7056
Production	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00	1200 00
Production (NPV)	1200 00	1008 50	9323 2	8619 0	7967 9	7366 0	6809 6	6295 2	5819 7	5380 1	4973 7	4598 0	4250 7	3929 6	3632 8	3358 3	3104 7	2870 1	2653 3	2452 9	2267 6	2096 3	1938 0	1791 6	1656 3	1531 1
Production Accumulated (NPV)	1200 00	1008 50	1940 83	2802 73	3599 52	4336 12	5017 09	5646 61	6228 58	6766 59	7263 96	7723 76	8148 83	8541 79	8905 07	9240 90	9551 37	9838 38	1010 372	1034 901	1057 577	1078 541	1097 920	1115 836	1132 399	1147 710
Functioning Costs	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0	−990 0
Functioning Costs (NPV) Accumulated	−990 0	−915 2	−846 1	−782 2	−723 1	−668 5	−618 0	−571 3	−528 1	−488 2	−451 4	−417 3	−385 7	−356 6	−329 7	−304 8	−281 7	−260 5	−240 8	−222 6	−205 8	−190 2	−175 9	−162 6	−150 3	−139 0
Energy	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500	−500
Energy Accumulated (NPV) Accumulated	−500	−462	−890	−128 5	−165 0	−198 7	−229 9	−258 8	−285 5	−310 1	−332 9	−354 0	−373 5	−391 5	−408 1	−423 5	−437 8	−450 9	−463 1	−474 3	−484 7	−494 3	−503 2	−511 4	−519 0	−526 0
Maintenance Costs	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300	−300
Maintenance Costs (NPV) Accumulated	−300	−280	−539	−778	−100 0	−120 4	−139 3	−156 8	−173 0	−187 9	−201 8	−214 5	−226 3	−237 2	−247 3	−256 7	−265 3	−273 3	−280 6	−287 4	−293 7	−299 6	−304 9	−309 9	−314 5	−318 8
Total Costs (NPV) Accumulated	−107 00	−989 5	−193 94	−284 95	−372 25	−456 14	−536 88	−614 69	−689 80	−762 42	−832 73	−900 91	−967 12	−103 151	−109 421	−115 535	−121 506	−127 343	−133 057	−138 657	−144 153	−149 551	−154 859	−160 084	−165 232	−170 310
Annual Increase Accumulated to buy a New Asset II	−500 00	−500 00	−100 000	−150 000	−200 000	−250 000	−300 000	−350 000	−400 000	−450 000	−500 000	−550 000	−600 000	−650 000	−700 000	−750 000	−800 000	−850 000	−900 000	−950 000	−100 0000	−105 0000	−110 0000	−115 0000	−120 0000	−125 0000
Global Result with II (NPV)–with Rent	−415 700	−398 318	−308 922	−231 196	−164 636	−108 803	−633 28	−279 04	−228 5	1371 1	2020 9	1727 7	4921	−169 09	−483 21	−894 83	−140 624	−202 033	−274 063	−357 133	−451 730	−558 411	−677 809	−810 634	−957 682	−111 9833
Global Result with II New Asset (NPV) Increase %—Without Rent	5930 0	4095 6	7468 8	1017 78	1227 27	1379 98	1480 21	1531 92	1538 78	1504 17	1431 23	1322 85	1181 71	1010 28	8108 6	5855 5	3363 1	6496	−226 85	−537 56	−865 76	−121 010	−156 939	−194 248	−232 833	−272 599
Global Result with Rent (NPV) without II	8430 0	6391 3	1183 93	1638 40	2005 61	2288 07	2487 80	2606 28	2644 52	2602 99	2481 71	2280 19	1997 44	1631 98	1181 81	6444 1	1673	−704 85	−152 452	−244 708	−347 797	−462 329	−588 984	−728 520	−881 770	−104 9655
Global Result with Rent and saving for a new Asset (NPV)	3430 0	1391 3	1839 3	1384 0	561	−211 93	−512 20	−893 72	−135 548	−189 701	−251 829	−321 981	−400 256	−486 802	−581 819	−685 559	−798 327	−920 485	−105 2452	−119 4708	−134 7797	−151 2329	−168 8984	−187 8520	−208 1770	−229 9655
ROI without Rent, with Production + Costs Accumulated	0.2	0.2	0.3	0.5	0.6	0.8	0.9	1	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.9	1.9	1.9	2
ROI with buying new Asset without Rent	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1

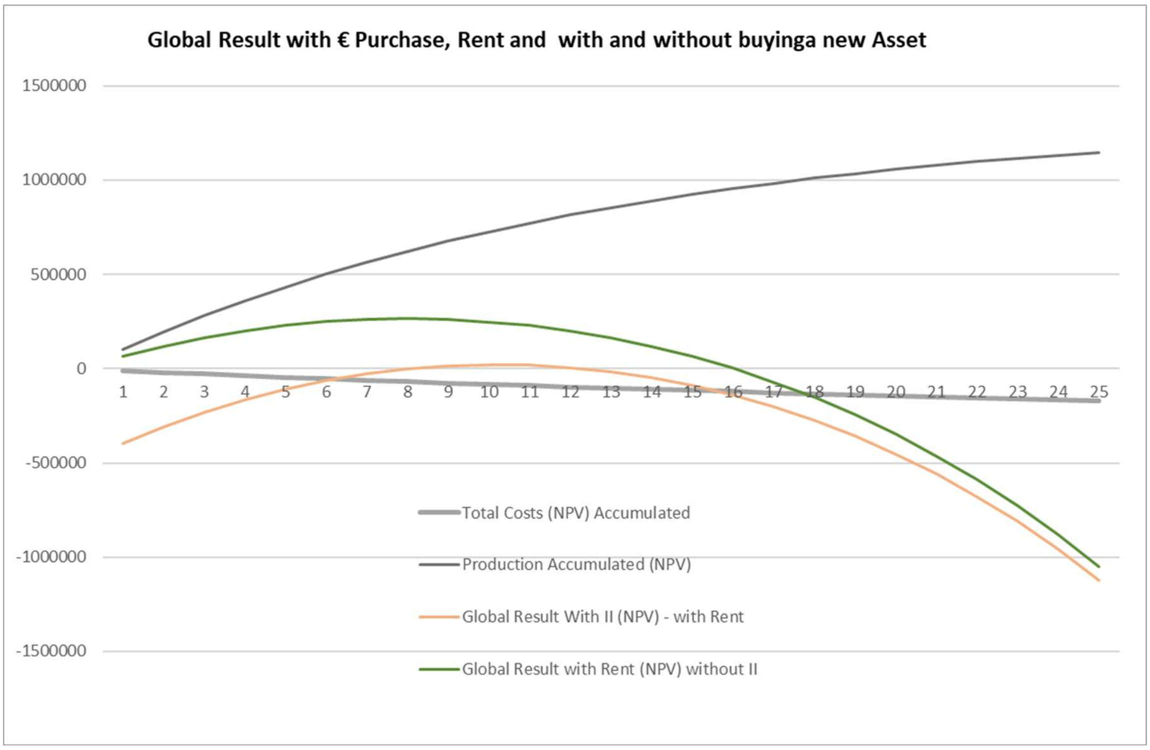

Figure 2. Global life cycles evaluation.

As can be seen in the figure the green line shows an interesting positive result for the option of a rent during 16 years.

The option to earn money to buy an equipment only gives a positive result between years 6 and 13 but it permits to buy an asset after that time as alternative to make a new Rent.

The graphic of Figure 3 compares LCI reduced to NPV over a 25-year horizon for two scenarios:

1. The blue light bars show the Global Result considering the earning to buy a New Asset (NPV) with an annual percentage increase without Rent;
2. The brown light bars show the Global Result (NPV) and the Rent.

From the Figure 3, it can be seen that with rent the positive results happen during 17 years, while considering an annual earning the positive results happen only during16 years. However, if the percentage of annual earnings increases, obviously the positive interval decreases.

The graph of Figure 4 compares the Net Present Value (NPV) over 25 years for different scenarios of acquiring and financing a new asset (purchase, purchase with recovery, rental and NPV with new/depreciated assets)—This graph highlights some results shown in Figure 2:

- The red line is the value of the Asset;
- The green line represents the Global Result with NPV without Initial Investment, but considering a Rent;
- The yellow line represents the Global Result with Rent and saving for a new Asset (NPV).

Figure 4 reinforce the idea that the Rent option gives a more enlarged positive period of positive return; however, this option does not give the solution to own the equipment.

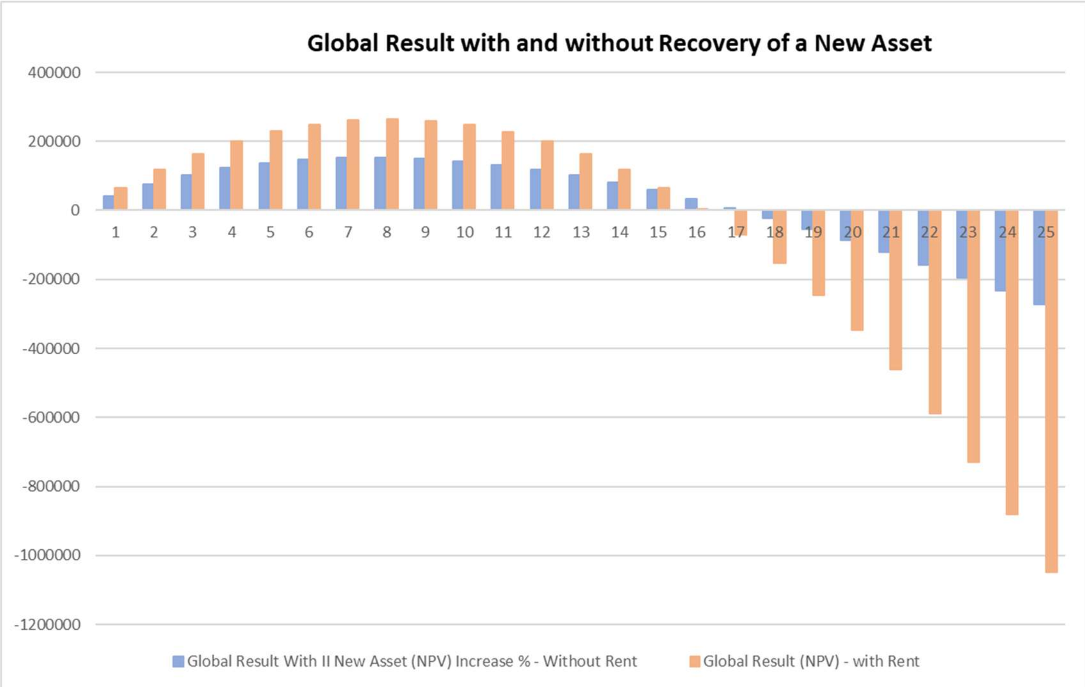

Figure 3. LCI with and without Recovery for New Asset.

Figure 4. Life cycles evaluation permitting to compare traditional LCI with Leasing/Renting.

The graph of Figure 5 shows the cumulative return on investment (ROI) where can be identified the Payback time for two scenarios: purchase with recovery (blue line) and ROI based on II (dark grey line).

- The dark grey line represents the ROI without Rent, with Production + Costs Accumulated;
- The blue line represents the ROI considering buying a new Asset without Rent.

As can be seen in Figure 5, it is reinforced the idea that with Rent the ROI and corresponding Payback, with the simulation values considered are better than with investing previously in a Physical Asset.

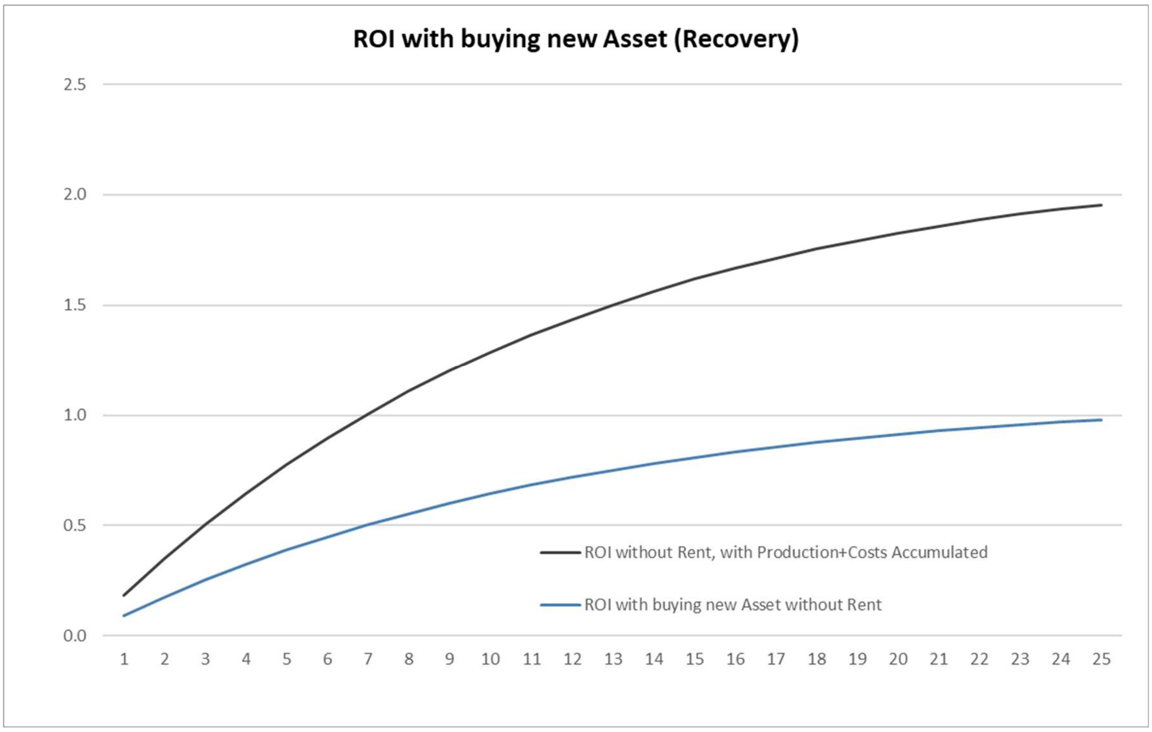

Figure 5. ROI evaluation with and without Recovery to buy a new Asset.

CONCLUSIONS

This study presented an in-depth analysis of lifecycle models for physical assets, with a focus on comparing acquisition, leasing and rental alternatives, using simulations based on financial indicators such as Net Present Value (NPV), Return on Investment (ROI) and accumulated financial movements. The results show that the decision on how to obtain assets should be guided by an integrated view of the life cycle, taking into account not only initial costs, but also operating costs, maintenance strategies, residual value and potential recovery gains, also taking sustainability into account, building a decision-making tool to managers.

From a methodological point of view, the use of life cycle simulation models makes it possible to explore different scenarios and support decisions based on quantitative evidence, reinforcing the importance of a systemic and forward-looking approach to physical asset management. It is this aspect that is highlighted, i.e., all options of possessing ought to be evaluated but the choosing must be according the one that gives the better life Cycle for the investment.

The integration of variables such as depreciation, planned maintenance costs and the benefits of asset recovery is fundamental to building more realistic models that are applicable to complex contexts such as the health sector or heavy industry.

In practical terms, this work provides a solid basis for supporting public and private decision-makers in defining more sustainable, efficient and economically viable investment strategies. Future research could explore the application of fuzzy models, multi-objective optimization and risk assessment, incorporating variables such as technological obsolescence, environmental regulations and social impact.

The conclusion is that life cycle analysis of physical assets, supported by robust analytical tools, is essential for maximizing the value of investments over time, ensuring decisions that are more in line with the strategic objectives of organizations and current sustainability requirements.

Furthermore, the study highlights the strategic relevance of integrating lifecycle-based decision-making into public procurement policies. By aligning financial planning with technological renewal cycles, organizations—particularly in the public healthcare sector—can enhance resilience, accountability, and service quality. The simulation approach developed also offers a transferable framework for application in other infrastructure-intensive domains, such as transportation, education, or energy. As a scientific contribution, this research advances the field by combining empirical simulation with theoretical lifecycle principles, reinforcing the applicability of quantitative decision-support tools in complex, high-stakes environments.

Finally, the math models developed prove to be robust enough to support the decision about the most adequate form of possession for physical life cycles that organization needs. In this way, they contribute to better management of their physical assets and, in turn, to the sustainability of organizations.

DATA AVAILABILITY

No restrictions apply to the availability of the data used in the paper. Data will be made available on reasonable request.

AUTHOR CONTRIBUTIONS

JTF: Conceptualization, Data curation, Formal analysis, Investigation, Project administration, Resources, Validation, writing–original draft, Writing–review & editing. IS: Validation, visualization, writing–review & editing. HR: Conceptualization, Validation, writing–original draft, writing–review & editing. JEd-A-e-P: Validation, Visualization, Writing–review & editing.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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