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Application of MHR and ABC Methods in the Calculation of the Costs of Scientific Publication

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Abstract – The paper compares the ABC (Activity-Based Costing) and MHR (Machine Hour Rate) methods for calculating the costs of publishing a scientific article, in a case study involving a CNC machine and open access publishing. ABC provides a detailed allocation of costs per activity, which is accurate but costly. MHR, simpler and more applicable in industrial environments, is less accurate in complex processes. Each method has specific advantages, and the choice depends on the complexity of the activities and the desired level of precision, influencing economic decisions and the efficient use of resources.

Keywords: Costing; MHR Method; ABC Method

I. INTRODUCTION

This paper addresses the issue of identifying the most appropriate technique for calculating costs in a dynamic economic context. It is essential to understand that due to the rapid advancement of data processing and storage technologies and the advent of artificial intelligence, computing resources are now more accessible, powerful, and cheaper, being available to anyone, anywhere, and anytime.

From an economic perspective, any production or service provision activity inevitably involves costs. In this context, the knowledge and understanding of these costs becomes an indispensable condition for substantiating correct and efficient decisions.

The complexity of the modern economy, characterized by fierce competition specific to the market economy, emphasizes the importance of quality information flow in the decision-making process. The quality of financial and cost information is essential, as it directly influences both immediate decisions and the long-term vision, implicitly determining the results obtained.

In the current economic environment, any decision error resulting from incomplete or deficient information on costs is severely penalized, underlining the need for precise and correct cost management.

Analyzing the specialized works in the field of cost calculation, [1-6], we discovered that each method has specific advantages depending on the complexity of the activities and the typology of the organizations, and the choice of the right technique depends on the desired precision in allocating costs and the necessary flexibility in managing them.

In another cost-focused study, [7] proposed an innovative and detailed process-based cost estimation model that considers various battery cell geometries, such as cylindrical, prismatic, and bag-like. This model uses user-specified performance data to enable flexible battery cell design and provide an accurate cost estimate a functionality absents in many of today's models.

Kádárová, [8] argues that companies frequently encounter problems related to waste in production processes. In a comparative analysis of the results obtained through various methods of production management and waste reduction on a pro-duction line, the focus was on reducing costs. For this, industrial engineering techniques were used, focused on technical and economic analysis, ergonomics and pro-duction management.

Cost calculation by classical method represents the present, the future being rep-resented by the calculation of costs with the help of artificial intelligence. Relich & Nielsen [9] states that the use of parametric modeling implies the need to collect a considerable amount of data on similar products, which may be a constraint to the pro-posed method. In addition, the definition of many parameters for the development and training of artificial neural networks, as well as the application of constrained programming techniques, can be seen as other limitations tag. In another study, Relich & Świć, [10] argues that the use of artificial neural networks increases the efficiency of the search process in the case of project prototyping, especially when several viable solutions are available. The research also highlights the application of artificial neural networks to determine cost estimation relationships throughout a product's life cycle. However, it is important to emphasize that although neural net-works process data, the calculations are still based on traditional methods.

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In this context, the present paper aims to analyze and compare two widely used cost calculation methods: the ABC (Activity-Based Costing) method and the MHR (Machine hour rate) method. Both techniques aim to allocate indirect costs, but they differ in their approach.

This comparison will highlight not only the efficiency of each method, but also their advantages and disadvantages, identifying the most appropriate technique according to the specifics of each economic entity and the complexity of its processes.

II. THEORETICAL ASPECTS

2.1 Activity-Based Costing (ABC)

The ABC method is a modern approach that emphasizes "activities" and "cost factors". This allows for detailed measurement of costs, task performance, re-sources used, and cost-generating objects. The concept of "activity" emphasizes the link between the resources consumed and the resulting products, while the "cost factor" helps to identify the elements that influence the price of a product [11].

Activity-Based Costing is a method of attributing indirect costs to activities, processes or products, starting from the activities that generate these costs, as opposed to the traditional approach, determining a real and well-founded cost. In the traditional system, indirect costs are first distributed to various departments and then allocated to individual products using criteria such as direct wages, direct working hours or ma-chine operating hours.

We imagine that in the factory all overheads are calculated according to the operating hours of the machines. This doesn't make much sense, because not all indirect costs are directly related to how long the cars run. As a result, the indirect and total costs attributed to the products become wrong and do not reflect reality, which can create serious problems for the business. In contrast, the Activity-Based Costing method distributes overhead expenses according to the activities that generate them. For example, for the costs related to the purchase of goods, they can be divided into several stages, such as placing orders, receiving the goods or checking and storing them. Thus, the cost for placing an order is divided according to the number of times an order was placed, and the cost for inspection is allocated according to the number of checks made [12-13].

The activity-based costing (ABC) method involves a structured multi-step process for accurately allocating costs and improving organizational efficiency. The first step is to identify the relevant costs, followed by the creation of groups of secondary costs (e.g. IT, administrative salaries) and primary costs (directly related to production, such as research, advertising). The activities are then measured using existing data, and the secondary costs are allocated to the primary ones based on these activities. Subsequently, the costs are distributed to the cost objects (products/services) according to the use of the activities, generating detailed reports. Finally, the information obtained is used to optimize resources and reduce costs, providing a clear picture of the company's performance and efficiency.

Advantages of the ABC method: The activity-based costing (ABC) method provides a clear understanding of overhead, being useful in decisions such as outsourcing production, setting the minimum price, comparing the efficiency of production units, optimizing distribution channels, evaluating customer profitability, calculating profit margins, and reducing the costs of activities. Through detailed analysis, ABC helps identify profitable segments and allocate resources efficiently, improving cost management and strategic decision-making.

Limitations of the ABC method: Although valuable, the ABC method has drawbacks: data collection can be expensive and requires automation, fixed costs are sometimes treated as variables, which can distort the results, certain expenses (e.g. the di-rector's salary) are difficult to allocate, and the implementation of an automated ABC system involves significant investments. These limitations must be carefully managed to ensure the accuracy and usefulness of the analysis.

2.2 Machine Hour Rate (MHR)

It was technological advances that led to the introduction of the MHR (Machine hour rate) method, an approach designed to overcome the limitations of the direct costing method. In contrast, MHR manages to meet several essential needs: it distributes indirect expenses efficiently towards the costs of products, work or services, monitors the optimal use of production capacities and directs the attention of technical, economic and managerial staff to the areas where machines, which have become central pieces of management accounting, generate expenses. At the same time, the method encourages a rational and well-thought-out use of labor.

Essentially, MHR places the machines or groups of machines, known as pro-duction centers, at the center of the costing process, these are the places where expenses occur. To put this method into practice, it is necessary to establish three main indicators: the hourly cost of the machine, called M.H.R., the operating time and the expenses with materials related to each product unit. Through this structure, the method provides a clear and well-organized perspective on cost management [11].

Calculating the hourly rate of a car involves several steps: the overhead of the factory is allocated to the production departments, then allocated to the machines, considered cost centers. Specific expenses (depreciation, energy) are attributed directly to the machine, and the actual working hours are estimated, deducting non-productive times (cleaning, heating). The total overhead is divided by the actual hours to obtain the hourly rate. For a full tariff, direct salaries and spare equipment costs are included. General

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expenses are divided into fixed (rents, taxes, lighting) and variable (depreciation, repairs, energy, water), the latter depending on the use of the car.

Depreciation is calculated based on the initial cost of the machine (including transportation and installation), and repairs and energy are considered variable expenses, adjusted for working hours. The final tariff results from the sum of fixed and variable hourly expenses [14-15].

Advantages of the MHR method: The Machine Hour Rate method based on the hourly rate of the machines has multiple benefits. This proves to be an accurate, practical and scientifically grounded approach, ideal for industries where machines play a central role in the production process. By considering the time factor, the method ensures accurate results and provides valuable information for estimating the costs of a project, setting production standards and determining sales prices. It also supports management in assessing the advantages of using machines over manual labor and allows differentiation between the contribution of skilled and unskilled labor to indirect costs.

In addition, it facilitates analysis of the efficiency and running costs of different machines, highlighting possible downtime through distinct hourly rates for fixed and variable expenses. Indirect cost ratios through this method are reliable, providing management with a solid basis for strategic decisions, especially in mechanized pro-duction contexts.

Disadvantages of MHR methods: The Machine Hour Rate method based on the hourly rate of cars has certain limitations. Its application involves an additional effort to monitor the operating time of the machines, which makes it an expensive solution. It also does not consider costs that do not directly depend on the operating time of the machines, which can lead to imprecise results, especially in situations where manual work plays a significant role.

Estimating machine working hours becomes challenging, especially without a pro-duction schedule set in advance. Therefore, this method proves to be inappropriate in contexts dominated by manual activity.

III.CASE STUDY- THE COST OF PUBLISHING AN ARTICLE

Any research initiative initiated to publish a scientific article inevitably involves the assumption of costs, an aspect well known by any researcher. Research and publication activities generate both visible and less obvious costs, the quantification of which may vary depending on the method used. Thus, the question arises: how can the total cost of a published research paper be accurately assessed?

The literature offers a variety of cost calculation methods, but the present paper aims to analyze two of them comparatively: the activity-based method (ABC) and the Machine Hour Rate (MHR) method. Both methods will be applied to estimate both the direct and indirect costs associated with the process of writing, reviewing and publishing a scientific article. The main objective of this comparative analysis is to high-light the differences in the allocation of financial and hu-man resources between the two methods, thus contributing to a clearer and more substantiated understanding of the effectiveness of each approach.

The paper involves applied experiments with a CNC machine, as part of research intended for publication in an open access scientific journal. This option involves significant costs: publication fee, experimental materials (e.g. steel block), indirect resources and the time of the staff involved in the whole process.

For a fair allocation of indirect costs, an average volume of five articles published annually is considered, allowing for proportional distribution of expenses. The research process, from the theoretical and experimental stages to writing and publication, requires a rigorous allocation of resources, essential for realistically estimating the total cost of a scientific publication.

3.1 Costs of publishing an article.

The costs associated with the production and publication of a scientific article can be classified into two main categories, depending on their nature and how they are allocated:

Direct costs - represent expenses that can be identified and directly attributed to specific scientific work. This category includes, for example, the publication fee imposed by the scientific journal, the consumable materials used in the experiments, as well as the costs associated with the operation of specialized equipment (e.g. CNC machines) involved in the research process.

Indirect costs - reflects the set of general expenses necessary to support the re-search activity, which cannot be directly associated with individual work. These include the working time of the staff involved (researchers, technicians, administrative staff), the depreciation of support equipment (e.g. office equipment, IT infrastructure), as well as the costs related to access to scientific databases or documentation platforms. In Table 1 are the annual indirect costs that support the research activity and are distributed among 5 articles.

Table 1. Types and amount of indirect costs.

No	Cost Type	Description	Value
1	Author's own time	Estimated value of personal time (€1/hour for 800 hours/year)	800 €
2	Equipment (Laptop, Printer)	Annual depreciation of office equipment.	300 €
3	Scientific database subscriptions	Annual cost of access to journals and databases	250 €
4	Utilities (Electricity, Internet)	Annual office bills	230 €
		TOTAL	**1580 €**

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Table 2. Types and amount of indirect costs.

No	Cost Type	Description	Value
1	Publication Fee	Payment to the open access journal for the publication of the article	500 €
2	Specialized Software	The annual cost of a CAD/CAM software license (€250/year) is divided into 5 items per year.	50 €
3	Consumable Material (Office)	Paper and ink for printing article sketches	15 €
4	Tools CNC	Roughing and finishing cutters used in experiments, which wear out completely for this article	160 €
5	Semi-finished (Steel Block)	The raw material processed on CNC.	25 €
6	Usage: CNC Machine (Including Power)	Cost of Using CNC Machine for 20 Hours	40 € /h
7	Transport to the Workshop CNC	Trips to the workshop where the CNC machine is located	30 €

3.2 Cost Calculation by MHR Method

The MHR method allocates indirect costs based on the time of use of a main re-source involved in the research activity – in this case, the laptop, considered an essential tool both for conducting research activities and for writing scientific material.

In this approach, the laptop is treated as a machine tool, being evaluated according to the total number of hours of annual operation, estimated at 600 hours. They represent 75% of the actual working time allocated by the author to scientific activities. Assuming that five articles are written and published over the course of a year, it follows that a single article corresponds to a volume of 120 hours of laptop operation.

Under the MHR method, direct costs are specifically attributed to the use of the numerically controlled machine tool (CNC), which is considered the main operational resource involved in carrying out experimental activities. The other categories of costs, which do not vary according to the direct use of re-sources through the hourly rate, are treated as fixed costs and are subsequently added to the calculation of the direct expenses associated with the preparation and publication of the scientific paper.

Direct cost calculation:

$$\text{MHR cost direct} = (\text{MHR} \cdot t) + \text{Chm} \quad (1)$$

$$\text{MHR cost direct} = (40 \cdot 20) + 25 = 825\ €/\text{article} \quad (2)$$

$$\text{MHR cost direct total} = \text{MHR cost direct} + \text{Fixed direct costs} \quad (3)$$

$$\text{MHR cost direct total} = 825+770 = 1595\ €/\text{article} \quad (4)$$

Indirect cost calculation:

$$\text{MHR cost indirect} = (\text{Cost indirect total})/(\text{Total hours laptop}) \quad (5)$$

$$\text{MHR cost indirect} = 1580/600 = 2{,}63\ €/h \quad (6)$$

$$\text{MHR cost indirect/article} = 120\ h \cdot 2{,}63\ €/h = 316\ € \quad (6)$$

$$\text{MHR total} = \text{MHR cost direct} + \text{Cost indirect} \quad 7)$$

$$\textbf{MHR total} = 1595+316 = 1911\ € / \text{article} \quad 8)$$

3.3 Calculation of the Cost by the Activity-Based Costing Method

The Activity-Based Costing (ABC) method involves allocating indirect expenses according to the specific activities that generate these costs, providing a more precise approach compared to traditional methods. Direct expenditure is directly attributed to each product, while indirect expenditure is distributed among five items, based on a clearly defined set of activities. These indirect expenditures are organized into four main categories of activities, each category being allocated with a specific proportion of the total indirect expenditure, depending on its contribution to the production process. This methodology facilitates a better understanding of costs and supports informed managerial decision-making.

To allocate indirect expenses to items, we choose cost factors for each activity. Since no detailed data is provided on the specific consumption of each item (e.g. different working hours per item), we assume that all 5 items consume indirect resources equally.

Table 3. Identifying activities and allocating expenses.

Activity	Description	Value
Research and writing	The author's own time for writing the article	800 €
Technical Support	Use and depreciation of equipment (laptop, printer)	300 €
Access to resources	Subscriptions to scientific databases for documenta	250 €
Office Operation	Utilities (electricity, internet) for office operation	230 €
	TOTAL	**1580 €**

Table 4. Indirect expense calculation per item.

Activity	Value
Research and writing	160 €
Technical Support	60 €
Access to resources	50 €
Office Operation	46 €
Total	**316 €**

The total cost per item is determined by summing the direct cost with the indirect cost.

$$\text{ABC total} = \text{ABC cost direct} + \text{ABC cost indirect} \quad (9)$$

$$\textbf{ABC total} = 1595+316 = 1911\ € / \text{article} \quad (10)$$

3.4 Comparative Assessment of the Approach

With regard to the MHR method, the approach in which the laptop is treated as the main resource and the indirect costs are allocated in proportion to its estimated time of use of 600 hours per year, i.e. 120 hours for each item, seems to be an atypical approach, given that the MHR is usually applied to production

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equipment, such as CNC machines, in this case the justification is plausible: the laptop is an essential tool in research and writing. However, the method has an important limitation: it does not consider differences in the intensity of various activities, such as the fact that drafting can take more time than researching. Uniform cost allocation, based on laptop usage time, simplifies reality more than would be advisable.

On the other hand, the ABC method provides a more detailed and appropriate approach to the allocation of indirect costs. It identifies specific activities, such as re-search and drafting, technical support, access to resources or administrative activities, and associates' costs to them according to the actual consumption of resources. However, the assumption that indirect resources are consumed equally for the five items is an oversimplification. In practice, the ABC method should be based on more specific cost factors, such as the hours of work dedicated to each individual activity for each item. A clear advantage of this method is the high degree of detail, which allows for a deeper understanding of how each activity contributes to the total cost.

The key differences between MHR and ABC are reflected in the way indirect costs are allocated. The MHR method uses a simplified calculation, based on the hours of use of the laptop (€2.63/h), without distinguishing between the types of activities. In contrast, the ABC method distributes these costs according to concrete activities, such as €160 allocated to research and writing, which provides a clearer picture of the contribution of each stage of the process.

At the level of detail, MHR is less granular, making it easier to apply in da-ta-limited situations. ABC, however, offers a more complex and accurate approach, requiring a detailed analysis of each activity and the resources consumed. Interestingly, in this case, both methods arrive at the same total cost of €1911 per item, a result made possible by the simplifying assumption that resources are distributed equally among the five items.

In terms of aspects that can be improved, in the case of the MHR method, the use of the laptop as the main resource for allocating indirect costs is less conventional. A more representative alternative could be the use of the researcher's total working time or a combination of several resources.

For the ABC method, the lack of detailed data on specific consumption per item limits accuracy. If, for example, an article involves several hours of documentation, then the cost of database access should be adjusted accordingly. In addition, both methods would benefit from an analysis of seasonal variations or differences between items, some works may be more complex and consume more resources than others.

Speaking of advantages and disadvantages, the MHR method has the advantage of being easy to apply, especially in contexts where there is a dominant resource. It also does not require the collection of large volumes of data. On the other hand, it ignores the differences between activities and can lead to a less precise allocation of costs in complex processes, such as scientific research.

The ABC method, on the other hand, allows for a detailed and realistic allocation of costs per task, which makes it easier to identify areas that can be optimized. It is more suitable in contexts where processes are diversified, and re-source consumption varies significantly. However, it requires detailed data and can be costly and time-consuming to implement.

IV. DISCUSSION

Convergence of results between MHR and ABC methods.

Both the Machine Hour Rate (MHR) method and the Activity-Based Costing (ABC) method led to the same total cost of €1,911 per item in the analyzed scenario. This uniformity of results is explained by a simplifying assumption, according to which indirect costs are divided equally between the five items, without reflecting the real differences in resource consumption.

Differences in approach in cost allocation.

The MHR method involves a proportional allocation of indirect costs according to the time of use of a single resource – the laptop. Thus, the 600 hours of annual operation translates into 120 hours per item, at a cost of €2.63/hour. This approach is reductive, as it places the laptop as a central resource, which is less realistic in the context of scientific research, where human resources, specialized equipment or access to databases usually have a more significant impact on costs.

In contrast, the ABC method provides a more nuanced picture, by assigning costs according to specific activities carried out in the drafting and publishing process (e.g., research, writing, technical support, access to resources, administrative activities). The costs are distributed based on the actual consumption of resources, which allows a more accurate estimate of reality – for example, €160 is allocated only for research and writing activities.

Recommendations for optimizing methods.

For the MHR method, it is recommended to reconsider the reference resource: re-placing the laptop with the researcher's total working time or with a composite model that includes more resources would allow for a more representative allocation of costs.

In the case of the ABC method, an improvement would be to introduce more precise cost factors, such as the number of hours worked for each activity associated with an item, and to adjust costs according to the complexity of each material (e.g. extensive documentation or frequent access to databases).

For both methods, it is recommended to consider sectional variations or differences between articles, as

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some works may require significantly more resources than others.

Considerations on the relevance and applicability of the methods.

The ABC method is more suitable for the field of scientific research due to its high level of detail and the ability to allocate costs according to specific activities, thus facilitating better management of resources. Although the MHR method is simpler and faster to apply, it provides a less accurate picture, being limited by the fact that it is based on a single resource and does not capture variations between process steps. For a more realistic cost estimate, both methods should be supported by detailed data on the actual consumption of resources per item. However, in complex contexts such as the publication of scientific articles, the ABC method remains the preferable option.

V. CONCLUSIONS

Based on the case study, both costing methods, MHR and ABC, are correctly applied and arrive at the same total cost of €1911/item, due to the equal distribution of indirect costs between the five items. However, the ABC method is more suitable for scientific research, as it allocates indirect costs to specific activities, providing a detailed picture and allowing for the optimization of resources. The MHR method, although simpler, is less accurate, relying on a single resource (the laptop) and ignoring variations between activities. For more realistic results, both methods would benefit from detailed data on the specific consumption of each article, but ABC remains preferable for complex processes such as publishing a scientific article.

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