Nanotechnology Practices and Cost Restructure for Effective Cost Management under Industry 4.0 Based Manufacturing Systems

Ahmed Maher Mohammad Ali, Sahar Mahede Jabir, Ameer Ageed Kadhim, Akeel Almagtome

Faculty of administration and Economics, University of Kufa, Najaf, Iraq

***Abstract*– This study offers a theoretical foundation for how nanotechnology impacts most commodities and materials in many ways, given high-tech production processes that increase goods' functional, chemical, and physical qualities. This influenced the cost structure of production and strategic cost management's efforts to adjust for the change. The study employed descriptive-analytic methods to investigate nanotechnology's impact on cost management. The study was based on a comprehensive review of previous studies on nanotechnology and Industry 4.0. The results imply strategic cost management as a vital management and accounting strategy for reallocating indirect costs based on specifications to produce items that meet consumer needs. With rising fixed costs, this study links nanotechnology and cost structure. Strategic cost management techniques minimize costs while preserving product quality, enabling organizations to stay competitive.**

Keywords **- industry 4.0, nanotechnology, cost restructure, cost management, strategic costing.**

DOI: 10.18421/TEM113-26
https://doi.org/10.18421/TEM113-26

Corresponding author: Akeel Almagtome,
The University of Kufa, Najaf County, Iraq.
Email: akeelh.alhasnawi@uokufa.edu.iq

Received: 20 March 2022.
Revised: 28 July 2022.
Accepted: 02 August 2022.
Published: 29 August 2022.

1. Introduction

Regarding atom slicing and energy generation, the world is undergoing technical improvement and progress beyond the perception and understanding of nuclear knowledge and science.

Nanotechnology offers a variety of uses in the food business and dramatically aids in the characterization, production, and manipulation of nanostructures. The nanostructures increase the solubility of dietary constituents in vivo and their bioavailability and targeted release. In addition, these nanostructures act as anti-caking agents, nano-additives, and nutraceutical delivery systems. The current paper discusses the many types of nanoengineered structures used in food nanotechnology to tailor the properties and uses of traditional food components. A literature review revealed several applications of various nanostructures in the food sector [1].

New technology has enabled the fragmentation of atoms into sizes smaller than one nanometer, allowing the introduction of various physical and chemical properties to materials to achieve rigidity, coagulation, and sustainability. We are now witnessing the fourth generation of technological advancements. The nanoscale is measured in size units, with one nanoscale equaling a fraction of a billionth of a meter square [2]. A nanometer is a unit of measurement equal to one billionth of a meter in length.

Micro- and nanotechnology are terms used to study the underlying principles and constituents of compounds and molecules with diameters ranging from one nanometer to one hundred nanometers [3]. Aiming to redesign and manufacture measuring tools from a collection of basic atoms of the material in a specific order, nanoscience applications in any field, whether physical, chemical, or biological, aim to produce particles for various other materials with

new properties that can be used for a specific purpose or lead to the development of new inventions [4].

Nanotechnology allows the control of atomic depth, with the possibility for fragmentation ten times the nuclear unit of measurement known as an angstrom, which is being possible with the technology [5]. The physical structure and chemical concentration of raw materials used to produce nanoscale-sized materials impact the characteristics of developing nanomaterials. Since materials formed from a collection of grains have a composition containing millions of atoms, this phenomenon does not occur during the manufacturing of conventional materials [6]. Depending on their size, these grains may or may not be visible to the naked eye, but they may be viewed under a microscope. Nanomaterials have distinct features because they are minimal and comprise just a few atoms. Various sources of nanomaterials in the environment, including ultraviolet radiation and gases produced by volcanoes, contribute to their presence [7]. Water contains nanometric sulfide, hydro-iron, and manganese oxide, all toxic. Naturally occurring nanoparticles in soil may be traced back to iron hydrates, organic compounds, and biotic origins; however, non-natural sources include industrial gas emissions and atmospheric sediments [8].

It is possible to create engineered nanomaterials, which are the result of applying techniques and technologies aimed at the atomic re-engineering of materials to produce environmentally friendly materials that do not require the use of natural resources and do so at a low cost. For good results, all of the techniques used are on the same atomic scale (atom by atom), and the nanomaterials are formed in two top-down approaches, one for each type of atom. First, large-scale materials have to be fragmented to access microscopic molecules [9]. The production of microparticles with fixed properties at the atomic level is straightforward: cutting enormous stone blocks into pottery and marmalade is one example of how to do it. The second method is to start from the bottom up [10]. This technology condenses large amounts of atoms or molecules to produce complex nanomaterials with pre-programmed physical properties. In acquiring oxides and metals, this second process, which is more advanced than the first, is critical, such as in the case of steam deposition and plasma deposition [11]. Even though nanotechnology offers a wide range of economically essential applications in many sectors, many governments worldwide are interested in using nanotechnology in the industry [12].

There is a lack of cost accounting studies in the realm of nanotechnology use in industry. As a result of nanotechnology, many cost accounting challenges will be exacerbated, resulting in the creation of particular accounting standards, procedures, and systems [13]. As a consequence of the outcomes of this study, it is hoped that more people will be aware of the role of nanotechnology in cost restructuring. It will make it possible to do more research into nanotechnology and to address numerous future nano-cost management issues. A primary focus of this research paper will be on multiple accounting challenges that have previously been highlighted or overlooked in studies, such as decreased unit costs and cost change structures that result in considerable fixed cost increases. The results of previous research could no longer predict what would happen if nanotechnology were utilized in the industry but did not present any apparent answers for the future. As a result of this groundbreaking research, the path will be cleared for future studies on new cost accounting difficulties associated with nanotechnology. The first section to be covered was the front portion. The part that follows is a review of the literature.

2. Literature Review

2.1. The Nanotechnology and Industry 4.0 Manufacturing Systems

Various sectors, including industrial, agricultural, medical, engineering, hydro, chemical, energy, construction, and electronics, are expected to benefit from nanotechnology. Therefore, nanotechnology is expected to play a critical role in various industries in the future [14].

The application of nanotechnology in manufacturing most goods and materials will benefit the consumer, including greater efficiency, higher rigidity and strength, and improved material softness. According to experts and practitioners, Nanotechnology will usher in a worldwide industrial revolution that will affect all industries simultaneously [15]. In the industrial sector, nanomaterials have aided in the discovery and development of a wide range of products, resulting in the opening of new markets for high-quality and low-cost goods, as well as contributing to the recovery of the economy and social well-being by addressing concerns about environmental sustainability [16]. Nanotechnology has significantly influenced the modification of physical and chemical characteristics over the years. Nanomaterials can also considerably improve the nutritional content of some foods by substantially increasing their surface area. Some individuals use them as food additives or taste enhancers, and others use them in cosmetics. In packaging, nanomaterials such as titanium dioxide are combined with other materials to create a more durable package [17]. Specifically, in the realm of the environment, nanomaterials have been

discovered to have the potential to improve the environment by removing pollutants through the operation of a vast surface area, making them a prominent participant in the disposal of contaminants, whether they are found in the air, the soil, or the water [18]. Examples of medical applications include nanotechnology in cancer treatment and the development of antidotes. A team of researchers from the University of Maryland has discovered nanoscale gold molecules that can be used to treat cancer tumors on the body's surface [10]. There are now active initiatives to employ nanotechnology to provide access to effective COVID-19 medications [19]. Numerous experimental investigations carried out in the field by practitioners, such as the forecast that nanotechnology would lead to a rapid improvement in the manufacturing process, expect that the unit cost will be reduced due to more efficient input utilization. Many things, such as file copying, are predicted to be produced quickly and inexpensively in the future [20]. However, this is expected to change in the future since nano-goods may be produced at a cheap cost in the future. Nanotechnology has an impact on the whole value chain. Products will be made at a competitive price while keeping high-quality standards. Nanoparticles will save various expenses under standard technology by cutting direct labor costs while eliminating distribution, shipping, storage, and other associated expenditures [21].

2.2. Nanotechnology and Cost Restructure

The traditional costing approach has been questioned for most of the twentieth century. It became increasingly difficult to calculate the cost of the correct product or assist managers in proper planning or decision-making after this system experienced a significant increase in technical production [22]. This was due to insufficient drivers of allocating overhead costs for products or services, resulting in errors in calculating product costs. At this point, managers and academics began investigating how to resolve these issues through a more dependable and proper implementation [23]. As a result of the findings of the studies, many researchers believe that strategic input techniques for cost management are the most innovative cost accounting and management techniques developed in the twentieth century, as well as being more reliable and accurate than the traditional cost system. Kaplan and Anderson state that most management and cost techniques (ABC, ABM, ABB, TDABC, BSC, PLCC, RCA, ABCI II, CI, TQM, JIT, VE, VA, CE, PRE, TC, BM, TOC, VCA, RE, and CPA) are meant to cut costs in different ways when sales expand. Using cost methods to distribute indirect expenditures and calculate profit is a more effective method of doing business. It is ideal for various tasks such as making decisions, evaluating product prices and pricing, enhancing customer profitability, and improving financial results [24]. Reducing the need for raw materials while simultaneously cutting production and storage costs, enhancing product quality, and boosting product sustainability through nanoscale applications is possible. Several difficulties and dangers involved with accounting for nanoscale things outweigh these advantages. To generate goods, a process necessitates three essential components: resources, labor, and indirect industrial expenditures. These expenditures are classified according to a set of linkages. Consequently, the impact of nanotechnology on traditional materials differs significantly from the impact of nanotechnology processing, in part because the approach reduces the size of material atoms to a fraction of their original size (1-100 nm) rather than a fraction of their original size (1-100 nm) [2]. According to Ali and Jabir's findings, nanomaterials cost management may be done throughout the procurement process [25]. On the contrary, it is possible to profit from nanoparticles throughout the whole life cycle of a product. The acquisition of nanomaterials is expensive, yet nanoparticles result in a large reduction in manufacturing costs, notwithstanding the high acquisition cost. Removing all non-host operations and resources means real cost savings, resulting in zero losses and damage to enhanced production volume and greater sales volume and selling price [6]. As a result of the cognitive evolution of nanotechnology, the cost structure has been influenced. The vast majority of production costs are indirect industrial costs, necessitating a clear and rapid response by cost accounting to reclassification and new allocation bases to determine the true cost of nanotechnology is a fictional character created by the author. The use of nanotechnology influences salaries. Since the resources are subject to pre-agreed-upon criteria and quality in the buying process, the researchers discovered that wages for turning conventional materials into nanoparticles within the company are direct wages [23]. This is because materials are disassembled and reassembled based on the quality requirements of the product, and as a result, they are a step in the manufacturing process. Because of advancements in nanotechnology, indirect costs in commodities have become significantly higher, necessitating methodologies and philosophies aimed at reallocating indirect industrial costs in light of technological innovation. The ABC system has been applied to nanotechnology method products, and only one study examined the allocation of a fixed or

indirect cost to a unit of product under the ABC system [26]. However, higher costs and time are expected when applying this technique to nanotechnology products, and there has been no study of the cost system to be used in the new nanotechnology manufacturing environment [27]. Therefore, in our research, we will place a strong emphasis on the issue of the customer's expenses and specifications. Researchers such as Walmsley et al. [7] argue that cost allocation is critical because it aids in the valuation and assessment of inventory for external reporting purposes, planning, and monitoring of the cost of activities and processes, as well as the formulation of several different strategic decisions. Companies have to adopt a new system, particularly when the use of technical data has resulted in a move away from direct labor and toward machine labor. As a result, objects have to bear additional indirect expenses that are not directly related to the item. It is possible to determine the unit cost of a product using two cost allocation methods, the Activity Based Costing System and the Attributes-Based Costing System, respectively. The following is a brief overview of each system.

2.2.1. ABC under Industry 4.0 Applications

Several concepts such as Industry 4.0, activity-based costing, and environmental concerns are discussed in contemporary accounting literature to increase the efficiency of manufacturing cost management. They consider ecological issues such as carbon emissions, energy recycling, and waste reuse and employ a mathematical programming model that incorporates Activity-Based Costing (ABC) and the Theory of Constraints (TOC) to achieve profit maximization while also minimizing environmental impacts. Using the old costing technique was suitable when direct labor was in high demand throughout a manufacturing process [28]. Traditional costing approaches are most effective for managing variable costs but ineffective for reducing indirect costs. Many criticisms of the conventional costing approach have been raised against it since the 1980s. However, not all of them are valid. In a standard costing system, allocating indirect costs to products or services is divided into two parts. In the first stage, indirect costs are assigned initially to cost centers, and in the second stage, indirect cost centers are assigned to command objects [29]. Traditionally, the traditional costing technique depends on insufficient single volume measurements of cost drivers to attribute costs to objects or services (such as machine hours or direct labor costs). Early in the twentieth century, an improved technique for allocating indirect costs and evaluating product profitability, known as the activity-based cost system, was proposed as being consistent with technological advancement and the automation of production lines. This new technique was adopted by the United States Government [30]. Many researchers believed that ABC was more dependable and accurate and would produce objective reports suitable for operational and strategic decision-making [31]. The ABC allocates indirect costs in two steps: first, it identifies costs for activities, and then it allocates costs for products based on their utilization of activities. After placing costs for activities, the ABC gives costs for products based on the product's utilization of activities. The product consumes activities that require the consumption of resources.

On the other hand, previous research verifies the contrasts between ABC and the traditional cost regime in terms of the allocation rules used to divide costs by cost element in the second phase and the number of allocation rules used to split costs by cost element. Furthermore, the TCS and ABC allocation systems do not meet the nano companies' current needs because the indirect cost rate is expected to rise. As a result, these companies will be confronted with the problem of future cost allocation and the need for accurate product cost information to help them assess the profitability of their product in light of the competitive position and specifications specified by the customer.

2.2.2. Attributes-Based Costing System

As stated by de Souza, et al. [32], the attributes-based cost technique corresponds to current technological developments as an appropriate tool for allocating indirect costs with two primary objectives: first, to obtain relevant information on the cost of products and services; and second, to get accurate product costs measures within strategic cost management that are focused on the needs and requirements of the customer. Using ABC11, one can identify indirect expenses in three simple steps. First, they list the fundamental qualities of all commodities, followed by the distinguishing traits that distinguish their products from other competing things, and lastly, the catalytic parameters that prompt the customer to seek the product. Second, value-adding activities are defined by the degrees to which each product characteristic is attained to eliminate non-value-adding activities. Then, products based on utilizing value-adding activities are determined [33]. Third, the development requires actions and characteristics, both of which entail using resources. Finally, customers' requests are combined with optimal resource usage. According to Hong et al. [34], the attributes-based cost method helps to reduce expenses and increase revenues. It has been reported that the ABC11 system allows

indirect costs to be distributed depending on each product feature, which supports management in decision-making, notably in choosing price and market share and improving the product quality. We discovered that nano-businesses should begin employing strategic input technologies for cost management rather than standard costing methods because the indirect cost rate is expected to increase. Conventional costing methods will provide difficulties for these businesses in allocating future costs, mainly if their enterprises generate more than one product line.

3. Data and Method

This study makes use of reviews of the literature. Taking the technique of theoretical analysis and theorizing about educational material. Theoretical books are vital resources for researchers to assess and develop new information. Specifically, this study highlights the importance of literary audits in strategic cost management and nanotechnology and searching for relevant publications using keywords such as "nanotechnology and cost structure" to find relevant studies. The study results reveal a total number of articles published in scholarly journals. However, the author's theory, which is supported by and summarizes his preliminary findings, presents. Specifically, this research aims to uncover previously undiscovered linkages between cost accounting and nanotechnology problems that have been neglected in previous research.

4. Results

Nanotechnology has an impact on cost restructuring and production process procedures, and this has been brought to the public's attention through the evaluation and review of various literary works on its application in the industry that have been published in journals up to the year 2022, as well as the creation of awareness about this influence. As a result of this research, it has been determined that nanotechnology impacts product cost restructuring. The findings indicate that it does so by altering sections of the manufacturing costs, among other things. Products will be more affordable, and shipping and storage expenses will be less expensive due to nanotechnology, while product quality will be increased. According to the findings, a relationship exists between the application of nanotechnology and cost restructuring. Nanotechnology allows the prediction of material functionality in advance and their mechanics and biology, robustness, and rigidity. This could be interpreted as increasing the fixed cost due to the requirement for an industrial cost allocation basis, which could be construed as increasing the fixed cost. In a thorough analysis of the literature, we realized that there had been no study on strategic input strategies for cost management, which would have given us the ability to allocate indirect costs to product units manufactured by nanotechnology. As a result of this investigation, the general public became more aware of the situation. To further cut costs as rapidly as can, we highly advise nanowires to start adopting strategic input technologies for cost control rather than standard costing approaches. Under the study's findings, nanotechnology is connected with significant financial difficulties for organizations and people alike. A distortion of product costs and a rise in indirect expenses emerge, leading to erroneous pricing decisions and a decline in the company's competitiveness over time.

5. Conclusions and Discussion

As a result of incorporating nanotechnology into the production process, a new industrial revolution is on the horizon. Nanoscale products increase the functional, chemical, and physical features of materials, such as better electrical conductivity and magnetic reluctance, while also boosting the mechanical properties of materials, such as strength and stiffness, and the biological properties of materials. In addition, nanotechnology influences the pricing structure of things since it allows reformulation. While traditional or strategic input in cost measurement has to be strictly allocated to the unit of product, the rate of indirect costs will be extremely high; any error in product cost calculation will result in incorrect pricing decisions, thereby reducing the competitiveness of the entire industry unit of the economy. As seen in Figure (1), it is predicted that most management practices and expenses will result in cost reductions as revenue increases.

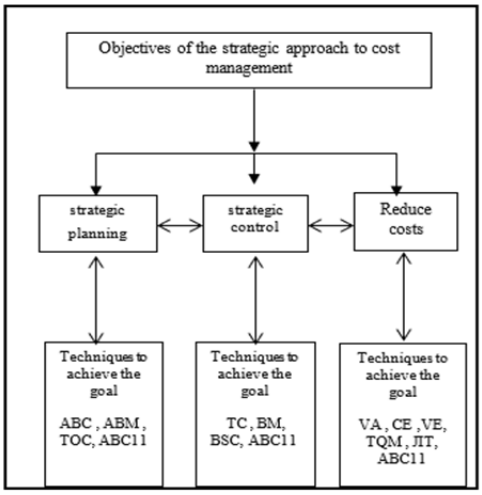

Figure1. The objective of Strategic cost management techniques

On the other hand, nanotechnology will cut production costs while simultaneously enhancing product quality. Because of this, the outcomes of this study indicated a relationship between nanotechnology and cost structure by raising the fixed costs that have to be more precisely allocated. This study centered on adjusting the cost structure and solution expected from strategic cost management to assign indirect costs associated with the deployment of nanotechnology, which gives much more advantages than the usual entry point into the field of science. To remain competitive, strategic cost management techniques have to be used to manage and reduce costs without compromising product quality. Companies can achieve this by focusing on costs and management techniques for cost reduction rather than cost containment, continuously improving the cost structure and adding value to it, and focusing on the customer.

References

[1]. Ali, A. M. M., & Jabir, S. M. (2022). Using Attribute-Based Costing and Theory of Constraints for Product-Mix Decisions: An Empirical Study in Iraq. *Journal of Management Information & Decision Sciences*, *25*.

[2]. Alvarez, T., Sensini, L., Bello, C., & Vazquez, M. (2021). Management accounting practices and performance of SMEs in the Hotel industry: Evidence from an emerging economy. *International Journal of Business and Social Science*, *12*(2), 24-35.

[3]. Amusawi, E. G., Almagtome, A. H., & Shaker, A. S. (2019). Impact of lean accounting information on the financial performance of the healthcare institutions: A case study. *Journal of Engineering and Applied Sciences*, *14*(2), 589-399.

[4]. Anderson, D. M., & Whitford, A. (2021). *Integrating Logics in the Governance of Emerging Technologies: The Case of Nanotechnology*. Cambridge University Press.

[5]. Cescon, F., Costantini, A., & Grassetti, L. (2019). Strategic choices and strategic management accounting in large manufacturing firms. *Journal of Management and Governance*, *23*(3), 605-636.

[6]. Chaudhary, V., Royal, A., Chavali, M., & Yadav, S. K. (2021). Advancements in research and development to combat COVID-19 using nanotechnology. *Nanotechnology for Environmental Engineering*, *6*(1), 1-15.

[7]. Wegmann, G. (2008). The activity-based costing method: development and applications. *The IUP Journal of Accounting Research and Audit Practices*, *8*(1), 7-22.

[8]. Ebrahimi, S. A., Azar, A., Safari, H., & Jafarnejad, A. (2021). Supply chain orders management based on both traditional and activity-based costing and their comparison. *Management Research in Iran*, *18*(4), 23-42.

[9]. Guo, W., Wang, Z., Wang, X., & Wu, Y. (2021). General Design Concept for Single-Atom Catalysts toward Heterogeneous Catalysis. *Advanced Materials*, *33*(34), 2004287.

[10]. Hamza, E. K., & Jaafar, S. N. (2022). Nanotechnology Application for Wireless Communication System. In *Nanotechnology for Electronic Applications* (pp. 115-130). Springer, Singapore.

[11]. Hong, J., Xue, K., Gai, N., Wei, D. S., & Hong, P. (2018). Service outsourcing in F2C architecture with attribute-based anonymous access control and bounded service number. *IEEE Transactions on Dependable and Secure Computing*, *17*(5), 1051-1062.

[12]. Kbelah, S. I., Amusawi, E. G., & Almagtome, A. H. (2019). Using resource consumption accounting for improving the competitive advantage in textile industry. *Journal of Engineering and Applied Sciences*, *14*(2), 575-382.

[13]. Konur, O. (2021). Nanotechnology Applications in Diesel Fuels and Related Research Fields: A Review of the Research. *Biodiesel Fuels*, 89-110.

[14]. Krimmer, R., Duenas-Cid, D., & Krivonosova, I. (2021). New methodology for calculating cost-efficiency of different ways of voting: is internet voting cheaper?. *Public money & management*, *41*(1), 17-26.

[15]. Krishna, V. D., Wu, K., Su, D., Cheeran, M. C., Wang, J. P., & Perez, A. (2018). Nanotechnology: Review of concepts and potential application of sensing platforms in food safety. *Food microbiology*, *75*, 47-54.

[16]. Lauritano, D., Limongelli, L., Moreo, G., Favia, G., & Carinci, F. (2020). Nanomaterials for periodontal tissue engineering: chitosan-based scaffolds. a systematic review. *Nanomaterials*, *10*(4), 605.

[17]. Massicotte, S., & Henri, J. F. (2021). The use of management accounting information by boards of directors to oversee strategy implementation. *The British Accounting Review*, *53*(3), 100953.

[18]. Milane, L., & Amiji, M. (2021). Clinical approval of nanotechnology-based SARS-CoV-2 mRNA vaccines: impact on translational nanomedicine. *Drug delivery and translational research*, *11*(4), 1309-1315.

[19]. Muthukrishnan, L. (2021). Nanotechnology for cleaner leather production: a review. *Environmental Chemistry Letters*, *19*(3), 2527-2549.

[20]. Nachtmann, H., & Needy, K. L. (2003). Methods for handling uncertainty in activity based costing systems. *The Engineering Economist*, *48*(3), 259-282.

[21]. Omerović, N., Djisalov, M., Živojević, K., Mladenović, M., Vunduk, J., Milenković, I., ... & Vidić, J. (2021). Antimicrobial nanoparticles and biodegradable polymer composites for active food packaging applications. *Comprehensive Reviews in Food Science and Food Safety*, *20*(3), 2428-2454.

[22]. Ostaev, G. Y., Khosiev, B. N., Nekrasova, E. V., Frantsisko, O. Y., Markovina, E. V., & Kubatieva, L. M. (2019). Improving the methodology for assessing the efficiency of labor in organizations of the agroindustrial complex: strategic accounting and analysis. *Indo American Journal of Pharmaceutical Sciences*, *6*(5), 9114-9120.

[23]. Pittroff, E. (2021). The legitimacy of global accounting rules: a note on the challenges from path-dependence theory. *Journal of Management and Governance*, *25*(2), 379-396.

[24]. Rababah, A. (2017). Nanotechnology and accounting issues. *Risk Governance & Control: Financial Markets & Institutions, 7 (2, 1)*, 224-230.

[25]. Sahani, S., & Sharma, Y. C. (2021). Advancements in applications of nanotechnology in global food industry. *Food Chemistry*, *342*, 128318.

[26]. Sanchez, F., & Sobolev, K. (2010). Nanotechnology in concrete–a review. *Construction and building materials*, *24*(11), 2060-2071.

[27]. Shang, Y., Hasan, M. K., Ahammed, G. J., Li, M., Yin, H., & Zhou, J. (2019). Applications of nanotechnology in plant growth and crop protection: a review. *Molecules*, *24*(14), 2558.

[28]. Taherimehr, M., YousefniaPasha, H., Tabatabaeekoloor, R., & Pesaranhajiabbas, E. (2021). Trends and challenges of biopolymer-based nanocomposites in food packaging. *Comprehensive Reviews in Food Science and Food Safety*, *20*(6), 5321-5344.

[29]. Tharayil, A., Rajakumari, R., Chirayil, C. J., Thomas, S., & Kalarikkal, N. (2021). A short review on nanotechnology interventions against COVID-19. *Emergent Materials*, *4*(1), 131-141.

[30]. Velmurugan, M. S. (2010). The Success and Failure of Activity-Based Costing Systems. *Journal of Performance Management*, *23*(2).

[31]. Walmsley, G. G., McArdle, A., Tevlin, R., Momeni, A., Atashroo, D., Hu, M. S., ... & Wan, D. C. (2015). Nanotechnology in bone tissue engineering. *Nanomedicine: Nanotechnology, Biology and Medicine*, *11*(5), 1253-1263.

[32]. de Souza, C. A., Westphall, C. B., Machado, R. B., Sobral, J. B. M., & dos Santos Vieira, G. (2020). Hybrid approach to intrusion detection in fog-based IoT environments. *Computer Networks*, *180*, 107417.

[33]. Weller, A. (2022). *Environmental impact of noble metal radionuclides and their use in nuclear forensics* (Doctoral dissertation, Hannover: Institutionelles Repositorium der Leibniz Universität Hannover).

[34]. Yu, Y., Zhang, M., & Huo, B. (2021). The impact of relational capital on green supply chain management and financial performance. *Production Planning & Control*, *32*(10), 861-874.