

Impact of Artificial Intelligence on Management Control Processes

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Abstract. Digital transformation has developed significantly in the 21st century, and special attention has been paid to it in business and society. It is becoming more relevant and presents the private and public sectors with new challenges. Computer and mobile devices, information, and communication technologies are actively used in social, economic, industrial, engineering, and other fields, to create and implement their respective new-generation software applications. New paradigms based on the software industry including the development, and creation of new methods and methodologies or perfecting the existing ones are receiving a lot of attention worldwide, on which artificial intelligence (AI) had a significant impact. Regarding the ongoing digital transformation of organizations and business models companies have been facing the challenge for years of digitalizing the processes in management control. These processes have been undergoing fundamental changes, driven by the rapid development of AI in recent years. In this context, one of the most innovative and significant technological breakthroughs was the development of generative AI. AI tool ChatGPT plays an important role in advancing scientific progress by promoting the use of artificial intelligence, improving user interaction and accelerating innovation in various industries. This paper explores how AI can increase the effectiveness and efficiency of decision-making and management control. Efficiency is achieved through strategic decisions and efficiency through operational decisions. By integrating AI technologies, organizations can automate repetitive tasks, streamline data processes, and improve financial reporting and forecasting accuracy. AI-based analytics provide managers with deeper insights that enable more informed decisions about resources, processes, products and services. In addition, the paper examines how AI has shifted organizational focus from operational efficiency to strategic priorities. This change has contributed to a more flexible and responsive management control framework that allows organizations to adapt quickly their control system to changing market conditions and maintain a competitive advantage. In addition, one of the most prominent fields today is nanomanufacturing and the optimization of production processes. Through AI-driven optimization, it becomes possible to refine the synthesis and assembly of nanostructures, significantly improving precision and efficiency in production.

1. Introduction

In the current era of digital transformation, characterized by exponential growth of big data, it remains a challenge for organizations to use sophisticated analytical methodologies and advanced AI algorithms to gain an edge in the competitive environment by improving management decisions.

It is worth noting that the COVID-19 pandemic has also precipitated profound global economic, social and technological transformations, significantly driven by the digitization of processes. In an era where approximately 15 zettabytes of information are generated monthly, traditional methods and technologies have proven inadequate for storing, processing, and analyzing such vast amounts of data.

Traditional data management methods and decision-making tools are becoming less effective, emphasizing the need for advanced AI-based solutions. This study explores the impact of three specific AI approaches on management control processes:

- **Predictive AI:** Prediction of future business developments based on historical data
- **Optimization AI:** Improving the quality of business data and increasing reporting speed
- **Generative AI:** Creation of various types of content, such as text, audio, imagery and synthetic data

These tools play a crucial role in improving decision-making, optimizing resources and processes and enhancing strategic planning within management control systems. The ability of AI to process large amounts of data, identify patterns, and create predictive models has revolutionized traditional management control concepts such as budgeting, management reporting, performance measurement, investment analysis, and risk management.

In today's ongoing business processes, the emergence of AI has brought revolutionary changes and has achieved significant results in almost all areas. AI has increased efficiency and productivity by automating repetitive and daily tasks, allowing managers to focus more on strategic and creative activities rather than on daily routines. Automating ongoing processes enables the rapid and error-free processes of various operations. It enhances innovations by providing new ways to solve complex problems, which makes it possible to create new products and services and strengthen existing ones. By the use of AI, companies can develop new business models, find the latest solutions for customer needs, and stay ahead of competitors.

In this paper, we will first explore how predictive AI can enhance planning capabilities and facilitates accurate financial forecasts; we also explore AI-based optimization for nanotechnology, focusing on improving nanostructure design, simplifying manufacturing processes, and improving accuracy and efficiency in applications. We then present the opportunities that optimization AI offers to improve investment decisions, cost simulations and risk management processes, thereby supporting business-partnering activities. In addition, we analyze the potentials of generative AI to automate complex data management and reporting tasks, optimize planning procedures and offer creative approaches to problem solving [1–6].

The schematic diagram below (Fig. 1) depicts the path of influence of AI on management control processes and outcomes and points to the potential challenges that need to be considered for the effective deployment of AI.

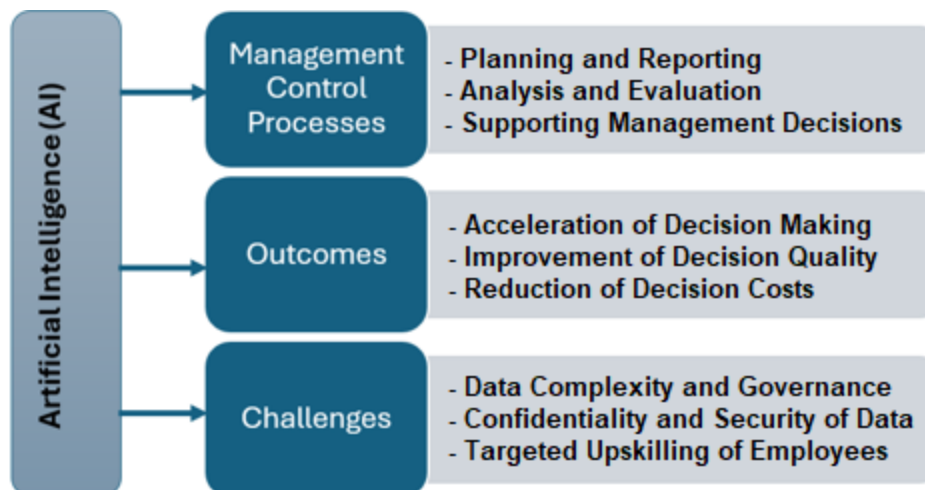


Fig. 1. Meaning and consequences of AI for management control processes.

To address these challenges and make the most of business data, AI has become a key solution. With its advanced ability to handle vast amounts of information, AI provides valuable insights and drives innovation across different industries. By adopting AI, companies can not only keep up with the digital transformation but also unlock new opportunities for growth and efficiency.

In this rapidly evolving landscape, the function of management control becomes increasingly vital. Management accountants and controllers integrate AI-based data analytics into the organizational framework, ensuring that strategic and operational goals are met. This function encompasses planning, analyzing and consulting activities, which are crucial for aligning AI-driven insights with business objectives. By coordinating planning processes, tracking performance, and addressing deviations promptly, controllers enhance decision-making processes, support strategic planning, and ultimately drive organizational success.

Through our research, we have identified the three AI types mentioned above and analyzed their validity on the management control processes to support managerial decisions.

One of the directions of our research is determining which approaches are best suited to optimize the specific management control processes. The major characteristics and application areas of each of the three types of AI are illustrated in the following overview (Fig. 2).

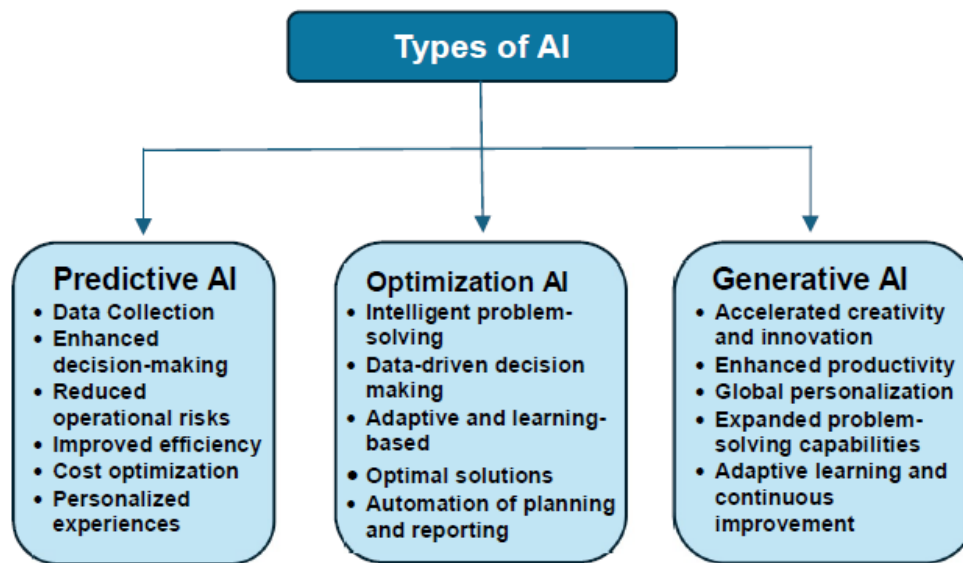


Fig. 2. Different types and applications of AI.

Predictive AI models are created based on historical data to forecast future events or unknown outcomes. These tools analyze existing data to find patterns and relationships that can be used to predict future data points. Advanced models apply machine learning algorithms and statistical models to help analyze historical data and make predictions about future events.

The working principle of predictive modelling is as follows:

1. Collection of data, e.g. historical volume data, previous quality and service information, time data, costs and revenues, geographic data, weather data, demographics and traffic data.
2. Data processing and cleaning, e.g. validation of data, identification and elimination of anomalies that may lead to distortion of forecasts.
3. Development and optimization of the algorithm.

Common approaches used in predictive AI include regression models, classification models, and time series models that analyze data collected or sequenced over time. The created model is then also evaluated, i.e. determining how close the predictions are to the actual values.

Optimization AI leverages smart data technologies to solve complex problems by finding the most effective solutions, whether it is cutting costs, time of service, or boosting efficiency. This process involves setting an objective, exploring potential solutions through advanced algorithms, and working within certain constraints. It is widely used in business and financial management to improve decision-making and streamline operations [7–13].

Our research also addresses the rather new technologies of **Generative AI**, which have a transformative impact on both scientific and business spheres. Generative AI has completely changed perceptions and views in scientific fields and social environments. At its core, it refers to AI models capable of creating new content, be it text, images, music, video compositions or code that closely mimics human-generated work. It generates texts, can write stories, or even engages in conversation.

Regarding management control processes generative AI can not only competently analyze data sets and make predictions, but also independently comment on business developments and deviations from targets and create proposals for actions.

In the dynamic world of communications, AI is revolutionizing the way businesses connect with their audiences by automating critical processes across multiple domains. Communication workflows are becoming more sophisticated through AI automation. Management accountants and controllers can now implement professional chatbots that seamlessly handle information requests and accurately reflect business developments in a predictable manner. These automated systems can trigger personalized notifications based on business developments, ensuring that acute management needs for action are not overlooked.

In addition, data analysis, which was once a time-consuming and complex task, is now simplified with AI-powered tools. Finance teams can now access real-time performance metrics, conduct business analysis, gather competitive intelligence, and create comprehensive reports with unprecedented speed and accuracy. The ability to track, measure, and optimize management decisions has never been more powerful.

Recommender engines can predict business developments, propose adaptive content strategies, and offer dynamic management measures to achieve specific business targets. These technologies help to ensure that management interactions are relevant, timely, and tailored.

2. Methodology

In this study, we used a literature review and case study methodology to examine the impact of AI on management control processes, specifically focusing on the application of these technologies to improve the effectiveness and efficiency of communication and decision-making.

Given the rapid development of AI tools and their significant influence on strategic business decisions and operational efficiency, we sought to understand these impacts through a detailed analysis of online articles and existing literature.

The research was conducted by reviewing a wide range of online articles, scientific papers, and industry reports published between 2019 and 2024. To ensure reliability, only peer-reviewed journals, reputable industry publications, and well-reviewed academic papers were included in the review.

The process involved searching major academic databases such as Google Scholar, Scopus, and Web of Science using keywords such as “Artificial Intelligence”, “Management Control”, “Decision Making”, “Predictive AI”, “Optimization AI”, and “Generative AI”.

The literature review methodology allowed us to collect a wide range of perspectives on the impact of AI on management control processes.

The papers were chosen to represent a variety of sectors, including general business management, finance and management control, to provide a comprehensive view of the use of AI in these areas.

3. Nature and Meaning of Management Control Processes

The function of management control, also known as “controlling” in German-speaking countries, is a fundamental management task in companies and organizations. It focuses on planning, analyzing, steering and providing business information to support decision-making and goal achievement. By integrating financial and non-financial data, management control provides transparency about the

business situation and development of the company and helps to optimize strategic and operational processes.

Management control activities include gathering, planning, and analyzing and interpreting business information for decision-making processes. These controlling activities play an important role in the coordination of different departments within the company. Thus, management control is a management function focusing on the improvement of operational processes and strategic decisions.

In order to carry out this task effectively and efficiently, various controlling activities are required, which can be structured and designed using the process model of the International Group of Controlling. According to this model, the following main processes of management control can be distinguished:

- Strategic planning
- Planning, budgeting and forecasting
- Investment controlling
- Cost accounting
- Management reporting
- Business partnering
- Project controlling
- Risk controlling
- Data management
- Enhancement (of organization, processes, instruments and systems)

The following explanations investigate whether and to what extent these processes can be optimized by applying different AI technologies. Therefore, specific use cases were developed to analyze how selected management control and decision-making processes can be designed effectively and efficiently with the help of predictive, optimization and generative AIs.

4. Application of AI for Management Control Processes

AI can be applied in different ways to improve management control activities and decision-making processes. In the following, we will first show how predictive AI can be used to create meaningful time and cost forecasts for a specific use case. We then examine the possibilities of optimization AI and generative AI to solve certain tasks of management control.

4.1. Application of predictive AI

The chosen application example is about predicting the duration and total cost of shipping 12,000 tons of cargo from China to Germany via Georgia, assuming a cost of \$250 per ton per day. Using a predictive AI tool, an attempt was made to estimate the required duration of transportation and the total cost of transporting the entire cargo. The following table shows the necessary steps and key components for preparing the forecast (Tab. 1).

Table 1. Steps and key components of creating the prediction model.

Steps and Components	Description
Data collection	Gathering historical shipment data, geographical data, weather data, traffic data, and customs data
Data processes	Cleaning and preparing the data by removing outliers, filling missing values, and normalizing the data
Feature engineering	Transforming raw data into meaningful features like distance, temporal features, and transportation specifics
Model training	Using machine learning models such as regression, classification, and time series models to learn from historical data
Model evaluation	Assessing model performance using metrics like accuracy, mean absolute error and root mean squared error
Prediction	Generating predictions for travel times, costs, and potential delays based on historical and real-time data
Continuous learning	Continuously retraining the models as new data becomes available to improve accuracy and adaptability
Example scenario	Describing the process of predicting transportation details for cargo from China to Germany via Georgia
Benefits	Highlighting the advantages such as increased accuracy, cost savings, improved efficiency, and risk mitigation

A Python program was created to forecast the estimated transport time and costs (Fig. 3). The model predicted a travel time of 16.94 days and total travel costs of \$50,820,000 for the distance of 11,000 km, assuming a transport speed of 800 km per day.

```

1 Define the given parameters
2 distance_km = 11000 # distance in kilometers
3 speed_km_per_day = 800 # speed in km per day
4 delay_days = 3 # additional delay in days
5 cost_per_ton_per_day = 250 # cost in dollars per ton per day
6 cargo_tons = 12000 # cargo in tons
7
8 # Calculate the predicted travel time (excluding delay)
9 predicted_travel_time_days = distance_km / speed_km_per_day
10
11 # Add the delay to the travel time
12 total_travel_time_days = predicted_travel_time_days + delay_days
13
14 # Calculate the total cost
15 total_cost = total_travel_time_days * cargo_tons *
    cost_per_ton_per_day
16
17 # Return the results
18 total_travel_time_days, total_cost

```

Fig. 3. Python model to predict duration and costs of sea cargo.

In result of the research, it can be stated that predictive AI is well suited for automating, optimizing planning, and cost accounting processes. In addition, the forecast values generated can be included in management reporting and improve risk controlling.

4.2. Application of optimization AI

To analyze the effectiveness of optimization AI, a specific decision situation was considered, in which the aim was to minimize the costs for a distribution network through an optimal choice of warehouse

locations. Regarding this use case, a logistics manager of a large e-commerce company operating in 5 major countries had to find the optimal warehouse layout to minimize overall costs and maintain a high level of customer service. The following initial parameters should be taken into account in the decision-making process:

- Package distribution in 5 major cities: A, B, C, D, and E
- Customer demand (packages per day) in each city: A (1000), B (1500), C (800), D (1200), E (500)
- A maximum of 3 warehouses can be built
- Fixed cost of building a warehouse: \$1,000,000
- Operating cost per package: \$2
- Transportation cost per package km: \$0.1
- Service level requirement: 90% of packages must be delivered within 1 day

The goal of using the optimization AI approach was to reduce the total costs (fixed costs + operating costs + transportation costs) as well as the service time. At the beginning, a distance matrix between cities was created that allowed multiple distances in km (Tab. 2):

Table 2. Distance matrix between cities.

	A	B	C	D	E
A	0	200	300	400	500
B	200	0	250	350	450
C	300	250	0	200	400
D	400	350	200	0	300
E	500	450	400	300	0

To solve the optimization problem the linear programming was chosen, which was implemented through Python (Fig. 4).

```

5
6 # Define cities and demands
7 cities = ['A', 'B', 'C', 'D', 'E']
8 demand = {'A': 1000, 'B': 1500, 'C': 800, 'D': 1200, 'E': 500}
9
10 # Define distances (in km)
11 distances = {
12     ('A', 'A'): 0, ('A', 'B'): 200, ('A', 'C'): 300, ('A', 'D'): 400, ('A', 'E')
13     ): 500,
14     ('B', 'A'): 200, ('B', 'B'): 0, ('B', 'C'): 250, ('B', 'D'): 350, ('B', 'E')
15     ): 450,
16     ('C', 'A'): 300, ('C', 'B'): 250, ('C', 'C'): 0, ('C', 'D'): 200, ('C', 'E')
17     ): 400,
18     ('D', 'A'): 400, ('D', 'B'): 350, ('D', 'C'): 200, ('D', 'D'): 0, ('D', 'E')
19     ): 300,
20     ('E', 'A'): 500, ('E', 'B'): 450, ('E', 'C'): 400, ('E', 'D'): 300, ('E',
21     'E'): 0
22 }
23
24 # Cost parameters
25 fixed_cost = 1000000
26 operating_cost = 2
27 shipping_cost = 0.1
28
29 # Decision variables
30
31 # Create the problem
32 prob = pulp.LpProblem("Warehouse Location", pulp.LpMinimize)
33
34 # Add the objective function
35 prob += (fixed_cost * sum(warehouse[i] for i in cities) +
36         operating_cost * sum(demand[i] for i in cities) +
37         shipping_cost * sum(sum(ship[i, j] * distances[(i, j)] for j in cities) for i in cities))
38
39 # Add the constraints
40 for j in cities:
41     prob += pulp.lpSum(ship[i, j] for i in cities) == demand[j]
42
43 # Can only ship from open warehouses
44 M = sum(demand.values()) # Big M constraint
45 for i in cities:
46     for j in cities:
47         prob += ship[i, j] <= M * warehouse[i]
48
49 # Solve the problem
50 prob.solve()
51
52 # Print results
53 print("Status:", pulp.LpStatus[prob.status])
54 print("\nOptimal Warehouse Locations:")
55 for i in cities:
56     if warehouse[i].value() > 0.5:
57         print(f"Warehouse in city {i}")
58
59 print("\nShipping Plan:")
60 for i in cities:
61     for j in cities:
62         if ship[i, j].value() > 0:
63             print(f"Ship {ship[i, j].value()} units from {i} to {j}")
64
65 print(f"\nTotal Cost: ${pulp.value(prob.objective):.2f}")

```

Fig. 4. Python code to optimize warehouse locations.

With this approach, the cities B and D were identified as optimal warehouse locations. This solution meets all constraints, as only 2 warehouses are required (less than the maximum of 3) and all cities are within a 1-day shipping distance.

The Optimization AI provides this solution along with sensitivity analysis, showing how the solution might change if certain parameters (like shipping costs or demand) were to change. As a result, the optimal warehouse locations and a shipping plan are issued.

The AI application has forecast total costs of \$2,306,000 for the construction of the distribution network (Fig. 5).

```

Output
Optimal Warehouse Locations:
Warehouse in city B
Warehouse in city D

Shipping Plan:
Ship 1000.0 units from B to A
Ship 1500.0 units from B to B
Ship 800.0 units from D to C
Ship 1200.0 units from D to D
Ship 500.0 units from D to E

Total Cost: $2306000.00

```

Fig. 5. Output of Python model to optimize warehouse locations.

The optimization algorithm chose the cities B and D as these are centrally located and are suitable for minimizing overall shipping distances. The warehouses in the two cities can cover all other cities within reasonable distances. In addition, using two warehouses instead of three saves on fixed costs.

This solution demonstrates how optimization AI can solve complex decision problems, balancing multiple factors to find the most cost-effective solution. In result of the conducted research, it can be stated that optimization AI offers improvement potential for strategic planning, investment control and cost estimation as well as for business partnering, project controlling and risk management.

4.3. Application of generative AI

The use of generative AI offers further opportunities for automating and optimizing management control processes. Our research in this field focused on the BART technology (Bidirectional and Auto-Regressive Transformers). This progressive approach combines an autoregressive decoder (such as GPT) and a bidirectional encoder (as in Bidirectional Encoder Representations from Transformers). The algorithm can solve various linguistic tasks, recover damaged text, talk in interactive mode, write short content and translate texts into different languages. Most importantly, it can create coherent and contextually relevant text, which is very important for applications such as text analysis, dialog systems and automatic content creating that can be used effectively in managing business processes.

```

def analyze_siemens_energy_financials():
    # Key Financial Metrics for 2023
    financial_metrics = {
        'Revenue': 3,
        'Orders': 50,
        'Order Backl',
        'Profit_befc',
        'Net_Loss':,
        'Free_Cash_F',
        'Equity_Rati',
        'Equity_Rati'
    }

    segments = list(profit_margins_2026.keys())
    margins_min = [x[0] if isinstance(x, tuple) else x for x in profit_margins_2026.items()]
    margins_max = [x[1] if isinstance(x, tuple) else x for x in profit_margins_2026.items()]

    x = range(len(segments))
    ax2.bar(x, margins_min)
    ax2.bar(x, margins_max)
    ax2.set_xticks(segments)

    # Print results in a formatted way
    print("\n== SIEMENS ENERGY FINANCIAL ANALYSIS 2023 ==\n")

    for category, items in results.items():
        print(f"\n{category}:")
        print("-" * 50)
        for item in items:
            print(item)

```

Fig. 6. Python code using the BART model to analyze and summarize text of reports.

As part of management control processes, the BART technology can be applied to carry out automated analysis of business reports for example. To illustrate BART's performance, an analysis of Siemens Energy's business development was carried out based on the annual report for the fiscal year

2023. The document has 122,683 words on 201 pages. The generative AI processes this text to create a summary, and the length of the original text and the summary are displayed as part of the output (Fig. 6).

When the code is run, it summarizes the input text, showing how generative AI can be used to extract key information from longer documents automatically. The analysis of Siemens Energy's 2023 annual report revealed the following financial information and strategic developments.

The revenue increased by 9.9% to 31.1 billion euros. However, the company posted a net loss of €4.588 billion, mainly due to quality and cost issues at Siemens Gamesa. Despite these challenges, orders (112 billion euros) and positive free cash flow (784 million euros) are promising indicators.

In addition, we can also get a brief analysis of operational and strategic developments, market and environmental context, research and development (R&D), forward outlook, risks, and mitigation.

The Python code provided uses the BART model to summarize a long text within Siemens Energy's annual report. As mentioned above, the original text length was 122,683 words. After summarizing, the length became only 475 words. Summary length and content may vary slightly depending on the exact processes, but this gives us a good idea of what to expect. The BART model effectively condenses the original text into a concise summary that outlines key points.

It can be said that the output of generative AI is completely original and functional. It is especially relevant for improving management reporting, business partnering, data management and further development of management control processes. The technology can also be applied to summarize relevant data form management reports and other documents to accelerate and improve planning and forecasting processes.

The three considered AI categories have a particularly profound impact on management control processes. The following table summarizes the main possible applications of the AI technologies examined (Tab. 3).

Table 3. Possible applications of AI technologies for management control processes.

Processes of management control	Predictive AI	Optimization AI	Generative AI
Strategic Planning	✓	✓	✓
Planning, Budgeting and Forecasting	✓		✓
Investment Controlling		✓	
Cost Accounting	✓	✓	
Management Reporting	✓		✓
Business Partnering	✓	✓	✓
Project Controlling		✓	✓
Risk Controlling	✓	✓	✓
Data Management			✓
Enhancement (of Organization, Processes, Instruments and Systems)			✓

Predictive AI has especially revolutionized planning and forecasting. By analyzing historical data and identifying patterns, predictive AI models can anticipate future trends, recognize potential risks and reveal opportunities with remarkable accuracy. This allows companies to make decisions that are more informed and develop proactive strategies.

Using predictive modeling and performance optimization techniques, artificial intelligence enables researchers to design more sophisticated nanodevices with reduced development costs and accelerated innovation. These improvements create opportunities for more targeted and efficient technology applications in many scientific and industrial domains.

Optimization AI has transformed resource allocation and process efficiency. These algorithms can analyze complex systems and identify optimal solutions for resource distribution, scheduling, and investment decisions. As a result, companies can achieve significant cost reductions and operational improvements [14–16].

The emergence of generative AI represents the latest frontier in AI's impact on management control. These tools can create new content, designs, and even strategic plans based on learned patterns. This technology is beginning to assist in scenario planning, report generation, and even creative problem solving in management contexts.

The integration of these AI technologies has led to more data-driven, agile, and adaptive management control processes. Companies leveraging AI have reported increased accuracy in financial forecasting, improved risk management, and enhanced decision-making capabilities.

However, this AI-driven transformation also presents challenges, including ethical considerations, data privacy concerns, and the need for upskilling the workforce. As AI continues to evolve, its impact on management control processes is expected to deepen, necessitating ongoing research and adaptation in both academic and practical spheres [17–25].

5. Conclusions

The study highlights the transformative impact of artificial intelligence (AI) on management control processes, demonstrating its potential to enhance both strategic and operational decision-making in organizations.

AI-driven management control systems are critical to meeting the challenges posed by the exponential growth of big data and the rapid pace of digital transformation. By automating routine tasks and providing deeper insights, AI enables management professionals to focus on strategic priorities, facilitating flexibility and responsiveness to dynamic market conditions.

AI optimization in nanotechnology accelerates innovation through precision design, efficient manufacturing and advanced materials synthesis. It lowers development costs, improves predictive modeling, and helps researchers create nanodevices that are more sophisticated with greater accuracy and speed.

This study shows that AI technologies not only increase efficiency, but also enable companies to maintain a competitive advantage by driving innovation, improving resource allocation, and adapting to the evolving business environment. As organizations continue to integrate AI into their management frameworks, its role in shaping future management control practices will become increasingly essential.

To further enhance the impact of this study, there are recommended to conduct: (1) Scalability insights (investigating how small and medium-sized enterprises can adopt and scale AI solutions in management control to ensure inclusivity) and (2) Quantitative evaluation (including quantitative results from AI implementations to strengthen the empirical evidence and validate the findings).

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