SOCIAL SCIENCES

MANAGEMENT ECONOMICS EDUCATION

APPLICATION OF INFORMATION TECHNOLOGIES

MEST JOURNAL

VOL. 13

NO. 2

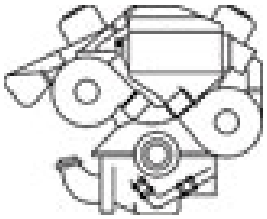
July 2025

ISSN 2334-7171

EDITED BY

Zoran Čekerevac

ISSN 2334-7058 (Online) DOI 10.12709/issn.2334-7058



ISSN 2334-7171
ISSN 2334-7058 (Online)
DOI 10.12709/issn.2334-7058
This issue:
DOI 10.12709/mest.13.13.02.00

MEST Journal

Management
Economics
Society
Technologies

Edited by
Zoran Čekerevac

CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

005+37+3+66

MEST Journal : Management, Education, Science & Society, Technologies /
editor-in-chief Zoran P. Čekerevac. –
[Štampano izd.]. – Vol. 13, no. 2 (2025) –
– Belgrade : MESTE NGO; Toronto : SZ & Associates, 2013- (Belgrade : Planeta Print d.o.o.).
– 30 cm Polugodišnje. - Drugo izdanje na drugom medijumu:
MEST Journal (Online) = ISSN 2334-7058
ISSN 2334-7171 = MEST Journal (Štampano Izd.)

COBISS.SR- ID 196182028

Circulation: 100 copies

FBIM Transactions DOI 10.12709/issn.2334-704X
ISSN 2334-704X (Online) ISSN 2334-718X (Print)

As of September 2022, the FBIM Transactions has been incorporated and merged with MEST Journal. Since then, they have been published under the common name **MEST Journal**.

MEST Journal online

DOI 10.12709/issn.2334-7058

www.mest.meste.org

Current Issue: DOI 10.12709/mest.13.13.02.00

MEST Journal is an international academic publication and the official journal of the non-profit organization MESTE. It is published both online and in print, and features scientific and professional research articles and reviews in English.

The journal is published from Belgrade, Serbia and Toronto, Canada. Its focus is international, addressing topics from a global perspective. However, articles concerning specific local events may also be considered for publication.

Scientific and technological developments — along with their socio-political impact around the world — are welcome topics in the MEST Journal.

The journal is indexed by Index Copernicus (ICI Journals Master List, ICV since 2015), ERIH PLUS (since 2017), as well as in EBSCO, Google Scholar, CrossRef, COBISS.SR, COBIB.RS, KoBSON, Scilit, CiteFactor, and others.

Publishers

- **MESTE NGO** – Belgrade
- **SZ & Associates**, Toronto, Canada

Editorial board – Scientific Board:

Editorial staff – Production:

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Design:	SZ & Assoc. – Toronto, Canada

Printed by: **Planeta print, Belgrade** Circulation: 100 copies
The journal was published online at URL: https://www.meste.org/ojs/index.php/mest/index

The MEST Journal is registered in doiSerbia of the National Library of Serbia, COBIB.SR, Matica Srpska Library, COBISS.SR, Google Scholar, CrossRef, OALIB, EleCas base of KoBSON, the Index Copernicus ICI Journals Master List from 2015 (*ICV 2022 =100.00*), EBSCO, Scilit, ROAD, ERIH PLUS, CiteFactor, and in the ResearchBib (IF: 2023 Evaluation Pending).

All published papers have been internationally reviewed

Two issues of journal are published annually, on January 15th, and July 15th.

ISSN 2334-7058 (Online) &
ISSN 2334-7171

THEMATIC AREAS

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MEST Journal
Year XIII, Vol. 13, Issue 2
DOI: 10.12709/mest.13.13.02.00

From the Editor

Belgrade, July 15th, 2025

Dear Readers, Authors, Reviewers, Language Editors, and Section Editors,

We are living in a time of unprecedented global tension and division. Not only are longstanding conflicts—such as the Ukraine–Russia confrontation, the Israel–Iran dispute, and the USA–Iran tensions—intensifying, but dramatic shifts in the world economy have also disrupted established norms while new global rules and relationships are emerging. In addition to traditional military confrontations, we now witness clashes driven by trade disputes, sanctions, and potential disruptions in existing supply lines. Such divisions are evident not only between nations but also within them, leading to disturbances both in international relations and in interpersonal dynamics. Greed and fear contend with uncertainty about whether major actors clearly understand their goals and possess a vision for unfolding events—a sentiment further reflected by recent electoral outcomes. This era is characterized by constraints on the flow of information, as well as on the movement of people and goods, marking a significant departure from trends observed in previous decades. Yet, even in these challenging times, there remains an underlying hope that reason will ultimately prevail.

In contrast, the submissions for this issue of the MEST Journal reflect a focus on theory and the practice of doing business in a stable environment. The July edition features 19 articles from authors based in Algeria, Bulgaria, China, Moldova, North Macedonia, Serbia, Slovenia, and the United States (listed alphabetically by country). Some authors contributed more than one article, reflecting both their productivity and deep engagement with the journal's themes.

Following our established practice, most articles were published as early previews immediately after the review process. This issue comprises 19 articles — including original research (8), reviews (8), an analytical report, and two position papers — covering a broad spectrum of academic disciplines.

While five of the articles are single-authored, the majority involve co-authorship, including two international collaborations. The published works span a diverse array of fields, including management, finance, information technology, societal studies, economic theories, decision-making, technology, and international cooperation.

I am proud to observe that the work presented in this issue is an exemplary showcase of high-quality scientific production. I extend my sincere gratitude to all authors for the trust they placed in us, and to the reviewers, language editors, and section editors for their steadfast commitment to excellence.

I am especially encouraged by the positive influence of artificial intelligence that emerges in some of these contributions. The results indicate that AI can significantly enhance manuscript preparation and final linguistic editing. Accordingly, the MEST Journal welcomes and recommends the use of artificial intelligence during the phase of manuscript preparation—including literature collection and final linguistic refinement. However, it is important to stress that, despite the many benefits afforded by these tools, the ultimate responsibility for the accuracy of data and the overall quality of the submitted article rests with the author. Therefore, a thorough review, including verification of bibliographic details and adherence to APA citation standards, remains essential before submission.

We invite authors to publish with us — supported by comprehensive editorial guidance, free publication, and compliance with Creative Commons 4.0 principles. Thank you for joining us on this academic journey. Together, we strive to ensure that MEST Journal remains a hub of rigorous scientific analysis, innovation, and an unwavering commitment to research integrity and precision.

Warm regards,

Prof. Dr. Zoran Čekerevac
Editor-in-Chief

MEST Journal
DOI 10.12709/mest.13.13.02.01

ACHIEVING SENSING AGILITY THROUGH THE INTEGRATION OF COMPETITOR AND MARKET INTELLIGENCE

Hanene Belahcene
Badji Mokhtar University, faculty of Economics, commerce and Management Sciences, Department of Management Sciences, Annaba, Algeria

Fatma Zohra Chaib
Badji Mokhtar University, faculty of Economics, commerce and Management Sciences, Department of Management Sciences, Annaba, Algeria

Sabrina Djedid
Badji Mokhtar University, faculty of Economics, commerce and Management Sciences, Department of Management Sciences, Annaba, Algeria
https://orcid.org/0009-0008-9016-6165

JEL Category: **M21, L15, D83**

Abstract

This study aims to determine the impact of the integration between market and competitor intelligence on achieving sensing agility in 30 Enterprises within the food industry in the towns of Annaba, Skikda, and El-Tarf (Algeria). This was conducted using a triangulation approach that combines qualitative data analysis from a guided interview protocol with four executives (analyzed using NVivo v14), and quantitative survey data analysis collected from 120 executives (analyzed using SPSS v25). The study reached a few findings, the most important of which is that there is no significant effect of competitor intelligence on achieving sensing agility in the presence of market intelligence for the Enterprises under study. Based on this result, the study recommends that food industry Enterprises gather comprehensive information about competitors and changes in the competitive environment from multiple sources, considering that information is the foundational element that determines the success or failure of both competitor intelligence and market intelligence processes.

Keywords: *Market Intelligence, Competitor Intelligence, Sensing Agility, Business Strategy, Competitive Analysis.*

Address of the corresponding author:
Hanene Belahcene
hanene.belahcene@univ-annaba.org

1 INTRODUCTION

In the modern world, information has become a foundational pillar for achieving success and competitive superiority, especially in the era of

globalization, increased openness to the external world, advancements in communication technologies, and the expansion of internet networks that have diminished distances and facilitated customer access to virtually any product. In this context, enterprises that possess more accurate and comprehensive information about markets, competitors, technologies, resources, and other components of the business environment are in a better position to seize emerging opportunities and mitigate potential threats.

As a result, enterprises have increasingly adopted methods and tools that enable systematic and ethical intelligence gathering regarding their environment, particularly its competitive aspects. This process requires accurately identifying reliable sources to obtain relevant information and effectively analyzing all elements shaping the competitive landscape.

Among the most prominent of these tools are market intelligence and competitor intelligence, which allow enterprises to be aware of changes in their competitive business landscape. These tools provide valuable insights into evolving customer needs and shifts in the competitive structure, thereby enabling enterprises to recognize, understand, and respond swiftly to emerging opportunities and threats.

Algerian enterprises are no exception to these global trends. They face similar challenges and disruptions, which may pose risks or create new growth opportunities, largely influenced by their competitive environments. In this regard, Enterprises operating in the Algerian food industry cannot afford to remain detached from the changes around them. They must develop a high degree of *sensing agility* to detect and respond to environmental changes that may create opportunities or threats. Achieving this level of agility necessitates effectively deploying both market intelligence and competitor intelligence.

Attaining this level of agility requires the strategic application of both market and competitor intelligence. Accordingly, this study examines how integrating these intelligence frameworks enhances sensing agility within a sample of food industry enterprises in Annaba, Skikda, and El-Tarf.

2 LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Enterprises today operate in an environment that is volatile, uncertain, and ambiguous, due to several factors, chief among them continuous technological advancements, the ever-evolving behaviors of customers, and the emergence of new competitors. These dynamics increase the risk of losing market share if enterprises are not fully aware of what is happening in their surroundings. As a result, enterprises have turned to methods and practices that provide them with accurate and reliable information regarding all aspects of their business environment, particularly about competitors and customers, to utilize such information in shaping their strategic and operational plans, making informed decisions, and executing actions swiftly.

2.1 Practices for Understanding Competitors and the Market

2.1.1 Competitor Intelligence

Enterprise is facing increasing challenges due to intense competition from rival enterprises, which, as pointed out by Mirkhan, Alsamarai, and Abdullah (2017, p. 102), are those entities that offer the same or similar products or services, whether currently or in the future, as well as those offering substitutes. This makes it essential to monitor these entities using competitor intelligence and focus on competitors, their capabilities, current activities, plans, intentions, and more.

Deschamps and Nayak (1995) emphasized that competitor intelligence involves tracking all changes in competitor structure, including the emergence of new product alternatives and new entrants into the industry, as well as analyzing the strategies and services of current and potential competitors (Tahmasebifard, 2018). Additionally, Zajac and Bazerman (1991) indicated that competitor intelligence centers around analyzing competitive behavior and direct rivalry, where the organization identifies a competitor as an adversary, monitors its actions, and takes reactive measures, either offensively or defensively, based on anticipated responses. These expectations are derived from available information regarding the competitor's objectives (understanding them helps

in predicting reactions to competitive moves), assumptions (which provide insight into future activities), and capabilities (knowledge of which reflects their strengths and weaknesses).

This leads to the conclusion that competitor intelligence assists the organization in understanding its position relative to key competitors in the competitive environment. In other words, it offers a clear understanding of the organization's strengths and weaknesses and those of its competitors, enabling the firm to identify a unique, untapped position that can lead to superior performance. Moreover, such intelligence empowers the organization to differentiate the value it offers to customers compared to that of its rivals, owing to the extensive knowledge it holds about them.

Based on the above, competitor intelligence can be defined as the ongoing process of gathering, analyzing, and disseminating information about competitors to provide a comprehensive understanding of their structure, culture, behavior, capabilities, and potential future strategies.

2.1.2 Market Intelligence

A limited understanding of the market's needs and requirements poses a significant risk to an organization's success. To mitigate this, organizations must leverage intelligence practices, particularly market intelligence, to gain deeper insights and make informed decisions. Deschamps and Nayak defined market intelligence as "a collection of information that outlines the organization's roadmap for current and future customer needs, preferences, new markets, retail opportunities, and major shifts in marketing and distribution" (Tahmasebifard, 2018). Additionally, Maltz and Kohil defined it as "a set of actions designed to obtain information about changes in the market environment to successfully implement the organization's marketing activities" (Jasim, Sulaiman, Zakuan, 2020). This implies that market intelligence enhances the organization's understanding of the market landscape, contributing to its success and competitive advantage. It has been noted that generating and disseminating market information creates a competitive edge, adds value for customers, and leads to improvements in sales, profitability growth, market share, success in new product launches, customer satisfaction, and return on investment, especially compared to enterprise that do not adopt market intelligence (Narver & Slater, 1990). McGrath and Romeri further argued that it allows for the reduction of marketing expenses, which significantly contributes to the organization's overall profit and performance.

Ciappei and Simoni stated that market intelligence supports marketing processes by providing accurate and reliable information on the changing needs and desires of current and potential customers. In the same context, Zhou, Brown, and Dev emphasized that market intelligence enables an organization to anticipate and quickly respond to its customers' evolving needs, as well as to offer an attractive marketing mix. Additionally, Waren, Souder, and Berkowitz noted that market intelligence is the most crucial element in achieving success in new product development, as it addresses customer needs (Tahmasebifard, 2018). In this regard, Narver and Slater mentioned that relying on knowledge derived from customer needs and preferences, market trends, and shifts in consumption patterns enables the enterprise to create products that cater to the target market's needs, leading to superior market performance (Narver & Slater, 1990).

From the above, the objectives of market intelligence can be summarized in the following points:

- A deep understanding of customer behavior, needs, and preferences.
- Creating value for customers.
- Identifying new opportunities and sources of competitive advantage.
- Developing effective marketing and business strategies.
- Enhancing the organization's performance and increasing its competitiveness in the market.

Thus, it can be concluded that competitive intelligence is continuously collecting, analyzing, and disseminating information about competitors, providing a comprehensive understanding of their structure, culture, behavior, capabilities, and potential plans. On the other hand, market intelligence involves the collection and analysis of various customer-related information, which is then used to make decisions that effectively address their needs.

2.2 Definition of Sensing Agility

Sensing refers to an organization's ability to perceive changes and developments in the external environment (Tsilionis & Wautelet, 2022). Similarly, it has been noted that sensing reflects the extent to which an organization can detect rapid shifts in its external environment, as well as swiftly changing customer needs (Chi, Ravichandran, & Andrevski, 2010). Within this context, strategic sensitivity is considered an integral part of the sensing process. It denotes the organization's ability to identify and comprehend changes occurring both internally and externally (Al-Fatlawi, Al-Karaawi, & Al-Rafei, 2019), Moreover, it also refers to the organization's awareness of its strategic direction and its understanding of the pathway through which it can realize its vision, mission, and strategic objectives, primarily by recognizing timely opportunities and responding more swiftly than competitors (Al-Tameemi & Abd-Alghafur, 2020).

Strategic sensitivity involves an open strategic process that enhances an organization's responsiveness to diverse viewpoints and modes of thinking. It therefore relies on active collaboration with internal and external stakeholders, including suppliers, customers, and even competitors, when identifying and shaping strategy. High strategic vigilance enhances an organization's ability to frame and reformulate strategic questions in a novel and comprehensive manner. Achieving this requires expanding the diversity of thought within the organization by guiding cognitive processes toward a broader conceptual horizon. Additionally, fostering high-quality internal dialogue strengthens the organization's ability to convert individual insights and perspectives into a shared strategic vision. As a result, collective decision-making becomes more aligned and effective. (Alyasiry, Al-Hasnawi, & Al-Shammari, 2020)

Accordingly, the components of strategic sensitivity elevate sensing agility by enabling the early and rapid detection of new opportunities, faster than competitors, and by facilitating proactive action. This includes the creation of hypotheses about future impacts, events, and observable market trends, and testing these hypotheses to pave new paths for products, services, and business models (Geiger, 2020). Ultimately, sensing empowers the generation of a combination of novel ideas, enabling the organization to develop innovative products that create value for both it and its customers (Ahammad, Basu, Munjal, Clegg, & Shoham, 2021).

2.3 Sensing Agility Via Competitor and Market Intelligence

Sensing agility reflects an organization's ability to perceive and detect opportunities and threats arising from changes and developments in its surrounding environment (Al-Raei, 2023). To sense such opportunities and threats effectively, the organization must have timely access to relevant information regarding all environmental changes, whether related to competitors, the market, technology, potential business relationships, and beyond.

This was emphasized in the study by Rimvydas and Justina (2020, p. 19), which defined sensing as involving the vast amount of information collection from various sources regarding environmental changes, followed by its analysis and transformation into actionable insights. This suggests that competitive and market intelligence is crucial in enabling sensing agility.

Numerous studies have highlighted this relationship, including two key contributions. The first is by Stenberg and Vu-Thi (2017, p. 09), who indicated that competitive intelligence, as a subset of competitive strategy, is a foundational element for achieving sensing agility regarding opportunities and threats. Competitive intelligence involves gathering all relevant information about competitors, such as their strategies, behaviors, capabilities, investments, products, services, customer base, targeted market segments, objectives, research activities, and the current and potential structure of direct competition. This information is then analyzed and disseminated to senior managers and executives, providing them with a clear understanding of their strategic position regarding key competitors. It also helps strengthen and identify weaknesses within the organization and its rivals, thus enabling the firm to sense current and emerging opportunities and threats effectively.

The second study, by Tahmasebifard (2018, p. 04), demonstrated that market intelligence allows data collection on customer needs, preferences, and shifts in consumption patterns. Analyzing and disseminating this information facilitates the proactive formulation of assumptions regarding current and future market trends and enables the organization to respond swiftly. As such, the insights provided by market intelligence regarding customer-related and market-related changes empower the organization to achieve agility in sensing potential opportunities and threats and to respond to them proactively.

Based on this understanding, the following general hypothesis is proposed:

H_1: The integration of competitive intelligence and market intelligence significantly influences the achievement of sensing agility.

This general hypothesis leads to the following two sub-hypotheses:

H_2: Competitive intelligence influences achieving sensing agility.

H_3: Market intelligence influences achieving sensing agility.

3 STUDY PROCEDURES

3.1 Research Methodology and Sample

This study employed a descriptive and analytical methodology to explore the perceptions and evaluations of executives from a sample of food industry enterprises located in the Algerian towns of Annaba, Skikda, and El-Tarf (see Table 1). The study aimed to assess the impact of competitive intelligence and market intelligence integration on achieving sensing agility. To gather the necessary data, both structured interviews and a questionnaire were utilized.

A structured interview guide consisting of seven questions was developed to investigate this relationship. The interviews were conducted with a purposive sample of four professionals (practitioners) from food industry Enterprises in Annaba and Skikda. These individuals were selected based on their in-depth knowledge and familiarity with competitive intelligence, market intelligence, and sensing agility, regardless of their specific job titles. Each of the four interviewees participated in two separate interviews between January and March 2024: the first to capture their initial responses, and the second to verify the reliability and consistency of their answers (see Table 2).

The questionnaire statements were adapted from validated scales used in previous studies on the research variables, with necessary modifications to suit the context of this study. Additionally, expert opinions were consulted to enhance its validity. The questionnaire employed a five-point Likert scale, with options ranging from "Strongly Agree (5)" to "Strongly Disagree (1)".

Once finalized, the questionnaire was distributed—often accompanied by an interview—to all senior-level executives at the selected Enterprises. This target group was chosen due to their comprehensive awareness of the organization's strategic activities, aligning with the study's focus on competitive intelligence, market intelligence, and sensing agility. Their position allowed them to respond more objectively and accurately than employees in lower-level roles.

However, during the distribution period (from January 30 to April 28, 2024), five Enterprises requested to limit the number of questionnaires distributed within their institutions due to work pressure. These were: Shehrazad Enterprise, Edough Enterprise, Seybouse Enterprise, Midou Pasta Enterprise, and Seybouse Lipid Products Enterprise (LaBelle).

As a result, 261 questionnaires were distributed. Among them, 102 were not returned, primarily due to employees being on leave or declining to respond due to workload. The results revealed that 39 out of 159 returned questionnaires were excluded from analysis due to incomplete or invalid responses, and 120 valid questionnaires were taken for statistical analysis (see Table 3).

Cronbach's Alpha coefficient was calculated to ensure the reliability of the questionnaire. A value of ≥ 0.70 is generally considered statistically acceptable. The results showed that all items met this criterion, with the overall reliability coefficient reaching 0.929, indicating high internal consistency. Tables 1-3 present these findings in detail.

Table 1. Number of Executives in the Sample from Food Industry Enterprises in the Towns of Annaba, Skikda, and El-Tarf

Nu.	Enterprise Name	Towns	Sector of Activity	Enterprise Size	Number of Executives
01	Radtaco Enterprise	Annaba	Pasta Production	Micro	03
02	Mahboubah Enterprise	Annaba		Medium	12
03	Midou Pasta Enterprise	Annaba		Small	06
04	DICOPA Enterprise	Annaba	Coffee	Medium	07
05	Qasr Al-Qahwa Enterprise	Skikda		Small	06
06	Amor Benamor Canning	Skikda	Canned Fruits and Vegetables	Medium	13
07	Lalla El-Atra Canning Enterprise	Annaba		Medium	07
08	Souamaa El Bahdja Canning	Annaba		Medium	07
09	Rashrash Abdelrazak Food Canning (CARA)	El-Tarf		Medium	13
10	Green Grill Manufacturing	Skikda		Medium	08
11	Boukraine Canning Enterprise	Skikda		Medium	11
12	SIPA Canning Enterprise	Annaba		Medium	13
13	Cap de Fer Enterprise	Annaba	Canned Fish	Medium	13
14	Bushra Soft Drinks Enterprise	Annaba	Soft Drinks	Small	05
15	Global Soft Drinks Enterprise	Annaba		Medium	15
16	Yousra Enterprise	Annaba		Micro	03
17	Al-Yaqout Enterprise	Annaba	Flour Milling	Medium	12
18	Seybouse Enterprise	Annaba		Medium	25
19	Blue Coast Enterprise	El-Tarf		Small	10
20	Baladi Enterprise	Annaba		Small	12
21	Russicada Enterprise	Skikda		Small	05
22	Sahli Dairy Enterprise	Annaba	Milk Bags & Cans	Small	10
23	EL-MAIDA Milk Enterprise	Annaba		Small	10
24	Afia Milk Enterprise	Annaba		Medium	08
25	Edough Enterprise	Annaba		Medium	33
26	Shehrazad Enterprise	Annaba	Biscuits & Confectionery	Medium	12
27	Saba' Sanabel Biscuit Enterprise	Annaba		Small	03
28	Quedubon Enterprise	Annaba		Micro	02
29	Al-Hilaliyat Enterprise	Annaba		Micro	02
30	Seybouse Lipid Products (LaBelle)	Annaba	Oil	Medium	11

Source: Prepared by the researchers based on data from the Enterprises under study

Table 2. Interview Information Sheet with Executives from Enterprises under Study

Enterprise	Position	Years of Experience	First Interview		Second Interview	
			Date	Duration	Date	Duration
Global Soft Drinks Enterprise	Commercial Manager	21 years	22/01/2024	1.5 h	26/02/2024	1 h
Green Grill Manufacturing	Commercial Manager	32 years	03/03/2024	1.5 h	11/03/2024	1 h
Qasr Al-Qahwa Enterprise	Commercial Manager	20 years	29/01/2024	1 h	31/01/2024	45 min
EL-MAIDA Milk Enterprise	HR Manager	12 years	22/01/2024	45 min	26/02/2024	45 min

Source: Prepared by the researchers based on the results of the field study

Table 3. Distribution of the Study Sample's Executives by Town

Towns / N° of Quest.	Annaba	Skikda	El-Tarf	Total
Total number of executives	231	43	23	297
Distributed questionnaires	195	43	23	261
Unreturned questionnaires	80	10	12	102
Returned questionnaires	115	33	11	159
Excluded questionnaires	39	/	/	39
Valid questionnaires	**76**	**33**	**11**	**120**

Source: Prepared by the researchers based on the field study results

To analyze the study results and test its hypotheses, the researchers relied on several statistical indicators in NVivo v14 and SPSS v25 software. These indicators include arithmetic means, standard deviations, and Pearson correlation coefficient to determine the nature of relationships, as well as simple and multiple regression coefficients to assess the significant impact of the independent variables on the dependent variable.

3.2 Results Analysis

3.2.1 Interview Results Analysis

Using NVivo v14 software, the researchers analyzed the interviews with four executives from the selected Enterprises. This analysis yielded linguistic, thematic, and cognitive mapping approaches.

The linguistic approach revealed a degree of similarity in the responses of the practitioners (interviewees), as measured by the Pearson correlation coefficient. The results indicated that all four Enterprises rely solely on sales consultants as a source of customer-related information. When it comes to gathering information on current and potential competitors, the Enterprises depend on both customers and sales consultants, except for EL-MAIDA Milk, which does not collect information on competitors.

The practitioners' responses revealed that most enterprises do not actively gather information regarding potential alliances between competitors, nor do they consider forming partnerships with stronger competitors or acquiring weaker ones.

Regarding the analysis and dissemination of collected data, practitioners (1 and 2) confirmed that their respective institutions engage in such processes. However, Qasr Al-Qahwa limits its efforts to analyze competitor product information available on the market and communicate this to decision-makers.

In terms of utilizing the analyzed information to anticipate market changes (related to customers and competitors) and make prompt, adaptive decisions, three of four practitioners confirmed that their institutions effectively leveraged this information.

Table 4 presents the textual similarity coefficients.

Table 4. Pearson Correlation Coefficients for Textual Similarity

Source A (Practitioner)	Source B (Practitioner)	Pearson Correlation Coefficient
Qasr Al-Qahwa (Practitioner 3)	Green Grill Manufacturing (Practitioner 2)	0.70
Green Grill Manufacturing (Practitioner 2)	Global Soft Drinks (Practitioner 1)	0.67
EL-MAIDA Milk (Practitioner 4)	Global Soft Drinks (Practitioner 1)	0.61
Qasr Al-Qahwa (Practitioner 3)	EL-MAIDA Milk (Practitioner 4)	0.60
Qasr Al-Qahwa (Practitioner 3)	Global Soft Drinks (Practitioner 1)	0.60
Green Grill Manufacturing (Practitioner 2)	EL-MAIDA Milk (Practitioner 4)	0.58

Source: Prepared by authors based on the outputs of NVivo v14

As for the objective approach, it determined the coverage rate to identify the question that received the most attention from each respondent (practitioner) and its content. Table 5 illustrates this.

Table 5. Coverage Rate of Interview Questions

Theme (Question)	Coverage Rate (%)				Overall Ranking by Coverage Rate
	Practitioner 1	Practitioner 2	Practitioner 3	Practitioner 4	
Information Gathering	42.96%	39.14%	25.54%	13.84%	1
Information Analysis and Dissemination	7.24%	8.20%	15.24%	5.57%	3
Organizational Adaptability Speed	5.75%	10.67%	12.25%	17.42%	2
Relevance of Analyzed Information to Market Change Detection	10.15%	6.78%	9.40%	8.86%	4
Relevance of Analyzed Information to Decision-Making Agility	9.89%	12.56%	14.72%	11.40%	—
Relevance of Analyzed Information to Operational Agility	11.66%	7.74%	4.46%	3.19%	—
Opinion on the Importance of Information Provided within the Organization	11.35%	13.17%	16.33%	37.78%	—

Source: Prepared by the authors based on the outputs of NVivo v14

It is observed from the table above that:

- *Practitioner 1's response* (from Global Soft Drinks Enterprise) recorded the highest coverage rate (42.96%) for the first question. The practitioner emphasized that the enterprise collects information daily about its customers (both wholesalers and end consumers) and weekly about competitors' activities. The information is gathered by sales consultants operating in all regions where the enterprise distributes its products. Sources include customers, enterprise employees, national trade fairs such as the Algerian Production Fair, and international exhibitions, particularly in Dubai, United Arab Emirates. This information is then communicated to the enterprise's commercial manager via mobile phone, email, or social media platforms, including WhatsApp, Viber, Telegram, and Facebook.
- *Practitioner 4's response* (from El Maida Milk Enterprise) came in third place with a coverage rate of 17.42% for the third question. He detailed that the enterprise's adaptability to market changes is very weak, stating that at times, the enterprise is unable to promote or distribute its products effectively due to the lack of marketing specialists who could help in formulating and implementing a clear marketing strategy. Furthermore, the enterprise's limited financial resources hinder its ability to carry out promotional campaigns for its products.
- *Practitioner 3's response* (from Qasr Al-Qahwa Enterprise) ranked third with a coverage rate of 15.24% for the second question. He elaborated that the enterprise analyzes data related to pricing, competitor product composition, and customer preferences, conducted solely by the commercial manager based on his expertise. However, the enterprise does not analyze external environmental changes, such as technological shifts. The results of these analyses, particularly on competitors' products and customer preferences, are compiled into reports that are then sent directly to decision-makers via email or handed over in person.
- *Practitioner 4's response* (from Global Soft Drinks Enterprise) also ranked fourth with a coverage rate of 10.15% for the fourth

question. In his response, he explained that the enterprise's collected and analyzed data on customers and competitors enabled it to detect potential threats such as changes in customer demand for its products and marketing campaigns conducted by competitors.

Meanwhile, the knowledge mapping approach, which uses illustrative diagrams, links the study's key concepts (competitive intelligence, market intelligence, and sensing agility) with various ideas presented in the four interviews. This approach helps structure mental perceptions and provides a clearer framework for answering interview questions. Figure 1 illustrates this.

Fig 1. Knowledge Map of the Relationship between Competitive Intelligence, Market Intelligence, and Sensing Agility

Source: Authors based on outputs from NVivo v14

It was observed, through the interconnection of statements in the previous figure, that the information collected and analyzed by the Enterprises under study contributed to enabling them to sense changes in customer preferences and requirements (Global Soft Drinks Enterprise), identify an opportunity through customer complaints about constant coffee consumption (Qasr Al-Qahwa Enterprise), and detect threats such as the entry of a new competitor's product (Green Grill Manufacturing Enterprise), or changes in competitors' product pricing and quality (Qasr Al-Qahwa Enterprise and Green Grill Manufacturing Enterprise), as well as successful marketing campaigns carried out by competitors (Global Soft Drinks Enterprise).

As a result of this sensing capability, the Enterprises were able to make quick decisions to exploit opportunities and avoid threats, which in turn led to a rapid adaptation to market changes, as reflected in the following actions:

- Launching a product in a new format tailored to customer preferences (Global Soft Drinks Enterprise).
- Offering a high-quality product (Green Grill Manufacturing Enterprise).
- Introducing a low-caffeine coffee product (Qasr Al-Qahwa Enterprise);
- Developing new pricing schedules in response to changes in competitors' prices (Green Grill Manufacturing Enterprise); and
- Executing more extensive and successful marketing campaigns than competitors, thanks to discounts and prizes (Global Soft Drinks Enterprise).

3.2.2 Questionnaire Results Analysis

This section presents the analysis of the findings by calculating the arithmetic means and standard deviations of the respondents' views on competitive intelligence, market intelligence, and sensing agility. Table 6 summarizes the results.

Table 6. Arithmetic Means and Standard Deviations of Respondents' Opinions on Competitive Intelligence, Market Intelligence, and Sensing Agility

Study Variables	Mean	Standard Deviation	Coefficient of Variation (%)	Overall Tendency
Competitive Intelligence	3.46	0.88	25.43%	High
Market Intelligence	3.77	0.73	19.36%	High
Sensing Agility	3.68	0.58	15.76%	High

Source: Prepared by the researchers based on outputs from SPSS v25

The data presented in the above table indicates that the interviewees' responses (representatives of the institutions under study) demonstrated a strong inclination toward competitiveness and market intelligence. This is evidenced by the mean scores of 3.46 and 3.77, respectively, along with standard deviations of 0.88 and 0.73. The relatively low level of dispersion suggests a high degree of consensus among respondents. These results indicate that the institutions under study actively engage in competitive intelligence practices. They continuously gather information on existing and potential competitors, including how competitors market their products, customer perceptions of those products, key suppliers, targeted geographic areas, and other relevant factors.

This collected information is then analyzed by the commercial officer, drawing upon their expertise in the field. The analysis results are subsequently made available to the decision-maker, either verbally or through reports, particularly when immediate decision-making is required. Otherwise, the information may be stored for future use. However, in the case of competitor-related intelligence, the analyzed data is often communicated directly to the decision-maker without being stored. According to interview findings, storing such information may pose a greater threat than opportunity, hence the preference for immediate action.

Regarding market intelligence, the institutions under study also demonstrate a high level of engagement. They continuously collect information related to customer needs, preferences, buying behavior, and satisfaction levels. Customer satisfaction is typically assessed through repeated and increasing product orders, as reported during interviews. Like competitive intelligence, this information is analyzed by the commercial officer using their professional expertise and then communicated to the decision-maker, either orally or in written reports. Storage of this data occurs only occasionally, primarily when deemed necessary for future use. Given that the customer is the core reason for the institution's existence and sustainability in the market, any information concerning them must be analyzed promptly, and the findings made immediately available to decision makers. This, too, was emphasized in the interview findings.

Regarding sensing agility, the general trend in respondents' answers also reflected a high level of agreement, with a mean score of 3.68 and a standard deviation of 0.58. The institutions under study exhibit the capability and responsiveness to detect changes in customer preferences, recognizing customers as fundamental to their market presence and longevity. Therefore, sensing any change in customer preferences is deemed essential. On the other hand, the institutions appear to place less emphasis on detecting potential strategic alliances formed by competitors. This lack of attention is attributed to a limited awareness of the significance that such coalitions can have in shaping future strategic directions.

3.3 Hypothesis Testing

Multiple regression analysis was employed to test the general hypothesis, which posited that: There is a statistically significant impact of the integration between competitive intelligence and market intelligence on achieving sensing agility at a significance level of $\alpha \leq 0.05$. This analysis was conducted after verifying the adequacy of the multiple regression model, both in terms of econometric and statistical validity. Econometric validation was established by ensuring the following conditions were met:

- *Absence of autocorrelation in residuals:* This was verified using the Durbin-Watson statistic,

which should fall within the acceptable range of [1.77, 2.23]. This interval was determined from the Durbin-Watson table for a sample size of n = 120 and a significance level of 0.05. The lower limit value was $d_1 = 1.69$ and the upper limit value was $d_2 = 1.77$, thus indicating a non-autocorrelation zone of $[d_2, 4 - d_2]$.

- *Absence of multicollinearity among the independent variables*: This was assessed using the Variance Inflation Factor (VIF) and Tolerance statistics. A VIF value exceeding 10 and a Tolerance value of < 0.05 indicate a multicollinearity problem in the regression model.
- *Normality of the residuals*: This was tested using either the Kolmogorov-Smirnov or the Shapiro-Wilk test. The residuals are normally distributed if the significance value of the test is ≥ 0.05.

The results of these diagnostic tests are summarized in Table 7.

Table 7. Model Diagnostic Tests

Dimension	Variance Inflation Factor (VIF)	Tolerance	Durbin-Watson Statistic	Shapiro-Wilk Statistic
Market Intelligence	1.705	0.586	1.731	/
Competitive Intelligence	1.538	0.650		
Residual Series	/	/	/	Sig = 0.000

Source: Prepared by the researchers based on SPSS v25 outputs

Based on Table 7, it is evident that all Variance Inflation Factor (VIF) values were below 10, and all tolerance values exceeded 0.05, indicating the absence of multicollinearity among the independent variables. Moreover, the Durbin-Watson statistics, which equals 1.731, falls within the acceptable range, confirming the assumption of no autocorrelation in the residuals.

Although the Shapiro-Wilk test suggests that the residuals do not follow a normal distribution, most statisticians agree that residuals tend to approximate normality when the sample size exceeds 30 observations and the deviation from normality is not substantial. Therefore, it can be reasonably assumed that the residuals are normally distributed, and the failure to meet the Shapiro-Wilk criteria does not significantly affect the results. This assumption is further supported by Figure 2.

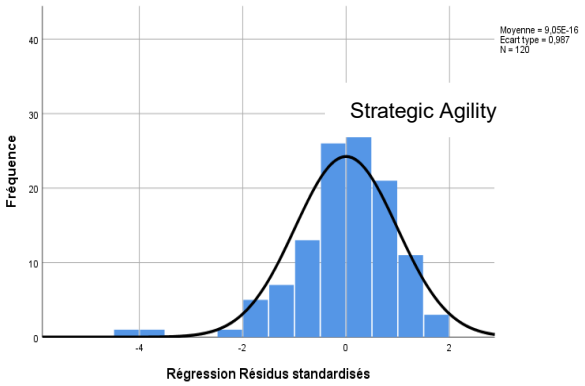

Fig 2. Normal distribution of residuals
Source: Outputs generated using SPSS v25

Statistically, the validity of each parameter in the model was tested using Fisher's F-test, where the calculated F-value must be greater than the critical value from the F-distribution table, or the significance level (Sig.) must be less than or equal to 0.05. The results of this test are presented in Table 8.

Table 8. Statistical Validity Test of the Model

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-value	Sig.
Regression	8.224	3	2.741	18.590	0.000
Residual	17.105	116	0.147	-	-
Total	25.328	119	-	-	-

Source: Prepared by the researchers based on SPSS v25 outputs

The results presented in Table 8 confirm the statistical validity of the multiple regression model. This is supported by the F-value, which exceeds the critical value, and the significance level (Sig.) of 0.000, which is less than 0.05. This indicates that at least one independent variable has a statistically significant effect on the dependent variable, meaning that at least one parameter

satisfies the significance criterion. The regression results will clarify which specific parameter(s) meet this condition.

After confirming the validity of the multiple regression model, it is now possible to test the effect of the interaction between Competitive Intelligence (X_1) and Market Intelligence (X_2) on achieving Sensing Agility as the dependent variable (Y). The following table presents the results of the multiple regression analysis:

Table 9. Results of Multiple Regression Analysis

Study Variables	Standard Error	B Coefficient	t-value	Sig. (t)	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Constant	0.327	2.442	7.467	0.000	0.312	0.097
Competitive Intelligence	0.077	0.053	0.684	0.496		
Market Intelligence	0.097	0.246	2.532	0.013		

Source: Prepared by the researchers based on SPSS v25 outputs

The results in the table above indicate a weak correlation between Competitive Intelligence, Market Intelligence, and Sensing Agility, with a correlation coefficient (R) of 0.312. The coefficient of determination (R^2) shows that only 9.7% of the variance in Sensing Agility is explained by changes in Competitive Intelligence and Market Intelligence. The remaining 90.3% is attributable to other variables not included in the model.

Moreover, the T-test results show that the significance level of the T-value for Market Intelligence and the constant term is below the accepted threshold of < 0.05, indicating a statistically significant effect. However, the t-value for Competitive Intelligence has a significance level of > 0.05, suggesting that it does not have a statistically significant effect on Sensing Agility in the presence of Market Intelligence.

Accordingly, the main hypothesis (H_1), which posits a significant effect of the Competitive Intelligence and Market Intelligence integration on achieving Sensing Agility in the institutions of interest, is rejected.

Two sub-hypotheses were tested using simple linear regression. Tables 10 and 11 present the validity of the models and the results of the respective tests.

Table 10. Model Validity Test for the Two Sub-Hypotheses

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value	Significance Level (Sig)
Sub-Hypothesis 1 (H_2)					
Regression	2.638	1	2.638	5.926	0.016
Residuals	52.529	118	0.445		
Total	55.167	119	/	/	/
Sub-Hypothesis 2 (H_3)					
Regression	5.168	1	5.168	12.196	0.001
Residuals	49.999	118	0.424		
Total	55.167	119	/	/	/

Source: Prepared by the researchers based on SPSS v25 outputs

From the above table, it is evident that the calculated F-values exceed their corresponding critical values. This is further supported by the significance values (Sig), which are less than the threshold of 0.05. These results confirm the validity of the model for testing both sub-hypotheses, which state: *"There is a statistically significant effect of both competitor intelligence and market intelligence on achieving sensing agility at a significance level of ($\alpha \leq 0.05$)".*
Table 11 presents the results of the simple linear regression analysis.

Table 11. Simple Linear Regression Results for the Two Sub-Hypotheses

Study Variables	Standard Error	B Coefficient	T-value	T-Significance	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Sub-Hypothesis 1 (H_2)						
Constant	0.446	2.517	5.646	0.000	0.219	0.048
Competitor Intelligence	0.122	0.298	2.434	0.016		
Sub-Hypothesis 2 (H_3)						
Constant	0.346	2.683	7.748	0.000	0.306	0.094
Market Intelligence	0.095	0.332	3.492	0.001		

Source: Prepared by the researchers based on SPSS $_{v25}$ outputs

Based on Table 11, we can conclude:

- *Regarding Sub-Hypothesis 1 (H_2)*: There is a weak correlation between competitor intelligence and sensing agility, with a correlation coefficient of 0.219. Furthermore, 4.8% of the variation in sensing agility is explained by changes in competitor intelligence, while the remaining 95.2% is attributed to other variables not included in the model. The t-test significance level was less than the adopted threshold of 0.05, indicating a weak but statistically significant effect of competitor intelligence on sensing agility.
- *Regarding Sub-Hypothesis 2 (H_3):* Similarly, there is a weak correlation between market intelligence and sensing agility, with a correlation coefficient of 0.306. Approximately 9.4% of the variation in sensing agility is explained by market intelligence, while the remaining 90.6% is attributed to other excluded variables. The t-value significance was also below the 0.05 threshold, indicating a weak but statistically significant effect of market intelligence on sensing agility.

Based on the above findings, the following sub-hypotheses, tested using simple linear regression, are accepted:

- *Sub-Hypothesis 1 (H_2): There is a statistically significant effect of competitor intelligence on achieving sensing agility in the enterprise under study at a significance level of ($\alpha \leq 0.05$).*
- *Sub-Hypothesis 2 (H_3): There is a statistically significant effect of market intelligence on achieving sensing agility in the enterprise under study at a level of significance of ($\alpha \leq 0.05$).*

On the other hand, the main hypothesis (H_1), that there is a statistically significant effect of the integration between competitor intelligence and market intelligence on achieving sensing agility in the enterprise under study at a significance level of ($\alpha \leq 0.05$), was rejected based on the results of the multiple regression analysis. The analysis revealed that competitor intelligence had no statistically significant effect on sensing agility when market intelligence was also included in the model.

This result can be explained by two main reasons:

- *From a statistical perspective*, the effect of competitor intelligence on sensing agility was weak, as shown by the low coefficient of determination (R^2) in the sub-hypothesis tests. Therefore, when its effect was assessed in the presence of market intelligence, it was not statistically significant. Generally, the weaker the effect, the higher the significance level (Sig).
- *From the interview* findings, the enterprise under study implements competitor intelligence in a broad but incomplete manner. While they collect, analyze, and disseminate data related to competitors' pricing and product composition, they tend to neglect other important aspects of competitor behavior. As a result, competitor intelligence did not have a significant effect on sensing agility when market intelligence was considered. On the contrary, market intelligence (collection, analysis, and

dissemination) was applied more rigorously, as the enterprise perceived customers as the cornerstone of their existence and sustainability. This drives them to gather and analyze all relevant customer information and use it effectively and promptly, hence the significant impact of market intelligence on sensing agility.

4 CONCLUSIONS

This study addressed two key types of competitive intelligence, competitor and market intelligence, and sensing agility, which has emerged as a crucial component in modern business management. Sensing agility is increasingly recognized as essential for organizational survival and sustainability in a constantly evolving environment.

The study began by analyzing competitor intelligence and market intelligence, both of which provide Enterprises with valuable insights into their competitive environment. Sensing agility, in essence, refers to an organization's ability to quickly perceive and respond to current or potential changes in its business environment. The research further explored the contribution of competitors and market intelligence in achieving sensing agility, using a sample of food industry Enterprises in the towns of Annaba, Skikda, and El-Tarf.

The findings revealed that most enterprises studied did not fully grasp the importance of collecting information on potential strategic alliances formed by competitors. The interview results indicate the primary focus was on short-term goals and immediate profit. The information gathering was largely centered on aspects of customers and competitors that directly impacted on current profitability, highlighting a general lack of awareness regarding the long-term benefits of strategic alliances.

This oversight may stem from the fact that the decision-makers in these Enterprises are still in the early stages of developing long-term strategic thinking and have not yet adopted modern managerial perspectives or forward-looking strategies.

Nevertheless, through their practice, albeit incomplete, of the intelligence process (collection, analysis, and dissemination), these Enterprises were able to detect opportunities and threats arising from customer and competitor dynamics, enabling them to make quick decisions and adapt to environmental changes in a timely and reactive manner.

However, the information sources used by these enterprises were limited, relying primarily on customers, sales consultants, and trade fairs. The analysis process was largely based on the analyst's experience, without employing modern analytical tools and techniques that could enhance the value of insights. Regarding dissemination, information was shared exclusively through reports sent to decision-makers.

Based on the above, the study recommends the following:

- Enterprise under study must become aware of the concept and importance of strategic alliances with or among competitors and allocate financial and human resources to analyze and evaluate the potential opportunities and threats associated with such alliances.
- They should diversify their sources of information, including internal sources such as information systems and board members, and external sources like reports from industrial and trade associations.
- It is essential that Enterprises gather comprehensive information about competitors and changes in the competitive environment from multiple sources, as information forms the foundation of effective competitor and market intelligence.
- Enterprise should develop a clear strategy for collecting, analyzing, and utilizing information in making strategic decisions.
- These Enterprises should also invest in information technologies, such as artificial intelligence tools, to support advanced data analysis. This would significantly enhance the quality and speed of strategic decision-making.

To conclude, this study highlights the critical role of competitor and market intelligence in fostering sensing agility within enterprises operating in dynamic and competitive environments. While the current practices among the studied Enterprises reveal gaps in strategic thinking and intelligence

application, the findings underscore the transformative potential of structured intelligence processes. By adopting modern analytical tools, expanding information sources, and embracing a long-term strategic mindset, enterprises can enhance their responsiveness, strengthen their competitive positioning, and ensure sustainable growth in an ever-changing market landscape.

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Received for publication: 02.05.2025
Revision received: 12.05.2024
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Belahcene, H., Chaib, F. Z., & Djedid, S. (2025, 07 15). Achieving Sensing Agility Through the Integration of Competitor and Market Intelligence. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 1-16. doi:10.12709/mest.13.13.02.01

Style – **Chicago** *Sixteenth Edition:*

Belahcene, Hanene, Fatma Zohra Chaib, and Sabrina Djedid. "Achieving Sensing Agility Through the Integration of Competitor and Market Intelligence." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 1-16.

Style – **GOST** *Name Sort:*

Belahcene Hanene, Chaib Fatma Zohra and Djedid Sabrina Achieving Sensing Agility Through the Integration of Competitor and Market Intelligence [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 1-16.

Style – **Harvard** *Anglia:*

Belahcene, H., Chaib, F. Z. & Djedid, S., 2025. Achieving Sensing Agility Through the Integration of Competitor and Market Intelligence. *MEST Journal,* 15 07, 13(2), pp. 1-16.

Style – **ISO 690** *Numerical Reference:*

Achieving Sensing Agility Through the Integration of Competitor and Market Intelligence. **Belahcene, Hanene, Chaib, Fatma Zohra and Djedid, Sabrina.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 1-16.

MEST Journal
DOI 10.12709/mest.13.13.02.08

THE REALITY OF USING ARTIFICIAL INTELLIGENCE IN THE ACCOUNTING FIELD IN ALGERIA

Karima Benhaoues
University of Badji Mokhtar Annaba, Annaba, Algeria
https://orcid.org/0009-0008-5886-4406

Karim Belaid
University of Badji Mokhtar Annaba, Annaba, Algeria
https://orcid.org/0009-0005-6648-0363

JEL Category: **M42, O33.**

Abstract

This study aims to evaluate the use of artificial intelligence technologies in the accounting field, emphasizing its importance in enhancing work quality and thoroughly examining the most significant impacts of this technology on the Algerian environment. To achieve the desired objectives, professionals were interviewed through a structured questionnaire distributed to 50 individuals. The obtained opinions were carefully analyzed, and the study hypotheses were tested using the SPSS V23 statistical package. Several key conclusions were yielded in the study, the most notable being that artificial intelligence (AI) technology provides essential support to accountants and external auditors, enabling them to transition away from routine tasks. Furthermore, AI significantly contributes to professional development by facilitating new experiences and skills acquisition that expedite the efficient completion of duties and functions. Compared to traditional methodologies, AI-enhanced accounting and auditing software also facilitates the detection of significant risks by enabling AI technology to process and analyze substantial volumes of complex financial data.

Keywords: *Technology, Artificial intelligence, Accounting, Financial data, Algerian environment.*

1 INTRODUCTION

Scientific and technological progress has led institutions to adopt scientific methods, especially considering the increasing competition among institutions, where time has become one of the most significant elements that control and determine their profits, and accordingly, keeping pace with the rapid and successive development in the business environment. It has become an imperative necessity to maintain their position. Maintaining their position is essential. Given the vast volume of data and information, organizations must leverage technology to ensure efficient processing and rapid results. No doubt, relying on traditional management does not achieve this goal. This has led institutions to rely on information

Address of the corresponding author:
Karima Benhaoues
karima.benhaoues@univ-annaba.dz

and communications technology by turning to electronic management or digitization. Consequently, reliance on traditional management has diminished. Electronic information has become an effective tool for building an information society, as electronic circulation of information has been credited with achieving speed and avoiding errors.

Digitization has impacted all aspects of life, including health, journalism, and education. Naturally, the economic sector is among those adapting to these advancements. During the technological revolution in information and communications, digital technology has led to artificial intelligence, which serves to help administrators with their management. The latter plays a vital role in digital transformation and adds additional value by reducing the burden of repetitive tasks and simulating the activities performed by intelligent beings (humans), such as the ability to think and learn from the experiences of the previous stage. It also helps to achieve operational efficiency, reducing costs through its ability to process vast amounts of data and information, and provide users with various services characterized by accuracy and speed of completion, which also helps in the decision-making process.

We also find that the accounting and auditing professions were not immune to these developments in the Algerian environment. This progress has led to an increase in the interest of accountants and auditors in adopting artificial intelligence techniques. It has revolutionized the way they work. It has also led to many positive changes, including but not limited to: improving accounting and auditing procedures and methods, tracking all files without relying on paper documents, enhancing the quality of professional judgment, etc. It also enables AI to complete all accounting stages for an entire year, aligning them with approved standards, preparing necessary reports, and suggesting solutions that benefit the institution.

Despite significant technological advancements worldwide, the integration of AI in the accounting and auditing professions has not yet been adequately monitored. AI serves as an alternative that ensures business continuity and prevents disruptions in emergencies and uncertain circumstances, such as the spread of the COVID-19 pandemic, while also helping to mitigate economic and human losses.

Since accounting and auditing are among the professions most impacted by AI, its adoption is expected to enhance the ability to handle complex tasks, improve professional performance, and increase practitioners' efficiency.

1.1 Problematic of the Study

Accordingly, the research idea has emerged and can be formulated with the following main research question:

RQ1 – What is the reality of adopting artificial intelligence in accounting and auditing professions in the Algerian environment?

The following sub-questions arise from the main research question:

RQ1.1 – Do accounting and auditing offices in Algeria have the technical qualifications to utilise AI?

RQ1.2 – To what extent does AI enhance the quality of work in Algeria's accounting sector?

RQ1.3 – Does using artificial intelligence impact the auditing and accounting profession?

1.2 Hypotheses of the Study

Based on the sub-questions, the study hypotheses were formulated as follows:

H_{01}: Accounting and auditing offices in Algeria do not have the technical qualifications to enable them to use artificial intelligence.

H_{02}: Artificial intelligence does not improve the quality of work in the accounting field in Algeria.

H_{03}: Artificial intelligence use does not impact auditing and accounting professions in Algeria.

1.3 Importance of the Study

It has become more and more necessary to pay attention to modern digitization techniques because of their importance and its connection to public service, especially in light of the services it provides to project management, as the importance of the research is evident in the fact that it addresses a newly emerging topic of AI as one of the emerging technologies of digital technology and its impact on the accounting and

auditing professions, while seeking its importance in achieving efficiency and effectiveness in the accounting environment.

1.4 Objectives of the Study

This study aims to:

- Analyze the accounting and auditing professions depending on artificial intelligence techniques.
- Recognize the significant contribution of artificial intelligence in developing the practices of the accounting and auditing professions;
- Detail the crucial importance of artificial intelligence and its contribution towards improving services in the accounting and auditing domains.
- Examine the multifaceted implications of artificial intelligence techniques in the accounting environment.

1.5 Methodology of the Study

This research relies on the descriptive and analytical approach to accurately describe scientific problems and reach positive conclusions. The nature of the research topic requires collecting and summarizing data and facts related to the newly emerging scientific field of artificial intelligence, which has developed through digitization.

This study will analyze various concepts and information obtained from the Algerian environment. The authors will use suitable statistical analysis tools to process the research data.

Finally, the authors will identify key findings and propose appropriate solutions for the research.

2 IMPORTANCE OF ACCOUNTING AND AUDITING PROFESSION

2.1 Concept of Accounting Profession

The accounting profession is one of the essential functions in any company. Accountants' jobs include recording economic events, preparing company accounts, and summarizing information in financial statements to determine the company's financial position. (Patra & Panda, 2006, p. 1).

The accounting function will transform with the advent of artificial intelligence. Through this technology, an accountant may input digital representations of invoices, leading to the automated recording of transactions. Furthermore, the accounting function will increasingly emphasize financial forecasting and risk management.

2.2 Importance of the Accounting Profession

The importance and role of the accounting profession lie in providing comprehensive accounting information about a company's activities, which aids in financial planning and strategic decisions. The quality of accounting information also determines the level of transparency in corporate governance and management. (The fundamental significance and objective of the accounting profession revolve around offering comprehensive accounting information concerning a company's business activities.) Thereby facilitating financial planning and strategic decision-making. Furthermore, the quality of accounting information is a key determinant of transparency in corporate governance and management. High-quality financial reports are essential to ensuring transparency, facilitating the attraction of local and international investments, and creating a sound investment environment, which enhances investor confidence and, consequently, promotes financial stability (High-quality financial reports are paramount for ensuring transparency, facilitating the attraction of both domestic and international investments, and establishing a robust investment environment, thereby enhancing investor confidence and, as a consequence, promoting financial stability) (Dauda, Ombugadu, & Aku, 2015).

2.3 Definitions of Auditing Profession

The auditing profession is carried out by a competent, independent, and impartial professional who evaluates financial statements, internal controls, organizational structures, procedures, and company processes based on a standardized quality framework. (The auditing profession is conducted by a competent, independent, and impartial professional who issues an opinion on financial statements, internal

controls, organizational structures, procedures, or any company process, based on established quality frameworks.)

There are many definitions of the auditing profession, the most important of which are listed below:

The American Accounting Association (AAA) defines the auditing profession as "a systematic and objective process of obtaining and evaluating evidence concerning facts and economic events to verify the degree of conformity between those facts and the specific criteria and to communicate the results to users of information interested in the investigation in this regard" (Zaaich & Khelaifia, 2024).

Ayachi (2019) defined the auditing profession as the systematic examination of a particular situation by an independent and competent person to ascertain the validity of the items to be audited and to verify compliance with standards.

The auditing profession is also known as one of the most important professions in the business environment, as it is concerned with reviewing and examining a firm's financial statements to provide an opinion on the validity and integrity of those financial statements (Al-Dalabih, 2018).

2.4 Importance of *the* Auditing Profession

The importance of auditing profession lies in the fact that it is a tool that aims to serve the users of audited financial statements, who are represented by (managers, current and future investors, financial institutions, various governmental organisations, trade unions, etc.) so that they can rely on them in making diverse decisions, imposing taxes and formulating various policies (Hayder & Abdulkareem, 2022).

2.5 Accounting and Auditing Profession Integration

Accounting and auditing are two significant processes related to financial activities. Accounting is considered a mirror that reflects economic events and financial transactions, as it ensures the preparation and disclosure of financial statements.

Auditing is also considered a part of the world of accounting, which in turn contributes to ensuring the accuracy and reliability of accounting.

Unlike internal audit, which is considered an operational audit that touches all aspects of the organization's activity.

The key aspects of the relationship between accounting and auditing are as follows:

- *Interdependence.* Accounting and auditing are interrelated processes. Accounting forms the foundation of finance, ensuring the precise recording and systematic aggregation of financial transactions. In contrast, auditing provides an independent certification of the accuracy and reliability of financial statements, ensuring they adhere to established accounting procedures.
- *Verification and Assurance***.** The audit process constitutes an independent attestation, affording stakeholders a degree of confidence in the dependability of financial information. It assures that financial statements, constructed by accountants, are materially accurate, free from significant errors, and comply with accounting principles and statutory requirements.
- *Dependency*. The auditor's work is typically performed upon the completion of accounting procedures.
- *Compliance and Regulation***.** The functions of accounting and auditing are closely tied to the imperative of compliance with accounting standards, statutory regulations, and legal obligations. To precisely record and report financial transactions, accountants apply established accounting principles and standards. Auditors subsequently examine the degree of adherence of financial statements to these principles and regulatory stipulations.
- *Feedback period***.** The conclusions and proposals derived from the audit function provide substantive feedback to accountants. Through the audit process, accountants gain insights into areas where financial reporting procedures, internal controls, and overall financial governance can be improved. This knowledge helps them implement necessary refinements to enhance accuracy and compliance.

- *Inputs and outputs*. Accounting inputs are the documents and data supporting the operations, and their outputs are the financial statements. A sequential relationship exists whereby the accounting outputs are utilized as the inputs for auditing.
- *Stakeholder Trust***.** The interconnectedness of accounting and auditing is essential for building and maintaining stakeholder trust. Dependable financial reporting, substantiated by independent audits, enhances the credibility of financial information. Consequently, this heightened credibility fosters trust among investors, lenders, regulatory bodies, and other relevant stakeholders. *(Abdimusoyevich, 2023)*.

3 APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN ACCOUNTING

3.1 Definition of Artificial Intelligence

There are many definitions of artificial intelligence by academics and technical experts, the most important of which are:

John McCarthy defined artificial intelligence (AI) as a “science and engineering of creating intelligent machines" (Owonifari, Igbekoyi, Awotomilusi, & Dagunduro, 2023).

Deloitte defined Artificial Intelligence in 2017 as "the application of a set of computerised tools to perform tasks that require imitation of human intelligence", and in 2018 PwC defined artificial intelligence as "an automated system that can perceive its environment through reasoning and learning to take appropriate actions" (Dibiaggio, Nesta, & Keita, 2022).

The OECD defined artificial intelligence in 2019 as a "machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments." (Fedyk, Hodson, Khimich, & Fedyk, 2022, p. 943).

From the above definitions, artificial intelligence can be defined as a field of machine science concerned with the creation of intelligent programmes and systems that simulate human mental abilities to achieve certain goals, such as solving complex problems.

3.2 Objectives of AI

Artificial Intelligence is one of the most prominent modern technologies that has invaded many fields of life and work, so it seeks to achieve many goals, the most important of which are:

- Understanding the nature of human intelligence by creating intelligent computer programs capable of simulating human behavior;
- Develop and enhance the computer's ability to perform new functions such as solving complex problems, diagnosing issues, and making decisions; and
- Access to systems that are intelligent and behave like humans in terms of understanding and learning.

3.3 AI’s Influence on Accounting and Auditing Professions

The impact of artificial intelligence, through its many branches, on the field of accounting can be explained through the following points:

- The use of *Expert Systems (ES)* in accounting and auditing has proven beneficial. Findings indicate that expert systems enhance various aspects of accounting practice, including cash flow appraisal and investment evaluation.

  Additionally, they assist in determining financial status by interpreting financial ratios and returns and analyzing financial reports. Specialized systems are also used in taxation. Expert systems assist auditors in planning and evaluating internal controls and identifying audit risks. Detecting fraud risks and recognizing errors are crucial. Equally important is their ability to process vast, complex data, enabling external auditors to complete their work more efficiently and accurately.

- *Use of Optical Character Recognition (OCR) in accounting and auditing***.** The OCR, as previously defined, finds application within accounting to automate the character recognition process involved in the digital entry and processing of invoices. This is achieved through the invoice scanning, followed by system-based analysis to identify and interpret the data. Thanks to intelligent data mining and machine learning techniques,

OCR can also find various information in the invoice and perform accounting translation, which allows the data to be processed promptly. Optical character recognition (OCR) improves image quality, allowing the auditor to read it and allowing information to be easily indexed and retrieved.

- *Use of Robotic Process Automation (RPA) in accounting***.** Robotic Process Automation (RPA) is a valuable tool for automating various accounting procedures, including reconciling information from heterogeneous systems such as QuickBooks, electronic spreadsheets (e.g., Excel), and client invoices. To illustrate, an accounting reconciliation functionary can deploy a software agent to autonomously compare these three data origins and ascertain discrepancies with notable rapidity, frequently within a minute's timeframe. Additionally, RPA is capable of discerning irregularities and outliers, which human auditors can then investigate.
- *Use of Machine Learning (ML) in Accounting and Auditing*. Machine learning finds application in accounting for model analysis and the generation of prognostications. Software leverages machine learning techniques on an entity's historical financial disclosures, allowing the predictive model to assimilate key features and attributes of the entity's financial and non-financial datasets.

Moreover, machine learning technologies automate the entry of transactions into accounting ledgers, streamlining one of the most monotonous and labor-intensive tasks in accounting.

The implemented system permits the granular coding of accounting entries. Complex business transactions are readily susceptible to disaggregation, described through established accounting terminology, and recorded within the framework of general ledgers. (Rachid, 2024)

- *Neural Network***.** It is the field that uses neuroscience by simulating the neural networks of the human brain, so that neural networks can learn and improve performance without being explicitly instructed on how to do something (Boughazela & Ould Bahammou, 2024).
- *Deep Learning***.** Deep learning is the second generation of machine learning. It offers multiple layers of learning from the big data sets it processes, refining the decisions and data classifications in each layer to produce an accurate and clear vision (Farahani & Esfahani, 2022).
- *Continuous Auditing***.** It is indicated that Continuous Auditing is a thorough electronic auditing method allowing auditors to provide some level of assurance on continuous data during or shortly after its disclosure, highlighting its association with paperless accounting information systems, significant technical hurdles, lack of standards and guidance, increased value of real-time financial information, and timely audit reports.
- *Decision Support* Systems. A Decision Support System (DSS) is defined as a computerized system engineered to automate aspects of the decision-making process. This multi-disciplinary system is engineered to address unstructured management problems and enhance the efficacy of decision-making processes. Its principal objective is the generation of diverse alternatives and potential outcomes to facilitate informed decision-making, thereby reducing reliance on purely manual human judgment. Decision Support Systems find application in numerous unstructured tasks within the domains of accounting and auditing.
- *Hybrid Systems*. Audit tasks exhibit heterogeneity in their nature, with specific tasks necessitating quantitative analysis, while others demand qualitative assessment, and a subset requiring an integrated approach encompassing both methodologies. Under such circumstances, a hybrid system integrating diverse AI technologies proves more efficacious. (Hasan, 2022)

3.4 Developing the accounting and auditing professions by using artificial intelligence

The use of artificial intelligence can contribute to the development of the accounting and auditing professions through several factors, the most important of which are:

- *Automate various tasks*. Various AI branches can be used to perform repetitive, rule-based tasks more efficiently and with fewer errors. By incorporating these automated tasks into the accounting and auditing processes, it is

possible to achieve reliable results. Automation enhances the efficiency of auditing and accounting but also offers the possibility of obtaining equally reliable results when combined with human control.

- *Reduce time and improve accuracy.* Leveraging traditional statistical techniques to analyse large amounts of data requires a significant investment of time from accountants and auditors to perform the necessary tests. By using artificial intelligence to analyse big data, accountants and auditors can reduce the time spent on auditing and accounting, thereby reducing costs and enhancing efficiency (Aitkazinov, 2023).
- *Reduce sampling risk.* Auditors use audit sampling techniques, which carry the risk of not detecting material misstatements in untested items. With the help of artificial intelligence systems, external auditors can examine an entire population, reducing the risk of overlooking material misstatements to verify the completeness and accuracy of the firm's transactions.
- *Fraud detection capability*. Artificial Intelligence and machine learning (ML) are used to infer fraud in financial statements by enhancing the efficiency of data analysis models and by studying financial statements and recognizing underlying patterns that indicate fraudulent activity. These techniques can effectively detect signs of fraudulent activity. (Ramzan, 2023).

Artificial Intelligence also offers numerous opportunities for the accounting sector. AI allows software to learn through experience and perform tasks. It has become a powerful tool for analyzing and automating the Accounting Function. (Dongre, Pandey, & Gupta, 2021).

3.5 Challenges facing AI technology in the accounting field

Despite its benefits, implementing AI in bookkeeping and financial reporting comes with challenges. Integrating AI with existing frameworks presents a significant obstacle. Many organizations employ legacy systems that necessitate costly and laborious modifications due to their incompatibility with contemporary AI innovations. Furthermore, a notable deficit in staff capabilities exists, and to effectively leverage AI innovations, the World Economic Forum has emphasized the necessity of upskilling bookkeepers and financial professionals.

This encompasses specialized guidance and a more profound understanding of artificial intelligence and data analytics. Information assurance and security also present critical impediments. Robust network security safeguards are essential, given that AI frameworks handle sensitive financial information. Organizations express concern regarding the potential for breaches to impede the adoption of AI innovation and the subsequent economic and reputational risks (Pandey & Rana, 2024).

4 THE EXPLORATORY STUDY

4.1 Methodology and Study Population

This study relied on the descriptive and content analysis method, where data were collected through a questionnaire and analysed using the SPSS program.

The study population consisted of accounting professionals in the Algerian environment, including accounting experts, external auditors, and certified public accountants.

Regarding the sample, it was not predetermined due to the low response rate from professionals, either due to refusal or procrastination. Instead, we aimed to align the number of returned questionnaires with an acceptable percentage. A total of 50 questionnaires were distributed, and Table 1 presents the approved questionnaire statistics.

Table 1. Questionnaire Statistics

Type of questionnaires	Distributed questionnaires	Unreturned questionnaires	Cancelled questionnaires	Analysable questionnaires
Repetition	50	5	5	40
Ratios	100 %	12.5 %	12.5 %	75%

Source: Table created by the researchers based on the questionnaire responses.

The questionnaire consists of two main sections:

- The first section includes demographic data (educational qualification, job title, and work experience).
- The second section includes three axes that will answer the study's hypotheses.

4.2 Measuring the Stability of the Study Tool

Cronbach's alpha coefficient was used to verify the reliability of the study tool (questionnaire), as represented in the following table:

Table 2. Cronbach's alpha stability coefficient results for the three axes

Questionnaire axes	Number of phrases	Cronbach's alpha value
The first axis	8	0.912
The second axis	6	0.899
The third axis	6	0.794
All Axes	**20**	**0.941**

Source: Researchers' elaboration based on SPSS V23 results.

Table 2 represents the Cronbach's alpha reliability coefficient for all the questionnaire axes reached (0.941), which is a very high value and indicates the reliability and stability of the questionnaire.

4.3 Analyzes the Results of the Study

4.3.1 Descriptive analysis of the personal variables of the study sample:

Table 3 highlights the scientific degree of the study sample:

Table 3. Scientific degree of the study sample

Educational qualification	Number	The ratio %
Baccalaureate	10	25
Master	22	55
PhD	8	20
Total	**40**	**100**

Source: Researchers' elaboration based on SPSS V23 results.

Table 3 demonstrates that the greater part of the respondents have a master's and bachelor's degrees, representing 55% and 25% respectively. It indicates that the respondents have an educational level that is useful in relying on their opinions.

Table 4 highlights the professional experience of the study sample:

Table 4. Professional experience of the study sample

Professional experience	Number	The ratio %
Less than 10 years	17	42.5
Between 10 and 20 years	14	35.0
Over 20 years	9	22.5
Total	**40**	**100**

Source: Researchers' elaboration based on SPSS V23 results.

Table 4 illustrates that the respondents representing 42.5% of the total sample have less than 10 years of work experience, which is the largest percentage of the study sample, followed by the 10 to 20 years category representing 35% of the total sample, while more than 20 years of professional experience group was of 22.5%. This explains that there is diversity in the gained professional experience among the respondents.

Table 5 highlights the professional practice of the study sample.

Table 5. Professional practice of the study sample

Professional practice	Number	The ratio %
External auditors	17	42.5
Accounting experts	15	37.5
Certified accountants	8	20
Total	**40**	**100**

Source: Researchers' elaboration based on SPSS V23 results.

Table 5 shows that most of the sample members were external auditors, who accounted for 42.5%, and concerning accounting experts, their percentage was 37.5%, while 20% were in the category of legal accountants.

4.3.2 Presentation and Analysis of Study Results

The results of the *first axis*, regarding the technical qualifications of professionals in the Algerian environment, were compiled as represented in the following table:

Table 6. Sample members' answers related to the first axis

Nº	Phrase	Arithmetic mean	Standard deviation	Rank	Trend
1	Your office uses some artificial intelligence techniques in accounting and auditing.	3.15	1.282	8	Neutral
2	Your office is interested in introducing advanced artificial intelligence software to improve accounting and auditing services.	3.20	1.322	7	Neutral
3	Your office constantly conducts training courses to keep up to date with artificial intelligence technology.	3.29	1.401	5	Neutral
4	Your office provides many experts to develop accounting and auditing information systems into smart systems.	3.32	1.356	4	Neutral
5	Artificial intelligence in your office is compatible with the requirements of the digital infrastructure in the Algerian environment.	3.27	1.283	6	Neutral
6	Artificial Intelligence technology provides the necessary assistance to accountants and external auditors.	3.63	0.982	1	Agree
7	Artificial Intelligence applications accurately provide accountants and external auditors with the necessary information.	3.60	1.007	2	Agree
8	Guided by artificial intelligence in accounting and auditing saves time and reduces effort.	3.43	1.124	3	Agree

Source: Researchers' elaboration based on SPSS V23 results.

We note from Table 6, which represents the opinions of professionals about the first axis, that a general neutral arithmetic mean of 3.36 and standard deviation of 1.219 was recorded, which indicates to some extent the respondents neutral on the accounting and auditing offices in the Algeria possess technical qualifications that allow them to apply artificial intelligence.

Concerning the order of the phrases, the sixth phrase “Artificial Intelligence technology provides the necessary assistance to accountants and external auditors” ranked first with a arithmetic mean of 3.63 and a high level of agreement, followed by the seventh “Artificial Intelligence applications provide accountants and external auditors with the necessary information accurately” which ranked second with a arithmetic mean of 3.60 and a high level of agreement, and the first phrase “Your office use some artificial intelligence techniques in accounting and auditing” ranked last with a arithmetic mean of 3.15. This indicates that accounting and auditing firms favor the use of artificial intelligence due to the benefits that artificial intelligence brings to these professions. To fully adopt and benefit from it, some obstacles must be removed.

The results of the *second axis*, which examined the contribution of artificial intelligence in improving the quality of the accounting and auditing professions, can also be summarized and illustrated in Table 7.

Table 7 presents professionals' opinions on the second axis, showing a high arithmetic mean of 3.61 and a standard deviation of 1.028. These values suggest a general agreement among respondents with the included statements.

Table 7. Sample members' answers related to the second axis

Nº	Phrase	Arithmetic mean	Standard deviation	Rank	Trend
9	Artificial intelligence enhances the professional growth of accountants and external auditors by enabling them to acquire new expertise and skills.	3.93	0.547	1	**Agree**
10	Artificial intelligence-powered accounting and auditing programs help identify various material risks.	3.17	1.523	6	**Neutral**
11	Artificial intelligence contributes to solving complex accounting and auditing issues promptly.	3.73	0.892	2	**Agree**
12	Artificial intelligence efficiently analyzes large financial datasets in a short time.	3.43	1.633	5	**Agree**
13	Artificial intelligence enables the shift from traditional auditing to modern continuous auditing.	3.70	0.493	3	**Agree**
14	Accountants and external auditors perform their work with the skill and care necessary for artificial intelligence use.	3.50	1.086	4	**Agree**

Source: Researchers' elaboration based on SPSS V23 results.

Concerning the order of the phrases, the ninth phrase “Artificial intelligence contributes to the professional development of accountants and external auditors through the acquisition of new expertise and skills” ranked first with an arithmetic mean of 3.93 and a high level of agreement, followed by the eleventh “Artificial intelligence contributes to solving complex accounting and auditing issues in time” which ranked second with an arithmetic mean of 3.73 and a high level of agreement. This explains that all respondents are convinced that AI has the potential to improve the quality of accounting and auditing through automation, which has become a convenient way to perform all their tasks.

And the tenth phrase “Artificial Intelligence-powered accounting and auditing programmes allow for the detection of various material risks” ranked last with a arithmetic mean of 3.17, so this explains the neutrality of the respondents to this phrase, as they recognise that (AI) can detect various intrinsic risks, But the area of professional doubt for the individual remains the fundamental difference with artificial intelligence technology The individual's capacity for professional doubt remains the fundamental difference compared to artificial intelligence technology.

The results of the third axis, which highlighted the most prominent risks related to artificial intelligence in accounting, can be summarized in Table 8.

We note from Table 8, which shows the opinions of professionals about the third axis, that it recorded a high arithmetic mean of 3.45 and a standard deviation of 1.243.

This suggests, to some extent, that participants agree AI in the accounting field entails many risks, such as inadequate protection of digital financial data.

Table 8. Sample members' answers related to the third axis

N°	Phrase	Arithmetic mean	Standard deviation	Rank	Trend
15	Artificial intelligence systems used in accounting and auditing are vulnerable to security and privacy threats.	3.80	1.085	1	**Agree**
16	Artificial intelligence could replace accountants and external auditors.	2.90	1.390	6	**Neutral**
17	The use of artificial intelligence has negative repercussions on the future of the accounting profession.	3.30	1.114	5	**Neutral**
18	The collection and storage of financial data by artificial intelligence leads to ethical violations.	3.63	1.292	2	**Agree**
19	The use of artificial intelligence in accounting and auditing is leading to increased reliance on digital decisions.	3.52	1.499	4	**Agree**
20	Using artificial intelligence in accounting may impact on the decisions of financial data users.	3.56	1.079	3	**Agree**

Source: Researchers' elaboration based on SPSS V23 results.

The fifteenth statement, "AI systems used in accounting and auditing are vulnerable to security and privacy threats," ranked first with an arithmetic mean of 3.80, and a high level of agreement, followed by the eighteenth "The collection and storage of financial data by artificial intelligence leads to ethical violations" which ranked second with an arithmetic mean of 3.63 and a high level of agreement, and the sixteenth phrase "Artificial intelligence could replace accountants and external auditors" ranked last with a arithmetic mean of 2.90.

4.3.3 Distributional Normality Test

To ensure that the data follow a normal distribution, we performed the Kolmogorov-Smirnov test to verify that the data follow a normal distribution, as shown in Table 9.

Table 9. Normal distribution test

All Axes	Kolmogorov-Smirnov Test	
	Statistics	Sig
	0.112	0.161

Source: Researchers' elaboration based on SPSS V23 results.

Table 9 shows that all study axes obtained a Sig value greater than the significance level (0.05). Therefore, it is concluded that the study sample data is subject to normal distribution.

4.4 Testing the Study Hypotheses

We chose a one-sample t-test at a significance level of 0.05, which is the appropriate test for the study hypotheses, so the theoretical t-value was estimated at 2.021.

4.4.1 Testing the First Main Hypothesis

The null hypothesis, H_0 and the alternative hypothesis H_1, were formulated as follows:

H_0: Accounting and auditing offices in Algeria do not have the technical qualifications to enable them to use artificial intelligence.

H_1: Accounting and auditing offices in Algeria have technical qualifications that enable them to use artificial intelligence.

According to Table 10, the alternative hypothesis was rejected. Consequently, the null hypothesis, which states that accounting and auditing offices in Algeria do not have the technical qualifications to enable them to use artificial intelligence, was accepted.

Table 10. T-test results for the first main hypothesis

The Axis	T theoretical	T calculated	Df	Sig
Technical qualifications of professionals in Algeria.	2.021	0.216	39	**0.653**

Source: Researchers' elaboration based on SPSS V23 results.

This acceptance is attributed to the calculated p-value of 0.216, which exceeds the conventional significance level (e.g., α = 0.05), indicating insufficient statistical evidence to reject the null hypothesis. The theoretical t-value of 2.021 from the Student's t-test is relevant for determining the critical region, but is not directly compared to the t-value for the acceptance/rejection decision in this manner.)

4.4.2 Testing the Second Main Hypothesis

The null hypothesis, $H_{0,2}$ and the alternative hypothesis $H_{1,2}$, were formulated as follows:

$H_{0,2}$: Artificial intelligence does not improve the quality of work in the accounting field in Algeria.

$H_{1,2}$: Artificial intelligence does improve the quality of work in the accounting field in Algeria.

Table 11. T-test results for the second main hypothesis

The Axis	T theoretical	T calculated	Df	Sig
Enhancing the quality of accounting and auditing professions using artificial intelligence in Algeria.	2.021	3.669	39	**0.000**

Source: Researchers' elaboration based on SPSS V23 results.

According to Table 11, the null hypothesis was rejected due to the calculated t-statistic of 3.669, which exceeded the critical t-value of 2.021. Therefore, the alternative hypothesis, asserting that artificial intelligence enhances the quality of work within the accounting field in Algeria, is accepted.

4.4.3 Testing the Third Main Hypothesis

The third hypothesis, H_{03} and the alternative hypothesis $H_{1,3}$, were formulated as follows:

$H_{0,3}$: The use of artificial intelligence does not impact on the auditing and accounting professions in Algeria.

$H_{1,3}$: The use of artificial intelligence impacts the auditing and accounting professions in Algeria.

Table 12. T-test results for the third main hypothesis

The Axis	T theoretical	T calculated	Df	Sig
The risks resulting from the use of artificial intelligence in accounting and auditing professions in Algeria.	2.021	2.27	39	**0.001**

Source: Researchers' elaboration based on SPSS V23 results.

According to Table 12, it can be said that the hypothesis stating that the use of artificial intelligence has repercussions on the accounting and auditing professions in Algeria, based on the calculated *t* results that were greater than the theoretical *t*, as follows: 2.27 and 2.021, respectively.

5 CONCLUSIONS

The study concluded that the adoption of artificial intelligence within the accounting field results in enhanced professional performance, consequently yielding work outputs of elevated quality, thereby fostering confidence in their professional contributions, while it was found that there are not enough technical qualifications for the adoption of artificial intelligence by accounting and auditing offices in Algeria due to the absence of a digital structure prepared to apply this technology, The main findings of this study can be summarised as follows:

- Compared to traditional methods, artificial intelligence in accounting helps complete duties and tasks quickly.
- Artificial Intelligence can process and analyse vast amounts of financial data.
- Artificial Intelligence provides accountants and auditors with the opportunity to move away from repetitive tasks and focus on delivering more value-added services.
- Lack of technical qualifications to allow accounting and auditing offices to adopt artificial intelligence technology in the Algerian environment.
- The two professions also face many risks that hinder their application, such as not protecting financial data and ensuring its security.

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Received for publication: 12.05.2025
Revision received: 19.05.2024
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Benhaoues, K., & Belaid, K. (2025, 07 15). The Reality of Using Artificial Intelligence in the Accounting Field in Algeria. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 17-30. doi:10.12709/mest.13.13.02.08

Style – **Chicago** *Sixteenth Edition:*

Benhaoues, Karima, and Karim Belaid. "The Reality of Using Artificial Intelligence in the Accounting Field in Algeria." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 17-30.

Style – **GOST** *Name Sort:*

Benhaoues Karima and Belaid Karim The Reality of Using Artificial Intelligence in the Accounting Field in Algeria [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 17-30.

Style – **Harvard** *Anglia:*

Benhaoues, K. & Belaid, K., 2025. The Reality of Using Artificial Intelligence in the Accounting Field in Algeria. *MEST Journal,* 15 07, 13(2), pp. 17-30.

Style – **ISO 690** *Numerical Reference:*

The Reality of Using Artificial Intelligence in the Accounting Field in Algeria. **Benhaoues, Karima and Belaid, Karim.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 17-30.

MEST Journal
DOI 10.12709/mest.13.13.02.06

THE IMPACT OF DIGITAL COMMUNICATION ON THE EFFECTIVENESS OF BUSINESS NEGOTIATIONS

Srdjan Blagojevic
Higher Business School of Vocational Studies "Cacak", Belgrade, Serbia

Albina Kecman
Higher Business School of Vocational Studies "Cacak", Belgrade, Serbia

JEL Category: **D83, M21, M54, O33**

Abstract

This paper explores the impact of digital communication on the effectiveness of business negotiations, emphasizing its advantages, challenges, and strategies for optimization. Digital platforms, such as Zoom, Microsoft Teams, and email, have transformed negotiations by overcoming geographical and logistical barriers, enabling time and cost savings, facilitating asynchronous communication, and promoting greater inclusivity. However, challenges such as reduced nonverbal cues, technical issues, cultural misunderstandings, and limited emotional connection can impede negotiation outcomes. Using descriptive scientific methods, including analysis, synthesis, induction, and deduction, the study integrates findings from literature and case studies to propose practical strategies. These include establishing clear communication protocols, prioritizing video calls, training staff on cultural sensitivity, combining synchronous and asynchronous channels, and leveraging emerging technologies such as artificial intelligence and virtual reality. The paper concludes that while digital communication offers significant opportunities, careful management of its limitations is crucial to maximizing the effectiveness of negotiation, with further research needed on cultural influences, AI applications, and long-term effects on business relationships.

Keywords: *Digital Communication, Business Negotiations, Digital Platforms, Cultural Differences.*

1 INTRODUCTION

In the contemporary business environment, digital communication has become a cornerstone of business negotiations, enabling organizations to overcome geographical, temporal, and logistical

Address of the corresponding author:
Srdjan Blagojevic
srdjan@hotmail.ca

barriers. Platforms such as Zoom, Microsoft Teams, email, and instant messaging applications like Slack facilitate rapid and efficient information exchange, thereby altering the dynamics of negotiation. While traditional face-to-face negotiations offer a wealth of nonverbal cues and emotional manifestation, digital channels introduce flexibility but also challenges such as reduced trust, technical issues, and misunderstandings due to limited nonverbal communication (Gelfand & Brett, 2004). This paper examines the impact of digital communication on the effectiveness of business negotiations, highlighting its benefits, challenges, and strategies for enhancing the negotiation process.

The paper aims to provide a comprehensive insight into the impact of digital tools and applications on business negotiations, comparing them with traditional methods and identifying factors that contribute to or hinder communication effectiveness. Special attention is given to the cultural, psychological, and technical aspects of negotiations using digital communication, as well as the potential of emerging technologies, such as artificial intelligence and virtual reality, to enhance business effectiveness. By examining relevant literature and real-world case studies, this paper aims to provide actionable insights and strategic guidance for negotiators navigating the digital era.

2 RESEARCH METHODS

This paper employs descriptive scientific methods, including analysis, synthesis, induction, and deduction. Analysis was conducted to understand the complex aspects of digital communication, including its impact on nonverbal cues and emotions during negotiations. Synthesis was used to integrate findings from various sources, including scientific articles, books, and case studies, to form a coherent picture of the topic (Thompson, 2021). An inductive approach enabled the derivation of general conclusions based on specific examples, such as successful digital negotiations in global companies. Deduction was used to apply theoretical frameworks, such as negotiation principles from the literature to practical situations in a digital context. The literature review encompasses a wide range of sources, from classic works on negotiation to contemporary studies on digital technologies, providing a solid foundation for analysis.

3 DIGITAL COMMUNICATION: TRANSFORMING THE NEGOTIATION PROCESS

Digital communication has enabled business negotiators to overcome traditional limitations, such as the need for physical presence and time-consuming traveling. Applications like Zoom and Microsoft Teams allow for instant meeting organization, regardless of participants' geographical distance. For instance, global companies such as IBM and Deloitte frequently utilize virtual platforms for discussions with clients and negotiations with partners, thereby saving significant costs and time (Fisher, 1981). This flexibility enables the inclusion of more diverse teams, including experts who might not be able to attend physical meetings, contributing to better business decisions.

However, negotiations using digital platforms are not without challenges. The lack of nonverbal cues, such as body language, facial expressions, and tone of voice, can significantly affect the understanding of intentions and emotions (Gelfand & Brett, 2004). For instance, a case study on negotiations between an American and a Japanese company showed that misunderstandings arose due to the inability of video calls to fully convey subtle signals stemming from different cultural customs, such as pauses in a speech that Japanese negotiators often use to express respect. Technical issues, such as interrupted connections or poor audio quality, further complicate the process, frequently causing frustration and even disrupting the flow of negotiations.

Additionally, digital communication can lead to misperceptions of authority and power. In traditional negotiations, physical presence and spatial dynamics (e.g., seating arrangements) often play a role in presenting hierarchy. In a digital environment, these signals are less prominent,

which can lead to a more egalitarian but sometimes less structured dialogue. This can be an advantage in collaborative negotiations but may be confusing in situations where a clear hierarchy is important (Kolb, 2015).

4 ADVANTAGES OF DIGITAL COMMUNICATION

Digital communication brings a range of advantages that significantly enhance the effectiveness of business negotiations. Time and cost savings are substantial. Virtual meetings eliminate the need for travel, enabling faster decision-making and reducing logistical costs (Lewicki, 2024). For example, a study on global supply chains showed that companies using digital platforms for negotiations with suppliers reduced coordination costs by 30% compared to those using traditional methods.

The ability to record and archive meetings improves project tracking. Platforms like Zoom allow negotiators to record discussions, facilitating follow-up and reducing the risk of misunderstandings. This is particularly useful in complex negotiations involving numerous details, such as partnership agreements or company mergers and integrations.

Digital communication also enables asynchronous information exchange, which can be crucial in negotiations between parties in different time zones. Email and applications like Trello or Asana allow negotiators to send and review messages at their convenience, reducing pressure on employees (Patton, 1999). This facilitates better-prepared and more thoughtful responses, enhancing the quality of agreements while minimizing the risk of future issues or questions.

Ultimately, digital tools facilitate broader participation, allowing experts from diverse fields to contribute seamlessly to the negotiation process. For example, in negotiations about a technical project, engineers, lawyers, and financial analysts can easily join via video calls, providing diverse perspectives and reducing the risk of overlooking key details. This inclusivity can lead to more innovative solutions and stronger partnerships.

5 CHALLENGES OF DIGITAL COMMUNICATION

Despite its numerous advantages, digital communication presents significant challenges that may undermine the effectiveness of negotiations. One of the most pressing issues is the markedly diminished emotional connection. The absence of physical presence complicates the process of building trust, which is fundamental to negotiations involving collaboration or conflict resolution—especially in cultural contexts where interpersonal rapport plays a critical role in decision-making (Ury, 1999). For instance, a study on virtual negotiations between European and Asian companies found that participants frequently perceived a lack of empathy in digital interactions, which consequently prolonged negotiations and led to less favorable outcomes. (Gelfand & Brett, 2004).

Ambiguous communication is also possible and poses a potential for misunderstandings. Text-based communication, such as email or messaging, is prone to misinterpretation due to the absence of nonverbal cues and emotional context (tone or intent). For instance, a hastily written message may appear overly direct or even offensive, despite the sender's intentions (Thompson, 2021). This is particularly problematic in negotiations involving participants from different cultures, where varying communication norms can lead to misunderstanding.

Technical issues present an additional obstacle. Disrupted connections, poor audio quality, or faulty equipment can interrupt the flow of negotiations, causing frustration and loss of focus. For example, during negotiations, technical problems can create an impression of unprofessionalism, which may undermine trust between parties. These issues require greater attention to preparation, equipment testing, and securing backup communication channels.

Psychological factors also play a significant role in digital communication. Such negotiations can evoke feelings of isolation or reduced motivation, especially if meetings are prolonged or participants are not fully engaged. The difference lies in whether the negotiator's income depends on the outcome or

if that is not their primary motivation. This phenomenon, referred to as 'Zoom fatigue,' became widespread during the COVID-19 pandemic when virtual meetings became increasingly intensive. This diminishes negotiators' focus, leading to unproductive discussions.

6 STRATEGIES FOR ENHANCING EFFECTIVENESS

To overcome the challenges posed by digital communication, negotiators can adopt a range of strategies, including:

- *Establishing clear communication rules at the start of negotiations*. This is crucial for avoiding misunderstandings. It involves agreeing on the use of specific tools (e.g., Zoom for meetings and email for formal proposals) and protocols for addressing technical issues, such as switching to an alternative platform in case of failure (Zartman, 2007).
- *Using video calls instead of relying solely on text-based communication*. This can help preserve nonverbal cues. While video calls cannot fully replace physical presence, they enable participants to see each other's facial expressions and gestures, which aids in building trust (Ury, 1999). For example, companies like Google use video calls for partnership negotiations and training employees to maximize visual and verbal communication.
- *Training employees on the use of digital tools and understanding cultural differences*. Cultural sensitivity is crucial in international negotiations, where different norms can affect message perception. For instance, in some cultures, such as Japanese, a pause during conversation may signal respect, while in Western cultures, it may be interpreted as uncertainty (Gelfand & Brett, 2004). For example, companies like Meta are developing VR-based collaboration tools for business meetings, which could transform the way professionals interact in the future.
- *Combining synchronous and asynchronous communication channels*. This increases flexibility. Participants can use video calls for critical discussions, while email should be used for exchanging contract drafts or detailed proposals. This strategy enables negotiators to tailor their approach to specific needs, reducing pressure for immediate responses and ultimately leading to better preparation (Malhotra, 2020).
- *Investing in new technologies*. Platforms using artificial intelligence, such as tools for tone analysis or real-time automatic translation, can help overcome linguistic and emotional barriers. Augmented reality (AR) and virtual reality (VR) also offer the potential for realistic virtual meetings, where participants can simulate physical presence. For example, companies like Meta are developing virtual reality solutions for business meetings, which could revolutionize future collaboration.
- Culture shapes negotiation processes and outcomes by influencing how negotiators perceive interests, power, and acceptable behaviors. (Gelfand & Brett, 2004).
- Effective global negotiation strategies require leaders to adapt their approaches to diverse cultural norms while maintaining a focus on mutual value creation. (Saee, 2008).

Finally, organizations should establish regular evaluations of their digital communication and negotiation policies, with an emphasis on corporate information security. This may include feedback from participants, analysis of negotiation performance, and identification of areas for improvement. For instance, companies can use anonymous post-communication surveys to determine whether technical or communication issues affect outcomes.

7 CASE: BUSINESS NEGOTIATION AT DM DROGERIE D.O.O.

The work of Sara Vrbat (2021) provides a comprehensive analysis of the role of successful business negotiation, using DM Drogerie d.o.o.'s operations in Croatia as a case study. As one of the leading retail chains, DM prioritizes the development of its employees' negotiation skills to achieve optimal business outcomes amid intensifying market competition. This case study provides insight into how a strategic approach to

negotiation can contribute to a company's success, with a particular emphasis on the flexibility of negotiation strategies in a hybrid environment.

DM Drogerie d.o.o. in Croatia has established a negotiation principle based on the individual contributions of each organizational unit. According to the study, every department within the company, from procurement to marketing, conducts independent negotiations with suppliers, partners, and other departments. These negotiations aim to secure the best possible terms, whether related to prices, delivery timelines, or collaboration conditions. The key element of success lies in the employee's ability to adapt their negotiation strategies to specific needs.

For example, the procurement department negotiates with suppliers to secure competitive prices and required delivery timelines. These negotiations require a combination of analytical skills, including assessing market trends and costs, and interpersonal skills, such as building trust with business partners. On the other hand, the marketing department may negotiate with media houses or influencers regarding advertising terms, which requires a different approach focused on creativity and distinctiveness.

Flexibility is a fundamental element of DM's negotiation strategy. Although the study does not explicitly mention a hybrid environment, it emphasizes the importance of adapting to different communication channels and contexts. This flexibility allows employees to conduct negotiations effectively, whether in person, via email, or through digital platforms such as video calls.

Successful negotiation at DM also requires technical readiness, and the company invests in providing the necessary technological tools, such as reliable internet connections, high-quality webcams, and video conferencing software, as well as employee training.

8 CONCLUSIONS

Digital communication has profoundly transformed business negotiations, bringing unprecedented flexibility, resource savings, and global connectivity. Advantages such as reduced costs, asynchronous negotiation, and inclusivity enable organizations to manage complex business relationships more efficiently. However, challenges such as reduced emotional connection, misunderstandings due to text-based communication, technical difficulties, and psychological factors like digital communication fatigue (e.g., Zoom communication fatigue) require careful management.

To overcome these challenges, several strategies can be implemented. Clear communication protocols, video conferencing, and cultural sensitivity training help bridge gaps in digital negotiations. Additionally, combining synchronous and asynchronous channels, along with investments in emerging technologies, ensures greater efficiency and adaptability in the negotiation process. It is imperative to invest in developing tools that enhance emotional and nonverbal communication, such as AI and VR platforms, which have the potential to bridge the gap between digital and traditional.

Future research should focus on several key areas: First, further study of the impact of cultural differences on digital negotiations, particularly in the context of new technologies, is needed. Second, research should explore how AI tools can improve the analysis of emotions and tone in negotiations. Third, it is essential to examine the long-term implications of utilizing digital platforms in business negotiations, with a particular emphasis on factors such as trust and loyalty. In conclusion, organizations should establish standardized frameworks for training negotiators in digital environments, ensuring they are adequately equipped to handle future challenges.

As digital communication continues to shape the business world, the human element—trust, empathy, and collaboration—remains the core of every successful negotiation. By combining technological innovations with a strategic approach, negotiators can harness the full potential of digital platforms while preserving the key aspects of human communication.

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Received for publication: 22.05.2025
Revision received: 14.06.2024
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Blagojevic, S., & Kecman, A. (2025, 07 15). The Impact of Digital Communication on the Effectiveness of Business Negotiations. *MEST Journal, 13*(2), 31-36. doi:10.12709/mest.13.13.02.06

Style – **Chicago** *Sixteenth Edition:*

Blagojevic, Srdjan, and Albina Kecman. "The Impact of Digital Communication on the Effectiveness of Business Negotiations." *MEST Journal* (MESTE) 13, no. 2 (07 2025): 31-36.

Style – **GOST** *Name Sort:*

Blagojevic Srdjan and Kecman Albina The Impact of Digital Communication on the Effectiveness of Business Negotiations [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 31-36.

Style – **Harvard** *Anglia:*

Blagojevic, S. & Kecman, A., 2025. The Impact of Digital Communication on the Effectiveness of Business Negotiations. *MEST Journal,* 15 07, 13(2), pp. 31-36.

Style – **ISO 690** *Numerical Reference:*

The Impact of Digital Communication on the Effectiveness of Business Negotiations. **Blagojevic, Srdjan and Kecman, Albina.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 31-36.

MEST Journal
DOI 10.12709/mest.13.13.02.03

REJOINDER TO JOFFE ON THE COMPATIBILITY OF LIBERTARIANISM AND ZIONISM

Walter E. Block
Harold E. Wirth Eminent Scholar Endowed Chair and Professor of Economics, Loyola University New Orleans, New Orleans, LA, USA
https://orcid.org/0000-0003-2215-4791

JEL Category: **Z0**

Abstract

Joffe in "Libertarianism and Zionism Can't Be Squared" maintains an either-or position on Zionism and libertarianism: you must choose one or the other, you cannot support both. If you do, you are illogical. Then he goes on to drive a wedge between the two. He mentions numerous arenas in which they supposedly divide. For example, the Israeli military's harsh response to the atrocities of October 7, 2023, is incompatible with libertarianism. The citizens of that country are Zionists, and they mistreat the Palestinians in numerous ways. But this thesis fails since highly respected libertarians, leaders of this movement, disagree with one another. Both cannot be correct, one of them must necessarily be taking an anti-libertarian position. For example, Ron Paul is pro-life, and Murray Rothbard is pro-choice. Any theory that claims one or the other of them is not a libertarian, such as Joffe's thesis does, is dead upon arrival. The present paper maintains, moreover, that there is no logical contradiction between the two as to the specifics. Namely, this author is in error in his condemnation of the Israeli citizenry and the IDF.

Keywords: *Zionism; libertarianism; logical coherence, Israel, contradiction.*

1 INTRODUCTION

Joffe (2024) is a very important essay. Its very title clearly explains why. There are many issues upon which libertarians disagree with one another. For the most part, in virtually all cases, they do so without being disagreeable to one another. The Israel-Hamas war in particular, and Zionism in general, is a sharp exception to this general rule. I myself am a case in point in this regard. No physical violence has of yet been employed against me, at least not so far. However, I have been brutally treated,[1] and disassociated from people and institutions with whom I have had a long, friendly, productive, and very satisfactory association. Included in this category are the Mises Institute, the Ron Paul Institute, the

Address of the author:
Walter E. Block
wblock@loyno.edu

[1] Verbally, only, unlike how for example Charles Murray has been dealt with by his intellectual enemies.

Libertarian Institute, and such individuals as Ron Paul, Hans Hoppe, Thomas DiLorenzo, Michael Rectenwald, Daniel McAdams, Scott Horton, Hunter DeRensis, and Ryan McMaken.

Interestingly, the breakups have all been in one direction. Libertarians who favor Hamas have jettisoned relationships with those who have taken sides with Israel. I know of no cancellations in the opposite direction. That is, to the best of my knowledge no libertarian Zionist has broken with any of his opposite numbers. I attribute this phenomenon to Israeli Derangement Syndrome (Futerman & Block, 2024).

It is thus very important that Joffe has written this essay of his. All libertarians owe him a debt of gratitude. I think his views are so important that I take the liberty of quoting, and replying to, every single last word, bar none, that he writes. I do so under the following headings: Section II: Chosen people. III. Impossible task. IV. Zionism. V. Religious establishment. VI. Martial law. VII. Equal rights. VIII. Bottles of urine. IX. Settler violence. X. Just fine treatment. XI. Group punishment. XII. Ancient texts. XIII. Invalid ancestral claims. XIV. Complex rationalizations. XV. Zionism or libertarianism. XVI. Conclusion

2 CHOSEN PEOPLE

Joffe: “Jews are the chosen people. God promised us the land of Israel, the only place we can truly be safe.”

Yes, in some ways we are indeed the chosen people. When God, or whoever it was, handed out IQ points, (Ashkenazi) Jews were at the head of the queue, and were given far more than our fair proportionate share of this characteristic. Evidence for this claim is that we Hebrews, on a basis proportionate to our population, have won more Nobel Prizes, more Fields Medals in mathematics, more chess grand masterships, have been responsible for more patents, more medical breakthroughs, more contributions to STEM fields, than any other group on the planet.[2] Nor are we too far behindhand when it comes to music, the arts, literature, philosophy, law, academia, computers, and other intellectual pursuits.

As an atheist, I cannot believe that God provided us with anything. Can one be either an atheist or a believer and still enjoy a valid libertarian standing? I do not see why not. I define libertarianism as a belief in and support of, the non-aggression principle (NAP) and in private property rights based upon homesteading. Theism is orthogonal to both.

Are Jews “truly safe” in Israel? Not at the present time. Not since 1948. Not before that time anywhere in the Middle East, nor, for that matter, anywhere else on the planet. The nations of the world disagree on many things, but not, it would appear on anti-Semitism; many of them have engaged in pogroms, and in forcibly expelling members of the Chosen People from their territories.

However, Israel is indeed a bolt hole, an insurance policy, for all Jews. If this nation exists, and we get kicked out of yet another country, as is our experience, at least the only Hebrew nation in the world will welcome us. Yes, things look pretty good for Jews in places like the US, Canada, much of Europe, Australia, etc. Apart from a few swastikas painted on synagogues and delicatessens, a few rapes and murders, the congressional Squad[3], all is well. But then again Germany looked pretty

[2] States Pinker (2006): “Does this mean that Jews are a nation of Einsteins? It does not. Their average IQ has been measured at 108 to 115, one-half to one standard deviation above the mean. However, statisticians have long known that a moderate difference in the means of two distributions translates into a large difference at the tails. In the simplest case, if we have two groups of the same size, and the average of Group A exceeds the average of Group B by fifteen IQ points (one standard deviation), then among people with an IQ of 115 or higher the As will outnumber the Bs by a ratio of three to one, but among people with an IQ of 160 or higher the As will outnumber the Bs by a ratio of forty-two to one. Even if Group A was a fraction of the size of Group B, to begin with, it would contribute a substantial proportion of the people who had the highest scores.” See also Murray, 2007; Regenstein, 2012

[3] Squad member and ex-congresswoman Cori Bush had this to say about AIPAC, and this is all too descriptive of the left wing of the Democratic Party, of which Kamal Harris is also a member: “now they should be afraid… They’re about to see this other Cori, this other side… There is nothing that happens in my life that happens in vain. So, this happened because it was meant to happen. And let me say, it’s because of the work that I need to do. And let me say this: AIPAC, I’m coming to tear your kingdom down!” (Robertson, 2024).

Remember, this woman held one of the highest offices in the entire country.

good for Jews in 1905, and we all know what happened there after but a few decades. When Hebrews tried to emigrate to Canada, for instance, then, the authorities turned us away with the reply to the question of how many immigrants from this community would be allowed into that gigantic country with few inhabitants: "None is too many."[4]

3 IMPOSSIBLE TASK

Joffe: "These were among the ideas drilled into me at an early age in Hebrew School, a program of afternoon and weekend education operated by many synagogues. I jettisoned this thinking during my teens as I embraced libertarianism. But I seem to be in the minority of Jewish libertarians, most of whom are trying to support Israel within a libertarian framework. I see it as an impossible task."

Do most Jewish libertarians support Israel? Murray Rothbard (1967) certainly did not. He was one of the most outspoken and vociferous critics of this country in all of political economy, let alone in the libertarian movement. Since he was so influential in this community,[5] many libertarians, Jewish or not, followed his lead on Zionism. Amongst them, I would list David Gordon (Gordon and Njoya, 2024) Marc Joffe (2024), Larry Moss, and Jerry Woloz. No formal survey of this matter has yet been conducted, so I can say no more on this matter.

4 ZIONISM

Joffe: "Zionism is the belief in a Jewish state, so it is clearly at odds with the Rothbardian anarcho-capitalist flavor of libertarianism which rejects any kind of state. But Zionism is also challenged from a minarchist perspective because it implies an established religion, Judaism."

Yes, indeed, Rothbard opposed Israel. He did this with a purple passion. And also, any kind of state is incompatible with pure libertarianism which is the only correct version in my view: the Rothbardian anarcho-capitalist variety. But Zionism, contrary to Joffe, is not at all equivalent to a belief in, and support of, a Jewish *state.* It is perfectly compatible with this doctrine to *oppose* a Jewish state in that or any other area, but to favor the existence of a Jewish *community* located there, in the total absence of any government. Moreover, although Rothbard as an anarcho-capitalist singled out Israel for blame and criticism, he did not do so as qua anarcho-capitalist. Those espousing this political-economic philosophy must view with alarm and hostility *all* states, and equally so, for they are all governments and thus necessarily violate the NAP.[6]

My debating partner is correct, however, in thinking that Israel could possibly[7] be singled out for special opprobrium from a minarchist or other non-anarcho-capitalist version of libertarianism, such as classical liberalism. This is why I entitled my co-authored book on Israel (Block and Futerman, 2021) in that manner, to oppose any such perspective.

Does Zionism require a state religion? Of course not. Many of the founders of that nation were atheists. It cannot be denied that in the actual state of Israel, Orthodox rabbis define who is Jewish and who is not (Harris, 2015), and that the Reform Jewish community is not exactly happy with this practice. But this is hardly a requirement of Zionism. If tomorrow all Jews converted to atheism, Zionism as such would remain completely untroubled. The essence of this perspective is that Jews be free to reside in peace in a certain portion of the Middle East. That is it, nothing more and nothing less.

5 RELIGIOUS ESTABLISHMENT

Joffe: "Minimal state libertarians often draw inspiration from American founders such as Thomas Jefferson and James Madison, who strongly supported the separation of 'Church' and State. The First Amendment starts by stating that 'Congress shall make no law respecting an

[4] This phrase is commonly attributed to either Canadian Prime Minister William Lyon Mackenzie King or to Frederick Charles Blair, director of the immigration office under his administration. They were asked in 1945 how many Jews they would allow into Canada as immigrants. See on this Abella and Troper, 1982.

[5] He was widely and very properly known as "Mr. Libertarian."

[6] They all tax people who have not agreed to pay such levies and demand a monopoly of initiatory violence in their geographical areas. See on this Spooner, 1870; Rothbard, 1972, 1983.

[7] But erroneously

establishment of religion or prohibiting the free exercise thereof.'"

True enough. Religion and the state are of course not totally severed in Israel. But we are not now discussing whether or not libertarianism and support for Israel are logically compatible. Rather, Joffe is raising the question of whether or not libertarian support for *Zionism* constitutes a logical contradiction. It is vitally important to distinguish between these two very different, but similarly sounding, issues. Joffe blatantly fails to do so. It should be clear that *Zionism* in no way, manner, shape, or form requires a theocracy.

Let us consider a voluntary Jewish theocracy located in some part of Eretz Yisroel. All Jews who participate in this venture voluntarily agree to take part in it. Would this be compatible with Zionism? Yes. Would it diverge from libertarianism? No. There is nothing involved in theocracy that is per se incompatible with libertarianism, provided, only, that it is unanimously agreed upon by all members. Of course, we are now talking of an ideal Platonic theocracy. Any actual extant one, including the degree to which Israel is guilty of such, is of course incompatible with libertarian. This goes for the governmental imposition of any idea, let alone that one. But this is not a criticism of Zionism. None of its tenets require any such imposition.

6 MARTIAL LAW

Joffe: "Although Israel's Declaration of Independence called for 'complete equality of social and political rights for all its citizens irrespective of religion,' a page on the Knesset website stated that the Declaration 'is neither a law nor an ordinary legal document'. This may be why Arab Israelis lived under a harsh form of martial law between 1949 and 1966."

Undeniably true. Religion and the state are of course not at all totally severed from one another in Israel, but we are now discussing whether or not libertarianism and support for Israel are logically compatible. In sharp contrast, Joffe is now raising the question of whether or not support for *Zionism* and libertarianism is a logical contradiction. It is vitally important to distinguish between these very different issues. Our author again fails to do so.

7 EQUAL RIGHTS

Joffe: "Despite controlling the West Bank since 1967, Israel still has not given its Palestinian residents equal rights, not just with respect to voting but also to freedom of movement. Perhaps that could be justified based on the West Bank being occupied territory, but that rationale breaks down when we see that illegal Jewish settlers (some of whom immigrated from overseas and some of whom converted) receive full citizenship. The disparate treatment by religion cements the idea that Israel is closer to a theocracy than an enlightened, classically liberal society."

These words on a piece of paper might possibly account for the fact that Arab Israelis lived under martial law. This does not sound likely, though. A more reasonable explanation, however, is that the Arabs just plain old do not much like Jews and feel obliged to kill them. Nor did this phenomenon occur only after the state of Israel was born in 1948. The Arabs, along with anti-Semites of many other nationalities. have been from time immemorial engaged in pogroms against people of the Hebrew persuasion. There have not been any mass murders of Jews in Judea or Samaria of late. Instead, the Arabs have confined themselves to picking off Jews in their twos and threes. Just a few at a time. Nothing to see here. Please move along. Why is this? Have the Arabs lost their desire to see Jewish blood on the floor? Not a bit of it. Rather, it is due to the "harsh" martial law about which Joffe bitterly complains. Are Jews not supposed to defend themselves from these micro-murders, in Joffe's view?

Israel has not given Palestinians equal rights? Yet, there are in Israel Arab judges, policemen, firemen, members of the Knesset, professors, lawyers, doctors, businessmen, etc. How, in contrast, have Jewish minorities been treated in Egypt, Lebanon, Iraq, Iran, Turkey, and Saudi Arabia? Not quite as well by any means.

Joffe compares the actions of the Israeli government with a supposed ideal situation and finds this institution wanting. Good for him. This is very insightful of him. This scholar has uncovered something very important. Who would have known any such thing, but for him?

This type of "reasoning" occurs in economics in the finding that real-world capitalism is at variance

with "perfect competition" a concoction that can only exist on a blackboard. Then, these interventionistic "economists" label this as a "market failure"[8] and call upon the government to rectify matters.

No, the real test in economics is between real-world capitalism and actual socialism. The former always wins, hands down. Similarly, the real contest in the Middle East is not between actual Israel and some idealized scenario of Joffe's, but between how each of the countries in that corner of the world treats its minorities. And again, Israel wins by a country mile. No, by a million miles. For the small number of Jews in Arab countries are not at all sworn to overthrow the governments of their hosts, and to kill as many of them as possible, while the far larger minority of Palestinians in Israel not only hold these views but acts upon them. Israel is saintly in its treatment of the Arabs residing in the only Jewish country on earth.[9]

"Disparate treatment by religion" in a pig's eye. There is no such thing. Non-Arab residents have as much "freedom of movement" as anyone else in that country. This harsh treatment accorded to the Palestinians stems from a very different source than religion. It is a result of fear of murderers and rapists. If anything, there has been far too much "freedom of movement" accorded to this segment of the population. Israel, to its great regret, issued numerous works permits to the Gazans; this "freedom" of theirs was then implicated in the events of October 7, 2023.

8 BOTTLES OF URINE

Joffe: "Most American Jewish libertarians do not make the trip to the West Bank, so you'll have to take my word for it: what I saw there in 2018 cannot be confused with libertarianism. When I visited, I could not get over the number of plastic bottles filled with urine soldiers drop from the border wall in Bethlehem and settlers drop from their apartments onto the Palestinian market in Hebron."

This is an anecdotal report issued by a person who has a strong hatred for Israel. His bias against this nation can be seen in every word he writes, including "and," "is", and "but." Why should we believe this report of his? However, let us stipulate, arguendo, that this claim of his is true. Other victims, such as Jews in their own country would not engage in any such silly and relatively harmless retaliation. Rather, they would not only carry but also use, the proverbial "big stick." The fact that there are so few such episodes, given the dire provocation posed by the Palestinians, is a credit not a debit to the all too patient Israelis. In no other country, the inhabitants of which have suffered so much at the hands of a criminal minority, would such slaps on the wrist be found. Elsewhere, instead of urine, it would have been bullets. If liquid were somehow required, it would have been acid.

9 SETTLER VIOLENCE

Joffe: "And that's just one highly visible abuse: the travel restrictions, property seizures, and exposure to periodic settler violence are undoubtedly more impactful on West Bank Palestinians' daily lives."

"Settler violence" on the part of the Jews? First of all, there are no Jewish settlers or colonists,[10] anywhere in Judea or Samaria. The People of the Book are the original and thus rightful owners (Block and Futerman, 2021) of that real estate, not the Arabs.

Second, Joffe misunderstands the libertarian position on "violence." This philosophical position is not at all opposed to the use of force. Libertarianism is not a branch of pacificism. Followers of this perspective make a sharp distinction between initiatory and defensive violence, eschewing the former but embracing the latter. It is the Arabs in these areas[11] who are guilty

[8] For a critique of this doctrine see Anderson, 1998; Barnett, et. al, 2005; Block, 2002; Callahan, 2000; Cowen, 1988; DiLorenzo, 2011; Guillory, 2005; Higgs, 1995; Hoppe, 2003; MacKenzie, 2002; Rothbard, 1985; Simpson, 2005; Tucker, 1989; Westley, 2002; Woods, 2009A, 2009B

[9] No. A correction: not saintly: rather, foolish and masochistic. The Israeli police and the IDF should stop treating these murderers and kidnappers with kid gloves.

[10] See; Gilley (2018), a very controversial essay was withdrawn from its initial publication

[11] Not the so-called "West Bank."

of initiating aggression. It is the Jews, there, who are merely defending themselves and/or retaliating against these deadly incursions. No truer words in this context were ever said than these: "If the Arabs put down their weapons today, there would be no more violence. If the Jews put down their weapons today, there would be no more Israel (Netanyahu)." This goes for both internally and externally located Arabs.

The problem with "settler violence" is that it has not been thorough enough. If it were, the Palestinians in Judea and Samaria would not be as enthusiastic as they now are in attacking innocent Jews.

10 JUST FINE TREATMENT

Joffe: "But aren't they all a bunch of terrorists who deserve to be treated harshly? The Palestinians I met treated me just fine despite knowing that I was Jewish. And, of course, there were all the young children and babies, who have had no chance to commit acts of terrorism during their short lives."

Again, with the personal, anecdotal reports. This is not the kosher manner of arguing in a scholarly context. As for the children, they are of course innocent. But they have been used as shields (Block, 2011, 2019, 2024) by Hamas. This terrorist organization has embedded itself into the civilian population, placing military weapons and rocket and missile launchers in hospitals, schools, playgrounds, Mosques, and residential areas, all frequented by, among other innocents, children. Who then, is guilty of their injuries and deaths? Obviously, to any fair-minded person, of whom, unfortunately, we cannot count Joffe, this is due to Hamas, not the IDF, even though it is the bullets and bombs of the latter that actually cause the fatalities.

Here is a scholar (Mearsheimer, 2024) who sees this point, clearly, but only in the context of a very different war:

"The alternative argument, which I identify with, and which is clearly the minority view in the West, is that the United States and its allies provoked the [Russian war with Ukraine] war. This is not to deny, of course, that Russia invaded Ukraine and started the war. But the principal cause of the conflict is the NATO decision to bring Ukraine into the alliance, which virtually all Russian leaders see as an existential threat that must be eliminated." He can clearly see that just because Russian armament is killing Ukrainians, it does not at all logically follow that this country is to blame for these deaths. Yet, he and many others totally and adamantly reject even the possibility that the exact same phenomenon is occurring in the Middle East."[12]

11 GROUP PUNISHMENT

Joffe: "Penalizing individuals that have not acted aggressively because of their group identity is not a practice I recognize as libertarian. Nor is the mass killing of non-combatants in Gaza, Even Israeli sources admit 16,000 civilian deaths in Gaza, more than a dozen times the number Hamas killed on October 7."

Israel is not "penalizing" any innocent people. Au contraire, the IDF is doing everything humanly possible to save the lives of innocents. It is doing more, exceedingly much more than any other army has done in the entire history of warfare, Joffe to the contrary notwithstanding. Before bombing a given target, the Israeli army distributes leaflets, warning of the forthcoming incursion, and urging civilians to retreat to safer areas.

Why, then, have so many blameless Gazans nevertheless perished? This is due to three reasons. One, Hamas will often not allow these noncombatants to depart. It wants to rack up their deaths, the better to blame Israel as a "mass killer," which claims Joffe has accepted holus-bolus. Two, Hamas places armaments and rocket launchers in, around and under hospitals, Mosques, schools, playgrounds, and residences.

[12] Unfortunately, he (Mearsheimer & Walt, 2008), like Joffe, does not at all see this identical point in the case of Israel. Just because the IDF if the proximate cause of these deaths does not mean it is the ultimate cause. Yes, it is Israeli bullets and bombs that are the immediate cause of these unfortunate incidences of collateral injuries and deaths. But is that country ultimately responsible for, guilty of, these episodes? No. A thousand-time no. Which organization, then, properly takes on this role. In a word, Hamas. If it did not perpetrate the atrocities of October 7, none of these deaths would now be occurring.

Three, these terrorists use their own people as shields.[13]

What is the IDF supposed to do? Not bomb these places since guiltless people will perish as a result? Consider the implication of Joffe's stance on this matter. Murderers will hence grab up innocent people, and use them as shields, and the cops will have to let them get away with their heinous crimes. Sharpshooters will not be able to ply their expertise lest one of these victims were killed. Murders would literally get away with murder. No, these people are not perishing "because of their group identity." They are dying because of the vicious depravity of their leaders, the group they put into office in a democratic vote. Not satisfied with the atrocities they perpetrated upon Israelis on October 7, Hamas is now engaged in sacrificing its own people as a public relations ploy.

Here is a multiple-choice exam question coming up, so please pay attention: Who is responsible for the "16,000 civilian deaths[14] in Gaza"; Hamas or the IDF? A point is scored if you answered with the former. Yes, it was IDF bullets and bombs that decapitated and killed Gazans who were undeserving of such a dire fate. But paradoxically, it is not that army that is guilty of these deaths! Rather, it is those, Hamas in this case, who use these civilians as shields.

And what is with this business of these demises being "more than a dozen times the number Hamas killed on October 7, 2023?" This war is not a tit-for-tat exercise. This is a battle to preserve the very existence of Israel. If the terrorists can remain in power and get away with the despicable act they perpetrated on that infamous day, this country cannot survive.[15]

All Hamas needs to do to ensure that not a single solitary innocent Gazan be killed in the future is release all their hostages and surrender to the IDF. They have not done anything of the sort. The blame for these 16,000 deaths[16] lies squarely in the bloody hands of Hamas. There is no correct proportion between the number of Israelis who were killed on October 7 and the number of Gazans who met this horrid fate subsequently. The ratio is entirely in the hands of the evil perpetrators; as soon as they are vanquished, the slaughter of Gazans for which they are and continue to be responsible, will come to an abrupt halt.

12 ANCIENT TEXTS

Joffe: "And, no, I do not believe a semi-accurate set of ancient texts that said God promised 'Judea and Samaria' to the Jews. Indeed, as an Ashkenazi Jew, I have no idea whether my lineage traces back to ancient Israel even if it could be traced."

First, a minor point: why the scare quotes around "Judea and Samaria?" Must we always use the description beloved of Israel's enemies, "West Bank"? More importantly, again Joffe is guilty of unfairly applying a criterion to Israel he would never even think of employing elsewhere. He is finding Israeli claims to land in Israel imperfect, and not even considering those on the other side. The Second Temple is built *below* an Arab Mosque, which appears *above*. This indicates the Jews were there first, not the other way around. A key point of the libertarian theory of justice in homesteading[17] is that the *first* to arrive and mix his labor with the land is the rightful owner of it, not the second. Another indication that the Jews beat the Arabs in this particular horse race is that the former was in existence some four or five

[13] See on this Alexander, 1993; Block, 2010, 2011, 2019; Clark, 2000; Otsuka, 1994, 2003; Rothbard, 1984; Statman, 2006; Thomson, 1991; Wasserman, 1987

[14] Most claim about 40,000, at the time of this writing, August 2024.

[15] According to the Hamas Covenant, which they have not renounced, but rather continue to support: "The Day of Judgement will not come about until Moslems fight the Jews (killing the Jews), when the Jew will hide behind stones and trees. The stones and trees will say O Moslems, 'O Abdulla, there is a Jew behind me, come and kill him...' The Qur'an is clear: 'And fight them until persecution is no more, and religion is all for Allah.' (8:39) This amounts to an open-ended declaration of war against those whose religion is not 'for Allah.'"

[16] Let us stipulate, arguendo, that this is the correct statistic

[17] Block, 1990, 2002A, 2002B; Block and Edelstein, 2012; Block and Nelson, 2015; Block and Yeatts, 1999-2000; Block vs Epstein, 2005; Bylund, 2005, 2012; Gordon, 2019A, 2019B; Grotius, 1625; Hoppe, 1993, 2011; Kinsella, 2003, 2006A, 2006B, 2007, 2009A, 2009B, 2009C; Locke, 1948; McMaken, 2016; Paul, 1987; Pufendorf, 1673; Rothbard, 1969, 1973; Rozeff, 2005; Watner, 1982.

thousand years ago, while the latter are Johnnies-come-lately. The Islamic religion came into existence with the advent of Mohammad, and his time on the planet is dated only some 1400 years ago.[18]

13 INVALID ANCESTRAL CLAIMS

Joffe: "We have no right to take land based on our religion or our wholly unverifiable ancestral claims. Instead, it is the refugees in Gaza who still have the keys to their family homes in 'Israel proper' that have a clearer right to reclaim stolen land."

Again with the scare quotes. Is it Joffe's view that Israel is not "proper?" Or that there is no land that is properly Israeli? Yes, Jewish ancestral claims to modern-day land are weak, but they are not "wholly unverifiable." More to the point, they are *better* than such claims on the part of the Arabs, *since the latter do not exist at all.* And there is a good reason for this absence: those people were not even in existence anywhere near the contested lands. So, once again this libertarian author is comparing the Israeli case with perfection, and of course, finding it wanting, and not even considering subjecting those of the other side to any such test.

It cannot be denied that some Palestinians still "still have the keys to their family homes" they abandoned in 1948. What happened during that fateful year? Some Arabs were absent from their home and gardens for fear of the soon-to-be-conducted Arab war against the fledgling Jewish state. Others, for all we know, innocently went on vacation at that time. However, during those months, the five Arab armies that were soon to invade baby Israel sent out a message to all Palestinians: leave the area immediately. In that way, it will be easier for us to kill all the Jews. If you stay, you will just get in our way. Depart now; we will wipe up these vermin in a few weeks and then you can come back home. The Jews pleaded with them to remain, but about a million of the Palestinians departed. In the event, as in the affairs of mice and men, these Arab army expectations went seriously astray. These Palestinians then wanted their "right of return." The Israeli government regarded them as traitors and would have none of it.

During the same epoch, also roughly one million Jews were kicked out of Egypt, Lebanon, Iraq, Syria, and Iran. They had done no wrong whatsoever. Israel welcomed them with open arms. The Arabs moved the displaced Palestinians into refugee camps, the better to display to the world the perfidy of the Israelis. Joffe claims that they "have a clearer right to reclaim stolen land." Again, his analysis is totally one-sided. He looks only at the displaced Arabs and ignores the in some ways similar experience of the displaced Jews. Perhaps a better plan might have been to give to the Palestinians the land in the Arab countries stolen from the Jews, instead of compelling them to live in those refugee camps.

14 COMPLEX RATIONALIZATIONS

Joffe: "As the war drags on, the pro-Israel libertarian must indulge in increasingly complex rationalizations or simply ignore facts. Why were the World Central Kitchen workers killed? Why were Israelis blocking aid trucks going into Gaza? Why is there no ceasefire even after the IDF has invaded every section of Gaza?"

The Kitchen workers killed was a mistake on the part of the Israeli military. In the view of some commentators, it is at least in the top four of national armies. Are they perfect? Of course not. Errors occur in the heat of battle. But they were not "on purpose" as were the execrable acts of October 7. Since when does an army worry about feeding enemy populations? Did the Allies in World War II support or oppose "aid trucks going into" Germany, Italy, and Japan? Should they have, before the surrender of the latter? Has any army in our entire history acted in any such manner? Why is there no ceasefire? That is because at the time of this writing, Hamas has not yet surrendered nor released its civilian hostages, some of them mere children.

15 ZIONISM OR LIBERTARIANISM

Joffe: "You can make all the claims you want but they don't stand the tests of fact, logic, and principle. Israel is an aggressive theocratic state

[18] See Yalman (2001)

that is inconsistent with libertarian principles. For Zionist libertarians the time has come to choose: you can be one or the other, but not both."

Let us stipulate, arguendo, that everything Joffe says in criticism of Israel, and in support of Hamas, is absolutely true. It then logically follows that any libertarian who disagrees with his analysis is wrong. But suppose that such a person still, irrationally, insists upon retaining his Zionist credentials. Does it then logically follow that he can no longer be a libertarian? This is Joffe's position, but he is in error here. Consider the following.

On abortion: Ron Paul is pro-life, and Murray Rothbard is pro-choice; both cannot be correct. One of them must of necessity be taking a position incompatible with libertarianism.[19] On immigration: Hoppe supports regulated borders, and Hornberger, open borders. Again, both cannot be correct. One of them must of necessity be taking a position incompatible with libertarianism.

Any theory that maintains that either Paul or Rothbard is not a libertarian,[20] or that either Hoppe or Hornberger no longer are members of this philosophical movement, is in dire error. These four are undoubtedly leaders of this community. Joffe's thesis necessarily implies that at least one of each pair "will have to choose." That is, he is not a libertarian. Therefore, his viewpoint must be rejected, QED.

16 CONCLUSION

What is going on here? What is going on is that we libertarians are dealing with highly complex issues. Were this not so, we would all be in agreement with them since we are without question very intelligent. But we all suffer from human intellectual limitations. That is what is going on here.

Murray Rothbard said it best: "Every dog gets one bite."[21] I see Murray, and I raise him at least a half dozen times: Every libertarian gets at least six bites, at least on highly complex issues. Yes, it is difficult to see a person as a libertarian who favors the minimum wage law or rent control; or the prohibition of marijuana or alcohol; prostitution, or pornography. But I am a big tent libertarian. I would have to look askance at a libertarian who deviated on even one of these issues. But I would be loathe to condemn him as a non-libertarian if he agreed with this doctrine on all other issues[22].

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[19] As it happens, neither position is compatible with libertarianism. For the correct view, see Block (2021).

[20] Or both, if evictionism (Block, 2021) is valid, then neither pro-life nor pro-choice can be the correct libertarian position

[21] Personal communication with the present author.

[22] As per impossible, given that libertarians are vociferously divided on so many macro-libertarian (McMaken, 2024) topics.

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Received for publication: 14.08.2024
Revision received: 17.08.2024
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Block, W. E. (2025, 07 15). Rejoinder to Joffe on the Compatibility of Libertarianism and Zionism. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 37-49. doi:10.12709/mest.13.13.02.03

Style – **Chicago** *Sixteenth Edition:*

Block, Walter E. "Rejoinder to Joffe on the Compatibility of Libertarianism and Zionism." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 37-49.

Style – **GOST** *Name Sort:*

Block Walter E. Rejoinder to Joffe on the Compatibility of Libertarianism and Zionism [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 37-49.

Style – **Harvard** *Anglia:*

Block, W. E., 2025. Rejoinder to Joffe on the Compatibility of Libertarianism and Zionism. *MEST Journal,* 15 07, 13(2), pp. 37-49.

Style – **ISO 690** *Numerical Reference:*

Rejoinder to Joffe on the Compatibility of Libertarianism and Zionism. **Block, Walter E.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 37-49.

MEST Journal
DOI 10.12709/mest.13.13.02.02

REJOINDER TO ORWELLIAN LIBERTARIANISM: GORDON AND NJOYA'S TOPSY-TURVY WORLD OF TWILIGHT ZONE LIBERTARIANISM

Walter E. Block
Harold E. Wirth Eminent Scholar Endowed Chair and Professor of Economics
Loyola University New Orleans, New Orleans, USA
https://orcid.org/0000-0003-2215-4791

JEL category: **P1**

Abstract

Gordon and Njoya, in their work "Orwellian Libertarianism: The Topsy-Turvy World of Walter Block," heavily criticize me on a variety of issues related to libertarian theory, including shields, swords, negative homesteading, Hamas, and Rothbard. This paper serves as my response to their critique. These two authors uniquely claim that libertarian philosophy is perfect as it currently stands and that any changes or alterations are inherently flawed. This is particularly interesting because both scholars have made significant and novel contributions to the philosophy of freedom, thereby contradicting their new thesis. Talk about being hoisted by your own petard. They are highly critical of my introduction of the concept of "negative homesteading" to libertarianism. However, they do not provide any substantial criticism of this idea; they only dismiss it because it is novel. This stick-in-the-mud viewpoint is very surprising and disappointing, especially coming from two world-class philosophers who have previously shown great innovation and open-mindedness in their academic pursuits.

Keywords: *Orwell, Twilight Zone, Libertarianism, Shields, Swords.*

Address of the author:
Walter E. Block
wblock@loyno.edu

REJOINDER TO ORWELLIAN LIBERTARIANISM

Gordon and Njoya (2024A)[1] join an increasingly long list of authors who maintain at best that my understanding of libertarian theory is imperfect, and, at worst, "unhinged."[2]

[1] Unless otherwise specified, all references to these authors will be to this one article of theirs, GN (2024A).

[2] This is the assessment of Hoppe, 2024. Other libertarian theorists who maintain that my views on libertarian theory are gravely mistaken in that I support

They start off their essay as follows:

"Walter Block asks us to consider the following case: Suppose someone is shooting at you. He has two babies strapped in front of his body. He is clearly an aggressor and, of course, you have the legal right to shoot back in self-defense. The moral and ethical (sic) considerations as to whether you ought to shoot back are the subject of debate, and Murray Rothbard has addressed those debates extensively, but from the perspective of libertarian law, there is clearly no legal dispute here. This is not a matter in which there are legal arguments on both sides, though there may be debates about what counts as proportionate use of force in defending yourself.

"Walter Block thinks otherwise. He thinks that, according to the non-aggression principle, you cannot use force in these circumstances, as shooting back would put the babies in the line of fire. He has invented a non-existent legal problem to bypass the powerful moral and ethical arguments advanced by Rothbard. Here is what Walter says:

"A GRABS B TO USE as a shield; A forces B to stand in front of him and compels him to walk wherever A wishes. A then hunts C to murder the latter by shooting him. C also has a gun. Is it legally permissible for C to shoot at A in self-defense under libertarian law? Were C to do so he would have to kill B, the innocent shield, to defend himself against the perpetrator, A. Assume that this tableau takes place on unowned property so that the issue of the owner's rules does not come into play.

"The first answer that comes to mind is that it is not. After all, B is a completely innocent person, and, seemingly, the non-aggression axiom of libertarianism was meant to apply to cases precisely like this one. This axiom states that it is illicit to initiate aggression against any non-aggressor, and B, by stipulation, is a non-aggressor. There are no exceptions to this general rule. Thus, it is difficult to see how C shooting B to get to A can be reconciled with libertarianism."

When I first read this excerpt to which they refer I was appalled at myself. This perspective is the exact opposite of what I have long believed. I could not believe that I had written this erroneous material. My first thought was that I should reread the entire essay from whence these mistaken words emanated. Gordon and Njoya (2024A)[3] did not even cite the article in which it appeared.[4] I spent a half hour frantically trying to locate it. I learned it was published in 2011A, thirteen years ago. I thought I had gained some wit and wisdom since then, but I was appalled that I had so severely misconstrued libertarian theory at that earlier time. I was thinking in terms of making an apology for these misbegotten words. Then, finally, I reread Block (2011A). I was relieved. I was then attacking these error-laden thoughts, the ones cited by GN as if they conveyed my view; I was not supporting them. That is to say, GN attributed to me the very opposite of my viewpoint, the one I had laid out in Block (2011A) in order to criticize.

GN state: "Walter Block thinks otherwise." However, do they quote me and cite the source of me saying or writing "otherwise?" That would seem to be the appropriate thing to do upon such an occasion. They do not; they do no such thing. Instead, they ascribe to me the very opposite of what I do say and write on more than several occasions. They really ought to do their homework a bit more assiduously and thoroughly.[5]

Whereupon some further considerations occurred to me. This essay of mine appeared in the Journal of Libertarian Studies. JLS is the gold standard for libertarian philosophy. How did this mistaken material ever get published by that journal in the first place? Happily, this was not at all the case.

Israel on Hamas include Rothbard (1967), Hoppe (2024), DiLorenzo (2024), McMaken (2024), Rectenwald (2024), Joffe (2024), Burgis (2024) and Mosquito (2018, 2023). For refutations of these papers, see, respectively, Block and Futerman (2021) on Rothbard; Block and Futerman (2024) on Hoppe; Block (2024A) on DiLorenzo; Block (2024B) on McMaken; Block (2024C) on Rectenwald; Block (2024D) on Joffe; Block (2024E) on Burgis; Block (2025), Farber, Block and Futerman (2018) on Mosquito. See also Gordon and Njoya (2024B) and this response to them: Futerman and Block (2024).

[3] Hence GN

[4] This is unusual in the scholarly literature, to say the least.

[5] And stop scaring me by quoting material I am criticizing as if I am supporting it.

GN attributed to me ideas I was criticizing, not supporting. Soon after the material GN attributed to me in Block (2011A), I wrote the following, introducing my own, correct, theory:

"In this scenario, either B or C must die, and the theory we have so far considered favors B, because, when we focus on only the two of them, B and C, and ignore A, it is C who 'initiating' violence against B, and not the other way around. However, there is another theory that I contend also deserves to be characterized as libertarian, which leads to the opposite conclusion. I call this the theory of negative homesteading."

This is why I refer to the Twilight Zone in the title of this paper. It is only in that neck of the woods do world-class scholars such as GN attribute to an author the exact opposite of what he is actually contending.

Next, consider this statement of GNs. Here, they do not attribute to me the exact opposite of my actual view, but they do, nevertheless, continue to misinterpret me:

"Walter's interpretation of the case is that when C shoots at A, he might hit B—who is in the line of fire—and, as Walter sees the matter, unless we can somehow depict B as an aggressor, C violates the non-aggression axiom. Clearly, Walter has made a mistake in presuming that the legality of self-defense in these circumstances requires that B must be viewed as an aggressor. In libertarian law, defending yourself does not violate the non-aggression axiom merely because an innocent person may somehow be in the line of fire. A has violated the non-aggression axiom by seizing B and putting B into the line of fire. If B is killed, A is the one who is legally responsible for his death, not C. The non-aggression axiom does not take away C's right to defend himself by firing back at A."

Wherein lies GN's error in this case? Here is one mistake. In my view, C, in self-defense against A, will *necessarily* shoot B, the innocent person, by posited assumption. GN, in sharp contrast, attribute to me the view that B "may somehow be in the line of fire." But, surely, there is all the world of difference between a situation where the defender may possibly kill an innocent person in self-defense, and one where this is the necessary, inevitable, and ineluctable result. I go so far as to claim that in each and every case of self-defense, there is at least the possibility that an innocent person may be negatively impacted, physically.

The second error is the GN write as if I disagree with their conclusion; they are writing as if to correct me in this matter: "If B is killed, A is the one who is legally responsible for his death, not C. The non-aggression axiom does not take away C's right to defend himself by firing back at A." But this is precisely my own conclusion, repeated over and over again, in all of my publications on this subject.

We now arrive at this further GN criticism of my work in this area: "There is a further problem with Walter's analysis. He wrongly thinks that shooting at B—the person in the line of fire—violates the non-aggression axiom, but this mistake now puts him in a difficult position because he also wants to say that C can shoot at A in self-defense. How can he climb out of the hole into which he has dug himself? His strategy is ingenious but depends on the false premise that shields are swords. By means of this strategy, he attempts to turn B into an aggressor. He offers an analysis that is impeccably reasoned but depends on the false premise that shields (in this case the babies) are swords (that is, in his view, the babies are aggressors). This premise is patently absurd. Shields are not swords and calling them swords does not change this. An argument with a false premise lends no support to a conclusion."

Let me first thank these scholars for the compliment that my reasoning is "impeccable" and that my "strategy is ingenious." However, I must demur on several points.

First, I do not "wrongly think … that shooting at B—the person in the line of fire—violates the non-aggression axiom…" I do not think this is a wrong thought at all. Rather, in my view, the very opposite is the case: C has every right to shoot A, even though by stipulation the innocent person B will also perish.[6]

[6] I am continually shocked that these very careful authors could so often and so egregiously misinterpret my clearly stated views.

Second, shields cannot be used as swords? These authors have obviously never seen any movies about ancient Roman gladiators who do this exact thing to each other: bashing their opponent with a shield. GN would not at all appreciate it if someone were to bash them in the nose with a heavy metal shield.[7] They would then rightly realize that this ostensibly defensive weapon could also be used offensively. This is hardly "patently absurd." Indeed, the very opposite is the case.

Third, those strapped on babies while not themselves purposeful aggressors[8] are nevertheless being used in an aggressive manner; they are being used against C by A as a sword/shield in order for the latter to murder the former.[9]

Another problem I have with these authors is that they are mighty shy about giving their own views. They write things like this: "… but from the perspective of libertarian law, there is clearly no legal dispute here. This is not a matter in which there are legal arguments on both sides," And this: "… there is no legal question of whether C has the legal right to defend himself against A, who is trying to murder him by shooting him." But enquiring minds want to know: what is their own view on these matters? They vouchsafe their readership with little or no response.

GN are by no means finished with denigrating my perspective on libertarianism. It turns out that they are not at all on board with my concept of negative homesteading. They write as follows:

"Walter has 'defended' the false premise that 'shields are swords' with this notion of 'negative homesteading,' but his defense fails, for two reasons. First, 'homesteading' has a clear meaning in libertarian theory. You homestead unowned property by mixing your labor with it and thus acquiring it. But there is no such concept as 'negative homesteading' in libertarian theory. Walter acknowledges that this concept is not found in 'classical libertarianism,' but that is the only libertarianism there is. 'Negative homesteading' makes no sense. It is like saying that a doctor who gives first aid to someone who has been shot is 'negatively shooting' them. Orwellian language of this sort that transforms things into their opposites is an assault on clarity."

GN are in effect claiming that libertarianism is a closed system. Nothing else can be, may be, or should be added to the mighty edifice created by Rothbard (1973, 1982). Rothbard himself would scarcely agree. Evidence for this claim? Rothbard's (1988) reaction to Hoppe's (1988, 1993, 1995) brilliant argument from argument.[10] This pertains to the justification of libertarianism itself. Previously, Mr. Libertarian[11] had predicated this philosophy, along with its two major foundations, the non-aggression principle and private property rights based on homesteading, on natural law. But when Hoppe (1988, 1993, 1995) offered his argumentation ethics, Rothbard (1988) readily, and enthusiastically, embraced it. Thus did libertarianism grow, GN to the opposite viewpoint notwithstanding. Have there been other additions to the libertarian structure? Certainly, there have been.

For example, if we include Mises (1949) as a libertarian[12], Rothbard (1962, chapter 10) completely annihilated the former's view that there could even exist such a phenomenon as a market monopoly.[13] Then there is Kinsella's (2008, pp. 47

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[7] I am inspired here by Johnson's refutation of Berkeley's theory of immaterialism by kicking a stone and saying, "I refute it thus." http://www.grubstlodger.uk/2023/06/i-refute-it-thus-in-which-johnson-kicks.html

[8] They are too young to have any such purposes

[9] By extension, Hamas (A) uses Gazans (B) as offensive shields to attack Israelis (C) by placing rocket launchers, missiles, and drones, in hospitals, schools, residential areas, etc. It is as if Hamas were strapping their babies onto the fronts of them, attacking Israelis, and then complaining of "genocide" when the latter shoot them. This is indeed the view of world opinion, and also of too many libertarians, see fn. 2, but it is gravely mistaken.

[10] For more on this see Block, 2004, 2011B; Gordon, 1988; Kinsella, 1996, 2002; Meng, 2002;

[11] Rothbard, of course

[12] That is a total no-brainer

[13] Sorry, I cannot resist telling my monopoly joke. If a business organization sells at a higher price than everyone else, it is profiteering; if it offers goods at the same price as others (this is difficult to contemplate since by definition it can have no competitors, but, hey, this is only a joke), it is guilty of collusion; if its prices are lower than those of other entrepreneurs, it is guilty of predatory price cutting.

et seq.; 2023b, Part III.C & n.86; 2023c, at p. 415, n.46) successful critique of Rothbard's (1998, p. 123 et seq.) support for patents.[14] Further, there is what Kinsella (2007, 2009) characterized as the "Blockian Proviso" in contrast to what is well known in our profession as the "Lockean Proviso."[15] Another addition to the ever-growing libertarian philosophy is evictionism, which in at least some opinions has superseded the pro-choice position of Rothbard (2007) and the pro-life stance of Ron Paul (LA Times, 2011).[16] Then there is the negative homesteading of Block (2010, 2011A, 2019), to which GN object, which contrasts with the positive homesteading phenomenon of Locke (1689). Also, Rothbard (1962, 1973, 1982) has substituted anarcho-capitalism for the more moderate view of libertarians who came before him such as Mises (1949), Rand (1957), Hayek (1944),[17] Friedman (1962). To this list we must add Block's (2010, 2011A, 2019) analysis of the shield and missile, vis a vis Rothbard's view to the contrary, Rothbard's amalgamation of economics, personal liberty, and foreign policy into one grand configuration)[18] and Rothbard's (1997) displacement of George (1879) on the 100% tax on land issue. Libertarianism is thus a living breathing enterprise, continually changing and hopefully always improving, and not the stultified written in concrete perspective maintained by GN.

Consider, alone, Hoppe's brilliant argumentation ethics. GN would be logically obligated to reject this as an important contribution to libertarian theory, not because it is wrong; but rather, only due to the fact that it is new. This seems to be a perspective difficult to defend.[19]

But GN are by no means finished in maintaining that my version of libertarianism is "Topsy-Turvy." They then aver as follows:

"The second reason Walter's[20] defense of 'shields are swords' fails is that the legal right to defend yourself has nothing to do with homesteading, genuine or imaginary. Libertarian homesteading is an account of the way property is acquired. This account belongs to a theory of justice and has nothing to do with the legal right of self-defense."

Here, GN are entirely correct. "Homesteading," traditionally in libertarian theory, concerns, only, the initial step in justifying property titles. But that is limited to regular, traditional, or ordinary, or usual libertarian theory. I have invented a new term, negative homesteading. It is addressed to the issue of whether or not people have a right to transfer misery, being hit with a lightning bolt, to others. My claim is that they do not, and this issue most certainly has plenty "to do with the legal right of self-defense." I note that GN have no argument to use against this admittedly new concept, except for the fact that it is novel. That hardly constitutes a valid argument against it.

Here is one last criticism on the part of these authors:

[14] Further initiatives along this line include Block, 2013, 2020; Boldrin and Levine, 2008; De Wachter, 2013; Kern, 2019; Kinsella, 2001, 2008, 2011, 2012A, 2012B, 2012C; Long, 1995; Menell, 2007A, 2007B; Mukherjee and Block, 2012; Navabi, 2015; Palmer, 1989; Sandefur, 2007

[15] "… at least where there is enough, and as good, left in common for others". (Locke, 1689, Chapter V, paragraph 27.)

[16] There have been cancellations, excommunications, and refusals to debate, over disagreements regarding Israel. (See fn. 2, supra). However, none have occurred on this issue, which, arguably, involves the deaths of far more innocent people worldwide than that one.

[17] For a critique on this book, see Block, 1996; for debate over it, see Friedman and Block. 2006.

[18] States McElroy (undated) on this important achievement of Rothbard's: "Murray N. Rothbard (1926-1995) – the greatest libertarian theorist of the 20th century …In forty-five years of scholarship and activism, Rothbard produced over two dozen books and thousands of articles that made sense of the world from a radical individualist perspective. In doing so, it is no exaggeration to say that Rothbard created the modern libertarian movement.3 Specifically, he refined and fused together: natural law theory, using a basic Aristotelian or Randian approach; the radical civil libertarianism of 19th century individualist-anarchists, especially Lysander Spooner and Benjamin Tucker; the free market philosophy of Austrian economists, in particular Ludwig von Mises, into which he incorporated sweeping economic histories; and, the foreign policy of the American Old Right – that is, isolationism."

[19] Murray's (2003) entire book is dedicated to the notion that the human condition is predicated upon intellectual, artistic, musical, scientific growth, change, and alteration. GN would undoubtedly agree this his thesis, but, presumably, with the sole exception of libertarianism.

[20] Just out of curiosity, I wonder at their continual use of my first name. Typically, in scholarly interaction, last names are utilized.

"The essential problem with Walter's interpretation of the legal rules of self-defense appears to be that he does not like the conclusions to which Rothbard's theory of justice leads. In an attempt to derive the opposite conclusions from those arrived at by Rothbard, Walter attempts to reinvent the meaning of libertarianism and to that end, he relies on an Orwellian transformation of 'shields' into 'swords.' His fundamental mistake is to treat a question of positive law—when do you have the legal right to shoot back in self-defense?—with the normative question of whether you ought to do so, given the presence of the babies. No wonder he finds himself in a topsy-turvy world."

Au contraire, I never once in all of my writings on the general issue of libertarianism, addressed the issue of "whether you ought to do so." Rather, I have confined myself to wrestling with the issue of "when do you have the legal right to shoot back in self-defense?" Libertarianism, properly understood, is limited to the proper use of violence; it is a theory of what kind of law is compatible with justice.

Indeed, in Block (2003) I explicitly made this very point, in response to several erstwhile libertarian critics of this philosophy:

"They misunderstand the nature of libertarianism. These arguments implicitly assume that libertarianism is a moral philosophy, a guide to proper behavior, as it were. Should the flagpole hanger let go? Should the hiker go off and die? But libertarianism is a theory concerned with the justified use of aggression, or violence, based on property rights, not morality. Therefore, the only proper questions that can be addressed in this philosophy are of the sort, if the flagpole hanger attempts to come into the apartment, and the occupant shoots him for trespassing, Would the forces of law and order punish the homeowner? Or, if the owner of the cabin in the woods sets up a booby trap, such that when someone forces his way into his property, he gets a face full of buckshot. Would he be guilty of a law violation? When put in this way, the answer is clear. The owner in each case is in the right, and the trespasser in the wrong. If force is used to protect property rights, even deadly force, the owner is not guilty of the violation of any licit law."

These authors actually agree with my interpretation of libertarianism but write as if we are 180 degrees apart. They accuse me of writing the exact opposite of my actual view. Most problematically, GN attribute to me the view that when the would-be assassin straps his own two children to his body, using them as a shield, the victim, his target, has no right to defend himself, given that by stipulation the only way he can do so is to shoot the two babies, to reach their father, the killer. They aver as follows: "Walter Block … thinks that, according to the non-aggression principle, you cannot use force in these circumstances, as shooting back would put the babies in the line of fire."

No, no, no, I am on record as writing the exact opposite (Block, 2024F)[21]: "I (I am Hamas) am going to kill you (you are Israel). I have a knife. I am going to murder not only you, but also your wife, kids, parents, siblings. I have strapped to the front of me my two young children, aged three. You have a gun. The only way you can stop me from killing you and your loved ones is to shoot me. However, if you do so, we posit that you will necessarily kill my completely innocent children."

Whereupon I take the position that Israel is in the right in killing two innocent children, in order to save its own life. I specifically criticize Rothbard for taking the opposite point of view.

We can't invent negative homesteading? It is to be rejected solely on the ground that it is entirely new? No, libertarianism does not belong in a mausoleum. There is no law, philosophical or otherwise, preventing this brilliant perspective from growing. A shield cannot be used as a sword, as an offensive weapon? Tell that to a Roman gladiator who had his head half taken off when the enemies shield was employed against him. There is simply no reason why the very same implement cannot be used for two different purposes. A metal shield can certainly be used as both an offensive and a defensive weapon. A truck can be used both as a consumer and a capital good. So can a violin.

[21] Note that 2024F was published on October 18, 2024. GN did not appear in print until a month later, on November 30, 2024. So, I could not have written this essay in response to their critique.

There is more in the libertarian philosophy than exhibited by GN.[22]

I am very grateful to GN for calling into question these views of mine. So far, they are only ones of a few to address my introduction of the new concept of negative homesteading. By far, the worst reception of a new breakthrough, in any subject, libertarianism or not, is to totally ignore it. Apart from them and just a few others, this was the fate of this new idea. Thanks to them, this is no longer the case. They reject this concept, however, on the grounds that it is new. GN would hold that the Magnus Carlson innovation in chess (Mukherjee, 2024) is not chess at all. If so, they would be wrong. Compatible with their rejection of negative homesteading, they would logically have to take the position that with the introduction of the three-point rule, what is not being played is no longer basketball. Ditto baseball with its designated hitter rule.

With equal justification, I could falsely accuse GN of taking candy from babies, and then remonstrate with them about the injustice of so doing. If their paper were published on April Fool's Day, I could understand it. I might not fully appreciate it, but I could understand it. But it was not. So I am completely in the dark as to why they would so seriously misconstrue my arguments and then criticize me for maintaining them. This is so very much unlike what we are accustomed to reading from these two brilliant authors. I conclude that intellectual fraud has taken place. It is more than likely that some other writer has actually written this essay, and fraudulently placed the names of GN as writers.

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Received for publication: 30.12.2024
Revision received: 07.01.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Block, W. E. (2025, 07 15). Rejoinder to Orwellian Libertarianism: Gordon and Njoya's Topsy-Turvy World of Twilight Zone Libertarianism. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 50-60. doi:10.12709/mest.13.13.02.02

Style – **Chicago** *Sixteenth Edition:*

Block, Walter E. "Rejoinder to Orwellian Libertarianism: Gordon and Njoya's Topsy-Turvy World of Twilight Zone Libertarianism." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 50-60.

Style – **GOST** *Name Sort:*

Block Walter E. Rejoinder to Orwellian Libertarianism: Gordon and Njoya's Topsy-Turvy World of Twilight Zone Libertarianism [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 50-60.

Style – **Harvard** *Anglia:*

Block, W. E., 2025. Rejoinder to Orwellian Libertarianism: Gordon and Njoya's Topsy-Turvy World of Twilight Zone Libertarianism. *MEST Journal,* 15 07, 13(2), pp. 50-60.

Style – **ISO 690** *Numerical Reference:*

Rejoinder to Orwellian Libertarianism: Gordon and Njoya's Topsy-Turvy World of Twilight Zone Libertarianism. **Block, Walter E.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 50-60.

MEST Journal
DOI 10.12709/mest.13.13.02.04

SHOULD THE STATE INVEST IN ELECTRIC CAR INCENTIVES, AND WHY NOT?

Zoran Cekerevac
Independent Researcher, Belgrade, Serbia
https://orcid.org/0000-0003-2972-2472

JEL Category: **H23, O33, Q48, Q54, Q58**

Abstract

Government subsidies are a powerful economic tool that allows the state to achieve its objectives. When combined with repressive measures, they become even more potent. The central question is whether the incentives are directed toward the right goals and carefully considered. If they are, the benefits can be substantial; otherwise, the consequences could be severe. This paper analyzes state investments in fostering electric vehicles (EVs). To better understand the effects of subsidies, the authors examined them from ecological, economic, and technological perspectives, as well as considerations of justification, timing, distribution of benefits, infrastructural challenges, and the potential creation of dependency on subsidies. The research is conducted based on established research questions regarding whether electric cars are the best option for addressing climate change, whether government incentives are the best and fairest solution for increasing the share of EVs among the total number of cars in various countries and globally, and what the impact of government incentives is in the EV sector. This topic involves multiple fields, which resulted in the creation of specific null and alternative hypotheses. The authors conducted a detailed analysis of the claims about the importance and effectiveness of electric vehicles (EVs) in ecology and economic development. They present results organized into sections that discuss the advantages and disadvantages of government incentives for EVs. The paper concludes with findings and recommendations for a more effective reduction of environmental pollution caused by urban transportation.

Keywords: *Electric vehicles (EVs), Government incentives, CO_2 emissions, Sustainable development, Economic growth, Public health, Technological innovations, Infrastructure.*

1 INTRODUCTION

1.1 Significance of the Topic

The topic of government investments in incentives for electric vehicles (EVs) is exceptionally important and timely, particularly in the context of global efforts to reduce greenhouse gas emissions, promote sustainable development, and transform the transportation sector. Government investments in EVs are indispensable within these objectives. This subject is multidisciplinary and needs examination from various perspectives.

Address of the author:
Zoran Cekerevac
zoran@cekerevac.eu

1.1.1 Pros

Government incentives for electric vehicles (EVs) offer a range of benefits across multiple domains, from environmental protection to economic growth. The following key advantages illustrate their broad impact.

- *Ecological Significance:* From an ecological standpoint, EVs have the potential to significantly reduce CO_2 emissions and other harmful gases when powered by electricity generated from renewable sources. The transportation sector is one of the largest sources of emissions, with automotive traffic occupying a significant place within it. Government incentives for EVs can accelerate the transition to *greener* transportation.
- *Economic Significance:* Incentives for EVs boost demand, stimulate production, create new jobs, and encourage innovation in the automotive industry (EmobEV, 2024). EVs reduce dependence on fossil fuels, which can increase energy security and trade balances in countries that do not possess sufficient fossil fuel resources. Investments in electric vehicles pave the way for new sectors' development, such as battery manufacturing, charging stations, and smart grids.
- *Social Significance:* EVs reduce air pollution in urban areas, improving air quality. That can positively affect public health. Incentives such as subsidies and tax breaks can make EVs more accessible to a broader population segment. Government support can encourage a shift towards more sustainable lifestyles.
- *Technological Significance:* Government incentives for EVs promote research and development of new technologies, such as advanced batteries, autonomous driving, and smart grids. This enhances the technological capacity of the country and strengthens its position in the global economy. Countries that invest in EVs can become leaders in this sector, granting them a more significant influence on the world market.

Based on the above, one can conclude that carefully planned government incentives can provide long-term economic benefits. In such cases, EV incentives can have a direct positive impact on the quality of life for citizens.

1.1.2 Challenges and Critiques

While the advantages of government investment in electric vehicle (EV) incentives are compelling, a detailed examination reveals several risks and challenges that need consideration. Some key challenges include:

- *Justification:* Questions arise regarding the justification for subsidies aimed at electric vehicle purchase and why there has been a sudden shift towards transforming the automotive industry when many fundamental issues related to EVs remain unresolved. As of 2023, electric vehicles, including battery electric vehicles (BEVs) and plug-in hybrids (PHEVs), represent only about 1-2% of the global vehicle fleet (Clsbe, 2022). Even if the number of electric vehicles were to increase tenfold, the impact on the environment might not be decisive. Are there more effective solutions available?
- *Timeliness:* Is it justified to promote the production and sale of electric vehicles at the current level of technological development? Evidence suggests that the electrical grids in most countries cannot replace fossil fuel-derived energy with renewable electric energy. In many regions, despite a minimal share of electric vehicles in the total vehicle fleet, a significant portion of electricity is still generated from coal-fired power plants. Would investing in public transportation and the research and development of more environmentally friendly electric vehicles be more prudent? Increased investments in research and development could potentially yield solutions that surpass current technologies more quickly.
- *High Costs:* Government incentives for EVs can be expensive if implemented on a large scale. This concern is particularly relevant for developing countries. Could this funding be allocated more effectively in alternative areas?

- *Unequal Distribution of Benefits:* Incentives often disproportionately benefit wealthier individuals who can afford higher-priced EVs. Meanwhile, those without any car, or low-income individuals reliant on older, less environmentally friendly cars, effectively subsidize the purchase of expensive vehicles. This dynamic can exacerbate the gap between the rich and the poor without producing significant environmental benefits.
- *Dependency on Subsidies:* If demand for EVs relies solely on subsidies, the market may become unstable if these incentives are reduced or eliminated.
- *Infrastructure Challenges:* Without adequate charging infrastructure, the incentive effectiveness may be limited. The number of charging stations, particularly in rural areas, is insufficient to meet the needs of an increasing number of EVs. Additionally, the electrical grid often lacks sufficient capacity in locations with high EV concentrations. There have been instances where diesel generators charged EV batteries. That is a suboptimal solution.
- *Global Context:* Considering that the atmosphere is shared by everyone, one might question whether the high cost of marginally cleaner air in certain areas is justified, especially if it leads to increased harmful emissions in other regions. Such a consideration is relevant globally and locally in contexts involving energy production from fossil fuel-based power plants.

The pros and cons highlight a range of complex issues that require careful reflection to avoid making detrimental decisions. A single poor decision can lead to a cascade of subsequent choices aimed at rectifying initial mistakes. Thus, the topic of government investments in EVs becomes critically significant for the future of transportation, the economy, and the environment. While government investments hold the potential to yield numerous benefits — including reduced emissions, economic growth, and improved quality of life — the success of these initiatives hinges on careful planning, addressing challenges, and a long-term commitment to sustainable development goals.

1.2 Overview of the Article

Section 2 presents a short review of electric vehicle (EV) manufacturers, their most significant models, and the attributes that make them recognizable. There is also a presentation of the current state of investments in electric vehicles and some preliminary results of government incentives. Section 3 discusses the main arguments that support the implementation of government incentives, while Section 4 addresses the arguments of those who oppose state intervention and government incentives for EVs. The authors discussed the issues from various perspectives, with particular emphasis on the role of public administration, the viewpoint of citizens, and the overall impact of EVs on the environment.

The following research questions guided this analysis:

a. *Are electric vehicles the best option for addressing climate change and protecting the environment?*
b. *What is the impact of government incentives on the production and acquisition of electric vehicles?*
c. *Are government incentives the best and fairest solution for increasing the share of electric vehicles in the overall fleet of passenger cars?*

To this end, the author formulated null hypotheses as:

h_{A0}: Electric vehicles are the best option for addressing climate change and protecting the environment.
h_{B0}: Government incentives do not affect the production and acquisition of electric vehicles.
h_{C0}: Government incentives are the best and fairest solution for increasing the share of electric vehicles in the overall fleet of passenger cars.

In this context, alternative hypotheses can be:

h_{Aa}: Electric vehicles are not the best option for addressing climate change or protecting the environment.
h_{Ba}: Government incentives do affect the production and acquisition of electric vehicles.

h_{Ca}: Government incentives are neither the best nor the fairest solution for increasing the share of electric vehicles in the overall fleet of passenger cars.

Section 5 presents conclusions about the research questions and the hypotheses put forth.

2 ELECTRIC VEHICLES AND GOVERNMENT INCENTIVES

2.1 Brief Overview of Electric Vehicles in 2025

Without reliable statistical data, based on estimations, global electric vehicle (EV) production exceeded 15–20 million units in 2024. In recent years, manufacturers have produced large quantities of small city cars. The demand for urban EVs is high in Europe. Small city cars are the most affordable, making them ideal for urban environments. Mid-sized cars are the most popular category because they offer a balanced combination of performance, size, space, and affordability. They typically allow enough room for battery placement, enabling a solid driving range. For instance, many mid-sized EVs provide a range of 400-500 kilometers, sufficient for most daily needs. Luxury vehicles offer high performance and advanced technology but come at a higher price point. Compared to other categories, luxury EV production is less. Yet it is increasing due to growing demand. The SUV and crossover segments are experiencing significant growth as they combine practicality with range.

A summarized overview of electric vehicles (EVs) by categories, manufacturers, current models for 2025, price ranges, and their specifications is presented in Table 1. This overview follows current trends and manufacturer announcements.

Table 1 Overview of Electric Vehicles Available in 2025

Category (Price Range)	Manufacturer	Models for 2025	Specificities
Small City Cars (20,000–35,000 EUR)	Renault (FR)	Zoe	One of the most popular EVs in Europe
	FIAT (IT)	FIAT 500e (IT)	Modern design, ideal for the city
	Renault-Nissan-Dongfeng (CN)	Dacia Spring (CN)	The most affordable EV on the market
	Peugeot (FR)	e-208	Sporty design, good range
	BMV Group (GB)	Mini Cooper SE	Compact and urban
Mid-sized Cars (35,000-55,000 EUR)	Tesla (US/CN)	Model 3	Best-selling EV in the global market
	Volkswagen (DE)	ID.3	Focused on the European market
	Hyundai (KR)	Ioniq 5	Futuristic design, fast charging
	KIA (KR)	EV6	Competitor to the Ioniq 5
	Škoda (CZ)	Enyaq	Spacious and family-friendly
Luxury Cars (80,000–150,000 EUR or more for premium models)	Tesla (US/CN)	Model S	High performance, long range
	Porsche (DE)	Taycan	Sports luxury EV
	Audi (DE)	e-tron GT	Competitor to Taycan
	Mercedes-Benz (DE)	EQS	Luxury sedan with cutting-edge technology
	Lucid Motors (US)	Lucid Air	Competitor to Tesla Model S
	BMW (DE)	i7	Luxury electric sedan
SUV & crossover EV (45.000–80.000 EUR)	Tesla (US/CN)	Model Y	Best-selling SUV EV in the global market
	FORD (SAD)	Mustang Mach-E	Sporty SUV
	Volkswagen (DE)	ID.4	Popular in the EU and the U.S.
	Hyundai (KR)	Ioniq 5	Crossover with fast charging
	Audi (DE)	Q4 e-tron	Luxury SUV EV
	Rivian (US)	R1S	Electric SUV designed for off-road use

Source: Author

2.2 Previous Results of Government Investments in Electric Vehicles

Investment in electric vehicles (EVs) is rapidly increasing worldwide. In the European Union (EU), governments and the private sector are engaged in promoting sustainable transportation actively. Government investments in electric vehicles are crucial for accelerating the transition to sustainable transport. The results have varied

depending on specific policies, market conditions, and infrastructure capacities. Below, we will examine the current state and provide an overview of the results achieved by regions and globally.

2.2.1 Global trends

The field of electric vehicles (EVs) is evolving rapidly, driven by technological advancements, environmental awareness, and government support. Different regions yield various outcomes depending on the area under consideration. Globally, the trends are as follows:

1. *Growth in Electric Vehicle Sales:* In 2022 and 2023, electric vehicle sales have continued to rise, particularly in China, the United States, and the EU. China remains the largest market for EVs, while the EU and the U.S. are making significant investments in infrastructure and incentives. In 2022, electric vehicles accounted for approximately 10% of global sales of new cars (Liu, 2023), with further growth expected.
2. *Investment in Battery Technologies:* Batteries are a critical factor for EVs, and investments in research and development (R&D) of batteries have significantly increased. Companies like Tesla, CATL, and others invest billions in these activities. There is considerable progress, with a focus on reducing costs while increasing battery capacity and lifespan. New technologies, like solid-state batteries, are being developed, promising more safety and efficiency.
3. *Charging Infrastructure:* New charging stations arise worldwide, which is crucial for the broader adoption of EVs. The network of fast and ultra-fast chargers is expanding. For example, ambitious plans are underway in the U.S. and EU to construct hundreds of thousands of new charging stations.
4. *Political Support and Regulations:* Many countries are introducing stricter emissions regulations and setting deadlines for the ban on the sale of new fossil fuel vehicles. Currently, incentives such as subsidies, tax breaks, and benefits for EV drivers are in place.
5. *Growth of the Used Vehicle Market:* As technology matures, the market for used electric vehicles is becoming increasingly important, making EVs more accessible to a broader range of consumers. There is a noticeable increase in supply and significantly lower prices already in the second year of vehicle operation. That is favorable for used vehicle buyers, but it can be discouraging for buyers of new vehicles.
6. *Smart Vehicles:* Electric vehicles lead in the integration of advanced technologies, such as autonomous driving and intelligent features, which further enhance their appeal.
7. *Global Competition and Collaboration:* The U.S. and Europe strive to increase their competitiveness through investments in domestic production and innovation. Collaboration between countries and companies is crucial for further technological development; however, existing collaborations are often limited to specific projects or companies, although global trends in cooperation are evolving. One of the most active collaborations in manufacturing is the Renault-Nissan-Dongfeng partnership. However, there is a noticeable interference from governments in the competitive dynamics among companies through the introduction of various restrictions, such as the 10% import duty imposed by the U.S. on China effective February 1, 2025 (Roščić, 2025). Cooperation in the creation and implementation of standards has proven to be much more effective.

These trends indicate that electric vehicles have become increasingly significant for the global transition toward more sustainable transportation.

2.2.2 Situation in the European Union (EU)

As mentioned, the EU is a global leader in supporting electric vehicles through subsidies, infrastructure projects, and stringent regulations. To date, manufacturers have made significant progress in various areas:

1. Green Policy and Regulations: The EU has set stringent targets for reducing CO_2 emissions. It encourages automakers to focus on electric vehicles. By 2035, the EU plans a ban on new ICE car sales. That includes gasoline and diesel engines, as well as hybrids. According to the latest announcements, there will be an allowance for the sale of ICE vehicles as long as they

utilize fuels from renewable sources. Additionally, the announcement of even stricter regulations on CO_2 emissions has compelled manufacturers to invest in EVs (BESEN, 2024). Concurrently, there is growing criticism from industry stakeholders and political groups who argue that these targets are unrealistic or overly ambitious. Many have also emphasized that if the EU does not ease its efforts, it could inflict existential damage on the leading European industry, the automotive sector. (Forbes, 2024) Some manufacturers have shifted their policies toward electric vehicles, such as Alfa Romeo, which has announced that it will keep internal combustion engines available as long as customers demand them (Monroy, 2025).

2. *Subsidies and Incentives:* Many EU countries provide financial incentives for purchasing electric vehicles, such as grants, tax breaks, and free parking or city driving privileges.
3. *Investments in Factories and Production:* Major car manufacturers, such as Volkswagen, BMW, and Renault, are investing billions in electric vehicles and battery production within the EU. Furthermore, new "gigafactories" for batteries are being established, including Northvolt in Sweden (Northvolt, 2022).
4. *Infrastructure:* The EU has built thousands of new charging stations and is actively working on further developing the network, particularly along highways. The aim is to ensure EV drivers have reliable and fast charging options across the continent. In 2023, in the EU, there were over 630,000 public charging stations (acea, 2024). The goal is to install one million public charging stations in the EU by 2025, and by 2030, there should be 3.5 million public connections active on EU roads. That could facilitate seamless travel for electric vehicles throughout the EU. Currently, most charging stations are AC chargers with slower charging speeds, but the number of DC fast chargers is rapidly increasing, especially along highways. Ensuring compatibility of all connections with various EV models is essential.
5. *Growth in EV Sales:* In 2022, approximately 1.83 million battery electric vehicles (BEVs) and plug-in hybrids (PHEVs) sold accounted for 18-22% of the total number of new cars sold. The largest market in the EU, with around 840,000 sold EVs, was Germany, followed by France, with approximately 400,000. In 2023, roughly 2.4 million EVs (BEVs + PHEVs) were sold in the EU, representing 20-25% of total vehicle sales. Over one million units were sold in Germany, while around 450,000 in France. Projections suggest that over 2.8 million vehicles were sold in the EU, which constitutes a share of 25-30% of total vehicle sales (BIHMK, 2024; Energetika.ba, 2024). The current sales growth of 2 to 5% is insufficient to meet the target for banning the sale of ICE vehicles.
6. *Subsidies and Tax Incentives:* Countries such as Germany, France, and the Netherlands offer significant subsidies for purchasing EVs, contributing to a rise in demand.

Despite these positive developments, notable challenges remain regarding the further adoption of EVs in the EU:

- *Dependency on Imported Batteries:* The EU still imports a significant portion of its batteries from China, although investments are underway to develop domestic manufacturing facilities.
- *Dependency on Critical Materials:* Battery production requires materials such as lithium, cobalt, and nickel, the markets for which are currently under considerable pressure. The EU is working to secure these resources and develop recycling technologies.
- *Cost of Electric Vehicles:* Although EV prices are gradually decreasing, they remain significantly more expensive than traditional vehicles, which may hinder mass adoption.
- *Uneven Support:* Some EU countries have better infrastructure and incentives than others.
- *Renewable Energy:* For EVs to be genuinely environmentally friendly, renewable energy sources must generate electricity. The EU is investing in renewable energy, but significant challenges still exist.

Considering the points mentioned above, it is evident that investments in electric vehicles are booming, and the EU stands as one of the global leaders in this transition. With support from governments, the private sector, and growing

environmental awareness, some anticipate that EVs will become the dominant mode of transport in the coming decades.

2.2.3 China

China is the world's largest producer and market for electric vehicles (EVs). The EV industry in China has experienced explosive growth in recent years, driven by clearly defined goals, strong government support, significant investments in technology, and rising domestic demand. While China leads in electricity generation from renewable sources, it is simultaneously the chief energy producer from fossil fuels (coal, oil, and natural gas). Approximately 30-33% of electricity in China comes from renewable sources, while fossil fuels account for 60-65%. Additionally, 4-5% of electricity comes from nuclear power plants, while other contributors, like waste-to-energy facilities, produce the remainder. China is at the forefront of installing new renewable energy capacities but continues to face challenges in reducing its dependence on coal. The country has ambitious targets for reducing greenhouse gas emissions and increasing the share of renewable sources, with a plan for 40% of total energy production to come from renewables by 2030.

China has achieved impressive results in the EV sector:

- *Market Dominance:* China has become the global leader in electric vehicles (EVs) and battery production. Chinese manufacturers such as BYD, NIO, and Xpeng are leading both production and sales of EVs, with electric vehicles constituting over 25% of new vehicle sales in the country in 2022. (Miladinović, 2024) Reports indicate that Chinese companies such as BYD and CATL dominate the global market for lithium-ion batteries, with an estimated market share of 70% to 80% in battery production by 2030 (Johnson, 2025). BYD became the world's largest producer of battery electric vehicles (BEVs) in 2023, surpassing Tesla in this segment. The reasons for success lie in model diversification, vertical integration, government support, and global expansion.
- *Subsidies:* The Chinese government has long offered substantial subsidies for the purchase of EVs, which has fueled widespread adoption.
- *Infrastructure:* China boasts the largest network of charging stations, with approximately 1.8 million public EV chargers reported by the end of 2022 (Zhang, 2024).
- *Exports:* Chinese EVs are becoming increasingly popular in global markets, particularly in Europe.

However, there are several challenges associated with EVs in China:

- *Overdependence on Subsidies:* The reduction of government subsidies in recent years has slowed growth in some segments.
- *Market Saturation:* Many local manufacturers create intense competition.
- *Access to Green Electricity:* Production capacities do not provide sufficient electricity from renewable sources, limiting the potential positive effects of electric vehicle implementation on overall environmental pollution.

2.2.4 UNITED STATES

The United States (U.S.) is one of the leading global markets for electric vehicles (EVs). In recent years, the U.S. has significantly accelerated the development of the EV industry, owing to government support, investments in technology, and rising consumer demand. However, compared to China and Europe, the U.S. still lags in some aspects of EV production and implementation.

The U.S. has achieved notable results in:

- *Sales Growth:* In 2022, EVs accounted for approximately 6% of new vehicle sales in the U. S, with Tesla as the dominant producer. In 2023, Americans bought around 1.4 million electric vehicles. That represented 8-10% of total new vehicle sales. This sales growth indicates that it will take many more years for the structure of cars on the U.S. roads to change.
- *Government Support, Federal and State Subsidies:* Incentives for consumers are provided through federal and state subsidies for the purchase of EVs. For qualified vehicles, federal tax credits of up to $7,500 are also included. This credit is deducted from the taxes individuals owe to the federal government, effectively reducing the vehicle's price.

- *Infrastructure:* By the end of 2024, the U.S. had over 200,000 public charging stations; however, this infrastructure is unevenly distributed. California has the most developed network, while rural areas lag. (Lewis, 2024) The U.S. government has announced plans to construct 500,000 new charging stations by 2030 through programs such as the Inflation Reduction Act (IRA, 2022).
- *EV Production:* Companies like Tesla, Ford, and GM invest heavily in EV manufacturing. In 2023, the U.S. produced approximately 1.85 million electric vehicles (BEV + PHEV), constituting 10-12% of total automobile production in the U.S. (Statista, 2024). Tesla is the largest EV manufacturer in the U.S., producing over one million vehicles in 2023.
- *Batteries:* The U.S. invests in building battery manufacturing plants, including Tesla's facility in Nevada and joint projects between GM and LG Chem. The goal is to reduce dependence on battery imports from China. The Inflation Reduction Act (IRA), enacted in 2022, promotes domestic production of EVs and batteries through tax incentives and subsidies.

However, significant challenges remain:

- *Political Divisions:* Support for EVs varies among states. Some actively support the transition, while others show less interest.
- *Infrastructure Shortcomings:* The charging stations network is still underdeveloped in rural areas, limiting the broader adoption of EVs.
- *Import Dependence:* The U.S. remains largely dependent on imports of batteries and critical minerals (e.g., lithium and cobalt) from China and other countries.
- *Competition:* Chinese EV manufacturers, such as BYD, are increasingly entering the U.S. market, posing challenges for domestic producers.
- *EV Prices:* Although EV prices are slowly decreasing, they remain higher than those of fossil fuel vehicles, which may limit accessibility.

2.2.5 Norway

Norway is a global leader in electric vehicle adoption and an exceptional example of how a country can successfully facilitate the transition to sustainable transportation. Some of the most significant outcomes include:

- *Record Sales:* In 2023, over 88.9% of all new passenger vehicles sold in Norway were fully electric vehicles (BEVs), while the number of light commercial vehicles decreased by 1.3% (Elbil, 2025). Norway is the first country in the world where electric vehicles dominate the new vehicle market.
- *Government Incentives and Subsidies:* Electric vehicles are exempt from high purchase taxes (VAT and customs duties), making them more competitive than internal combustion engine vehicles. Public charging stations are often free or very low-cost. EV owners can park for free in public parking lots. EVs are permitted to use HOV lanes even with just one occupant.
- *Infrastructure:* Norway boasts a dense charging station network, including fast and ultra-fast chargers. As of 2022, there were over 20,000 public charging points throughout the country (Mokkelgard, 2023), making charging practical and accessible. The extensive network of charging stations facilitates the easy use of EVs.
- *Environmental Awareness:* Norwegians are highly conscious of environmental challenges and support sustainable initiatives. The government actively promotes EVs as part of its strategy to reduce greenhouse gas emissions.
- *Geographical and Economic Advantages:* Norway enjoys inexpensive electricity due to its abundance of hydroelectric power. A relatively small population and well-developed infrastructure further ease the adoption of EVs.

Like everywhere else, Norway faces challenges in the implementation of electric vehicles, including:

- *Loss of Revenue:* As more individuals transition to EVs, the government loses revenue from fuel taxes and vehicle registration fees, which may become a concern in the future.
- *Increased Load on the Electrical Grid:* With the growing number of EVs, the electricity demand is rising, potentially straining the grid.

- *Cost of EVs:* Although EVs are more affordable due to incentives, their absolute price remains high.

As evidenced by the above points, Norway serves as a global example of a successful transition to electric vehicles. Thanks to strong government support, robust infrastructure, and ecological awareness among citizens, Norway has become a country where EVs are the norm rather than the exception.

2.2.6 India

India is relatively new to the electric vehicle (EV) sector but invests in EV promotion and development to cut air pollution and fossil fuel dependency. Though behind China, Europe, and the U.S., India has made significant progress and has ambitious plans for the EV market.

Some of the most notable outcomes include:

- *Sales Growth:* In 2023, EV sales in India surpassed one million vehicles, marking a substantial increase compared to previous years. Most of these sales consist of electric two-wheelers (scooters and motorcycles) and three-wheelers, while electric cars and light commercial vehicles hold a smaller share.
- *Government Initiatives and Policies:* The Indian government offers subsidies through the "Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME II)" program (BlueWeave, 2024). This program, valued at approximately $1.2 billion, aims to stimulate the production and purchase of EVs through subsidies and support for infrastructure development. EV buyers can benefit from tax incentives, making electric vehicles more affordable. In some states, EVs are exempt from excise duties and road taxes. The Indian government aims for 30% of all vehicles to be electric by 2030.
- *Charging Infrastructure:* India has over 10,000 public charging stations, although the infrastructure is still underdeveloped, particularly in rural areas. The government and the private sector are investing in establishing charging stations, including fast and ultra-fast chargers. There is ongoing construction of a charging network, but many regions of the country still lack adequate facilities.
- *Support for Domestic Manufacturing:* The government encourages the production of batteries and components for EVs through initiatives such as the "Production Linked Incentive (PLI) scheme."
- *Success Stories:* Electric scooters and motorcycles have gained immense popularity, particularly among youth and in urban areas. Companies such as Ola Electric and Ather Energy are experiencing significant sales growth. Some cities, including Bangalore and Delhi, have introduced electric bus fleets to mitigate air pollution. Electric rickshaws have also become popular in urban transportation, especially for short distances.

Given the level of EV adoption achieved so far, significant challenges remain, particularly regarding:

- *Low Purchasing Power:* Despite subsidies, the prices of EVs are still high for the average Indian consumer.
- *Insufficient Infrastructure:* The charging network is still under development and insufficient for mass adoption. That is particularly evident outside major cities.
- *Dependency on Imports:* India still heavily relies on imported batteries and critical minerals, which increases the cost of EVs.
- *Lack of Awareness:* Many consumers in India remain insufficiently informed about the benefits of EVs.

3 ARGUMENTS FOR STATE INVESTMENT IN EV INCENTIVES

There are numerous arguments related to the social, economic, and environmental benefits of state investments in incentives for electric vehicles (EVs). These incentives represent a strategic step towards a sustainable, green economy. The role of public administration is crucial in facilitating the transition, effectively implementing policies, and maximizing the benefits associated with the adoption of electric vehicles. Proponents of government investments in incentives for electric cars cite diverse reasons, such as:

- The reduction of harmful gas emissions, environmental protection, and combating climate change.

- The improvement of public health and reduction of healthcare costs.
- The economic growth and the creation of new jobs.
- The development of charging infrastructure and promotion of sustainable mobility.
- Encouragement of innovation and technological advancement.

The reasons for government investment vary, but at least nominally, they are most motivated by harmful gas emissions reduction, environmental protection, improvement of air quality, and the fight against climate change. The transportation sector is one of the largest sources of carbon dioxide (CO_2) emissions and other pollutants that contribute to global warming. Electric vehicles produce significantly fewer emissions when charging is powered by renewable energy, contributing to the fight against climate change (Andrić, 2025, 01 22). Many countries have committed to emission reduction by international agreements, such as the Paris Agreement (UNFCCC, 2015). EV incentives help countries meet their obligations and avoid penalties or negative consequences for their reputation.

Internal combustion (IC) vehicles emit harmful gases and particulates (e.g., CO, HC, NOx, and PM2.5), which can cause health problems such as respiratory diseases and cardiovascular deaths. EVs produce no exhaust emissions during operation, significantly improving air quality in urban areas and reducing healthcare costs. Internal combustion vehicles also generate noise, which detracts from the quality of life in urban settings. In contrast, EVs are significantly quieter, contributing to reduced noise pollution and positively impacting the quality of life by decreasing stress for residents.

The traditional automotive industry faces significant pressure from tightening regulations on permissible air pollution and potential reductions in demand. Even with the application of the most advanced technologies, it is unlikely that they will meet future standards due to the inherent limitations of internal combustion engine processes. Incentives for EVs boost demand, fostering innovation in batteries and electric motors. That, in turn, stimulates economic growth and creates new jobs, particularly in industries focused on manufacturing, innovation, and infrastructure. Global EV markets are growing rapidly, and countries that do not invest in this technology risk falling behind their competitors. Incentives can assist domestic manufacturers in developing competitive EV models and remaining relevant in the global market. Countries with developed electric vehicle infrastructure are becoming more attractive for investment.

Many nations depend on imported oil, making them vulnerable to price fluctuations and geopolitical crises. Electric vehicles can be powered by locally produced electricity, thereby reducing dependence on imported fossil fuels and increasing energy independence (Automobili, 2025). An increase in the use of electric cars will raise the need for electricity. If this energy does not come from renewable sources, it could lead to increased usage of fossil fuels. Governments can align EV incentives with investments in renewable energy to ensure that EVs genuinely contribute to emissions reductions.

There is a noticeable lack of charging infrastructure for vehicles around the world, which can be a barrier to the widespread adoption of electric vehicles. It is also unrealistic to expect that electric vehicle manufacturers or electricity producers will be able to provide adequate charging stations on their own. Government incentives often include investments in infrastructure, facilitating the quicker development of the charging network and increasing the convenience of EVs for users. Investment in charging stations and the electrical grid is crucial for electric vehicle utilization (BESEN, 2024). Strengthening infrastructure improves availability and reduces "range anxiety" for consumers, thus enhancing the adoption of these vehicles.

The initial cost of EVs can be high, which deters consumers. Government incentives decrease the costs of purchasing and maintaining EVs, making them more accessible to a broader population. Financial incentive programs are often accompanied by awareness campaigns regarding the benefits of electric vehicles and the importance of sustainable transportation, contributing to consumer behavior changes and increased acceptance of new technologies. If public administration successfully creates policies that encourage the adoption of electric vehicles, including financial incentives, regulations, and the

construction of necessary infrastructure, its engagement with manufacturers and local communities becomes essential for developing strategies that meet the specific region's needs.

In summary, the stated arguments suggest that government investments in incentives for electric vehicles provide a wide range of benefits, from emission reductions and health improvements to economic growth and increased energy independence. These incentives are critical for accelerating the transition to a sustainable transportation system and achieving long-term climate goals. This transition supports the development of a sustainable transportation framework. A comprehensive approach to state investments in electric vehicles represents a clear strategy for creating a more sustainable future. This strategy benefits not only the environment but also the economy and social welfare.

4 ARGUMENTS AGAINST STATE INVESTMENT IN EV INCENTIVES

Numerous counterarguments related to social, economic, and environmental benefits follow Government investments in incentives for electric vehicles.

Each advantage also presents challenges, such as:

- The validity of claims that electric vehicles positively contribute to environmental protection.
- The accuracy of assertions that automotive engines are the primary contributors to air pollution.
- The legitimacy of claims regarding economic growth and new job creation.
- The financial burden is placed on taxpayers.
- Potential economic downturns due to improper execution of investments.
- Concerns regarding overreliance on government subsidies.
- Technical challenges and battery safety issues.

Although electric vehicles are considered environmentally friendly, their production, use, and recycling carry numerous environmental risks.

For instance, the average electric vehicle contains approximately 83 kg of copper, whereas a gasoline vehicle contains about 23 kilograms. (Bennett, 2022).

The battery of the Renault Zoe contains approximately 8 kg of lithium (Lima, 2020), while the equivalent Renault Clio does not contain any lithium.

If the entire vehicle fleet were to be electric vehicles, the energy systems of many countries would be unable to sustain this demand, especially with only renewable energy sources.

Lithium-ion (Li-ion) batteries now account for about 95% of all electric vehicle batteries, with demand increasing by 55% in 2022 (IEA, 2023). Batteries production requires significant energy and raw materials, while recycling is complex and costly.

According to T&E (2022), the production of a small vehicle like the Renault Zoe emits 6.85 tons of CO2, compared to 4.49 tons emitted during the production of the gasoline-powered Clio.

According to available data, the CO_2 emissions from these two vehicles become comparable after approximately 17,000 kilometers of driving. They reach the milestone during the third year of operation. (Cekerevac, 2025)

Literature compares the health impacts of emissions from internal combustion engines, fossil fuel power plants, steel mills, and cement factories. Several studies have demonstrated that emissions from industrial sources, particularly power plants and steel mills, are key contributors to air pollution that can lead to respiratory and cardiovascular diseases (Oberschelp, Pfister, & Hellweg, 2023). Urban heating plants predominantly use fossil fuels and contribute significantly to this issue. Research indicates that approximately 72% of buildings in Europe utilize fossil fuels for heating (Le Corre, 2024, 04 18)

According to Oberschelp, Pfister, & Hellweg (2023), exhaust emissions from vehicles are directly linked to urban pollution and have an immediate impact on public health, particularly in cities with high traffic levels.

That raises the question of whether new electric vehicles will automatically improve street conditions. The most likely answer is no. Therefore, a prudent choice for public administration would be to remove older vehicles

from the streets through buyback and recycling programs at market prices that are certainly lower than subsidies for purchasing electric cars. Such an approach would effectively eliminate pollutants.

However, if we consider CO_2 emission more broadly, we must also include the impact of wildfires. The most recent wildfire in California, which occurred in January 2025, emitted approximately 4.4 megatons of carbon dioxide (CO_2) (Petersen, 2025). That corresponds to the emissions associated with the production of about one million Clio cars, or an annual emission of around 4.9 million vehicles (assuming an emission of 120 g/km CO_2 and an annual mileage of 7,500 km). Additionally, this wildfire was smaller in scale compared to the annual fires in Chile and Canada.

The validity of claims regarding economic growth and the creation of new jobs raises a significant dilemma concerning the transition to electric vehicles (EVs): Will economic growth and job creation offset the losses in traditional sectors related to internal combustion engines (ICE)?

Several key reasons suggest that EVs may not significantly increase job numbers or could even lead to a net loss of jobs:

- *Reduced Jobs in Manufacturing:* Compared to ICE vehicles, EVs have fewer moving parts. For example, an electric motor typically has only 20 to 30 components, while an ICE engine can have over 200 parts. The production of EVs is often more automated, which diminishes the need for human labor. A smaller number of components and greater automation may lead to a reduction in manufacturing jobs.
- *Job Losses in Traditional Sectors:* If EVs become dominant, the production of ICE engines, transmissions, exhaust systems, and other components will decline, resulting in job losses in these sectors. ICE vehicles require regular maintenance (like oil changes and filter replacements), while EVs have lower maintenance demands. This may contribute to a decrease in jobs in auto service centers. Overall, it is anticipated that the transition to EVs could lead to job losses in the traditional automotive industry sectors.
- *Concentration of Battery Production:* The production of batteries for EVs is currently concentrated in a few countries (e.g., China, Japan, South Korea), suggesting that other nations may not benefit from this growth. Battery manufacturing is capital-intensive and highly automated, which limits job creation. It can be expected that battery production will not necessarily generate enough jobs to offset losses in other sectors.
- *Uneven Distribution of Benefits:* The EV industry requires a highly skilled workforce (engineers, programmers, battery specialists), while the traditional industries employ many less-skilled workers. Regions dependent on ICE vehicles and components production may experience economic downturns, while new jobs are created elsewhere. The uneven distribution of benefits could lead to regional economic inequalities and increased population migration.
- *Limited Growth in New Sectors:* Although new jobs will emerge related to the construction and maintenance of charging stations, the number of these positions may not be sufficient to compensate for losses in traditional sectors. Battery recycling is still under development, and the number of jobs in this sector is currently limited. It is anticipated that new sectors associated with EVs may not generate enough jobs to offset these losses.
- *Economic Risks:* The EV industry depends on government subsidies and incentives. If subsidies are decreased, industry growth may slow, adversely affecting job creation. High competition and rapid technological advancements could lead to instability in the EV sector, potentially jeopardizing jobs. Economic risks may limit the long-term growth and job stability in the EV sector. Additionally, one should not overlook the vehicle owners, who may experience a significant depreciation in the value of their purchased vehicle immediately after acquisition. According to Cekerevac (2025) and Autoscout24.de, the small electric vehicle Renault Zoe depreciates approximately one-third of its original price by the fifth year of use. Since small cars are primarily intended for urban driving, they

accumulate relatively low annual mileage. That significantly affects the cost per kilometer driven.

Active policies are needed to support worker training, promote new sectors, and encourage regional development to mitigate negative effects. Without such measures, the transition to electric vehicles may lead to a net loss of jobs and increased economic inequalities.

From the taxpayer's perspective, several key risks and issues are significant when examining government incentives for electric vehicles.

Government incentives are funded by public resources, specifically through tax revenues, making it significant to understand how the government utilizes these resources and what potential risks exist for taxpayers. Key points of concern may include:

- *High Costs to Taxpayers:* Government incentives for EVs directly burden the state budget. That implies that taxpayers bear the costs through higher taxes or reduced funding for other public services (healthcare, education, infrastructure). Sustained subsidies over a prolonged period could significantly burden public finances.
- *Unequal Distribution of Benefits:* Incentives for EVs often benefit wealthier segments of the population, as EVs remain more expensive than traditional vehicles. Low-income taxpayers may find themselves at a disadvantage, as they pay taxes that support those who can already afford EVs. Incentives may be concentrated in urban areas or regions with better infrastructure, while rural areas remain neglected.
- *Investment Efficiency:* Do incentives contribute to reducing CO_2 emissions, or do only certain groups benefit from them? If the incentives do not lead to a substantial increase in EV numbers and a corresponding reduction in harmful emissions, this may constitute a waste of public funds. Could these resources be better allocated to other environmental projects (e.g., renewable energy, public transportation)?
- *Dependency on Subsidies:* If demand for EVs relies solely on subsidies, the market may become unstable when those subsidies are reduced or eliminated. This could result in losses for taxpayers if investments do not pay off. The next question is, will the EV industry become self-sustainable without ongoing government incentives? If not, taxpayers will need to continue financing this support.
- *Environmental and Social Risks:* The production of batteries for EVs requires significant amounts of energy and critical materials (lithium, cobalt), which may have adverse environmental and social consequences. Here is a question about whether these risks are factors in the incentive costs. Due to unresolved battery recycling issues, taxpayers may incur costs for cleaning and remediating environmental damage.
- Transparency and Accountability: Is there a transparent system to monitor how funds from the incentives are utilized? Taxpayers have the right to know how their money is spent and if there was a regular evaluation of the incentive programs to determine whether they achieve the desired outcomes.
- Long-Term Economic Effects: The transition to EVs may lead to job losses in traditional sectors. A question is: Will new jobs in the EV sector compensate for losses? If incentives disproportionately benefit specific groups or regions, they may exacerbate economic inequalities. On the other hand, the closure of manufacturing plants for vehicles that use or produce internal combustion engines currently leads to job losses. Furthermore, to reduce costs, companies will eliminate many jobs even without the closure of plants. For example, Volkswagen, the largest automotive manufacturer in Europe, plans to eliminate over 35,000 jobs in Germany by 2030 (Biznis.rs, 2024). The transition to electric vehicles does not guarantee job security. Volkswagen plans to close its factory in Brussels, which produces the Audi Q8 e-tron. Audi planned to cease production in February 2025. Such a move would result in the loss of jobs for nearly 3,000 workers (Huseinagić, 2024).

Taxpayers have the right to demand that public funds be utilized responsibly and efficiently, with minimal risks and maximum benefits for society. With government incentives for improper

implementation of electric vehicles, numerous negative economic consequences may arise. These consequences can impact taxpayers, the economy, and society. The risks faced by taxpayers also affect the broader community. If the incentives do not result in EV usage increasing and a reduction in CO_2 emissions, it may lead to wasted funds. Poor incentive management may lead to corruption, nepotism, or misuse of resources.

Improper implementation of incentives can result in a loss of trust in government institutions and inefficient expenditure of public funds. Incentives must be properly planned, executed, evaluated, transparent, and accountable to taxpayers to mitigate these risks.

Ultimately, it is important not to lose sight of the technical challenges and battery safety. Electric motor drives have been relatively well studied thus far, and their expected performance is understood. However, battery technology remains an area of experimentation and has not yet reached a mature stage. Lithium-ion batteries, currently the dominant technology in EVs, offer numerous advantages but present uncertainties and challenges that are not yet fully resolved. Some of the key issues and uncertainties associated with EV batteries include:

- *Safety concerns:* spontaneous ignition and explosions. Lithium-ion batteries carry the risk of thermal runaway, which can potentially lead to spontaneous ignition or explosion. Nonetheless, statistics indicate that EVs are generally safer than internal combustion engine (ICE) vehicles concerning fire risks. Research shows that the incidence of fire in EVs is approximately 25 per 100,000 sold units, whereas, for ICE vehicles, it is around 1,530 per 100,000 sold units (Hoey, 2023). The most common causes are battery damage (e.g., due to an accident), manufacturing defects, overheating, or the use of inappropriate chargers. Electric vehicle (EV) manufacturers employ advanced Battery Management Systems (BMS) to mitigate the risks of overheating and thermal runaway. Despite their rarity, fires attract significant attention because of their dramatic nature. To further reduce these risks, technology is continuously advancing.
- *Submerging*: Submerging an electric vehicle in water can cause serious issues, including both short-term and long-term damage to the battery and electrical systems. If water penetrates the electrical components, it can lead to short circuits and damage vital parts of the vehicle. This hazard becomes especially significant when vehicles are fully submerged. In extreme cases, this may result in short circuits or even fires. These issues are especially pronounced when submerged in seawater, and an additional concern is that fires may occur later, even a month after the vehicle has been dry, rendering the car unsafe and potentially hazardous. (Goff, 2024; HB911, 2024; Tanim, 2024)
- *Durability and Degradation of Batteries:* Lithium-ion batteries lose capacity over time. The typical lifespan of a battery ranges from 8 to 15 years, depending on usage and environmental conditions. Batteries degrade due to the number of charge/discharge cycles, high temperatures, and depth of discharge (DoD). This degradation can reduce the range of vehicles over time. Most EV manufacturers offer warranties for batteries lasting 8 years or 160,000 kilometers, which covers a significant portion of the vehicle's lifespan. Although battery degradation poses a serious challenge, temperature management and proper charging can help alleviate this issue.
- *Environmental Issues:* The production of lithium-ion batteries requires substantial energy and critical materials (lithium, cobalt, nickel), which can have negative environmental and social consequences, such as habitat loss and poor labor conditions. Battery recycling is still evolving and remains costly. Only 5-10% of lithium-ion batteries are recycled currently, while the remainder are disposed of or used in secondary applications (e.g., energy storage).
- *Performance in Extreme Conditions:* Batteries lose capacity and performance at low temperatures, which can reduce the range of an EV by 20-40% in winter conditions. High temperatures can

accelerate battery degradation and increase the risk of thermal runaway. As demonstrated, the performance of batteries for electric vehicles is sensitive to extreme conditions; however, manufacturers are actively working to improve temperature management.

- *Uncertainties in Technological Development:* Lithium-ion batteries are dominant. Alternatives, such as solid-state and lithium-sulfur batteries, are being explored. These technologies promise good energy density, faster charging, and improved safety, but they are not yet commercially available. In 2023, Chinese companies Hina Battery and JAC introduced the first electric vehicle with sodium-ion batteries, the Sehol E10X model. (Kazbašić, 2023). New Battery Chemistry requires the development of new manufacturing processes, which can be challenging and costly.
- *Economic Challenges:* Batteries remain the most expensive component of electric vehicles (EVs), although prices are declining. The cost of lithium-ion batteries has decreased from $1,000 per kWh in 2008 to $143-$157 per kWh in 2021 (VreleGume, 2021) and further reduced to $115-$133 per kWh in 2024 (BloombergNEF, 2024). However, the pace of further price reductions may be slower. Lithium, cobalt, and nickel prices can fluctuate by impacting battery costs. While economic challenges persist, trends suggest that battery prices will continue to decline.
- *Charging Infrastructure:* Fast charging can accelerate battery degradation and increase the risk of overheating. Conversely, it is hard to expect drivers to be satisfied with several hours of battery charging. The lack of charging stations, particularly in rural areas, may limit the use of EVs. Charging infrastructure is critical for the broader adoption of EVs. It requires further investment.

5 CONCLUSION

It can be argued that government subsidies are often economic measures driven by political decisions. They can effectively stimulate economic growth, environmental initiatives, and/or social policies if the objectives are well-defined and quality implementation plans are established. Government incentives for electric vehicles (EVs) sought to achieve all three goals. However, based on the analysis, we conclude the governments introduced the incentives prematurely and directed them toward inappropriate purposes. The main issue is that these incentives supported an immature product.

In this context, lithium-ion batteries represent the most significant problem. Their production requires substantial energy and significant quantities of lithium. Lithium extraction processes cause considerable environmental degradation. The batteries are highly priced, and recycling remains underdeveloped and economically unviable. The manufacturing costs of electric vehicles are significantly higher than those of their gasoline-powered counterparts. All this poses risks for both manufacturers and consumers. Manufacturers would produce, and potential buyers would purchase, with everything flowing according to the principles of supply and demand. There would not be any harm had governments refrained from intervening with their subsidies and various incentives for electric vehicle buyers without proper consideration.

Governments have attracted many buyers through subsidies for electric vehicles and restrictions on internal combustion engine (ICE) vehicles. Buyers did not have complete information about electric cars and have unnecessarily spent significantly more money on vehicle purchases. That way, they formed a small EV fleet with substantial demands for electricity supply across various locations. Germans bought approximately 396,000 electric cars in 2023 out of 2.845 million new vehicles (about 14%). Even in Norway, which many consider a leader in EV adoption, the share of electric cars among all registered vehicles in 2023 was below 14%. Moreover, automobiles are not the only vehicles with ICE engines; there are buses, trucks, tractors, construction machinery, etc.

From the perspective of vehicle owners, aside from their desire to help the planet, there is no valid reason to purchase an electric vehicle. The discouraging factors include:

- *Significant Initial Cost Difference:* Electric vehicles are often substantially more

expensive than conventional vehicles, and the economic argument about reduced operational costs often does not justify this initial expense.

- *Battery Replacement Costs:* After a certain number of kilometers or years, the owner must replace the battery. Replacing the battery can be very costly. That further increases the total cost of ownership.
- *Limited Tax Incentives:* Tax incentives and subsidies are often temporary measures, and it is uncertain how long they will last. Once the government withdraws these incentives, the economic rationale becomes even less attractive.
- *Reduction in Government Revenue:* The transition to electric vehicles may decrease government revenue from fuel taxes. That must lead to tax policy changes and new challenges in funding infrastructure.

From an environmental perspective, the impact of 1-2% of electric vehicles is virtually negligible. Furthermore, it takes a minimum of two years for the CO2 emissions generated during the production of an electric vehicle to offset those from gasoline engines. The manufacturing process of electric vehicles, particularly batteries, results in higher CO2 emissions compared to the production of conventional vehicles. The replacement of vehicles with engines that are twenty years, or older, would yield a much more visible impact. Governments could have utilized taxpayer money more rationally by organizing the buyback and recycling of registered old vehicles. This approach would remove polluters from the streets, while modern EURO6 vehicles contribute significantly less to environmental pollution. Instead of distributing funds for purchases, they could have invested in the development of new battery technologies and similar initiatives, and then, upon achieving positive results, start supporting production.

It should not be overlooked that most of the electricity is generated from fossil fuels, thereby diminishing the effects of implementing electric vehicles. Additionally, the impact of heating homes with fossil fuels must not be forgotten. There are also concerns related to industrial pollution, wildfires, wars, and more.

Subsidies have also introduced risks in the social sphere. They have supported a wealthier group of individuals in purchasing more expensive vehicles, with funds being taken from all taxpayers. The poorer segments of the population have effectively subsidized the wealthier demographic.

Based on the research findings and these conclusions, it can be stated that there is evidence to reject the null hypotheses in favor of the alternative hypotheses:

h_{Aa}: Electric vehicles are not the best option for addressing climate change or protecting the environment.

h_{Ba}: Government incentives influence the production and procurement of electric vehicles.

h_{Ca}: Government incentives are neither the best nor the most equitable solution for increasing the share of electric vehicles in the overall passenger car fleet.

In conclusion, we must note that governments have not chosen the right moment to implement subsidies for electric vehicles; more broadly, they should not have provided subsidies for these purposes at all. A substantial amount of money has been invested, yet the effects remain negligible. The issue of electric vehicles is not of vital importance and has presented numerous unnecessary challenges.

6 RECOMMENDATIONS

Based on this study and prior experience, we can conclude that the modernization of automotive powertrains may yield only cosmetic results. For true environmental preservation, systemic changes in the organization of life and transportation in urban areas are necessary. It is crucial to alter the perception of transportation and vehicle ownership.

A public bus in urban transit occupies as much road space as three small cars, yet it can transport up to 35 times more passengers while consuming 11 times more fuel than a single car. After completing one route, the bus continues onward, while the small car remains parked. A personal vehicle spends 95% of its time parked.

Implementing a car-sharing model could decrease the number of cars by at least ten times. If buses were used exclusively instead of cars, the

number of vehicles could be decreased by an additional twenty-fold. Such a transportation arrangement would lead to reduced production of vehicles and batteries, as well as decreased pollution resulting from these manufacturing processes. The streets would become more accessible, parking problems would be resolved, and traffic congestion would disappear.

Only a reorganization of transportation can bring about significant results in environmental protection.

Notes

For more information on the application of various powertrains in vehicles, please refer to: Cekerevac, Z., & Prigoda, L. (2025). Ecological and Economic Risks of Using Gasoline, Electric, Hybrid, and Hydrogen-Powered Vehicles. *MEST Journal – SP FBIM Transactions, 13*(SP), 1-22. doi:10.12709/13.13.SP.01

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Received for publication: 02.02.2025
Revision received: 20.02.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Cekerevac, Z. (2025, 07 15). Should the State Invest in Electric Car Incentives, and Why Not? (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 61-80. doi:10.12709/mest.13.13.02.04

Style – **Chicago** *Sixteenth Edition:*

Cekerevac, Zoran. "Should the State Invest in Electric Car Incentives, and Why Not?" Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 61-80.

Style – **GOST** *Name Sort:*

Cekerevac Zoran Should the State Invest in Electric Car Incentives, and Why Not? [Journal] // MEST Journal. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 61-80.

Style – **Harvard** *Anglia:*

Cekerevac, Z., 2025. Should the State Invest in Electric Car Incentives, and Why Not?. *MEST Journal,* 15 07, 13(2), pp. 61-80.

Style – **ISO 690** *Numerical Reference:*

Should the State Invest in Electric Car Incentives, and Why Not? **Cekerevac, Zoran.** 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 61-80.

MEST Journal
DOI 10.12709/mest.13.13.02.05

PROTECTING BLOCKCHAIN FROM IOT DEVICE ATTACKS: CHALLENGES AND SOLUTIONS

Zoran Cekerevac
Independent Researcher, Belgrade, Serbia
http://orcid.org/0000-0003-2972-2472

Serghei Ohrimenco
Academy of Economic Studies of Moldova, Chisinau, Moldova
https://orcid.org/0000-0002-6734-4321

Petar Cekerevac
Independent Researcher, Belgrade, Serbia
https://orcid.org/0000-0001-6100-5938

JEL Category: **C88, D85, K24, L86, O33**

Abstract

This paper focuses on the challenges and solutions in protecting blockchain technology from attacks through IoT devices, emphasizing the importance of integrating these technologies into modern systems. The study is based on the null hypothesis that there is no significant correlation between security challenges posed by IoT devices and the compromise of integrity, availability, or immutability of blockchain technology. While IoT devices enhance operational efficiency, they simultaneously represent vulnerabilities for potential cyberattacks that may jeopardize the security of blockchain systems. Identified security challenges, including DDoS attacks, data manipulation, ransomware, and protocol compromise, are analyzed through real-world cases and technological solutions. The analysis reveals that Zero Trust architecture, smart contracts, cryptographic algorithms, and artificial intelligence significantly enhance the security and resilience of integrated systems. User education, standardization of IoT security protocols, energy-efficient solutions, and collaboration between industries and regulatory bodies are key to mitigating risks. Based on the analysis, a significant correlation between IoT-related security challenges and blockchain compromise was established, rejecting the null hypothesis. The paper offers recommendations for improving the security of these technologies, highlighting the need for continuous monitoring and innovation in IoT and blockchain environments. It is intended to be useful for cybersecurity professionals, researchers working on IoT and blockchain integration, and companies implementing IoT devices in industrial and commercial contexts.

Address of the corresponding author:
Zoran Cekerevac
zoran@cekerevac.eu

Keywords: *Blockchain, IoT Security, DDoS, Smart Contracts, Zero Trust.*

1 INTRODUCTION

1.1 Blockchain and the Internet of Things (IoT)

Thanks to Bitcoin, distributed ledger technology (DLT) has become widely recognized. Nowadays, this innovative system and the Internet of Things (IoT) are among the most researched technologies. Many are attempting to apply this ledger system in various fields. We believe it is meaningful in areas requiring permanent record-keeping and/or monetization. In specific cases, it can serve as the optimal solution, but frequently, its implementation may not justify the costs or complexity.

Blockchain is highly effective in situations requiring immutability, transparency, and data verification and when tokenization and monetization are necessary:

- Due to its structure based on immutable blocks, it ensures that entered data remains permanent and unchangeable. This feature is crucial for transaction records, contracts, documentation, and supply chain tracking. (Valencia-Payan, Griol, & Corrales, 2024)
- It is frequently associated with economic models involving tokenization. For instance, systems like cryptocurrencies or decentralized finance (DeFi) enable direct exchange and monetization without centralized intermediaries. (Zetzsche, Arner, & Buckley, 2020)
- Much has been written about blockchain technology; here, we will only mention the basic principles necessary for understanding this work. Blockchain functions as a distributed ledger facilitating the tracking of transactions and assets. For easier comprehension, blockchain can be considered an operating system, while Bitcoin is one of the applications running on it (Cekerevac, Prigoda, & Maletic, Blockchain Technology and Industrial Internet of Things in the Supply Chains, 2018).

A distributed ledger represents a database accessible at multiple locations, with data entered through participant consensus (Belin, 2018). Blockchain links records via encrypted blocks relying on previous entries, ensuring immutability and security. Depending on the application, blockchain may be:

- Private, e.g., Hyperledger Fabric, suitable for corporate systems (2023),
- Consortium, e.g., R3 Corda, enabling collaboration among a limited number of participants (R3, 2025), or
- Public, e.g., Ethereum, provides open access and benefits like smart contracts (Ethereum, 2025).

Among these, public blockchains are the most demanding and complex to maintain.

Interoperability and scalability challenges have inspired the idea of “blockchain within blockchain.” This approach represents a step toward the development of 'Internet 2.0.' Internet 2.0 integrates decentralized technologies such as blockchain, cryptocurrencies, and smart contracts to enhance security and transparency. Projects like Polkadot and Cosmos facilitate network communication and scalability, addressing critical interoperability issues (Palkadot, 2024; Cosmos Network, n.d.).

The Internet of Things (IoT) refers to a system of connected devices, machines, objects, and even people and animals with unique identifiers that transmit data over a network without direct user interaction (Wigmore, 2016). Within IoT, the Industrial Internet of Things (IIoT) subcategory has emerged for industrial applications. IIoT devices communicate with each other, improving processes (M2M - Machine-to-Machine). IIoT technologies require higher reliability, precision, security, and interoperability to ensure the efficient operation of facilities. A comparison between a smartphone and a high-end digital camera illustrates the difference between IoT and IIoT—IIoT is better suited for demanding conditions. IIoT technology is heterogeneous, involving various platforms and equipment, and its implementation follows phases such as device connection, data monitoring and analysis, activity automation, and Edge Computing. Each phase includes specific steps, from data collection to automated analytics and device-level management. Examples of IoT devices include smart thermostats that optimize energy consumption and agricultural sensors that enhance irrigation efficiency.

1.2 Security in the Context of Blockchain and IoT Integration

With the rapid development of IIoT and IoT, a growth in cyberattacks on networked devices is expected, highlighting the need for enhanced protection. Integrating blockchain technology and IoT devices can play a key role in improving security, transparency, and operational efficiency in interconnected systems:

- *Data Security:* Blockchain secures data using advanced cryptographic methods, preventing manipulation and reducing the risk of cyberattacks (Bobde, et al., 2024). IoT devices frequently send and receive sensitive information, and blockchain enhances the system's resilience against security threats.
- *Transparency:* Blockchain provides a clear record of interactions and transactions between IoT devices, enabling tracking and problem resolution in industrial and logistical applications (Douaioui & Benmoussa, 2024).
- *Interoperability:* IoT systems are often heterogeneous, comprising devices from different manufacturers. Blockchain facilitates communication and information exchange among these devices, establishing consistent standards.
- *Automation:* Smart contracts within blockchain automate processes based on IoT data, reducing human intervention and increasing efficiency (Zafar, Bhatti, Shabbir, Hashmat, & Akbar, 2021)
- *Monitoring and Management:* Blockchain enables continuous tracking of IoT devices and the data from origin to end-use. For example, in supply chains, blockchain helps identify the origin of products and track their journey (Douaioui & Benmoussa, 2024)

This integration is significant as it unlocks the potential of IoT technology to enhance security and efficiency in industrial processes and daily applications.

1.3 About the Paper

1.3.1 Aim of the Paper

This paper aims to identify the key security challenges that blockchain technology may face due to attacks via IoT devices, alongside analyzing potential solutions and strategies to mitigate these risks. The focus is on understanding how IoT devices can compromise blockchain systems' integrity, availability, and immutability while proposing specific technical, procedural, and organizational approaches to enhance security.

1.3.2 Research Question and Hypotheses

In their study, the authors defined the research question and corresponding hypotheses. This approach provided a structured framework for academic analysis, focusing on identifying security threats, analyzing case studies, and proposing future recommendations.

Research Question: What are the primary security challenges that arise from IoT-driven attacks on blockchain systems, and which solutions are most effective in addressing them?

Null Hypothesis (H_0): There is no significant correlation between security challenges posed by IoT devices and the compromise of key aspects of blockchain technology, regardless of the implementation of advanced cryptographic algorithms, access control mechanisms, or Zero Trust architecture.

Alternative Hypothesis (H_a): There is a significant correlation between security challenges posed by IoT devices and the compromise of key aspects of blockchain technology, whereby advanced cryptographic algorithms, access control mechanisms, and Zero Trust architecture can reduce these risks.

1.3.3 Methodology

This review paper is based on an analysis of available literature and the structural synthesis of data, aiming to identify challenges and solutions for protecting blockchain technology from attacks via IoT devices. The methodological approach encompasses:

1. *Research Framework*. The framework stems from the research question and key areas, including IoT device challenges, blockchain vulnerabilities, and protection strategies.
2. *Literature Review*. The research involved a review of scientific databases, including Google Scholar, Kobson, IEEE Xplore, and

Scopus. Keywords for source identification included terms such as *IoT security blockchain*, *IoT attacks blockchain vulnerabilities*, and *Blockchain cybersecurity IoT*. The focus was on papers published in the last five years, with a few relevant exceptions.

3. *Categorization of Challenges and Solutions*. Security challenges, such as DDoS attacks, MITM attacks, and data manipulation, were identified, while mitigation strategies encompassed advanced cryptographic mechanisms, Zero Trust architecture, and IoT security protocols.
4. *Analysis and Data Synthesis.* All collected data were systematized into thematic areas:
   - Overview of Security Threats identifies the main types of attacks via IoT devices and their impact on blockchain technology.
   - Technological Solutions for Protection include research on existing security mechanisms and their effectiveness.
   - Methods to Protect Blockchain from IoT Attacks and
   - Recommendations for the Future provide suggestions for improving blockchain security within IoT contexts.

   The discussion links challenges to corresponding solutions with case study examples from literature.
5. *Quality Assurance*. This included analyzing consistency, source relevance, and linguistic clarity using relevant tools.

2 SECURITY THREATS

Blockchain technology in IoT systems opens numerous opportunities across various sectors. It also introduces significant risks (Shah, Ullah, Li, Levula, & Khurshid, 2022). While blockchain is inherently well-protected, integrating with IoT devices demands additional security measures to preserve the system's overall safety. This integration can compromise system security in several ways. For instance, compromised IoT devices may introduce malicious data into the blockchain. Attacks such as Man-in-the-Middle (MITM) may disrupt communication between devices and the network (Cekerevac, Dvorak, Prigoda, & Cekerevac, 2017). Furthermore, IoT botnet attacks like DDoS can overwhelm blockchain networks and reduce their functionality (Ibrahim, Al-Haija, & Ahmad, 2022).

2.1 IoT Vulnerabilities

IoT devices represent critical points in systems for several reasons. First, the physical accessibility of IoT devices, often located in remote or unprotected areas, may allow sabotage or unauthorized access. Additionally, weak user authentication systems can make it easier for attackers to gain control over devices. Insecure communication channels further increase the risk of data interception, while limited IoT device resources hinder the implementation of encryption, authentication, and constant monitoring, making them vulnerable to attacks.

2.2 Attacks on Blockchain via IoT Devices

Attacks using IoT devices to compromise blockchain technology are diverse and include:

- Trojanization of devices (SC, 2023) through malicious software that sends manipulated data,
- Ransomware attacks that block operations until a ransom is paid, and
- Firmware attacks result in unauthorized control over data.

Additionally, Sybil's attacks enable the creation of numerous fake identities to manipulate consensus processes within blockchain networks. IoT devices are often used as bots in DDoS attacks, which can overwhelm the network and compromise functionality. Compromised IoT devices may manipulate data required for transaction validation or attack network protocols, jeopardizing communication between devices and the blockchain network. (Humayun, Jhanjhi, Alsayat, & Ponnusamy, 2021; Balogh, Gallo, Ploszek, Špaček, & Zajac, 2021)

2.3 General Security Threats

Beyond specific risks, blockchain can be exposed to general threats, including the lack of universal security standards for IoT devices and their integration with blockchain technology. Additional challenges include the limited capacities of IoT devices for energy-intensive security functions such as encryption and data verification, which can reduce the entire system's efficiency (Zaheer, et al., 2024).

3 TECHNOLOGICAL SOLUTIONS FOR PROTECTION

Technological solutions for protecting blockchain from attacks via IoT devices involve a combination of security mechanisms, protocols, and strategies tailored to both systems. One key approach is network segmentation (Sengupta, 2020), which separates IoT devices from the core network using VLANs or dedicated Wi-Fi networks. When IoT devices exhibit suspicious behavior, blockchain networks can quickly isolate compromised devices, preventing the spread of threats.

Communication security is another critical aspect, achieved through robust authentication methods and end-to-end encryption for communication between IoT devices and blockchain networks. Digital signatures provide additional protection by authenticating and verifying data, preventing information manipulation. Furthermore, Zero Trust architecture ensures that network access is granted only after verifying the identity and context of each device and user. TLS/SSL protocols further secure encrypted communication, reducing the risk of data interception. (Liu, et al., 2024)

Data validation automation via smart contracts enables automatic validation of information sent by IoT devices to blockchain networks, speeding up processes and reducing human error. Artificial intelligence (AI) use plays a pivotal role in anomaly detection by analyzing IoT device behavior to identify suspicious activities (Demertzis, Iliadis, Tziritas, & Kikiras, 2020). Additionally, AI can be employed for potential threats predictive analysis based on historical data and behavioral patterns.

Alongside these technical approaches, collaboration between IoT device manufacturers and blockchain networks remains essential. Standardizing security practices contributes to establishing universal standards for integrating IoT devices with blockchain technology, while information sharing on threats enhances protection through collective efforts.

4 METHODS TO PROTECT BLOCKCHAIN FROM IOT ATTACKS

Blockchain technology with its inherent characteristics such as decentralization, cryptographic protection, and data immutability, already possesses a high level of resilience against attacks. Key elements, such as consensus mechanisms (e.g., Proof-of-Work or Proof-of-Stake), encrypted transactions, and distributed ledgers, further contribute to the security and stability of blockchain networks (Becher & Urwin, 2025). However, as the number of IoT devices continues to grow, the complexity of systems demands a comprehensive approach to protection.

Protecting blockchain from threats originating through IoT devices involves preventive actions that prevent data manipulation, strengthen communication protocols, enable advanced analytics, and isolate compromised devices. Data authentication mechanisms, such as algorithms for stricter validation of IoT device information, are crucial for maintaining transaction integrity and preventing the entry of compromised information into the system. Security layers, such as encrypted channels based on TLS (Transport Layer Security) protocols, ensure secure communication between IoT devices and blockchain networks, reducing the risk of data interception or manipulation during transmission. (SSL, 2021)

Artificial intelligence (AI) plays a significant role in enhancing anomaly detection in transactions involving IoT devices. Analytical tools enable the identification of compromised devices, allowing preventive measures to be taken before the network is endangered. Additionally, blockchain networks can isolate suspicious devices, preventing the spread of potential threats and ensuring the security of the core system.

Beyond technical solutions, IoT device manufacturers play a crucial role in implementing security measures. Certification of devices by recognized certification organizations ensures product quality and safety. Regular firmware and software updates, the implementation of robust authentication and encryption methods, and internal security audits further increase device resilience against threats. On the other hand, blockchain networks can conduct detailed device authentication checks during connection, implement continuous certificate and security setting verification, utilize smart contracts for automated data validation, and isolate compromised devices. (Tsaur, Chang, & Chen, 2022)

For the successful integration of IoT devices with blockchain technology collaboration between manufacturers and blockchain networks is required. Joint efforts in defining and implementing security standards, and sharing information about threats and security incidents, enhance protection and achieve long-term security in connectivity. This collaboration ensures that all devices on the network meet the required security standards before being granted access.

The following papers analyzed in detail the topic of IoT security: (Cekerevac, Dvorak, Prigoda, & Cekerevac, 2017; Maletic & Cekerevac, 2019; Cekerevac, Prigoda, & Čekerevac, 2025; Čekerevac, Prigoda, & Čekerevac, 2025A)

5 CASE STUDIES

The technological advancements on the Internet of Things (IoT) have led to the integration of blockchain technology, significantly improving security, scalability, and interoperability in connected systems. The Internet of Things (IoT) has reached a level of integration into everyday objects, from smart toasters to mirrors displaying fitness exercises and statistics (Velazquez, 2022). A novelty in these devices' development is their connection to blockchain technology, which enhances functionality and security. The following examples illustrate successful cases of blockchain solutions implemented in IoT ecosystems.

5.1 Examples of Successful Implementations of Security Solutions for Blockchain and IoT

5.1.1 Helium

Helium is a decentralized network that utilizes blockchain to connect IoT devices through so-called "Hotspots." These devices combine a wireless gateway with a blockchain mining system, enabling users to provide network coverage and earn Helium's token, HNT. The network's key functionality is the Proof-of-Coverage algorithm, which uses radio signals to validate network coverage, even with variable connection quality. Migration to the Solana blockchain allowed faster transactions and support for smart contracts, while the LoRaWAN protocol ensured long-range and low energy consumption. Practical applications of Helium include connecting sensors in smart cities for air quality monitoring, controlling agricultural parameters such as soil moisture and temperature, and tracking shipments in logistics. Helium, known as "The People's Network," further promotes a participatory governance and development model. (Helium, 2025)

5.1.2 Xage Security

Xage Security provides pioneering solutions for protecting IoT devices using blockchain and applying the principles of zero-trust architecture. Their platform, called Xage Fabric, employs distributed architecture to eliminate central points of vulnerability. It ensures granular access control and privileged account management, while network segmentation prevents lateral attacker movement. Additionally, resistance to threats posed by quantum computers ensures long-term system security. Xage Security is relevant in industries such as:

- Energy, where it protects infrastructure like power plants.
- Manufacturing, by securely connecting industrial IoT devices.
- Transportation, by securing smart transportation systems; and
- Government agencies, by safeguarding data and operational infrastructures.

Its scalable solutions improve security and productivity in digital environments. (Xage, 2025)

5.1.3 Atonomi

Atonomi offers a decentralized security layer specifically designed for IoT. Utilizing blockchain to register device identities and manage reputations, Atonomi enables secure connections for validated devices. Each IoT device receives a unique identity recorded on the blockchain, ensuring immutability and authenticity. The system monitors device behavior over time, assigning reputation scores to detect anomalies. Communication between devices is protected via end-to-end encryption, while real-time analytics enable automated detection of potential threats. Atonomi is designed for heterogeneous IoT environments, facilitating easy connections between diverse devices. Practical applications include smart homes, where Atonomi secures communication between devices like smart thermostats and security cameras and healthcare,

industrial IoT, and transportation, providing comprehensive protection for IoT ecosystems. (Atonomi, 2018)

5.1.4 IOTA

Based on the innovative Tangle network, IOTA differs from traditional blockchain technologies. By utilizing Directed Acyclic Graphs (DAG), IOTA enables fee-free transactions, scalability, and energy efficiency, making it particularly suitable for IoT ecosystems. Each transaction in the Tangle network confirms the previous two, decentralizing the validation process and eliminating the need for energy-intensive nodes or miners. IOTA allows secure storage and data exchange between IoT devices, increasing trust within the network. Its applications include resource management in smart cities, supporting mobility and transportation through microtransactions, industrial IoT, and healthcare, and providing secure medical data storage. Scalability and energy efficiency make it an ideal solution for a wide range of IoT applications. (Alsboui, Qin, Hill, & Al-Aqrabi, 2020; Alshaikhli, Al-Maadeed, & Saleh, 2025)

5.1.5 RIZON

RIZON is a blockchain platform focused on interoperability and support for digital currencies and business applications. Leveraging the Tendermint engine and Cosmos SDK infrastructure, RIZON facilitates fast and secure transactions and seamless integration with other blockchain networks via the Inter-Blockchain Communication (IBC) protocol. The platform supports issuing stable digital currencies pegged to fiat, making them suitable for everyday transactions. RIZON is particularly applicable in financial services, e-commerce, supply chain tracking, and decentralized applications. Its high scalability and flexibility allow adaptation to various applications and user needs, making it an attractive choice for companies looking to integrate blockchain technology. (Tendermint, 2025; Rizon, 2022)

5.2 Analysis of Real-World Attacks and Their Solutions

The analysis of real-world attacks on IoT devices reveals significant security challenges that can compromise connected blockchain systems. Examples of documented attacks on IoT devices with implications for blockchain systems and the solutions implemented include:

1. ***Deauthentication Attacks on IoT Devices***

Deauthentication attacks became widely known around 2014 when security researchers uncovered vulnerabilities in Wi-Fi devices used in IoT systems. Victims of these attacks often included users of smart home devices, automation systems, and industrial IoT (IIoT) systems. Attackers used deauthentication techniques to disrupt communication between IoT devices and the network, compromising data integrity and operational reliability. As a result, systems became non-functional, leading to service interruptions and potential data loss. (Kristiyanto & Ernastuti, 2020; Gebresilassie, Rafferty, Chen, Cui, & Abu-Tair, 2023)

- *Attack:* Deauthentication attacks exploit vulnerabilities in Wi-Fi standards by sending specific packets that force devices to disconnect from the network. These attacks often target security cameras and control systems, jeopardizing user privacy and security.
- *Solution:* Using blockchain technology for device authentication, such as the Elliptic Curve Digital Signature Algorithm (ECDSA), helps prevent such attacks by ensuring that only authorized devices can access the network. Additionally, implementing new Wi-Fi standards like WPA3 reduces vulnerabilities to deauthentication attacks. The WPA3 standard introduces improvements such as Simultaneous Authentication of Equals (SAE), further mitigating vulnerabilities.

2. ***Jeep Cherokee Hacking Incident***

One of the most serious incidents, the Jeep Cherokee hacking case of 2015, highlighted vulnerabilities in IoT-connected vehicles. The demonstration showed how attackers could take control of a car, compromising functions such as braking and steering.

- *Attack:* Security researchers demonstrated how they managed to gain control over the Jeep Cherokee vehicle by exploiting vulnerabilities in its infotainment system. Attackers could manipulate functions like braking, acceleration, and steering, raising significant concerns about the safety of connected cars (Blane, 2021)

- *Solution:* In response, manufacturers implemented software security patches for vehicles. Additionally, they introduced stricter measures to secure communication channels between cars and servers, including enhanced encryption and authentication. (McCracken, 2019)

3. **Attacks on Smart Homes**

Attacks on smart homes gained attention in 2016 when researchers uncovered vulnerabilities in devices such as smart thermostats and security cameras. One notable case involved the hacking of smart cameras, enabling attackers to access user networks and sensitive private data. These attacks often target devices with weak security settings, such as default passwords or unencrypted communication. As a result, compromised networks could also jeopardize blockchain systems connected to IoT devices, undermining data integrity and user privacy.

- *Attack:* Attackers exploited vulnerabilities in smart devices to gain control of networks. Hacking smart thermostats allowed attackers to manipulate heating settings, while compromised security cameras provided access to video footage and network data. (Hunter & Moody, 2017; Alam & Tomai, 2023)
- *Solution:* Implementing Zero Trust principles, where each device is verified before being granted network access, is key to preventing such attacks. Regular firmware updates, strong password use, and encrypted communication further enhance the security of smart devices. (Hunter & Moody, 2017)

4. Mirai Botnet Attack

The Mirai botnet attack of 2016 infected millions of IoT devices using default or weak passwords. Infected devices were turned into bots **that** carried out massive DDoS attacks, causing global disruptions to services like Twitter and Spotify. The attack highlighted IoT devices' vulnerabilities due to inadequate security practices, while IoT networks connected to blockchain could potentially also face risks.

- *Attack:* Mirai malware scanned the internet to identify devices with weak passwords, using a predefined list for rapid identification of vulnerable devices. The infected devices became part of a botnet that executed attacks. (Fruhlinger, 2018; Bursztein, 2017)
- *Solution:* Changing default passwords to more complex ones, regularly updating firmware, and implementing systems to detect and block suspicious traffic (IDS/IPS) are essential steps to prevent similar attacks. (Joodat, n.d)

5. Ransomware Attacks on IoT Devices

One of the more recent incidents, the ransomware attack on Colonial Pipeline in 2021, highlighted **vulnerabilities** in IoT devices within critical infrastructure. Although not directly related to blockchain, this attack underscored the vulnerabilities of IoT devices and operational technologies (OT) used in industrial systems. The attack caused significant consequences, including fuel shortages and financial losses.

- *Attack:* Attackers exploited network vulnerabilities within the company to install **ransomware**, resulting in the shutdown of key systems for fuel distribution (Mittal, 2024). Attackers locked IoT devices and demanded ransom, potentially impacting blockchain systems that rely on those devices. (AgilePQ, 2021)
- *Solution:* The company enhanced network segmentation to restrict access to critical systems, reducing potential security risks. It also established policies for regular **software** and firmware updates on IoT devices to minimize vulnerabilities. Although not directly applied in this instance, blockchain is gaining traction as a reliable method for ensuring data integrity in industrial IoT systems. (Lubin, 2023)

These examples emphasize how IoT and blockchain technology integration can be vulnerable and how effectively implemented innovative solutions can improve security.

6 THE FUTURE OF BLOCKCHAIN SECURITY IN THE IOT ERA

The future of protecting blockchain from attacks via IoT devices requires the implementation of Zero Trust architecture, where every device and user is verified before gaining network access. Artificial intelligence can play a pivotal role in anomaly detection and threat prediction, while the development of quantum-resistant cryptographic algorithms becomes essential due to potential threats from quantum computing. Standardizing

security protocols for IoT devices, including encryption and regular updates, is crucial for enhancing security, combined with decentralized authentication via blockchain to eliminate central points of vulnerability.

User education on the importance of strong passwords and recognizing threats is a significant factor, while interoperable solutions enable easier integration of IoT devices with different blockchain networks. The focus should also be on developing energy-efficient technologies, establishing standards for cybersecurity resilience testing, and automating security processes through smart contracts. Finally, collaboration between industries, academic institutions, regulatory bodies, and international organizations is necessary to ensure an integrated approach to addressing challenges.

7 CONCLUSIONS

Protecting blockchain technology from attacks via IoT devices is becoming increasingly significant with the growing adoption of IoT and its integration with decentralized systems. The key security challenges stem from vulnerabilities in IoT devices, such as weak passwords, insecure communication, and limited resources for implementing advanced protective measures. These challenges can compromise the integrity, availability, and immutability of blockchain systems, requiring a proactive and multi-layered approach to risk mitigation.

- The analysis of technological solutions showed that implementing Zero Trust architecture, advanced cryptographic algorithms, and smart contracts significantly enhances security. AI technology used for anomaly detection and threat prediction further ensures the resilience of IoT and blockchain networks. Establishing security standards and fostering collaboration between manufacturers, industry, regulatory bodies, and academic institutions are crucial steps toward improving protection. Based on the analysis, conditions have been met to reject the null hypothesis (H_0), confirming a significant correlation between IoT-related security challenges and blockchain technology compromise.

Recommended protective measures have extensive applicability across key industries, including healthcare, transportation, energy, and manufacturing. For example, blockchain technology can ensure the confidentiality and integrity of medical data in healthcare systems. Smart contracts automate logistical processes in transportation. Energy-efficient IoT devices connected to blockchain networks can improve operational reliability in industrial production, while Zero Trust architecture secures critical infrastructure like power plants and distribution networks. These approaches increase security but also promote productivity and sustainability within digital ecosystems.

Recommendations for the Future Work

Research on quantum-resistant cryptographic algorithms represents a vital step in preparing blockchain systems for emerging threats from quantum computing. Future studies on the effects of user education in reducing IoT device vulnerabilities could provide valuable insights for shaping security policies. Interdisciplinary research that connects technology, economics, and regulations can contribute to a better understanding of how security standards impact the global adoption of blockchain in IoT ecosystems.

The paper provides recommendations for future work and analyzes real-world cases. It highlights the importance of continuous monitoring and improvement of protective measures. These efforts aim to preserve confidentiality, integrity, and the functionality of blockchain systems within IoT environments.

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Received for publication: 06.04.2025
Revision received: 03.05.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Cekerevac, Z., Ohrimenco, S., & Cekerevac, P. (2025, 07 15). Protecting Blockchain From IoT Device Attacks: Challenges and Solutions. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 81-93. doi:10.12709/mest.13.13.02.05

Style – **Chicago** *Sixteenth Edition:*

Cekerevac, Zoran, Serghei Ohrimenco, and Petar Cekerevac. "Protecting Blockchain From IoT Device Attacks: Challenges and Solutions." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 81-93.

Style – **GOST** *Name Sort:*

Cekerevac Zoran, Ohrimenco Serghei and Cekerevac Petar Protecting Blockchain From IoT Device Attacks: Challenges and Solutions [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 81-93.

Style – **Harvard** *Anglia:*

Cekerevac, Z., Ohrimenco, S. & Cekerevac, P., 2025. Protecting Blockchain From IoT Device Attacks: Challenges and Solutions. *MEST Journal,* 15 07, 13(2), pp. 81-93.

Style – **ISO 690** *Numerical Reference:*

Protecting Blockchain From IoT Device Attacks: Challenges and Solutions. **Cekerevac, Zoran, Ohrimenco, Serghei and Cekerevac, Petar.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 81-93.

MEST Journal
DOI 10.12709/mest.13.13.02.07

DO INVESTOR SENTIMENTS DRIVE STOCK RETURNS?
EVIDENCE FROM CSI300 FUTURES

Leila Douch
University of Tlemcen, Department of Finance and Accounting, Personnel and Organization Management Laboratory, Tlemcen, Algeria
https://orcid.org/0000-0001-8403-7350

Fodil Benkhaldi
University of Tlemcen, Department of Management, Public Governance And Social Economy Laboratory, Tlemcen, Algeria
https://orcid.org/0009-0007-9458-9942

Mohammed Boumediene
University of Tlemcen, Department of Management, Personnel and Organization Management Laboratory, Tlemcen, Algeria
https://orcid.org/0009-0009-1001-4194

JEL Category: **G14, G41, G40**

Abstract

The impact of investor sentiment on stock prices has long been debated in financial economics, sparking discussions between traditional and behavioral finance. This study aims to analyze the effect of individual investors' emotions on stock market returns in Shanghai and Shenzhen, utilizing the DCC-GARCH model. By examining daily investment return series data for the joint index of both stock exchanges, the CSI300 futures return, during the period (2010-2020), the study provides insights into how investor sentiment shapes market trends. Additionally, a specialized index, constructed using the PCA method, is a key indicator for investors' emotions in China. The findings reveal a strong positive effect of investor sentiment on stock market performance, highlighting its role in driving price movements. Furthermore, the study identifies a significant positive dynamic conditional correlation between investor sentiment and stock returns for the CSI300 futures index. These results emphasize the importance of behavioral finance in understanding market dynamics, as emotional biases continue to influence stock volatility and long-term investment trends.

Keywords: *Behavioral finance, CSI300 futures index, Financial Markets, Investor Sentiment, Stock Return.*

Address of the corresponding author:
Leila Douch
leila.douch@univ-tlemcen.dz

1 INTRODUCTION

Finance examines financial markets and their phenomena, including all of their developments, especially the effects resulting from human behavior. This process is influenced by many factors, with the investor's personality, tendencies, desires, and interests being primary, as they directly affect investment decisions. Numerous theories analyze the behavior of both individual and institutional investors, beginning with traditional finance, which describes how prices evolve and how to optimally allocate economic resources when financial options are neither time-bound nor inherently risky. Traditional finance posits that prices reflect all available information and assumes rational decision-making. However, a departure from ideal rationality introduces widespread risks to financial markets, such as the emergence of economic bubbles, which serve as key indicators of investors' failure to assess rationally and integrate information into their financial decisions. This gap led to the rise of behavioral finance as a branch of behavioral economics, focusing on the influence of psychology on the behavior of financial practitioners and its subsequent impact on markets. Behavioral finance is grounded in two key assumptions. The first assumption, proposed by Delong, Shleifer, Summers, and Waldman (1990), is that investors are influenced by emotions, specifically, beliefs about future cash flows and investment risks that are not supported by facts. The second assumption, confirmed by Vishny and Shleifer (1997), is that speculating against emotional investors is costly and risky. As a result, rational investors, often referred to as arbitrageurs, are less aggressive in pushing prices to align with the present value of cash flows, as outlined in the standard model. This concept is known in behavioral finance as the limits of arbitrage. (Baker & Wurgler, 2007, p. 130) Behavioral finance helps explain why and how markets may fail to be efficient.

This study aims to investigate the impact of investor sentiment on stock returns and the Chinese financial market, by conducting a standard analysis of the CSI300 Futures Index and the Investor Sentiment Index over 2010-2020.

2 LITERATURE REVIEW

Traditional finance generally revolves around the efficient market hypothesis (EMH) developed by Eugene Fama (1970), which asserts that investors make decisions rationally. The EMH also posits that asset prices reflect all available information, ensuring market efficiency (Kumar & Goyal, 2016). (Fama E. , 1970; 1976) introduced three forms of capital market efficiency, each based on the type of information reflected in prices. That is central to the definition of an efficient market: *"a market in which prices reflect all relevant information."* These forms include:

- *Weak efficiency:* No investor can earn excess returns by developing trading strategies based on historical price or return data.
- *Semi-strong efficiency:* No investor can earn excess returns from trading strategies based on publicly available information.
- *Strong efficiency:* No investor can earn excess returns by utilizing any information, whether publicly available or private.

In classical finance theory, rationality is understood as goal-directed action under certain constraints. Rationality is always tied to human action, which involves two key aspects:

1. The concept of preferences, where consistent decisions are made among different alternatives, and
2. The concept of expected utility, where the investor aims to maximize their expected utility (Schindler, 2007).

The expected utility theory in economics describes the process through which rational agents make decisions under uncertainty, considering not just expected outcomes, but also their variability (Sapra & Zak, 2008). While one might believe decisions are based solely on logic, in practice, emotions play a significant role in decision-making and often guide actions without restraint (Montier, 2009). This departure from the traditional models has led to behavioral finance, which integrates psychology and finance, exploring how psychological factors influence financial practitioners' behavior and the effects on markets.

Behavioral finance provides insights into why and how markets may be inefficient (Sewell, 2010). It has rapidly developed, demonstrating that internal and external behavioral factors shape investors' financial decisions (Shefrin, 2000; Shleifer, 2000;

Warner et al., 2001). The central premise of behavioral finance is that investor behavior often contradicts the assumptions of traditional finance, impacting financial markets. This field applies behavioral economics to economic decision-making, exploring how individuals make decisions and how these actions can be understood through established psychological theories. Shiller describes behavioral finance as "finance from a broader social scientific perspective, including psychology and sociology," which contrasts sharply with the efficient market theory. Barberis and Thaler define it as the analysis of how investors fail to rationally incorporate new information or make decisions inconsistent with maximizing expected utility (Raines & Leathers, 2011). Behavioral finance relies on two core concepts: cognitive psychology and the limits of arbitrage. Cognitive psychology studies how people think, perceive, and remember information, while the limits of arbitrage describe situations where arbitrage opportunities are limited due to irrational market behavior (Kumar, 2016).

3 PREVIOUS RESEARCH ON INVESTOR SENTIMENT AND STOCK RETURNS

Many previous studies have examined the topic of investors' emotional biases and their relationship to stock returns from multiple perspectives. Selden authored The Psychology of the Stock Market, asserting that price movements in financial markets are largely determined by investors' mindset and trading behavior in 1912. In 1956, Leon Festinger introduced the theory of cognitive dissonance, followed by Pratt in 1964 with contributions to utility theory and risk aversion. In 1968, Raiffa discussed the differences between human behavior and traditional economic assumptions, while in 1973, Tversky and Kahneman presented the concept of availability bias (Boda & Sunitha, 2018).

This study will review a selection of these works, highlighting their key aspects. It is worth noting that the examined studies encompass various countries and regions, reflecting both temporal and geographical diversity.

1. Wayne Y. Lee, Christine X. Jiang, and Daniel C. Indro (Stock Market Volatility, Excess Returns, and the Role of Investor Sentiment, 2002):

This study examines the effect of noise traders' risk on expected returns and their conditional volatility in three financial markets. It addresses the question: How do noise traders' sentiments affect the risk-return trade-off? The study used GARCH testing on a sample of three financial market indices: DJIA, S&P500, NASDAQ, and the Investors' Intelligence Index of New Rochelle to represent investor sentiment from January 5, 1973, to October 6, 1995. The results indicate:

- Sentiment is a significant factor in explaining stock returns and their volatility.
- Sentiment is a priced risk factor.
- Stock returns are positively correlated with changes in sentiment, and these changes significantly impact the volatility and expected returns.
- Upward (downward) changes in sentiment lead to lower (higher) volatility and are associated with higher (lower) excess returns.
- The importance of sentiment in explaining conditional volatility and expected returns is consistent across indices and periods (Lee, Jiang, & Indro, 2002).

2. Rahul Verma, Hasan Baklaci, and Gökçe Soydemir (The Impact of Rational and Irrational Sentiments of Individual and Institutional Investors on DJIA and S&P 500 Index Returns, 2008):

This study explores the relative effects of rational and irrational sentiments on stock returns in the DJIA and S&P 500 indices. The study uses investor sentiment data from the American Association of Individual Investors (AAII) and the Intelligence Individual Index. The sentiment index is divided into rational and irrational categories, with additional variables such as economic growth, interest rates, and inflation. Using monthly data from October 1988 to April 2004, the study applies the VAR regression model and finds:

- Rational sentiment has a greater impact on stock returns than irrational sentiment.
- Irrational sentiment leads to immediate positive market responses, followed by negative corrections in subsequent periods.
- Past stock returns have a significant impact on irrational sentiment, but not on rational sentiment.

- Irrational sentiment influences stock returns more quickly and dramatically than rational sentiment (Verma, Baklaci, & Soydemir, 2008).

3. Maik Schmeling (Investor sentiment and stock returns: Some international evidence, 2009):

This study investigates whether consumer sentiment (as a proxy for individual investor sentiment) influences expected stock returns in 18 industrialized countries. It tests whether sentiment effects are more pronounced in countries with less developed institutions or those prone to herd behavior. Using data from January 1985 to December 2005 across 18 countries, the study finds:

- Sentiment negatively predicts future stock market returns.
- When sentiment rises, stock returns tend to decrease, and vice versa. This relationship holds across different stock categories (growth, value, small-cap).

The effect of sentiment on returns is stronger in countries with underdeveloped institutions and cultures prone to herd behavior (Schmeling, 2009).

4. Usman Bashir et al. (Investor Sentiment and Stock Price Crash Risk: The Mediating Role of Analyst Herding, 2024).

This study analyzes the impact of investor sentiment on firm's stock price crash risk by using Chinese A-Share firms' data this study assesses the potency and existence of a relationship between crash risk and investor sentiment in the Chinese stock market and introduces analyst herding as a mediating variable for explaining the relationship between crash risk and investor sentiment. By utilizing a large data set of A-share listed firms on Chinese stock exchanges, comprising 19,371 firm-year observations for the period of 2004–2019, an investor sentiment index is constructed. Results point towards a positive, significant relation between stock price crash risk and investor sentiment. Furthermore, the stock price crash exhibits a positive relationship with analyst herding, i.e., it significantly mediates between the stock price crash risk and investor sentiment. By measuring the relationship between crash risk, investor sentiment, and analyst herding, this study provides systematic support for the mediating role of analyst herding in deepening the market sentiment, which results in crash risk. These findings are robust when tested using alternative proxies and after controlling for firm-specific variables, economy-wide shocks, time trends, and year fixed effects.

5. Cheema and Fianto (Investor Sentiment and Stock Market Anomalies: Evidence from Islamic Countries, 2024):

Studies of the Ramadan effect argue that higher stock returns in Muslim countries during Ramadan relate to higher investor sentiment. However, Islamic countries rank low on the Hofstede Individualism Index, a proxy for investor overconfidence. Therefore, this study examines the impact of investor sentiment on stock market anomalies in two advanced Islamic finance jurisdictions: Malaysia and Indonesia. It hypothesizes that stock market anomalies are stronger following high sentiment if investors in Malaysia and Indonesia are overconfident. The results show that the long and short legs of the stock market anomalies earn relatively low returns following high investor sentiment, indicating overpricing during high sentiment. Moreover, the short leg earns relatively lower returns than the long leg following high sentiment because the short leg is more overpriced than the long leg when sentiment is high. Therefore, consistent with the hypothesis, the long-short returns of anomalies are stronger following high investor sentiment because of the relatively lower returns of the short leg than the long leg.

6. Maurya, Bansal, and Mishra (Investor Sentiment and Its Implication on Global Financial Markets: A Systematic Review of Literature, 2025):

This study aims to systematically review the literature on how various factors influence investor sentiment and affect financial markets. This study also sought to present an overview of explored contexts and research foci, identifying gaps in the literature and setting an agenda for future research. The systematic literature investigation yielded 555 journal articles, with a few other exceptional inclusions. The data were extracted from two databases, namely Scopus and Web of Science. VOSviewer and Biblioshiny by R have been used for bibliometric analysis. The period of

investigation is from 1985 to July 2023. This systematic literature review helped us identify factors influencing investor sentiment and financial markets. This study broadly classified these factors into two categories, rational and irrational. Rational factors include economics and monetary policy, exchange rates, interest rates, inflation, government mandatory regulations, earnings announcements, stock splits, dividend decisions, audit quality, environmental, social, and governance aspects, and ratings. Irrational factors include behavioural and psychological influences, as well as discussions on social media and online platforms. News and entertainment also shape sentiment, geopolitical tensions, war events, and calendar anomalies. Environmental factors, natural disasters, religious events, and festivals contribute to market fluctuations. Irrationality can be caused by government or supervisory body regulations and corporate events. Using these factors, this study has developed an investor sentiment model. In addition, this review identified research trends, methodology, data, and techniques used by researchers.

Since the early days of behavioral finance theory, there has been debate and discussion regarding the impact of investors' emotional biases on stock returns and the overall performance of financial markets. Numerous previous studies have explored this topic, yielding varying results on the direction of sentiment effects on stock returns. Some studies have confirmed a negative relationship between stock returns and investors' emotional biases, while others have identified a positive correlation. Meanwhile, some studies—aligned with the efficient market hypothesis—have denied the existence of any relationship.

Previous literature has debated the varying impact of investors' emotional biases on stock returns. Most studies have found that stocks with more objective valuations and greater arbitrage difficulty are disproportionately affected by investor sentiment. It is generally stated that small-cap stocks are more influenced by emotions than large-cap stocks.

Additionally, previous studies focusing on the relationship between stock returns and behavioral indicators have employed various econometric methods, including ARCH and GARCH models, Johansen’s cointegration test, and VAR models. These methods assume linear relationships between independent and dependent variables and examine specific characteristics such as long-term and short-term causality (cointegration models), volatility (ARCH and GARCH), and error correction (VECM).

Reviewing the points of agreement and divergence among previous studies, we note that the current study aligns with prior research in its main subject and overall objective. However, it differs in several aspects, representing the scientific gap that this study aims to address:

- The study integrates the research problem with investors' emotional biases and stock returns
- Rather than relying on the commonly used questionnaire method in behavioral studies, this study aimed to construct a dedicated index to measure investors' emotional biases. Following the Baker-Wurgler methodology, an empirical analysis was then conducted to assess the impact of these biases on stock returns. Unlike previous studies that limited their analysis to the first principal component, this study employed the first and second components derived from Principal Component Analysis (PCA). Additionally, to more precisely capture the influence of emotional biases on investor behavior, a daily time frame was adopted, rather than monthly or yearly intervals.

4 DATA AND METHODOLOGY

In recent years, China has experienced significant economic growth, becoming the largest economy in Asia and the second-largest economy globally. It is considered the primary driver of regional and global economic growth, especially after the global financial crisis.

The CSI300 index futures contract was introduced on April 16, 2010, at the China Financial Futures Exchange (CFFEX) to support China's financial markets. China Financial Futures Exchange Co., Ltd was established with the approval of the State Council of the People's Republic of China and the China Securities Regulatory Commission (CSRC). It is an integrated exchange that offers trading and clearing services for financial futures, options, and various derivatives.

On September 8, 2006, CFFEX was founded in Shanghai by the Shanghai Futures Exchange, Zhengzhou Commodity Exchange, Dalian Commodity Exchange, Shanghai Stock Exchange, and Shenzhen Stock Exchange. The establishment of CFFEX and the development of China's financial futures market hold significant strategic importance in deepening financial market reforms, strengthening the financial system, facilitating the robust performance of financial markets, and adapting to the new normal of economic development.

The company is committed to serving the real economy and supporting China's capital market by offering secure, efficient, and well-performing financial derivative products and services. CFFEX facilitates the proper transfer and allocation of financial risks, enhances financial market efficiency, and promotes social and economic prosperity.

CFFEX is responsible for organizing and managing the trading, clearing, and settlement of financial futures contracts and various derivatives. It formulates relevant regulations and ensures self-regulation within the market. The exchange also publishes market data and related information. Additionally, it provides technologies, venues, and facilities to support trading operations. Finally, CFFEX performs additional functions approved by the CSRC.

By adhering to high standards and focusing on market stability, CFFEX strives to expand its offerings of financial derivative products, improve its product lines in equities, interest rates, and foreign exchange, and meet the diverse risk management needs of market participants. (Cffex, 2025)

This study uses daily stock return data from the China Stock Exchange (Shanghai Shenzhen 300) futures contracts, spanning January 2010 to December 2020. The data, sourced from the Eastmoney and CFFEX databases, includes 2555 observations.

4.1 Futures Market Sentiment Index

Using principal component analysis based on Baker and Wurgler (2007), we create a composite sentiment index for the futures market using the following proxies:

- Open Futures OI
- Relative Strength Index (RSI)
- Psychological Line Index (PSY)
- Trading Volume (VOL)

The following section defines each variable separately.

A- The Relative Strength Index (RSI):

It is a widely used market indicator that reflects whether a market is overbought or oversold. It is considered one of the proxies for market sentiment and is calculated as follows:

$$RSI_t = 100 * \frac{RS_t}{1 + RS_t}$$

$$RS_t = \frac{\sum_{t=1}^{6} \max(P_t - P_{t-1}, 0)}{\sum_{t=1}^{6} \max(P_{t-1} - P_t, 0)}$$

P_t - The closing price of the stock *i* at the moment *t*.

When $RSI < 50$, the stock's losses exceed its gains. Conversely, when $RSI > 50$, it means that gains outweigh losses.

The market is considered overbought when $RSI = 80$, and it is oversold when $RSI = 20$. (Yao & Li, 2020)

B- Psychological Line (PSY) Indicator:

Yang and Gao (2014) proposed a sentiment indicator to measure market psychology in the Chinese stock market.. It is calculated as follows:

$$PSY_t = \frac{T^U}{T} * 100$$

Where:

- T^U represents the days in which the closing price of stock i at time t is higher than its closing price at time t-1.
- T is the trading period.

The market is considered overbought when $PSY = 75$ and oversold when $PSY = 25$. (Gao, Liang, Xu, & Xie, 2020)

C- **Open Interest (OI):**

OI is considered a forward-looking sentiment indicator, as highlighted by Wang (2000). Instead of focusing on net positions or long/short positions, OI was selected to study its predictive potential for returns in futures markets.

It is regarded as an indicator that provides a clearer interpretation of traders' actions. Due to its nature, OI is similar to other market sentiment indicators and is widely accepted among futures market participants. (Gao,2020)

D- Trading volume:

Wurgler and Baker (2006) stated that trading volume serves as an indicator of investor sentiment. Similarly, Baker and Stein (2004) suggested that when irrational investors are optimistic, they trade more actively, increasing market liquidity. (Jaziri & Abdelhedi, 2018)

Table 1. Results of the principal component analysis method for the composite sentiment index of the futures market

Component	Standard deviation	Variance (%)	Cumulative Proportion (%)
1	1.2121	36.73	36.73
2	1.0993	30.21	66.94
3	0.8202	16.82	83.76
4	0.8059	16.24	100

Source: Prepared by the researchers

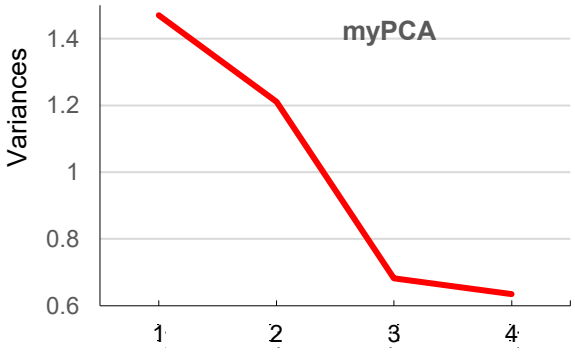

Fig. 1: Variation of the main components representing the composite sentiment index for the futures market

Source: Authors' analysis

From Table 1 and Figure 1, we notice that after standardizing each of the four components using the PCA method, the first and second main components have the highest explanatory power compared to the rest of the components, and they represent the best linear combination of the variables used according to the weighting coefficient, as they explain 66.94% of the standard sample variance, and the first and second eigenvalues are much higher than 1.00, so we conclude that two factors capture the common variance, and therefore the composite index of investor sentiment depends on the first and second main components. Given the weak short-term impact of macroeconomic variables, we exclude them from the analysis. Thus, we have the equation of investors' future emotional biases as follows:

$$SENTf_t = 0.658PSY_t - 0.201OI_t + 0.544RSI_t - 0.479VOL_t$$

4.2 Testing the suitability of the ordinary least squares method to estimate the model

Table 2 shows the results of estimating the relationship between the sentiment index and the returns of the CSI300 index, which shows a positive and statistically significant relationship between them, as the degree of influence was estimated at 0.0892, which means that any change of one unit in the sentiment index leads to a positive change in the returns of the CSI300 index by 0.0892 units.

Table 2. Results of estimating the model using the OLS method

Dependent Variable: FUTUR_RETURN
Method: Least Squares
Date: 08/24/21 Time: 21:27
Sample (adjusted): 4/16/2010 9/30/2020
Included observations: 2514 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.023475	0.013516	1.736747	0.0826
SENTF	0.089226	0.011002	8.109800	0.0000

R-squared	0.025514	Mean dependent var	0.004919
Adjusted R-squared	0.025126	S.D. dependent var	0.676483
S.E. of regression	0.667931	Akaike info criterion	2.031531
Sum squared resid	1120.682	Schwarz criterion	2.036169
Log likelihood	-2551.634	Hannan-Quinn criter.	2.033214
F-statistic	65.76886	Durbin-Watson stat	1.915632
Prob(F-statistic)	0.000000		

Source: Authors' calculations

The estimation results of the relationship between the sentiment index and the CSI 300 Index returns, as presented in Table 2, show a statistically significant correlation between the two variables. The estimated coefficient is 0.0892, indicating that a one-unit change in the sentiment index leads to a change of 0.0892 units in the index returns.

To examine the presence of multicollinearity among the independent variables, the Variance

Inflation Factor (VIF) test was applied. A VIF value equal to 1 indicates that the variable is not correlated with any other explanatory variable, implying no multicollinearity within the regression model. In general, VIF values below 5 are considered acceptable, while values exceeding 10 may indicate serious multicollinearity issues. The results of the VIF test in Table 3 show that all variables have VIF values close to 1, confirming the absence of multicollinearity and supporting the robustness of the regression estimates.

Table 3. Results of the Variance Inflation Factor (VIF) Test

Variance Inflation Factors
Date: 05/05/25 Time: 10:47
Sample: 1 2614
Included observations: 2556

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	9.50E-08	1.030418	NA
FUTURE_SENT	6.29E-08	1.030418	1.000000

Source: Authors' analysis

4.3 ARCH Effect Test

As observed in Table 4, the probability of the Chi-Square test is below 5%, leading us to reject the assumption of constant conditional variance. This confirms the presence of the ARCH effect in the residuals, indicating time-varying volatility. Given these findings, the GARCH model should be applied to account for this variability.

Table 4. Results of the ARCH effect test for the residuals of the model estimation using the OLS method

Heteroskedasticity Test: ARCH

F-statistic	264.6490	Prob. F(1.2553)	0.0000
Obs *R-squared	239.9796	Prob. Chi-Square(1)	0.0000

Source: Authors' analysis

Table 5. Results of estimating the GARCH(1,1) model

Dependent Variable: FUTURE_RETURN
Method: ML ARCH - Generalized error distribution (GED)
Date: 01/06/21 Time: 20:32
Sample (adjusted): 1 2556
Included observations: 2556 after adjustments
Convergence achieved after 16 iterations
Presample variance: backcast (parameter = 0.7)
GED parameter fixed at 1.5
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.009024	0.009369	0.963213	0.3354
FUTURE_SENT	0.055914	0.007408	7.547931	0.0000
Variance Equation				
C	0.003445	0.000738	4.670457	0.0000
RESID(-1)^2	0.058558	0.005207	11.24592	0.0000
GARCH(-1)	0.929072	0.005462	170.0861	0.0000

R-squared	0.022117	Mean dependent var	0.005289
Adjusted R-squared	0.021734	S.D. dependent var	0.675425
S.E. of regression	0.668045	Akaike info criterion	1.634956
Sum squared resid	1139.809	Schwarz criterion	1.646392
Log likelihood	-2084.473	Hannan-Quinn criter.	1.639103
Durbin-Watson stat	1.911715		

Source: Authors' analysis

4.4 Estimating the GARCH Model

We will estimate the GARCH(1,1) model below, considering that the time series of returns and indicators of emotional biases do not follow a normal distribution and that fluctuations are present in the graphs of each variable.

Based on Table 5, it is clear that the GARCH coefficients are significant and statistically significant at 5%, and there is a positive effect of the emotional biases included in the average equation on stock returns; that is, the more positive the investors' feelings are and the more optimistic they are about improving future economic conditions, the more their purchase rate of securities increases, which pushes prices up as a result of increased trading on them.

As for the variance equation, we note that the squared error coefficient is significant, which

confirms the existence of the ARCH effect. The β value of 0.92 indicates that the variance resulting from a high volatility value will be followed by another high variance. The GARCH model coefficients (1,1) are positive and their sum is less than 1, which fulfills the model's stability condition, as:

$\alpha+\beta = 0.058558+0.929072 = 0.98763 < 1$

This indicates the continuity of the impact of previous fluctuations, shocks, and variations in the current volatility. Consequently, investor sentiment captures the persistence of market volatility and accumulates it in capital markets. In other words, previous emotional biases of investors lead to stock market fluctuations and continue over the long term.

4.5 Estimation of the GARCH(1,1) Model with Sentiment Index

From the results of Table 6, the GARCH(1,1) coefficients and the bias index in the mean and variance equation are significant, and the emotional bias index included in the variance equation hurts the conditional variance. This means that in the event of an increase or rise in the emotional bias index, the CSI300 index will record low volatility and vice versa. That can be explained by the fact that investors' pessimism about the economic and financial conditions will push them to sell securities due to loss aversion and their belief that stock prices will decline in the future, which will lead to a decrease in trading in them, causing instability in the financial market.

4.6 Estimation of the DCC-GARCH Model

Table 7 shows the results of estimating the DCC-GARCH model according to Engel's methodology using the t-student distribution. We notice that the coefficients of the DCC-GARCH model are positive, and their sum is less than one, where $\theta_1+\theta_2=0.024763+0.611714=0.636477<1$, but they are not significant, which means that the fluctuations are unstable. We also notice that the dynamic conditional correlation coefficient is substantial and positive. This indicates a positive dynamic conditional correlation between investors' emotional biases and stock returns, meaning that the CSI300 futures returns are sensitive to any change in investors' emotional biases over time.

Table 6. Estimation results of the GARCH(1,1) model with the inclusion of the sentiment index in the mean equation and the conditional variance equation

Dependent Variable: FUTURE_RETURN
Method: ML ARCH - Generalized error distribution (GED)
Date: 01/06/21 Time: 20:36
Sample (adjusted): 1 2556
Included observations: 2556 after adjustments
Convergence achieved after 19 iterations
Presample variance: backcast (parameter = 0.7)
GED parameter fixed at 1.5
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)
*FUTURE_SENT

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.010452	0.009350	1.117880	0.2636
FUTURE_SENT	0.055396	0.007420	7.465421	0.0000
Variance Equation				
C	0.004650	0.000863	5.389921	0.0000
RESID(-1)^2	0.060118	0.005273	11.40131	0.0000
GARCH(-1)	0.923028	0.005865	157.3814	0.0000
FUTURE_SENT	-0.001429	0.000452	-3.162515	0.0016

R-squared	0.022052	Mean dependent var	0.005289
Adjusted R-squared	0.021669	S.D. dependent var	0.675425
S.E. of regression	0.668067	Akaike info criterion	1.633182
Sum squared resid	1139.884	Schwarz criterion	1.646906
Log likelihood	-2081.207	Hannan-Quinn criter.	1.638159
Durbin-Watson stat	1.911868		

Source: Authors' analysis

Table 7. Estimation results of the DCC-GARCH model

```
  ********************
 **   SECOND STEP    **
********************


  *************
 ** SERIES  **
*************
#1: futur_return
#2: futur_sent

The dataset is: C:\Users\HP\Desktop\new03.in7
The estimation sample is:  1 - 2557

 ******************************
 ** MG@RCH(1) SPECIFICATIONS **
 ******************************
Conditional Variance : Dynamic Correlation Model (Engle)
Multivariate Student distribution, with 13.7821 degrees of freedom.

Strong convergence using numerical derivatives
Log-likelihood = -5671.81
Please wait : Computing the Std Errors ...

 Robust Standard Errors (Sandwich formula)
                  Coefficient  Std.Error  t-value  t-prob
rho_21              0.062517   0.020498    3.050  0.0023
alpha               0.024763   0.017386    1.424  0.1545
beta                0.611714    0.14759    4.145  0.0000
df                 13.782082     2.2373    6.160  0.0000
No. Observations :      2557  No. Parameters  :        12
No. Series       :         2  Log Likelihood  : -5671.814
Elapsed Time : 0.422 seconds (or 0.00703333 minutes).
```

Source: Prepared by researchers

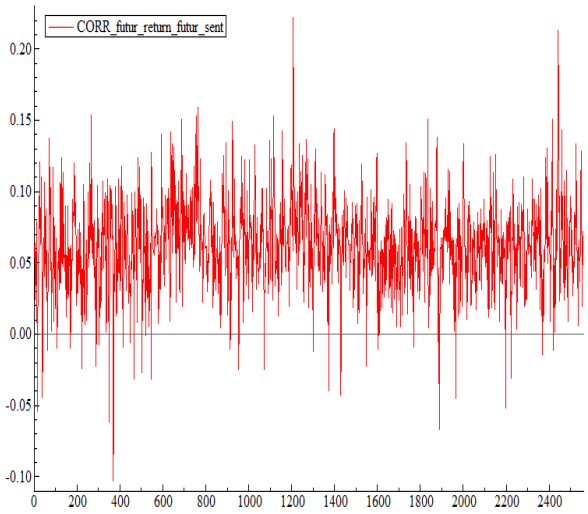

Fig. 2 Dynamic conditional correlation between CSI300 futures stock returns and investors' emotional biases in the futures market
Source: Prepared by the Authors

From Figure 2, we notice that the dynamic conditional correlation between the futures returns series and investors' emotional biases has changed over time, sometimes rising and sometimes falling. We also found a significant increase of more than 30% during the crisis that hit the Chinese financial market in 2015.

5 CONCLUSIONS

Through this paper, we tried to measure and analyze the impact of investors' sentiments on stock returns across 2010-2020 in China. This was done by addressing the most important theoretical beliefs that govern this relationship, after which we tried to project what was stated in the theoretical aspect onto the reality of the Chinese economy by relying on the DCC-GARCH model. We presented the economic variables used in estimating this model according to what economic theory dictated to us and what was used in previous studies that addressed the subject, and according to the nature of the Chinese economy, using the RSI, PSY, OI, and VOL variables. The study found that investor sentiment positively influences the stock returns of the CSI300 index. Furthermore, there is a strong dynamic conditional correlation between the two, indicating that fluctuations in investor sentiment significantly impact the index's performance over time. This relationship suggests that the returns of the CSI300 index are highly responsive to changes in investor sentiment, making them particularly susceptible to market mood shifts.

The findings of this study underscore the significant influence of investors' emotional biases on stock returns in the futures market. This highlights that investment decisions are not always rational or objective, often leading to mispriced assets and unwarranted fluctuations in financial markets. Such sentiment-driven distortions weaken market efficiency, as shifts in supply and demand may not accurately reflect the intrinsic value of assets.

Furthermore, excessive market volatility fueled by investor sentiment can profoundly affect the real economy. Sharp price swings—whether upward or downward—can disrupt investment and consumption patterns, creating instability. Recognizing the critical role of sentiment, governments and central banks implement monetary and fiscal policies aimed to restore confidence, such as interest rate reductions or increased government spending. Historical examples include the 2008 global financial crisis, where investor panic triggered market collapses, and the post-COVID-19 economic recovery, where renewed trust drove economic revitalization.

Additionally, the study's findings support the integration of psychological and emotional factors into economic policymaking. The sentiment index developed in this research could be a valuable tool for financial and monetary authorities, enabling them to identify early signs of market volatility or financial bubbles and implement preventive measures to mitigate risks. A deeper understanding of sentiment's impact on the economy enhances the ability to analyze economic trends and make more informed financial and business decisions.

Finally, this study reinforces the relevance of behavioral economic models, which incorporate psychological factors to explain market dynamics and macroeconomic behavior. By integrating sentiment indicators into these models, economists can better anticipate irrational market movements, allowing policymakers to craft more sustainable and effective economic strategies that account for investor psychology.

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Received for publication: 03.05.2025
Revision received: 12.05.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Douch, L., Benkhaldi, F., & Boumediene, M. (2025, 07 15). Do Investor Sentiments Drive Stock Returns? Evidence From CSI300 Futures. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 94-106. doi:10.12709/mest.13.13.02.07

Style – **Chicago** *Sixteenth Edition:*

Douch, Leila, Fodil Benkhaldi, and Mohammed Boumediene. "Do Investor Sentiments Drive Stock Returns? Evidence From CSI300 Futures." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 94-106.

Style – **GOST** *Name Sort:*

Douch Leila, Benkhaldi Fodil and Boumediene Mohammed Do Investor Sentiments Drive Stock Returns? Evidence From CSI300 Futures [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 94-106.

Style – **Harvard** *Anglia:*

Douch, L., Benkhaldi, F. & Boumediene, M., 2025. Do Investor Sentiments Drive Stock Returns? Evidence From CSI300 Futures. *MEST Journal,* 15 07, 13(2), pp. 94-106.

Style – **ISO 690** *Numerical Reference:*

Do Investor Sentiments Drive Stock Returns? Evidence From CSI300 Futures. **Douch, Leila, Benkhaldi, Fodil and Boumediene, Mohammed.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 94-106.

MEST Journal
DOI 10.12709/mest.13.13.02.17

THE IMPACT OF PRACTICING SERVANT LEADERSHIP DIMENSIONS ON ENHANCING ORGANIZATIONAL CITIZENSHIP BEHAVIOR

Samira Gaoussi
Badji Mokhtar University, Faculty of Economics, Commerce and Management Sciences, Annaba, Algeria.
https://orcid.org/0009-0009-9618-2745

JEL Category: **M12, M14, M53**

Abstract

Considering the growing interest in contemporary leadership styles that focus on the human element, servant leadership has emerged as an effective approach for enhancing performance and positive behaviors within organizations. Accordingly, the present study aims to measure the impact of servant leadership—through its dimensions of empowerment, concern for subordinates, and subordinate development—on the enhancement of organizational citizenship behavior (OCB) within a pharmaceutical company. The study adopted a descriptive-analytical approach, utilizing a questionnaire as the primary tool for data collection from a sample of the institution's employees. After analyzing the data using SPSS Version 21, the results indicated that all dimensions of servant leadership and organizational citizenship behavior were present at a high level. However, testing the relationship between the variables revealed a statistically significant effect only for the concern for subordinates' dimension on OCB. The dimensions of empowerment and development showed no significant impact. This outcome is attributed to the specific organizational context of the pharmaceutical group, where the leader's humanistic and supportive role is perceived as a key factor in motivating voluntary behaviors. Accordingly, the study recommends strengthening this dimension within leadership policies and reconsidering the methods used to implement empowerment and professional development in ways that enhance their behavioral effectiveness.

Keywords: *Servant Leadership, Organizational Citizenship Behavior, Empowerment, Concern for Subordinates, Development of Subordinates.*

Address of the author:
Samira Gaoussi
samira.guoussi@univ-annaba.dz

1 INTRODUCTION

In today's world of management and leadership, a variety of approaches and strategies are employed by leaders to strike a balance between organizational objectives and the human needs of

employees. Among these approaches, servant leadership stands out as a unique model that places the interests of individuals and the organization at the core of the leadership process, transcending traditional concepts centered on authority and control. Introduced approximately four decades ago, the principle of servant leadership quickly proved its effectiveness across various organizational settings. This leadership style has brought about a profound transformation in how organizations are managed, as it prioritizes the needs of employees, emphasizes empowerment, fosters a collaborative environment, and focuses on developing skills and competencies by providing growth opportunities—thus cultivating a positive culture that reinforces mutual respect and appreciation.

Amid the challenges faced by today's business environment—characterized by rapid changes, competitive pressures, employee frustration, and declining motivation it has become essential for organizations to adopt such innovative and progressive managerial concepts that emphasize their human resources. This requires leadership that can effectively address these challenges while focusing on employees' psychological and social well-being. In today's dynamic business landscape, managers must adopt leadership styles that foster employee commitment to their teams and workplaces. Employees who go beyond the boundaries of their formal duties and proactively contribute to the development of their organizations are likely to make additional efforts in collaboration and in serving the organization's broader interests. In doing so, they demonstrate voluntary, informal behaviors encompassed by the concept of Organizational Citizenship Behavior (OCB).

Based on the above, the research problem is formulated in the research question:

RQ: What is the impact of practicing the dimensions of servant leadership (empowerment, concern for subordinates, development of subordinates) on enhancing organizational citizenship behavior at the Biocare Pharmaceutical Group – El-Tarf?

Accordingly, the following sub-questions are posed:

RQa: What is the level of availability of servant leadership dimensions at the Biocare Pharmaceutical Group in El-Tarf Province?

RQb: What *is the level of organizational citizenship behavior among employees at the Biocare Pharmaceutical Group in El-Tarf State?*

1.1 Research Hypotheses

The following study hypotheses are formulated:

Main Hypothesis:

H1 - There is a statistically significant effect at the significance level ($\alpha \leq 0.05$) of practicing the dimensions of servant leadership on organizational citizenship behavior at the Biocare Pharmaceutical Group – El Tarf State.

Sub-Hypotheses:

H1a - There is a statistically significant effect at the significance level ($\alpha \leq 0.05$) of the empowerment dimension on organizational citizenship behavior at the Biocare Pharmaceutical Group– El-Tarf state.

H1b - There is a statistically significant effect at the significance level ($\alpha \leq 0.05$) of the concern for subordinates' dimension on organizational citizenship behavior at the Biocare Pharmaceutical Group – El-Tarf State.

H1c - There is a statistically significant effect at the significance level ($\alpha \leq 0.05$) of the development of subordinates' dimension on organizational citizenship behavior at the Biocare Pharmaceutical Group – El-Tarf State.

1.2 Significance of Study

Servant leadership represents a new model and a fundamentally different perspective from other leadership styles. It can be considered a philosophical approach to understanding leadership, grounded in ethical principles that prioritize the well-being of the group over personal interests. It is characterized by the leader's devotion to serving others with humility, integrity, and a noble purpose embraced as a personal mission. Such behavior inspires followers through the leader's unique conduct, positioning them as an equal member within the group.

The significance of this study increases in light of the transformations occurring in contemporary business environments, which are marked by instability and rapid technological changes. These conditions can negatively impact employee commitment to their jobs. Consequently, adopting servant leadership has become essential for reinforcing organizational citizenship behavior and fostering positive behaviors among employees.

1.3 Methodology

The study employed the descriptive-analytical approach, as it is most suitable for analyzing organizational phenomena and understanding the relationships between variables. Accordingly, the research relied on relevant literature, academic studies, and related articles, in addition to utilizing a questionnaire as the primary tool for data collection. The collected data were then analyzed using appropriate statistical methods, allowing for the extraction of accurate quantitative results that align with the study's objectives.

2 STUDY FRAMEWORK

This section presents literature related to the study variables.

2.1 Servant Leadership

Servant leadership represents one of the modern approaches to leadership thought. This section presents the concept of servant leadership, along with its dimensions, function, and characteristics, as outlined below.

2.1.1 Concept of Servant Leadership

The theoretical roots of servant leadership originate from Robert Greenleaf, who introduced the concept in his famous 1970s article, "The Servant as Leader." He emphasized that a true leader serves first; that is, the primary motivation for leadership comes from the desire to serve others. According to Greenleaf, a person does not become a leader due to authority or position, but because of their dedication to supporting and inspiring others. Leadership does not begin with authority but with service. An individual first embraces the role of a servant, driven by a genuine desire to help, and through that service, grows into a true leader. This perspective challenged traditional leadership concepts that associate leadership with power and control, offering a human-centered alternative focused on care, empowerment, and development (Hai, 2021).

Based on this, servant leadership can be defined as "a transcending of self-interest, which is the main characteristic of this type of leadership. Servant leaders are not seen as those who control others, but as servants who help individuals and organizations grow and succeed. It prioritizes the well-being and growth of followers, rooted in ethics, selflessness, and empowerment, fostering both individual and community development. Servant leaders exhibit a high degree of fairness and transparency in their interactions, encourage a work environment that fosters trust, participation, and cooperation, prioritize the needs of employees, and work to remove barriers that hinder their performance" (Howladar & Rahman, 2021).

2.1.2 Dimensions of Servant Leadership

Based on the core concept introduced by Greenleaf regarding servant leadership namely, care, empowerment, and development the researcher adopted this idea as the foundation for constructing the study's model. Servant leadership is viewed as a human-centered alternative to the traditional leadership model, emphasizing care (concern for subordinates), empowerment, and development (fostering subordinate growth).

The core principles of servant leadership—care, empowerment, and development—manifest in specific leadership behaviors that directly impact subordinates. These key dimensions can be understood as follows:

- *Empowerment*. This refers to granting followers freedom and trust to make decisions related to their work. Servant leaders do not dominate or impose authority; rather, they empower others by providing guidance and encouraging them to take responsibility, thereby creating opportunities for growth and development (Benson & Peprah, 2021).
- *Concern for Subordinates.* This involves addressing their emotional needs in a tangible and prioritized manner.
- *Development of Subordinates*. Demonstrating genuine interest in their professional development, enhancing their skills, and increasing their creativity (Sabri & Faraj, 2022, p. 169).

2.1.3 Functions of the Servant Leader

Servant leadership plays a pivotal role in creating a work environment that fosters growth and innovation by prioritizing the needs of employees. It performs functions that influence employee behaviors, which are as follows (Coetzer, Bussin, & Geldenhuys, 2017, p. 12):

- Strategic Servant Leadership:
  - Servant leadership represents an advanced strategic model that combines the principles of service with the other, making it an effective tool for achieving various goals, including formulating, translating, and implementing a vision with noble purposes. The servant leader creates an inspiring vision based on three main components: noble purposes, creating value for society, and linking the past, present, and future. To realize this vision, the servant leader must translate it into a mission and practical objectives, a clear strategy, capability structures (*skills and knowledge*), absorptive capacity (the number and type of positions), and supportive policies, systems, and procedures.
  - *Being a Role Model and Ambassador of the Vision:* This includes the leader's commitment to principles such as self-awareness, self-knowledge management, self-management, self-improvement, self-disclosure, and adherence to rules. It also involves embodying values like authenticity, humility, integrity, and courage, as well as developing a personal capacity to serve as a role model.
- Operational Servant Leadership:
  The Operational role of Servant Leadership is considered a fundamental element in terms of:
  - *Alignment, Care, and Talent Development*. The servant leader performs several tasks, including building trust-based relationships by understanding the needs, aspirations, and capabilities of others; providing a supportive work environment; empowering followers by aligning skills with roles; creating an effective work environment; and developing them professionally, emotionally, and ethically. This also involves active listening and unleashing their potential in alignment with the organization's vision.
  - Continuous Monitoring and Improvement: The servant leader practices what is known as institutional care, which includes *taking* responsibility for the public good, practicing good governance, and continuously improving systems, policies, procedures, and services. This function fundamentally requires accountability as a key element for success.

2.1.4 Characteristics of the Servant Leader

The servant leader possesses numerous traits that merit understanding and exploration to develop a deeper comprehension of them. These traits are as follows:

- *Ability to Listen.* This refers to active listening and understanding of what is being communicated. It involves attentiveness, honesty, empathetic understanding, patience, and a willingness to accept others' perspectives (Gandolfi & Stone, 2018).
- *Ability to Foster Harmony*. This trait enables the promotion of employees' physical, mental, and social well-being—an essential element for any professional community to function effectively and fulfill its duties.
- *Accountability*. The leader provides guidance and support while holding each individual accountable for their achievements. This form of accountability enhances role clarity, fosters collective commitment, and supports decision-making and information sharing (Sousa & Van Dierendonck, 2015, p. 4).
- *Self-Awareness*. This refers to the leader's awareness of their own emotions, behaviors, and their impact on the team. Since servant leadership is inherently inspirational and motivational, it requires the leader to be conscious not only of the needs of individuals within the team but also of how their personal influence affects the group.
- *Collective Values*. A servant leader who demonstrates commitment to community values will maintain strong relationships with the team. A true servant leader strives to enhance the sense of belonging and teamwork within an environment grounded in shared values; and
- *Vision and Foresight*. This is the ability to envision and imagine a better future for the team and the organization, anticipate the outcomes of decisions, and understand how

events might unfold before they happen. In addition to envisioning the future, the servant leader has the foresight to discern how things will realistically operate (Ellis, 2019, pp. 76-77).

2.2 The concept of Organizational Citizenship Behavior

Organizational Citizenship Behavior (OCB) was first introduced by Bateman and Organ in 1983 and has since become a subject of extensive study in later years. Although the concept has been further developed and refined by several researchers, such as Podsakoff, MacKenzie, Paine, and Bachrach, among others, across various sectors, research on OCB remains relatively limited. In the workplace context:

- Organ defines *Organizational Citizenship Behavior* as "individual discretionary behaviors that are not directly or explicitly recognized by the formal reward system of the organization, but in aggregate promote the effective functioning of the organization" (Kolade, Oluseye, & Osibanjo, 2014, p. 39); and
- Similarly, Siqueira views OCB as "informal actions voluntarily undertaken by employees for the benefit of the organization. These actions fall under social exchange processes and are performed spontaneously by employees without being required or specified in formal contracts or job descriptions" (Silva, Vieira, Klein, Estivalete, & de Andrade, 2024, p. 2).

2.2.1 Factors Influencing OCB

Researchers have examined various factors that influence the extent to which employees engage in OCB. These factors directly and indirectly affect an employee's willingness to exhibit behaviors that go beyond their formal role OCB (Hahangir, Akbar, & Haq, 2004, pp. 80-82):

- *Job Satisfaction and Organizational Commitment*. Employees who are satisfied with their jobs are more inclined to engage in positive behaviors such as cooperating with colleagues and supporting the organization's goals.
- *Role Perception*. Clear role definitions increase voluntary behaviors, while role ambiguity tends to reduce positive behaviors. Additionally, role conflict limits employees' ability to demonstrate extra-role behaviors due to conflicting responsibilities and workplace pressures.
- *Leadership and Leader–Subordinate Relationship*. Employees who have a positive relationship with their leaders are more likely to offer help and cooperation. Effective communication with the leader fosters a positive work environment, which in turn motivates OCB.
- *Perceptions of Organizational Justice*. When employees perceive those organizational decisions are made fairly and transparently, they are more willing to engage in positive behaviors. Perceived justice also boosts motivation to participate and enhances the sense of organizational belonging.
- *Personal Traits*. Employees with a high sense of conscientiousness are more likely to be committed and act responsibly. A positive mood also increases the willingness to participate in the workplace and fosters mutual respect among colleagues.
- *Employee Age and Professional Experience*. Younger employees tend to be more flexible and adaptable to work demands, which increases their commitment to the organization. Older employees, on the other hand, may exhibit a stronger sense of loyalty. As employees gain experience, they become more aware of organizational values, enhancing their sense of belonging to the organization.

2.2.2 Dimensions of OCB

We have represented OCB through four main dimensions, which are widely agreed upon in the literature:

- *Altruism*. Refers to helping colleagues perform tasks and solve problems without expecting any reward.
- *Sportsmanship*. Involves refraining from complaining or expressing dissatisfaction, even in difficult circumstances (Neves, Palma-Moreira, Andrade, & Au-Yong-Oliveira, 2024, p. 2).
- *Conscientiousness*. Indicates a serious commitment to exceeding the minimum job requirements and reflects the employee's obedience to rules and regulations; and
- *Courtesy*. Refers to polite behavior toward others and includes considerate actions aimed at reducing work-related conflicts (Samad, Zakaria, Hussein, Dahalan, & Abdullah, 2024, p. 689).

2.2.3 The Relationship Between Servant Leadership and OCB

Servant leadership can influence employee behavior in several ways by serving as a positive role model. Servant leaders significantly promote OCB through qualities such as empathy, humility, and integrity. Their behavior inspires the adoption of these traits, making employees more inclined to emulate such conduct and engage in similar actions. Moreover, when a servant leader demonstrates genuine concern for employee well-being, they are perceived as sincere and trustworthy, which fosters a psychological commitment among employees to imitate their behavior.

Chon and Zoltan (2019) confirmed that when servant leaders show strong concern for the needs of their subordinates and treat them fairly, this can trigger OCB as a reciprocal response from employees. Overall, the promotion of positive social values through role modeling, fostering psychological safety, and empowering subordinates creates a work environment where employees are more inclined to engage in voluntary behaviors that enhance the overall performance of the organization (Demissie, Alemu, & Tensay, 2024, p. 12)

When examined from a broader perspective, the relationship between servant leadership and OCB can also be understood through the lens of Social Exchange Theory. This theory suggests that social interactions create implicit obligations to reciprocate. Employees often feel a sense of duty to engage in OCB when they observe their leaders displaying genuine care and concern. Such leaders are then perceived as admirable and possessing integrity, which in turn can lead to a psychological commitment from subordinates to reciprocate (Henilesta & Putranto, 2024).

3 METHODOLOGICAL AND ANALYTICAL FRAMEWORK

This section presents the analytical framework of the field study, including the research methodology, tools, and data analysis to test the study's hypotheses.

3.1 Study Population and Sample

The statistical population consists of all permanent employees at Biocare Laboratories located in El-Tarf State, Algeria, totaling 200 employees. This institution specializes in the manufacturing of solid-form pharmaceutical products and produces over 1.2 billion units annually, positioning it as one of the leading companies in the pharmaceutical industry in the country.

Due to the impracticality of accessing the entire population, considering constraints related to effort, time, and deadlines, a sampling method was adopted. A total of 130 paper-based questionnaires were distributed using a non-probability purposive sampling technique. Out of these, 122 valid questionnaires were retrieved, and deemed suitable for statistical analysis. These respondents constitute the final sample for the present study.

3.2 Study Instrument

The study tool is considered a fundamental pillar in the applied aspect. Therefore, the following tests were conducted for it after presenting its components.

3.2.1 Description of the Study Questionnaire

The questionnaire consists of two main sections. The first section includes 18 items (numbered 1 to 18) that measure the independent variable: Servant Leadership, which comprises the following dimensions: empowerment, concern for subordinates, and development of subordinates. Each dimension is measured by six items.

The second section pertains to the dependent variable: Organizational Citizenship Behavior (OCB), which is measured by 13 items. It includes four dimensions: altruism, courtesy, conscientiousness, and sportsmanship, with the last dimension represented by items numbered 11 to 13.

A five-point Likert scale was used, ranging from *"Strongly Disagree"* (1) *to "Strongly Agree"* (5). The interpretation of the arithmetic mean scores is as follows:

- [1–1.8) – *Very Low Agreement*
- [1.8–2.6) – *Low Agreement*
- [2.6–3.4) – *Moderate Agreement*
- [3.4–4.2) – *High Agreement*
- [4.2–5] – *Very High Agreement.*

3.2.2 Study Instrument Tests

The results of the construct validity test of the study instrument are presented in Tables 1 and 2

Table 1. Construct Validity of the Servant Leadership Variable

Dimensions	Nu	Pearson Correlation Coefficient	Significance Level (sig)	Dimensions	Nu	Pearson Correlation Coefficient	Significance Level (sig)
Empowerment	1	0.779**	0.000		11	0.840**	0.000
	2	0.772**	0.000		12	0.766**	0.000
	3	0.745**	0.000	Subordinate Development	13	0.814**	0.000
	4	0.552**	0.000		14	0.775**	0.000
	5	0.804**	0.000		15	0.785**	0.000
	6	0.686**	0.000		16	0.752**	0.000
Concern for Subordinates	7	0.773**	0.000		17	0.796**	0.000
	8	0.664**	0.000		18	0.744**	0.000
	9	0.816**	0.000	**: Statistically significant at the 0.01 level (2-tailed).			
	10	0.850**	0.000	*: Statistically significant at the 0.05 level (2-tailed).			

Source: Prepared by the researcher using SPSS v21.

The *Pearson correlation coefficients* between the items of the *servant leadership* dimensions and their respective dimensions are all *positive*, and the *significance level (sig)* for each item is *less than 0.05*, indicating that the validity for the *servant leadership variable* items is met.

As for the *construct validity results* of the OCB variable, they are presented in Table 2 below.

Table 2. Construct Validity of the Organizational Citizenship Behavior Variable

Dimensions	Nu	Pearson Correlation Coefficient	Significance Level (sig)	Dimensions	Nu	Pearson Correlation Coefficient	Significance Level (sig)
Altruism	1	0.829**	0.000	Conscientiousness	8	0.786**	0.000
	2	0.716**	0.000		9	0.821**	0.000
	3	0.761**	0.000		10	0.822**	0.000
	4	0.635**	0.000				
Courtesy	5	0.812**	0.000	Sportsmanship	11	0.842**	0.000
	6	0.805**	0.000		12	0.792**	0.000
	7	0.775**	0.000		13	0.811**	0.000
**: Statistically significant at the 0.01 level (2-tailed).							

Source: Prepared by the researcher using SPSS v21

The *Pearson correlation coefficients* between the items of the *OCB* dimensions and their respective dimensions are all *positive*, and the *significance level (sig)* for each item is *less than 0.05*, indicating that the *validity condition* for the *OCB variable* items is met.

3.2.3 Reliability Test

The condition for the reliability of the questionnaire is considered satisfied if Cronbach's *Alpha reliability coefficient* is greater than *0.7.* The results are detailed in Table 3 below.

Table 3. Cronbach's Alpha Reliability Coefficient

Variables	Number of Items	Cronbach's Alpha Coefficient
Empowerment	6	0.8130
Concern for Subordinates	6	0.8740
Development of Subordinates	6	0.8680
Servant Leadership	18	0.9220
Altruism	4	0.7210
Courtesy	3	0.7130
Conscientiousness	3	0.7370
Sportsmanship	3	0.7450
Organizational Citizenship Behavior	13	0.7830
Overall Study Instrument Reliability	31	0.9050

Source: Prepared by the researcher using SPSS v21.

The overall *Cronbach's Alpha coefficient* was *0.905*. Additionally, the Cronbach's Alpha values for the study's axes and their respective dimensions ranged between *0.713* and *0.922*, all of which exceed the acceptable threshold of *0.70*.

Accordingly, the *reliability of the study questionnaire is confirmed.*

3.2.4 Normality Test

The results of the skewness and kurtosis coefficients are presented in *Table 4* as shown hereafter.

Table 4. Normality Test

Variables	Skewness Coefficient	Kurtosis Coefficient
Servant Leadership	-0.913	0.8440
Organizational Citizenship Behavior	-0.278	0.2820

Source: Prepared by the researcher using SPSS v21.

All *skewness coefficient values* are less than *2*, and all *kurtosis values* are less than *7*. Accordingly, the study variables are *normally distributed*, which permits the use of *parametric tests* instead of non-parametric ones, such as simple linear regression tests.

3.3 Statistical Processing Methods

The Statistical Package for the Social Sciences (SPSS), version 21, was used to conduct the analysis. The following statistical methods were employed:

- Pearson correlation coefficient.
- Reliability coefficient (Cronbach's Alpha).
- Normal test.
- Frequencies and percentages.
- Arithmetic means.
- Standard deviation.
- Multiple linear regression.

3.4 Presentation and Analysis of Servant Leadership Dimensions

The dimensions of servant leadership will be analyzed sequentially as follows.

3.4.1 Empowerment Dimension

The results for the *arithmetic mean* and *standard deviation* of this dimension are shown in Table 5.

Table 5: Arithmetic Mean and Standard Deviation for the Empowerment Dimension

No.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
1	The leader grants subordinates full authority to make work-related decisions.	3.40	1.065	High	4
2	The leader delegates to subordinates the freedom to handle difficult situations as they see fit.	3.51	1.046	High	2
3	Subordinates have broad freedom to express their opinions regarding tasks.	3.37	1.115	Moderate	5
4	Subordinates rely on themselves to carry out their assigned tasks without turning to the leader.	3.07	1.183	Moderate	6
5	The leader encourages and motivates subordinates to take responsibility for their tasks.	3.69	1.099	High	1
6	Our leader avoids authoritarianism, excessive bureaucracy, and strict supervision.	3.41	1.184	High	3
Empowerment (Overall)		**3.41**	**0.803**	**High**	--

Source: Prepared by the researcher using SPSS.

The table results indicate the level of empowerment practice is high, as the overall mean reached 3.41, with a standard deviation of 0.803, revealing a degree of dispersion in respondents' answers.

The high mean scores for the empowerment dimension reflect employees' perception that leaders are committed to granting them the trust and authority needed to perform their tasks efficiently, and independently. This indicates a supportive work environment that allows subordinates the freedom to make decisions and encourages active participation, thereby fostering a sense of initiative and responsibility.

3.4.2 Concern for Subordinates Dimension

The results for the *arithmetic mean* and *standard deviation* of this dimension are presented in *Table 6* as follows.

Table 6. Arithmetic Mean and Standard Deviation for the Concern for Subordinates Dimension

No.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
7	The leader strives to help subordinates work in a comfortable environment.	3.76	1.013	High	1
8	The leader spends some time with subordinates engaging in personal-level conversations.	3.49	1.100	High	4
9	The leader is highly willing to provide support and assistance.	3.68	1.054	High	2
10	The leader genuinely cares about the well-being of others.	3.56	1.045	High	3
11	The leader prioritizes the needs and desires of subordinates.	3.32	1.070	Moderate	5
12	The leader sacrifices personal benefits and interests to fulfill our needs.	3.28	1.093	Moderate	6
Concern for Subordinates (Overall)		**3.52**	**0.833**	**High**	--

Source: Prepared by the researcher using SPSS.

The level of concern for subordinates in the institution under study is considered high, as the arithmetic mean reached 3.52, with a standard deviation of 0.833, indicating a degree of dispersion in respondents' answers.

The elevated results indicate that leaders place significant value on the emotional and personal aspects of their employees. This includes listening to their concerns, supporting their needs, and engaging with them positively, which helps create an organizational climate characterized by empathy and mutual trust.

3.4.3 Development of Subordinates Dimension

The results for the arithmetic mean and standard deviation of this dimension are presented in Table 7 as demonstrated hereafter:

Table 7. Arithmetic Mean and Standard Deviation for the Development of Subordinates Dimension

Nu.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
13	The leader is keen on developing subordinates' personalities and enhancing their skills.	3.70	0.942	High	5
14	The leader allows subordinates to present new ideas related to their tasks.	3.77	0.769	High	2
15	The leader provides opportunities for subordinates to expand their knowledge and experience.	3.72	0.884	High	3
16	The leader seeks to share work experience with us.	3.70	0.880	High	4
17	The leader shows great concern for our success and ensures the achievement of our professional goals and aspirations.	3.66	1.009	High	6
18	The leader helps us overcome work-related problems and difficulties.	3.89	0.825	High	1
Development of Subordinates (Overall)		**3.74**	**0.689**	**High**	--

Source: Prepared by the researcher using SPSS.

The leaders' focus on *developing subordinates* in the institution of interest is *high*, with an *arithmetic mean* of *3.74* and a *standard deviation* of *0.689*, indicating a degree of variability in participants' responses.

The findings show a high level of employee appreciation for their leaders' efforts in supporting their professional development. The elevated scores for this dimension indicate that leaders are committed to enhancing employees' skills, offering continuous guidance, and providing opportunities that contribute to their career advancement.

Based on the above, all dimensions of servant leadership can be presented and analyzed as follows in Table 8

Table 8. Arithmetic Mean and Standard Deviation for the Servant Leadership Axis

Nu.	Variables	Mean	Standard Deviation	Level of Agreement	Rank
1	Empowerment	3.41	0.803	High	3
2	Concern for Subordinates	3.52	0.833	High	2
3	Development of Subordinates	3.74	0.689	High	1
Servant Leadership (Overall)		**3.55**	**0.672**	**High**	---

Source: Prepared by the researcher using SPSS v21.

It can be seen from Table 9 above that the level of practicing servant leadership is high, with an overall arithmetic mean of 3.55 and a standard deviation of 0.672, indicating a degree of dispersion in respondents' answers. The study reveals a high level of servant leadership practice across its three core dimensions, aligning with prior literature that emphasizes its role in enhancing employee engagement and human capital development. These findings suggest that servant leadership not only improves leader-follower relationships but also serves as a strategic driver for achieving organizational objectives. Thus, servant leadership emerges not merely as a managerial approach, but as a leadership ethos that redefines authority through a lens of trust, empowerment, and human-centered engagement.

3.5 Presentation and Analysis of Organizational Citizenship Behavior Dimensions

The analysis of the dimensions of OCB will be presented as follows:

3.5.1 Altruism Dimension

The results for the *arithmetic mean* and *standard deviation* of this dimension are presented in Table 9.

Table 9. Arithmetic Mean and Standard Deviation for the Altruism Dimension

Nu.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
1	Individuals willingly help each other in completing assigned tasks and duties.	3.80	0.881	High	4
2	Individuals strive to adhere to the institution's regulations, rules, work systems, and internal guidelines with full respect.	4.01	0.828	High	2
3	Individuals assist their colleagues in solving work-related problems willingly.	3.92	0.767	High	3
4	Individuals make great efforts to voluntarily help new colleagues learn work methods and how to complete tasks.	4.05	0.691	High	1
Altruism (Overall)		**3.94**	**0.586**	**High**	--

Source: Prepared by the researcher using SPSS v21.

The level of altruism among respondents is high, with an arithmetic mean of 3.94 and a standard deviation of 0.586, indicating a degree of dispersion in responses. The high scores on the altruism dimension reflect a strong willingness among employees to provide support and assistance to their colleagues without expecting a return or being formally instructed to do so. This indicates a prevailing culture of cooperation and solidarity in the workplace and serves as evidence of a collective sense of responsibility and voluntary behavior that enhances team effectiveness and contributes to achieving organizational goals more efficiently.

3.5.2 Courtesy Dimension

The results for the *arithmetic mean* and *standard deviation* of this dimension are presented in Table 10.

Table 10. Arithmetic Mean and Standard Deviation for the Courtesy Dimension

Nu.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
5	Individuals in our institution voluntarily take on additional tasks and responsibilities to complete their work without complaint.	3.64	0.996	High	3
6	Individuals strive to assist each other in personal matters.	3.67	0.922	High	2
7	Individuals in our institution comply with values, policies, procedures, and work rules (e.g., attendance, punctuality, etc.).	3.93	0.898	High	1
Courtesy (Overall)		**3.75**	**0.749**	**High**	**--**

Source: Prepared by the researcher using SPSS v21.

The level of courtesy among respondents is high, with an arithmetic mean of 3.75 and a standard deviation of 0.749, indicating a degree of variability in responses. The mean scores for courtesy dimension indicate that employees consistently interact with kindness and respect in the workplace, demonstrating sensitivity to others' feelings and actively avoiding behaviors that could cause discomfort or embarrassment. This reflects a mature organizational behavior that helps foster positive professional relationships, reduce tensions, and create a work environment characterized by mutual respect and understanding.

3.5.3 Conscientious Dimension

The results for the *arithmetic mean value* and *standard deviation* of this dimension are presented in *Table 12* hereafter.

Table 11. Arithmetic Mean and Standard Deviation for the Conscientiousness Dimension

Nu.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
8	Individuals in our institution strive to overcome difficulties facing organizational processes and protect the institution from risks.	4.00	0.668	High	1
9	Individuals offer organizational improvements to help distinguish the institution (e.g., by making suggestions).	3.86	0.672	High	2
10	Individuals voluntarily assist supervisors in completing tasks and resolving work-related problems.	3.81	0.720	High	3
Conscientiousness (Overall)		**3.89**	**0.556**	**High**	**--**

Source: Prepared by the researcher using SPSS v21.

The respondents exhibit a high level of conscientiousness, as reflected in an arithmetic mean of 3.89 and a standard deviation of 0.556, suggesting minimal variability in responses. This finding highlights a strong, self-driven commitment that surpasses formal job requirements, with individuals demonstrating keen attention to accuracy, punctuality, and meticulous detail to ensure work quality. It indicates a strong sense of professional responsibility that motivates employees to take proactive initiatives, contributing to the establishment of high standards of discipline and credibility within the organization.

3.5.4 Sportsmanship Dimension

The results for the *arithmetic mean* and *standard deviation* of this dimension are presented in Table 12 as shown below:

*Table 12. Arithmetic Mean and Standard Deviation **for the Sportsmanship Dimension***

No.	Statement	Mean	Standard Deviation	Level of Agreement	Rank
11	Individuals seek to understand their colleagues' opinions before making decisions and accept them with an open mind.	4.07	0.758	High	2
12	Individuals in our institution are able to endure heavy workloads and uncomfortable conditions with patience.	3.87	0.704	High	3
13	Individuals in our institution strive to enhance the institution's image and reputation within its surrounding environment.	4.07	0.632	High	1
Sportsmanship (Overall)		**4.00**	**0.569**	**High**	--

Source: Prepared by the researcher using SPSS v21.

The level of sportsmanship among respondents is high, with an arithmetic mean of 4.00 and a standard deviation of 0.569, indicating a moderate level of variation in responses. The elevated mean scores for the sportsmanship dimension suggest that employees are accepting challenges and less-than-ideal working conditions while maintaining a positive attitude that reduces complaints and enhances persistence in completing tasks with a good spirit. This reflects an organizational culture that values adaptability, and the ability to turn challenges into opportunities, which positively impacts team stability and workflow continuity.

The results for the *Organizational Citizenship Behavior* axis and its dimensions are presented in Table 13.

Table 13. Arithmetic Mean and Standard Deviation for OCB Axis

No.	Variables	Mean	Standard Deviation	Level of Agreement	Rank
1	Altruism	3.94	0.586	High	2
2	Courtesy	3.75	0.749	High	4
3	Conscientiousness	3.89	0.556	High	3
4	Sportsmanship	4.00	0.569	High	1
Organizational Citizenship Behavior (Overall)		**3.90**	**0.415**	**High**	---

Source: Prepared by the researcher using SPSS v21.

From the table above, it is evident that the level of commitment to and practice of Organizational Citizenship Behavior is high, with an overall mean score of 3.90 and a standard deviation of 0.415, indicating a relatively low level of dispersion in responses. The findings show a high level of organizational citizenship behavior among employees, reflecting the Prevalence of positive, voluntary actions beyond formal job duties. These results align with prior research highlighting OCB as a form of self-directed commitment that fosters team cohesion and contributes to organizational stability and effectiveness.

Organizational citizenship behavior is not merely measured by what is done, but by what is willingly initiated, quietly sustained, and collectively embraced beyond formal directives.

4 EVALUATION OF HYPOTHESES

Since the study variables follow a *normal distribution*, parametric tests are used to test the hypotheses, including *multiple linear regression*, instead of non-parametric alternatives. The results are presented below.

The multiple linear regression model is valid. This is evidenced by the calculated F value of 5.215, which exceeds the critical (tabulated) value of 2.68, and the statistical significance level (Sig.) of 0.002, which is less than the conventional threshold of 0.05.

Table 14. Testing the Main Hypothesis of the Study

Independent Variables	Dependent Variable	Correlation Coefficient (R)	Coefficient of Determination (R^2)	Calculated F Value	Significance Level (Sig.)
Servant Leadership (all dimensions)	Organizational Citizenship Behavior	0.342	0.117	5.215	0.002

Source: Prepared by the researcher using SPSS v21.

Furthermore, there is a positive correlation between Servant Leadership (in all its dimensions) and Organizational Citizenship Behavior, as indicated by the correlation coefficient R = 0.342.

The coefficient of determination (R^2 = 0.117) suggests that Servant Leadership collectively explains 11.7% of the variation in Organizational Citizenship Behavior, while the remaining 88.3% is attributable to other factors.

Accordingly, the main hypothesis of the study is accepted, which states: "There is a statistically significant effect at the significance level (α ≤ 0.05) of practicing the dimensions of servant leadership on organizational citizenship behavior at the Biocare Pharmaceutical Group – El Tarf State."

The following final table presents the results of testing the sub-hypotheses to determine the effect of practicing servant leadership dimensions on organizational citizenship behavior.

Table 15. Results of Multiple Linear Regression for Testing the Sub-Hypotheses

Independent Variables	Unstandardized Coefficients (A)	Standard Error	Standardized Coefficients (Beta)	Calculated T-Value	Significance Level (Sig.)	Statistical Decision
Constant	3.250	0.205	–	15.825	0.000	---
Empowerment	0.010	0.057	0.019	0.173	0.863	**Rejected**
Concern for Subordinates	0.149	0.067	0.298	2.203	0.030	**Accepted**
Development of Subordinates	0.025	0.078	0.042	0.322	0.748	**Rejected**

Source: Prepared by the researcher using SPSS v21.

Based on the above results, the following can be concluded:

➢ First Sub-Hypothesis Testing

The calculated T-value is 0.173, which is less than the critical T-value of 1.97.

The significance level (Sig.) is 0.863, which is greater than 0.05

Therefore, the first sub-hypothesis is rejected which states that "There is a statistically significant effect at the significance level (α ≤ 0.05) of the empowerment dimension on organizational citizenship behavior at the Biocare Pharmaceutical Group– El-Tarf state ."

➢ Second Sub-Hypothesis Testing

The calculated T-value of 2.203 is greater than the tabulated T-value of 1.97. Additionally, the significance level (sig) of 0.030 is less than the threshold of 0.05. Accordingly, the second sub-hypothesis is accepted: "There is a statistically significant effect at the significance level (α ≤ 0.05) of the concern for subordinates' dimension on organizational citizenship behavior at the Biocare Pharmaceutical Group – El-Tarf State."

➢ Third Sub-Hypothesis Testing:

The calculated T-value of *0.322* is less than the tabulated T-value of *1.97*. Moreover, the significance level (sig) of *0.748* is greater than the threshold of *0.05*. Accordingly, the third sub-hypothesis is rejected: "There is a statistically significant effect at the significance level (α ≤ 0.05) of the development of subordinates dimension on organizational citizenship behavior at the Biocare Pharmaceutical Group – El-Tarf State."

5 CONCLUSIONS

Based on the findings of the study, the following conclusions can be drawn:

- The results indicate that all dimensions of servant leadership—namely empowerment, attention to subordinates, and their development—are present to a high degree within the pharmaceutical institution under study. This reflects a clear managerial awareness of modern leadership practices that focus on the human element.
- The findings also reveal that organizational citizenship behavior (OCB), across its various dimensions, is strongly manifested among employees. This suggests the existence of a positive organizational environment that fosters voluntary initiatives and supportive behaviors toward the institution.
- Despite the high levels of mean scores, the results of statistical tests show that only the dimension of "attention to subordinates" has a significant impact on organizational citizenship behavior. This reinforces the hypothesis that supportive human relationships remain the most influential factor in encouraging positive voluntary behavior in the workplace, particularly in high-pressure environments such as pharmaceutical institutions.
- The results can also be interpreted to mean that OCB is often more influenced by the emotional and psychological relationship between leaders and subordinates than by organizational, administrative, or professional factors alone. Thus, leaders' attention to subordinates fosters emotional commitment, through which employees feel an intrinsic desire to engage in positive behaviors beyond what is formally required.
- In some cultures, empowerment, and development may not be viewed as a direct responsibility of leadership or may not hold significant value in the eyes of subordinates when compared to personal attention. This indicates that appreciation and human support are among the most impactful factors influencing feelings of belonging and motivation toward positive behaviors within the organization.

It can also be explained that subordinates respond more to the humanistic aspect than to developmental or administrative dimensions. The feeling that the leader personally cares for them, listens to their concerns, and supports them on a personal level enhances their loyalty and positive behavior toward the organization.

6 RECOMMENDATIONS

Based on these conclusions, the following recommendations are proposed:

- Prioritize the "attention to subordinates" dimension as a leadership focus. Given that this was the only dimension with a significant direct effect on OCB, it is important to implement training programs for leaders that focus on developing human communication skills, active listening, and empathy as key drivers for encouraging voluntary and positive behavior.
- Enhance human resource investment in professional development by allocating greater resources and developing well-structured plans to enable employees to grow their skills in line with their needs and ambitions, potentially increasing the future impact of this dimension.
- Adopt flexible leadership approaches tailored to the characteristics of each organizational environment. Since the effectiveness of servant leadership dimensions may vary across contexts, leaders should act with flexibility and strategic foresight in choosing the most appropriate approach.
- Re-evaluate empowerment and development methods by reviewing current practices to ensure they are not merely symbolic but rather reflect genuine empowerment and development that instills trust and a sense of contribution in employees.

Activate the role of human resources as a human-centered support function, not merely administrative, by identifying emotional and job engagement indicators and implementing targeted improvement plans to strengthen the leader-subordinate relationship.

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Received for publication: 16.05.2025
Revision received: 11.06.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Gaoussi, S. (2025, 07 15). The Impact of Practicing Servant Leadership Dimensions on Enhancing Organizational Citizenship Behavior. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 107-122. doi:10.12709/mest.13.13.02.17

Style – **Chicago** *Sixteenth Edition:*

Gaoussi, Samira. "The Impact of Practicing Servant Leadership Dimensions on Enhancing Organizational Citizenship Behavior." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 107-122.

Style – **GOST** *Name Sort:*

Gaoussi Samira The Impact of Practicing Servant Leadership Dimensions on Enhancing Organizational Citizenship Behavior [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 107-122.

Style – **Harvard** *Anglia:*

Gaoussi, S., 2025. The Impact of Practicing Servant Leadership Dimensions on Enhancing Organizational Citizenship Behavior. *MEST Journal,* 15 07, 13(2), pp. 107-122.

Style – **ISO 690** *Numerical Reference:*

The Impact of Practicing Servant Leadership Dimensions on Enhancing Organizational Citizenship Behavior. **Gaoussi, Samira.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 107-122.

MEST Journal
DOI 10.12709/mest.13.13.02.09

PROSPECTS AND OPPORTUNITIES FOR THE APPLICATION OF THE NUDGE CONCEPT IN RESEARCH PRACTICE

Antoaneta Kirova
College of Management, Trade and Marketing, Sofia, Bulgaria
https://orcid.org/0000-0002-7799-423X

Darin Trayanov
District Slatina, Municipality of Sofia, Bulgaria

JEL Category: **R41, R110**

Abstract

The aim is to discuss the essence and field of application of the Nudge Theory in behavioral analysis by experts to improve the stages of the development and implementation of the entire cycle of public policies. The topic of nudging is relevant from the point of view of the efforts towards a friendlier green environment. It concerns the possibilities to include the participation of individuals and society in specific policies. The research involves several tasks. One task is to present the theory based on a literature review of existing publications. This review highlights the strengths, weaknesses, opportunities, and threats that pertain to theory. Another task is to showcase examples of good practices. The research also emphasizes the role of society, identifying it as the key stakeholder in the efficient application of nudges. In the conclusion section, the authors present recommendations regarding possible future applications. The paper also identifies three principles that guide applying new behavioral insights to the development policies design and implementation. A specific field of focus is public transport, where nudging is of particular importance.

Keywords: *Nudge, public policies, public transport, human behavior, positive influences*

1 INTRODUCTION

The authorities have undertaken measures in partnership with interested parties. These measures share a common goal: to influence human behavior and create a positive impact on the community. Various policies address several factors that shape the decision-making process, affecting their approval and eventual implementation.

This paper proposes a hypothesis regarding public policies. It suggests that their manageability and goal achievement should include behavioral analysis conducted by experts. Such analysis would help guide the development stages and facilitate future implementation using so-called *nudges*.

Address of the corresponding author
Antoaneta Kirova
toni.kirova@gmail.com

By and large, nudges and their tools do not involve material costs and there comes no additional financial burden for taxpayers. The nudges-related topic is interesting from the point of view of a well-structured theory based on successful experiments of their further application in the practice of public policies in different areas. However, change management needs nudges, which fully reflect the possible positive outcomes of their implementation, having in mind suitable measures to overcome potential resistance from individuals and the whole society.

The primary purpose of the paper is to present the theory and practical possibilities of nudges based on the following research tasks:

1. Presentation of the Nudge Theory as an essence, a literature review of existing publications and highlighting its strengths, weaknesses, opportunities, and threats.
2. Showcase examples of good practices and represent stakeholders in the application of the Nudge Theory.
3. Conclusions and recommendations regarding possible applications.

The study limitations are a result of the lack of good practices in the field of nudging in Bulgaria.

2 LITERATURE REVIEW

The development and implementation of public policies is a process in which there is interaction with many interested parties, resulting in the intersection of the interests of legitimate authorities, civil society organizations, and business associations. According to John Morris Clark (1918), human behavior is determined by the character of the individual whose desires play a predominant role in a situation of a need to manage income depending on the opportunities and threats of the surrounding environment. The political economy classic, Adam Smith, the author of *The Wealth of Nations* (1776), also offers a psychological perspective that guides individual behavior in his Theory of Moral Sentiments (1779) (Wikipedia, 2025a).

During the 1960s, the representatives of cognitive psychology (Amos Tversky and Daniel Kahneman) tackled the decision-making process by identifying three heuristics (anchoring, availability, and representativeness) and their accompanying biases, which form the basis of behavior-influencing models (Tversky & Kahneman, 1974). Recently, the most common version of the theory of rational choice, the theory of the expected utility, has been challenged, and *rational* behavior can be referred to as *reasonable* or *predictable* behavior. In his studies on human behavior, Tullock (1966) starts from the premise that individuals make decisions based on rational choice. This view is also shared by another scientist, the supporter of positivism Karl Popper, despite his thesis that rationality does not influence the individual decision-making process (Shea, n.d.).

Thaler and Sunstein, two of the most prominent behavioral experts, define nudges as "any aspect of the choice architecture that changes people's behavior predictably without forbidding any options or significantly changing their economic incentives". In their book *Nudge - Improving Decisions about Health, Wealth and Happiness* (Thaler & Sunstein, 2014), they argue that by influencing decision-making choices, public policymakers can encourage behavior that is desirable from the point of view of societal interests based on the *dual system* principle (*automatic* and *reasonable*). The application of nudge tools involves attempts to influence everyday choices and behavior without changing incentives, that is, without affecting society's freedom of choice or introducing mandatory measures. Thaler and Sunstein's behavioral insights focus on reshaping the architecture of individual choices across various domains, including the environment, healthcare, pension schemes, and organ donation.

As a concept from behavioral science, Nudge encompasses suggestions and instructions aimed at influencing the behavior and decision-making of social groups or individuals. The attention paid to this concept is due to its widespread application in British and American policy practice. Specific bodies have been created to implement measures in the field of nudges at the national level (in the UK, Germany, Japan, and others), as well as at the international level (OECD, World Bank, UN, and EU) (OECD, 2017). The European Commission's Joint Research Center established the Behavioral Foresight and Analysis Unit (2014), now the Behavioral Foresight and Analysis Policy Design Unit (Wikipedia, 2025b).

The literature (including Thaler and Sunstein's book) presents several examples of explicit measures designed to guide conscious decision-making, classified as nudges. These include financial incentives, prohibitions, educational campaigns, and attempts at persuasion or norm-setting. The possible areas of application of the nudge concept are the following:

- When introducing rules and policies related to environmental protection (reduction of domestic pollution, consumption of non-renewable resources, recycling, etc.).
- In various projects related to safety and reducing risky behaviors (including road safety, safe working conditions, etc.).
- In collecting taxes, fees, and overdue debts.
- In healthcare, patient care, campaigns for leading a healthy lifestyle, as well as in campaigns for blood donation and increasing organ donation.
- In education, to increase class attendance.
- In the field of consumer behavior, to influence choice.
- In charity-related initiatives.
- In management consulting direct thinking, consequently impacts, in the right direction, from the perspective of business interests, but also the public interest that public policymakers strive to pursue.

The well-known Hood's model (1986), abbreviated as NATO, divides policy instruments into four broad categories by means of which governments dispose to change public behavior, i.e., Nodality, Authority, Value, and Organization (NATO). The inclusion of nudges within the presented model suggests that they are not "sticks" (rules) that limit choice, nor are they "carrots," as according to Thaler and Sunstein, nudges do not replace tangible incentives, for example, economic ones. However, nudges show some similarity to the *carrot* in that they leave citizens with freedom of choice, though, they also, remind of and resemble *instructions*.

The role of nudges is also to change the choice environment and thus influence the perception of a given choice alternative. For example, in terms of encouraging people to become transplant organ donors (Manzano & Pawson, 2014), instead of offering *payment* as a direct incentive (as is the case with blood donation in some countries), the nudge *reverses* the incentive, i.e. people do not want to register as potential donors, but passively accept to become donors by default.

Figure 1 shows how policy interventions can help people make better decisions. This includes unconscious bias and re-bias through nudges (the upper area), as well as conscious removal of bias through the application of self-correction and self-reflection techniques, both of which are aimed at achieving an "optimal" decision. (Amir & Lobel, 2008).

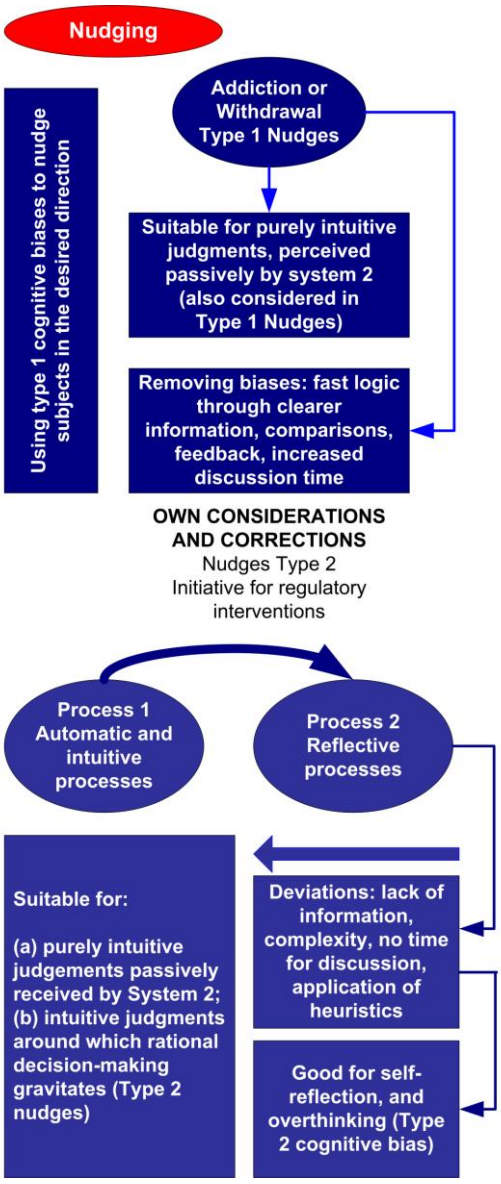

Figure 1 Graphical presentation of the process of nudging, self-reflection, and correction in relation to the interaction of System 1 and System 2

There are also a good deal of criticisms of the nudge theory, such as the presence of politically motivated initiatives in *nudging* people, without evidence that their thinking and actions would change for the better in the long term as well as negative sentiments in a part of society towards the nudge methods considering them partially illegal, with doubts existing about their links to ethics, their classification as a *social manipulation*, etc. (Barton & Grüne-Yanoff, 2015), (Tannenbaum, Fox, & Rogers, 2017), (Bovens, 2009), (Goodwin, 2012), (Wilkinson, 2013). Sunstein responds to criticism in his work *The Ethics of Influence* (Sunstein C. , 2016). Other considerations at the public level express uncertainty about the degree of compatibility of the nudge theory with existing legislation.

According to the World Development Report 2015 (Lunn, 2014), the application of behavioral economics is in tune with the attitudes of the OECD, the World Bank, and the EU about development policy. The report identifies three principles that guide applying new behavioral insights into the design and implementation of development policy:

- *Automatic thinking*. People make most judgments and choices automatically, not consciously. As a result, small changes in the choice architecture of decision-making (such as framing and default choices) could be made with the expectation that they will have a significant effect on behavior.
- *Social thinking*. People's actions and thinking are often influenced by the behavior of those they communicate with and connect to. Understanding how social norms and networks influence individuals can help policymakers envisage the social constructions that draw people into certain frameworks and patterns of collective behavior, as well as help develop more innovative and effective interventions.
- *Mental model thinking.* People in society share a common perspective for making sense of the surrounding world and understanding themselves. Mental models often arise from the cognitive side of social interactions, which people usually call culture. A well-established example of a mental model is the stereotype, which affects processes of inclusion and exclusion. However, mental models are flexible and interventions to gain insight into behavior can be directed toward promoting developmental goals.

Seven EU Member States were analyzed in terms of institutional development[1], interested in utilizing the potential of behavioral insights for policymaking, based on the PRECIS model (for assessing political support, resources, expertise, coverage, integration, and structure of different behavioral units). The Report formulates four key conclusions:

1. There is significant momentum in capacity building and a growing inclination to apply behavioral insights to policymaking.
2. There is certainly room for improved knowledge exchange between policymakers and academia. For example, there is significant potential in analyzing big data to extrapolate useful insights for policy.
3. Behavioral insights should be integrated throughout the policy cycle, including implementation challenges, to facilitate the rapid and efficient generation of evidence.
4. A systematic approach to analyzing and collecting evidence is essential for raising awareness about the impact of policy decisions.

There are opportunities to take more action to improve the effectiveness of behavioral policy initiatives, shed light on their long-term impact, and increase transparency through more effective communication and evidence-sharing with citizens. (Dessart, Sousa Lourenco, & Rafael Almeida, 2016).

At a European Union level, the Handbook for Better Regulation has been developed. It is being supplemented (EC, 2021), where repeatedly behavioral approaches and insights are mentioned, in the context of possible tools for conducting impact assessments – how to analyze problems and define policy options, especially when consumers are involved. In the EC

[1] The UK, the Netherlands, Germany, France, and Denmark as EU leaders in institutionalizing behavioral insights practices.

Handbook, it is explicitly noted that policy will be better informed and more effective when consumers' biases, and behavioral tendencies as well as if the actual decision-making process are considered. Furthermore, behavioral biases are mentioned in the Handbook as one of the four main categories of problems (the other three being market failures, regulatory failures, and equal treatment). Such a clear recognition of the limits of consumer rationality and their direct connection to public policies sends a strong signal. It further increases the importance of behavioral science for EU policymaking.

At a national level, in Bulgaria, the application of behavioral approaches is becoming increasingly common in simplifying administrative procedures. Alternative approaches to state regulation are being sought associated with a lower burden for citizens and businesses. With the amendment of the Law on Normative Acts in 2016, the obligation to conduct a preliminary impact assessment when introducing new regulations was introduced, and one of the main problems that the Bulgarian administration currently faces in preparing these assessments is related to the development and proposal of non-regulatory options for action. Behavioral insights and approaches can provide alternative methods to achieve public policy goals. These methods often eliminate the need to introduce new regulatory requirements. Companies frequently dislike such requirements because they result in additional compliance costs. Unfortunately, so far in Bulgaria such initiatives are more of an exception than a standard practice. In ensuring the efficiency of official warnings and advice, regulators should consider the fact that choices are influenced by the available information. One promising option is their application in pricing strategies or product descriptions, which automatically change the consumer's thinking and bias the attention paid to the purchase costs.

There are also areas where the findings of behavioral economics create the conditions for individuals to make significant costly mistakes, such as when gambling, trading in financial markets, purchasing insurance, or behaviors with long-term effects on health. The potential for substantial harm, coupled with the challenges in quantifying these effects, highlights the need for further research. It also underscores the importance of developing regulatory policies that use an empirical approach to generate context-specific evidence.

The research suggests that *nudge* in public policy involves using behavioral, economic, and psychological insights to influence public behavior to help achieve policy goals. The approach advocated by Thaler and Sunstein in their 2009 book Nudge emphasizes the concept of nudging. This concept is based on the idea that people rely on mental shortcuts, or heuristics, in everyday decision-making. However, these shortcuts do not always align with their long-term interests. Examples include decisions about eating habits, exercise, road safety, or saving for the future. (Thaler & Sunstein, 2009). It does not involve striving to convince people of the merits of adopting a certain behavioral course or undertaking an action leading to achievement and maintaining well-being in the long term.

It can also be concluded that nudges tend to reshape the choice environment. This ensures that, when people rely on their instincts and use familiar mental shortcuts, they are more likely to select the best option available. Such an option aligns with policy goals, aiming to enhance their well-being and preserve their welfare.

3 NUDGE THEORY TOOLKIT

Policymakers often support discussions on combining nudges with other types of policy measures. This approach can lead to the creation of a *kit* of tools or the application of nudges *in a package* to induce large-scale behavior change. However, some authors argue that there is no evidence of agreed-upon guidelines for designing an effective mix of tools containing nudges. The first to raise attention to containing nudge tools were Michalek, Meran, Schwarze, and Yildiz (Michalek, Meran, Schwarze, & Yildiz, 2016). The debate on the toolbox and policy in environmental protection and sustainability—particularly the analyses of their respective effects—has drawn the attention of several scholars (Howlett & Rayner, 2007; Flanagan et al., 2011; Rogge & Reichardt, 2013), yet no unified approach to their definition has been achieved. We understand the term *toolbox* as a combination of different types of nudges and their interaction to account for influences and modifications in people’s behavior.

Focusing on the "toolbox" perspective, one should first look for examples of nudge systems that include prohibitions, obligations, and control mechanisms. (following Sunstein's *mixed nudge systems* (Sunstein C. R., 2014)). Some aspects of such a toolkit are intrusive by their nature and can hardly be seen as a "political intervention, resulting from insights into the cognitive characteristics of the decision-making process." (see (EC, 2021)). However, regulators, given the different behavioral patterns, concluded that to achieve the desired response to a given measure, it should be implemented through a *set of mutually complementary nudges* influencing the subject's decisions in the chosen direction. At the same time, according to critics, prohibitions and obligations lead to an environment with a predominant influence of regulatory measures. Two points of view are formed, i.e., *for* and *against* increased regulation, and for one of them to prevail, there must be evidence (empirical and experimental) of the real impact of the nudges in attempts to eliminate or at least limit a given harmful behavior (for most of the population).

Due to the restrictive nature of prohibitions, obligations, and control mechanisms, a strategy that involves mixing them with nudges (i.e. a *mixed* strategy) would be difficult to implement in a democratic society. Nevertheless, it may be possible to deploy such a combination in the form of periods of mandatory tightening of measures. (Guala & Mittone, 2015). A tightening period can be described as a temporary ban aimed at reducing or eliminating rapid and emotional reactions often characterized by Type 1 biases (Barton & Grüne-Yanoff, 2015). An example of such a "mixed" strategy can be found in the period of restrictions against the COVID-19 pandemic since in Bulgaria there wasn't a situation of full lockdown. In addition, it should be borne in mind that command-and-control policies necessarily include some elements of nudge, since command sets the normative default of desired behavior from a social point of view.

Nudges account for a heterogeneous population of active and passive choices (Selinger & Whyte, 2011). Active choosers represent deliberate decision-making. They carefully evaluate available information and make choices based on their preferences. On the other hand, passive choosers rely on intuitive behavior, often opting for default options as part of their decision-making pattern. (Goldin, 2015). Given this heterogeneity, a mixed strategy of nudges and other non-restrictive tools seems particularly plausible, as such a combination will influence the relevant channels (Griffiths, 2013). However, there is still insufficient scientific evidence on how these policy interventions work on groups in practice, mainly due to the limited amount of empirical research available. Studies in health and nutrition indicate that combining these two tools can effectively promote the formation of healthy habits. Further research has shown that providing information and advice tailored to cognitive process engagement techniques can significantly improve the likelihood of fostering long-term behavior change (Gardner, 2012). Therefore, habit formation may be one of the most promising aspects of a toolkit including nudges and other non-restrictive policy instruments.

Along with discussing different toolkits involving nudges, it is also interesting to consider the parallel use of multiple nudge interventions (*double nudges*). For example, in a polluted environment (a circumstance that implies a negative descriptive norm) people tend to generate more waste, compared to a clean environment, where their habits change (Cialdini, 2003). At the same time, a random person maintaining cleanliness in the first case creates a positive nudge, unlike an individual polluting the environment in the second case and creating a negative nudge.

In 2009, Cass Sunstein, head of the Office of Information and Regulatory Affairs (OIRA), created the first public opinion research institution. As mentioned above, the UK also established a Behavior Insight Unit, also known informally as the *Nudge Unit* (in 2010), researching public attitudes, creating insights into behavior, and accordingly implementing push-type actions to facilitate the adoption of implemented policies while making general suggestions for improving services provided on a public basis (OECD, 2010), led by David Halpern[2], a prominent British

[2] Halpern and Sanders define the essence of the Unit's work by referring to the quest to encourage people to behave in a certain way, using insights gained from behavioral science.

psychologist. The example was followed by several other countries, such as Australia, Canada, and some of the EU, such as the Netherlands, Germany, Greece, Latvia, etc. Studies in human behavior began to be actively applied in Asian countries (India, Indonesia, Singapore), and South America (Chile, Peru, etc.). Prestigious international institutions such as the World Bank, the UN, the OECD, and the European Commission take the lead and are in turn establishing behavioral research and modeling units. According to the OECD, 202 institutions have been established worldwide to apply insights to public policies. It should be mentioned that within the EU there are several initiatives for innovation in the public sector, which can be implemented through the so-called Public Policy Labs operating at national, regional, and local levels. That means using the opportunities to attract several stakeholders, looking for intersections of their interests, and reflecting them in the best way when shaping regional, national, and local policies. (OECD, 2019)

In the Republic of Bulgaria, there is an Institute of Public Administration under the Council of Ministers, within which, in my opinion, a team could be built, including experts in public policies, social psychologists, behavioral economists, etc., to study the experience and practices of the public sector, to form insights and to make proposals for stimulating measures. Radoslav Milanov's monograph "Identification of Good Practices in the Implementation of Alternative Measures to Regulation by Using Behavioral Economics Approaches" summarizes foreign experience in the field of activity of Behavior Analysis Teams and makes several proposals for Bulgaria (Milanov, 2018).

4 EXAMPLES OF NUDGE EFFICIENCY

The basis of the nudge theory is its role as an effective tool, suggesting a relatively easy and painless implementation of change. Given the lack of a defined methodology for implementing nudges, a structured 7-step model is designed to facilitate change by effectively applying these principles. We outline the proposed model in Figure 2. The point of applying the nudge method is to make stakeholders, such as employees in companies (working in the business sector) or in government institutions, aware of the importance of the problem and allow them to choose a solution. Alongside fostering overall awareness among individuals, this approach strengthens relationships at the organizational level, enhances corporate culture, and boosts operational efficiency.

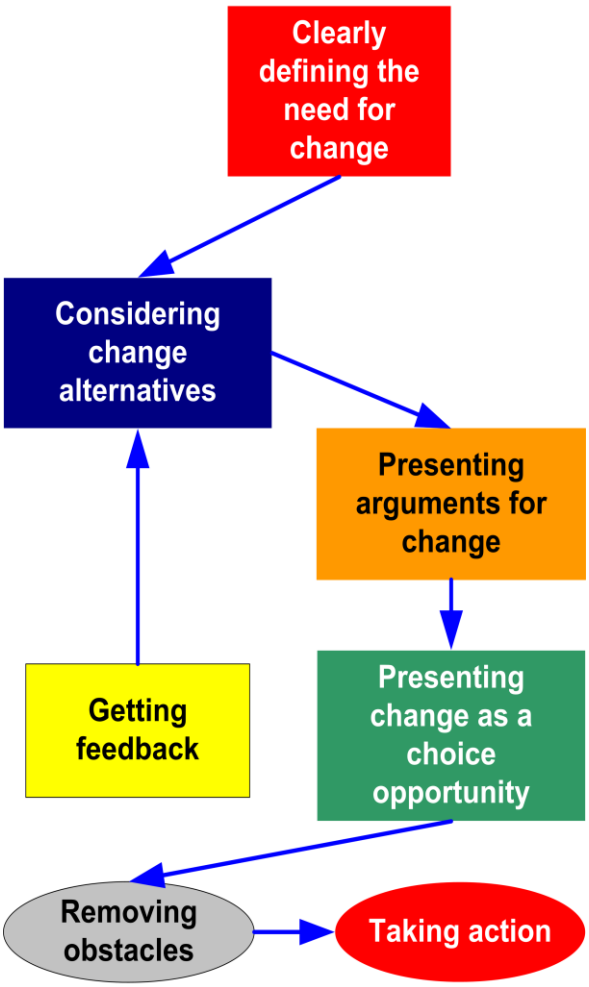

Figure 2. Seven-step model for managing change by incorporating the push process

In this sense, the practical application of the Push Theory should be directed towards complementing the change management models that ignore the perspective of all participants in the change process and thus create bottlenecks in the policy implementation. The problem is formulated as information asymmetry and bounded rationality, which has led to less transparency,

distrust in measurement, and an inaccessible and incomprehensible explanation style.

In Chile, SERNAC[3], SEC[4], and LabGob[5] carried out a joint initiative to verify the level of dissatisfaction with electricity bills due to their complexity and inaccessibility in three stages. The first stage (August – October 2015) included diagnosis and problem formulation. SERNAC conducted a baseline survey on the level of knowledge, understanding, and satisfaction with electricity bills. The level of dissatisfaction due to low levels of understanding was identified, resulting in a "heat map" (showing a focus on the amount to be paid and much less on other parts). Based on the results of the survey, the Chilean government initiated a parallel process of improving the dissemination of bill information and better awareness of their content. The second stage of the initiative (October 2015 – April 2016) includes designing and testing prototypes of new *bills* prepared by LabGob, which is also based on user research (including a test group of over 800 users, workshops, and trials, as well as interviews with user organizations and companies). Following the actions taken, innovative ideas for a bill were developed, leading to the prototype's implementation in December 2015.

The third and final stage, conducted from May to August 2016, involved the launch of pilot projects based on the prototype within 3 municipalities. The subsequent user survey showed that the new bill model leads to a 47.2% higher level of trust, more clarity about the bill (50.6%), and a higher level of satisfaction with it (47.3%) compared to the previous ones. The launch of the bill at the national level is scheduled for December 2016, and by March 2017, the new Bill has been reviewed, corrections have been made, and accordingly, it has received approval.

The conclusions and recommendations based on the above example of change management through the inclusion of various public opinion-pushing tools and active participation of interested users are that all this leads to a successful process of identifying the two main challenges (communication and semantic deficits, as well as a lack of knowledge about the services provided). Similar measures can be successfully applied in preparing information on the consumption of other energy sources, e.g., in domestic gas, water, and telecommunications markets. Also, it can be successfully adopted by other countries' governments.

In the context of the impact assessment and review of its Energy Efficiency Directive, the European Commission is commissioning a cross-country study to assess how different label designs influence consumer understanding and purchasing decisions. (BIT, 2024). It has been noted that the low level of purchases of energy-efficient appliances highlights the discrepancy between the stated desire to reduce energy consumption costs and consumer behavior at the time of purchase, where energy efficiency is only one of the specified purchase criteria. (EC, 2015).

Singapore Workforce Development Agency under the Ministry of Labour (MOM, 2025), influenced by the successful practices carried out by the Behavioral Research Team in the United Kingdom in the form of Employment Centers, decided to revamp the employment facilitation process, aiming to increase the effective percentage of people seeking and finding work in the country. By conducting interviews with career counselors and job seekers regarding the established procedures, the researchers established the presence of four key barriers to job seekers finding a job: passivity on the part of candidates, relying primarily on the activity of career counselors to find a job; low level of commitment of job seekers, in terms of participation in retraining courses, job interviews, etc.; unrealistic expectations regarding the future workplace (related primarily to the amount of pay); lack of motivation and self-confidence (especially after multiple unsuccessful attempts to find a job). As a result of the intervention, 3 months after the career center visit, 49% of job seekers who went through the updated program had found a job, compared to 32% of those who applied through the existing process. That shows that the nudge, aimed at specifically motivating job seekers to take more responsibility for the search process, planning, completing tasks, helping job seekers

[3] Government agency in Chile responsible for protecting consumer rights. *Source*: (Servicio Nacional del Consumidor (SERNAC), 2000)

[4] Chile's regulatory authority for the production, promotion and sales of fuel and electricity

[5] Government Innovation Lab, created by the Chilean government in 2014 as an interdisciplinary group

have more realistic job expectations, and increasing their self-esteem, was implemented effectively.

To understand how behavioral insights can be used to improve adults' numeracy and language literacy, the UK Department for Business, Innovation, and Skills (BIS [6]) established a Research Center about behavioral insights for adult skills and knowledge (ASK) in collaboration with the Behavioral Research Team (BIT) in September 2014. One of the first issues identified by the Center concerns retention rates as well as actual achievement in adult education programs. The findings have shown that a lot of UK college programs have lost their relevance due to about 50% deteriorated attendance rates within the frames of the current academic year. The use of behavioral nudges in the form of simple text messages, based on the principles of positive feedback, social support, and planning, has shown a positive impact on improving attendance, achievement, and retention rates of participants in post-19 education programs. As a result, several UK colleges are looking to introduce similar ways of communication with learners, using behavioral insights to reduce dropout rates and raise attainment in adult education which has the potential to improve literacy and numeracy levels in the UK in the long term.

The Danish Business Authority (DBA, 2024), responsible for regulating business in the country and creating an eco-business environment for growth uses behavioral insights to support the creation of a legislation system and services to facilitate interactions between Danish businesses and the Authority. The work focuses on developing behaviorally informed interventions and their testing, using preliminary insights to investigate problems, design solutions and implement new interventions. The Danish Business Authority is working in collaboration with The Danish Nudging Network and Roskilde University to develop a behavioral insights policy model. The model contains specific addresses to individuals or businesses about the need to voluntarily provide feedback and a presentation of the ways information should be presented (graphs, illustrations, etc.). A total of 600 companies were addressed. The changes led to a significant increase in the response rate.

5 ENCOURAGING COMMUTERS TO INCREASE THEIR USE OF PUBLIC TRANSPORT

The pursuit of sustainable urban mobility increases the importance of nudges as a powerful behavioral intervention, with nudges referring to changes in the architecture of choice that can influence decisions without imposing restrictions. Part of them are also economic incentives, such as free-of-charge travel. Shifting travel patterns from private cars to public transport modes can help reduce the negative impacts of travel while meeting the need for mobility. The primary strategy for encouraging people to adopt alternative travel methods in urban areas focuses on the ongoing enhancement of mass public transport options. However, there are also prohibition signs, such as limiting car traffic on certain routes, or soft measures such as information campaigns highlighting the disadvantages of car traffic. It is also common to combine different measures, such as using incentives and information campaigns at the same time (JT03410762, 2017). The way to achieve the desired outcome of the policies and measures aimed at changing travel patterns is to ensure that consumers perceive them as fair and effective. How messages and information are presented plays a crucial role in how recipients perceive their credibility (Aravind, Mishra, & Meservy, 2024). Traditionally, the analysis of individuals' travel decision-making process has been based on microeconomics, focusing on rational actors who prioritize economic factors related to income levels, travel purposes, and the existence of suitable routes when choosing travel options.

The war in Ukraine and the subsequent sanctions against Russia have further increased the pressure to provide more affordable public transport due to higher oil and gas prices and the general impoverishment of the people. From the citizen's point of view, the benefits of free public transport are unconditional. This is a financial

[6] Department for Business, Innovation & Skills was replaced by Department for Business, Energy & Industrial Strategy (GOV.UK, 2025)

relief, especially for the poorest, and it would also encourage a significant percentage of people to get out of their cars. The reduction in traffic and the undeniable benefits for the environment are also the motives of the city authorities for such a step. The problem is that it is too expensive. Although it will pay off in the future, the budgets of most municipalities cannot withstand such a burden here and now, especially in large cities with an extended transport network. One solution in this direction is Germany, where the parliament decided that during the summer - June, July, and August - all citizens would be entitled to a subsidized monthly card that would allow them, for 9 euros, to use the so-called regional public transport - city buses, metro and trams, as well as regional trains (news.bg, 2025) A large-scale field experiment in Rotterdam, the Netherlands, tested whether nudges could increase public transport use. In this case, the nudge involved providing free travel cards to citizens, resulting in 4,000 trips on six bus routes in one week. This experiment shows that public transport operators can increase public transport use.

The local authorities in several European cities have taken even more radical steps by making public transport completely or partially free of charge. Starting as an experiment, the experience results show a positive cost/benefit ratio encouraging possible followers in this direction. The city-state of Luxembourg provides free public transport to its citizens and foreigners. The measure was introduced in recent years and is considered successful, although time passed is not enough to assess the measure's result adequately. The capital of Estonia has been known for years for providing free public transport to its residents, with a referendum decision in 2013 by a significant majority, due to the heavy traffic in the city, but also because of the consequences of the financial crisis that has spread. Residents of Tallinn still pay a symbolic fee to get a card to use buses and trams.

Similar examples are provided by other cities, such as Aubagne in the South of France, where public transport has been free since 2009. At first, it was a test project. The initiative turned out to be particularly successful, leading to a 10% reduction in street traffic in 3 years, with an incredible increase in the popularity of public transport. In Dunkirk, on the border with Belgium, a similar step was taken in 2018. A few months later, a quarter of the city's parking spaces remained vacant, despite the town previously having a problem with a lack of parking spaces. On weekends, the occupancy of vehicles increased further. Other interesting results are that the number of people using private cars has decreased by a third, and 5% of commuters have completely given up using them when traveling in urban areas.

Public transport in Valletta, Malta, is completely free-of-charge from 2022, while in Belgrade this measure is in force from 1st January 2025, as part of a major urban transport reform that includes a complete renewal of the fleet over the next three years (news.bg, 2025). Some European towns, such as Kaposvar, Hungary, as well as the Danish island of Hørø in the Baltic Sea, are also providing free-of-charge local bus services.

In Manchester, UK, three free bus lines are available in the city center, primarily for tourists, but they are open to everyone. In the Alpine resort of Laveno, Italy, a town of around 6,000 people near the Swiss border, free city lines are also available to tourists and locals. The message represents a complete lack of need for private cars. Geneva, Switzerland, offers a very high standard, a bonus for tourists is the free use of the public transport network. When staying in a hotel or campsite, everyone receives a card for the free use of public transport during their stay. In addition to buses, trams, and trains, that, also, includes the taxi boats on Geneva Lake.

There are European cities where public transport is partially free. For instance, in Amsterdam, Netherlands, ferries on the IJ River, at the mouth of the Amstel, are free of charge. In Hasselt, Belgium, the free public transport measure was introduced in 1997 but was canceled in 2014 due to financial insolvency.

Recent developments in the field of public policy include principles from behavioral economics and social psychology, which expand the possibilities for studying passenger attitudes (Cole & Greer, 2013). Unlike traditional economic models, behavioral economics considers the activity and motivation of travel, so that is where the focus should be on offering sustainable travel alternatives from individuals, which travelers, free to make independent choices, can choose. This can be achieved by implementing pushy digital

messages, which have proven to be very effective soft interventions (Bamberga, Fujiib, Frimanc, & Gaerling, 2011). Empirical studies show that psychological triggers can effectively change people's behavior to encourage the use of public transportation (Jesse & Jannach, 2020), and also on-board messages related to the sustainability of public transport travel can contribute to the necessary impact on potential passengers (Klöckner & A. Blöbaum, 2010). Setting preferences for choosing the most desirable travel alternative also has a positive impact on consumer choice (Zimmermann, Feike, Hein, & Gewald, 2023). Deciding based on the default option requires less time and effort, and having additional recommendations makes the choice easier, especially if the decision is also related to financial difficulties.

6 CONCLUSION

The application and use of the Nudge Theory toolkit should be regulated when used in public organizations. Given the tendency of citizens to make irrational decisions, behavioral insights can be used in the fields of financial markets and banking products, energy consumption, transport, and road traffic. For example, under the influence of calls for air quality protection, many people turned to alternative mobility, shared trips, etc. A clear methodology for developing and implementing push tools in public policies is essential. This ensures that such tools can be regularly applied in future projects. At the same time, it helps build the administration's capacity by providing knowledge about the behavior of individuals targeted by specific policies. Developing a clear procedure for identifying problems and researching and analyzing data on citizens' attitudes is crucial for the nudges' implementation to establish good practices.

Although research on nudges is constantly growing, several research questions remain unanswered. The theoretical rationale for nudges, along with numerous case studies, provide compelling evidence for their efficiency in many different areas, it is risky to formulate general conclusions since there are also unsuccessful attempts to nudge people. Finally, the combined use of classical policy instruments with nudges is an area that requires further empirical testing. In the context of long-term effects, the use of nudges is appropriate in a mixed strategy, with the joint use of different types of nudges (*double nudges*). However, this area requires further research, especially in practical implementation.

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Received for publication: 06.03.2025
Revision received: 16.03.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Kirova, A., & Travanov, D. (2025, 07 15). Prospects and Opportunities for the Application of the Nudge Concept in Research Practice. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 123-136. doi:10.12709/mest.13.13.02.09

Style – **Chicago** *Sixteenth Edition:*

Kirova, Antoaneta, and Darin Travanov. "Prospects and Opportunities for the Application of the Nudge Concept in Research Practice." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 123-136.

Style – **GOST** *Name Sort:*

Kirova Antoaneta and Travanov Darin Prospects and Opportunities for the Application of the Nudge Concept in Research Practice [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 123-136.

Style – **Harvard** *Anglia:*

Kirova, A. & Travanov, D., 2025. Prospects and Opportunities for the Application of the Nudge Concept in Research Practice. *MEST Journal,* 15 07, 13(2), pp. 123-136.

Style – **ISO 690** *Numerical Reference:*

Prospects and Opportunities for the Application of the Nudge Concept in Research Practice. **Kirova, Antoaneta and Travanov, Darin.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 123-136.

MEST Journal
DOI 10.12709/mest.13.13.02.10

DIGITAL TRANSFORMATION AND SUSTAINABLE ENVIRONMENTAL MANAGEMENT

Davorin Kralj
Alma Mater Europaea University, Maribor, Slovenia, Europe

JEL Category: **D22, L86, M15, O33, Q01, Q56**

Abstract

Recently, several studies have examined sustainable environmental management and digitalization, focusing on how digital transformation within companies influences their sustainable ecological practices. To monitor the development of environmental management and the digital transformation of society, a conceptual framework for collecting data on information society and as a framework for comparative analysis is essential. Therefore, fundamental indicators on the extent of ICT use in society at different levels of business and organization and following the EFQM business excellence model are crucial. That is mainly because of the logical design of the business excellence model and the meaningful, established business organizational units in the model. Business Environmental Excellence transcends traditional corporate responsibility; it has become a critical priority that global businesses must embed within their sustainable, green policies and strategic frameworks. The research done in this paper focuses on the extent of Slovenian micro and small companies' digital transformation and which areas of the business system are most often the subject of digital transformation with impacts on sustainable environmental protection. This paper explores whether the companies analyzed prioritize creating new value for customers through digital transformation and investigates which dimensions of this transformation are most commonly associated with the concept.

Keywords: *Digital Transformation, Environmental Management, Business and Organization, Micro and Small Companies in Slovenia.*

1 INTRODUCTION

Changes in the socio-economic environment require increasing awareness of tightening competitive conditions and a further push to improve operations. One of the results of this tendency is the continuous improvements in the quality of operations and handling of the environment, and the market position. Due to increasingly unpredictable changes in the market and the rapid development of science and technology, even the world's largest companies, even the most successful ones, must adopt the principles of flexible business and organization if they want to avoid being overshadowed by those companies that are ready to do so. Management of the business process should be flexible and easy, due to the possibility of adapting to market

Address of the author:
Davorin Kralj
davorin.kralj@siol.net

requirements, but at the same time, it is complex and comprehensive. Due to the complexity of operating within the competitive dynamics of the global market, businesses will prioritize product excellence and customer satisfaction. Companies should recognize environmental management firstly as human virtue and then as part of business competitiveness.

The company recognizes its mission in developing the core business by incorporating the latest knowledge and technology in digitization, the quality of which comes from a focus on excellence in all areas. To achieve the mission and contribute to a society based on knowledge of the modern digitalization ecosystem and innovation, we want to introduce the principles of digital culture quality and excellence into everyday business practice. Therefore, the management and management system of the company are based on:

- Customer focus (customer experience),
- Orientation towards results (data strategy),
- Leadership and stability of purpose (digital business models, products and services),
- Management based on processes and facts (processes and digital solutions for business support),
- Development and inclusion of employees (development of digital personnel and digital jobs),
- Constant learning, innovation, and improvement,
- Developing partnerships,
- Digital culture,
- Social responsibilities of the company (cyber security).

When designing the company's digitization strategy, we proceed with the following assumptions:

- Education, creativity, innovation, and the ability to cooperate represent a combination of values and skills of employees, which is an essential factor in the successful development and establishment of a company in the global market.
- The successful operation and organization of a modern company in a digitized eco-system rely on a close connection between the stakeholders involved. This connection includes the mutual exchange of knowledge and good practices and engagement with a broader environment of fundamental character.
- The company should provide customers with a wide range of options, opportunities, and initiatives to actively engage in shaping the company's business models, contributing to its development, and co-designing its digital products and services.
- The development priorities focus on exploring contemporary trends and dynamics in business and organizational practices within the digital society. It originates from the interaction of the ever-changing environment and human interaction with the environment.
- The reference framework of key digital competencies proposed by the European Commission within the framework of the concept of lifelong learning, and approved by the European Parliament and the European Council, is represented by the following:
    - Communicating in a mother tongue,
    - Communicating in foreign languages,
    - Mathematical competencies and foundational competencies in the field of science and technology,
    - Digital literacy,
    - Learning competencies,
    - Social and civic competencies,
    - Self-initiative and entrepreneurship,
    - Cultural awareness and expression.

Management plays a pivotal role in this process. Through its example, expertise, experience, and skills, it should guide the planning of the company's digital transformation, paving the way for successful organizational development. Continuous updating and expanding knowledge remain among the most significant challenges faced by modern management.

It has been recognized that with existing business process characteristics often linked with efficiency, new features are necessary, among them knowledge, environmental awareness, encouraging human relationships, excellence, supportive contact with natural and other environment, humanization, ethnic functioning, and credibility. Scholars interested in ecological management discuss it from different perspectives. Most companies are trying to implement environmental management from a theoretical point of view in everyday situations. It

is significant to underscore that environmental management is a concept used every bit as a theory in practice in different aspects from different points of view. Similar cases exist in concepts of management, organization, and quality. The theoretical foundations of environmental management remain insufficiently examined. Consequently, its interpretation and application in business practice lack systematicity and consistency (Kralj, 2011).

At the dawn of the twenty-first century, sustainable business development (SBD) and digitalization are coming of age. Leading global corporations are adopting SBD and digital transformation (DT) as a strategic framework for integrating their business enterprises. That means creating innovative solutions to the complex needs and requirements of the business environment and thinking strategically about leading change. SBD and digital transformation take a comprehensive perspective of the corporation and its business environment. That includes direct relationships with suppliers, distributors, customers, partners, employees, and shareholders and indirect linkages with stakeholders, competitors, related industries, and the natural environment (the eco-systems) (Kralj, 2013).

2 THE INCREASING DIGITALIZATION OF ECONOMIES

The increasing digitalization of economies has highlighted the importance of digital transformation and how it can help businesses stay competitive in the market. However, disruptive changes do not only occur at the company level. They also have environmental, societal, and institutional implications. That is why the research on digital transformation has received growing attention, with a wide range of topics investigated in the literature in the last two decades.

Disruptive changes, understood as changes in a company and its operating environment caused by digitalization, possibly leading to the current business becoming obsolete (Kralj, 2011) trigger DT in different environments due to rapid or disruptive innovations in digital technologies. These changes create high levels of uncertainty. Industries and companies try to adapt to these new environments through different options. For example, when banks implement e-banking to gain competitive advantages.

DT is similarly linked with digital strategy, supply chain management, leadership, value creation, or entrepreneurship. This could suggest that an approach focused only on DT is insufficient, even while it remains crucial to consider other aspects of this process, including the company's overall strategic structure.

More than 440 answers from 55 countries and 20 different industry sections were received in 2 years and 5 months (29 months), from June 2020 to the end of October 2022. The great majority of 34% of participants originate from the manufacturing sector, 13% came from the information and communication sector, and 10% from the education sector. The results show that the survey is representative of all sizes of companies, as both large companies and SMEs are covered – the great majority, about 55%, being SMEs (<250 employees)(KIdschun, 2024).

Although digitalization is a key component of corporate strategy for more than half of the companies, around 15% lack clearly defined measurable goals. Another major impediment is the inadequate monitoring of activities to reach company targets in digital transformation.

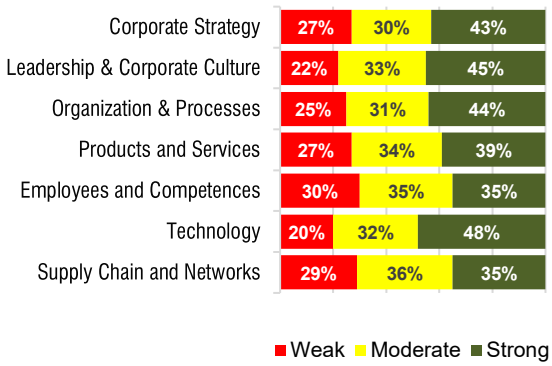

Fig. 1 The Digital Transformation Assessment Source: (Kidschun, 2024)

When analyzing the importance of leadership & corporate culture, more than 60% of the companies reported that their top management is actively driving the digital transformation forward (Kidschun, 2024).

3 THEORY AND AIM OF THE STUDY

The research focuses on digital transformation and sustainable ecological management within

the company's operations. It covers the definitions of digitization, digital transformation, and sustainable environmental management. Additionally, it explores various approaches to environmental management across different periods. Finally, it examines the relationship between ecological management and digital transformation within the context of global competitiveness.

The narrower subject of the research is the company's comprehensive business process, digital transformation, and sustainable management. Many authors have published papers on sustainable environmental management as a basis for continuous improvement and/or business excellence. Very few authors have concretely examined the role and importance of the digital transformation of the company and sustainable management of the environment. Therefore, companies should check the importance of the company's digital transformation and ecological management in their perception, the perception of the client, and the broader social community. The proposed model for digital transformation and ecological management indicators aims to enhance both digital transformation and environmental management. Its focus is improving business administration related to the environment and sustainability within real business sectors.

Additionally, the model serves as a tool for evaluating environmental and sustainability factors in specific companies. The model is designed for use in various corporations (companies) and allows further development dependent on a single company. The central section of the paper presents a model of digital transformation and environmental management indicators in companies based on the theoretical findings and the author's practical experience.

Managing sustainability and quality to achieve excellence means managing an organization, business, or unit so that every job and every process is performed correctly, the first time, every time. To be successful, this must be viewed as a holistic approach that affects and involves, everyone – employees, customers, suppliers, shareholders, and society. It must be driven from within the organization, as it cannot be imposed from outside and is not simply a cost-cutting or productivity-improvement exercise (Kralj, 2013). The EFQM Excellence Model was introduced in early 1992 as the framework for assessing organizations for the European Quality Award. It is now the most widely used organizational framework in Europe. It has become the basis for most national and regional Quality Awards (Pentapalli, 2020). The EFQM Excellence Model is a practical tool that can be used in several different ways:

- As a tool for Self-Assessment
- As a way to Benchmark with other organizations
- As a guide to identifying areas for Improvement
- As the basis for a common vocabulary and a way of thinking
- As a structure for the organization's management system (Pentapalli, 2020)

Fig. 2 EFQM Model 2020
Source: (Al Balushi, 2025)

The EFQM Model is a globally recognized framework that supports organizations in managing change and improving performance. Over the years, it has undergone several improvement cycles to ensure its continued relevance. These updates allow it to remain a leading guide for organizations aiming for a long-term, sustainable future.

The specific content and visual identity of the EFQM Model may have changed over time. What has not changed are the underlying principles on which it is based regardless of the organization's

size or whether it is public, private, or third sector. These principles remain as important today as ever, and this latest edition of the EFQM Model continues to emphasize the significance of:

- The primacy of the customer.
- Taking a long-term, stakeholder-centric perspective.
- Understanding the cause-and-effect relationships between why an organization acts, how it performs those actions, and the outcomes it achieves (EFQM, 2020).

Using the EFQM Model provides the opportunity to see the whole, take a holistic perspective, and appreciate that an organization is a complex but, at the same time, an organized system. Like the wider world, an organization should not be viewed as linear, mechanical, or predictable. It is better understood as a complex adaptive system composed of interdependent humans within a dynamic, living world. Any organization using the EFQM Model:

- Recognizes that it does not operate in isolation but is part of a larger, complex ecosystem. Within this network, known and unknown players can support or obstruct its progress. Therefore, it actively seeks to engage, learn, and grow by maximizing opportunities to collaborate with others in its ecosystem.
- Accepts the opportunity to act as a Leader in its sphere of influence, behaving as an inspiration to others and demonstrating what can be achieved for the benefit of others as well as itself.
- Recognizes that it will encounter ever-increasing speeds and volumes of change. To succeed, it must be ready to anticipate, address, and respond appropriately to these challenges. At the same time, organizations must embrace the dual responsibility of managing the present while forecasting the future and ensuring they are prepared for it (EFQM, 2025).

Digital transformation is a significant component of business excellence.

EFQM Diagnostic Tool, RADAR is the acronym that EFQM uses to describe the logic behind the diagnostic tool it has developed to help any organization:

- Better manage its current way of working.
- Diagnose its current strengths and opportunities for improvement. At its highest level, the RADAR logic emphasizes that an organization should:
  - Define the Results it aims to achieve as part of its strategy.
  - Establish appropriate approaches to ensure the delivery of these results, in the present and future.
  - Deploy these approaches appropriately.

Assess and Refine the deployed approaches to learn and improve. The RADAR elements are divided into several attributes for a more comprehensive analysis. Each attribute is accompanied by a detailed description that clarifies its meaning and outlines what the organization should demonstrate (EFQM, 2025).

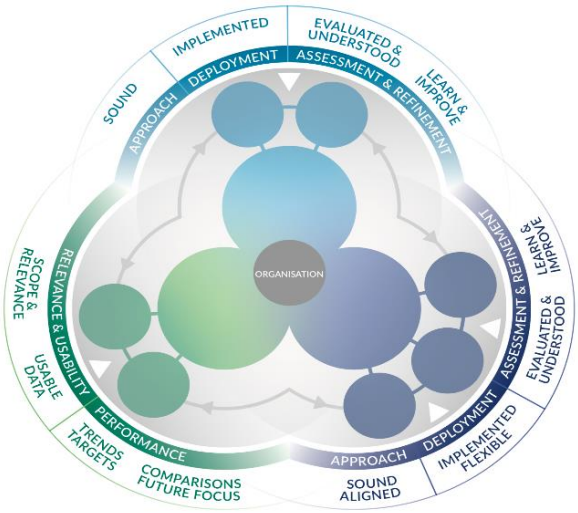

Fig. 3: EFQM Diagnostic Tool: RADAR
Source: (EFQM, 2025)

An individual or a team can use the RADAR logic at the Attribute level, in conjunction with the EFQM Model:

- To identify an organization's current strengths and opportunities for improvement.
- To define an organization's future by outlining desired outcomes and the necessary actions to achieve them (EFQM, 2025).

One of the most widely used voluntary environmental initiatives is the ISO 14001:2015 ecological management standard. ISO 14001:2015 is a global standard for environmental management that provides a structured framework for ensuring compliance and driving

continuous improvement. Its flexibility makes it widely applicable to diverse organizations, including manufacturers, service providers, and government agencies (ISO, 2015). ISO 1400:2015 was developed by the International Organization for Standardization to provide a template for environmental management systems. For facilities to obtain ISO Certification they must:

- Develop a policy statement on the organization's commitment to the environment.
- Identify the environmental impacts of products, activities, and services.
- Commit to compliance with applicable laws and regulations.
- Set environmental goals for the organization and develop the means to achieve them.
- Establish roles and environmental Responsibilities within the organization.
- Maintain documents about the EMS and related procedures.
- Monitor key activities and track EMS performance to correct problems and prevent reoccurrences.
- Audit the EMS to ensure its effectiveness in meeting objectives and targets, verifying that it remains suitable and appropriate.
- Commit to continual improvement of the EMS (ISO, 2015).

An EMS is an organizational structure with associated responsibilities and procedures to integrate environmental considerations and objectives into the ongoing management decision-making processes and operations of an organization. According to an EPA summary, an EMS is a continual cycle of planning, implementing, reviewing, and improving the processes and actions that an organization undertakes to meet its business and environmental goals. Most EMSs are built on the "Plan, Do, Check, Act" model. This model leads to continual improvement based on:

- Planning, including identifying environmental aspects and establishing goals [Plan];
- Implementing, including training and operational controls [Do];
- Checking, including monitoring and corrective action [Check]; and
- Reviewing, including progress reviews and acting to make needed changes to the EMS [Act] (Pentapalli, 2020).

Organizations must integrate Environmental Business Excellence based on EFQM, Environmental Management ISO 14001:2015, and digital transformation if they are curious about the Fourth Industrial Revolution (4IR) and its role in building a greener future. In this new era, online technology is more than just gadgets and apps. It's a key player in embracing more eco-friendly behaviors, creating a strong correlation between digital transformation and sustainability. Digitization, or the digital transformation of society, is a trend that has started to be talked about more seriously in the last few years, even though the digitization process has been going on for more than a decade (Homopolitikus). Societies or countries where citizens are very digitally literate, have a well-developed (digital) infrastructure, and digital solutions are generally used at all levels have significantly fewer problems adapting to the new situation. Such companies are called digitally mature companies.

With issues like climate change, global warming, and biodiversity loss threatening the world, using digital solutions to power sustainable initiatives is no longer optional. Digital transformation leverages the internet and online resources, providing green alternatives to traditional methods and introducing technology for a more sustainable future.

The transformation benefits all parts of your business, from predictive maintenance reducing environmental burdens to cloud computing and teleconferencing tools diminishing carbon output with virtual exchanges. Every byte transmitted and every online transaction executed can contribute to a clean, green, digital, and sustainable landscape.

Yet, as we navigate this journey, encountering challenges like cybersecurity risks, digital literacy gaps, initial investment costs, and resistance to change is inevitable. But the prize, a green future, carbon footprint reduction, optimized resource use, and a healthy planet, is unequivocally worth it.

Buckle up as we delve into the emerging world of digital transformation and sustainability. It's time to discover how digital solutions conserve our environment and pave the way to a better future (Digital Transformation, 2024).

Digital technologies foster innovative sustainability solutions. For example, Artificial Intelligence and machine learning analyze data for sustainable strategies, while IoT tools optimize energy usage. Blockchain promotes eco-friendly supply chain transparency, and emerging technologies facilitate carbon capture. These digital innovations help businesses meet ESG targets, create greener products and services, and contribute to global environmental goals (Homopolitikus, 2022).

Many organizations are now several years into their digital transformation journeys, and they look to measure progress, gauge maturity, and benchmark against peers in their industry. Measuring maturity helps them determine where they are in their transformation journey, create goals and plans, both short and longer-term, and make impactful transformation project investments. The crucial questions remain how to assess this maturity, the key pillars and factors of maturity, and which capabilities are new and different compared to business as usual.

Companies must improve capabilities in stages to develop and scale digital businesses rapidly. If the company doesn't have the right qualifications to execute its acceleration strategy, it won't go far. Before leaders launch their initiatives, they should take three steps to determine whether their organization has all the capabilities it needs:

1. Evaluate the maturity of the organization's digital business.
2. Determine what digital business acceleration looks like for the enterprise.
3. Identify the new capabilities the organization will need (Dawson, 2021)

4 METHODOLOGY

Empiric research in its main chapter addresses the importance of environmental business excellence and digital transformation indicators in Slovenian small business practice. The chapter also contains the research methodology; from the plan of collecting the data, plan implementation, research instrument, and analyzing method to answers interpretation. The following is a detailed analysis of the answers. The content of the research has been original. The fundamental point is the answer to questions; how are environmental business excellence management and digital transformation integrated into the management and administration of companies; which indicators have a crucial role when dealing with successfulness and efficiency of companies? Our research indicates that a sizeable number of previous hypotheses relating to environmental business excellence management and digital transformation would appear to be correct and are logically justified.

Digital business involves six business and technology dimensions. Together, they create a certain level of digital maturity across the organization (see Figure 4). Various initiatives require different levels of maturity across these dimensions. Examples include optimizing the current business model and transforming the business model to adapt to new challenges.

The research topic is a comprehensive business organization process inside an enterprise in a modern, competitive economy, with particular emphasis on environmental business excellence management and the implication of the EFQM Model and ISO 14000 Standards with indicators of digital transformation. The research strives to underscore the importance of ecological business excellence management and digital transformation in how an enterprise, its customers, and the broader community perceive these aspects. It also strives to identify environmental and digital indicators within enterprises that reflect the current state of ecological attributes, environmental business excellence management, and transformation progress. An example of an application was based on a random sample of 110 Slovenian enterprises (AJPES, 2024). The results include questionnaire replies from 110 received questionnaires.

The purpose of this paper is to study and define the most significant indicators influencing environmental business excellence management and digital transformation effectiveness and efficiency in enterprises, focusing on Slovenian enterprises. The focus is on environmental and digital indicators as the result of excellent ecological business management, environmental/digital policy, and a strategic direction toward achieving environmental/digital

goals as well as constant and continuous training and awareness-raising in stakeholders, employees, customers, suppliers, and the broader social community.

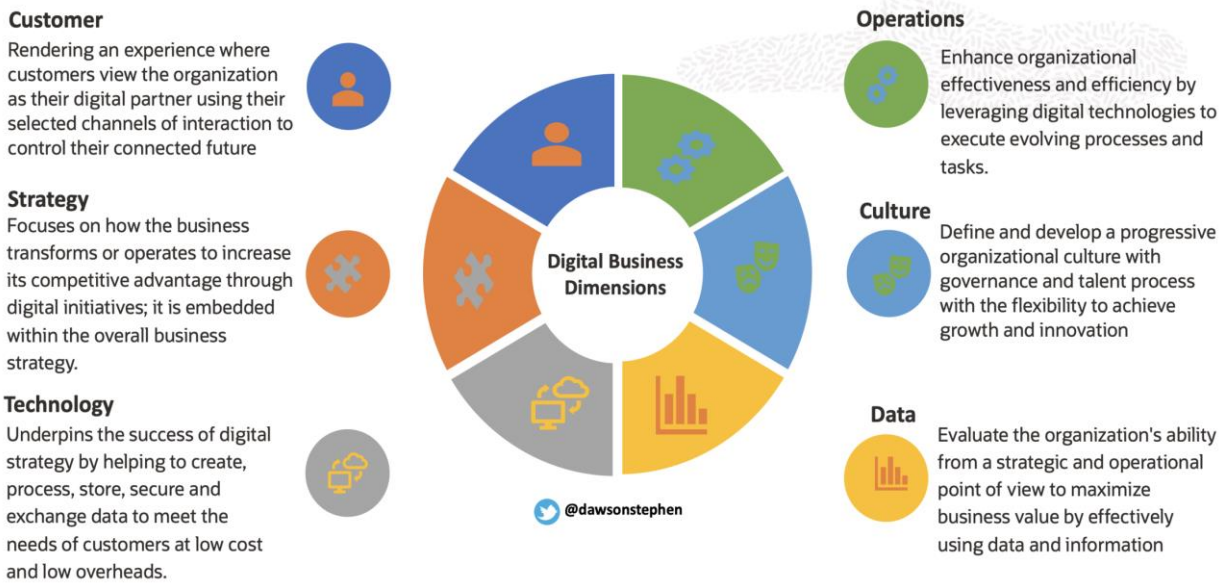

Fig. 4 Digital Business Dimensions / Capabilities

(Dawson, 2021)

The research objective was to set or determine and prove the role and significance of environmental/digital management indicators in an enterprise's operations. The reflection included interdisciplinary thinking which enables us to understand and manage the process of ecological business excellence and digital management in terms of sustainable development. Based on the assumption that an enterprise respects and complies with environmental legislation, it was analyzed to see what types of environmental and digital indicators and measures contribute to constant and continuous improvement in terms of sustainable development.

In the research, the following assumptions were tested:

- Assessing environmental care (protection) and digital transformation in enterprises are practiced on a declarative level (rather than being practiced).
- Enterprises holding a certificate of environmental management perform better in environmental and digital indicators and are more effective than those without such a certificate.

The research was designed as a qualitative case study. It was conducted in 2023 and 2024.

The basic information on the sample unit (the organization studied) and the respondent (the person who completed the questionnaire), was acquired based on the responses from the first (8 questions) and second cluster or set of questions (the first 5 questions).

The research included 110 enterprises performing various activities. Among them, the highest number goes to limited liability companies (52.5%), joint-stock companies (14.7%), or institutes (11.9%). In contrast, the lowest number is to sole proprietors, unlimited liability companies, investment companies, and companies of other legal forms (altogether 14.8%). Over half of enterprises (57.8%) are involved in servicing activities while 28% are engaged in manufacturing. Other enterprises are either predominantly servicing or predominantly manufacturing. In the recent period, in Slovenia and the EU, a slowdown in the spread of ISO 14001 and EMAS environmental certificates has been observed. The number of ISO 14001 certificates awarded per million inhabitants in Slovenia increased by 4.8 percent in 2020 despite the epidemic, which, however, meant a 2.8

percentage point lower growth than in the previous year. Growth declined in the EU, from 5 percent in 2019 to almost zero in 2020. The situation with EMAS certificates is even less favorable. The number of certificates per million inhabitants in Slovenia has stagnated for the third year. A 3.8% growth was recorded in the EU in 2020, but the prevalence of this certificate in 2021 remained at the level of the previous year. According to the spread of ISO 14001 environmental certificates, in 2020, Slovenia still lagged most of the new EU members, but it still ranked above the EU average. The opposite is the case with EMAS certificates, where Slovenia also lagged the EU average in 2021, but only Cyprus, Estonia, and Slovakia surpassed it among the new EU members (Zelena Slovenija, 2023). 41.9% of the enterprises have established an environmental management system in compliance with ISO 14001:2015 Standard, 32.6% of the enterprises have established such a system in compliance with the legislation in force in the Republic of Slovenia, 4.1% of the enterprises have established other systems. (data for the year 2022).

A qualitative case study was conducted to acquire information and research results from the complete questionnaires. However, only part of the research results is presented in this paper. The findings from the research results cannot be generalized to all forms or types of environmental business excellence and digital management.

5 RESEARCH RESULTS

Only part of the results of the analysis are here. They were conducted to find the most suitable environmental business excellence and digital indicators and indicate devices in different areas of an organization. The focus of this paper is leadership. By way of factor analysis, the most suitable indicators were selected. Based on the indicators, the indicating devices were set. They represent the average value of the selected indicators.

The new digital leader can learn, adapt to changes in their environment, and seek out new skills and experiences at work. They are also champions of collaboration and demonstrate a drive to lead. They know how to empower, support, experiment, and learn — and when to switch between these behaviors. They are humble enough to seek out those with the right skills to support them when needed. They demonstrate business acumen, the ability to handle and examine data, and mental endurance.

Aon's Digital Leader Model unites these elements by combining the three tenets of an agile mindset, leading change, and driving the business forward (MacKay, 2024). See Figure 5.

Fig. 5: Aon's Digital Leader Model
Source: (MacKay, 2021).

In the continuation, an example of leadership and a set of questions concerning the leadership characteristics in an organization - measured on a scale from 1 (I do not agree at all) to 5 (I agree entirely) - are presented. The focus is on two key aspects of leadership: a general perspective on enterprise management and the role of leadership in achieving environmental business excellence and sustainable management, emphasizing the interconnection between these two dimensions. By way of factor analysis using the Principal Axis Factoring method, followed by Varimax Rotation, the most suitable indicators to assess the mentioned dimensions aspects of leadership (3 for a general view on management of an enterprise and 5 for environmental and digital management) were selected among 25. (See Table 1.)

Table 1 Leadership – Factor Loadings After an Orthogonal Rotation

	Leadership in the area of environmental and digital management	Leadership in general
Environmental and digital management measures are planned, executed, controlled, and enhanced incessantly.	0.84	0.13
Leaders assess the efficiency and effectiveness of environmental and digital management business processes.	0.83	0.14
Leaders encourage launching initiatives and searching for new opportunities and solutions to address environmental and digital problems.	0.78	0.19
Leaders efficiently inform their employees about environmental and digital issues.	0.76	0.23
The management has a clear vision, strategy, and objectives concerning environmental and digital management.	0.68	0.18
Leaders encourage and promote autonomy at work.	0.18	0.94
Leaders identify the need for organizational changes and are the first to opt for changes.	0.12	0.92
Leaders encourage and enable their employees to cooperate in decision-making.	0.31	0.65

In Table 1 factor loadings after an orthogonal VARIMAX rotation are presented. The factor structure is distinct as each indicator has high factor loadings only with one factor. The highest indicators of leadership quality indicating devices in terms of environmental and digital management are:

- Clear vision, strategy, and goals.
- Careful planning, executing, and enhancing measures.
- Efficiency and effectiveness assessment.
- Promoting initiative and searching for new opportunities and solutions for tackling environmental and digital problems
- Providing information about business excellence and environmental and digital issues.

The dimension is most prominently marked by the indicator *Environmental and digital management measures are planned, executed, controlled, and enhanced incessantly*, in which the highest factor loading is obtained. The Cronbach reliability coefficient (alpha) value, which measures the reliability of a measuring instrument, is 0.9, suggesting the appropriateness of the choice of indicators.

The indicator Leadership quality in general was determined by the following indicating devices:

- Encouraging and promoting autonomy at work.
- Encouraging and promoting employee cooperation in decision-making and identifying the needs for organizational changes.

The indicator, Leaders encourage and enable their employees to co-operate in decision making, has a lower factor loading and thus a lower contribution to this dimension. Based on the reliability coefficients, the selected indicators can be used for computing indicators, namely the average value of each indicator, about a specific dimension as shown in Table 2.

Table 2: Descriptive Statistics of Leadership Indicators and Dimensions

	N	Min	Max	Arithmetic mean	Standard deviation
Environmental and digital management measures are planned, executed, controlled, and enhanced incessantly.	107	1	5	3.35	1.21
Leaders assess the efficiency and effectiveness of environmental and digital management business processes.	107	1	5	3.16	1.12
Leaders encourage launching initiatives and searching for new opportunities and solutions to address environmental and digital problems.	107	1	5	3.22	1.14
Leaders efficiently inform their employees about environmental and digital issues.	110	1	5	3.18	1.11
The management has a clear vision, strategy, and objectives concerning environmental and digital management.	110	1	5	3.71	1.13
Leadership in the area of environmental and digital management	110	1	5	3.33	0.98
Leaders encourage and promote autonomy at work.	100	1	5	3.89	0.88
Leaders identify the need for organizational changes and are the first to opt for changes.	108	1	5	3.91	0.86
Leaders encourage and enable their employees to cooperate in decision-making.	105	1	7	3.65	1.01
Leadership in general	109	1	5	3.81	0.83

The enterprises that positively or favorably assess Leadership in general typically positively assess Leadership in terms of environmental management.

Organizations plan, implement, and control processes to meet their customers and other participants' expectations and requirements and generate higher value for them. Managing the functioning of a digital management system is part of business processes in an organization that is concerned with sustainable development. We were interested in the processes related to environmental management, which were tested through the following indicators.

Three-quarters of enterprises do not have a specific Digital Management Department, 16% have such a department inside another department/function, and 7.6% have an independent Digital Management Department, as shown in Table 3. The data obtained show the leadership's attitude towards the organization of the Digital Management Department. In some enterprises, environmental management is an outsourced service.

Table 3: Survey Results on the Presence of a Digital Management Department in Enterprises

	Percentage
There is no Digital Management Department.	76.4
The Digital Management Department is inside another department/function.	16.0
There is an independent Digital Management Department.	7.6
Total	100

Table 4: Responsibility for Business Process Analysis and Environmental Management in Enterprises with or without a Digital Management Department

		Is there a Digital Management Department in your enterprise?		Total
		Yes	No	
Who oversees the analysis of business processes and digital management in your enterprise?	No answer	7.1%	31.4%	25.4%
	Nobody	-	12.8%	9.6%
	Executives	25.0%	33.7%	31.6%
	Other departments	25.0%	12.8%	15.8%
	Digital Management Department	35.7%	2.3%	10.5%
	Other	7.1%	7.0%	7.0%
Total [%]		100.0%	100.0%	100.0%
Total N		18	82	100

Table 5: How frequently do you monitor the efficiency of digital management?

	Percentage
Not at all.	20.9
Annually.	27.0
Semi-annually.	16.5
Every three months.	9.6
Monthly.	19.1
At least weekly.	7.0
Total	100.0

A clearer picture of the situation and entity in charge of the analysis of business processes and digital management (whether an enterprise has a Digital Management Department or not) is shown in Table 5. One-fourth of the enterprises were reluctant to/did not know how to answer the question about who oversees such an analysis; most of them belong to a group that does not have a specific Digital Management Department. Interestingly, among enterprises with a special department dealing with digital management, the analysis of business processes and digital/environmental management is undertaken by the same department only in 35.7% of the enterprises. In one-third of the enterprises that do not have such a department, the analysis is undertaken by the executives. It is a fact that familiarity with the processes from the digital/environmental management perspective does not depend only on the Digital Management Department but also on accountability and competence as well as working methods in a particular enterprise. Analyses of processes are undertaken by those in charge of processes; a digital professional may be a member of such a team.

6 CONCLUSIONS

The shift towards the fourth industrial revolution and sustainability implies promoting digital literacy among your workforce and customers. Disparities in digital skills can compromise operational efficiency, employee morale, market reach, and customer satisfaction. Promoting digital literacy and inclusion is crucial to prevent global inequalities. It makes language easy to understand, uses simple words, and organizes information logically (Digital Transformation). The shift towards the fourth industrial revolution and sustainability implies promoting digital literacy among your workforce and customers. Disparities in digital skills can compromise operational efficiency, employee morale, market reach, and customer satisfaction. Promoting digital literacy and inclusion is crucial to prevent global inequalities. It makes language easy to understand, uses simple words, and organizes information logically (Digital Transformation, 2024).

The most important thing in digital transformation is the role of leadership. Digital transformation is taking over the business and corporate world now. Companies and their front-runners have recognized the influence that it has. Therefore, they have and will continue to transition to it. Although culture clashes are the leading barrier to digital transformation, they can be controlled and turned into a tool for growth. It is worth reiterating that digital culture is not all about technology, but also the products, services, mindset, and means of achieving set goals. In such an organization, a high level of trust and honesty in communication between the management and other employees,

within the management, between teams, and even between the organization and its customers and other companies is achieved. Employees can ask questions and get honest and helpful answers. Information exchange is effective when the system and communication network enable management and employees to access relevant information at the necessary time. It should also allow them to share their perspectives and personal goals during discussions about the company's objectives. Additionally, it facilitates verifying ideas and learning from one another (Kralj, 1994). Good managers help people find out what is important about their work and in what way the work of each employee contributes to achieving the company vision. Employees are interested in learning whether their work, and in what way, influences common goals. Employees ask themselves why changes are required for themselves and why for the company.

Managers, who speak in favor of changes, must act in compliance with their words, spoken in public, formally or non-formally. Their actions must support the "story of the company", they also must be good communicators, and they must know how to present their "story of the company" in a convincing way (Rao, 2000). In the early stages of introducing a learning organization in the company, such credibility is of great significance. The development of Environmental and Digital Management Systems is constantly improving. New environmental issues dictate the redefining of the interest of customers, users, developers, and others in the environmental aspects and impacts of products (Kralj, 2010). The development of indicators is an evolving process, continuously refined and enhanced. The long-term orientation of the organization depends on:

- Organizational culture,
- Management philosophy,
- long-term and enduring choice of resources (capital, work, knowledge).

The shift towards the fourth industrial revolution and sustainability implies promoting digital literacy among your workforce and customers. Disparities in digital skills can compromise operational efficiency, employee morale, market reach, and customer satisfaction. Promoting digital literacy and inclusion is crucial to prevent global inequalities. It makes language easy to understand, uses simple words, and organizes information logically (Digital transformation). Our initial research has proved that sustainable excellence in business with digital transformation can bring about increased short-term, especially financial gains. Adopting sustainable business practices and embracing digital transformation can pose significant risks if not strategically implemented. The more a company engages with environmental initiatives and digitalization, the stronger its connection becomes with its stakeholders, with whom it shares a common vision. The research findings can serve as a valuable starting point for an in-depth analysis of the benefits of temporary sustainable business excellence and digital transformation.

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Received for publication: 17.02.2025
Revision received: 24.03.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Kralj, D. (2025, 07 15). Digital Transformation and Sustainable Environmental Management. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 137-150. doi:10.12709/mest.13.13.02.10

Style – **Chicago** *Sixteenth Edition:*

Kralj, Davorin. "Digital Transformation and Sustainable Environmental Management." Edited by Zoran Cekerevac. MEST Journal (MESTE) 13, no. 2 (07 2025): 137-15**0**

Style – **GOST** *Name Sort:*

Kralj Davorin Digital Transformation and Sustainable Environmental Management [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 137-150

Style – **Harvard** *Anglia:*

Kralj, D., 2025. Digital Transformation and Sustainable Environmental Management. *MEST Journal,* 15 07, 13(2), pp. 137-150.

Style – **ISO 690** *Numerical Reference:*

Digital Transformation and Sustainable Environmental Management. **Kralj, Davorin.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 137-150.

MEST Journal
DOI 10.12709/mest.13.13.02.11

IMPACT OF INFORMATION ON BANKING SERVICES

Rahem Lekhdiri
Mohamed Cherif Messaadia University, Finance, Accounting, Taxation and Insurance Laboratory, Souk Ahras, Algeria
https://orcid.org/0009-0007-5380-305X

JEL Category: **D83, G21, J24, M15, O33**

Abstract

This study examines the role of information technology in enhancing the quality of banking services, with a specific focus on Algerian financial institutions. The research outlines an intellectual framework highlighting the critical importance of utilizing information technology effectively to access and manage necessary data, which is fundamental for fostering a competitive advantage. The analysis emphasizes the increasing awareness of the role that human skills and intellectual capital play in the evolving future economy. These elements are identified as key factors for the successful development of organizations. However, the study acknowledges the challenges Algerian banks face in estimating the direct impact of information technology on performance. Success in the financial sector is not solely determined by adopting advanced technologies, but rather by their appropriate application and integration. A significant obstacle for Algerian banks is the lack of skilled professionals capable of leveraging these tools effectively. The findings highlight the need for targeted investments in human capital to elevate the quality of products and services to a level comparable with that of developed nations. The study concludes by stressing the strategic alignment of information technology with institutional goals as a pathway to achieving sustainable growth and competitive service delivery.

Keywords: *Information Technology, Banking Services, Intellectual Capital, Quality Management, Skilled Workforce.*

1 INTRODUCTION

Banks today operate in a highly competitive environment due to globalization and openness to the outside world. In such circumstances, it is essential to adopt more modern concepts to keep pace. Information is one of them. Information has historically been a cornerstone of civilization and progress for nations and societies. There is a clear trend toward understanding the information's role in business success and societal development, and leveraging it for competitive advancement at individual, organizational, and community levels. Undoubtedly, there is a growing awareness of the importance of maximizing societal benefits from information usage, given its significant role in societal evolution.

Given the unique features of banking services, adopting such a concept is indispensable. It is the path to survival and continuity in the banking market while delivering high-quality services.

Address of the author:
Rahem Lekhdiri
l.rahem@univ-soukahras.dz

These services have become an essential system that requires efficient management through various approaches and frameworks. Among these, information is a critical area of focus and discussion for researchers and scholars. Access to accurate and timely information empowers banking employees to make more effective decisions. This, in turn, improves performance levels and enhances service quality to meet the desired standards.

Algeria's banking system is experiencing declining performance levels. To address this, it has become necessary to adopt new methods and principles to revitalize the sector. This sector plays a vital and strategic role in driving economic development. It is also crucial for keeping pace with growth and progress.

1.1 Research Problem

In recent years, particularly with the exponential growth of information and communication technology, terms such as "knowledge" and "knowledge economy" have gained prominence. Against this backdrop, the research problem can be articulated in the following main question:

To what extent does information contribute to improving the quality of banking services?

From the primary question, several sub-questions arise, whose answers will address the main research problem:

- What is the quality of banking services, and how is it measured?
- To what extent do banks value information?
- What is the role of information in banking services?

1.2 Research Hypotheses

Based on the above, the following hypotheses are proposed for discussion and evaluation:

- There is no statistically significant impact of information on the quality of banking services, as service quality is primarily evaluated based on the type of service and the way it is delivered.
- Evaluating the quality of banking services can only be based on the client's expectations.
- Agencies do not adopt an information management approach, and their employees cannot define the concept.

1.3 Research Objectives

The study aims to address the subject by achieving the following points:

- Presenting a conceptual framework for the quality of banking services.
- Highlighting the overall importance of information.
- Exploring the extent to which institutions value this subject.
- Emphasizing the significance of information in banks and its role in improving the quality of banking services.

1.4 Importance of the Study

This study's significance lies in demonstrating how to prioritize information as a fundamental component in measuring organizational capabilities. It enables banking sector employees to handle various emerging issues by equipping them with sufficient decision-making efficiency and effectiveness.

1.5 Research Methodology

The descriptive-analytical method was adopted To address the research problem and test the proposed hypotheses. In the theoretical section, key concepts and terms related to the subject were examined to identify the research elements, aligning with the nature of the study.

1.6 Previous Studies

1. *A study by Neal Pollock* (Evaluating Knowledge Performance and Technology Used by Public and Private Organizations, 2002)
   The study aimed to evaluate the performance of knowledge management and information technology used by public and private organizations. It sought to assess the overall performance of knowledge management and IT to achieve noticeable success and improve work performance and outcomes. The descriptive-analytical method was used, and the results revealed that IT management performance in the studied organizations was still in its infancy. Most efforts to achieve organizational goals were at the level of small-scale entities. The study recommended training end-users of IT systems and encouraging them to establish new metrics to

evaluate the quality and support of IT strategies for internal business needs.

2. A study by Al-Khawaldeh and Hunaiti (The impact of the use of information technology on creativity in Jordanian public institutions, 2005) aimed to identify the effect of IT usage on administrative creativity in Jordanian public organizations. A questionnaire was designed and distributed to a sample of 184 individuals. The SPSS statistical package was used to analyze the data, employing descriptive statistical methods to examine the sample's perceptions regarding IT dimensions and administrative creativity. Regression analysis was used to test the impact of independent variables on the dependent variable, along with one-way ANOVA. The results indicated:
   - A statistically significant relationship between IT usage dimensions (system programs, suitability of system information, information integration, productivity, and training) and administrative creativity.
   - There is no statistically significant relationship between demographic / functional variables and administrative creativity, except for work experience.
3. A study by Hussein (Information Technology and Its Impact on Improving the Level of Hotel Service Performance: An Applied Study in Al-Sudair Hotel, 2022) aimed to determine the impact of information technology (IT) on hotel service performance. It was conducted on a sample of 50 employees at Al-Sadir Hotel. The research utilized a questionnaire as the primary data collection tool, supplemented by personal interviews. Several statistical indicators were used, including the arithmetic mean, standard deviation, correlation, and F and t-tests, to assess the impact of the independent variable on the dependent variable.

   The study concluded that the hypothesis suggesting a causal relationship between the two variables was not supported. It highlighted low levels of IT utilization in the hotel, inadequate skills among its human resources, limited reliance on internal networks, and a lack of cooperation between employees and the organization in building databases.
4. A study by Ghalem and Quraishi (The Role of Information Technology in Supporting and Activating Customer Relationship Management, 2011) aimed to identify the role of IT in supporting and activating customer relationship management (CRM). It covered IT, CRM, the steps necessary to establish an electronic CRM strategy, and the impact of IT on CRM. The study found the following:
   - Organizations' use of IT enables them to activate CRM processes, fostering lasting customer relationships.
   - IT empowers organizations to identify and meet all customer needs and desires.
   - Adopting a CRM program helps organizations achieve tangible financial results by leveraging various customer interactions, retaining customers for extended periods, and gaining essential customer knowledge that distinguishes the organization.
   - Implementing a CRM program requires organizations to reengineer their business processes to focus on customers and maximize their benefits.
   - CRM has become essential due to the widely accepted principle that acquiring a new customer costs five times more than retaining an existing one.

2 CONCEPTUAL FRAMEWORK OF INFORMATION SYSTEMS

Amid rapid transformations, information today is considered a fundamental resource. Organizations striving for progress compete to be the first to acquire the right information. Due to the fast-paced developments in the economic and technological sectors, organizations must adapt to external changes. Managing information efficiently is a cornerstone and a strength for any organization. Its strategic significance lies in empowering decision-makers to function efficiently, enhancing organizational operations and activities, and boosting the organization's ability to formulate precise plans, policies, and strategies that drive the achievement of its goals.

Data serves as the raw material for any information system, while information is processed data ready for use, assisting decision-making.

2.1 Data and Information

We live in the era of information or the information revolution, where information has become the

foundation for decision-making, whether at a macro level for policy formulation or a micro level for organizational strategy development. This section will address:

1. The concept of data and information.
2. Characteristics of data and information.
3. Sources of information.
4. Types and importance of information.

2.1.1 The Concept of Data and Information

2.1.1.1 The Concept of Data

Data is the raw material from which information is extracted. It forms the basis upon which management depends, converting it into actionable information.

Definition: Data is a collection of unorganized facts, possibly in numbers, words, or symbols that lack relationships or real meaning and do not influence the recipient's behavior. Data is processed to convert it into useful information for decision-making. In its raw form, data has no significant implications (Maloukhiya, 2006).

2.1.1.2 The Concept of Information

Definition: Information is "organized data available at a specific time and place, enabling decision-makers to take the necessary action. It is the result of data processing." (Munir, 2012)

Another definition states that information is "data that has been classified and organized in a way that allows for its use and benefit. Consequently, information has meaning and influences the reactions of its recipients." (Muhammad, 2005)

Thus, data is the raw material necessary for producing information. Applying the concept of systems, data represents the input processed to produce output, i.e., the information generated by the system (Basyouni, 2010).

2.1.1.3 Distinguishing Between Data and Information

The distinction between data and information is relative, depending on their utility. What may be considered information for one person could be data for another. The differentiation depends on whether the data can support decision-making. If a person believes the data is suitable for aiding decision-making, it is considered information. Otherwise, it remains raw data, awaiting further refinement to contribute to decision-making (Deeb, 2010).

2.1.2 Characteristics of Information and Data

Attributes of Information (Al-Tani, 2005)**:**

- *Relevance*: Information must be relevant for a specific purpose at the time it is needed.
- *Comprehensiveness*: Comprehensive information provides recipients with all they need to know about a given situation.
- *Timeliness***:** Timely information is available when required.
- *Clarity***:** Information must be clear and free of ambiguity.
- *Accuracy***:** Information should be error-free in collection and recording.
- *Flexibility***:** Information should be adaptable to meet the various needs of users.
- *Measurability***:** The ability to quantitatively measure information generated by formal information systems.

Characteristics of Data (Owais, 2011)**:**

- Data should be accurate, reflecting reality and expressing the truth.
- The relative importance of data must exceed its acquisition cost.
- Data should be adequate.
- Data must be current to ensure usability.
- Data must be consistent, without contradiction or conflict.
- Data should be comprehensive, neither excessively brief nor overly detailed.

2.1.3 Sources of Information

Information sources are categorized into two main types (Owais, 2011):

- *Internal Sources*
  These are either oral or documented:
  - *Oral Sources:* Discussions among workers, meetings, or consulting colleagues within the same or other organizations. These oral interactions are considered an internal source of data.
  - *Documented Sources,* including:
  - *Primary Sources* include academic journals, conference proceedings, university dissertations, laws, and regulations. These sources are often authored by experts and provide direct access to information.
  - *Secondary Sources* include dictionaries, government reports, and printed

publications. These sources are pre-defined and ready for use, offering summarized information.

- *External Sources*
  These are official data collected outside the organization, often tailored to specific needs. Additionally, informal internal data may contribute to the decision-making process.

2.1.4 Types and Importance of Information

Information can be classified in a few ways. The French legal perspective categorizes information into three types:

1. *Nominal Information*, divided into:
   - *Objective Information* pertains to the individual receiving it, such as name, social status, residence, and criminal record**.**
   - *Personal Information***:** Referring to others but related to the recipient's context.
2. *Intellectual Works*: Information protected by intellectual property laws, whether related to literary, artistic, or industrial property.
3. *Publicly Available Information*: Information accessible to everyone without ownership, such as stock market reports and weather forecasts.

Another classification divides information into:

1. *Formal Information*: Officially provided through standardized procedures, directly relevant to decision-making.
2. *Informal Information*: Widely used in management activities, often personal, conveyed orally, and may include expectations and rumors. This type is excluded from computerized systems due to its unstructured nature.

Information is important because of:

1. It is essential for building societies and making decisions; without it, societies follow rather than lead.
2. A major area for substantial investments, provided they occur in a legally regulated environment ensuring protection.
3. In public administration, administrative information is a key determinant of efficiency.
4. It is crucial to provide decision-makers with accurate and appropriately quantified information to meet their needs.

2.2 Introduction to Information Systems

In today's rapidly changing business environment, where quick decisions are essential, information systems have become vital for institutions, serving as a resource for achieving future objectives and making successful decisions. The design of effective information systems is critical for analyzing an organization's internal and external environments, identifying strengths and weaknesses, and leveraging information as a strategic asset.

2.2.1 Concept of Information Systems

Before delving into the notion of information systems, it is important to understand the general concept of a system and its components.

2.2.1.1 Nature of a System

A system is a collection of interconnected resources (people, equipment, machines, funds, records, etc.) that interact within a specific framework, functioning as a unified entity to achieve one or more objectives in a given environmental context (Al-Taher, 2011).

The components of a System are:

1. *Input***:** External resources, including human resources, equipment, data, and information.
2. *Processing:* Transformative operations that convert inputs into outputs.
3. *Outputs:* Tangible or intangible products resulting from processing, including information. Outputs of one system may serve as inputs for another.
4. *Feedback:* Corrective information enables plan adjustments, ensuring efficiency and goal attainment.

2.2.1.2 Nature of Information Systems

The modern world is characterized by numerous interconnected systems, such as communication, economic, political, and legal. Among these are management information systems, defined as follows:

- *Definition 1* (Munir, 2012)*:* "A set of electronic components that collect, analyze, publish, and operate data and information to answer specific inquiries."
- *Definition 2* (Supattra, 2007)*:* "A coordinated and comprehensive set of subsystems that integrate rationally to transform data into

information in various ways to enhance productivity, aligning with managerial patterns and agreed quality standards."

- *Definition 3* (Hugues, 2000)*:* "An information system, whether manual or automated, is a communication process involving the collection, processing, storage, and transmission of data to relevant individuals within the organization to provide necessary information for decision-making."
- *Comprehensive Definition:* An information system supports management by enhancing administrative functions and organizing operations. It converts inputs into outputs to achieve organizational goals and success. It is an integrated system relying on human-machine interaction (e.g., computer systems).

2.2.2 Objectives of Information Systems

Information systems, in their various types, aim to achieve specific objectives, which can be summarized as follows (Al-Hazaymah, 2009):

1. *Cataloging Data Sources*: Information systems aim to identify and list all available sources of data and information, requiring an accurate survey of these resources.
2. *Providing Periodic Reports***:** These systems generate regular reports for decision-making authorities, including essential data and information needed for administrative decisions.
3. *Ensuring Precise Monitoring*: Information systems provide feedback to decision-makers, facilitating comprehensive oversight of administrative decision-making and implementation processes.
4. *Reducing Decision Errors*: Information systems help decrease the rate of errors in administrative decision-making.
5. *Supporting Future Planning*: These systems play a significant role in supplying public administration with the necessary information and data for developing plans.

2.2.3 Resources and Characteristics of Information Systems

2.2.3.1 Resources of Information Systems

An information system consists of five primary components that form the essential resources required (Al-Sabbagh, 2000):

1. *Human Resources*: Individuals are vital for the operations and procedures of all information systems, including users and technical specialists responsible for system operation and maintenance.
2. *Hardware Resources*: This includes all hardware and physical components used in data and information processes, such as computers, media devices, and computer peripherals.
3. *Software Resources*: Encompasses all the instructions required to process data, including operating systems and programs that direct the physical components of computers.
4. *Data Resources*: Raw facts recorded using specific symbols (words, letters, shapes, etc.), which can be referenced later.
5. *Network Resources*: Comprises communication technologies, long-distance communication tools, and various types of networks that connect the system to the outside world.

2.2.3.2 Resources of Information Systems

1. *Output Relevance*: This refers to how well the output of an information system aligns with the needs of decision-makers. The degree of alignment can be assessed by analyzing the system's informational attributes.
2. *Behavioral Alignment*: Information systems meet the needs of decision-makers across various functional areas, regardless of their differing personal decision-making styles.
3. *Support in Analysis*: Systems enhance decision-makers' abilities to handle information by utilizing statistical and mathematical models to solve problems, whether complex or semi-complex.
4. *Quick Retrieval*: Also referred to as 'timeliness,' this attribute ensures that delivering information outputs at the right moment helps reduce prediction errors and minimize alternative opportunity costs.
5. *Subsystem Design*: Dividing the system into meaningful subsystems allows for efficient execution as a whole and opens the way to address constraints effectively.
6. *Flexibility and User-Friendliness*: Systems should be built to accommodate future

changes, making them adaptable and easily accessible to a broad range of users.

7. *Integration*: The system should adopt a holistic methodology to cover all functional areas of the organization, producing meaningful and useful information.
8. *Streamlined Data Flow*: Integration in information systems avoids duplication and overlap in data collection and storage, consolidating similar functions and streamlining operations where possible (Al-Zangi, 2007).

2.2.4 Steps and Functions of Information Systems

Steps in designing information systems are (Basyouni, 2010):

- *Defining Information Needs*: Identify the problems that must be solved at all administrative levels.
- *Setting System Goals*: Users should establish system objectives based on information requirements, ensuring that decision-makers can operate the system effectively and efficiently.
- *Determining System Constraints*: Internal and external constraints, referred to as system boundaries, must be defined based on available resources and design flexibility.
- *Identifying Information Requirements and Sources*: Collect information that enhances managers' insight and understanding of critical areas such as problems and alternatives.
- *Developing Design Alternatives*: Explore conceptual designs and select the most suitable one to serve as a blueprint for system construction.
- *Preparing the Conceptual Design Report*: Present a summary of problems, objectives, and expected benefits, including potential organizational changes.
- *System Implementation*: Roll out the system to the organization.
- *System Evaluation and Selection*: Assess the system's performance and select the best options.
- *System Maintenance*: Ensure the system is continuously updated and functional.

The functions of an information system can be outlined as follows (Hussein A. H., 1997):

- *Data Collection*: This process involves internal organizational activities—such as generating reports, conducting meetings, and employing other methods—and external data gathering through techniques, e.g., interviews. The data is then entered into the system and stored.
- *Data Processing*: This entails transforming raw data into meaningful information through diverse processing techniques and computational methods. The processed data is then stored in databases.
- *Data Management*: This is the organizational unit responsible for storing, updating, retrieving, and organizing data into files and databases, ensuring they are kept up to date.
- *Data and Information Control and Protection*: This involves ensuring data accuracy through reviews and safeguards against manipulation or system breaches. Protection measures include user passwords and software that logs all actions performed on the data, including by whom and when.
- *Information Production*: This is the final step in data processing, where the required information is generated for system users. It may take the form of reports, templates, or indicators and is stored in databases for decision-makers in the organization.

3 QUALITY OF BANKING SERVICES

The presence of an information system alone is insufficient to ensure success. Such systems must exhibit specific characteristics, including timeliness, accuracy, comprehensiveness, and reliability. These qualities ensure the system's effectiveness and its optimal utilization across various organizational aspects.

The significance of banking services has grown as a key differentiator in the competitive landscape of banks and financial institutions. Outstanding service quality has become the primary factor distinguishing one bank from another, as banking service offerings are nearly identical across institutions. Consequently, the level of service quality has become a powerful competitive tool for ensuring growth and sustainability, particularly for banks.

3.1 Fundamental Concepts - Banking Service Quality

3.1.1 Concept of Banking Services

3.1.1.1 Nature of Services

Services are defined as intangible offerings that contrast with the tangible nature of goods. They are not visible but can be observed through their outcomes over time.

According to the American Marketing Association, a service is defined as "activities or benefits offered for sale or associated with a specific product" (Suriyah, 2008)Kotler defines a service as "an activity or benefit provided by one party to another, which is essentially intangible and does not result in ownership. The provision of the service may or may not be tied to a physical product" (Talib, 2010).

3.1.1.2 Banking Services

Banking services are defined as a set of activities and operations with both tangible and intangible beneficial components offered by banks. They are perceived by beneficiaries for their utility and value in satisfying their financial and credit needs, both present and future. Simultaneously, these services act as a source of profit for the bank through the reciprocal relationship between the parties (Al-Ajameh, 2005).

Banking services may involve a fee or be offered free of charge in some cases.

Based on these definitions, banking services encompass a variety of activities and operations provided by banks to cater to the needs of diverse customer groups.

3.1.2 Importance of Banking Services

The importance of services arises from their characteristics and role in daily life. Unlike goods whose consumption can often be delayed, services, particularly in the banking sector, require immediate utilization.

Banking services are the primary tools banks rely on to fulfill customer needs and achieve their goals. The success of any banking institution depends on its management policies for service programs. Furthermore, banking services impact other elements of the banking marketing mix, including pricing, promotion, and distribution channels. These services form the core of a bank's existence, around which the rest of the marketing mix is structured (Haddad, 2006).

3.1.3 Characteristics of Banking Services

Characteristics of Banking Services (Talib, 2010):

1. *Intangibility*: Services are intangible, meaning they cannot be seen, touched, or experienced before use. This presents a challenge for service providers to describe and portray their services effectively to prospective customers. However, adding tangible elements, such as the physical location of the service, the personnel involved, and the service delivery environment, can help mitigate the difficulties of marketing intangible banking services.
2. *Simultaneity*: Services are produced and consumed simultaneously. Banking services rely heavily on the provider, as such services necessitate shared expertise, tools, and processes. Customers often participate in designing the service, a feature especially relevant to banking. Thus, these services cannot be delivered by unqualified providers (Al-Bakri & Al-Rahoumi, 2008).
3. *Heterogeneity:* Maintaining a consistent level of service quality is challenging due to variables like timing, speed, and tools used. Banking services may vary between different institutions, among employees within the same institution, and even from the same employee at various times (Kader, 2008-2009).
4. *Geographic Dispersion:* Banking services are distributed through branches and agencies across various regions. Unlike industrial institutions that rely on specialized intermediaries, banks expand their market reach by opening new branches, enabling them to meet the needs of their customers more effectively. The location and selection of branches are crucial in banking service distribution (Hassani, 2010-2011).
5. *Non-ownership*: Consumers of banking services have the right to use the service for a specified period but do not own it, highlighting a fundamental difference between goods and services.
6. *Non-storability*: Like other services, banking services cannot be stored or saved for future use. They are produced and delivered upon demand.

7. *Unique Banking Characteristics* are:
   - *Balance Between Growth and Risk:* When banks offer loans, they assume risks. Striking a balance between business expansion and risk management requires robust monitoring measures.
   - *Demand Fluctuations*: Services cannot be stored, and while stable demand is manageable, fluctuating demand poses challenges in planning, pricing, promoting, and distributing services.
   - *Credit Responsibility*: Banks bear significant responsibility for safeguarding customer deposits and profits. Deposits form the primary funding source for banks and play a vital role in their profitability.

3.1.4 Types of Banking Services (Mariam, 2011)

Banking services can be categorized into the following groups:

1. *Customer-Oriented Banking Services*
   These services involve commission fees as remuneration for the bank and include:
   - *Deposit Services*: Banks accept various types of customer deposits, which can be categorized based on the depositor's ability to withdraw funds:
     - Current deposits.
     - Fixed-term deposits.
     - Notice deposits.
     - Savings deposits.
   - *Custodial Services*: Banks offer secure vaults for customers to store valuables, protecting them from risks such as theft or loss. Items are returned to their original physical condition.
   - *Check Collection Services*: A check serves as a payment and withdrawal instrument. It authorizes a bank (drawee) to pay a specified amount to a third party (payee) as directed by the issuer (drawer).
   - *Securities Safekeeping*: Banks provide secure facilities to safeguard customer-owned financial securities.
   - *Underwriting Services*: Banks frequently serve as intermediaries in facilitating stock subscription processes on behalf of companies.
   - *Foreign Currency Exchange*: Banks mediate the buying and selling of foreign currencies on behalf of their clients.
2. *Lending and Credit Services for Businesses*
   These services generate interest income for the bank and include:
   - *Loans and Credit Facilities*: Banks extend loans to individuals and businesses, ranging from short-term to medium-term and long-term loans.
   - *Commercial Paper Discounting*: is a form of banking credit where banks discount commercial papers to provide immediate liquidity.
3. *Investment in Bank Resources*

Banks allocate a portion of their financial resources to trade securities and other financial instruments to generate revenue.

Banking institutions often allocate a portion of their resources, alongside deposits entrusted to them, to invest in purchasing securities and generate profits.

3.1.5 General Influences on Service Delivery:

The factors influencing the design of banking service policies offered by a bank in the market can be divided into:

- *External Influences*: They include the following key aspects (Al-Taher, 2011):
  - The strength and activities of competitors.
  - Economic forecasts and future economic conditions.
  - The general commercial climate.
- *Internal Influences*: This category of factors includes the following dimensions:
  - The bank's capacity to provide new banking services or to modify and enhance existing ones.
  - The skills and experience of the bank's management and staff, as well as branch operations.

3.2 Service Quality in Banking

Issues related to service quality have garnered significant attention from researchers and academics, particularly banking marketers. Service quality in banking is considered strategically valuable because its study helps banks enhance the institution's reputation and

image among its clients. This, in turn, strengthens their position against competitors, reduces costs, and increases productivity, market share, and profitability, thereby improving banking performance.

3.2.1 The Concept of Banking Service Quality

Quality is a contemporary concept that emphasizes the delivery of distinctive products and services. Below are some definitions of quality (Al-Sakranah, 2009).

The International Organization for Standardization (ISO) defines quality as:

"The total characteristics of a material that determines its ability to meet stated or implied needs." (ISO, 2015)

It is also expressed as: *"The total characteristics of a product that enhances its ability to satisfy specific customer needs, or as a set of features and characteristics that strengthen satisfaction."* (Khaleq, 2010)

Others describe it as: *"A feature or set of features that distinguish one entity or service offered by a bank from its competitors."* (Mariam, 2011)

The American Society for Quality defines it as: *"The total attributes and characteristics that affect the ability of a product or service to meet specific needs and perform various functions aligned with the user's environment."* (Al-Sakranah, 2009)

Regarding service quality, Lewis Orledge & Michel define it as focusing on meeting needs and requirements and clarifying how they are sequentially organized based on customer expectations. Perceived service quality is the customer's judgment of the service, derived from comparing their expectations with their perceptions of the actual service performance (Khaleq, 2010).

This definition emphasizes that perceived quality is the customer's judgment, meaning that service quality should be defined from the client's perspective

3.2.2 Levels of Banking Service Quality:

Research has identified five levels of banking service quality:

- *Expected Quality*: The quality customers believe should exist.
- *Management-Perceived Quality*: The quality deemed appropriate by the service institution's management.
- *Standard Quality*: Defined by the service specifications.
- *Actual Quality*: How the service is performed.
- *Desired Quality*: What customers wish to experience.

Some scholars categorize service quality into the following three levels (Kortel, 2007):

1. *Organizational Quality*: Related to the organization's reputation and general image.
2. *Interactive Quality*: The outcome of interactions between employees within the organization and the customers.
3. *Physical Quality*: Pertains to the environment surrounding the delivery service.

Another classification distinguishes between:

1. *Process Quality*: Judged by customers during delivery service.
2. *Outcome Quality*: Assessed by customers after the service has been performed.

Some researchers suggest two levels of banking service quality (Deeb, 2010):

1. *Technical Quality*: This quality depends on bank staff possessing advanced knowledge and expertise in banking services and diverse procedures. It is particularly suitable for complex banking services such as contracts and pension plans, where technical knowledge is a critical requirement.
2. *Functional Quality*: This focuses on the service encounter and how services are delivered, requiring psychological interaction between the bank and its clients.

Bank management should aim to enhance the quality of its banking services by setting strategic goals for service quality, monitoring customer needs and expectations, measuring quality and customer satisfaction, reorganizing around the customer, redefining managerial roles, determining productivity benefits, reducing service costs, and building a solid foundation for customer loyalty.

Denton Keith identified principles guiding bank management (Mariam, 2011):

- Clear vision by the bank’s management, understanding, and respecting customer follow-up.

- Adequate support from bank management, alongside fostering a strategic banking environment.
- Understanding the banking business and its components, and using methods to improve service quality
- Demonstrating the need for innovation, attracting the right individuals, training them, qualifying and refining their skills, and establishing incentive and reward systems

3.2.3 Measuring Service Quality in Banking:

Scientific theories for measuring banking service quality rely on two main approaches:

1. *The Directional Approach*: This approach is based on the idea that service quality represents a directional concept that leads to satisfaction but is not synonymous with it. It is linked to the client's perception of the actual service performance. Although researchers implicitly acknowledge the importance of customer perceptions of service quality, they view service quality and customer satisfaction as distinct concepts.

   The common explanation for this difference is that service quality, as provided and perceived by customers, is a form of direction based on long-term cumulative evaluation. In contrast, satisfaction is a transient and fleeting psychological state. Other researchers argue that customers form their attitudes toward a service based on their previous experiences. Thus, attitudes adapt according to the level of satisfaction achieved through interactions with the service institution.

   Several studies have confirmed the efficiency of focusing on customers' perceptions of service performance to evaluate quality.

2. *The Gap Theory Approach*: This approach assesses service quality by measuring the difference between customer expectations and their perceptions of the service. Service quality is determined by the gap between expected service and perceived service (actual performance). In essence, delivering high-quality service requires meeting and continually exceeding customer expectations.

A comprehensive study indicates that perceived service quality ranges from optimal to acceptable. Service quality can be evaluated as follows:

- If expected quality exceeds perceived quality (actual performance), service quality is below satisfactory.
- If expected quality equals perceived quality, service quality is satisfactory.
- If the expected quality is lower than the perceived quality, service quality surpasses satisfaction and approaches optimal quality within the defined timeframe.

The gap model identifies seven types of gaps, emphasizing discrepancies between customer expectations and service delivery:

- *The Management Gap:* is the difference between what the banking institution's management believes customers expect and their actual needs.
- *The Standards Gap*: is the difference between management's perception of customer expectations and the service standards established to meet those expectations.
- *The Delivery Gap*: is the gap between the bank service delivery standards and the performance level achieved.
- *The Communication Gap*: is the difference between the service quality the bank promotes through advertising and other communications and the actual quality delivered.
- *The Perception Gap*: is the gap between the quality-of-service customers receive and how they perceive or interpret that quality.
- *The Interpretation Gap*: is the difference between the bank's promotional claims about service quality and how customers understand and believe those claims.
- *The Service Gap*: there is the overall difference between customer expectations of service quality and their experience with the service delivered.

3.2.4 Approaches and Methods to Improve Banking Service Quality:

To enhance the quality of banking services, the following steps should be taken (Murad, 2008):

1. *Continuous Use of Research and Studies*: Banks should enhance service quality by consistently utilizing research and studies to collect information on service roles and dimensions, establish performance standards, assess employee performance, and understand customer expectations and perceptions. This approach forms the

foundation of any effective service improvement program.

2. *Recruiting and Employing the Best Talent*: Banks should strive to select and employ the best individuals to deliver distinguished services.
3. *Focusing on Internal Marketing Programs*: Internal marketing involves treating employees as internal customers. When a bank values its employees as much as its external customers, it enhances employee motivation and satisfaction, which ultimately improves service quality, meets customer expectations, and fosters customer loyalty.
4. *Quickly Addressing Customer Problems*: The faster customer problems are resolved, the greater their satisfaction and loyalty to the bank. Satisfied customers act as advocates for the bank, recommending it to others.
5. *Educating Customers About Services*: Banks can enhance their credibility with customers by educating them about the services offered. Increased customer awareness of banking services leads to better decision-making and higher satisfaction.
6. *Developing a Quality-Driven Organizational Culture*: Achieving service excellence requires making quality a core belief among all bank employees. Quality should become an organizational value that fosters satisfaction and motivation.
7. *Emphasizing the Role of Quality Teams*: Quality teams consist of employees who can coordinate, work together, and strive for outstanding performance to create customer satisfaction.

3.2.5 Commitment and Administrative Dedication to Service Quality

The effectiveness and success of service quality improvement programs or customer care initiatives are contingent on a radical transformation in the organization's culture. This transformation must begin with senior management and extend to all operational levels. It requires the presence of effective leadership styles, as effective leadership at all levels serves as the cornerstone for the success of service quality programs.

4 CONCLUSION

Banking management has long sought to modernize and develop its methods to keep pace with the radical transformations occurring in the global economy, accompanied by the growing importance of information and the emergence of new measures of wealth. Amidst these changes, banking institutions are required to find alternatives to traditional management systems to address issues more effectively and tackle obstacles that hinder customer loyalty and satisfaction with the services provided, while also addressing employee dissatisfaction.

Overcoming these barriers is of utmost importance. It necessitates abandoning traditional administrative approaches and adopting more modern management concepts, such as giving due attention to information management and recognizing its role, along with focusing on human resources, in achieving efficiency and effectiveness in the long term.

However, implementing such an approach in banking institutions is highly challenging, as it requires competent and qualified intellectual capacities capable of dedication and innovation to achieve excellence in performance within a supportive environment.

Despite efforts to develop and modernize Algerian banks, challenges remain. These efforts include employee training initiatives, incentive systems, and advanced technologies to improve operations and provide necessary information for better-quality services. However, this study reveals that banking services have not yet met globally acceptable quality standards. Furthermore, the banking sector remains one of the economic sectors that most need a continuous flow of information. The study yielded the following findings:

- The agencies studied do not implement information management practices, and their employees cannot define the term *knowledge management* due to the absence of a culture related to this concept.
- Information is a crucial factor in achieving quality banking services. It provides customers with the necessary information, fostering trust in staff and enhancing the bank's image. This

influences customers' decisions to continue their relationship with the bank.
- Differences in how customers and management perceive banking service quality create challenges in establishing a unified framework for its measurement.
- The quality of banking services depends on the degree of customer participation and their ability to provide information that enables service providers to identify and meet their needs**.**
- The agency measures customer satisfaction based on complaints received from customers.

Based on the findings, the following recommendations are proposed:

- Algerian institutions must adopt knowledge management as a modern and advanced administrative approach characterized by efficiency and effectiveness, moving away from classical management methods to catch up with global advancements.
- Bank officials should be directed to the importance of information and its role in the banking sector.
- All necessary conditions and capabilities should be provided to facilitate the learning process within the banking institution.
- Bank officials and managers must prioritize establishing a department for information management and technology.
- Efforts should be made to attract and appoint highly qualified and skilled individuals and continuously develop their capabilities.
- Opportunities should be given to skilled employees to introduce improvements to certain banking operations.
- Bank employees should be sent on training missions abroad to acquire technology and enhance their informational capabilities.
- Attention should be given to internal customers (employees), as they ultimately possess the information that the institution seeks to disseminate among its members.
- Efforts should be made to stay updated and connected with modern technologies to enhance service efficiency.

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Received for publication: 26.02.2025
Revision received: 15.03.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Lekhdiri, R. (2025, 07 15). Impact of Information on Banking Services. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 151-165. doi:10.12709/mest.13.13.02.11

Style – **Chicago** *Sixteenth Edition:*

Lekhdiri, Rahem. "Impact of Information on Banking Services." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 151-165.

Style – **GOST** *Name Sort:*

Lekhdiri Rahem Impact of Information on Banking Services [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 151-165.

Style – **Harvard** *Anglia:*

Lekhdiri, R., 2025. Impact of Information on Banking Services. *MEST Journal,* 15 07, 13(2), pp. 151-165.

Style – **ISO 690** *Numerical Reference:*

Impact of Information on Banking Services. **Lekhdiri, Rahem.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 151-165.

MEST Journal
DOI 10.12709/mest.13.13.02.14

STAGES IN THE CONSUMER BUYING DECISION-MAKING PROCESS

Milan Mihajlovic
Military Academy, University of Defense in Belgrade, Serbia
https://orcid.org/0000-0001-7949-2631

Aleksandar Savic
Military Academy, University of Defense in Belgrade, Serbia
https://orcid.org/0000-0002-9640-1583

Vladan Sarcevic
Military Academy, University of Defense in Belgrade, Serbia
https://orcid.org/0009-0009-5153-6845

JEL Category: **D11, M31**

Abstract

Deciding to purchase a product or service is a process in which reasons for and against the purchase of specific products or services are created and confronted in a customer mind. The result of this process can be a decision to buy a product or service. According to the psychological processes that play a key role, there are at least two types of purchase decision-making. One of the forms of making a purchase decision is the routine making of a purchase decision. Routine purchase decisions are the most common in people lives. For example, deciding to buy bread and other foodstuffs occurs routinely, almost always in the same store (market), at a similar time during the day, week, or month. Long-term memory (long-term memory) plays a key role in routine purchasing decisions. This paper investigates the buying habits of consumers. It analyzes the entire decision-making process of consumers when purchasing through five stages: awareness of the need, search for information, evaluation of alternatives, purchase, and evaluation after purchase.

Keywords: *Consumer, Purchase, Need, Decision, Buying behavior, Decision-making*

1 INTRODUCTION

Since the emergence of marketing as an activity, the consumer has always been the main focus of marketing activities. Marketing has always adapted to the consumer and his needs and satisfaction. Today, however, marketing experts focus on something else, on making a purchase decision. Who is a consumer, what influences the consumer and his decision-making, and more precisely, what factors influence him, and how does a particular market affect his purchasing behavior? These are just some things that marketing experts should pay attention to during market research and its consumers.

Address of the corresponding author:
Aleksandar Savić
aleksandar22071993@gmail.com

To determine how an individual consumer makes a purchasing decision, marketing experts must analyze the entire process before a purchase. The actions include identifying the need, gathering information about specific products, narrowing down the options to those that qualify for further consideration, and ultimately deciding between these alternatives. The process does not end there—it extends to post-purchase behavior, such as assessing satisfaction or dissatisfaction with the chosen products.

2 CONSUMERS AND THEIR MARKET BEHAVIOR

Since the beginning of marketing, more precisely in the early 20th century, the goal has been to offer products or services that will satisfy the needs of a targeted consumer segment while being profitable. The consumer has not always been in focus. Mass production, and profit were the most important, but this has changed over time in the production concept of marketing. The biggest challenge nowadays is fully understanding the needs and preferences of consumers and what factors influence their purchasing decisions. Other significant challenges involve assessing whether consumers will maintain their use of the product and exploring additional factors that influence their behavior in the market. Consumer behavior and purchasing decisions are in constant flux, driven by globalization and societal development. Various factors also significantly impact consumers decisions, often leading to critical challenges for marketing (Gupta et al., 2004).

The consumer can be characterized as a complex being, influenced by numerous factors, capable of consciously or unconsciously changing their purchase decision instantaneously. The consumer mind can also be regarded as a black box, where the outcome—specifically, the purchase decision—remains unpredictable (Alalwan et al., 2017). Therefore, marketing experts must constantly analyze consumers and be in line with the times and technology. They must apply various scientific methods of studying consumers, such as psychology and sociology. That will give them insight into what the consumer wants. Below, we will analyze the consumer in more detail, their characteristics, and what exactly influences their purchase decision.

2.1 Who is a Consumer?

If any person were to ask who a consumer is, in most cases, they would get the answer that it is the same person as the buyer. This is not entirely correct. According to the definition, and also according to practice, the consumer and the buyer are not the same persons, so they have different meanings. It is essential to distinguish the concept of a buyer from that of a consumer. The consumer is the one who uses the product or benefits from the offered service. Meanwhile, the buyer is the one who performs the act of purchasing or acquiring the product, regardless of whether they will use it or not. Also, the buyer can participate in the mediation process, while the consumer only buys a product that will satisfy the desired needs through consumption.

Thus, we arrive at the primary definition of a consumer. It refers to a person (legal or natural person, household, or organization) who purchases or uses products or services provided by a specific economic entity. Consumers are crucial for businesses because they generate revenue by buying products or services that enable them to continue their business (Hsu & Lin, 2015). This is why it is emphasized how important the consumer is to the organization, consumers keep them alive.

Another important fact is that the consumer is the bearer of needs for a precisely defined product that they want and that will effectively satisfy that same need. If the consumer determines that a specific product matches the product they want, the purchase decision is finalized. However, making a purchase decision is not a simple process. The consumer goes through certain stages when making a decision. More precisely, they must first recognize their need, after which they actively seek information (Savić et al., 2024). This is followed by possible alternatives evaluation, grounded in reviewing the data gathered, ultimately leading to the final purchase decision. This is not the last stage of the entire process either; nowadays, what matters is the consumer's behavior after the purchase, i.e. whether they will continue to consume the same product or try an alternative (Mehrad & Mohammadi, 2017).

Identifying the appropriate motivation is crucial to encouraging consumers to purchase and use the product. The task of studying consumer behavior is to predict consumers' desires and needs and offer that product as soon as they imagine it. It is also significant to present the product in the best light so that the consumer will automatically be intrigued and understand how it is perfect for satisfying their needs.

2.2 Types of Consumers

Although there are many different divisions, the most important is the division of consumers according to their specifics, so there are three types of consumers (Rachatanon et al., 2019):

- End or final consumers,
- Economic consumers and
- Non-economic consumers.

They differ based on autonomy in decision-making. The end consumer has the highest autonomy, while economic and non-economic consumers have less.

The end consumer independently makes a purchase decision based on emotions and logic with less influence from external environmental factors.

Final consumers are end consumers who purchase products for consumption and satisfy their needs, and not for further sale (Savić & Bonić, 2022). Thus, there are types of products intended for final consumers, which are (Singh et al., 2020):

- Ordinary (essential, impulsive, urgent) products,
- Specific (homogeneous and heterogeneous) products,
- Special products,
- Unsought products.

When looking at economic and non-economic consumers, or organizational consumers, in short, decisions are not made by subordinate employees, but by decision-makers at high hierarchical levels of the business entity. These consumers purchase certain products to resell them (Sullivan & Kim, 2018). In this process, organizational consumers refine, process, and resell these modified products at a higher price to final consumers.

2.3 Factors influencing consumer behavior

Every person is seen as a consumer and every person has different behavior, something that makes them different from other consumers. The psychology behind consumer behavior is an exceptionally fascinating discipline. It continually uncovers interesting results and new facts about the factors shaping consumer behavior. Marketing experts must constantly analyze which factors, apart from the product itself and its characteristics, influence the decision to purchase. There is a wide range of different factors that can affect the consumer. According to Kotler, there are four types of factors that influence consumer behavior, which are (Tuncer, 2021):

- Personal factors,
- Social factors,
- Psychological factors and
- Cultural factors.

Consumer behavior and their decision to purchase are influenced by a series of interrelated factors.

3 STAGES IN THE CONSUMER BUYING DECISION-MAKING PROCESS

Theoretical frameworks propose four distinct methods for identifying the fundamental stages of consumer decision-making during a purchase. The introspective method is based on one's behavior analysis and is limited in scope. The retrospective method applies a survey of a small group of consumers to determine the reasons for their last purchase (Savić et al., 2023). The prospective method assumes identifying a relevant consumer who will explain how they arrived at a specific purchase decision. The prescriptive method is based on researching a smaller group of consumers who need to describe the ideal approach to purchasing a product or service effectively.

According to the available literature, the most commonly analyzed is the classical (traditional) decision-making model that views the consumer as someone who solves their problems by purchasing products and services. The consumer purchase decision process consists of the following five stages (Yahia et al., 2018):

- Need awareness
- Information search
- Evaluation of alternatives
- Purchase
- Post-purchase evaluation

Figure 1. Consumer decision-making process

The decision-making process begins when a consumer becomes aware of a specific need (Zhao et al., 2020). If the need is strong enough or has been translated into a desire, the consumer is motivated to seek out information about products and services that can satisfy that need.

3.1 Awareness of the need

The purchasing process begins when a person becomes aware of a need; therefore, this stage is also called need or problem recognition. Needs can be stimulated by external and internal stimuli, which motivates the consumer to act or behave. In the case of needs triggered by external stimuli, an example might be a person passing by a bakery and seeing freshly baked bread, which stimulates hunger in that person. In the second case, one of the person's needs (e.g., hunger, thirst, etc.) grows to a certain level and becomes a trigger.

There are several types of problem or need recognition among consumers (Radovanović et al., 2024):

- Routine problem solving, which requires a quick response from the consumer to overcome the gap between the actual and desired state.
- Urgent problems, which are usually unexpected and demand immediate reaction from the consumer. These cases do not always lead to the most rational solutions.
- Planned problem recognition, where the problem exists but solving it does not require a quick response from the consumer, or when it is expected that the necessary conditions for its resolution will be met.

The outcome of the need recognition stage can be as follows (Mitrović et al., 2024):

- The consumer assesses that the problem is not important or urgent enough to be addressed immediately.
- The consumer decides to engage in solving the problem.

This stage is crucial for marketing for two reasons. The first reason is to understand the motives that lead to the need for purchasing certain products. The second reason is that the level of need depends on time and various stimuli.

Marketing experts should identify the circumstances that trigger a specific need. By gathering information from a larger number of consumers, marketing experts can identify the most common stimuli that drive interest in a particular product category and develop marketing strategies that will attract consumer interest.

3.2 Searching for information

When a consumer assesses that a need or desire is significant and should be fulfilled, he seeks information about the most effective way to achieve it. This begins the information search phase. The traditional approach to analyzing the decision-making process assumes that consumers will collect as much information as necessary to decide on a particular type of product and service. This is considered consumer rationality, although it is immeasurable (Vuković, 2024). There are several types of consumer decision-making: extensive, limited, and routine. Consumers first collect the most significant information, and then expand it to the extent they consider necessary. They collect information until

it is no longer worthwhile or takes too much time. Otherwise, the consumer may be exposed to too much information and therefore could not accept and process it to make an adequate decision.

Consumers have the opportunity to use different sources of information in their environment. We can divide information sources into (Milenković et al., 2023):

- Memory (own experience),
- Personal (family, friends, etc.),
- Marketing (commercial propaganda),
- Independent or public (media, consumer organizations),
- Experiential sources.

Personal sources have an evaluation function, while marketing sources have a commercial and informational function.

We distinguish between internal and external information seeking. Internal seeking refers to experience with products and services that can solve a problem. Consumers prefer this way of seeking information because it offers quick and automatic answers to their requests (Zupur & Janjetović, 2023). External seeking involves collecting information from various external channels, such as friends, commercial propaganda, consumer informants, etc. Consumers who lack an opinion or have limited experience with a particular product or service rely on external information seeking. The dominant sources of information can be marketing, personal, and neutral sources.

Marketing sources include displays and billboards, advertisements in the media, personal selling in facilities, product design, and product packaging. Social sources are information from friends, family, colleagues at work, leaders, and others whose influence in the purchasing process is respected (Golubović & Janković, 2023). Neutral sources are government agencies, consumer organizations, and various professional associations. Nowadays, the Internet stands out as the most influential source of external information and is seen as a distinct source. Instead of visiting stores, websites can provide consumers with more necessary information about the products/services under consideration, which is why the Internet has an increasing influence on pre-purchase research.

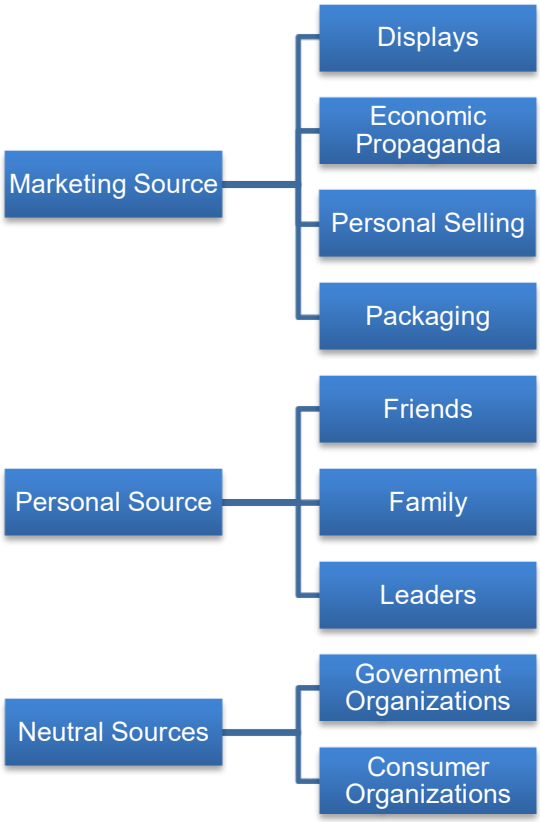

Figure 2. External sources of information

By collecting information, the consumer learns about competing products and their characteristics. The process begins with the total set of available products that the consumer can access.

3.3 Assessment of Alternatives

Alternative evaluation refers to the stage in which the consumer has sufficient information to decide. Under specific circumstances, the consumer makes a quick decision, e.g., if it is a quality product with an acceptable price and after-sales services. The consumer analyzes the brands of a particular product, thus assessing the quality and trust in the manufacturer of a selected product (Gojković et al., 2023). An individual consumer will only be familiar with some brands – that is, a known set of brands based on their own experience or from personal and other sources. Some product brands will meet the purchase criteria of the consumer, forming the consideration set. As the consumer gathers more information, only a few will remain on the shortlist, creating the choice set. All brands in the choice set may be acceptable. From this set, the person decides on the final selection.

Several concepts are applied when evaluating alternatives (Zekić & Brajković, 2022).

- The first concept involves the evaluation of product attributes. Products have many attributes, and the consumer decides to purchase a product based on the attributes that are important to him.
- The second concept refers to the so-called hidden attributes of the product evaluation.
- The third concept emphasizes the image of the product brand, as decisive for the choice between alternative products.
- The fourth evaluates products from the point of view of utility for the consumer.

Decision rules for measuring consumer preference can be compensatory and non-compensatory. Compensatory decision rules are based on positive and negative evaluations of alternatives, i.e. product brands. A simple rule suggests that the consumer selects the alternative with the most favorable product characteristics. In contrast, a complex compensatory rule ranks the attributes according to their relative importance.

In non-compensatory rules, we distinguish between bound, unbound, and lexicographic rules. Bound rules mean a minimum level of acceptability of a particular alternative and the consumer will not consider the options below that level. Unbound rules are identical to bound rules, except that they are applied to the evaluation of individual product attributes. The consumer will consider each alternative that satisfies each of the specific features. According to lexicographic rules, the consumer first sorts the attributes by importance, and then compares different product brands by evaluating the same attribute.

Based on the criteria and evaluation rules, the consumer ranks the alternatives from the least desirable to the most desirable. The consumer analyzes the trademarks of a specific product, thus assessing the quality and trust in its manufacturer. In most cases, the ranking is done based on the brand or price of the product, which the consumer primarily associates with quality. Often, criteria such as style, prestige, or brand image are used in evaluating alternatives, which are difficult to measure.

An individual consumer will only be familiar with some brands – that is, a known set of brands based on their own experience or from personal and other sources.

Some product brands will satisfy the consumer's purchase criteria and this is the consideration set. As the consumer gathers more information, only a few will remain on the shortlist and this is the choice set. All brands in the choice set may be acceptable. From this set, the person decides on the final selection.

Criteria used in evaluating alternatives can be (Inđić et al., 2023):

- Price, additional costs, and acquisition costs,
- Durability and cost-effectiveness.
- Brand, style, store image, and time needed to shop,
- Store location, decor, atmosphere, and friendliness of staff.

4 SHOPPING

A purchase stems from a choice based on a ranking list of alternative products available to the consumer. It only denotes an act or phase of the consumer's decision-making process in purchasing products and services. A large number of authors refer to the act of purchasing as the "heart" of consumer behavior. It involves the exchange of products and services for an appropriate amount of payment. From the company's point of view, this phase in the purchasing process is crucial, because it confirms the correctness of the marketing strategy and enables the continuation of business and the realization of profits.

For a purchase to occur, there must be a serious intention to purchase, and considering this intention, we distinguish (Hemed, 2022):

- Fully planned purchase
- Partially planned purchase
- Unplanned purchase

An entirely planned purchase involves selecting a product and brand before visiting the store. It results from high consumer involvement and a complex decision-making process because the consumer knows exactly what he wants and where he will buy the product. A partially planned purchase occurs when the consumer decides only on the product before arriving at the place of purchase and chooses the brand at the point of sale, and this type also shows high consumer involvement. At the point of purchase, the

consumer may make the final decision under the influence of numerous stimuli related to sales promotion methods or the activities of the sales staff. The third form of purchase is an unplanned purchase in which the consumer has not selected a product or brand before arriving at the point of sale. Therefore, it is spontaneous, i.e., unexpected and often triggered by visual stimuli at the point of purchase.

An interesting division is also in trial and repeat purchases. Trial purchase implies that the consumer purchases a specific product for the first time and that the experience in use determines whether they will choose the same brand again. Repeat purchase is synonymous with consumer brand loyalty. It indicates consumer satisfaction based on a previous positive experience with a product or service.

The purchase decision is influenced by three factors in the environment. More precisely, these factors influence the translation of intention into an actual decision to purchase a particular product or service. There are situations in which the consumer is not entirely sure whether to buy a product or not due to certain factors that influence the decision. These factors influence the consumer to either temporarily or permanently abandon the purchase of a particular product or, despite these negative influences, proceed with the purchase. The first refers to the opinions of others about the product brand. The second factor implies that the consumer will find the expected situation in the purchase, while the third, very attractive for the marketing activity of the company, refers to the influence of unexpected factors on the consumer's purchasing behavior such as new information that the consumer has found, for example, negative reviews, a change in opinion about what type of product he wants, new discounts on previously unknown products, and the like. The above factors significantly enable marketing to influence the consumer's decision to purchase products and services. After the consumer undergoes the process of reassessment when coming into contact with unfavorable factors, the decision to purchase a particular product is concluded, and the decision-making process begins. The consumer must make three critical decisions related to purchasing a product. The first decision concerns the choice of place of purchase. The selection of place of purchase is influenced by the location of the store, the layout of the store, the assortment of the store, the friendliness of the staff, the provision of additional services, etc. The second decision is related to the price and method of payment as the basic categories of purchase. The cost can be with or without tax, with a discount, etc. Payment can be made in cash or on credit. The third decision involves the availability, i.e. the delivery terms of the product. The consumer habitually evaluates all three decisions together and when they match their attitudes and assessments, they purchase a particular product or service.

Direct marketing has recently gained significant popularity among companies. This approach involves utilizing printed advertisements, catalogs, television, and the Internet to reach potential buyers and establish purchasing relationships. These potential buyers are, in essence, the consumers.

Since the consumer decision-making process occurs within the individual, it presents challenges for accurate measurement. However, two approaches are used in marketing research to measure consumer decision-making through purchasing products and services (Savić et al., 2022). According to the input-output approach, the company encourages consumers with certain stimuli (e.g. an attractive price) to measure their reaction based on this. The second approach, better known as “monitoring”, seeks to determine the reality of the purchasing process itself at the place of occurrence. This approach uses three methods: verbal, physical, and observation. The verbal method is based on questioning after the purchase has been made. The physical method uses the so-called information from a screen or table that operates on the principle of a multi-attribute matrix. The observation method is based on audiovisual means (e.g. cameras) to determine the observer's observation. In practice, a combination of these two approaches is most often used in consumer research.

4.1 Post-purchase rating

Post-purchase evaluation or behavior is later integrated into the consumer decision-making process. This phase is analyzed through the

following elements: product use, satisfaction or dissatisfaction with the product, behavior in case of dissatisfaction, and the final decision on product disposal (keep or sell).

4.1.1 Product usage

The post-purchase evaluation process starts when consumers begin using products or services. Whether they use a particular product or service, consumers can be divided into users and non-users. Understanding the different ways in which consumers consume products and services is crucial for a company's marketing activities. In this regard, four factors have been identified. The first factor relates to the frequency of use or consumption of products and services. It is known that some products are used constantly, some occasionally, and some only once. The second factor is related to the amount of consumption. In marketing, the quantity consumed holds significant importance. This information reveals both the intensity of consumer demand and the portion of income allocated for purchasing a particular product or service. The interval of use is the third factor that must be analyzed. This is especially evident in the marketing analysis of products that are consumed discontinuously. The purpose of consumption is a factor that deserves the same attention as the previous three. Companies are trying to expand the purpose for which a particular product can be used. Two further factors worth considering, alongside those already mentioned are time and place: the time a product or service is utilized and the location of its use.

4.1.2 Consumer satisfaction

Consumer satisfaction is the fit between the customer expectations about a product and the product perceived performance.

- The consumer will be dissatisfied if the product performance falls short of expectations.
- If the product meets expectations, the consumer will be satisfied.
- If the product exceeds expectations, the consumer will feel exceptionally pleased.

These feelings influence whether the consumer will repurchase the product and whether they will talk favorably or unfavorably about the product to others. The consumer forms their expectations based on the messages they receive from salespeople, friends, and other sources of information. The greater the imbalance between expectations and product performance, the greater the consumer's dissatisfaction. Here, the consumer's response style becomes significant. Some consumers exaggerate the discrepancy when the product is flawed and become dissatisfied. Other consumers minimize this discrepancy and are less dissatisfied. Consumer satisfaction or dissatisfaction with a product affects its post-purchase behavior.

Consumer satisfaction is key to retaining existing customers and attracting new ones. Consumer satisfaction with purchased and used products and services is believed to affect their future behavior toward a given manufacturer or company. Therefore, creating value and customer satisfaction is the heart of modern marketing thought and practice. The fundamental goal of marketing a company is to profit from a satisfied customer.

Customer engagement requires a company to examine consumer expectations about the quality and performance of its products or services. Maintaining a balance between expectations and the delivered standards of products or services provides managers with insight into customer satisfaction. It is assumed that satisfied customers will develop long-term loyalty, ultimately contributing to the company's profitability. In marketing, careful consideration is essential when setting customer expectations. If expectations are set too low, there is a risk that only a limited group of consumers will be satisfied. Conversely, if expectations are set too high, consumers may be disappointed. Creating value for consumers and achieving their satisfaction are key aspects of the development and management of customer relationship marketing.

All products and services, according to their performance in the process of use and consumption, are divided into 3 categories:

- Products and services that have fully met consumer expectations from the point of view of utility and cost,
- Products and services that have shown ideal performance and

– Products and services that are in line with expectations.

4.1.3 Consumer behavior in case of product dissatisfaction

Dissatisfaction with a purchase or product is often the result of doubts about whether a good decision was made. It occurs immediately after the act of purchase and reflects a kind of consumer frustration (Savić et al., 2023). It is a conflict between different consumer beliefs and attitudes, and the desire to reduce the expected risk after deciding to purchase a product. The consumer usually regrets not choosing another alternative, which he subsequently assumes provides him more satisfaction.

4.1.4 Final decision on product disposal

The final decision regarding product disposal depends on several factors. It is influenced by consumer satisfaction or dissatisfaction with the product and its performance, the degree of product wear, and the evolving roles of consumers during the product life cycle. New products are placed on the market, while old ones are removed for various reasons (obsolescence, non-competitiveness), all to achieve the best possible satisfaction of consumer needs and desires. Factors that influence the consumer final decision on product disposal are classified into the following groups:

– Psychological factors related to the consumer, like personality, attitudes, emotions, social class, and stratum.
– Product characteristics, including condition, age, size, style, and color.
– Situational factors external to the product, like finances, place of storage, and functionality of use.

5 CONCLUSIONS

The consumer mind is remarkably complex, despite perceptions that the decision-making process is straightforward. In reality, they navigate numerous factors to arrive at a final decision on what to purchase and whether to continue using a particular product in the future.

Marketing managers must be meticulous when forming marketing activities. Failing to research the influences on consumer behavior and purchasing decisions could result in overlooking the right segment of target consumers, posing a serious issue for businesses. There are a large number of different factors that influence the consumer. All of these factors must be covered if you want to achieve an impact on the consumer.

When looking at markets, there is a significant difference in the purchasing process and the behavior of consumers in these markets. In the final consumption market, buyers and consumers appear, more precisely individuals and households, while in the business consumption market, profit and non-profit organizations can be found that buy different products, but in both markets. Some characteristics of these markets influence consumer behavior, where different behavioral models are created.

The conclusion highlights the importance of research for modern consumers. If consumers feel a need or desire to purchase a product, they should explore information about alternative options before deciding. That helps ensure that, after purchasing, dissatisfaction with the chosen product is avoided. Consumers choose product alternatives that will satisfy their desires and on which they can further rely. If the product satisfies the desire, satisfaction arises, which can develop into loyalty to a particular brand.

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Received for publication: 10.02.2025
Revision received: 04.04.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Mihajlovic, M., Savic, A., & Sarcevic, V. (2025, 07 15). Stages in the Consumer Buying Decision-Making Process. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 166-176. doi:10.12709/mest.13.13.02.14

Style – **Chicago** *Sixteenth Edition:*

Mihajlovic, Milan, Aleksandar Savic, and Vladan Sarcevic. "Stages in the Consumer Buying Decision-Making Process." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 166-176.

Style – **GOST** *Name Sort:*

Mihajlovic Milan, Savic Aleksandar and Sarcevic Vladan Stages in the Consumer Buying Decision-Making Process [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 166-176.

Style – **Harvard** *Anglia:*

Mihajlovic, M., Savic, A. & Sarcevic, V., 2025. Stages in the Consumer Buying Decision-Making Process. *MEST Journal,* 15 07, 13(2), pp. 166-176.

Style – **ISO 690** *Numerical Reference:*

Stages in the Consumer Buying Decision-Making Process. **Mihajlovic, Milan, Savic, Aleksandar and Sarcevic, Vladan.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 166-176

MEST Journal
DOI 10.12709/mest.13.13.02.19

THE ROLE OF THE MANAGEMENT ACCOUNTANT IN LEADERSHIP DECISION-MAKING PROCESSES

Dragan Milacic
Higher Business School of Vocational Studies "Cacak", Belgrade, Serbia
https://orcid.org/0000-0002-3380-1678

Sonja Zarkovic
Higher Business School of Vocational Studies "Cacak", Belgrade, Serbia
https://orcid.org/0009-0003-5714-5964

JEL Category: **A10, M10, M41**

Abstract

Successful company management requires constant adaptation to dynamic business conditions. Sound managerial decisions must rely on precise, comprehensive, and timely data, with accounting playing a key role in this process. Modern technologies continuously reshape business landscapes, and management teams must adapt swiftly. One major challenge, especially in management accounting, is redefining reporting strategies in an era of digital transformation. The increasing reliance on data-driven decision-making demands advanced analytics, enabling companies to react more effectively to market shifts. Accounting information systems have evolved, becoming more sophisticated and functional with the introduction of Enterprise Resource Planning (ERP) systems. These systems enhance efficiency across departments by supporting planning, budgeting, forecasting, and financial reporting, ensuring data consistency and operational effectiveness. Effective leadership is also essential in ensuring that management teams and employees successfully navigate these changes. Strong leaders foster a culture of innovation, adaptability, and collaboration, enabling teams to integrate new technologies and methodologies. Successful leadership in a digitalized world requires agility, strategic vision, and clear communication, ensuring teams remain motivated and aligned with organizational objectives.

Keywords: *Leadership, accounting, management, teams and teamwork, decision-making.*

1 INTRODUCTION

Teamwork presents various challenges due to the diversity in employees' personalities, skills, and experiences. However, strong leadership plays a pivotal role in turning these differences into strengths, fostering collaboration and efficiency. In today's dynamic business environment, successful company management requires continuous adaptation, relying on precise and timely data, with accounting serving as a crucial source of information.

Address of the corresponding author:
Dragan Milačić
milacicdragan@gmail.com

Managerial decisions are strongly influenced by accurate financial and operational data, making accounting indispensable in guiding business strategy. As the business landscape evolves, accounting has transcended its traditional role, becoming a key component in managerial decision-making. With the advancement of information technologies, financial and management accounting now integrate the concept of "controlling," serving as an essential mechanism for overseeing and optimizing business operations.

The rapid digital transformation, alongside the implementation of AI and ERP systems, has significantly reshaped management processes. These technologies enhance efficiency, streamline decision-making, and enable proactive financial planning. This paper analyzes the evolving role of management accountants, the impact of digital solutions on leadership dynamics, and the essential tools for navigating modern business challenges. By examining these aspects, the paper offers a comprehensive perspective on strategic management in the digital era.

2 TEAM MANAGEMENT LEADERSHIP TECHNIQUES

A leader employs various strategies to manage their team, including motivation, rewards, and influence. To effectively implement management strategies, a leader must understand their work environment and tailor their approach to fit the unique dynamics of the team (Milačić, 2025).

Motivation is the fundamental force that drives human actions, guiding and sustaining goal-oriented behavior. It shapes how individuals act and has been a topic of extensive study among many authors. Motives initiate human activity, direct it in a certain direction, and maintain it until the goal is achieved. Leaders and researchers have long sought the answer to a fundamental yet crucial question: what drives human activity? (Milačić, 2025). Uncovering this answer would be invaluable for leaders, enabling them to more effectively motivate their teams and drive both organizational success and individual growth.

In addition to discovering the content of the needs that drive people's activity, leaders and researchers have always been interested in the question of the motivation process and how human activity is triggered. Therefore, we will try to explain the mechanism or process of motivation. The presentations are organized into key contributions to the theory of motivation, specifically focusing on two groups of motivation theories: the content theory and the process theory of motivation. (Vesić, 2010) states that motivation is one of the most important topics in leadership. The reason for this is straightforward: organizations achieve their goals by ensuring that employees and leaders effectively perform their roles. Employee and leadership performance is driven by three key factors: the ability to perform, the opportunities available to perform, and the will or motivation to perform.

The ability of employees to achieve performance is achieved through their education and on-the-job training. The company's organizational structure enables employees to reach their full potential in performance. An employee may have the necessary competence, and the organization may provide the right conditions, yet all of this becomes meaningless if they lack the motivation to perform. Motivation can be defined as the process of initiating, directing, and maintaining human behavior toward a specific goal. The fundamental mechanism of motivation is based on three elements: need, drive, and reward (Armstrong, 2001).

Organizational success relies on the efficient performance of all participants, particularly leaders and employees. For work to be truly effective, individuals must be motivated, engaged, and aligned with the organization's goals, ensuring their efforts are directed toward productive outcomes. Therefore, it is essential to motivate team members and all employees to work towards achieving the desired goals. In principle, human behavior is directed toward achieving certain goals. This means that individual behavior is most often goal-oriented, and this fact must be considered when influencing individuals' behavior and motivating them to achieve organizational goals. For individuals to be directed toward achieving organizational goals, the organizational goals must be aligned with their individual goals, so that meeting their individual goals also means attaining the organizational goals.

Organizational success depends directly on the level of employee motivation. To achieve the maximum level of employee motivation, leaders must understand the needs and driving forces of the people they manage and know how to ensure their satisfaction. Ensuring high levels of productivity and creativity in employees over the long term and in a stable manner heavily depends on employee satisfaction. (Beke-Trivunac, 2014)

Salaries and reward models have a strong motivational character in work efficiency. Therefore, this topic remains highly relevant, compelling organizations to adopt thoughtful, strategically aligned reward policies. The reward system—which encompasses salaries, various incentives, advancement methods, and the broader domain of human resource management—plays a key role in organizational functioning.

An adequate reward system enhances employee satisfaction and motivation, encouraging both knowledge creation and sharing. Knowledge management requires (Nešović, Balaban, & Župljanin, 2019):

1. Identifying, creating, presenting, and distributing knowledge in the organization.
2. Creating an incentive environment within the organization that will promote the creation and transfer of knowledge.
3. Sharing knowledge.

Manipulation is a leader's technique, which he uses to manage and influence his team members. A leader develops manipulative skills throughout life through interactions with others. In each successful manipulation, the leader's skill is further improved. Failed attempts at manipulation influence future efforts to persuade or exert control. Manipulation is defined as the leadership of a mass of people in a direction that is important for the leader to achieve the goal.

Team building emerged in the early 1980s in the United States, becoming a hallmark of the evolving capitalist economy. Today, every strong company in the world regularly organizes team building for its employees. Team building serves to foster collaboration among colleagues, strengthen their sense of belonging to the organization, and cultivate trust throughout the organization.

Brainstorming is defined as a group problem-solving technique that involves the spontaneous generation of ideas by all team members, as well as the process of idea creation by one or more individuals to solve a specific problem. This method gained widespread recognition through Osborn's book *Applied Imagination* (1953). He began developing the concept of "creative problem-solving" in 1939 while working in marketing, noticing the difficulty employees had in independently generating innovative ideas for advertising campaigns.

3 MANAGEMENT ACCOUNTANT'S ROLE IN DECISION-MAKING

Making business decisions increasingly relies on accounting information, which holds both internal and external strategic value. The key role of management accountants lies in their ability to collect, analyze, and interpret data, supporting investment decisions, risk management, budgeting, the development of strategic initiatives, and broader decision-making processes (Suljović, 2024). Their expertise enables executives, business owners, and corporate boards to make optimal choices based on precise financial insights.

Using accounting data, management accountants conduct analyses to forecast trends, prepare budgets, evaluate business performance, and develop strategic plans, which they present to senior management for decision-making. Additionally, they identify opportunities for improvement, manage financial operations, and ensure regulatory compliance (Suljović, 2024).

A management accountant oversees financial systems and supervises bookkeepers and data processors (Malinić, 2013). To operate effectively, they must possess a deep understanding of economics and essential communication, analytical, and persuasive skills. Their primary function is to assist executives in making informed and effective decisions regarding investments, operational structure, and risk management.

The evolving business environment has transformed the role of management accountants, shifting their focus towards external orientation, teamwork, and strategic alignment with corporate objectives. Changes in economic conditions have prompted a reevaluation of traditional

management accounting, with modern management accountants playing an active role in value creation, organizational processes, and the execution of strategic initiatives (Lalević, 2007). Their informational output now serves multiple departments, including engineering, marketing, and cross-functional teams, ensuring a broader impact across the organization.

As expert advisors and team leaders, management accountants play an increasingly active role in designing and managing information systems, serving as key contributors to internal control and information management. Their role extends beyond traditional financial reporting, incorporating external data sources for comprehensive financial and operational assessments. Consequently, businesses emphasize the development and implementation of advanced management accounting techniques, including activity-based costing, target costing, life cycle costing, kaizen costing, and quality costing. These modern methodologies address the limitations of conventional accounting systems, ensuring cost efficiency throughout the product life cycle.

In the face of ongoing economic shifts, information has become a powerful asset in business decision making. Management accounting now serves as a vital strategic tool that directs company operations by responding to external market impulses. Modern business leaders recognize the value of accounting data in project planning, performance control, cost-benefit analysis, revenue management, and internal and external communication (Lalević, 2007).

Management accountants now take on diverse roles, including business analysts, strategy formulators, internal consultants, change agents, information sources, team leaders, information system designers, and performance measurement specialists. Their broad expertise allows them to bridge gaps between departments, making them an indispensable part of corporate leadership. Due to their extensive knowledge across various disciplines, they serve as the "eyes and ears" of top management, uniquely positioned to oversee company-wide operations (Lalević, 2007).

Finally, contemporary business dynamics necessitate the strategic involvement of management accountants within organizations. As integral members of executive teams, they are expected to anticipate market changes, implement technological innovations, and optimize company databases and information systems to enhance competitive advantage (Žarković, 2025).

4 IMPACT OF NEW TECHNOLOGIES ON MANAGEMENT ACCOUNTING

The rapid advancement of new information technologies has profoundly transformed the way organizations and individuals operate, significantly enhancing various business activities, including accounting (Rupić, 2022). Modern technology has become an integral component of every organization, streamlining processes and reducing the time required for management teams to make crucial decisions. Automation and digitization accelerate the flow of information to end users, enabling more informed decision-making. In today's business landscape, building and sustaining an effective accounting system is nearly unfeasible without the integration of modern technologies, as digital transformation is a fundamental global trend shaping corporate operations (Damerji, 2021).

With the continuous evolution of information technologies, numerous software solutions have emerged, becoming essential tools for accountants. These advancements have not only improved efficiency but also fostered greater innovation and creativity in accounting practices (Rupić, 2022). A major milestone in Serbia was the adoption of the Law on Accounting (Official Gazette of the RS, 73/2019 and 44/2021), which requires legal entities and entrepreneurs to issue accounting documents exclusively in electronic form, secured with an electronic signature. This legislative change marks a significant step forward in the digitization of financial reporting and compliance.

In modern accounting, cloud computing and blockchain technologies are increasingly utilized, providing enhanced security, transparency, and accessibility. The integration of artificial intelligence (AI) has introduced groundbreaking tools for financial analysis, transaction processing, and decision support. AI-driven predictive

analytics, for instance, leverage historical data to generate accurate business forecasts, assisting businesses in strategic planning. Moreover, AI plays a crucial role in automating invoice processing, reducing human error, and improving overall efficiency. As a result, accountants are compelled to continuously update their knowledge and skills to keep pace with evolving technological demands.

The digital revolution has also drastically shortened the time required for data application, enabling accountants to generate detailed financial reports with unprecedented speed and accuracy. AI's ability to process vast amounts of information minimizes errors in financial records and enhances compliance with regulatory standards (Agostino, 2021). Looking ahead, AI's role in accounting is expected to expand further, integrating deeper predictive analytics, advanced financial planning tools, and autonomous accounting systems capable of handling complex tasks with minimal human intervention (Ivy, 2020). Technological advancements have a greater impact on the accounting profession than on most other fields. Research suggests that accounting is among the top professions poised for full automation and digitization over the coming years, with many traditional processes expected to be replaced by sophisticated software solutions. Large multinational corporations already rely on cutting-edge technologies for optimizing business functions, and auditors benefit greatly from automation in areas such as audit planning, risk assessment, and financial compliance.

Prominent accounting firms such as KPMG and PwC have conducted surveys of business organizations' interest in adopting paperless accounting systems, ensuring system uniformity, and integrating external software interfaces. Most respondents expressed a willingness to embrace these technological shifts, recognizing the efficiency and accuracy gains associated with digital transformation. The evolution of accounting has been heavily influenced by enterprise information systems, which synchronize various business operations and align them with financial management functions.

Enterprise Resource Planning (ERP) systems play a vital role in modern accounting, connecting different organizational functions through a centralized database (Menon, 2019). The global ERP market is dominated by SAP, Oracle, and Microsoft, with these companies offering advanced solutions tailored to the needs of various industries.

In Serbia, while international ERP providers maintain a strong presence, domestic IT firms also contribute to system development based on specific user requirements. While state and public institutions tend to favor globally recognized ERP solutions, private businesses often opt for locally developed platforms that cater to their unique operational demands (Spasić, 2014).

The future of accounting will be shaped by continued digital innovation, compelling accountants to adapt and refine their roles within an evolving technological framework. The integration of AI, cloud-based solutions, and blockchain technology will drive accounting toward heightened precision, efficiency, and strategic financial insight, reinforcing its importance in modern corporate decision-making (Lehner, Ittonen, Silvola, Eva, & Wuhrleitner, 2022).

5 ERP SYSTEMS IN MANAGEMENT DECISIONS

In today's rapidly evolving market, managers must make critical decisions that strike a balance between speed and accuracy, ensuring effective outcomes while minimizing risks. Resource planning plays a crucial role in this process, and modern businesses heavily rely on Enterprise Resource Planning (ERP) systems to streamline operations and enhance efficiency.

ERP solutions have become indispensable in contemporary business management, automating essential processes and improving decision-making. These systems allow users to access real-time business information, providing instant insights into the current state of operations. By leveraging ERP, companies can optimize their workflows, shorten response times, and make well-informed decisions that drive productivity and growth (Menon, 2019).

At its core, ERP integrates business functions, connecting various departments and stakeholders through a centralized database. This seamless interaction ensures that data remains easily

accessible and up to date, reducing information transfer delays and increasing operational efficiency. By automating routine tasks and enhancing strategic planning, ERP systems empower organizations to maintain competitiveness in an ever-changing business landscape.

The foundation of an ERP system is its integrated database, which centralizes the company's business process data and transactions, making them easily searchable and accessible from any location. Once entered, the data is recorded across all relevant business functions, significantly reducing the time needed to share information (Ivanović, 2021). ERP connects business functions with their users, serving as a platform that integrates people, processes, and technologies across the enterprise — ultimately delivering significant cost savings.

The key driver for the development and implementation of ERP systems is the recognition that companies lose their competitive advantage in the global economy if the information is stored in separate modules and different computer systems. The widespread adoption of ERP systems in corporate operations began in the early 21st century. Since then, these systems have evolved, shifting focus toward Internet-based solutions that enable access to system resources at any time and from any location. The improved ERP system goes a step further, given that the system is focused on Internet-oriented solutions and that new technologies have appeared (collections of applications that are organized into functional areas, i.e., modules), new modules such as Supply Chain Management (SCM), Customer Relationship Management (CSM), Sales Force Automation (SFA), Advanced Planning and Scheduling (APS), Business Intelligence (BI) and electronic business (e-Business). The ERP system integrates a wide range of business processes into a single information platform, designed to optimize operational efficiency. Beyond recording business events and transactions, it also supports planning, simulation, and decision-making at operational, tactical, and strategic levels, utilizing data generated from its database to assist company leadership (Ivanović, 2021).

The application of an expanded ERP system has significantly improved the work of management accountants. It has streamlined data collection, making the process faster and more efficient. Additionally, it has reduced the time required to prepare financial plans and generate periodic reports for management. At the same time, the system has increased the frequency and variety of periodic reports, enhancing the overall reporting process. In addition, the expectations of the ERP system are aimed at the easier application of modern management accounting techniques such as Activity-Based Costing (ABC), Target Costing (TC), and performance measurement frameworks like the Balanced Scorecard (BSC) and other similar methodologies. Moreover, the implementation of the ERP system is expected to impact on employees involved in internal reporting by reducing the time needed for data collection, while simultaneously increasing the time available for data analysis and managerial decision-making.

According to research results (Dropulić, 2020), the implemented ERP system significantly supports business monitoring through key financial indicators, such as profitability, liquidity, indebtedness, asset turnover, and cash flow. Additionally, it enables tracking both quantitative and qualitative metrics at various levels—departments, segments, individual markets, and products—while also enhancing the development of business plans and simulations. The implementation of the ERP system has had a partial effect on improving the collection of data used for internal reporting by managers, specifically enhancing its coverage and timeliness. Additionally, it has significantly increased the accuracy of data gathered from both society and the environment. The ERP system has had a substantial effect on internal management reporting, particularly enhancing the reporting processes for both top management and lower-level management. The research also revealed that the ERP system has a partial influence on the preparation and control of the financial plan.

The ERP system showed a partial impact on the implementation of modern management accounting techniques in the research, receiving an average rating. However, a more significant influence was observed in specific techniques, such as target cost management and performance measurement systems. The implementation of the

ERP system significantly reduced the time employees spent collecting data for internal reporting (Dropulić, 2020).

Based on research conducted in Serbia regarding the implementation of ERP systems, it was concluded that in the last decade, the largest application of ERP systems was observed in the electronic industry, followed by administrative and support services, and slightly less in accommodation and food services. The ERP system is used the least in construction, wholesale and retail trade, transport, and storage (Knežević, 2015). According to research (Malinić, Todorović, & Jovanović, 2012) on the application of ERP systems in management accounting in domestic practice, the application of this new technology in accounting increased work efficiency. It also helped reduce the time management accountants need to complete their tasks.

Over the past two decades, particularly in the context of entrepreneurship and corporate development, ERP systems have emerged as a significant and transformative innovation. Lutovac (2012) identifies three key components through which ERP enhances team connectivity and organizational efficiency:

1. Integration. ERP enables centralized data access, reducing informational barriers between departments. For example, the sales team can monitor real-time inventory levels and align their activities with production and procurement, improving coordination and minimizing risk.
2. Automation. Digital technologies accelerate routine tasks such as payroll, inventory control, and reporting. By minimizing manual work, ERP systems free employees to focus on strategic activities.
3. Analytics. Advanced ERP tools generate deep insights into performance. When combined with artificial intelligence, they enhance forecasting and support data-driven decision-making.

Beyond internal operations, ERP systems have become central to digital commerce and enterprise-wide process automation. The global ERP market continues to expand—driven largely by advances in technologies such as generative AI.

6 CONCLUSIONS

A successful organization is built on strong human resource management, with teamwork serving as its foundation. The ability to cultivate and organize employees effectively determines the company's capacity to achieve long-term success. To ensure optimal performance, team leaders and their deputies must possess exceptional leadership and communication skills, enabling them to guide, motivate, and coordinate teams while fostering collaboration among employees, business partners, and stakeholders.

Effective leadership goes beyond simply overseeing operations. It involves creating a cohesive and adaptable team culture, encouraging innovation, and maintaining open lines of communication within the organization. Regular team meetings and strategic discussions with partners strengthen business relationships and enhance overall efficiency, allowing companies to respond effectively to evolving challenges.

It is not enough to only establish theoretical frameworks for team development. These principles must be systematically implemented in daily operations to ensure sustained success. A well-organized team actively applies key management strategies, transforming potential into tangible results. Leadership is a crucial factor in connecting strategy with execution, ensuring that both individual and collective efforts align with the company's vision.

Organizations must continuously adjust their structure to meet the demands of an ever-changing business environment. Whether responding to external economic shifts or internal operational needs, adaptability is the key to maintaining competitiveness. Businesses that prioritize human resource development and place their employees at the center of their strategy empower teams to drive innovation, productivity, and long-term sustainability.

A dynamic, well-structured organization invests in its people, values collaboration, and fosters a growth environment, ensuring that employees and management are prepared for current and future challenges.

A well-functioning organization relies on high-quality human resource management and is

structured around the principle of teamwork. The team leader, as well as his deputies, should possess highly developed leadership and communication skills that will enable team management as well as conduct regular meetings with the team, partners, and others. and others. It is also possible to successfully form a team and implement all the important elements that do not have to remain just in theory but can be systematically applied in practice and become a significant factor in a successful business. Every organization should shape its structure so that it is ready to adapt to the challenges of its environment (near or far) at any time. It is essential to prioritize the organization itself and its human resources. The challenges facing the accounting profession are reflected in the need for rapid adaptation and transformation of organizational practices and processes, without compromising fundamental accounting principles and standards.

We have seen that teamwork is the core of a successful business. When teams are connected and function as a cohesive unit, the organization achieves better results and adapts more quickly to market changes. The ERP system helps to strengthen team synergy through better information management and automation of key processes. Companies are not only improving operational efficiency but also transforming their business culture.

A well-implemented ERP system plays a crucial role in helping companies maintain a delicate balance between data security and the seamless flow of information, ensuring they remain agile in an ever-evolving regulatory landscape. By integrating various business processes into a unified system, ERP enhances efficiency, reduces operational redundancies, and provides real-time insights that support informed decision-making. Beyond its technical advantages, an ERP system serves as a strategic cornerstone, empowering organizations to foster innovation, optimize resource allocation, and streamline workflows. As industries face increasing complexities and global challenges, this tool equips businesses with the adaptability needed to respond proactively to market shifts, regulatory changes, and emerging technological trends. With improved transparency and automation, companies can strengthen collaboration across departments, enhance customer experience, and build resilience to navigate future uncertainties with confidence.

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Received for publication: 31.05.2025
Revision received: 15.06.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Milacic, D., & Zarkovic, S. (2025, 07 15). The Role of the Management Accountant in Leadership Decision-Making Processes. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 177-186. doi:10.12709/mest.13.13.02.19

Style – **Chicago** *Sixteenth Edition:*

Milacic, Dragan, and Sonja Zarkovic. "The Role of the Management Accountant in Leadership Decision-Making Processes." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 177-186.

Style – **GOST** *Name Sort:*

Milacic Dragan and Zarkovic Sonja The Role of the Management Accountant in Leadership Decision-Making Processes [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 177-186.

Style – **Harvard** *Anglia:*

Milacic, D. & Zarkovic, S., 2025. The Role of the Management Accountant in Leadership Decision-Making Processes. *MEST Journal*, 15 07, 13(2), pp. 177-186.

Style – **ISO 690** *Numerical Reference:*

The Role of the Management Accountant in Leadership Decision-Making Processes. **Milacic, Dragan and Zarkovic, Sonja.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 177-186.

MEST Journal
DOI 10.12709/mest.13.13.02.13

STRESS MANAGEMENT AND GENERATION Y

Kiril Postolov
University Ss. Cyril and Methodius, Faculty of Economics, Skopje, North Macedonia
https://orcid.org/0000-0003-3966-5539

Boris Postolov
Renewable Energy Supply, Skopje, North Macedonia

JEL Category: **D91, I15, I31, J28, J81, M12, M54**

Abstract

Workplace stress is recognized as one of the most critical psychosocial risks in today's work environment, with profound implications for employee well-being and organizational performance. This paper provides a comprehensive examination of the concept of stress, drawing on historical and contemporary scientific perspectives, emphasizing physiological, psychological, and organizational dimensions. Theoretical foundations are analyzed through the work of Selye, Lazarus, Shapiro, Slavich, and others, alongside an exploration of predominant sources of occupational stress, including organizational, psychosocial, individual, and digital stressors. The article focuses on high-risk professions such as healthcare, education, information technology, and service sectors. Furthermore, the study investigates stress coping strategies, including professional training, teamwork, employee assistance programs (EAPs), flexible work arrangements, positive organizational culture, and supportive leadership. An original empirical study involving over 50 respondents examines generational, gender-based, and professional differences in stress perception and response and the influence of managerial support. The findings highlight the necessity for a systemic and integrated approach to stress management that transcends individual responsibility and promotes organizational and cultural transformation. The paper concludes with practical recommendations tailored to the Macedonian context to enhance psychological well-being and workplace effectiveness.

Keywords: *Occupational stress, organizational stressors, coping mechanisms, psychological health, human resource management*

1 DEFINITION OF STRESS

Work-related stress is a widespread phenomenon that can develop quickly into a chronic condition, given the vital role of work in modern life (Slater, 2004). Occupational stress is associated with reduced productivity, sleep disturbances, an increased risk of workplace accidents, and the development of both physical and mental health disorders.

The term *stress* was first introduced in the 1930s by Canadian endocrinologist Hans Selye, who used it in a medical context to describe the body's response to prolonged exposure to external stimuli. Selye (1956) defined stress as the general,

Address of the corresponding author:
Kiril Postolov
kiril.postolov@eccf.ukim.edu.mk

nonspecific response of the organism to any demand for adaptation. Rather than responding with a targeted physiological mechanism, the organism activates a broader set of biological reactions to cope with the stressor.

Richard Lazarus expanded the understanding of stress by shifting the focus toward psychological processes. According to his transactional model, stress is not solely a product of external stimuli or physiological reactions, but rather the result of an individual's cognitive appraisal of environmental demands (Lazarus, 1966; Lazarus & Folkman, 1984). Stress arises when an individual perceives that the needs of a situation exceed their available coping resources. The importance of this subjective interpretation in understanding workplace stress cannot be overstated, as individuals may perceive similar situations in vastly different ways.

Shapiro (2009) emphasized the psychological effects of stress and the role of emotional regulation and mindfulness as effective coping strategies. The modern work environment often imposes continuous cognitive and emotional demands, particularly in occupations requiring high levels of empathy and interpersonal engagement, such as healthcare or social work. These pressures frequently lead to emotional exhaustion and professional fatigue.

Slavich (2016) defines stress as a psychological state that arises when an individual perceives that environmental demands exceed their coping abilities, emphasizing the personal and dynamic nature of the perception of stress. Stress is understood as a psychophysiological reaction triggered by personal, professional, or social challenges that exceed one's coping resources.

Contemporary research further emphasizes the dynamic interplay between the individual and the environment, framing stress as an ongoing, interactive process (Cohen, Gianaros, & Manuck, 2016). This perspective highlights the necessity of continuing research and proactive stress management practices. It allows organizational leaders to treat stress not merely as an individual issue but as a systemic risk factor that can hinder productivity, employee satisfaction, and organizational resilience. Effective interventions can prevent the escalation of stress into burnout, absenteeism, or turnover, while fostering a healthier and more sustainable workplace environment.

2 ANALYSIS OF STRESS FACTORS

Employees' perceptions of stressful situations depend on their resources and social support network. Stress factors can be categorized into the following groups:

- Organizational factors
- Psychosocial factors
- Individual factors, and
- Digital (technological) sources of stress.

2.1 Organizational Stressors

According to Brough et al. (2017), organizational stressors include excessive workload, lack of autonomy, role ambiguity, and limited development opportunities. Empirical evidence suggests that a fast-paced work environment and unrealistic expectations contribute to chronic stress and reduced employee engagement. Additionally, organizational changes introduced without proper communication intensify employee pressure (Hakanen et al., 2022). Excessive workload increases the risk of emotional exhaustion and diminishes performance (Schaufeli, 2017).

A toxic organizational culture and poor leadership practices—especially authoritarian leadership—are associated with heightened stress and anxiety. Conversely, transformational leadership reduces stress levels and fosters organizational commitment. Uncertainty during periods of change or restructuring significantly elevates workplace stress (Wang et al., 2021).

2.2 Psychosocial Stress Factors

Psychosocial stressors include workplace conflicts, lack of social support, and disrupted work-life balance. The absence of social support from colleagues or supervisors fosters feelings of isolation and vulnerability (Giorgi et al., 2021). Interpersonal conflicts, particularly with supervisors, may lead to long-term psychological consequences such as anxiety and depression.

Perceived injustice, discrimination, and ineffective communication are strong occupational stress predictors. Modern work models—such as hybrid or remote work—while offering flexibility, may also increase stress due to blurred work-life

boundaries and lack of personal recovery time (Wang et al., 2021). Work-related stress and emotional exhaustion are particularly pronounced in highly competitive and profit-driven work cultures (Maslach & Leiter, 2016).

2.3 Individual Stress Factors

Individual stress factors relate to personal characteristics, cognitive appraisal, and coping abilities. Individuals high in neuroticism, with low self-esteem, or perfectionist tendencies are more susceptible to stress. According to Schaufeli (2021), self-critical individuals are at greater risk of experiencing strain.

Moreover, the perception of a stressor and the individual's coping capacity are crucial in determining stress intensity. Active coping strategies, such as planning and problem-solving, are associated with better psychological outcomes (Giorgi et al., 2021). Personal values, expectations, and one's physical and mental health status also modulate stress perception.

2.4 Digital Stressors (Technostress)

The rise of digitalization—accelerated by the COVID-19 pandemic—has introduced new sources of stress, commonly referred to as technostress. While digital tools enhance flexibility and productivity, they also contribute to psychological strain. Tarafdar et al. (2015) and Molino et al. (2021) identify several categories of digital stressors:

- Technological overload – constant notifications and multitasking lead to cognitive fatigue.
- Technological invasion – the boundary between work and private life becomes increasingly unclear (Wang et al., 2021).
- Technological complexity – digital tools can create frustration, particularly for those with limited IT skills.
- Technological insecurity – rapid technological changes may lead to fear of skill obsolescence.
- Technological surveillance – continuous monitoring affects employees' sense of autonomy and privacy (D'Arcy & Lowry, 2017).

3 PROFESSIONS PRONE TO STRESS

In recent years, rapid technological change, evolving job demands, and the emergence of new work models have significantly increased exposure to occupational stress. While stress was once associated with specific high-risk professions, it is now prevalent across various industries, including healthcare, education, technology, and services. Research since 2010 has demonstrated a direct link between occupational stress and mental health, as well as its impact on individual well-being and organizational performance (Eurofound & EU-OSHA, 2014; WHO, 2019).

The following sections outline professions most vulnerable to chronic work-related stress:

- Healthcare Professions: Chronic Pressure and Emotional Burden

  Healthcare workers, particularly during and after the COVID-19 pandemic, face persistent stress due to shift work, long hours, and emotional strain in patient care. Zhang et al. (2020) reported high stress levels among medical personnel in China, while Prasad et al. (2021) emphasized the heightened emotional stress experienced by women in healthcare. Prolonged exposure to such conditions often leads to professional overexertion, reduced work capacity, and mental disorders.

- Education Sector: Digital Transformation and Professional Overload

  In the education sector, the integration of digital technologies and increased administrative burdens contribute to cognitive and emotional overload. Day and Qing (2009) emphasized that teachers continuously engage in emotional labor, leading to decreased motivation and professional satisfaction. Pressley (2021) identified lack of resources, conflicts with parents and administrators, and technological overload as primary stressors. These factors severely affect teachers' mental health and job retention.

- **IT** and **Technology Professions: Cognitive Demands and Permanent Availability**

  Professionals in the IT and technology sectors are exposed to high cognitive demands and a culture of continuous availability. Tarafdar et al. (2015) observed that startup employees frequently experience intense pressure, which manifests as chronic stress and physical symptoms (e.g., headaches, muscle tension). Additionally, fear of missing out (FOMO) and rapid technological changes fuel anxiety and professional instability.

- **Service Sector: Emotional Labor and Customer Exposure**

  Workers in the service sector, including hospitality, finance, and customer service, are regularly exposed to stress due to frequent interpersonal interactions and emotional regulation demands. Grandey (2000) introduced the concept of emotional dissonance, where employees must display positive emotions despite internal fatigue, leading to psychological exhaustion. Low wages, insecure contracts, and customer aggression exacerbate these stressors. According to Zapf et al. (2001) and Hülsheger & Schewe (2011), such working conditions result in increased irritability, sleep problems, and high turnover.

- **Social and Helping Professions: Borderline Conditions and Burnout Risk**

  Professionals in social work, mental health, and counseling frequently engage with clients in crisis, exposing them to secondary trauma and empathic strain. Bride (2007) identified a high prevalence of vicarious trauma in these professions. The emotional demands and ethical challenges can lead to severe burnout and mental health deterioration. Continuous supervision, team-based support, and psychological resilience training are essential preventive measures.

4 SYNTHETIC AND COMPARATIVE ANALYSIS OF STRESS COPING STRATEGIES

Research conducted over the past three decades demonstrates a notable evolution in strategies for managing workplace stress. During the 1990s, interventions were predominantly individual-oriented and reactive, focusing on mitigating the consequences of stress after it had already manifested. Common methods included relaxation techniques, cognitive restructuring, and social support mechanisms.

After 2005, however, the focus shifted toward systemic and organizational approaches. These modern strategies take into account the broader context of organizational culture, leadership styles, and employee mental health, emphasizing prevention rather than reaction. They include practices such as flexible work arrangements, comprehensive well-being programs, and the use of digital tools to monitor employees' physical and psychological states (Khoury et al., 2015).

Among the most prominent contemporary strategies are mindfulness-based interventions, particularly Mindfulness-Based Stress Reduction (MBSR) programs, which have shown significant effectiveness in reducing stress and anxiety (Khoury et al., 2015). Similarly, Cognitive-Behavioral Therapy (CBT) has gained popularity in workplaces that implement structured mental health initiatives.

Employee Assistance Programs (EAPs) have evolved from offering fundamental counseling services. They are integrated platforms that include psychological support, coaching, and digital resources (Attridge, 2019). In parallel, flexible work models—such as remote work, reduced hours, and increased autonomy—have proven to improve work-life balance and decrease chronic stress.

The field of positive organizational psychology (Sullivan-Singh et al., 2015) has introduced new concepts, including organizational well-being, psychological capital, and a culture of recognition, all of which foster stronger individual and team capacities to cope with stress.

Emphatic leaders, who exhibit emotional intelligence and open communication, contribute significantly to psychological safety and reduce organizational tensions, play a critical role.

Contemporary models, unlike classical theories such as those by Selye or Lazarus, perceive stress as a systemic, dynamic phenomenon. The Job Demands-Resources (JD-R) Model (Bakker & Demerouti, 2007) emphasizes the equilibrium between job demands and available resources as essential for stress management. Although Lazarus's cognitive appraisal theory remains influential, modern approaches have expanded to incorporate biopsychosocial and organizational dimensions.

In conclusion, stress coping strategies have evolved from individual and reactive responses to systemic, proactive, and integrated approaches. A sustainable strategy for managing occupational stress now requires a foundation built on mental health culture, empathetic leadership, organizational flexibility, and psychological support systems.

5 RESEARCH METHODOLOGY

The majority of the surveys were conducted online, enabling efficient distribution and access to a broader respondent base. This approach allowed the researchers to reach a larger sample within a shorter timeframe and at a lower cost. Moreover, online participation preserved respondent anonymity, which is known to enhance the likelihood of obtaining honest and accurate answers. To complement this, a portion of the questionnaires was distributed in person, ensuring greater diversity in responses.

Participant selection was based on the following criteria:

- Individuals born between 1981 and 1996 (Generation Y).
- Participants with academic-level education.
- This sample size ensures that the requirements for reliability, representativeness, and statistical relevance are met. It also provides a balanced approach between data accuracy and participant availability. Finally, the sample is also limited by time and financial constraints.
- The questionnaire consisted of two parts, with a total of 14 questions:
  - Part 1 included four demographic questions regarding gender, education level, age group, and work experience.
  - Part 2 explored participants' attitudes toward effective stress management. This section utilized a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to assess opinions on various workplace stress coping mechanisms.

The first table presents the demographic characteristics of the respondents, including gender, education level, age group, and work experience, and is displayed as Table 1.

Table 1. Demographic Characteristics of the Respondents

Category	Subcategory	Frequency (N)
Gender	Male	29
	Female	25
Education Level	Bachelor's Degree	45
	Master's Degree	7
	Doctorate (PhD)	2
Age	Under 25	25
	26–31	14
	32–37	4
	38–43	9
	Over 43	2
Work Experience	Up to 5 years	19
	6–10 years	28
	11–15 years	5
	Over 15 years	2

Source: Own research of the authors

The data from these demographic categories were used to gain a better understanding of the respondents' background and their potential influence on the perceptions of stress management within this generation.

Subsequently, we constructed Table 2 based on the collected responses and calculated the mean score for each statement.

Table 2. Selected Questions Related to Stress Management

No.	Statement	1	2	3	4	5	x̄
1	Stress is a nonspecific response of the organism to demands for adaptation to changing conditions.	1	2	8	11	32	4.31
2	Sources of stress include: organizational, psychosocial, individual, and digital factors.	0	0	5	20	29	4.44
3	The leadership style can be a potential source of stress.	0	0	1	15	38	4.69
4	Job enrichment is a source of stress.	20	20	14	0	0	1.89
5	A disrupted work-life balance is a source of stress.	0	0	0	10	44	4.81
6	Organizational conflict is a source of stress.	1	1	1	12	39	4.61
7	A high degree of perfectionism is a source of stress.	0	3	6	10	35	4.43
8	The most stress-prone professions include healthcare, education, IT, service, and helping professions.	5	10	5	15	19	3.61

Source: Own research of the authors

In the process of data collection through the survey, the responses were analyzed using descriptive statistics. For each question in Part 2 of the questionnaire, we calculated the mean score, which offered valuable insight into the general attitudes of respondents toward stress management. This statistical method enabled us to identify trends, recurring patterns, and notable variations across the responses. These findings will be further elaborated in the subsequent sections of the paper. Notably, the final two questions were specifically designed to examine perceptions of contemporary stress management approaches, such as the promotion of mental health culture and the implementation of flexible working practices. The results for these questions are visually represented in Charts 1 and 2.

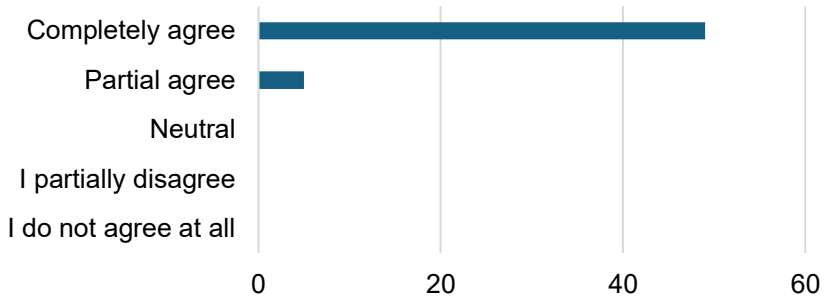

Chart 1. *Mental health culture, leadership, flexibility, and psychological support as the foundation for effective professional stress management*

Source: Own research of the authors

Chart 1 presents the four foundational pillars for effective management of professional stress: the cultivation of a mental health-oriented culture, supportive leadership practices, organizational flexibility, and the provision of psychological support. These elements are closely interrelated, collectively fostering an environment conducive to early recognition and effective mitigation of stress. A strong mental health culture encourages openness, leadership behavior models support

and empathy, flexibility enables employees to balance demands more effectively, and psychological services offer essential interventions. Together, they contribute to enhanced employee well-being and organizational resilience.

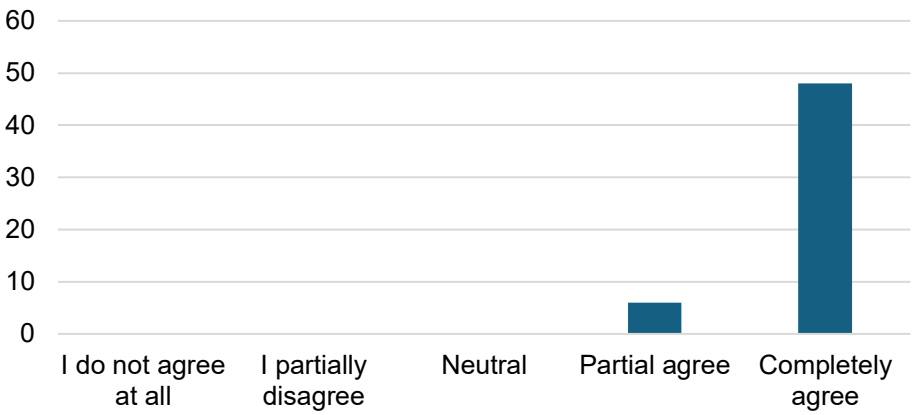

***Chart** 2. Flexible work arrangements (remote work, reduced hours, autonomy) contribute to better work-life balance and reduction of chronic stress.*

Source: Own research of the authors

Chart 2 demonstrates the role of flexible work arrangements, such as remote work, reduced working hours, and increased autonomy, in fostering a healthier work-life balance. These practices enable employees to better manage their personal and professional responsibilities, thereby mitigating chronic stress.

6 RESULTS AND INTERPRETATION

The analysis of the collected data yielded several significant insights into respondents' perceptions of professional stress and its underlying causes.

The highest average score ($\bar{x}$ = 4.81) was attributed to the item concerning disrupted work-life balance, identifying it as the most dominant source of stress. This finding aligns with contemporary research emphasizing the impact of the digital era and the "always-on" culture, which contribute to chronic overload, emotional fatigue, and erosion of personal boundaries.

High mean scores were also recorded for questions addressing leadership style ($\bar{x}$ = 4.69), organizational conflict ($\bar{x}$ = 4.61), and psychosocial and digital stressors ($\bar{x}$ = 4.44). These results underline the significance of interpersonal dynamics, organizational climate, and adaptive management in increasingly digitalized work environments.

An unexpected outcome emerged from the question related to job enrichment ($\bar{x}$ = 1.89), which had the lowest average rating. This suggests that increased responsibility is not perceived as inherently stressful. Rather, stress arises in the context of inadequate support, poor leadership, and disproportionate workloads without appropriate recognition or compensation.

Graphs 1 and 2 further illustrate the respondents' prioritization of mental health, empathetic leadership, flexible working hours, and psychological support as essential components of effective stress management strategies.

A strong mental health culture, characterized by open communication and the destigmatization of mental health issues, emerged as an influential factor. Supportive and empathetic leadership was also found to significantly contribute to a positive work environment. Organizational flexibility enables employees to better balance professional and private responsibilities, while access to psychological support enhances individuals' resilience to stress. These findings highlight the need for an integrated approach encompassing all these dimensions to effectively manage workplace stress.

Chart 2 emphasizes the importance of flexible work arrangements in improving work-life balance and reducing chronic stress. Remote work, reduced working hours, and increased autonomy allow employees greater control over their time and tasks, directly contributing to lower stress levels and higher overall job satisfaction. The results confirm that flexible work models have long-term positive effects on both individual well-being and organizational performance.

7 RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

1. Promote flexible work models, including remote work, adjustable working hours, and employee autonomy in decision-making, to support work-life balance and mitigate long-term stress exposure.
2. Foster emotionally intelligent leadership through training programs focused on empathy, active listening, and early recognition of stress symptoms, enabling managers to offer timely and appropriate support.
3. Cultivate a mental health culture by initiating internal awareness campaigns, ensuring access to psychological counseling, and providing regular training in stress management techniques.
4. Minimize organizational conflict by establishing transparent procedures, encouraging team collaboration, and applying mediation strategies to resolve interpersonal misunderstandings.
5. Regularly review job roles and responsibilities to ensure that job enrichment promotes personal and professional growth rather than contributing to overload, thereby enhancing motivation and resilience.

8 CONCLUSION

Workplace stress is a multidimensional phenomenon that emerges from the dynamic interplay between individuals, their work environment, and the broader socio-economic context. An examination of theoretical models—from Selye's biological approach, through Lazarus and Folkman's cognitive-appraisal theory, to contemporary psychosocial frameworks proposed by Shapiro, Slavich, and Cohen—reveals that stress is not merely a reaction to external demands but a complex process shaped by perception, coping resources, and contextual adaptation.

The study confirms that professional stress is particularly pronounced in emotionally intensive and high-demand occupations such as healthcare, education, information technology, and service industries. Stressors such as limited autonomy, poor communication, ambiguous roles, and digital overload were found to significantly affect employees' mental and physical well-being, as well as organizational effectiveness.

Empirical data from 54 respondents emphasized the role of social support, competent leadership, and access to professional development as protective factors. In this regard, contemporary stress management must be both holistic and context-sensitive. The integration of mental health initiatives, flexible work arrangements, emotional intelligence development, and a supportive organizational culture constitutes not only a reactive but also a proactive approach to workforce resilience.

Ultimately, effective stress management transcends individual coping mechanisms; it necessitates collective commitment, cultural change, and strategic human resource practices aimed at sustaining workplace health and long-term organizational success.

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Received for publication: 21.04.2025
Revision received: 06.05.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Postolov, K., & Postolov, B. (2025, 07 15). Stress Management and Generation Y. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 187-196. doi:10.12709/mest.13.13.02.13

Style – **Chicago** *Sixteenth Edition:*

Postolov, Kiril, and Boris Postolov. "Stress Management and Generation Y." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 187-196.

Style – **GOST** *Name Sort:*

Postolov Kiril and Postolov Boris Stress Management and Generation Y [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 187-196.

Style – **Harvard** *Anglia:*

Postolov, K. & Postolov, B., 2025. Stress Management and Generation Y. *MEST Journal,* 15 07, 13(2), pp. 187-196.

Style – **ISO 690** *Numerical Reference:*

Stress Management and Generation Y. **Postolov, Kiril and Postolov, Boris.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 187-196.

MEST Journal
DOI 10.12709/mest.13.13.02.12

INFLUENCE OF PRODUCT QUALITY ON CONSUMER PERCEPTION WHEN CHOOSING A SPORTS BRAND

Snezana Ristevska-Jovanovska
Ss. Cyril and Methodius University, Faculty of Economics, Skopje
https://orcid.org/0000-0003-1019-0218

JEL Category: **M31**

Abstract

This paper examines the impact of product quality on shaping consumer perception when selecting a sports brand. The research investigates three key aspects: the intrinsic quality of the product, its origin, and the innovation incorporated into its design. A quantitative survey was conducted with 174 valid responses, collected between January and March 2024 in the Republic of North Macedonia, providing a detailed analysis of consumer perceptions of various sports brands in the market. The results, validated through applying the Kruskal-Wallis test, reveal statistically significant differences in brand evaluations. Notably, brands that maintain consistent quality and integrate innovative features are more likely to secure consumer trust and foster loyalty. Moreover, the study emphasizes the importance of authentic brand presentation and high product standards as drivers of positive consumer experiences. This research significantly contributes to brand management theory and provides practical recommendations for market positioning strategies. Its insights are valuable for academics and practitioners, aiming to enhance competitiveness in today's dynamic business environment. These findings underscore the need for sports brands to innovate while maintaining high quality, ensuring they meet consumer demands in a competitive marketplace. This overview establishes the theoretical foundation for the research, which will examine in detail the key aspects of product quality and its impact on consumer perception.

Keywords: *Quality evaluation, Brand awareness, Product, Consumer perceptions, Sport brand, Quality evaluation*

1 INTRODUCTION

Product quality is a key factor in shaping consumer perceptions and influencing purchasing decisions, particularly when choosing sports brands (Keller, 2013). High-quality products are often associated with trust, reliability, and satisfaction. That strongly impacts consumer preferences. When consumers perceive a brand's products as high-quality, they are more inclined to choose the specific brand over competitors. This perception is influenced by product performance, durability, and overall value. In the sports market,

Address of the author
Snezana Ristevska-Jovanovska
snezanarj@eccf.ukim.edu.mk

brand recognition and reputation play a significant role in consumer behavior. A brand with consistent high-quality product offers will likely establish strong consumer loyalty and increase its market share. Consumers are more inclined to trust and choose familiar, high-quality brands, which leads to repeated purchases and positive word-of-mouth recommendations (Kotler & Armstrong, 2008). As research shows (Cheng-Han, Chien-Lung, & Kuo-Kuang, 2016; Ching-Jui, Wen-Hua, Chin-Hua, & Ya-Yi, 2016), the implementation of integrated branding strategies that combine product quality with virtual experience and consumer perceptions is confirmed by examples from leading brands such as Clinique (2021), Covergirl (2021), and Eucerin (2021), while further analyses of brand associations and positioning (Delgado-Ballester & Hernández-Espallardo, 2008; Distility, 2021; Dubey & George, 2012; Gomoescu, 2016; Guettler, 2017; Hamerman & Johar, 2013; Junghyun & Eun Ah, 2016) underscore the complexity of branding strategies that are crucial for fostering positive consumer perceptions in today's competitive business landscape. Ultimately, product quality helps shape consumer attitudes, forming the foundation for favorable perceptions and preferences. By consistently offering high-quality products, sports brands can build lasting relationships with consumers and secure their position in a competitive market.

Quality - is a cornerstone of consumer satisfaction and loyalty. It encompasses tangible and intangible aspects, such as durability, functionality, and user experience (Aaker, 2016).

Perceived Quality: Zeithaml (1988) highlights that perceived quality influences consumer preferences more significantly than objective quality measures. When products meet or exceed expectations, they create positive associations that encourage repeat purchases (Ching-Jui et al., 2016).

Consistency: Consistent quality across product lines and customer interactions reinforces reliability and trust. Brands that maintain ambitious standards are more likely to build loyal customer bases.

Innovation: In competitive markets, quality is often linked to innovation. Products incorporating new features or technologies stand out and are perceived as superior, further enhancing reputation. In conclusion, understanding and effectively managing the quality of the product is essential for influencing consumer perceptions. Businesses integrating these elements into their strategies are better positioned to attract, satisfy, and retain customers in a competitive marketplace.

Sports brands prioritize two key components of brand awareness: (Keller, 2013)

1. **Brand Recognition**: The ability of consumers to identify the product through its visual or auditory elements, such as the Nike swoosh or Adidas's three stripes. This recognition is often driven by consistent exposure across multiple Rand retail displays.
2. **Brand Recall**: The consumer's ability to remember the product when thinking about sports-related products like running shoes, jerseys, or gym equipment. This is influenced by how well a brand's marketing efforts resonate with its audience and the emotional connections it fosters.

When these elements are strong, sports brands enjoy a competitive edge, as consumers naturally gravitate toward them for their reliability and association with athletic excellence.

2 RESEARCH METHODOLOGY

For this study, research was conducted to compare the sport Brand **D** (in the following text **D**), with its competing brands, Brands A (in the following text **A**), Brand B (in the following text **B**), Brand C (in the following text **C**), Brand E (in the following text **E**), and Brand **F** (in the following text **F**), All these brands are present in the sports market in North Macedonia. A questionnaire was distributed to 190 respondents, 183 of whom were qualified to answer the questionnaire, and 174 provided valid responses. The respondents were asked to rank these brands based on their level of satisfaction.

Respondents rated them using 1-to-5 scale (1 = unsatisfactory, 5 = excellent). The analysis is supported by a stacked bar chart that visually compares the percentage ratings across key satisfaction categories.

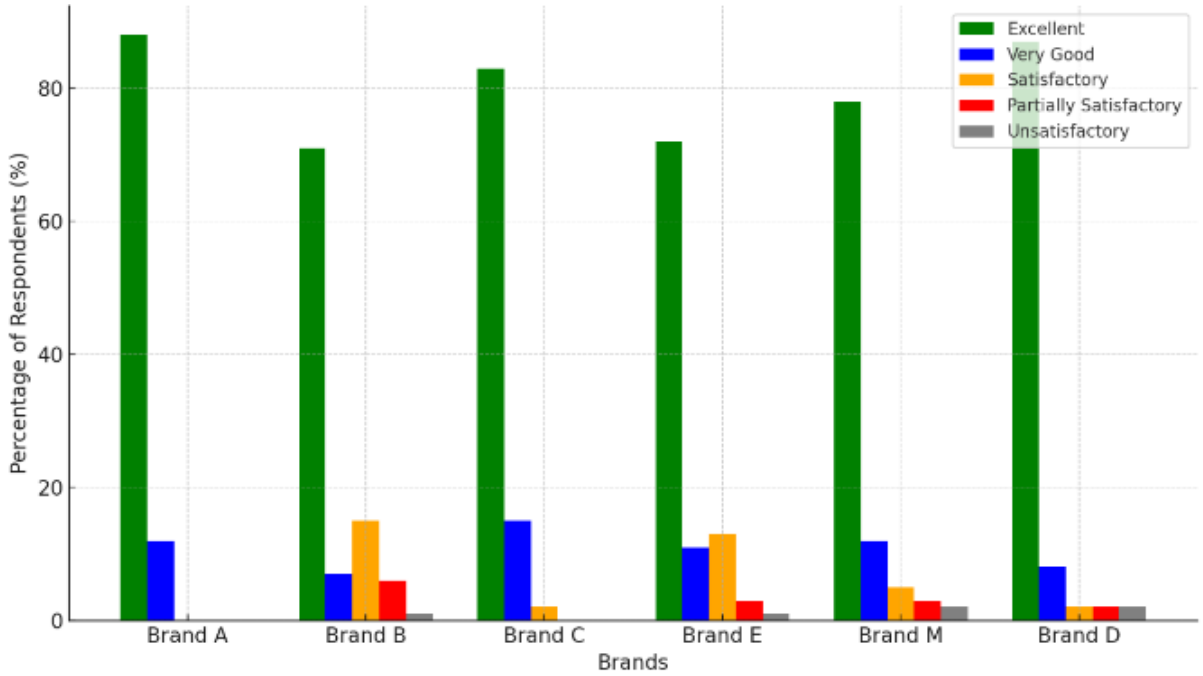

Fig. 1 Consumer Rating of Different Sports Brands

Source: Author's research

A was rated as excellent by 88% of the respondents, and 12% rated it as particularly good. No respondents rated it as satisfactory, partially satisfactory, or unsatisfactory, indicating an elevated level of trust in this brand. **B** was rated as excellent by 71% of the respondents, 7% rated it as particularly good, 15% as satisfactory, 6% as partially satisfactory, and 1% as unsatisfactory. **C** was rated as excellent by 83% of the respondents, 15% as particularly good, 2% as satisfactory, and no one rated it as partially or unsatisfactory. **D** was rated as excellent by 72% of the respondents, 11% as particularly good, 13% as satisfactory, 3% as partially satisfactory, and 1% as unsatisfactory. **E** was rated as excellent by 78%, 12% as very good, 5% as satisfactory, 3% as partially satisfactory, and 2% as unsatisfactory. **F** was rated as excellent by 87% of the respondents, 8% as particularly good, 2% as satisfactory, 2% as partially satisfactory, and 2% as unsatisfactory. As a starting point for this study, primary quantitative data were used, which were obtained through a structured questionnaire. The respondents were contacted electronically and asked to complete the online questionnaire. The respondents expressed their views and opinions about selected sports in comparison to the competing brands in the sports market of the Republic of North Macedonia. The research was conducted from January 2024 to March 2024. The questionnaire used in the survey included questions about three quality factors, (such as product quality, product origin, and product design) that are explained through the activities they encompass. First, the respondents were asked to rank these criteria on a scale from 1 to 5 based on their importance, and then they were asked to rate each sports brand on those criteria. Afterward, using the Kruskal-Wallis test, an analysis was made to determine if there were statistically significant differences in the respondent's perceptions regarding the six brands for each group (factor) individually (Kruskal, & Wallis,1952).

In Table 1 it can be seen that the majority of respondents are female, i.e., 79% of the respondents, and only 21% are male. In terms of age, it can be seen that 64% of the respondents are between the ages of 18 and 30, 21% are between the ages of 31 and 60, and only 15% are over the age of 61. Regarding the financial situation of the respondents, 41% have an income of up to 40,000 dens, 35% have an income of 40,001 to 60,000 dens and 24% have a monthly income of over 60,000 dens.

Table 1. Sample Structure

Gender	Number of Respondents	% of Respondents
Male	37	21%
Female	137	79%
Age		
18-30	111	64%
31-60	37	21%
60+	26	15%
Monthly Income MKD		
Up to 40 000	71	41%
40001 to 60000	61	35%
Over 60000	42	24%
Total Number	**174**	**100%**

Source: Author's research

Table 2. Respondents' perceptions of the importance of factors when deciding on a sports brand

	Questions	Importance
	Quality factors	**4.485**
1	Product quality (composition)	4.715
2	Product origin	4.353
3	Product design	4.387

Source: Author's research

The research was conducted based on 2 groups of factors: Situational and communication satisfaction factors and their influence on consumer perceptions when choosing sports brand. Consumers first rated the importance of factors when deciding on a sports brand on a scale of 1 to 5, with one being the least important and five being the most important. The most important factor for sports users from quality factor is product quality (composition) with an average importance of 4.485. The next are Product design and Product origin with an average importance of 4.387 and 4.353 respectively.

According to data on the positions, **A** is best positioned in terms of product origin with an average value of 4.493 followed by product quality with an average value of 4.398, and product design with an average value of 4.327. **B** is best positioned in terms of product origin with an average value of 4.198 followed by product quality with an average value of 4.099, and product design with an average value of 4.368. **C** is best positioned in terms of product origin with an average value of 4.387, followed by product design with an average value of 4.368, and product quality with an average value of 4.298. **D** is best positioned in terms of product quality with an average value of 4.376 followed by product origin with an average value of 4.352, and product design with an average of 4.343. **E** is best positioned in terms of product quality with an average value of 4.103 followed by product origin with an average value of 4.017, and product design with an average value of 4.016. **F** is best positioned in terms of product design with an average value of 4.601, followed by product origin with an average value of 4.31, and product quality with an average value of 4.159.

Table 3. Consumer perceptions of individual groups of factors by brands

Questions	Brand A	Brand B	Brand C	Brand D	Brand E	Brand F
Product quality	4.398	4.099	4.298	4.376	4.103	4.159
Product origin	4.493	4.198	4.387	4.352	4.017	4.313
Product design	4.327	4.023	4.368	4.343	4.016	4.601
Quality factors	**4.406**	**4.107**	**4.351**	**4.357**	**4.045**	**4.358**

Source: Data from the conducted research

All six brands are well-perceived in terms of the quality factors of their products. The Kruskal-Wallis test was applied for each factor individually to determine whether there were statistically significant differences in perceptions between the six brands. The results of the calculations are shown in Table 3.

Positioning is determined based on three key factors: (1) product quality, (2) product origin, and (3) product design. According to product quality (Composition), **A** is positioned in first place with an average value of 4.398, followed by D in second place with an average value of 4.376. In third place is **C**, which has an average value of 4.298, and in fourth is **F**, with an average value of 4.159.**E** is

positioned in fifth place with an average value of 4.103 and then follows the last, in position number six, **B** with an average of 4.099.

According to product origin (Table 3), **A** is positioned in first place with an average value of 4.493, followed by **C** in second place with an average of 4.387. In third place is **D** with an average value of 4.352. In fourth place, with an average value of 4.313, is **F**. **B** is positioned in fifth place with an average value of 4.198, and then follows the last, in position number six, **E** with an average value of 4.017.

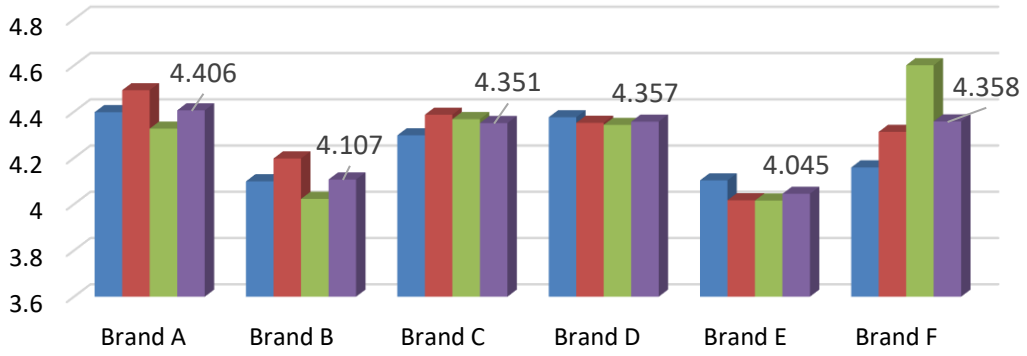

Fig. 2 Rating for Different Sports Brands

Source: Author's own research

According to product design as the third factor (Table 3), **F** is positioned in first place with an average value of 4.601, followed by **C** in second place with an average value of 4.368, in third place is **D** with an average value of 4.343, in fourth place is **A** with an average value of 4.327. **B** is in fifth place with an average value of 4.023, followed by the last, in position number six, **E**, with an average value of 4.016.

Table 4. Differences in perceptions of quality factors – Kruskal-Wallis test results

	Brand	Mean value for all companies	Mean value	Mean rank	Kruskal-Wallis test
1	A	4.271	4.406	387.4	0.01113
2	B		4.107	322.3	
3	C		4.351	367.4	
4	D		4.357	387.4	
5	E		4.045	325.5	
6	F		4.358	383.7	

Source: Author's research

Furthermore, the test results indicate an absence of statistically significant differences in consumers' perceptions regarding the quality factors of individual brands (Table 4). The significance threshold should be explicitly stated to provide clarity regarding statistical relevance. In this study, the Kruskal-Wallis test yielded a p-value of 0.01113. Given that the commonly accepted threshold for statistical significance is $\mathbf{p < 0.05}$, this result indicates that the differences in consumer perceptions across the analyzed brands are statistically significant and unlikely to have occurred by chance.

In terms of these factors, consumers perceive **A** best (4.406). Immediately after it, with a minimal difference, are **F** (4.358) and **D** (4.357). Then comes **C** with a score of 4.351, and finally, the worst-rated are **E** (4.045) and **B** (4.107). The respondents' perceptions regarding the quality factors for **A**, **F**, **D**, and **C** are higher than the average perception of these factors for all brands (4.271). According to the data on quality factor positioning, **A** holds the top spot, indicating it is perceived as having the highest quality among the six brands. **C** and **D** closely follow; however, **D** is rated slightly higher than **C**, suggesting that consumers have marginally greater confidence in its quality attributes. **F** is positioned at a level comparable to **C** and **D**, reflecting a similar overall quality performance.

In contrast, **E** and **B** are evaluated as the lowest, which implies that they are seen as having inferior quality relative to the others. This evaluation delineates a clear hierarchy in consumer perceptions: while several brands perform well, **A** emerges as the leader, whereas **E** and **B** lag, indicating significant opportunities for quality improvement. The analysis results set the stage for the next section, which will present the main conclusions and offer target recommendations for enhancing market strategy.

Table 4 encapsulates the quality perceptions for six sports brands, assessed through three key parameters:

- *Mean Value* parameter represents the arithmetic average of the ratings given for each brand. For instance, **A** has a mean value of 4.406, indicating a high average quality rating.
- Based on the non-parametric Kruskal-Wallis test, the mean rank summarizes all individual ratings assigned to the brands. A higher mean rank (e.g., 387.4 for **A**) suggests that the ratings are consistently higher than those of others. Conversely, **B**, with a mean rank of 322.3 is perceived as having lower quality.
- *Kruskal-Wallis Test* ($p = 0.01113$, as shown for **C**) indicates statistically significant differences in quality perceptions among the brands.

Respondents perceive some brands (such as A, D, and F) as having higher quality, while others (like B and E) are rated lower. The Kruskal-Wallis test confirms that these differences are statistically significant and not due to random chance.

3 CONCLUSIONS

Companies should aggressively promote only one characteristic in the target market. Each brand should choose one attribute and position itself as "Number 1" for that attribute. Buyers tend to remember the market leader more easily, especially in a society overloaded with communication. **A** received the highest consumer preference score in our survey, with a mean rating of 4.406, positioning it as the top-performing brand in perceived quality. To maintain its leadership position, **A** should continue reinforcing its identity through sustained marketing efforts and consistent product innovation.

The promotion efforts for the so-called “medical sports brand” may be a key factor for achieving great success in the sports market. For **D** it is recommended to apply a differentiation strategy by emphasizing its superior product quality. Because **D** ranks second in product quality perception (4.376) and third in product origin perception (4.352), the brand can strengthen its position by highlighting its consistent quality standards and superior material composition. Differentiation helps the company to compete by creating a unique identity that resonates with consumers. If the brand does not differentiate itself, it will be perceived as like competitors and will have to rely on price-based competition.

A cost-based pricing strategy could also enhance **D**‘s market positioning. This approach would not require reducing prices for existing products but rather introducing a new product line with the same or slightly lower quality at a significantly reduced price point. For example, offering new products at 50% lower prices than existing premium products could expand the brand’s reach to a larger segment of consumers in the Republic of North Macedonia.

This dual-branding approach, maintaining an established premium line while launching an affordable alternative, would allow the company to attract more customers while sustaining the perceived exclusivity of its high-end offerings. Brands with lower consumer perception scores, such as E (4.045) and B (4.107), need strategic improvements to enhance their market standing. These brands should focus on improving product quality, investing in stronger branding, and considering competitive pricing models to attract more customers.

Market conditions should be continuously observed, analyzed, and responded to with appropriate management strategies. A well-developed marketing communication strategy, focusing on brand credibility, reputation-building, and consumer trust, will further enhance brand loyalty and long-term market success.

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Received for publication: 18.02.2025
Revision received: 06.03.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Ristevska-Jovanovska, S. (2025, 07 15). Influence of Product Quality on Consumer Perception When Choosing a Sports Brand. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 197-204. doi:10.12709/mest.13.13.02.12

Style – **Chicago** *Sixteenth Edition:*

Ristevska-Jovanovska, Snezana. "Influence of Product Quality on Consumer Perception When Choosing a Sports Brand." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 197-204.

Style – **GOST** *Name Sort:*

Ristevska-Jovanovska Snezana Influence of Product Quality on Consumer Perception When Choosing a Sports Brand [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 197-204.

Style – **Harvard** *Anglia:*

Ristevska-Jovanovska, S., 2025. Influence of Product Quality on Consumer Perception When Choosing a Sports Brand. *MEST Journal,* 15 07, 13(2), pp. 197-204.

Style – **ISO 690** *Numerical Reference:*

Influence of Product Quality on Consumer Perception When Choosing a Sports Brand. **Ristevska-Jovanovska, Snezana.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 197-204.

MEST Journal
DOI 10.12709/mest.13.13.02.16

MULTIAXIAL HIGH-CYCLE FATIGUE IN MODERN ENGINEERING: PERSPECTIVES AND CONTRIBUTIONS

Nikolay Tonchev
"Todor Kableshkov" Transport University, Faculty of Transport Management, Sofia, Bulgaria
https://orcid.org/0000-0002-9110-2488

Antoaneta Kirova
College of Management, Trade and Marketing, Sofia, Bulgaria
https://orcid.org/0000-0002-7799-423X

JEL Category: **C5, C6, D24, L23, O3**

Abstract

The process of modeling quality indicators from mechanical and simulation tests aiming to establish the fulfillment of specific technical requirements is linked to resource efficiency. Imposing such a modern approach in the design process increases the efficiency of the used materials' expected capacity. The proposed design enhances material strength while reducing structural weight, leading to lower fuel consumption and a corresponding decrease in greenhouse gas emissions. Its successful implementation relies on continuous research to identify innovative solutions and advanced computational approaches that expand existing knowledge and best practices. This paper presents a comprehensive review of multiaxial and multicycle fatigue, a critical factor in the design of essential components exposed to complex loading conditions. The purpose is to review and examine the current state of this type of testing, modeling approaches, experimental techniques, and current real-world applications in the fields of aerospace and automotive design. The aim is to draw the attention of engineers, researchers, and industry professionals working with high-performance materials and structures that study complex stresses.

Keywords: *High-cyclic fatigue, Resource efficiency, Neural modeling, Machine learning, Fatigue modeling.*

1 INTRODUCTION

The aim of this paper is to focus on the design of components under complex loading conditions (multiple forces from different directions simultaneously), and multi-axial and high cyclic fatigue from the automotive and aviation sectors.

Address of the corresponding author
Nikolay Tonchev
tonchev@vtu.bg

The defined task imposes several requirements on the design of components, as preventing safety-critical fatigue failures is critical for accident avoidance.

Weight optimization is crucial in the design process, as it directly influences material selection in the automotive sector. Fuel costs and environmental concerns play a key role in determining the choice of materials in automotive design. This interdisciplinary challenge integrates mechanical engineering, materials science, and computer modeling to address three main aspects: fatigue failure prevention, simulation-based optimization, and sustainable lightning.

Reducing aircraft masses decreases energy consumption during flights. Every eliminated kilogram of mass results in 106 kg of jet fuel savings per year and reduces greenhouse gas emissions in aviation proportionally. This relationship is a driving innovation, such as the development of carbon fiber-reinforced polymers in plane wings, thereby achieving a 15-20% weight reduction compared to aluminum (Pryanshu, 2023).

Modern components, such as aircraft landing gears and automotive axles, are subject to bending and torsional loads, requiring accurate models to predict fatigue life. Traditional approaches, such as Miner's rule and critical plane methods, remain fundamental; however, they have limitations in addressing variable amplitudes and complex stress conditions (Bin, Jianhui, & Xiuli, 2014). Recent advances include computational models that incorporate additional hardening effects and synergistic interactions between mechanical and control systems. For example, validated real-time simulation frameworks allow designers to test servomotor configurations under dynamic loads while maintaining numerical stability (Pineau, Gailletaud, & Lindley, 1996).

Galvorn carbon nanotubes replace copper cables (2-3% of the aircraft mass), offering significant weight reduction and a negative carbon footprint from manufacturing (-2.3 kg CO_2 e/kg). Another impact of Galvorn carbon nanotubes is that aluminum production emits 16.7 kg CO_2 e/kg; in contrast, advanced composites and Galvorn reduce this to ≤5 kg CO_2 e/kg. Reducing material waste by 30-50% through additive manufacturing in components such as turbine blades also decreases emissions. Making everything lighter offsets higher SAF (sustainable aviation fuel) costs by reducing fuel consumption per flight (DexMat, 2023).

The integration of mechatronic system modeling allows simultaneous optimization of structural, electrical, and control parameters. An example of waterjet cutting machines is demonstrated where a 69% weight reduction is achieved by optimizing the topology with improved manufacturing accuracy. This approach reduces development resources by 40-60% compared to sequential design methods while enabling multidisciplinary design exploration (Priarone, Catalano, & Settineri, 2023).

On the other hand, the manufacturing processes and the new materials (composites, additive manufacturing) mentioned above require knowledge of the existing methodologies to determine how the fatigue models will be updated. The high testing costs make accurate modeling particularly valuable in reducing development time and expenses. These results align with a simulation and optimization framework, integrated into the entire product life cycle, ensuring balanced performance, safety, and environmental goals. Current research is focused on hybrid optimization algorithms and machine learning to address these challenges while maintaining real-time simulation capabilities.

2 MATERIAL FATIGUE: THEORIES, MODELS & APPROACHES BY LOAD & CYCLES

2.1 Characteristics and Features of Low- and High-Cycle Fatigue

Low-cycle fatigue (LCF) occurs under elevated stress conditions, often exceeding the material yield strength, resulting in significant plastic deformation during each cycle. This permanent deformation is a defining characteristic of this fatigue mechanism. As a result, LCF typically leads to failure within a relatively small number of cycles, usually fewer than 10^4. That is due to the higher stress amplitudes and the resulting plastic strains. The LCF is analyzed using *E-N* (or *ε-N*), which includes both elastic and plastic strain components to predict fatigue behavior. The Coffin-Manson relationship is commonly used to

describe the behavior of materials under low-cycle fatigue (LCF) conditions, leading to microstructural changes such as crack propagation, mechanical work hardening, and strain concentration.

High-cycle fatigue (HCF) operates at stress levels much lower than the yield strength, involving predominantly elastic deformation. Materials subjected to HCF do not experience permanent changes in shape before failure. HCF is key in achieving a greater number of cycles to failure, often exceeding 10^5 cycles. Lower stress levels require more cycles to initiate and propagate cracks. HCF uses the "stress-life" (S-N) method, which focuses on the relationship between applied stress and the number of cycles to failure (refer to Table 1). This method emphasizes elastic behavior and uses S-N curves (Wehler curves). Failure in HCF results from the gradual propagation of microscopic cracks over time, without significant changes in the overall material structure. It is often initiated by surface imperfections or inclusions (Kim & Hwang, 2019).

Table. 1. Fatigue: Low vs. High Cycle

Aspect	Low-Cycle Fatigue (LCF)	High-Cycle Fatigue (HCF)
Stress Levels	High (near/above yield strength)	Low (below yield strength)
Deformation	Plastic deformation	Elastic deformation
Cycle Count	< 10^4cycles	> 10^5 cycles
Analysis Method	Strain–Life (E – N)	Stress–Life (S – N)
Material Behavior	Microstructural changes (plasticity)	Microscopic crack growth
Applications	Severe stress environments	Vibrations/rotating machinery

2.2 Approaches to High-Cycle Fatigue

The object of our study is high-cycle fatigue (HCF) under multiaxial loading. In the case where the modeling process is considered, based on experimental observations accompanied by theoretical justification, several key approaches are available. The main point is to predict the formation of macrocracks under the influence of cyclic stresses in the elastic regime. The equivalent stress criterion of Sines and Crossland, most used for HCF, integrates the shear stress amplitude with the hydrostatic stress.

Equation on Sines:

$$\sqrt{\frac{1}{3}[(\sigma_{1a}-\sigma_{2a})^2+(\sigma_{2a}-\sigma_{3a})^2+(\sigma_{1a}-\sigma_{3a})^2]} \leq$$
$$\leq A-\alpha(\sigma_{xm}+\sigma_{ym}+\sigma_{zm})$$

Crossland's criterion includes the maximum hydrostatic stress.

Balthazar and Malcher review various theories for predicting, emphasizing the importance of invariant stress measurement methods (Balthazar & Malcher, 2007).

In a study by Li and de Freitas (2002), a rapid procedure for assessing HCF under multiaxial random loading using Crossland's criterion for fatigue damage assessment is presented. Evidence supports the unified mechanics' theory for predicting HCF lifetime, which integrates principles of materials physics to model dislocation, damage accumulation, and macrocrack initiation.

Sandberg's dissertation (2015) examines the application of experiments, computational methods, and modeling in HCF design, emphasizing the importance of accurate material parameters and a fine FE mesh for reliable predictions. A comparative study validates the equivalent stress approach in the Crossland and Sines criteria, showing their effectiveness in predicting multiaxial fatigue limits (Tchoupou & Fosting, 2015).

The critical plane method identifies the plane with the greatest stress (usually a combination of normal and shear stress) and estimates durability. Models based on strains with predominantly elastic behavior, along with energy models that estimate dissipated energy per cycle as an indicator of resistance loss and failure, are applied in the analysis. (Wei, et al., 2019).

Hassan Alkarawi's research applied the critical plane method, considering various fatigue damage models, including the Fatemi-Socie and Bannantine-Socie approaches (Alkarawi, 2018). Energy-based models play a crucial role in assessing fatigue life. The statistical distribution of strain and fatigue life in the LCF-HCF range is analyzed in a paper by Coffin-Manson and Morrow, providing insight into the energy dissipation per cycle. (Tridello & Paolino, 2023).

To further clarify this point, experimental evidence shows that in non-linear failure accumulation, identical cyclic loads can result in different failure rates depending on the load history. An example of this is that a pre-stressed condition can reduce the number of cycles. It has been found that in the nonlinear accumulation of fatigue damage in aircraft engine alloys under multi-axial loading, the interaction between low-cycle fatigue (LCF) and high-cycle fatigue (HCF) cycles increases fatigue damage. (Suman, 2013).

A modified nonlinear fatigue damage accumulation model accounting for load interaction effects highlights the importance of nonlinear damage accumulation in fatigue life prediction. (Lv, Huang, Zhu, Gao, & Zuo, 2014)

Considering the influence of the average stress, at the same amplitude, on the stress with a positive average value, a faster accumulation of failures is achieved. The study of the pre-stress state on high-cycle fatigue (HCF) behavior and fatigue crack propagation in steel with a complex phase composition demonstrates how material fatigue resistance is significantly affected. (Kim, Song, Sung, & Kim, 2021) A pre-applied stress state can reduce the number of cycles, as demonstrated in a study on the stress recovery behavior of a shape memory Fe-Mn-Si alloy under HCF loading. This has been observed under failure conditions due to relaxation induced by phase transformation during cyclic loading (Ghafoori, Hosseini, Leinenbach, Michelis, & Motayalli, 2017) Multi-component loads, for variable amplitudes and phases, use combinations of Rainflow in identifying cycles, such as Miner's rule for accumulated failure: $D = \sum_{i=1}^{k} \frac{n_i}{N_i}$, where n_i is the number of cycles at a given stress level, and N_i is the life at that level (Sun, Wen, Li, Cao, & Fei, 2025).

Developments in computation approaches have produced advanced models for analysis and exploration, such as a combination of critical planes and energy criteria, for example, the Liu-Mahadevan model, which integrates normal, shear, and hydrostatic components:

$$\left(\frac{\sigma_{a,c}}{f_{-1}}\right)^2 + \left(\frac{\tau_{a,c}}{f_{-1}}\right)^2 + \beta\left(\frac{\sigma_{H,a,c}}{f_{-1}}\right)^2 = 1$$

where β is a material constant.

A limitation of this modeling approach lies in the material inhomogeneities, which influence crack initiation and are challenging to describe using macroscopic models. Therefore, the development of universal models remains an active area of research, especially for complex scenarios such as out-of-phase loads and random amplitudes. The Liu-Mahadevan model, on top of a unified multiaxial fatigue damage model, integrates components of normal, shear, and hydrostatic stresses, providing a comprehensive approach to fatigue life prediction (Liu & Mahadevan, 2005)

This case has been validated using experimental results for isotropic and anisotropic materials, demonstrating its general applicability. The microstructure of the material significantly influences the high-cycle fatigue (HCF) behavior through several key mechanisms, like grain size. Smaller grains (fine grain structure) improve toughness due to the Hall-Petch effect, where grain boundaries act as crack propagation barriers. For example, alloys with controlled grain size show higher fatigue resistance. A study of the high-cycle fatigue behavior of β-annealed Ti-6Al-4V alloy shows that smaller primary α-grains improve the resistance to HCF due to the increased yield strength (Jeong, Kwon, Goto, & Kim, 2017). Investigation of the very high cycle fatigue (VHCF) behavior of Ti-6Al-4V alloy highlights the role of microstructure in crack initiation and fatigue behavior (Yuan, Zhao, Yue, Gu, & Zhang, 2024)

The Hall-Petch effect is extensively documented in materials science. The grain boundaries act as pinch points that impede the propagation of dislocations, thereby increasing the yield strength. Studies on titanium alloys have shown that fine-grained lamellar microstructures exhibit better resistance to fatigue crack initiation and propagation compared to coarser-grained structures. Anisotropic materials with preferential grain orientation can form critical planes with increased stress, which accelerates cracking. Fatigue strength may improve in solid phases containing carbides or intermetallic compounds. There are exceptions, such as sulfide inclusions (MnS) in steels, which promote crack initiation under cyclic loading and act as stress concentrators. The non-uniform distribution of alloying elements (e.g., Mn, C) also leads to local changes in mechanical properties which influence

failure propagation. This applies to pores and microcracks, leading to the gradual formation and growth of larger cracks over time. Thermal or mechanical processing generates residual stresses in the microstructure that can accelerate or retard the accumulation of damage depending on their load orientation. The review of the effect of sulfide inclusions on the mechanical properties and failures of steel components is reviewed by Maciejewski (2015). The presence of sulfide inclusions in steel highlights their influence on the fatigue limit and crack propagation rate (Bigelow & Flemings, 1975)

Recrystallization alters the grain structure and phase distribution, and hardened steel with a martensitic structure exhibits a higher fatigue limit compared to pearlitic structures, which are typically formed after rolling. Martensite in steel significantly increases the yield strength and hence the fatigue limit of the material. Studies have shown that the ultrafine-grained ferritic-martensitic structure has a substantially higher fatigue limit than the coarse-grained ones. (Nikitina, Islamgaliev, Ganeev, & Frik, 2023). It has been observed that under cyclic loading, the ferrite-perlite structures accumulate defects more rapidly due to the uneven distribution of cementitious lamellae. Treatments aimed at producing bainitic structures reduce this effect due to the finer microstructure.

Mean stress plays a significant role in high-cycle fatigue (HCF), influencing the endurance limit and failure accumulation rate. This refers to mechanical stress, not electrical stress, and is defined as the mean value of the cyclic load. Its effects become evident through the following mechanisms.

For a uniform stress amplitude, a positive mean stress (e.g., tensile) reduces the material's durability. This is accounted for in classical fatigue models.

- *Goodman curve:*

$$\sigma_a = \sigma_{-1}(1 - \frac{\sigma_m}{\sigma_{UTS}})^2$$

where: σ_a - is the allowable stress amplitude, σ_{-1}- is the endurance limit of a symmetrical cycle, σm is the mean stress, σ_{UTS} - is the tensile strength

Goodman dependence is a widely used method in fatigue analysis to account for the impact of mean strain on fatigue life. It is often represented graphically in a Goodman diagram, which plots mean strain versus alternating strain. The Goodman diagram helps engineers assess the safe cyclic loading of a part by ensuring that the combination of mean and alternating stresses remains below the failure curve. Positive mean stress typically reduces fatigue life because it increases the effective peak stress experienced by the material, bringing it closer to the critical failure threshold. Understanding the relationship between mean stress and fatigue life is crucial for designing components that endure cyclic loading conditions.

- *The Gerber curve in fatigue analysis:*

$$\sigma_a = (1 - \frac{\sigma_m}{\sigma_{UTS}})$$

The Gerber curve is often used in fatigue assessment to account for the impact of mean strain on fatigue life. It is especially well-suited for materials exposed to cyclic loading. The comparison between Goodman and Gerber correction methods highlights the effectiveness of the Gerber curve for dealing with different mean stress scenarios, thus accounting for the nonlinear relationship between the mean stress and the alternating stress. The Gerber curve integrates both tensile strength and mean stress, offering a comprehensive approach to fatigue analysis. This makes it suitable for a wide range of materials and applications. The mean stress, however, can induce local residual stress in the material that alters the resistance to crack initiation. For example, under positive mean stress, dislocations move more easily, accelerating the formation of microcracks.

The influence of residual stress on crack initiation and propagation has been considered in detail in various studies, highlighting how positive mean stress can accelerate microcrack formation (Nakada, Norimitsu, Tanaka, Tsuchiyama, & Takaki, 2015)

In alloys with a heterogeneous phase structure (e.g., pearlitic steels), the average stress influences the stress distribution between ferrite and cementite, thereby modifying local ductility.

The Sines criterion is used in fatigue analysis to predict the lifetime of materials under multiaxial

loading. It combines the shear stress amplitude τa with the hydrostatic stress σ_H, which includes the mean stress. The criterion is expressed as follows:

$$\tau_a + \alpha\sigma_H \leq \beta$$

where α and β are material constants.

A comprehensive review of defect accumulation models for multiaxial fatigue testing, including all criteria considered to date, is also made (Meggiolaro, Pinho de Castro, & Miranda, 2009).

For a combination of normal and shear voltages, the average voltage is included in the equivalent voltage criteria. For example, in the heat treatment industry, controlling the mean stress by thermal processes (e.g., backwash) can improve durability by relaxing residual stress. In HCF calculations, engineers use mean stress correction factors to avoid conservative predictions.

The average stress is influenced by the microstructure of the materials. At positive mean stress, dislocations move more easily in the grains, which accelerates the formation of microcracks. The average stress can affect the orientation of the grains, which changes the local mechanical properties and fatigue resistance. In alloys with a heterogeneous microstructure, the mean stress can affect the distribution of stress between different phases, which changes the local ductility and resistance to crack initiation.

The presence of hard inclusions (e.g., carbides) in alloys can be affected by the average stress, increasing the probability of crack formation around them. It can induce residual stresses in the material that alter the microstructure and affect fatigue behavior.

In some materials, mean stress can lead to microstructural changes, such as the formation of martensitic structures in some alloys, which changes the mechanical properties.

3 ANNEXES AND CONTRIBUTIONS OF THE RESEARCH REVIEW

Since the study must have a focus, the task we have set ourselves in this review is to determine the relevance of fatigue damage prediction and optimization for the automotive and aviation industries in the current research encountered:

In both industries, complex loading conditions depend on components exposed to multi-axial loads, necessitating advanced fatigue prediction models. For example, research on fatigue life prediction in automotive applications highlights the importance of considering real-world loading scenarios that involve complex stress distributions and multi-axial forces (Agrawal, et al., 2023)

Studies of additively manufactured lattice structures in aerospace applications highlight the need for accurate fatigue failure models to ensure structural integrity under high-cycle fatigue regimes. (Colucia & De Pasquale, 2023).

It has already been noted that weight reduction is a priority in both sectors, requiring a precise understanding of fatigue behavior to avoid over-design. A study of steel-polymer plates for automotive fuel cells showed how topology optimization and material selection can reduce weight while maintaining structural performance (Anand, Mielke, Heidrich, & Xiangfan, 2024) To reduce the section while ensuring the same design stress, it is necessary to implement materials with relatively higher strength. (Tontchev, Zumbilev, Yankov, & Zumbilev, 2021). This problem requires a multi-criteria method of solving, the governing parameters being either the alloying elements (such as quantity and type) or processing parameters, and the quality indicator is the technologically innovative effect. The introduction of new materials, such as composites and additive manufacturing, necessitates the updating of fatigue models.

Studies of the fatigue behavior of CFRP materials reveal challenges under inconsistent loading conditions, highlighting the need for tailored predictive tools (De Giorgi, Nobile, & Palano, 2022) This involves subjecting CFRP specimens to cyclic loading to determine their fatigue life and damage progression. Testing may be performed under tensile, compressive, or flexural conditions. In these methods, temperature changes are used to detect fatigue failures and evaluate the stiffness reduction of CFRP materials. Delamination testing aims to measure the rate of delamination growth under cyclic loading. The fatigue limit for CFRP materials typically falls in the range of 50-70 % of their tensile strength, and the critical number of cycles averages about 3 million cycles.

The high costs associated with experimental testing make modeling extremely important for reducing development time and costs. The

aerospace industry uses digital mock-ups and simulation tools to optimize design processes and reduce costs, highlighting the value of predictive modeling (Dassault Systemes, 2025).

3.1 Inputs in Mathematical Modeling of High-Cycle Fatigue Using Regression Models

Mathematical modeling approaches for high cyclic fatigue (HCF) using regression models is an area in materials science and engineering that combines experimental data with mathematical approaches to predict component lifetimes. Modeling HCF is difficult because failure occurs at stress levels well below static failure thresholds, and microstructural features play a dominant role in crack initiation. There is significant statistical scatter in fatigue life data, and environmental factors can dramatically alter fatigue behavior. Regression models are used to establish mathematical relationships between input variables (stress amplitude, mean stress, frequency, temperature, etc.) and output variables (cycles to failure, probability of failure). These models can range from simple curve-fitting approaches to complex machine-learning algorithms. A detailed discussion of regression modeling techniques and their applications is presented below.

These models primarily use stress amplitude as the predictor variable and cycles to failure as the outcome. When multiple factors affecting fatigue life are considered, this approach may include different factors but may oversimplify nonlinear relationships in fatigue. In this case, it is modeled with nonlinear regression models, of which the more sophisticated include Gaussian process regression or neural networks.

New materials, such as composites and additive manufacturing (AM), are changing fatigue prediction models in the automotive and aerospace industries by introducing new challenges and requiring advanced computational approaches. Composite materials (e.g., carbon fiber-reinforced polymers) exhibit anisotropic properties, requiring fatigue models to account for directional dependencies. Enhanced series-parallel (ESP) constitutive models simulate composites by treating the fibers and matrix as parallel materials in the alignment direction and serial in the transverse directions, enabling accurate predictions of stresses and strains under multiaxial stress. Cumulative fatigue damage indices update component properties (e.g. stiffness degradation) layer by layer to predict residual strength in laminated structures (Salomon, Rastellini, Oller, & Onate, 2005).

Surface and defect parameters are integrated into the S-N curve models to constrain fatigue behavior. For AM 316L stainless steel, these parameters adjust the predictions based on the laser settings and subsequent machining (e.g. heat treatment) (Serjouei & Afazov, 2022)

3.2 Regression Models for HCF

Regression models aim to predict cycles to failure based on input variables such as stress amplitude, mean stress, temperature, and defect geometry.

A. Stress-Life (S-N) Curve Modeling

This classic approach fits experimental data to equations like:

1. *Basquin's equation*: $\sigma_a = \sigma_f'(2N)^b$, where σ_a is stress amplitude and N, cycles to failure.
2. *Power law relationships:* $log(N) = A - B \cdot log(\sigma)$.
3. *Stromeyer's equation:* $S = S_0 + (S_1 - S_0)e^{-\alpha N}$.

These models primarily focus on stress amplitudes as the predictor variable and are widely used for metals and alloys.

B. Multiple Linear Regression

This method incorporates multiple factors affecting fatigue life:

$$log(N) = \beta_0 + \beta_1(\sigma_a) + \beta_2(\sigma_m) + \beta_3(freq) + \beta_4(temp)$$

While simple, it may oversimplify non-linear relationships inherent in fatigue phenomena.

These models focus primarily on stress amplitude as a predictor variable and are widely used for metals and alloys (Zhou, et al., 2022).

Advanced nonlinear approaches include methods such as Gaussian regression, which effectively captures complex interactions between variables. In composite materials, moisture absorption can degrade matrix properties and reduce interfacial bonding, affecting life predictions. Regression

models must account for time-dependent environmental degradation. Symbolic regression combining domain knowledge with machine learning for interpretation and accuracy (e.g., defect geometry effects in AlSi10Mg alloys) (Yu, et al., 2023). Symbolic regression has been applied to predict HCF life in Laser Powder Bed Fusion (L-PBF) AlSi10Mg alloys. By integrating defect geometries (size, location, morphology), these models outperform traditional empirical approaches in accuracy and generalization. Neural networks encompass highly nonlinear behaviors, but in some cases may lack physical interpretation. Nonetheless, techniques such as polynomial regression or machine learning models (e.g. neural networks) address the complex relationships between input variables and fatigue life outcomes (Meeker, et al., 2024) Bayesian regression, (Bayesian methods) incorporate prior knowledge and update predictions based on new data, effectively managing fatigue life variability caused by inconsistencies in materials or environmental factors (Gibson, Roger, & Cross, 2023).

Material fatigue inherently involves scatter, best described by random effects models that account for variability in individual batches or test conditions by including both fixed effects (e.g., stress amplitude) and random effects (e.g., batch-to-batch variation). (Dong-Yoon & Yu, 2014). Probabilistic methods related to the Weibull distribution modeling the failure probability under cyclic loading belong to this group of methods (Karolczuk, Skibicki, & Pejkowski, 2022). Bayesian regression accounts for uncertainty in forecasts and random effects models incorporating variability in different batches or material types (Gu, Lian, Lv, & Bao, 2022).

In deriving reliable and adequate models in HCF for DM, it is necessary to ensure that a sufficient experimental qualitative sample supports model development. To verify the accuracy of predictions, validation should be performed using separate datasets. Uncertainty can be quantified by incorporating statistical variance into the forecasts using probabilistic methods. It should also be assessed whether the models are consistent with physical mechanisms or are purely empirical. The latter aligns with the application's scope, which is evaluated based on the model's limitations regarding material types, stress ranges, and impact environments.

By combining experimental knowledge with advanced regression techniques, reliable predictions can be achieved while effectively managing data variability. This approach integrates statistical and computational methods to account for inherent uncertainties, scatter, and nonlinear relationships. All of this is critical for safety-critical industries such as automotive and aerospace. This computational approach is resorted to for a well-defined problem with a small data sample. When the observations are in a larger volume, the use of machine learning algorithms is resorted to which have their advantages over traditional regression models for HCF. The regression techniques are summarized in Table 2.

Table 2. Summary of Regression Techniques

Methods	Advantages	Limitations
Stress-Life (S-N Curve)	Simple, widely used	Limited to a single-variable analysis
Multiple Linear Regression	Incorporates multiple factors	Oversimplifies non-linear effects
Symbolic Regression	Balances of accuracy and interpretability	Requires domain-specific knowledge
Probabilistic Models	Accounts for scatter	Computationally intensive

3.3 Machine Learning vs. Regression for HCF: Advantages

The main advantage of machine learning (ML) algorithms over traditional regression models for predicting high cyclic fatigue (HCF), consists in sampling data with many variables and improving prediction accuracy. The data variables can be elements of the material compositions in their compositions or parameters of the modes by which each sampled material was produced.

ML algorithms, such as neural networks and gradient boosting, are excellent at modeling nonlinear interactions between variables (e.g., voltage amplitude, temperature, frequency) that traditional regression models often simplify. This makes ML particularly useful for fatigue life prediction of materials with complex behavior, such as composites or alloys produced by additives (Singal, et al., 2013).

It has been shown that in engineering applications ML can identify subtle patterns in fatigue data that traditional models may miss, leading to more reliable predictions. (Koprinkova-Hristova & Tonchev, 2011). (Koprinkova-Hristova & Tonchev, 2012).

3.3.1 High Dimensional Data Processing

Traditional regression models struggle to process large datasets with multiple predictors or features. ML algorithms can efficiently process high-dimensional data by applying feature selection techniques (e.g., random forests or Lasso regression) to identify the most relevant variables. One application outside the technique domain of the method is referred to in the next work (Chowdhury, et al., 2023).

In contrast to deterministic regression models, machine learning techniques often yield probabilistic results, enabling the quantification of uncertainty. This is particularly valuable for HCF modeling, where the variability of fatigue life data is significant due to the heterogeneity of material and environmental factors (Singal, et al., 2013)

ML algorithms can integrate diverse datasets, such as experimental fatigue data, along with microstructural information or environmental conditions, resulting in a multidimensional analytical framework. This adaptability allows the creation of more comprehensive models than traditional approaches. ML automates the model training and optimization process, reducing the manual intervention required in conventional regression analysis. In addition, ML models are scalable and can be updated efficiently as new data become available ML algorithms provide advanced feature importance analysis, and information about the relative importance of input features (e.g., voltage amplitude versus average voltage). All of this helps researchers understand which factors have the greatest influence on fatigue behavior (Desai, Wang, Vaduganathan, Evers, & Schneeweiss, 2020).

While ML offers these advantages, it also has limitations, including the need for large data samples to enable effective learning. It may lack physical interpretation compared to regression models based on fatigue mechanisms. Computational intensity compared to simpler regression techniques. However, using strengths, ML algorithms are increasingly being adopted for advanced HCF modeling where traditional methods fail to address complexity and variability. Machine learning algorithms now allow real-time adjustments to fatigue testing parameters, reducing cycle times by up to 50% while improving fault detection accuracy. For example, high-performance systems combined with artificial intelligence analysis offer simultaneous evaluation of lightweight materials such as composites under different stress conditions. Specialized neural networks predict fatigue life for advanced composites and aluminum alloys, addressing challenges in automotive design. These models incorporate data from Digital Image Correlation (DIC) and Acoustic Emission (AE) sensors to map crack propagation. (Avevor, Adeniyi, Eneejo, & Selasi, 2024)

Physically Informed Neural Networks (PINNs) simulate multiaxial loading scenarios, reducing dependence on physical prototypes. This approach has reduced development costs by 30% in automotive component validation (Schneller, et al., 2022)

3.3.2 Contributions to Aerospace Engineering Related to Material Fatigue

The optimization of additive manufacturing for AI-driven models has refined the microstructural properties of Ti-6Al-4V alloys used in aerospace components, resulting in a 20-30% improvement in fatigue crack resistance. Grain orientation and cooling rate are optimized through machine learning. It is critical for turbine blades and airframe parts. In terms of design, artificial intelligence-driven bio-printed geometries reduce component weight by 15% while maintaining yield strength, facilitating the development of lightweight structures for space exploration applications (Awd & Walther, 2025).

A neural network trained on 250,000 finite element samples predicted fatigue failure in rocket fuel chambers with an average error of 6.8%, achieving results in 0.1 ms. It is 3,000 times faster than traditional finite element methods. Early NASA prototypes use neural networks to estimate fatigue damage in reusable rocket engines during operation, enabling adaptive load management.

Physically Informed Neural Networks (PINNs) determined embedding defect characteristics (size, position, morphology) into loss functions improves predictions for additively manufactured

Ti-6Al-4V alloys. PINNs reduce errors by 20-30% in high-cycle modes compared to purely data-driven models, A characteristic feature of PINNs is that they generalize better with limited experimental data, which is critical for expensive testing of aerospace composites. Fiber Bragg gratings (FBGs) and vibration sensors feed live data into neural models, enabling adaptive updates to in-flight fatigue lifetime estimates (Li, Sun, Tian, Huang, & Zhao, 2024). Machine learning models (e.g., AutoGluon) have been shown to extract fatigue curves incorporating defect statistics improving the reliability of selective laser-melted (SLM) titanium parts. Physically informed neural networks (PINNs) account for AM-induced defects (e.g., porosity, nonmelted particles) in Ti-6Al-4V and TA15 alloys, reducing prediction errors by 20-30% compared to traditional methods. Defect characteristics such as size and morphology are incorporated into the loss functions for physically consistent results (Liu, Gao, Zhu, He, & Xu, 2025), (Wang, Zhu, Luo, Niu, & He, 2023)

ANNs trained on a single composite (e.g., IM7/977) accurately predict fatigue life for new materials (e.g., T800/5245), reducing experimental costs (Mathur, Gope, & Sharma, 2007). Radial Basis Function Neural Networks (RBF-NN) predict fatigue crack growth in aircraft-grade aluminum alloys (e.g., 2024-T3, 7075-T6) with high accuracy, enabling proactive maintenance (Younis, Kamal, Younis, & Younis, 2021)

Machine learning plays a transformative role in optimizing material properties for high-cycle fatigue resistance, particularly in advanced manufacturing and critical engineering applications. It involves machine learning models analyzing huge datasets from ultrasonic fatigue tests and microstructural imaging to identify and refine grain orientation, phase uniformity, and defect distribution. Improved resistance to fatigue crack initiation and propagation is being monitored, with studies reporting a 20-30% improvement in fatigue life for critical components such as turbine blades and housings. ML algorithms play a crucial role in optimizing additive manufacturing parameters—such as temperature gradients and cooling rates—that influence microstructure evolution. This enables the production of titanium and aluminum alloys with customized fatigue-resistant properties, reducing design iteration cycles by over 50% and accelerating the development of safer and more durable components.

By accurately predicting fatigue thresholds and performance based on process parameters and microstructural characteristics, ML models significantly reduce the need for extensive physical testing. This is particularly valuable for additively manufactured materials where traditional evaluation methods are time-consuming and expensive. Deep learning and genetic algorithms facilitate the reverse engineering of complex, bio-inspired geometries for metamaterials. These ML-driven designs achieve up to 15% weight reduction while maintaining or improving yield strength and fatigue resistance, which is critical for aerospace and automotive applications (Awd, Saeed, Muenstermann, Faes, & Walther, 2024).

Table 3. A summary of the role of machine learning in determining material fatigue

Role	Impact
Microstructural optimization	Increases fatigue crack resistance by 20-30%
Optimization of process parameters	Reduces cycles of, controlling design by >50% and adjusts fatigue properties at high cycles
Predictive modeling	Minimizes costly physical testing and accelerates process development
Material design/ geometry	Enables lightweight, high-strength designs with up to 15% weight savings
Physics-based modeling	Improves the accuracy and reliability of predictions
Real-time monitoring	Improves manufacturing precision and consistency

Physical machine learning frameworks combine experimental data with first-principles models (e.g., fracture mechanics, cyclic plasticity) to provide robust, physically consistent predictions. This approach improves model explainability and reliability, bridging the gap between empirical and theoretical understanding. ML techniques enable real-time process monitoring and anomaly detection during manufacturing, ensuring consistent quality, reducing material waste, and improving structural integrity. Based on the study performed, summarized results are given in Table 3.

4 CONCLUSIONS

Despite the progress of AI models, there are difficulties in extrapolating beyond the ranges of training data. Positive experiences have been gained in the use of hybrid approaches combining physics models and transfer learning. Here, we highlight the contributions of AI and digitalization to fatigue testing in the aerospace industry. Neural networks enable ultra-fast and precise failure predictions for critical components. In the automotive sector, AI helps optimize design by reducing structural weight. Future research needs to address data shortage. While PINNs provide physically consistent results, explaining ANN decisions remains crucial for certification. Neural models transform aerospace fatigue analysis from reactive inspections to predictive, simulation-driven workflows – essential for extending component life in next-generation spacecraft and hypersonic vehicles. Machine learning enables the integration of intelligent, adaptive data processing systems into the design and testing stages, providing improved fatigue resistance, reliability, and efficiency in high-performance engineering sectors.

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Acknowledgments

This paper was prepared by two participants within the framework of the FABER Project CA23109 ("Fatigue Benchmark Repository"), under the COST Program (European Cooperation in Science and Technology).

Received for publication: 25.05.2025
Revision received: 15.06.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Tonchev, N., & Kirova, A. (2025, 07 15). Multiaxial High-Cycle Fatigue in Modern Engineering: Perspectives and Contributions. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 205-219. doi:10.12709/mest.13.13.02.16

Style – **Chicago** *Sixteenth Edition:*

Tonchev, Nikolay, and Antoaneta Kirova. "Multiaxial High-Cycle Fatigue in Modern Engineering: Perspectives and Contributions." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 205-219.

Style – **GOST** *Name Sort:*

Tonchev Nikolay and Kirova Antoaneta Multiaxial High-Cycle Fatigue in Modern Engineering: Perspectives and Contributions [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto: MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 205-219.

Style – **Harvard** *Anglia:*

Tonchev, N. & Kirova, A., 2025. Multiaxial High-Cycle Fatigue in Modern Engineering: Perspectives and Contributions. *MEST Journal*, 15 07, 13(2), pp. 205-219.

Style – **ISO 690** *Numerical Reference:*

Multiaxial High-Cycle Fatigue in Modern Engineering: Perspectives and Contributions. **Tonchev, Nikolay and Kirova, Antoaneta.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto: MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 205-219..

MEST Journal
DOI 10.12709/mest.13.13.02.18

PRESENTATION OF THE THREE PHASES OF CHINA-CEEC COOPERATION IMPLEMENTATION

Marko Vidnjevic
China-CEEC Innovation Cooperation Research Center, Ningbo University of Technology, PR China, University Alma Mater Europaea, Slovenia,

JEL Category: **F13, F15, O19, Q56, O33**

Abstract

The author reflects on his first experience in China in 2014, highlighting the World Trade Organization's (WTO) discriminatory treatment of China despite its membership since 2001. Over time, China has emerged as a key global trade player, notably after signing the RCEP (Regional Comprehensive Economic Partnership) agreement,which covers aproximately 30% of the world's GDP. At the 2021 China-CEEC summit, President Xi Jinping emphasized equal collaboration, balanced economic growth, and the significance of innovation. Trade between China and CEEC countries increased by 85% over nine years, with key projects like the Budapest-Belgrade railway underway. China is committed to green growth and digital transformation through the establishment of research centers and the promotion of sustainable energy. Cooperation in science and technology includes creating an innovative collaboration network linking research institutions and enterprises. A talent cooperation project fosters the exchange of high-level professionals between China and CEEC, with research centers coordinating resources and projects. Agreements with CEEC include infrastructure projects such as the Peljesac Bridge and support long-term partnerships. China continues to enhance its role in the international economic arena by focusing on sustainability, innovation, and interconnected development.

Keywords: *Xi Jinping, China-CEEC, WTO, Ningbo Innovation Cooperation Research Center, RCEP.*

1 INTRODUCTION

When the author first visited China in 2014 and attended a seminar entitled *WTO Rules and China's Approach*, organized by the Ministry of Commerce of the People's Republic of China, he did not clearly understand the seminar's purpose. However, with the benefit of hindsight, it has become evident. The author finds it difficult to reconcile the fact that, at that time, the World Trade Organization treated China in a way that undermined China's status. According to one of the lecturers, the WTO regarded China as a less developed country compared to other WTO members.

China became a WTO member in 2001. For comparison, several other CEEC member states joined in a similar timeframe, including Albania (2000), Croatia (2000), Estonia (1999), Latvia

Address of the author:
Marko Vidnjevič
marko.vidnjevic@almamater.si

(1999), Lithuania (2001), and North Macedonia (2003). (WTO, 2023)

China's entry into the WTO was a turning point in its economic rise, opening doors to global trade and accelerating its integration into international markets. With greater access to trading partners, lower borrowing costs, and a stronger position in global supply chains, China quickly became a dominant player. WTO membership also drove key reforms of liberalization, which led to an increase in foreign investment inflows (Kralj, Borsic, & Senekovic, 2022). This transformation fueled the rapid growth of companies like Huawei, Alibaba, and Lenovo, which leveraged China's expanding market access and economic modernization to compete head-on with established Western firms in technology and manufacturing.

At the seminar at that time, the organizers presented quite a few important and today very recognizable Chinese companies that benefited from China's entry into the WTO, among them Huawei, which is the leading technological company in the world in 5G mobile technology. As part of the seminar, participants visited Hainan Island, which was transformed into a free trade port after signing the world's largest free trade agreement in 2020. The signatories of the RCEP have a total of 2.2 billion inhabitants and generate around 30 percent of the global gross domestic product (GDP), so the trade agreement between them represents a major positive step forward for trade and investment in the region. Just 20 years after joining the WTO, China has risen so quickly that it is now able to write the rules of trade in the regional environment by itself, a point emphasized by Chinese Premier Li Keqiang at the signing of the agreement, where he stated that "the signing of the RCEP is not only a milestone in East Asia's regional cooperation, but also a victory for multilateralism and free trade" (CPPCC-China, 2020).

At the 2021 China–CEEC Summit, Xi Jinping, President of the People's Republic of China, praised the ongoing cooperation and outlined key guidelines for its future development. Among other points, he emphasized that nine years had passed since the launch of cooperation between China and the Central and Eastern European countries (CEEC) — a decision that, in his view, responded to the spirit of the times and aligned with prevailing development trends. (China-CEEC, 2024).

President Xi Jinping did not forget to mention that during the summit; countries are increasingly trying to fight against COVID-19. He said that in the face of such unprecedented challenges, countries must come together and respond with solidarity and coordination like never before.

2 PRESIDENT XI JINPING CCEEC SUMMIT SUMMIT ANALYSIS

The first was decision-making through consultation. All participating countries, regardless of their size, are equal partners in a cooperation mechanism that includes extensive consultation, joint input, and shared benefits. Driven by the belief that "*17 plus 1 can be more than 18,*" we have established a multi-dimensional cooperation framework led by a summit of leaders covering 20-plus sectors to ensure the participation of all CEE countries.

The second was ensuring equitable benefits for all participating partners. To make our cooperation more balanced, we have been striving for economic cooperation and cultural exchanges, giving equal importance to trade and investment, and making sure that the fruits of cooperation are shared by all countries and communities. Trade between China and the CEE countries is almost 85 percent higher today than nine years ago, and the growth of Chinese imports from the CEE countries is 22 percentage points higher than the growth of exports.

The third was promoting common development with openness and inclusion. Through mutual learning, we drew on each other's strengths, and through consultation and cooperation, we narrowed down differences and resolved disagreements. When cooperating, we followed generally accepted international rules and considered market principles, and the EU standards.

The fourth was achieving higher growth through innovation. With an innovative and pioneering spirit, we took early steps to explore the possibility of aligning interregional cooperation with Belt and Road cooperation. It made Central and Eastern Europe the first region where all countries signed Belt and Road cooperation agreements.

In 2020, overall relations between China and the EU made new progress despite the challenges caused by the pandemic. China-CEE cooperation is an integral part of China-EU relations, whose good progress means new opportunities for cooperation between China and CEE. (China-CEEC, 2024).

The summit was held during China's 14th Five-Year Plan for Economic and Social Development and the start of the country's renewed effort to develop a modern socialist society. And if we recall, China was faced with maintaining the stability of its industrial and supply chains that year. China was ready to cooperate with the countries of Central and Eastern Europe on vaccines. Until then, Serbia had received one million doses of vaccines from the Chinese company. In the latter vaccine development, cooperation took place between Hungarian and Chinese vaccine manufacturers.

The Technical University in Ningbo sent several packages of protective masks to Slovenia, as there was a chronic shortage. More. The same university previously provided instructions for protection against the SARS-CoV-2 virus, and Alma Mater Europaea was the first institution to translate and distribute this manual (the original editor of which was Prof. Tingbo Liang from China) throughout Slovenia. (AMEU-ECM, 2020)

Some key projects resulting from this cooperation include the Budapest-Belgrade railway line, a $2 billion initiative set to be completed by 2025. As the first Chinese–Hungarian development project implemented under EU regulations, it plays a strategic role in facilitating the faster transport of Chinese goods to Europe via Greek ports. The renewed railway line is also part of the broader Silk Road initiative, strengthening connectivity between Asia and Europe while supporting the EU's goal of shifting cargo and passenger transport to rail, reducing emissions, and improving logistics efficiency in the region (China-CEEC Custom Information Center, 2022).

Another key project under this cooperation is the E763 highway in Serbia, which was developed in partnership with China. The Preljina-Požega section, a €450 million investment financed through a loan from the Export-Import Bank of China, is a critical part of the highway corridor stretching from Belgrade to Montenegro. The project improves interregional connectivity, facilitates trade, and supports local economic development by attracting investors and revitalizing nearby towns and villages. Once completed, it will enhance Serbia's transport infrastructure while aligning with the broader Belt and Road Initiative, further strengthening ties between China and the region (China-CEEC, 2019).

Beyond large infrastructure projects, China-CEEC trade and investment ties have strengthened significantly over the past decade, with two-way investment reaching nearly $20 billion. In the first quarter of 2023 alone, China's direct investment in CEECs rose by 148 percent in annual comparison, reflecting growing interest from Chinese companies in sectors such as auto parts, home appliances, logistics, and energy. Trade between China and CEECs has grown at an average annual rate of 8.1 percent since 2012, with imports from CEECs increasing by 9.2 percent annually. The China-Europe freight train network has also expanded, with 16,000 trains operating in 2022, further enhancing connectivity. Poland, Hungary, and Slovakia have become key destinations, reinforcing China's role as a major trading partner for the region (Ministry of Science and Technology of the People´s Republic of China, 2023)

3 THOUGHTS AND SUGGESTIONS MADE BY PRESIDENT XI JINPING

During the 2021 summit, one of the key themes emphasized by President Xi Jinping was the fight against COVID-19 and the importance of strengthening trust through cooperation. He stated that the fight against the pandemic was the most urgent task for us. To complete this task, China would cooperate with CEE countries through solidarity, coordination, and cooperation. Our two sides could strengthen joint response and experience sharing on prevention and treatment, explore cooperation in traditional medicine, and strengthen public health and medical cooperation. It was emphasized that both sides should remain committed to open engagement, promote liberalization and facilitation of trade and investment, strive to build an open global economy and help move the global economy out of the shadow of the crisis as soon as possible.

Building on these priorities, he proposed to pursue high-quality Belt and Road cooperation while accelerating large-scale projects such as the Budapest–Belgrade Railway. At the same time, continued support for China–Europe Railway Express growth would help unlock the full potential of the partnership.

It was also stated that China would strive to establish a China–CIS Customs Information Center and a central customs clearance coordination point for countries along the China–Europe Land–Sea Expressway. Cooperation could also be explored on a pilot basis under the Smart Customs, Smart Borders, and Smart Connectivity initiative.

It was emphasized that both sides should strive for concrete results and increase the outcomes of cooperation that benefit both parties. Further efforts were encouraged to enhance mutually beneficial trade and investment cooperation, ensuring balanced and sustainable trade growth. China announced plans to import more than $170 billion worth of goods from Central and Eastern European countries over the following five years.

It was also proposed to strengthen business cooperation at the sub-national level and to continue developing China–CEE business cooperation demonstration zones and industrial parks in Chinese cities such as Ningbo and Cangzhou.

It was also stated that agricultural cooperation should be deepened to double the agricultural exports of CEE countries to China and increase two-way agricultural trade by 50 percent over the following five years.

Strengthening exchange and cooperation across culture, education, tourism, sports, media, and the press was identified as a continued priority, alongside fostering connections between think tanks, young professionals, and subnational entities. For that year, a new round of educational policy dialogue and consortium meetings for higher education institutions was scheduled, with additional support directed toward the founding of a university in Hungary by Fudan University.

It was highlighted that both sides should focus on green development and create future-oriented cooperation. To strengthen the green agenda, the China-CEE Green Development and Environmental Protection Year was presented as an opportunity to deepen exchanges and cooperation in the green economy, clean energy, and related fields.

The summit further highlighted the need to strengthen cooperation in science, technology, and innovation (STI). China proposed establishing a China–CEEC STI Research Center, organizing a China–CEEC Forum for Young Talents in Science and Technology, and publishing the 2020 China–CEEC STI Indicator Scorecard. It was also noted that various emerging business models could support expanded collaboration in the digital economy, e-commerce, and health sectors. Additionally, China expressed support for the development of a China-CEE dialogue mechanism on e-commerce cooperation and a China-CEE alliance in the public health industry. (Huo, 2022)

It is needless to emphasize that, already a year after the CCEEC 2021 summit, China has accelerated the implementation of the plan mentioned by President Xi Jinping. Among other things, the bridge to the island of Pelješac in Croatia was already opened in 2022 (China Daily, 2022), and the construction of the Belgrade (Serbia) - Budapest (Hungary) railway began. (China Daily, 2023)

The author wants to highlight an essential point raised by the Chinese President, the need to strengthen cooperation in science, technology, and innovation (STI). Given the significance of this topic, a dedicated chapter will be devoted to examining the operation of the China-CEEC STI Research Center. In this section, there will be also provided an overview of the Research Center's key activities, emphasizing its role in fostering collaboration and advancing STI initiatives.

In the first part of this chapter, the concept of cooperation of the Research Center with individual groups in CEEC and the method of communication will be presented. The second part of the chapter is dedicated to the presentation of operational content. For the final, the third part presents a concrete task carried out by a group of experts from Croatia, Bosnia and Herzegovina,

Serbia, and Romania, led by Prof. Dr. Goran Pavel Šantek from the University of Zagreb (Croatia).

4 WORKING MECHANISM FOR COLLABORATIVE INNOVATION NETWORKS

Collaborative Innovation Network is a regular multilateral innovation exchange and cooperation channel jointly supported and promoted by the competent science and technology authorities of China and CEE countries. It aims to exchange innovation cooperation needs and development plans in several key areas, create innovation cooperation opportunities, serve innovation cooperation among enterprises, research institutes, universities, and other institutions in China and CEE countries, and exploit the innovation cooperation potential between China and CEE countries.

It is proposed that the collaborative innovation network will be composed of three parts: national STI functional departments, working groups (in various fields), and coordinating groups (in different fields). The national STI functional departments are the innovation (or science and technology) authorities of the CEE countries. The coordinate group is appointed by each national STI functional department. The working groups are formed with selected and recommended members by the coordinating group among research institutions, universities, science academies, enterprises, clusters, technology transfer centers, incubators, science and technology parks, etc.

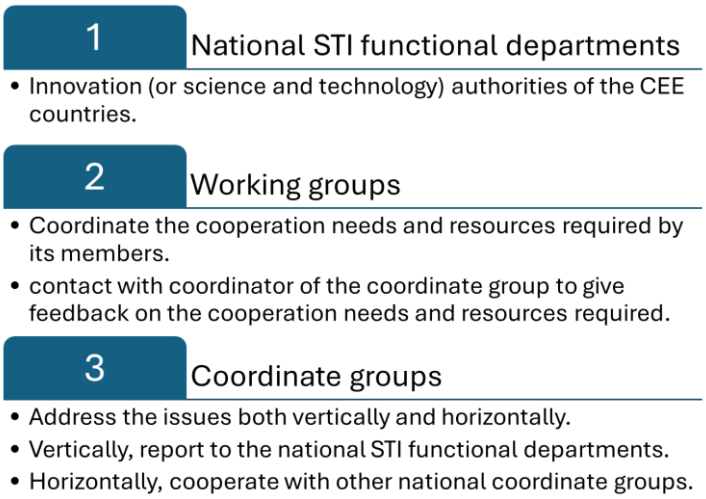

Fig. 1 Collaborative Innovation Network

Source: Author

The operational mechanism works as follows: the working group will coordinate the cooperation needs and resources required by its members and contact the coordinator of the coordinating group to give feedback on the cooperation needs and resources required. The coordinate group will address the issues both vertically and horizontally. Vertically, the coordinating group will report to the national STI functional departments on the resources needed and organize and promote the implementation of resource mobilization. Horizontally, the coordinate group will cooperate with other national coordinate groups to solve the resource issues and cooperation needs raised by the native working groups.

Based on various technology transfer entities and resources, information on the supply and demand of technology transfer can be deeply explored through a collaborative innovation network. All-round and multi-angle docking and promotional activities can be promoted through the promotion platform and co-construction alliance. The network, by actively assuming the role of a platform for resource gathering and information exchange, can unite multiple actors. It aims to jointly promote two-way technology transfer between China and CEE countries, coordinate resource allocation, and enhance the mobility of resources and the transformation of achievements. In doing so, it contributes to scientific and technological development on both

sides and fosters a mutually beneficial, win-win cooperation dynamic.

In the following, I will present part of the project content, which is related to the specific operational duties of the colleagues from the CEEC group.

5 HIGH-LEVEL TALENT COOPERATION: ESTABLISHMENT

5.1 Project Introduction

The "Talent Cooperation" project (hereinafter referred to as "Talent Cooperation") aims to leverage the technical needs and talent resources of various regions and platforms, fostering deeper innovation partnerships between China and Central and Eastern European countries. It provides pathways for high-level talents from Central and Eastern Europe interested in employment, innovation, entrepreneurship, and project collaboration in China.

The initiative focuses on high-level talents eager to pursue innovation and entrepreneurship in China. It promotes talent engagement through research centers and facilitates project cooperation with domestic scientific research institutes and enterprises. Additionally, it supports cooperative projects seeking government approvals, project funding, and relevant awards (see Section 6 for a definition of high-level talents).

Applicants may propose project ideas for evaluation or collaborating on projects initiated by research institutes, enterprises, or other entities, based on mutual interest. Submitted projects must align with the applicant's expertise, address the technological development needs of enterprises, or hold long-term strategic significance.

5.2 Suggestions for Cooperation Content

Since the China-CEEC STI Research Center has established a good cooperation foundation with local governments and has rich working experience in such applications, it is suggested that both parties carry out project cooperation and divide their responsibilities as follows:

1. Recommend high-level talents who meet the application conditions.
2. Assist China in maintaining close communication with foreign applicants, promptly convey Chinese information and requirements, and actively promote communication between the two sides.
3. Cooperate to complete the project application, provide relevant materials required for the application, such as a job certificate, thesis certificate, etc., and ensure the authenticity and integrity of the materials.
4. Ensure that the foreign party applies to participate in the project docking and defense.
5. Once the project is selected, ensure the foreign applicant works in the cooperative organization.

Responsibilities of the research center:

1. Find application units such as scientific research institutions and enterprises and be responsible for maintaining close communication with the application units and providing relevant materials.
2. Providing a list of materials required by the foreign party to apply for the project.
3. Writing application materials and completing the application work.
4. Facilitate coordination and evaluation between the enterprise and the foreign applicant.
5. Perform public relations maintenance.
6. Coordinate the entire process of managing project funds and distributing rewards.

By building innovation cooperation complexes with relevant institutions in various countries, the Research Center will jointly promote cooperation in science, technology, and innovation and explore new paths for international STI cooperation service industries. It will develop a collaborative network with core members and form a platform with multiple stakeholders to promote innovation cooperation between China and CEE countries (CCEECCIC, 2023).

Among many initiatives, this was demonstrated through the "Innovative Youth Share the Future" China-CEEC Forum for Young Science & Technology Talents and the China-CEEC Youth Innovation and Entrepreneurship Competition. The Forum, held in Ningbo in 2021, fostered cooperation among young scientists, focusing on talent exchange and innovation (China-CEEC, 2021). Meanwhile, the Competition, held in May

2023, provided a platform for young innovators and entrepreneurs to collaborate on projects and drive future development (China-CEEC, 2023). These initiatives highlight efforts to strengthen talent cooperation and innovation between China and CEECs.

6 FOREIGN EXPERT PROJECT (CASE PRESENTATION)

The China-CEEC Research Center prepared a project through the mechanisms and based on the letter of intent (number 2022-007), which enabled foreign experts, mostly from the countries of Central and Eastern Europe, to participate in the year 2022-2023.

More important than the letter of intent itself is that the CEEC Research Center has followed the directions given by President Xi Jinping at the China-CEEC Summit. In the articles of the agreement, for example, it is also stated that the partner (foreign experts):

"*Assist the research center to establish contacts with at least 20 scientific research institutions, science and technology parks, technology transfer centers, and innovation government departments in Croatia, Bosnia and Hercegovina, Serbia, and Romania, carry out technology transfer (also part of the Innovation Collaborative Network), and carry out various science and technology docking and cooperation activities.*" (Letter of Intent, 2022-007)

By this agreement, a group of experts from Croatia, Bosnia and Herzegovina, Serbia, and Romania compiled a list of institutions from each of these CEEC countries. The list includes scientific research institutions, science and technology parks, technology transfer centers, and government departments focused on innovation, as presented in Table 1.

Table 1. Proposed Institutions for Collaboration from Selected CEEC Countries

Croatia	Bosnia and Herzegovina	Serbia	Romania
University of Zagreb	University of Business Studies, Banja Luka	University of Belgrade	Banat University of Agricultural Sciences and Veterinary Medicine of Timisoara
University of Split	University of Banja Luka	University of Nis	University of Bucharest
University of Osijek	University of Mostar	University of Novi Sad	University POLITEHNICA of Bucharest
University of Rijeka	University of Sarajevo, Faculty of Mechanical Engineering	Ministry of Science, Technological Development and Innovation of Serbia	Alexandru Ioan Cuza University of Iasi (UAIC)
Ruđer Bošković Institute	Association of Technology Engineers of the Republic of Srpska	Serbian Academy of Sciences and Arts	Aurel Vlaicu University of Arad (ARAD)
Science Park	Innovation Center Banja Luka	Science Technology Park Belgrade (STP Belgrade)	Ovidius University of Constanta
Tech Park	Alliance of innovators of the Republic of Srpska	The Chamber of Commerce and Industry of Serbia	Technopolis Group
Zagreb Innovation Center	University of Tuzla	University of Kragujevac	Observatory of Public Sector Innovation (OPSI),
The Ministry of Economy and Sustainable Development, Sector for Innovation	Institute of Technology	Ministry of Education, Science and Technological Development of Serbia	OpenAIRE
Ministry of Science and Education, Sector for Science and Technology	Association for Scientific and Technical Education of Youth in BiH, Sarajevo	Association of Lawyers for Medical and Health Law of Serbia, SUPRAM - Serbia	National Authority for Scientific Research In Romania

7 CONCLUSIONS

In conclusion, modern Chinese society is increasingly oriented toward development, science, and global cooperation. The analysis conducted in this study has demonstrated that China's economic policies, infrastructure projects, and trade agreements have solidified its position as a key actor in the global economy. Here, it is necessary to emphasize that the system is reinforced by innovations and fair competition, which we have not yet fully grasped in the EU.

There are vast cultural differences, and as President Xi Jinping emphasized in his speech at the 2019 Conference on Dialogue among Asian Civilizations the growing global challenges facing humanity require joint efforts by countries worldwide. He highlighted the role of culture and civilization in addressing these shared issues, promoting the idea that cooperation across civilizations is essential for peaceful coexistence and sustainable development. This vision aligns with China's strategic partnerships with CEECs, where economic cooperation has been complemented by cultural exchange and mutual learning.

In this article, we indicated exactly that. From trade agreements such as RCEP to major infrastructure projects like the Budapest-Belgrade railway and the E763 highway, China has positioned itself as a driving force for regional development. The continuity of China's strategic orientation under the leadership of President Xi Jinping reflects an ambition for global peace, cooperation, and shared prosperity. For those of us who lived during the era of the (Tito's) Socialist Federal Republic of Yugoslavia, this kind of international engagement echoes aspirations that were once deeply held. The emphasis on mutual respect between civilizations and the rejection of cultural superiority aligns with the cooperative model China has promoted in its relations with Central and Eastern European countries.

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Received for publication: 11.01.2025
Revision received: 01.06.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Vidnjevic, M. (2025, 07 15). Presentation of the Three Phases of China-CEEC Cooperation Implementation. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 220-228. doi:10.12709/mest.13.13.02.18

Style – **Chicago** *Sixteenth Edition:*

Vidnjevic, Marko. "Presentation of the Three Phases of China-CEEC Cooperation Implementation." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 220-228.

Style – **GOST** *Name Sort:*

Vidnjevic Marko Presentation of the Three Phases of China-CEEC Cooperation Implementation [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 220-228.

Style – **Harvard** *Anglia:*

Vidnjevic, M., 2025. Presentation of the Three Phases of China-CEEC Cooperation Implementation. *MEST Journal,* 15 07, 13(2), pp. 220-228.

Style – **ISO 690** *Numerical Reference:*

Presentation of the Three Phases of China-CEEC Cooperation Implementation. **Vidnjevic, Marko.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 220-228.

MEST Journal
DOI 10.12709/mest.13.13.02.15

ANALYSIS OF CHINA'S GROWING COMPETITIVENESS IN THE AUTOMOTIVE INDUSTRY: OPPORTUNITIES FOR COLLABORATION

Kang Zheng
Mechanical and Vehicle Academy, Ningbo University of Technology, Zhejiang ATTC Automobile Technology Service Co., Ltd, Ningbo, China
https://orcid.org/0000-0003-1944-2098

Martin Kralj
University of Ljubljana, Ljubljana, Slovenia
https://orcid.org/0009-0002-6799-2035

Marko Vidnjevic
China-CEEC Innovation Cooperation Research Center, Ningbo University of Technology, Alma Mater Europaea - ECM, Maribor, Slovenia
https://orcid.org/0009-0004-1107-1186

JEL Category: **F14, F15, L62, O33, Q55**

Abstract

This paper explores the competitive challenges and opportunities facing the European automotive industry due to the green transition, digitalization, and growing global competition. With the EU's declining global market share, increasing reliance on imports, and slower progress in electric vehicle (EV) innovation, the European sector is undergoing significant shifts. Despite these challenges, the growing presence of Chinese automakers presents opportunities for collaboration, particularly in EV development. By forming strategic partnerships with China and aligning regulatory frameworks, the EU can leverage these opportunities to drive innovation, enhance market competitiveness, and strengthen its position in the automotive sector. Slovenia is highlighted as a case study of how EU countries can benefit from such collaborations, focusing on high-value-added services like research and development, engineering, and advanced manufacturing. The paper argues that through cooperation with China, Europe can address the changing dynamics of the global automotive market, meet its sustainability targets under the European Green Deal, and remain competitive in the automotive industry.

Address of the corresponding author:
Martin Kralj
martin.kralj007@gmail.com

Keywords: *Automotive, International trade, Trade policy, Globalization, Global competitiveness, China, Slovenia*

1 INTRODUCTION

The European automotive industry has long been a cornerstone of innovation and economic growth in the region. With over a century of experience producing vehicles powered by internal combustion engines (ICE), it has established a global reputation for engineering excellence, quality, and creativity (European Parliament, 2024a).

In 2022, the automotive industry contributed 237 billion euros to the European Union's total gross value added. Germany was the largest contributor, with 144.2 billion euros, followed by Spain with 12.8 billion euros, Italy with 12.2 billion euros, France with 11.1 billion euros, Sweden with 11 billion euros, and Czechia with 10.5 billion euros (Eurostat, 2024).

Furthermore, this sector is one of Europe's most research-intensive, with an annual investment of €59 billion in research and development (R&D), equivalent to 15% of its gross value added. Such investment qualifies the automotive industry as a leader in advanced manufacturing and a significant contributor to technological progress (European Parliament, 2024b).

According to ACEA, 213 automobile assembly, engine, and battery production plants were operating in the EU in 2022, an increase from 194 in 2021. Germany had the largest share with 54 facilities, followed by France (31), Italy (23), and Poland (19). Central and Eastern European countries, including Slovakia, Czechia, Hungary, Romania, and Poland, collectively accounted for 47 facilities, reflecting their substantial role in the EU's automotive production network (ACEA, 2023).

The EU's automotive supply chain is uniquely dispersed across multiple Member States, reflecting its integration into the broader European economy. Historically, countries such as Germany, France, Italy, Spain, and Sweden have occupied central roles in the industry. However, since the early 2000s, economic integration has enabled emerging economies in Central and Eastern Europe, including Poland, Czechia, Hungary, Slovakia, and Romania, to take on more significant roles within the value chain. This shift has been driven primarily by the outsourcing of supplier networks and manufacturing from Western European carmakers to these countries, where labor costs are lower and skilled workforces are readily available (Hindriks, Hogetoorn, Zani,, Ravera, & Gelibolyan, 2024).

This distribution is also evident in the employment footprint of the automotive sector across the EU. In 2022, the industry supported 13.8 million jobs. Of these, 2.6 million jobs were directly tied to motor vehicle manufacturing. Germany had the highest level of direct automotive manufacturing employment, with 872,446 jobs, followed by France (214,904), Poland (209,396), Czechia (172,012), Italy (165,218), Romania (159,293), Spain (142,288), Hungary (97,306), and Slovakia (75,721). In many of these regions, automotive production constitutes a significant share of industrial employment. For example, in Slovakia, automotive manufacturing accounted for 15.5% of total manufacturing employment, followed by Czechia (14.5%), Hungary (13.4%), Romania (12.4%), and Germany (10.9%) (ACEA, 2024b).

The broader impact of the automotive industry extends even further. According to the latest report, it now supports approximately 13.8 million jobs across the EU, equivalent to 6.1% of total EU employment, underscoring its importance to the region's workforce (European Parliament, 2024b).

2 CHALLENGES IN THE EUROPEAN AUTOMOTIVE INDUSTRY

Lately, the European automotive industry has faced significant challenges at the crossroads of the green transition, digitalization, and intensifying global competition. Among these, the emergence of China as a dominant player in the global automotive market has profoundly reshaped the competitive landscape, creating both threats and opportunities for European manufacturers (European Parliament, 2024a).

Historically, the United States was the primary market for European automotive exports, contributing over 22% of the total domestic value added in vehicle products as recently as 2015. However, this dynamic has shifted significantly recently, with China overtaking the United States as the largest consumer of EU automotive products (Eurostat, 2024). Furthermore, in 2022, China overtook Germany as the world's second-largest car exporter, disrupting the global automotive market in a manner reminiscent of

Japan's rise in the 1980s and South Korea's in the 1990s (Mazzocco & Sebastian, 2023).

The European Union's automotive sector is experiencing a significant decline in global competitiveness, driven by falling production, increasing reliance on imports, and challenges in electric vehicle (EV) innovation. Between 2000 and 2022, the EU's share of global vehicle production fell from 31%, or 18 million, to 15%, or 13 million vehicles. In contrast, China's share increased from 4%, or 2 million, to 32%, or 27 million cars, as global production expanded from 58 million to 85 million units (European Parliament, 2024b).

An additional challenge is the aging vehicle fleet in Europe. The average age of cars in the EU has risen from 11.8 years in 2020 to 12.3 years in 2022. Further, there are notable differences in the average age of vehicles across Europe. Countries like Ireland (9.1 years) and Luxembourg (7.9 years) have relatively newer fleets due to higher vehicle turnover. In contrast, countries such as Slovenia (11.2 years), Croatia (13.3 years), and Slovakia (13.7 years) experience slower vehicle replacement. Countries like Greece (17.3 years) and the Czech Republic (15.9 years) face even older fleets (ACEA, 2024b).

This decline in production has been accompanied by a significant shift in trade dynamics. Between 2017 and 2022, imports of Chinese vehicles into the EU increased fivefold, reaching 561,000 units. By 2022, China had become the largest non-European supplier to the EU, accounting for 14% of all vehicle imports (European Parliament, 2024b).

Furthermore, most European manufacturers are falling behind in electric vehicle innovation due to high battery costs and slower technological advancements. Only one of the world's top 15 battery-electric vehicles is made in the EU. Meanwhile, China has become a global leader, with competitive domestic firms expanding to new markets and serving as a manufacturing export hub for multinational companies. (European Parliament, 2024a) China's leadership extends beyond production to EV adoption. In 2023, nearly 60% of new electric car registrations occurred in China, compared to 25% in Europe and 10% in the United States (IEA, 2024).

3 GLOBAL AUTOMOTIVE TRADE

China's import and export data of automotive products further highlight its evolving role in the global automotive industry.

Table 1. Top 5 exporters of automotive products, 2023 (WTO, 2024)

	Value (bn $)	Share in world exports/imports			
Exporters	2023	2000	2005	2010	2023
EU	833	45.4	49.5	46.6	44.6
China	170	0.3	1.1	2.6	9.1
Mexico	158	5.3	3.8	5.1	8.5
Japan	157	15.3	13.3	13.7	8.4
USA	156	11.8	9.4	9.1	8.3

	Annual percentage change			
Exporters	2010-23	2021	2022	2023
EU	3.9	12.8	1.7	19.0
China	14.9	60.2	33.6	37.0
Mexico	8.4	10.5	9.6	22.8
Japan	0.4	11.0	-2.3	16.2
USA	3.5	13.7	9.7	13.3

Table 2. Top 5 importers of automotive products, 2023 (WTO, 2024)

	Value (bn $)	Share in world exports/imports			
Importers	2023	2000	2005	2010	2023
EU	684	36.7	38.8	35.2	36.4
USA	383	29.0	21.9	17.7	20.4
Canada	92	8.0	6.1	5.6	4.9
UK	88	6.8	6.8	5.6	4.7
China	72	0.7	1.4	4.9	3.9

	Annual percentage change			
Importers	2010-23	2021	2022	2023
EU	4.7	11.7	2.1	23.3
USA	5.5	10.0	14.5	16.8
Canada	3.4	17.7	19.0	15.4
UK	3.1	6.9	18.0	24.7
China	2.4	15.0	-7.6	-12.8

The European Union remains the largest exporter of automotive products, with exports valued at $833 billion in 2023, accounting for 44.6% of global automotive exports. However, this share has gradually decreased from 49.5% in 2005, reflecting a decline in its relative position. Between 2010 and 2023, EU automotive exports grew at an average annual rate of 3.9%, with notable recoveries in 2021 (12.8%) and 2023 (19.0%). On the import side, the EU accounted for $684 billion in automotive imports in 2023, representing 36.4% of global imports. This marks a relatively stable position since 2010 (36.7%), with a sharp increase of 23.3% in 2023.

In contrast to the EU's stable but moderate growth, China has demonstrated significant expansion in automotive exports. By 2023, China's exports reached $170 billion, contributing 9.1% to global automotive exports, up from 1.1% in 2005. Between 2010 and 2023, China achieved an annual export growth rate of 14.9%, with substantial increases in 2021 (60.2%), 2022 (33.6%), and 2023 (37.0%). At the same time, China's automotive imports declined to $72 billion in 2023, representing 3.9% of global imports, down from 4.9% in 2010. Consecutive negative growth rates in 2022 (-7.6%) and 2023 (-12.8%) highlight China's growing capacity to meet domestic demand through local production.

This analysis underscores the contrasting trajectories of the EU and China. While the EU retains its leadership in export value, its growth has been moderate compared to China's rapid expansion. Simultaneously, China's declining reliance on imports reflects its increasing self-sufficiency and growing role in shaping global automotive trade dynamics. Although a more detailed investigation into the underlying factors would be beneficial, the presented data is sufficient to highlight China's rapid emergence as a dominant force in the global automotive market.

Regarding to China and the EU's automotive exports and imports, it is also evident that Mexico has shown steady long-term export growth, averaging 8.4%, falling short of China's 14.9%. On the other hand, Japan has experienced minimal long-term export growth, averaging just 0.4%, but recorded a strong rebound in 2023 with a 16.2% increase. The United States has maintained stable export expansion over time, with consistent year-over-year increases and a growth rate of 3.5% from 2010 to 2023. In 2023, U.S. exports grew by 13.3%, maintaining a strong upward trend similar to the previous two years.

On the import side, the United States has demonstrated steady long-term growth, with an acceleration in 2022 and 2023, reaching 16.8%. Among the top five importers of automotive products, the United States recorded the highest increase from 2010 to 2023, averaging 5.5% annually. Canada has shown moderate historical growth, with a sharp rise in imports in recent years, recording 19.0% in 2022 and 15.4% in 2023. The United Kingdom has experienced relatively slow long-term growth but saw a significant increase in imports in 2022 and 2023, reaching 24.7% in the most recent year.

4 TECHNICAL HARMONIZATION

Despite their growing competitiveness and expanding presence in the European automotive market, Chinese automakers face significant challenges, particularly in navigating legal compliance and certification requirements.

By 2030, vehicle manufacturers in the EU will face the challenge of complying with over 100 pieces of legislation covering safety, emissions, energy, materials, data, and security. The absence of a coherent framework has led to excessive reporting, overlapping requirements, and inconsistencies with international UNECE standards (ACEA, 2024a).

The United Nations Economic Commission for Europe (UNECE) standards play a critical role in the global automotive market by establishing uniform regulations that enhance vehicle safety, environmental sustainability, and technological innovation. These standards are particularly relevant in a globalized industry where manufacturers and suppliers operate across multiple markets. UNECE regulations, developed under the 1958 Agreement, provide technical and safety guidelines for road vehicles. Initially focused on Europe, these regulations have expanded to include 64 member countries across Asia, Africa, and Latin America. Each regulation targets specific areas of vehicle design and performance, such as lighting, braking systems, emissions, and advanced technologies like

autonomous driving systems (European Commission, 2025)

The Whole Vehicle Type-Approval System (WVTA) allows vehicles certified in one EU Member State to be marketed across the Single Market. Under the WVTA, once a manufacturer secures type approval for a car in one EU Member State, it can be marketed across the EU without additional testing. The certification is granted by the designated type-approval authority, while compliance assessments are conducted by authorized technical services. Globally, UNECE harmonization facilitates international market access. Regulation (EU) 2018/858, introduced in 2020, further tightened oversight and mandated Certificates of Conformity (CoC) for vehicle registration and sales (European Commission, 2025)

To address these challenges, the European Automobile Manufacturers' Association (ACEA) recommends simplifying regulations by grouping them into batches, prioritizing forward-looking rules, and creating a task force to assess the consistency of new laws (ACEA, 2024a).

5 AUTOMOTIVE COLLABORATION

Streamlined harmonization and simplified trade processes could help Europe transform growing Chinese competitiveness into an opportunity for collaboration. Duthoit (2023) argues that if Europe struggles to compete with China in the short term, it could adopt a collaborative approach, much like the U.S. partnership with Japanese automakers in the 1980s. However, he warns that Europe should avoid acting too late. Allowing Chinese investment in European car assembly could create jobs and generate economic value by localizing production.

Gupta (2024) underscores that collaboration and joint ventures with Chinese automakers present a significant opportunity for Europe to enhance its competitiveness and drive innovation. He cautions that protectionist measures are unlikely to offer a sustainable solution. Gupta also points out that some European automakers are already leveraging collaboration to maintain their market position. For instance, companies like Volkswagen and BMW are accelerating their EV programs and forming alliances with Chinese firms, such as BMW's partnership with Great Wall Motors to produce the electric Mini in China.

One of the most recent examples of successful collaboration with Chinese automotive manufacturers is BYD's decision to establish a new energy vehicle production facility in Szeged, Hungary. Announced in December 2023, this facility will be the first BYD passenger car factory in Europe. The investment is expected to create thousands of local jobs, strengthen regional supply chains, and facilitate technological exchange between China and Hungary. This development underscores the growing trend of Chinese automotive firms localizing production in Europe to enhance market access and integration within the European automotive industry (BYD, 2023).

6 OPPORTUNITIES FOR SLOVENIA

Slovenia serves as a prime example of how EU countries can leverage collaboration with China to strengthen their automotive sectors. As Minister Matjaž Han, Slovenia's Minister of the Economy, Tourism, and Sport, emphasized, "*The global automotive industry in particular is interconnected, and through further cooperation, we can create synergies that will benefit all parties involved. We aim to promote partnerships that will combine Slovenia's excellent technical know-how and advanced manufacturing capabilities with the innovative technologies of our international partners. This will not only improve our manufacturing capabilities but also create a vibrant ecosystem for research and innovation*." (Slovenian Ministry of the Economy, Tourism and Sport, 2024)

Chinese companies, such as ATTC, the largest private type-approval company in China's automotive industry, see Slovenia as a key partner for accessing the EU market. ATTC has expressed its commitment to long-term collaboration with the Slovenian government, companies, and laboratories for type-approval of vehicles and components in the EU. Their efforts aim to support the introduction of Chinese products for new energy vehicles, original equipment manufacturers, and intelligent driving suppliers while promoting growth in the Slovenian automotive industry (Slovenian Ministry of the Economy, Tourism and Sport, 2024). This partnership could enable Slovenia to focus on high-value-added jobs in services, such as

engineering consulting, research and development, and advanced manufacturing.

However, such collaboration might also present challenges that require careful consideration. Zoltán Peredy et. al. (2022) highlight that Chinese automotive manufacturing has undergone rapid innovation, leading to increasingly automated production processes. This raises concerns that while collaboration may bring technological advancements, it could also reduce the need for extensive local labor, limiting job creation in Slovenia. Additionally, some authors raise further concerns regarding long-term dependencies. To mitigate these challenges, the partnership must carefully balance the needs of both parties and focus on successful long-term collaboration.

7 CONCLUSIONS

The European automotive industry stands at a pivotal moment, facing significant challenges from the green transition, digitalization, and intensifying global competition, particularly from China. These pressures require a strategic response that balances innovation, collaboration, and regulatory alignment. While competition with Chinese automakers presents significant challenges, it also offers opportunities for mutual growth through partnerships and investments.

The analysis identifies several key findings. The European automotive sector has historically been a global leader, contributing significantly to economic growth and innovation. However, it is experiencing a decline in global market share, struggling with EV production, and becoming increasingly reliant on imports. Meanwhile, China has rapidly emerged as a dominant player, now the second-largest vehicle exporter worldwide. Additionally, the aging vehicle fleet in the EU poses challenges to sustainability targets, necessitating an accelerated transition to EVs.

China's competitive edge in global automotive exports is particularly strong in the EV sector. The country has become the world's largest producer and exporter of EVs, capitalizing on advanced battery technology, cost-efficient manufacturing, and an integrated supply chain. Leading Chinese manufacturers, such as BYD and Nio, are expanding their global reach by offering high-quality EV models at competitive prices. As demand for EVs grows in Europe, Chinese automakers are well-positioned to meet this demand, further altering trade dynamics in the industry.

Technical harmonization remains crucial for the seamless integration of Chinese vehicles into the European market. Regulatory frameworks, including UNECE standards and the Whole Vehicle Type-Approval System, play essential roles in ensuring compliance, reducing trade barriers, and fostering cooperation between European and Chinese automakers. Simplifying regulations and aligning policies can enhance market access and encourage joint ventures.

The collaboration represents a viable strategic approach, as demonstrated by past trade relations, such as U.S.-Japan cooperation in the 1980s. Some European automakers are already forming alliances with Chinese firms to strengthen their EV production capabilities. These partnerships can foster innovation, create high-value jobs, and enhance overall competitiveness.

Slovenia demonstrates how EU countries can position themselves to benefit from these opportunities. With its strategic geographical location, advanced technical expertise, and strong manufacturing ecosystem, Slovenia has the potential to serve as a hub for collaboration between Europe and China. Partnerships with Chinese firms, such as ATTC, could enable the country to focus on high-value-added activities, including research and development, engineering, and advanced manufacturing. Additionally, Slovenia's strategic location positions it as a key player in helping Europe achieve sustainability goals by importing affordable EVs from China to regions with aging vehicle fleets. In the future, this could extend to facilitating local manufacturing, following examples of successful regional collaborations in neighboring countries.

Moving forward, Europe's ability to maintain its leadership in the automotive sector will depend on fostering strategic alliances, simplifying regulatory frameworks, and promoting innovation. These steps are essential for ensuring the sector's sustainability, competitiveness, and role as a driver of economic growth in a rapidly evolving global market.

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Received for publication: 11.01.2025
Revision received: 30.01.2025
Accepted for publication: 08.07.2025.

How to cite this article?

Style – **APA** *Sixth Edition:*

Zheng, K., Kralj, M., & Vidnjevic, M. (2025, 07 15). Analysis of China's Growing Competitiveness in the Automotive Industry: Opportunities for Collaboration. (Z. Cekerevac, Ed.) *MEST Journal, 13*(2), 229-236. doi:10.12709/mest.13.13.02.15

Style – **Chicago** *Sixteenth Edition:*

Zheng, Kang, Martin Kralj, and Marko Vidnjevic. "Analysis of China's Growing Competitiveness in the Automotive Industry: Opportunities for Collaboration." Edited by Zoran Cekerevac. *MEST Journal* (MESTE) 13, no. 2 (07 2025): 229-236.

Style – **GOST** *Name Sort:*

Zheng Kang, Kralj Martin and Vidnjevic Marko Analysis of China's Growing Competitiveness in the Automotive Industry: Opportunities for Collaboration [Journal] // MEST Journal / ed. Cekerevac Zoran. - Belgrade – Toronto : MESTE, 07 15, 2025. - 2 : Vol. 13. - pp. 229-236.

Style – **Harvard** *Anglia:*

Zheng, K., Kralj, M. & Vidnjevic, M., 2025. Analysis of China's Growing Competitiveness in the Automotive Industry: Opportunities for Collaboration. *MEST Journal,* 15 07, 13(2), pp. 229-236.

Style – **ISO 690** *Numerical Reference:*

Analysis of China's Growing Competitiveness in the Automotive Industry: Opportunities for Collaboration. **Zheng, Kang, Kralj, Martin and Vidnjevic, Marko.** [ed.] Zoran Cekerevac. 2, Belgrade – Toronto : MESTE, 07 15, 2025, MEST Journal, Vol. 13, pp. 229-236.

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ISSN 2334-7058 (Online)
DOI 10.12709/issn.2334-7058