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# Blockchain for Business: An Overview and Benchmarking Analysis of Key Technologies

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**Abstract:** *The adoption of blockchain technology in business applications has seen rapid growth in recent years. As enterprises explore the potential benefits of blockchain, it becomes imperative to evaluate various blockchain technologies to make informed decisions about their implementation. This paper presents an overview of blockchain technologies tailored for business use cases and analyzes prominent platforms such as Hyperledger Fabric, Hyperledger Sawtooth, Corda, and Consensys Quorum. This study provides valuable insights for enterprises seeking to deploy blockchain solutions by evaluating key metrics such as performance, scalability, security, and consensus and conducting a cross-industry benchmarking analysis. The evaluation process will be based on a comparative and in-depth analysis of the current state of research. The findings shed light on the potential benefits of each blockchain technology, facilitating informed decision-making and promoting the responsible adoption of blockchain in the business environment.*

## 1. INTRODUCTION

Blockchain recently has gained popularity and an increased interest in the scope of transforming and improving business operations and processes. The design initially presented by Nakamoto has evolved into more elaborate models that have the capabilities to fulfill the business needs to tackle challenging and complex issues. The emergence of smart contracts in the digitalization and automation of business workflows has made blockchain technology more suitable for application in most industries such as healthcare, supply chain, finance, insurance, automotive, cyber security, etc., making blockchain an attractive technology and increasing interest among the research community, businesses, and governments.

For blockchain to be viable for businesses certain premises require adjustments. A crucial requirement is the implied shift toward permissioned networks where user participation is contingent and identity authentication of the users enables them to remain identifiable at all times within the network. A paramount for blockchain for business is performance. Therefore, high transaction throughput and low latency of transaction confirmation should characterize the network. Business transactions and the pertaining data must be private and confidential, highlighting the unnegotiable need for a blockchain for business to be secure. Thus, new blockchain platforms, such as Hyperledger Fabric, Consensys Quorum, Corda, etc, to address these requirements emerged. These platforms enabled the exploration of the blockchain potential to transform business across industries.

In this paper, the authors aim to explore the applications and latest advancements of the blockchain for business technologies in cross-industries and make a relevant benchmarking analysis. The paper focuses on the potential benefits of blockchain technology for business use cases intending to

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facilitate informed decision-making for the adoption of these technologies. The remainder of this paper is organized as a literature review of the top blockchain for business technologies and their latest advancements and projects. Followed by methodology, analysis of the benchmarking, and future research directions for blockchain. The conclusion section concludes the paper.

## 2. LITERATURE REVIEW

**Hyperledger Fabric**, as defined by [Androulaki et al. \(2018\)](#) and also known as the blockchain for business, is part of the Hyperledger umbrella project. Its modular architecture and plug-and-play capability characterize it, enabling network designers to plug their preferred components, such as consensus and membership services. The ledger can be split to match different participants with different roles thus giving them different access to data. Smart contracts on Hyperledger Fabric are called Chain Code and can be written in one of the many supported programming languages. The chain codes define the system's business rules and can address different levels of real-world business complexities due to their configurable capacities. The peers on a Hyperledger Fabric network have a clear separation of duties or functions – endorsing peers, orders, and committing peers. This allows a Fabric network to achieve low latency and high throughput for transactions. There is no cryptocurrency associated with the mining of transactions in Fabric. This makes Fabric transactions more deterministic and more suited to an enterprise context. When transactions are committed to the ledger the committing peers update the world database representing the latest state of each asset, as well as record the changes in the transaction's ledger.

Fabric is considered a cross-industry blockchain, with use cases that encompass its versatility for business. Based on Hyperledger Fabric, [Wutthikarn and Hui \(2018\)](#) developed a prototype of an application for dental clinic service with the scope of fostering interoperability between clinics and reducing costs by sharing medical equipment and transactions. Their solution, which uses in addition another Hyperledger project, Composer, is shown to have improved cost-effectiveness and the quality of service offered to the population. [Diaz and Kaschel \(2023\)](#) implemented and tested an Electronic Health Records management system with support for user roles based on Hyperledger Fabric with RAFT consensus implementation and quantitatively measured the scalability with Caliper, concluding that a dual-channel architecture is by a low magnitude more performant and scalable. [Shaikh et al. \(2022\)](#) proposed a Hyperledger Fabric-based architecture for e-healthcare information and privacy management, resulting in a solution that provides more efficient information integrity, provenance, and storage procedures. [Xiao et al. \(2019\)](#) proposed a data identity authentication scheme based on Fabric. Their proposed scheme is deployable for the insurance industry and it aims to improve data security and practicability among the parties. The results they obtained support their proposal. [Bodemer \(2023\)](#) explored a Hyperledger Fabric-based blockchain solution with AI-enhanced smart contracts to address the prevailing challenges in the insurance industry and based on preliminary tests indicated a positive impact on transparency, reduction of fraudulent claims, and optimization of risk assessment processes. [Haque et al. \(2023\)](#) proposed a solution based on this permissioned blockchain for the insurance industry, especially the branch that covers farm insurance, in the Bangladesh case, providing a secure and efficient system against fraudulent cases. The results of the authors' experimental results indicate that the solution is also scalable. [Z. Shi, Zhou, Hu et al. \(2019\)](#) evaluated the benefits of a Hyperledger Fabric-based solution to address the most relevant issues in the pharmaceutical drugs supply chain. Their solution is integrated with IoT devices, like RFIDs, sensors, locators, and QR codes to enable real-time tracking. Functional results show that the application of the blockchain in this case improves transparency and safety while reducing manual operations, leading to a decrease of



human errors. [Kumar \(2023\)](#) explored the employment of the Fabric-based solution aimed at preventing drug counterfeiting, emphasizing the cost and safety aspects of the solution. [Banik et al. \(2023\)](#) proposed employing a platform based on Fabric with the scope of managing vehicle data and ensuring the confidentiality and integrity of such data. The solution empowers authorities to be able to track vehicles even beyond the borders of the state. It addresses issues like the counterfeiting of registration documents or other data manipulations. The measured performance indicates that the solution is usable. [Chen et al. \(2023\)](#) proposed a scheme for the traceability of data in the tea supply chain based on Fabric using IPFS as storage and the ECDSA algorithm for identity confirmation. The solution aims to support anti-counterfeiting efforts in the tea production industry. The performance parameters measured with Caliper show low latency both in the read and write of the transactions. [Foschini et al. \(2020\)](#), have conducted quantitative research on the performance of Hyperledger Fabric. The results of their experiments show that Go is the best-performing language for smart contracts development in Hyperledger Fabric. [Shalaby et al. \(2020\)](#) evaluated the performance of Hyperledger Fabric focusing specifically on how the end-to-end latency and throughput are affected by the batch timeout, batch size, and endorsers while varying the number of parallel transactions. Their results indicate that the latency increases as the number of transactions and batch timeout increase and that throughput increases as the batch size increases.

**Hyperledger Sawtooth** as defined by [Olson et al. \(2018\)](#) is an enterprise-level permissioned modular blockchain platform launched by the Linux Foundation and contributed by IBM, Digital Asset, and SAP. It is implemented in the form of Blockchain-as-a-Service and can execute smart contracts developed in general programming languages without the constraint of knowing the inner workings of the core of the platform. Sawtooth recognizes two distinct environments: the core ledger system environment and the application-specific environment and segregates these environments thus facilitating the application development and keeping the system safe and secure. From an architectural point of view, as explored by [K. T. Sharma \(2019\)](#), Sawtooth follows a pragmatic approach, by providing a REST API for clients to interact with a validator using the JSON/HTTP standards. This API treats the validator as a black box for submitting transactions and fetching results. The validator receives the requests that come through the API, validates the transaction signature, and forwards them to the responsible transaction processor. The network's validators work together over the network layer to keep the global state of the blockchain consistent. Transaction processors encapsulate the business logic validate the transaction, and decide whether a transaction is added to the next block. Sawtooth's consensus mechanism is a Nakamoto-style consensus algorithm that is designed to be a production-grade protocol capable of supporting large network populations. Its PoET (Proof of Elapsed Time) consensus mechanism enables it to integrate with hardware security solutions, referred to as "trusted execution environments". It also supports other consensus mechanisms, including PBFT.

Sawtooth is considered a cross-industry enterprise blockchain and it has found use in several cases. [Owens et al. \(2019\)](#) proposed a Hyperledger Sawtooth blockchain-based design pattern for a general crypto-asset framework where secondary smart contracts can control assets. [Moriggl et al. \(2020\)](#) concluded that Hyperledger Sawtooth performs well in the field of cybersecurity of Electronic Health Records, with one particular difference in the case of record deletion. [Pilares et al. \(2022\)](#) proposed an Electronic Health Records - specific framework based on dual-channel Sawtooth and IPFS for distributed data storage to address the complexities encountered in the field. [Khan et al. \(2021\)](#) proposed a Hyperledger Sawtooth blockchain focused on the cyber-physical control of power grid control and monitoring system of renewable energy. The results of their work show the benefits of blockchain deployment in such a distributed system, highlighting

integrity, transparency, confidentiality, control access, and security. The performance of Hyperledger Sawtooth was benchmarked by [Ampel et al. \(2019\)](#) using Hyperledger Caliper. Through their experiment, they concluded that the performance of Sawtooth is impacted by several factors. They observed a direct impact of the input transaction rate and batch size on the throughput. Specifically, they observed a linear dependency between these parameters. The relation between the input transaction rate and memory usage is exponential and could lead to a potential bottleneck in transaction speed. [J. Shi, Yi and Kuang \(2019\)](#) empirically studied the performance of Sawtooth and provided insights on the adjustment of the Scheduler and Maximum Batches parameters for optimal performance in a cloud environment. [Moschou et al. \(2020\)](#) concluded that the most performant language smart contracts in Hyperledger Sawtooth are the ones written in Go.

**Corda**, a unique permissioned private enterprise blockchain, as defined by [Brown et al. \(2016\)](#) is open source, open design, development, governance, and standards. Corda allows businesses and individuals to transact privately, between legal-identifiable counterparties, on a single network that is meant to be highly scalable, and where applications developed by independent developers are interoperable due to network-wide standards. Its end-state principles are privacy, legal footing, and assured identity. The only parties who have access to the details of a transaction are those who participate in the transaction and those who need to assure themselves of transaction provenance. Deals recorded by the ledger are, by contract, accepted as admissible evidence and legally binding by all parties in any dispute. Parties will have assurance over the identity of participants in the network. This is made possible due to Know Your Customer (KYC) requirements of all participants of the network, and the core identity framework which enables Corda to assign a single user profile to any legal entity, whether it be an organization or an individual. Corda architecture offers scalability, longevity, and interoperability. The network is scalable to support billions of transactions daily across industries. Different versions of Corda and multiple applications can coexist and interoperate on the same network regardless of the version.

[Fiorenza et al. \(2020\)](#) propose an R3 Corda-based solution integrated with a mobile application aimed at enabling patients to control the entities that may have access to their Electronic Health Records. [Minango et al. \(2023\)](#) explore the employment of R3 Corda in a proof of concept for the supply chain, obtaining benchmarking results in four parameters that indicate good performance. [Kumari et al. \(2023\)](#) explore a supply chain management system that preserves privacy among the parties involved in the process. [Pradhan et al. \(2023\)](#) designed and deployed a Corda-based multiple peer and notaries network to address relevant cybersecurity issues of a peer-to-peer energy trading network, integrated with the latest transaction broadcasting and validation services. The measured performance of the network indicates optimum parameters and performance.

**ConsenSys Quorum** as defined by [ConsenSys Quorum \(2018\)](#) is a soft fork of public Ethereum Blockchain meaning that the Quorum solution is unchanged Ethereum base code. Quorum's solution addresses the issues observed with using Ethereum for business by providing a primary feature that includes privacy – transactions. Peer/node permissions using smart contracts ensure that only known parties can join the network. Allowing fine-grained access only to participants who are involved in a specific transaction or access to entities such as regulatory bodies. The basic architecture consists of two main components. Quorum node, a soft fork of Go Ethereum client (geth), modified by adding a thin layer on top which enables Quorum to use a voting-based consensus mechanism instead of proof-of-work and allowing transactions and smart contracts to be privately executed. The second main component is Constellation, a two-part system responsible for implementing the privacy feature of Quorum. The first part of the Constellation consists of

Transaction Managers that store and allow access to encrypted transaction data, and exchange encrypted payloads with other participants' transaction managers, but they do not have access to any sensitive private keys. Enclave, the second part, works with the transaction manager to strengthen privacy by managing encryption and decryption in an isolated way. The Enclave stores private keys and is essentially a virtual HSM (Hardware Security Module), a known encryption method in the business tech.

A. Sharma et al. (2022) proposed the employment of Quorum for financial accounting and through statistical analysis proved that this technology is one of the best fits in terms of consistency and trust for accounting implementation. They also observed improved transparency, efficiency, and lower costs. Zeydan et al. (2023) proposed a Quorum-based solution for the telecommunication industry aimed at creating a trusted environment among different stakeholders to transparently and securely manage the lifecycle of automated vertical network services in a multi-cloud and multi-domain environment. Shaik and Reddy (2023) focused on Quorum as the basis of a new framework aimed at ensuring the legitimacy and uprightness of the client certifications that eventually comprise e-portfolios. Ktari et al. (2022) utilize this blockchain in the context of the Tunisian olive oil supply chain in a multi-blockchain and multi-sensor architecture to trace the end-to-end process of olive oil production. Li et al. (2023) propose a framework for Trusted Computing as a Service based on the Quorum blockchain, the ESP32 microcontroller with the ATECC508A security chip adding layers of encryptions to the information processed by smart contracts to control the visibility of that information among the peers. Sethuraman and Angamuthu Rajasekaran (2021) propose a solution based on the Quorum blockchain integrated with IPFS to address the single point of failure in IoT networks. Carare et al. (2021) implemented a model based on the Corda blockchain to automate the process of Bilateral Derivatives Over-The-Counter Post Trade transactions by designing a mechanism of the workflow states of the transaction, based on the asynchronous communication among the parties, improving the accuracy and efficiency of this special process performed in the banking industry.

### 3. METHODOLOGY

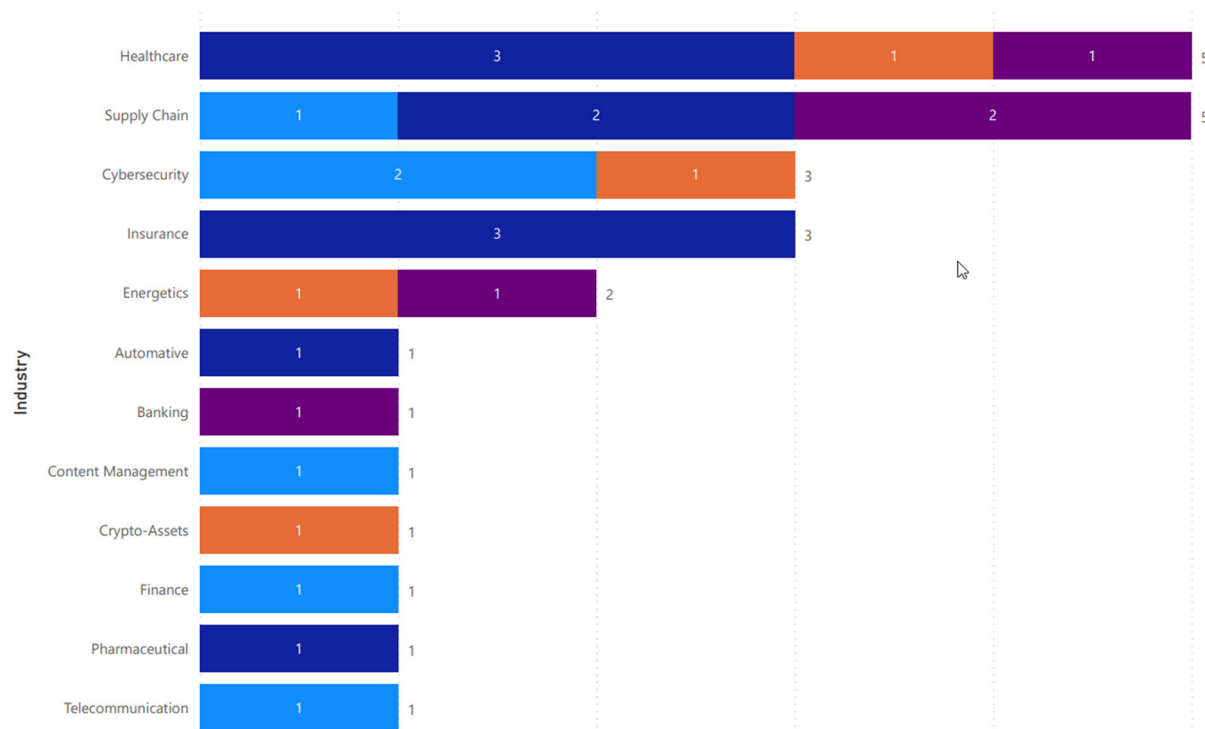
The methodology is based on a literature review of recent scientific papers, publications of industry reports, and real-world projects on the blockchain for business key technologies and their application in different industries. This review serves as a compass for identifying and understanding the current landscape of blockchain for business technologies and their application, potential, and benefits. Through the review, the aim is to identify and capture the latest trends, innovations, advancements, and challenges in the adoption of blockchain technologies within the business context. KPIs of the selection process of the publications reviewed are the year of publication, the relevance of the publication, the industry, and the use of blockchain technology. The publication search is conducted in top academic research databases such as Scopus, Web of Science, ScienceDirect, IEEE Xplore, Springer, etc with keywords defined based on KPIs and within the last five years of publication. Considering the relevant real-world projects the search is based also on the publication on each blockchain technology website. After the selection process, a cross-industry benchmarking analysis is conducted. Publications are classified and analyzed based on the blockchain for business technologies, based on the industry, and based on performance and architecture KPIs such as consensus mechanism, activity, performance, scalability, and security. The analysis offers insights into which blockchain for business technologies dominates specific industries and concludes the strengths and weaknesses of each technology to guide the practical adoption of blockchain technologies in diverse industries.

#### 4. ANALYSIS & FUTURE RESEARCH DIRECTIONS

Based on the corpus of publications that regard business use cases of general-purpose blockchains, it is evident there is a high interest in blockchain branches like Hyperledger Fabric and Hyperledger Sawtooth under the Hyperledger umbrella project. The interest has been constant in recent years specifically in the healthcare and insurance industry. Even though blockchain for business is designed to be of general purpose and to adapt to business needs and requirements across various industries, the reviewed papers indicate that specific blockchain projects are more popular in specific industries. The bar chart in Figure 1 summarizes the spread of blockchain technologies per industry.

No Papers by Industry and Technology

Technology ● ConsenSys Quorum ● Hyperledger Fabric ● Hyperledger Sawtooth ● R3 Corda



**Figure 1.** Benchmarking of Blockchain Technologies for Industry

**Source:** Own research

The sample analyzed in this paper indicates a preference for ConsenSys Quorum in cybersecurity-related applications and other fields related to the ICT industry and a preference for R3 Corda in highly distributed solutions. The reasons for this composition lie in the specific features of the technologies and their integrability in field-relevant ecosystems. Performance parameters also play an important role, presumably skewing the business case implementations based on the most relevant performance parameters for the industry. However, the data that was studied does not suggest enough insights to distinguish the best-performing technology in terms of latency and throughput but rather indicates that optimization per case is achievable. Future research to explore performance benchmarking is suggested. An important emphasis is placed on security, whichever overall is covered by all the technologies taken into consideration in this paper. It should be noted that a degree of freedom is provided to the implementer, specifically by the Hyperledger projects in terms of consensus mechanisms that can be deployed on a specific-case basis. The corpus of the articles and papers that were objects to this study indicate a

preferred technology stack to complement blockchain technologies. The trendiest emerging one resulting from the analysis is the combination of Hyperledger projects with IPFS. Therefore, further research aimed to identify and benchmark the best-fit stacks is to be considered in the future. The analyses show that blockchain in most cases serves as the backbone for more complex architectures and infrastructures that tackle complex industry issues.

## 5. CONCLUSION

Through this paper, the authors provided an overview of the employability of blockchain for business. The focus was on general-purpose blockchains for business and the scope of the field implementations highlighting relevant performance benchmarking. The selected dataset suggests a strong interest in blockchain for business applications in fields like healthcare, supply chain, cybersecurity, and insurance. In these industries, blockchain tackles complex issues while offering optimal performance and increasing efficiency, transparency, and security. A trend towards integrated solutions is present, with blockchain serving as the backbone of the proposed architectures. With regards to the performance, it is concluded that it can be fine-tuned based on the given business case through a combination of a set of parameters. A high degree of flexibility is identified about the programming languages that can be used to develop and deploy smart contracts per blockchain solution. Experimental results provide insights into the best-performing languages, among which are generic programming languages. Flexibility is also observed in the consensus mechanisms that are applied, especially on Hyperledger projects. This enables a better-fit solution for the business by prioritizing the requirements for a valid solution in a given industry. Overall, blockchain for business is scalable, flexible, and interoperable and thus it empowers businesses across industries to gain advantages through its employment. The study is limited in terms of the use cases it has reviewed and recognizes that a more in-depth review of a wider corpus of data is required to deduct more representative results across industries.

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# Conceptual Model of a Software Accessibility Evaluation System

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**Abstract:** *The percentage of people with disabilities has increased, with 1.3 billion people worldwide having some form of disability. Advancements in technology have made it easier for people with disabilities to access resources. However, many computer systems and software lack built-in accessibility features, making accessibility assessment software tools crucial for creating an accessible digital environment. They serve to automate the collection of interface usage data, its analysis, or the solution of potential problems in providing digital accessibility. These tools record user interactions, analyze accessibility issues, and make recommendations for improvement. In this regard, this paper aims to propose a high-level conceptual model of a software accessibility evaluation system's prototype. The main objective is to study attributes of software quality and existing systems for evaluating accessibility.*

## 1. INTRODUCTION

The development of software technologies in the direction of offering more complex functions and services is caused by the need for digitization of businesses. At the same time, for a business to be competitive and sustainable, many of its activities must be carried out in a digital environment. Therefore, due to the coverage of an increasingly wide range of functionalities, the software becomes more and more complex, and from there also arise many problems related to ease of use and more precisely, related to its trouble-free use by users with special needs or specifically, with their accessibility.

According to the World Bank, 15% of the world's population experiences some form of disability, and the prevalence of disability is higher in developing countries (World Bank, 2023). The World Health Organization states that approximately 1.3 billion people experience a significant disability, or 16% of the world's population, i.e. 1 in every 6 of us (World Health Organization (WHO), 2023). Obstacles to the full social and economic inclusion of people with disabilities may be related to inaccessible physical environments and transportation, lack of assistive devices and technologies, non-adapted means of communication, gaps in service provision, and discriminatory prejudice and stigma in society (World Bank, 2023).

The provision of an accessible digital environment is of particular importance for the development of software and to be adapted to the needs of users with different types of disabilities. Part of the development of accessible software technologies is the accessibility testing and evaluation systems. Their primary task is to derive information about how easily users can work with a piece of software and provide recommendations for improving future designs and implementations. Accessibility assessment is formalized through international standards that offer recommendations and give guidelines for the technical implementation of common problems in software development related to its use by people with disabilities. For example, accessibility

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testing tools are often based on US federal government Section 508 and the Web Content Accessibility Guidelines (WCAG) of the W3C (Ismail & Kuppusamy, 2022; Jo et al., 2022; Marthasari et al., 2023; Navarro et al., 2022).

In this regard, **the purpose of the current paper** is to propose a high-level conceptual model of a software accessibility evaluation system's prototype. The main objective is to study attributes of software quality and existing systems for evaluating accessibility.

## 2. LITERATURE REVIEW

### 2.1. Software Quality Attributes

Software developers are faced with the challenge of creating products based on the user experience and combining aesthetics, functionality, ergonomics, and the ability to quickly perform tasks, while at the same time having to comply with the limitations imposed by digital devices and the special needs of end users.

Software quality is crucial for various reasons, including user satisfaction, customer retention, reduced costs, brand reputation, competitive advantage, compliance and standards, maintainability and scalability, risk mitigation, and adaptability to change. High-quality software ensures a positive user experience and contributes to customer loyalty by meeting expectations and providing value.

Reduced costs can be achieved by identifying and fixing bugs early in the development process, which is more cost-effective than addressing issues later. A positive brand reputation for high-quality products can increase trust and credibility in the market.

Compliance with standards ensures that software meets regulatory requirements and is suitable for specific use cases. Maintainability and scalability are also benefits of quality software, as well-structured code, thorough documentation, and best practices make it easier for developers to update and extend the software over time.

All of these benefits are considered in the software product quality model inscribed in ISO/IEC 25010:2023(en). It categorizes software quality into eight main characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability (International Organization for Standardization, 2023). Each of these is composed of a set of related sub-features. The group of functional suitability includes functional completeness, functional correctness, and functional expediency. Productivity efficiency refers to resource utilization, capacity, and time behavior. Compatibility is associated with coexistence and interoperability.

According to ISO/IEC 25010:2023(en), accessibility is a sub-characteristic of usability, together with appropriateness, recognisability, learnability, operability, user error protection, and user interface aesthetics. Reliability includes maturity, availability, fault tolerance, and recoverability. The characteristic "security" includes sub-characteristics: confidentiality, integrity, non-repudiation, accountability, and authenticity. Maintainability is associated with modularity, reusability, analysability, modifiability, and testability. The final characteristic of the quality model is portability, which refers to adaptability, installability, and replaceability.

According to the standard, accessibility is associated with the degree to which a product or system can be used by people with the widest range of characteristics and abilities to achieve a specific goal in a specific context of use. Some of the other characteristics in the quality model can be measured quantitatively, others only qualitatively ([International Organization for Standardization, 2023](#)).

According to ISO/IEC 25010:2023(en), accessibility can be defined or measured either as the degree to which a product or system can be used by people with certain disabilities to achieve specific goals with effectiveness, efficiency, freedom of risk, and satisfaction in a particular context of use or through the presence of product properties that support accessibility ([International Organization for Standardization, 2023](#)). In this regard, the question arises whether means exist to measure the properties of products that determine their affordability. Measurement is all about testing and evaluating the accessibility of software.

## 2.2. Software Accessibility Evaluation

Software quality for accessibility is crucial for creating an inclusive user experience. It ensures software is usable by individuals with diverse abilities, allowing a broader range of users, including those with disabilities, to access and interact with the application. This ensures legal compliance, as accessibility regulations and standards are established in various regions and countries.

According to the opinions of various authors, it can be summarized that testing is mostly done by users who follow a pre-written script with tasks ([Ara et al., 2023](#); [Budake et al., 2023](#); [Maqbool & Herold, 2024](#); [Rahal et al., 2023](#); [Rodríguez et al., 2023](#)). The purpose of testing is to obtain feedback from users in the form of quantitative and/or qualitative data. The assessment is carried out by software quality experts and for this reason, is also known as expert evaluation. It can also be performed as a result of the tests carried out. The accessibility evaluation is carried out after choosing an appropriate method, the implementation of which may involve users and representatives of some of the other teams involved in the development of a given system, such as designers and developers.

The studies carried out indicate that the stages of the accessibility testing and evaluation process are not precisely distinguished, both by international standards and by specialists in the field. Some authors study only the accessibility evaluation process ([Badzio et al., 2022](#); [Faraji Sabokbar et al., 2021](#); [Faria & Abreu, 2023](#); [Floriano et al., 2022](#); [Núñez et al., 2019](#); [Valtolina & Fratus, 2022](#)), others only the testing process ([Johnson & Lilley, 2022](#); [Mateus et al., 2021](#); [Oncins, 2021](#); [Pandey et al., 2022](#); [Seo & Rogge, 2023](#); [Sík-Lányi & Orbán-Mihálykó, 2019](#)), but in the literature they are rarely united in a comprehensive accessibility research process. No information was also found on a clear grouping of the applied methods and means, which corresponds to their phased application. In a previous study, the author made attempts to derive a unified process of web accessibility audit, which consists of the following stages: planning; research; evaluation; reporting, and subsequent control ([Nacheva, 2022](#)). The web accessibility audit process is based on a controlled business process, the input of which is the user requirements, formed research objectives, and a prototype of the web system under investigation. As output artifacts of the process, web accessibility audit reports and recommendations for improving web accessibility are obtained. However, in the literature, we do not find an analogous process of auditing software accessibility, which we consider to be a potential field for the development of scientific knowledge in the field of software quality and, in particular, ensuring its accessibility.



Several companies often do not implement any methods and means of testing or evaluating the accessibility of the products they develop. It relies solely on the subjective judgment of developers, designers, and managers, who are usually not familiar with the details of accessibility issues in software. In these cases, we cannot speak of the observance of a structured work process (business process) of accessibility research, since it is mainly based on decision-making, discussion, and professional cooperation to achieve certain results - creating accessible software. The nature of this way of working means that the structure of the workflow will be different each time.

Software accessibility evaluation tools assess software applications or websites for accessibility to individuals with disabilities. These tools cover aspects like screen reader compatibility, keyboard navigation, color contrast, alternative text for images, focus indicators, captions and transcripts, text resizing, and form accessibility. Popular tools like WAVE, Axe, and NVDA help developers identify and address accessibility issues, creating a more inclusive digital experience for all users (Gaggi et al., 2019; Nganji, 2018; Pamuji et al., 2023). These tools help developers create more accessible digital products for all users.

WAVE is an online tool that provides detailed accessibility reports, visual representations of web pages with annotations, and error identification. It supports the evaluation of dynamic content (WebAIM, 2023). Axe is a browser extension and command line tool that integrates with various development environments and browsers employs rules based on WCAG, provides actionable insights, and allows automated testing (Deque Systems, Inc., 2023). It supports popular web browsers and applications, allows customization of settings, and supports braille displays.

WAVE and Axe focus on evaluating web content, while NVDA is a screen reader software applicable to various digital environments. WAVE and Axe are used by developers and designers to test and fix accessibility issues, while NVDA is used by individuals with visual impairments to access digital content (NV Access, 2023). WAVE and Axe support automated testing, while NVDA requires manual interaction for evaluation. WAVE and Axe are widely used during the development phase, while NVDA is used by end-users for real-time interaction with digital content. The choice of tool depends on the specific needs and workflows of the user or development team.

Biometric accessibility evaluation tools are less common than traditional tools, but they can be used to assess the usability and accessibility of biometric authentication systems. Biometric authentication offers enhanced security, user convenience, inclusivity, efficiency, and reduced fraud compared to traditional methods like passwords or PINs (Shaheed et al., 2024). However, privacy concerns, security vulnerabilities, intrusiveness, and the cost of implementation are some of the cons. Biometric data is unique and personal, raising privacy concerns. The accuracy and reliability of biometric systems can be influenced by factors like environmental conditions, hardware quality, and individual variations (Sasikala, 2024). Security vulnerabilities can be susceptible to hacking or spoofing attempts. Intrusiveness may be experienced by some users due to concerns about data storage and use. Accessibility challenges may arise for individuals with certain disabilities, such as fingerprint recognition (Dargan & Kumar, 2020). Lack of standardization in biometric technology may lead to interoperability issues and varying levels of accessibility across different systems.

Considerations for accessibility evaluation tools include usability testing, user feedback surveys, and security audits. Usability testing provides insights into user experience and potential accessibility challenges, while user feedback surveys allow gathering opinions and concerns



from users, including those with disabilities. Security audits identify potential security vulnerabilities but focus more on security aspects than user experience or accessibility.

Usability testing tools like Lyssna (former UsabilityHub) and Optimal Workshop can be used to gather user experience insights and assess the overall usability of biometric authentication processes (Lyssna, 2023; Optimal Workshop Ltd., 2023).

Considerations for biometric authentication evaluation include accuracy and error rates, adaptability, user feedback, security and privacy, customization, and compliance with accessibility standards. High accuracy is crucial for successful authentication, and biometric systems need to be highly customizable and adaptable to accommodate users with diverse needs.

Biometric evaluation tools are less common, and organizations often rely on a combination of usability testing, user feedback, and adherence to accessibility standards. Customization and adaptability are essential for biometric systems to accommodate users with diverse needs. While usability testing tools can help gather insights into user experience, customization features in biometric systems are crucial.

While there may not be specific biometric accessibility evaluation tools readily available, usability testing platforms can play a role in assessing the overall usability of interfaces, including those incorporating biometric authentication. Organizations should also consider specific aspects related to biometric systems, such as accuracy, adaptability, and compliance with accessibility standards, to ensure inclusive user experiences.

### 3. CONCEPTUAL MODEL OF A SOFTWARE ACCESSIBILITY EVALUATION SYSTEM

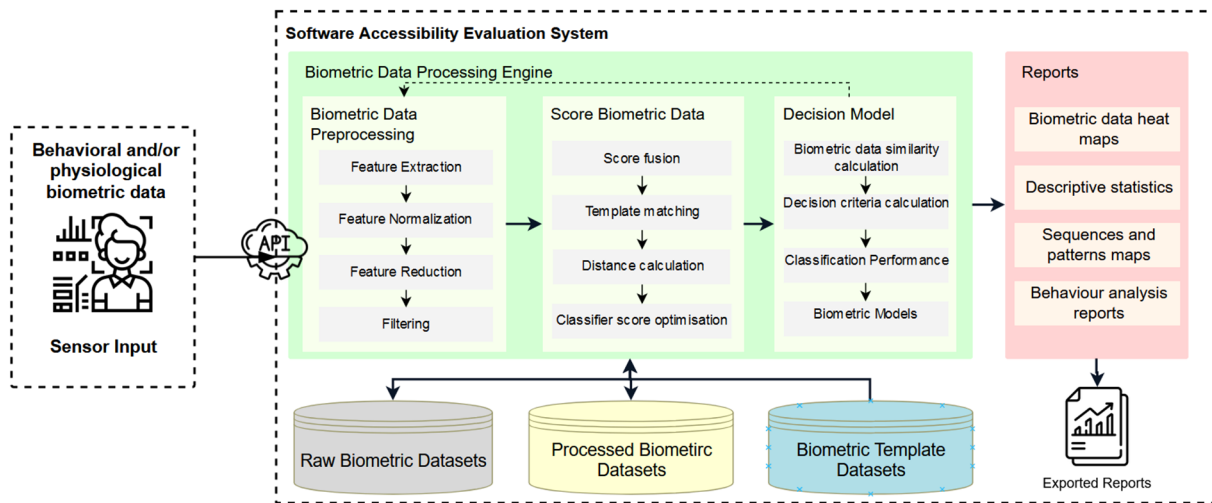
The development of a software accessibility evaluation system should focus on exploring users' mental models, providing maximum freedom for testing, receiving quantitative data, and tracking rules for building accessible interfaces. Challenges include users being out of their comfort zone when using unusual devices, research needing to be conducted in a laboratory or moderator-controlled environment, providing unambiguous data presentation, and combining opportunities for moderated and unmoderated accessibility research. Despite these challenges, the development of an accessible assessment system is crucial for improving user experience and software accessibility.

Mainly, the software evaluation tools can be based on working with:

- a. questionnaires to obtain feedback on satisfaction with working with the system or application under study;
- b. log files, in which the results of the operation of the system or application on the server side are recorded;
- c. interactions with the applications – e.g., these could be the screen taps and gestures performed when interacting with the mobile device, based on which the achieved performance can subsequently be established and respectively the number of errors made. Similar, for example, are A/B tests;
- d. biometric data – behavioral and/or physiological, of which facial expression analysis, audio recording processing (voice analysis), and gaze tracking are most commonly used in accessibility research. It should be noted that depending on the type of disability, different biometric data should be analyzed.

Based on this, a high-level conceptual model of the software accessibility evaluation system is proposed in Figure 1, illustrating the general types of activities performed by biometrics processing systems.

The system aims to integrate multiple modules with versatile purposes but faces challenges in implementing it due to technological features and architecture. It should consider the appropriate architectural pattern for integrating internet application and biometric system functionality, specific hardware devices for recording biometric data, the need for specialized modules for processing biometric data, physical storage of application data, and user identification approach. This requires a complex system with numerous components and integration of current technologies. We propose two main modules: Biometric Data Processing Engine and Reports. The first one is responsible for the preprocessing of raw data, scoring of processed biometrics, and creating decision models. The second module represents biometric data heat maps, and descriptive statistics and generates reports about users' behavior patterns.



**Figure 1.** Conceptual Model of a Software Accessibility Evaluation System

Source: Own elaboration

The **Biometric Data Preprocessing Module** involves identifying and extracting distinctive features from raw biometric data, ensuring a condensed and informative representation. Normalization standardizes the data to ensure consistency across samples, removing variations due to different capturing conditions. Feature reduction reduces the dimensionality of the feature space while retaining the most relevant information, improving computational efficiency, and reducing the risk of overfitting. Filtering removes noise or irrelevant information from the biometric data, enhancing the signal-to-noise ratio. These stages collectively contribute to a robust and efficient biometric system by refining the raw input data, making it suitable for accurate matching and identification. Each stage plays a crucial role in addressing challenges associated with variations in biometric traits and environmental conditions.

The **Score Biometric Data Module** involves processing pipeline, including fusion, template matching, distance calculation, and classifier optimization and requires careful consideration of various factors. Template matching criteria include accuracy in matching biometric templates. Distance calculation criteria involve precision in calculating dissimilarity between templates, with lower scores for smaller distances indicating higher similarity. Fusion criteria integrate multiple matching scores for improved accuracy. Classifier optimization criteria

enhance classifier performance through optimization techniques, with higher scores for improved classification metrics. The overall score is calculated by assigning weights to each component based on their importance, and the overall score is calculated by combining the scores from template matching, distance calculation, fusion, and classifier optimization. Adjusting the weights and individual scores based on specific application requirements and priorities is also possible.

The **Decision Model Module** involves similarity calculations, decision criteria calculations, classification performance, and biometric model generation. Similarity calculations measure the resemblance between presented biometric data and stored reference data, providing a basis for decision-making. Decision criteria calculations set thresholds for identification or authentication, balancing security and convenience. Classification performance evaluation assesses the accuracy and reliability of the biometric system, including metrics like accuracy, precision, recall, F1 score, etc. Biometric model generation creates mathematical or statistical models that represent unique characteristics of individuals based on their biometric traits, used for storing reference templates and generating features for classification. The generation of effective models is crucial for the overall accuracy and reliability of the biometric system. The effectiveness of each stage contributes to the overall performance and security of the biometric system.

Future developments should include an architectural model and interactive prototype based on the proposed system. The author should present an architectural model and interactive prototype for future development.

#### 4. CONCLUSION

In conclusion of this publication, it can be summarized that the research on the accessibility of software applications can be conducted through software quality testing and evaluation systems. These types of systems are used to study mostly the functional suitability, reliability, performance efficiency, and usability of the software. Aspects of accessibility testing and evaluation are considered part of usability testing and analysis, from the perspective of the software product quality model formalized in ISO/IEC 25010:2023(en).

The methods and tools of software quality research are diverse. They can be implemented with or without the participation of representatives of the target audience. Software products integrate various technologies, among which biometric data processing-based ones are gaining popularity. Biometric technologies are the most suitable for accessibility research due to their independence from the external environment, high accuracy of the results, improvement of communication capabilities, especially from the human side, and work with mental commands.

The proposed software accessibility evaluation system model is crucial for creating software that is accessible to all users, including those with disabilities. It ensures equal access, legal compliance, and user experience improvement. Such a system will help organizations comply with regulations and standards, avoiding potential legal issues. It also expands market reach by catering to users with disabilities, aligning with corporate social responsibility. Accessible software positively influences a company's brand reputation, increasing customer loyalty. It also improves employee productivity by ensuring workplace applications are usable by all employees, promoting a more inclusive work environment. The proposed system model also fosters innovation and creativity by addressing accessibility challenges.

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# Impact of Electronic Data Interchange on Business Communication and Communication Strategy Evolution in the Digital Age

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**Abstract:** *The research focuses on strategic approaches employed by businesses to enhance communication efficiency amidst the pervasive digital metamorphosis, with a primary emphasis on the role of EDI. The study unfolds in two dimensions: first, the optimization of communication channels through EDI, emphasizing accelerated information flow, reduced errors, and strengthened relationships. Second, it delves into personalized communication in the digital transformation era, revealing how companies leverage EDI for tailored messages, heightening customer engagement and conversion rates. The study explores the evolving role of communication professionals, emphasizing the acquisition of data analysis skills in a data-driven business environment. The paper introduces a specialized algorithm to illuminate the intricacies of the EDI process, providing a systematic approach to grasp the electronic organization, translation, and transmission of data. It underscores the importance of cybersecurity, especially in handling sensitive data in increased digital interactions. The study offers guidance on enhancing communication strategies amid ongoing digitization.*

## 1. INTRODUCTION

In the contemporary business landscape, Electronic Data Interchange (EDI) stands as an important technology reshaping the dynamics of information exchange. EDI, at its core, involves the electronic transmission of structured business documents between trading partners (Sun, 2023). It replaces traditional paper-based methods, fostering efficiency by streamlining processes and minimizing manual intervention (Addo, 2022).

Business communication encompasses the strategies and practices employed by organizations to convey information both internally and externally (Cornelissen, 2020, p. 336). In the digital age, the landscape of business communication has undergone a paradigm shift. It now extends beyond traditional mediums to incorporate diverse digital channels, emphasizing the need for adaptability (Ancillai et al., 2019) and strategic utilization of technology to ensure effective message dissemination.

Communication strategy in the digital age reflects the dynamic approach organizations adopt to navigate the complexities of the contemporary business environment (Teubner & Stockhinger, 2020). It involves leveraging digital tools, data-driven insights, and technology-driven platforms to tailor communication efforts. This strategic adaptation is essential to engage diverse audiences (Hyland-Wood et al., 2021), enhance brand perception, and align with the rapidly evolving expectations of stakeholders in the digital realm.

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The research is organized into distinct sections: “Optimizing Communication Channels Through EDI” explores how EDI accelerates information flow, reduces costs, and strengthens inter-organizational relationships. “Personalized Communication in the Digital Transformation Era” investigates EDI’s role in tailored communication, enhancing customer engagement and real-time responsiveness. “Evolution of Communication Professionals in a Data-Driven Landscape” emphasizes the important role of communication professionals in adopting EDI and acquiring data analysis skills. The research methodology includes a practical example, showcasing a specialized algorithm for electronic data organization, translation, and transmission within the EDI process. “EDI in the Automotive Industry” scrutinizes EDI’s role in streamlining coordination and addressing industry-specific challenges. “Addressing Cybersecurity Challenges in the Digital Age” underscores the importance of robust cybersecurity measures in EDI implementation. The concluding sections, “Discussion” and “Conclusion”, provide practical guidelines and summarize the transformative impact of EDI on communication strategies. Together, these sections offer a concise exploration of EDI’s influence on modern communication channels and strategies.

## 2. OPTIMIZING COMMUNICATION CHANNELS THROUGH EDI

The strategic integration of Electronic Data Interchange (EDI) significantly shapes the optimization of communication channels (Culot et al., 2019) in today’s business milieu. The acceleration of information flow stands as a cornerstone of EDI’s impact. By displacing traditional paper-based documentation and eliminating manual data entry, EDI establishes a streamlined and expeditious channel for information exchange (Carvalho et al., 2020). This paradigm shift is particularly noteworthy when contrasted with conventional methods like mail or fax systems. An equally critical aspect of EDI lies in its capacity to institute a standardized format for transactions (Kumar et al., 2020). This universal adherence to a standardized foundation serves as a safeguard against potential pitfalls such as data misinterpretation and formatting discrepancies. EDI has been shown to contribute to a noteworthy reduction in transaction costs (Oleiwi, 2023). This revelation underscores not only the efficiency gains but also the economic advantages associated with the adoption of EDI. The integration of automated processes, synonymous with EDI, transcends mere operational efficiency and becomes a catalyst for profound enhancements in inter-organizational relationships and substantive cost savings (Abbasnejad et al., 2021). The integration of automated processes, synonymous with EDI, transcends mere operational efficiency and becomes a catalyst for profound enhancements in inter-organizational relationships and substantive cost savings. In terms of relationship enhancement, the automated processes facilitated by EDI engender a heightened level of reliability and consistency in business transactions. The standardization intrinsic to EDI protocols minimizes the risk of misunderstandings, cultivating stronger, more resilient relationships between collaborating entities (Camarinha-Matos et al., 2019).

The systemic reduction of manual intervention within the transactional process translates into tangible cost savings (Syed et al., 2020). By obviating the need for intermediaries to review documents, EDI significantly contributes to operational cost reductions, offering a transformative economic dimension.

## 3. PERSONALIZED COMMUNICATION IN THE DIGITAL TRANSFORMATION ERA

Personalized communication in the digital transformation era refers to the practice of tailoring communication strategies and messages to individual recipients based on their preferences, behaviors (Nobile & Kalbaska, 2020), and characteristics in the context of the ongoing digital transformation.

In this era, businesses leverage advanced technologies and data-driven insights to create customized interactions with their audience, aiming to enhance customer engagement and satisfaction. The previous discussion on the functionalities of Electronic Data Interchange (EDI) in order processing and fulfillment significantly contributes to understanding how EDI is applied in the context of personalized communication during the digital transformation era (Ali & Govindan, 2023). The automated exchange of order information through EDI establishes a foundation for personalized communication. By facilitating the direct transmission of electronic messages containing specific details about customers, products, quantities, prices, and delivery instructions (Rosário & Raimundo, 2021), EDI enables organizations to customize their communication based on individual preferences. The structured format of EDI orders, defined by message standards like EDIFACT (Sahinaslan et al., 2022), provides a unique framework that supports the interpretation of data. This structured approach allows organizations to effectively utilize EDI data for tailoring communication to the individual needs of customers. Integration with existing order management systems further enhances the efficiency of the process, enabling the direct transfer of data into internal systems.

This integration reduces the risk of errors associated with manual data entry, providing organizations with accurate information for more personalized communication. Real-time visibility and tracking, key advantages of EDI in order processing (Sahraoui et al., 2023), align with the requirements of personalized communication. Instant access to order statuses and inventory levels allows organizations to respond to customer needs in real time, fostering a personalized and responsive communication approach.

#### 4. EVOLUTION OF COMMUNICATION PROFESSIONALS IN A DATA-DRIVEN LANDSCAPE

Positioned at the nexus of traditional and emerging communication methodologies, contemporary communication professionals find themselves at the forefront of businesses increasingly embracing EDI for streamlined communication. Professionals are entrusted with orchestrating seamless technological integrations, transcending conventional practices and necessitating adaptability to navigate sophisticated digital tools effectively (Mally, 2023). At the core of this transformative phase lies the imperative for professionals to acquire proficiency in data analysis. EDI, as a prime example, demands a nuanced understanding of data flows, document preparation (Kosmol et al., 2019), and the complex process of translating information into standardized EDI formats. This acquisition of skills is a direct response to the exigencies of effective communication within the realm of electronic information exchange.

The tangible evolution of communication strategies in the context of EDI is evident in the meticulous steps of the EDI process. From the electronic organization of data in document preparation to the translation into the EDI format using specialized software (Sun, 2023), each phase underscores the need for adept mapping expertise. The subsequent connection and transmission phase, whether through direct connections or EDI Network providers, encapsulates the essence of contemporary communication strategies.

#### 5. RESEARCH METHODOLOGY – PRACTICAL EXAMPLE OF HOW EDI WORKS

A specialized algorithm developed by Panteon Plus - Belgrade, will be employed to illuminate the intricacies of the EDI process. This proprietary algorithm, designed with a focus on enhancing clarity and efficiency in electronic data interchange (Addo, 2022), serves as a valuable tool

for dissecting each phase of the EDI workflow. The presented algorithm outlines the process: Prepare the documents, Translate the documents into EDI format, Transmit the EDI documents to your partner.

### **Algorithm: EDI Processing**

```
def edi_process(data):  
    prepared_data = prepare_documents(data)  
    translated_data = translate_to_edi_format(prepared_data)  
    transmitted_data = transmit_edi_documents(translated_data)  
  
    return transmitted_data  
  
def prepare_documents(data):  
    # Logic for collecting and organizing data  
    prepared_data = # Prepared data in electronic format  
  
    return prepared_data  
  
def translate_to_edi_format(data):  
    # Logic for translating data to EDI format  
    translated_data = # Translated data in EDI format  
  
    return translated_data  
  
def transmit_edi_documents(data):  
    # Logic for transmitting EDI documents  
    transmitted_data = # Transmitted data  
    return transmitted_data  
  
# Example Usage  
edi_result = edi_process(your_data)
```

The provided algorithm delineates the EDI process, furnishing professionals with a systematic approach to grasp the electronic organization, translation, and transmission of data. The presented methodology ensures a clear understanding of the intricacies involved in modern communication strategies, emphasizing the role of EDI in the dynamic landscape of digital communication.

## **6. EDI IN THE AUTOMOTIVE INDUSTRY**

In the complex world of the automotive industry, characterized by demanding processes such as Just-in-Time (JIT) and Just-in-Sequence (JIS) production, Electronic Data Interchange (EDI) stands out as a main technology (Nürk, 2019). It serves to streamline coordination and ensure a standardized exchange of logistics information between Original Equipment Manufacturers (OEMs) and their extensive network of suppliers (Deng & Xu, 2023). Within the present-day challenges of the automotive sector, EDI proves to be a robust solution. Fueled by high-quality demands and unrelenting time pressure, the industry relies on EDI to achieve rapid updates of delivery forecasts, process and meet clients' delivery specifications, and comply with legal and tax-law requirements.

Looking ahead, EDI positions itself as an adaptive response to future challenges. These challenges encompass the ever-shortening product cycles, unexpected delivery bottlenecks, and the transformative impact of innovations such as Artificial Intelligence (AI), Cloud computing, Big Data, and the Internet of Things (IoT) (Buckley et al., 2023, p. 94, 95, 114). Additionally, as the industry undergoes significant transformations due to trends like e-mobility and the emergence of new digital ecosystems, EDI remains a versatile and indispensable tool. In addressing the diverse requirements of the industry, various options for EDI communication play an important role. EDI integration facilitates direct document exchange via a company's ERP system, ensuring seamless connections with the systems of business partners. For smaller partners lacking their own ERP systems, Web EDI provides a practical web-based interface on EDI platforms (Malallah & Abdulrazzaq, 2023) for efficient document exchange. Exploring the key EDI standards prevalent in the automotive sector reveals the comprehensive nature of EDI's role.

## 7. ADDRESSING CYBERSECURITY CHALLENGES IN THE DIGITAL AGE

As organizations embrace Electronic Data Interchange (EDI) for streamlined business processes, prioritizing cybersecurity in EDI implementation becomes paramount. The secure exchange of sensitive business data is integral to safeguarding an organization's reputation, financial integrity, and customer information (Efijemue et al., 2023). EDI involves the computer-to-computer exchange of standardized electronic business documents between trading partners. To reduce cybersecurity risks, organizations must implement robust data security controls and adhere to stringent practices. The main components of securing EDI operations include implementing secure communication protocols (Sun, 2023), compliance with data protection regulations, effective management of user identities and access, securing systems and networks, continuous monitoring for security events, and vigilant vendor management (Meagher & Dhirani, 2024).

While EDI facilitates seamless data exchange, it also introduces cybersecurity risks due to the nature of the data involved (Biasin et al., 2023). Sensitive business information, such as purchase orders, invoices, and payment details, is transmitted between different computer systems during EDI transactions. This valuable data is a target for cybercriminals seeking financial gain. Unauthorized access to data poses a significant risk in EDI systems. Hackers gaining entry to an organization's EDI system can exploit or steal sensitive information, including customer data, financial records, or trade secrets (Abu-ulbeh et al., 2023). Additionally, they might manipulate or delete data, disrupting business operations and resulting in financial losses. To address these risks, organizations must implement robust cybersecurity measures for their EDI systems. This includes encrypting data during transmission and storage, establishing stringent access controls and authentication protocols (Omotunde & Ahmed, 2023), regular monitoring and updates for system vulnerabilities, and developing incident response and disaster recovery plans. To further reduce risks, organizations can opt to engage specialized EDI service providers. Through its proprietary business network (Oleiwi, 2023), Panteon.net®, the company ensures reliable and secure electronic data transmission, boasting over a decade of specialized experience in the field.

Collaboration with trading partners and service providers is very important, ensuring they follow cybersecurity best practices through security control verification and regular security audits.



## 8. DISCUSSION UNVEILING UNIQUE IMPACTS OF EDI IN COMMUNICATION OPTIMIZATION

Optimizing communication channels through Electronic Data Interchange (EDI) establishes a standardized framework that accelerates information flow while concurrently reducing operational costs (Kopczewski et al., 2020). This resonates with established research, which emphasizes the dual benefits of efficiency and cost reduction in EDI implementation. The application of EDI in fostering personalized communication during the digital transformation era is evident through its facilitation of direct and tailored exchanges of detailed order information.

The study aligns with existing literature that emphasizes the efficient customization of communication through proper data interpretation using EDI standards.

The evolution of communication professionals in a data-driven landscape (Smit et al., 2022), particularly within the context of EDI, is marked by a distinct focus on acquiring data analysis skills. This mirrors broader industry trends where communication professionals are increasingly required to navigate sophisticated digital tools and processes. In the automotive industry, EDI emerges as an important technology (Okano & Fernandes, 2019), streamlining the exchange of logistics information in complex supply chains. The results underscore its adaptability and efficiency in addressing the industry's challenges, aligning with similar studies that highlight the broader applicability of EDI solutions in sectors with complex logistical demands. Addressing cybersecurity challenges in the digital age is emphasized due to the sensitive nature of data exchanged (Biasin et al., 2023) through EDI. The study underlines the necessity of robust data security controls, encryption protocols, and vigilant monitoring to reduce potential risks, aligning with established cybersecurity best practices in digital transactions. These findings provide a nuanced understanding of the specific impacts of EDI without reiterating previously presented facts.

## 9. CONCLUSION

Despite the improved efficiency and accelerated information flow provided by EDI, the key to success in the digital era lies in the thorough preparation and training of personnel. The study recommends companies invest in comprehensive training programs that enable employees to acquire data analysis skills, document preparation proficiency, and an understanding of the essential processes of translating information into standardized EDI formats (Andiyappillai, 2020). The anticipated increase in digital interactions necessitates enhanced security measures. It is recommended that companies establish robust security protocols, including data encryption, regular security audits, and staying in line with the latest advancements in cybersecurity to safeguard sensitive EDI data.

Given the shifting dynamics of communication, collaboration between communication professionals and IT teams becomes important. This synergy allows for seamless technological integrations, aligning communication strategies with the capabilities of sophisticated digital tools. To anticipate future challenges, this research recommends companies stay informed about the development of new technologies (Awan et al., 2021). Monitoring trends in artificial intelligence, cloud technologies, big data, and the Internet of Things enables adaptive and resilient communication strategies.

The study also recommends researching tailored EDI solutions that cater to the specific needs of the industry (Kamasak et al., 2023). Customizing EDI integration to the sector's specific



requirements enhances efficiency and effectiveness, ensuring a fluid and responsive communication environment.

These recommendations, stemming from an in-depth analysis of the impact of Electronic Data Interchange on business communication and the evolution of communication strategies in the digital age, provide practical guidelines for companies seeking to improve their communication strategies amid the ongoing process of digitization. These guidelines represent fundamental principles for navigating the complex intersection of communication and technology in the modern era. Future research could delve deeper into effective strategies for personnel training and preparation, ensuring organizations are well-equipped to maximize the benefits of EDI adoption.

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# Impact of Digitalization on the Performance of Human Resources in Listed Companies in Morocco

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Companies Listed on the  
Casablanca Stock Exchange



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**Abstract:** *The digital age has brought about significant upheavals in the functioning and structure of organizations worldwide. This article investigates the impact of digitalization on the performance of Human Resources (HR) within companies listed on the Casablanca Stock Exchange in Morocco. The adopted methodology is based on structural equation modeling. In this regard, a survey was conducted among the HR departments of 70 companies listed in Casablanca. The results show significant correlations between the implementation of digital technologies in HR processes and an improvement in the performance of these departments. This article highlights the importance of digitalization as a strategic lever to enhance the efficiency of HR functions while underscoring the unique challenges faced in the Moroccan context. These findings provide valuable insights for practitioners and decision-makers looking to optimize their HR strategies in the digital age.*

## 1. INTRODUCTION

The digital age has ushered in a plethora of changes and transformations to organizations around the globe. Digitalization, encompassing the integration and use of digital technologies, profoundly alters how businesses operate, simultaneously presenting opportunities and challenges (Brynjolfsson & McAfee, 2014). In this global context, Human Resources (HR) departments are not left behind. Historically focused on administrative and operational tasks, HR is now at the heart of these upheavals, striving to enhance their performance and add value to the organization (Stone et al., 2015).

Morocco, regarded as an emerging market with an active stock exchange in Casablanca, provides a unique setting for studying these dynamics. Listed companies, in particular, operate in an environment where shareholder expectations, corporate governance, and transparency are paramount. Consequently, understanding how digitalization impacts HR performance within these companies is of paramount importance (El Akremi et al., 2018).

This article aims to probe the impact of digitalization on the HR performance of companies listed on the Casablanca Stock Exchange. Drawing on a robust methodology based on structural equation modeling and a comprehensive survey, this research endeavors to highlight the consequences, opportunities, and challenges related to this digital shift in the Moroccan landscape.

In this regard, Structural Equation Modeling (SEM) is a multidimensional statistical approach that combines factor analysis and regression techniques to examine complex relationships between observed and latent variables (Bollen, 1989; Kline, 2011). This technique allows for the

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understanding of the validity of theoretical constructs while simultaneously evaluating a series of interdependent hypotheses related to the relationships between these constructs.

In the context of the impact of digitalization on HR performance, SEM takes on special significance. It helps ascertain whether the measured indicators accurately reflect the underlying concepts (latent variables) they are intended to represent, such as the different dimensions of “HR performance” (Hair et al., 1999). Moreover, it provides the ability to check if, for instance, the integration of digital technologies influences HR performance, considering other relevant variables (Byrne, 2010). Lastly, through various fit indices, SEM sheds light on the alignment between the theoretical model and the collected data (Hu & Bentler, 1999).

To this end, this article will be structured as follows: the second section will present a literature review concerning the impact of digitalization on the HR performance of listed companies. The third section will introduce the conceptual model and its hypotheses. The fourth section will showcase the results and discussion, and the fifth conclusion.

## 2. LITERATURE REVIEW

The digital transformation of businesses is a widely studied topic due to its significant implications for the management and performance of Human Resources (HR). Listed companies, often subject to the pressures of shareholders and regulators, may adopt a specific perspective on digitalization. Regarding theories on digitalization and HR, the theory of digital transformation, according to Kane et al. (2015), suggests that digital transformation is not limited to the adoption of digital technologies. It also encompasses cultural and operational transformation, with HR playing a pivotal role in this cultural shift. Similarly, Barney (1991), through his resource-based theory, posits that companies possessing rare, inimitable, and irreplaceable resources can gain a competitive edge. In the context of digitalization, HR competent and trained in new technologies can represent such a resource, as emphasized by Teece (2007).

From an empirical standpoint on the impact of digitalization on HR performance, Stone and Deadrick (2015) illustrated that adopting digital technologies can enhance HR productivity by automating various tasks and providing data-driven decision-making tools. Cappelli and Keller (2014) observed that the use of digital platforms in recruitment improves candidate quality while reducing the recruitment process’s duration. Moreover, Pfeffer (2015) highlighted that e-learning platforms allow HR to deliver more tailored training, thereby optimizing their effectiveness.

Concerning digitalization and listed companies, El Akremi et al. (2018) postulated that these firms might feel increased pressure to adopt digital technologies due to shareholder expectations and regulatory standards. In agreement with Mallin (2018), listed companies, in pursuit of greater transparency, can leverage digital tools to amplify communication and cooperation between staff and management, subsequently influencing HR performance.

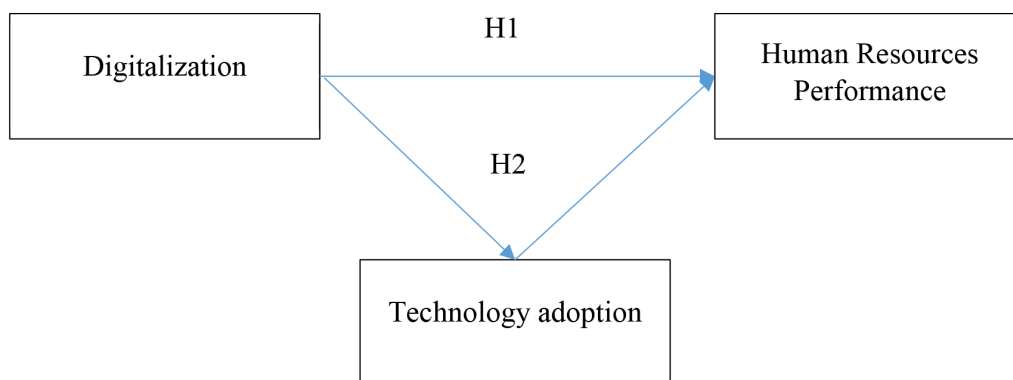
Regarding national literature, Abdelkhalek et al. (2021) analyzed the impacts of digitalization on the Moroccan economy and suggested approaches to enhance labor market productivity and flexibility. They recommend intensifying the development of e-governance and prioritizing the adoption of digital technologies in the financial sector to invigorate the economy. The significance of e-commerce and the digitalization of agriculture to address sectoral challenges is also emphasized. However, they underscore the need to prevent a digital divide and ensure that

agricultural digitalization helps combat poverty. Ultimately, digital metamorphosis will be pivotal for Morocco's economic dynamism.

Additionally, [Elhazziti et al. \(2023\)](#) examined Morocco's efforts in digital transformation, highlighting its shortcomings and proposing directions based on new benchmarks. This transformation has focused on digitization policy, training human resources, and expanding digital access. While the public administration is gradually adopting this transformation, cultural and organizational challenges hinder its effectiveness. Despite various initiatives since the 1990s, results have been mixed, as evidenced by Morocco's ranking in e-government indicators. Nonetheless, the COVID-19 crisis has underscored the urgency of this transformation to facilitate access to public services.

### 3. THE CONCEPTUAL MODEL

The digital revolution is transforming many sectors, and human resources are no exception to this trend. With the rise of technologies, companies are urged to adopt and integrate digital tools to remain competitive. In Morocco, listed companies, like other businesses worldwide, seek to capitalize on the benefits of digitalization to optimize the performance of their human resources. However, this shift to digital comes with significant challenges. The proposed conceptual model below aims to study the impact of digitalization on the performance of human resources in listed companies in Morocco.



**Figure 1.** The Conceptual Model

**Source:** Own research

In this context, digitalization is a multi-dimensional concept that encompasses various aspects such as automation, analytics, mobility, and virtualization ([Brynjolfsson & McAfee, 2014](#)). When integrated into the realm of human resources, these elements can potentially transform HR processes, improve efficiency, and contribute to better decision-making ([Stone et al., 2015](#)). The conceptual model and the hypotheses presented above analyze the relationship between digitalization and Human Resources performance. The latent variables considered encompass digitalization, covering areas such as technological integration, HR analytics, virtualization, and automation. Additionally, the performance of human resources is addressed from the angles of operational efficiency, employee satisfaction, and recruitment quality.

The mediating variable in this study concerns the adoption of technologies by employees. It is crucial because it could potentially modulate how digitalization influences HR performance. Two main hypotheses are stated: on one hand, it's suggested that digitalization has a direct positive effect on HR performance. On the other hand, it is proposed that the adoption of

technologies by employees acts as a mediator in the relationship between digitalization and HR performance. To quantify these variables, various scales were chosen. The scale related to digitalization relies on the work of Brynjolfsson and McAfee (2014), however, it has been revised to fit an HR context. HR performance is measured using a scale inspired by Stone et al. (2015), incorporating criteria such as operational efficiency, employee satisfaction, and recruitment quality. Finally, the evaluation of technology adoption by employees is based on a scale derived from the work of Davis (1989) and Venkatesh et al. (2003).

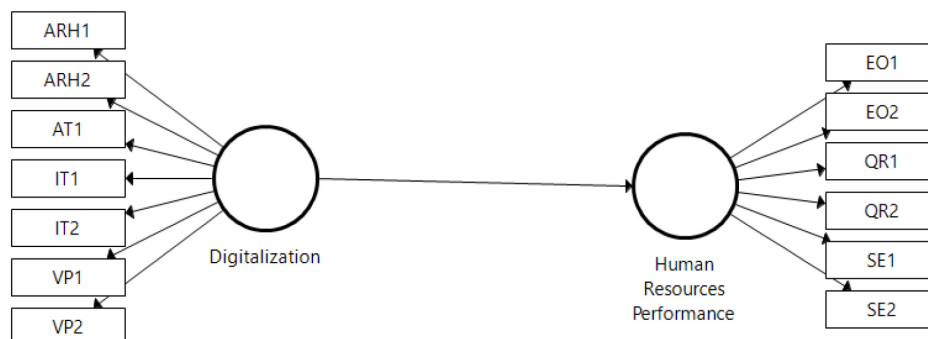
**Table 1.** Variables and Their Measurement Scales

Variables	Measurement Scale	Meaning	Authors
<b>Digitalization</b>	Technological Integration	Degree of adoption and implementation of advanced technologies within HR processes	Shet et al. (2021)
	HR Analytics	Use of data for predictive analysis and decision-making	Mohammed (2019)
	Process Virtualization	Implementation of dematerialized HR processes accessible remotely	Mohamed et al. (2022)
	Task Automation	Degree of technology use to automate routine HR tasks	Stone et al. (2015)
<b>Performance of Human Resources</b>	Operational Efficiency	Measure of how digital tools and processes improve HR operations	Zavyalova et al. (2022)
	Employee Satisfaction	Measures the satisfaction level of employees regarding the digital tools and processes established by the HR department	Jafari and Van Looy (2022)
	Recruitment Quality	Assesses the impact of digitalization on HR's ability to recruit quality candidates	van Esch and Black (2019)
<b>Adoption of Technologies by Employees</b>	Intention to Use	To what extent do employees intend to use the newly introduced technologies?	Anton et al. (2014)
	Frequency of Use	How often do employees use the introduced technologies?	Sundaram et al. (2007)
	Perceived Usefulness	Do employees see the technologies as useful for their work?	Majumder and Mondal (2021)

Source: Own research

#### 4. RESULTS AND DISCUSSION

This section aims to present the results of our analysis focused on the evaluation of human resource performance concerning digitalization. It is essential to ensure the validity and reliability of the measures taken in this analysis, hence the implementation of a systematic approach.



**Figure 2.** Path diagram model without mediator interaction

Source: Own calculations

**Table 2.** Reliability and validity indicators

	<b>Cronbach's Alpha</b>	<b>Rho_A</b>	<b>Composite Reliability</b>	<b>Average Variance Extracted (AVE)</b>
<b>Digitalization</b>	0,899	0,902	0,921	0,624
<b>Human Resources Performance</b>	0,893	0,898	0,918	0,652

**Source:** Own calculations

The analysis of the measurement model is a fundamental component of our study. The primary objective was to confirm the validity and reliability of the observed variables. Several methods were employed to achieve this goal. For instance, we used composite reliability to measure the internal consistency of items within the same construct. Ideally, this reliability should be equal to or greater than 0.7 for confirmatory models. However, during exploratory phases, a value of 0.6 can be deemed acceptable. Indicators, or questions on a scale, underwent meticulous scrutiny to confirm their relevance. An indicator is deemed reliable if it displays significant loading on the construct it is supposed to measure. Another key component of our analysis pertains to the Average Variance Extracted (AVE). It measures the portion of the variance captured by the construct compared to that due to measurement error. An AVE of 0.5 or greater typically signifies satisfactory convergent validity. Regarding the discriminant validity of our measures, we relied on the Fornell-Larker criterion. According to this criterion, the square root of the AVE for each construct should exceed its correlations with all other constructs in the model. Additionally, Table 2 presents the reliability and validity indicators for the “Digitalization” and “Human Resource Performance” constructs. For each construct, four main measures are indicated: Cronbach’s Alpha, rho\_A, Composite Reliability, and Average Variance Extracted (AVE). For Cronbach’s Alpha, Digitalization has a value of 0.899, nearing 1, thus indicating exceptional internal reliability. Similarly, Human Resource Performance displays a value of 0.893, also nearing 1, showcasing its excellent internal reliability. As for rho\_A, Digitalization has a value of 0.902, while Human Resource Performance is at 0.898. These values, very close to 1, confirm outstanding internal consistency for the elements of each construct. Regarding Composite Reliability, Digitalization records a value of 0.921, and Human Resource Performance a value of 0.918. Values exceeding 0.9 indicate very high composite reliability for both constructs. It’s vital to mention that a value exceeding 0.7 is typically seen as acceptable, making these results particularly impressive in terms of reliability. Finally, regarding Average Variance Extracted (AVE), Digitalization achieves a value of 0.624, and Human Resource Performance a value of 0.652. Given that these figures surpass 0.5, they suggest satisfactory convergent validity for both constructs.

When assessing the performance of human resources concerning digitalization, it is essential to differentiate the various factors and concepts involved. Discriminant validity plays a central role in this process. It is used to verify whether a concept, such as human resource performance, is distinctly separate from other concepts, like digitalization, with which it should not theoretically be associated. This examination helps to understand to what extent a specific element of the model is independent and distinct from others.

To ensure this distinction, the Fornell-Larcker technique is commonly referenced. In the context of evaluating human resource performance in relation to digitalization, this method stipulates that for a concept like human resource performance to demonstrate appropriate discriminant validity, the square root of the AVE associated with this concept must be greater than its correlations with other concepts, such as digitalization. In other words, human resource performance should exhibit a variance more strongly associated with its own indicators than with those of digitalization or other relevant concepts.

**Table 3.** The Fornell-Larcker criterion

	Digitalization	Human Resources Performance
Digitalization	0,790	
Human Resources Performance	0,757	0,807

Source: Own calculations

Based on the Fornell-Larcker criterion, it appears that the discriminant validity is satisfactory for these two concepts. Each of the concepts, “Digitalization” and “Human Resources Performance”, distinctly stands out from the other. The values on the diagonal (square roots of the AVEs) are greater than the off-diagonal correlations, indicating that each concept shares more variance with its indicators than with the other concept. This strengthens the confidence in the model’s ability to clearly differentiate between “Digitalization” and “Human Resources Performance.”

The table presented below highlights the cross-loadings of various indicators in relation to two key concepts: “Digitalization” and “Human Resources Performance.” These cross-loadings illustrate the correlation of each indicator with each of the concepts. Regarding the main loadings versus the cross-loadings, ideally, an indicator should show a pronounced main loading on its own concept while having lesser cross-loadings with other concepts.

By observing the loadings, for indicators like “HR Analytics1”, “HR Analytics2”, “Task Automation1”, “Technological Integration1”, “Technological Integration2”, “Process Virtualization1”, and “Process Virtualization2”, the main loadings on “Digitalization” surpass their cross-loadings on “Human Resources Performance.” Conversely, for “Operational Efficiency1”, “Operational Efficiency2”, “Recruitment Quality1”, “Employee Satisfaction1”, and “Employee Satisfaction2”, the main loadings on “Human Resources Performance” exceed those on “Digitalization.”

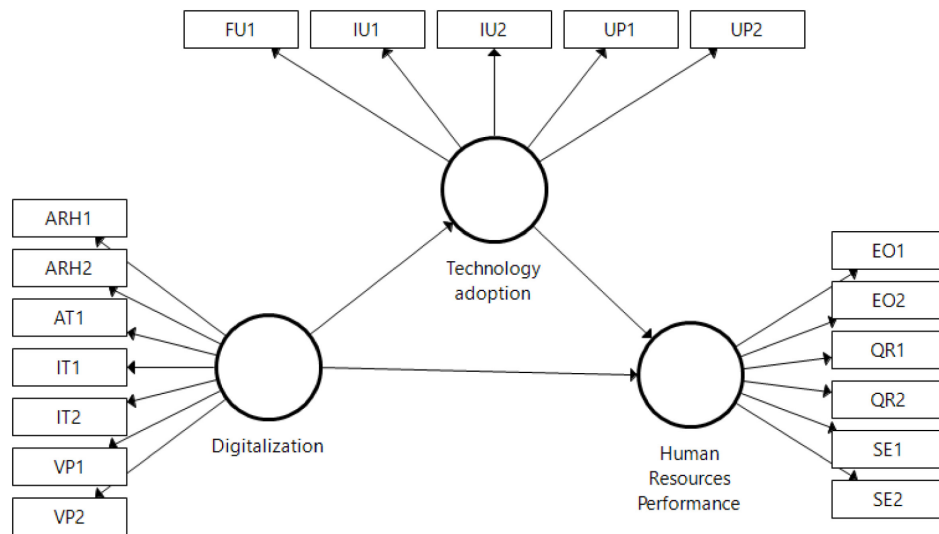
However, some indicators, such as “Recruitment Quality2”, show a substantial main loading on “Human Resources Performance” (0.754), but their cross-loading with “Digitalization” is also significant (0.489). This suggests that this indicator is closely related to both concepts, which could raise questions about discriminant validity.

**Table 4.** Cross-loadings

	Digitalization	Human Resources Performance
HR Analytics1	<b>0.843</b>	<b>0.667</b>
HR Analytics2	0.705	0.603
Task Automation 1	<b>0.751</b>	<b>0.586</b>
Operational Efficiency1	0.600	0.779
Operational Efficiency2	<b>0.623</b>	<b>0.833</b>
Technological Integration1	0.786	0.635
Technological Integration2	<b>0.858</b>	<b>0.611</b>
Recruitment Quality1	0.628	0.861
Recruitment Quality2	<b>0.489</b>	<b>0.754</b>
Employee Satisfaction1	0.623	0.778
Employee Satisfaction2	<b>0.680</b>	<b>0.833</b>
Process Virtualization1	0.797	0.495
Process Virtualization2	<b>0.780</b>	<b>0.554</b>

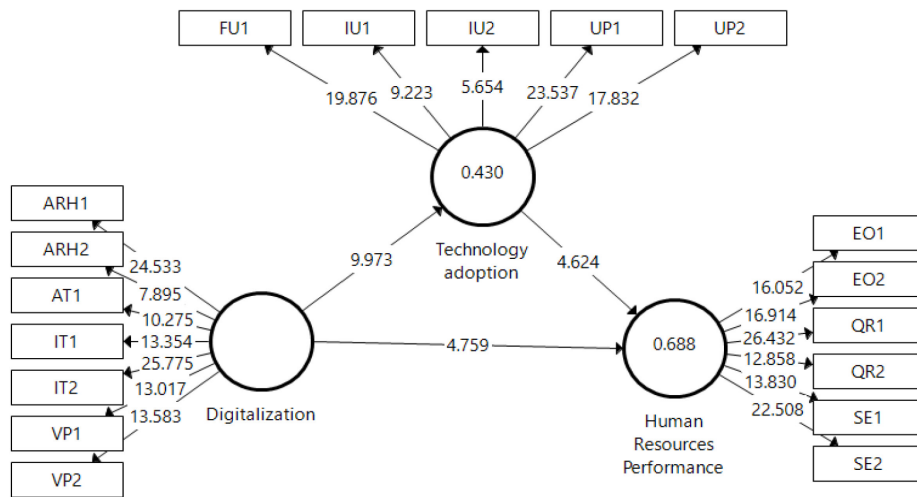
Source: Own calculations





**Figure 3.** Path diagram model with mediator interaction

Source: Own calculations



**Figure 4.** Structural model

Source: Own calculations

For a model to be considered adequate, the  $R^2$  value of the endogenous latent variables must be greater than 0.26. Although the table does not explicitly display the  $R^2$  values, they can be inferred from the overall context and the path coefficients. The coefficient of determination ( $R^2$  value) represents the predictive accuracy of the structural model and is comparable to the square correlation between the real and predicted values of an endogenous construct. An  $R^2$  value approaching 1 indicates high predictive accuracy. To understand the relevance of the structural relationships, it's essential to consider the path coefficients and their significance levels, assessed through t-values and the intensity of the relationships. Regarding the relationship between digitalization and employees' technology adoption, the data reveals a strong positive association ( $\beta = 0.655$ ;  $t = 9.707$ ), suggesting that digitalization has a significant impact on employee technology adoption. Moreover, employees' technology adoption is positively correlated with human resource performance ( $\beta = 0.459$ ;  $t = 4.571$ ), suggesting this adoption optimizes HR performance. Furthermore, digitalization has a positive effect on human resource performance, as demonstrated by the  $\beta$  coefficient of 0.452 and the t-value of 4.665. In conclusion, digitalization has a direct effect on HR performance and on employee technology

adoption, which, in turn, influences HR performance. Integrating digitalization and technology adoption is crucial in the HR sector and requires heightened vigilance during the planning and execution of HR strategies.

**Table 5.** Structural Model Evaluation Results

	Coefficient $\beta$	Standard Dev.	T-Statistic	P Values
Employee Technology Adoption → HR Performance	0.459	0.100	4.571	0.000
Digitalization → Employee Technology Adoption	0.655	0.068	9.707	0.000
Digitalization → HR Performance	0.452	0.097	4.665	0.000

Source: Own calculations

According to experts, the R2 value indicates the proportion of variation in the dependent variables explained by predictive variables. Table 6 highlights two factors: Employee Technology Adoption and HR Performance. The  $\beta$  coefficient for “Employee Technology Adoption” is 0.430, with a standard deviation of 0.087. Its t-statistic of 4.937, significant at the threshold of 0.000, demonstrates its marked influence on the variable in question. The “Human Resource Performance” displays a  $\beta$  of 0.688 (standard deviation 0.067) and a t-statistic of 10.250, highlighting a more pronounced influence than technological adoption.

**Table 6.** Bootstrapping Results for R2

	Coefficient $\beta$	Standard Dev.	T-Statistic	P Values
Employee Technology Adoption	0.430	0.087	4.937	0.000
Human Resource Performance	0.688	0.067	10.250	0.000

Source: Own calculations

The f2 measure is commonly used to evaluate the magnitude of the relationships between latent variables in structural equation models. The change in the f2 value when omitting an exogenous construct from the model is used to determine the influence of this construct on the model’s endogenous variables. To determine the relevance of the f2 effect, conventional thresholds are adopted: 0.02 indicates a weak effect, 0.15 a moderate effect, and 0.35 a significant effect.

**Table 7.** Bootstrapping Results for f2

	Coefficient $\beta$	Standard Dev.	T-Statistic	P Values
Employee Technology Adoption ► HR Performance	0.385	0.228	1.688	0.092
Digitalization ► Employee Technology Adoption	0.753	0.301	2.498	0.013
Digitalization ► HR Performance	0.374	0.207	1.803	0.072

Source: Own calculations

According to Table 7:

- The impact of “Employee Technology Adoption” on “Human Resource Performance” has an effect size of 0.385. This figure, situated between 0.15 and 0.35, indicates a moderate effect. The t-statistic is 1.688 with a p-value of 0.092, suggesting that this relationship is not statistically significant at the usual threshold of 0.05.
- The influence of “Digitalization” on “Employee Technology Adoption” reveals a very pronounced effect size of 0.753 (greater than 0.35). The t-statistic is 2.498 with a p-value of 0.013, meaning this relationship is statistically significant at the 0.05 threshold.

- The impact of “Digitalization” on “Human Resource Performance” also shows a moderate effect with a size of 0.374. With a t-statistic of 1.803 and a p-value of 0.072, this relationship approaches statistical significance without reaching it at the conventional threshold of 0.05.

**Table 8.** Cross-Redundancy Results of the Indicators (Q2)

	SSO	SSE	Q <sup>2</sup> (=1-SSE/SSO)
Employee Technology Adoption	350,000	266,605	0,238
Digitalization	490,000	490,000	
Human Resource Performance	420,000	240,961	0,426

Source: Own calculations

Table 8 highlights the cross-redundancy of indicators, commonly referred to as Q2, used to evaluate the predictive validity of a model. A positive Q2 value indicates satisfactory predictive validity, while a negative value reveals the model’s inability to predict for the concerned indicator.

For the “Technology Adoption by Employees” indicator, with an SSO (Observed Sum of Squares) of 350,000, an SSE (Estimated Sum of Squares) of 266,605, and a Q2 of 0.238, even though the latter is positive, its value indicates a reasonable predictive validity but not ideal.

For the “Digitalization” indicator, both the SSE and SSO display a value of 490,000, suggesting the model captures no variation for this indicator. Therefore, no Q2 value is specified, indicating the model does not predict this indicator.

Regarding the “Human Resources Performance” indicator, its SSO is 420,000, its SSE is 240,961, and its Q2 is 0.426, reflecting robust predictive validity for this indicator. This shows the model is suitable for predicting human resources performance.

**Table 9.** Model Adjustment

	Original Sample (O)	Sample Mean (M)	95%	99%
Saturated Model	0,087	0,068	0,083	0,089
Estimated Model	0,087	0,067	0,082	0,089

Source: Own calculations

Table 9 focuses on the model fit using the standardized root mean square residual (SRMR) as the primary criterion. This indicator is essential for assessing the fit quality of a model concerning the observed data. Delving into the results, the saturated model displays an SRMR of 0.087 for the original sample, a sample mean (M) of 0.068, with confidence intervals from 0.083 at 95% to 0.089 at 99%. On the other hand, the estimated model shows similar values: an SRMR of 0.087, a sample mean (M) of 0.067, and confidence intervals from 0.082 at 95% to 0.089 at 99%. When comparing the two models, each displays an SRMR for the original sample below the threshold of 0.10, suggesting an adequate fit. However, since these values slightly exceed 0.08, it’s clear that there’s room for improvement. Looking at the sample mean, the saturated model’s mean stands at 0.068, while the estimated model’s is 0.067, indicating a suitable fit. The confidence intervals, both at 95% and 99%, show that the SRMR values remain consistent and uniform between the two models. The saturated model, which encompasses all potential correlations among the constructs, provides a proper fit, though there are opportunities for optimization. Similarly, the estimated model, relying on the overall model structure, illustrates a consistency in its fit in relation to the observed data.

## 5. CONCLUSION

In conclusion, this article aimed to examine the impact of digitalization on the performance of Human Resources within companies listed on the Casablanca Stock Exchange. In an era where digital transformation is redefining the business world, the role of HR becomes paramount. Our results, based on a rigorous methodology, confirm the positive influence of digitalization on HR performance. It is also proven that the adoption of technologies by employees plays a significant mediating role in this relationship. Thus, digitalization holds a central position in the performance of Human Resources of companies listed on the Casablanca Stock Exchange. The results of the structural model validate the proposed hypotheses. On one hand, digitalization has a direct positive impact on HR performance ( $\beta=0.452$ ,  $p<0.000$ ). On the other hand, the adoption of technologies by employees is a significant mediator in this dynamic. Indeed, digitalization positively promotes the adoption of technologies by employees ( $\beta=0.655$ ,  $p<0.000$ ), which in turn favorably influences HR performance ( $\beta=0.459$ ,  $p<0.000$ ). These conclusions highlight the necessity of digital transformation and technological acceptance to improve HR performances in Morocco. They suggest that to get the most out of digitalization, companies should not only invest in technology but also promote its adoption by employees.

Furthermore, this article confirms the vital role of digitalization in enhancing the Human Resources department. Moroccan companies, especially those listed on the Casablanca Stock Exchange, should perceive this digital transformation not only as an operational imperative but also as a strategic opportunity to boost their efficiency and competitiveness. The active adoption of technologies by employees is also a determining factor in maximizing the benefits of digitalization. These conclusions reaffirm the primary role of Human Resources in the digital age and encourage more companies to take steps in digitalization to boost their performance.

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# Digital Transformation and Its Influence on Governance: Insights from Moroccan Service Sector SMEs

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**Abstract:** *The current digital era presents both challenges and opportunities for businesses worldwide. This research delves into the relationship between digital transformation and the governance of Small and Medium-sized Enterprises (SMEs) in the Moroccan service sector. Utilizing responses from a survey of leaders from 200 SMEs throughout Morocco, the study employs Structural Equation Modeling (SEM) to elucidate the intricate relationships. The results indicate a notable link between the adoption of digital strategies and improved governance. Yet, hurdles such as integrating technology and enhancing employee skills remain. This paper provides a deeper understanding of the nexus between digital transformation and governance, spotlighting the distinct context of Moroccan SMEs.*

## 1. INTRODUCTION

Digital transformation, a topic extensively discussed in academic literature, serves as a pivotal driver of competitiveness in today's world (Porter & Heppelmann, 2014; Westerman et al., 2014). In a global setting marked by intensified competition and rapid technological advancements, companies, regardless of size, are consistently challenged to adapt their methods and strategies. For small and medium-sized enterprises (SMEs), this transformation extends beyond mere digitization of operations. It has a profound impact on various organizational aspects, including governance (Bharadwaj et al., 2013). Morocco, as an emerging economy, presents a unique case in this context. Although the nation's service sector has demonstrated significant growth in recent years (World Bank, 2018), the nuances of digital transformation and its influence on SME governance in this sector remain relatively uncharted. With this backdrop, this article aims to bridge this knowledge gap by highlighting the relationship between digital transformation and the governance of SMEs in Morocco's service sector. By surveying business leaders, we endeavor to understand how adopting digital practices shapes the management and direction of these entities.

To delve into the impact of digital transformation on Moroccan SMEs' governance, we employed Structural Equation Modeling (SEM). Esteemed for its efficacy in probing complex theories in social research and business (Hair et al., 2016), SEM allows for intricate analysis of

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relationships between multiple dependent and independent variables. By leveraging SEM, we identified both direct and indirect relationships between digital transformation and various facets of SME governance. To ensure the validity of our research, we followed the guidelines established by [Anderson and Gerbing \(1988\)](#) concerning measurement validation and model fit assessment. As such, this article is organized as follows: the second section introduces a literature review on the impact of digitalization on the governance of SMEs in the Moroccan service sector. The third section outlines the conceptual model and its underlying hypotheses. The final section presents the results accompanied by a discussion and conclusion.

## 2. LITERATURE REVIEW

Digital transformation has emerged as a predominant topic in academic literature in recent years, particularly regarding its impact on businesses, with a specific emphasis on SMEs. [Berman \(2012\)](#) posits that digital transformation pertains to the utilization of digital technologies to innovate or refine existing processes, corporate culture, and customer experiences to adapt to market shifts. It isn't solely confined to the integration of technology into operations; it also includes the potential for a comprehensive revamp of business operations and models. Although the majority of studies have centered on digital transformation within large corporations, [Matt et al. \(2015\)](#) noted that SMEs, given their adaptability and scale, are in an optimal position to capitalize on digital transformation, despite their often-constrained resources. A pivotal aspect of digital transformation is its effect on corporate governance. [Hess et al. \(2016\)](#) emphasized that digitization overturns conventional governance structures, fostering enhanced communication and swifter decision-making. This is especially pertinent for SMEs, where communication pathways are generally more streamlined than in larger corporations. Nonetheless, despite its advantages, digital transformation poses challenges, predominantly for SMEs. As highlighted by [Reis et al. \(2018\)](#), these challenges encompass limited resources, a deficiency in technical expertise, and apprehensions regarding security and privacy.

Moreover, the literature review presented below offers insight into the pivotal works on this subject. In this framework, [Berman \(2012\)](#) illuminated how digital transformation influences the operations, culture, and customer experiences of businesses. He points out that this transformation isn't merely about integrating new technologies but also entails a shift in business models and operational processes. [Matt et al. \(2015\)](#) centered their discussion on the strategies that businesses, notably SMEs, can employ to attain a successful digital transformation. The authors stress the significance of flexibility and adaptability for SMEs attempting to navigate an ever-changing digital environment. [Hess et al. \(2016\)](#) deliberated on the diverse strategic choices SMEs might evaluate when orchestrating their digital transformation, accentuating the paramount importance of governance in guaranteeing successful execution. [Reis et al. \(2018\)](#) delivered an exhaustive review of research on digital transformation, with a special focus on the hurdles and prospects for SMEs. The authors propose that despite the myriad potential advantages, SMEs might grapple with issues like constrained resources and a deficiency in technical expertise. [Verhoef et al. \(2021\)](#) examined digital transformation through a multidisciplinary lens, spotlighting its ramifications on various facets of corporate governance, spanning from strategy to marketing and including human resources.

## 3. THE CONCEPTUAL MODEL

Digital transformation profoundly impacts the way companies operate, interact, and evolve. Despite having limited resources compared to larger corporations, Small and Medium Enterprises (SMEs) are at the vanguard of this transformation, seeking competitive edges through digitization.

The success of digital transformation hinges not just on the adoption of new technologies but also on how these technologies are integrated and managed within the organization, underscoring the vital role of governance (Anim-Yeboah et al., 2020; Matt & Rauch, 2020; Ziółkowska, 2021).

Our conceptual model delves into the effects of digital transformation on the governance of SMEs, emphasizing the pivotal variables in both digital transformation and SME governance. We propose the following hypotheses:

**H1:** Digital transformation has a direct positive effect on SME governance.

**H2:** External elements, such as market trends and regulations, shape the impact of digital transformation on SME governance.

**H3:** Digital competencies act as a mediator between digital transformation and SME governance.

**Table 1.** Variables and Their Measurement Scales

Variables	Measurement Scale	Meaning	Authors
<b>Independent Variables:</b>			
<b>Digital Transformation (DT):</b>	<b>Technology Adoption (Tech):</b>	This refers to the degree to which an SME adopts and uses new technologies in its daily operations. This can include the adoption of software, hardware, or other technological tools.	Kumar et al. (2021)
	<b>Process Digitization (PDig):</b>	This pertains to the conversion of traditional business processes into digital processes. This could include going paperless or using electronic management systems.	Doyle and Cosgrove (2019)
<b>Environmental Factors (EF):</b>	<b>Market Trends (Market):</b>	This concerns current or anticipated market developments that may influence an SME's performance, such as consumer demand or industry innovations.	Genc et al. (2019)
	<b>Regulations (Reg):</b>	This refers to laws and regulations that may impact an SME's operations, like data protection regulations or industry standards.	Zheng et al. (2021)
	<b>Competition (Comp):</b>	This pertains to the level and nature of competition that the SME encounters in its sector.	Masyhuri (2023)
<b>Dependent Variable:</b>			
<b>SME Governance (SMEG):</b>	<b>Decision Making (Dec):</b>	This pertains to how decisions are made within the SME, such as centralized decision-making or employee participation.	Hauser et al. (2020)
	<b>Internal Communication (Com):</b>	This concerns the quality and effectiveness of communication among various levels and departments within the SME.	Mbhele and De Beer (2022)
	<b>Organizational Structure (Struc):</b>	This refers to how the SME is structured, for instance, whether it has a hierarchical, matrix, or flat structure.	Gentile-Lüdecke et al. (2020)
<b>Mediating Variables:</b>			
<b>Digital Skills (DS):</b>	<b>Technical Skills (TechSkill):</b>	This pertains to specific skills required to use and integrate digital tools and technologies, such as programming or database management.	Sousa and Rocha (2019)
	<b>Continuous Training (ConTrain):</b>	This concerns the initiatives and opportunities provided by the SME for its employees to continuously enhance their digital skills.	North et al. (2019)
	<b>Adaptability to Digital Tools (Adap):</b>	This refers to the ability of the SME's employees to quickly adapt to new digital tools and technologies.	Thoumrungroje and Racela (2022)

**Source:** Own research

The Digital Transformation (DT) of an SME is influenced by the adoption of technology (Tech), and the digitization of processes (PDig). The equation for this relationship is:

$$TN = \lambda_1 \times \text{Tech} + \lambda_2 \times \text{PDig} \quad (1)$$

Here,  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  are the coefficients that represent the strength of the relationship between DT and each of its components (Tech, PDig, and IntT).

The governance of an SME (SMEG) is influenced by Digital Transformation (DT), Environmental Factors (EF), and Digital Skills (CN). The equation for this relationship is:

$$\text{GPME} = \theta_1 \times \text{TN} + \theta_2 \times \text{FE} + \theta_3 \times \text{CN} \quad (2)$$

Here,  $\theta_1$ ,  $\theta_2$  and  $\theta_3$  are the coefficients that signify the strength of the relationship between SMEG and each of its influencing factors (DT, EF, and DS).

The Digital Skills (DS) of an SME are influenced by technical skills (TechSkill), continuous training (ConTrain), and adaptability to digital tools (Adap). The equation for this relationship is:

$$\text{DS} = \psi_1 \times \text{TechSkill} + \psi_2 \times \text{ConTrain} + \psi_3 \times \text{Adap} \quad (3)$$

Here,  $\psi_1$ ,  $\psi_2$  and  $\psi_3$  are the coefficients that indicate the strength of the relationship between DS and each of its components (TechSkill, ConTrain, and Adap). In these equations, the coefficients ( $\lambda$ ,  $\theta$  and  $\psi$ ) represent the relative importance of each component in influencing the respective latent variable. These coefficients would typically be estimated from empirical data using structural equation modeling techniques.

#### 4. RESULTS AND DISCUSSION

In this section, we outline the outcomes of our investigation centered on the influence of digital transformation on the governance of SMEs within Morocco's service sector. Ensuring the validity and consistency of the metrics utilized in this analysis was paramount, prompting us to adopt a systematic approach.

Table 2 presents the reliability and validity indicators for three main constructs: Digital Transformation (DT), Environmental Factors (EF), and SME Governance (SMEG). Four metrics are used to evaluate each construct: Cronbach's Alpha, rho\_A, Composite Reliability, and Average Variance Extracted (AVE).

Cronbach's Alpha assesses the internal consistency, measuring the reliability of a set of scale or test items. Generally, a value above 0.7 indicates satisfactory consistency, suggesting that the items within the scale correlate well with each other. All constructs exceed this threshold. Specifically, SME Governance (SMEG) achieves the highest value at 0.937, while Environmental Factors (EF) have the lowest, though still respectable, value of 0.896. This underlines the strong internal consistency across all constructs.

Rho\_A, commonly referred to as Dillon-Goldstein's Rho, offers another perspective on internal consistency. Values close to 1 indicate outstanding reliability. All constructs have rho\_A values



above 0.9, emphasizing their high reliability. Both Digital Transformation (DT) and SME Governance (SMEG) are especially consistent, with values surpassing 0.93.

Composite Reliability (CR) measures the overall reliability of a group of related but distinct constructs. A value greater than 0.7 is considered satisfactory. All constructs exhibit excellent composite reliability, with SME Governance (SMEG) leading at 0.951. Environmental Factors (EF), although having the lowest value at 0.917, still show commendable reliability.

Average Variance Extracted (AVE) determines the amount of variance captured by a construct relative to measurement error. An AVE value higher than 0.5 is considered significant, indicating good convergent validity. Each construct meets or exceeds this standard. Digital Transformation (DT) has the top AVE at 0.800, implying that 80% of the variance in the observed variables relates to the underlying construct. Meanwhile, Environmental Factors (EF) have the lowest AVE but still surpass the suggested standard with a score of 0.649.

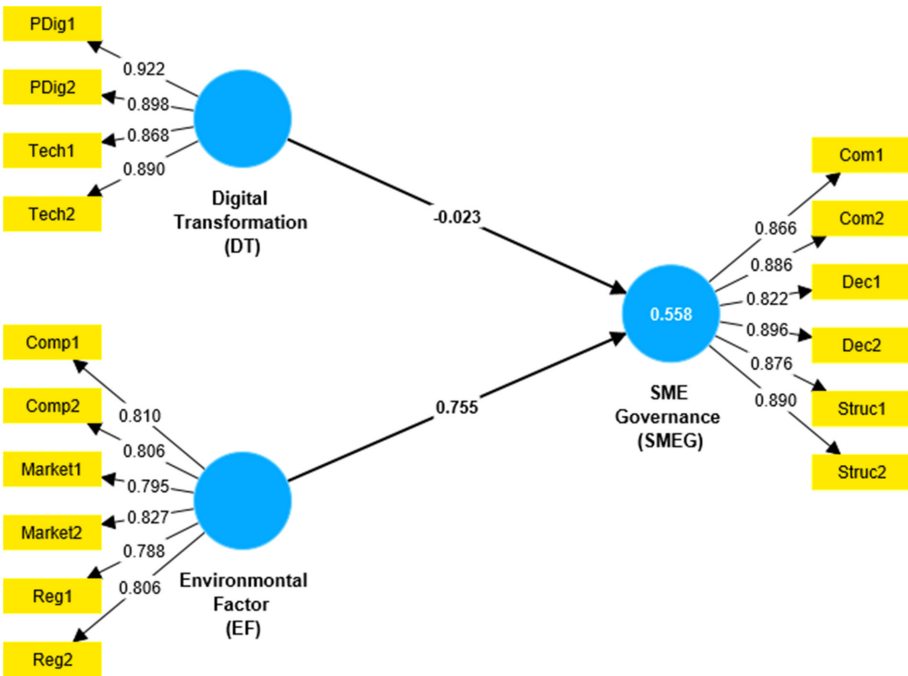


Figure 1. Path diagram model without mediator interaction

Source: Own calculations

Table 2. Reliability and validity indicators

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Digital Transformation (DT)	0,917	0,931	0,941	0,800
Environmental Factors (EF)	0,896	0,917	0,917	0,649
SME Governance (SMEG)	0,937	0,939	0,951	0,762

Source: Own calculations

Table 3 displays the results of the Fornell-Larcker criterion, a technique utilized to determine discriminant validity in structural equation modeling. Discriminant validity evaluates whether a construct is uniquely different from other constructs within the same model. By the Fornell-Larcker criterion’s standards, a construct exhibits strong discriminant validity if the square root of its Average Variance Extracted (AVE) surpasses its correlations with other constructs.

The values on the leading diagonal indicate the square root of the AVE for each construct: 0.895 for Digital Transformation (DT), 0.806 for Environmental Factors (EF), and 0.873 for SME Governance (SMEG). These figures are pivotal in determining discriminant validity because they should be more significant than any other value in their respective row or column.

The off-diagonal values denote the correlations between constructs. For satisfactory discriminant validity, these numbers should be smaller than the diagonal values for their respective constructs. For example, the correlation between Digital Transformation (DT) and Environmental Factors (EF) stands at 0.363, less than the square root of AVE for both DT (0.895) and EF (0.806), indicating distinct validity between these constructs. In contrast, the correlation between Digital Transformation (DT) and SME Governance (SMEG) is 0.251, which is less than the square root of AVE for both DT (0.895) and SMEG (0.873), highlighting their distinct validity. However, a correlation of 0.747 exists between Environmental Factors (EF) and SME Governance (SMEG). Even though this number is smaller than the square root of AVE for SMEG (0.873), it closely approaches the AVE square root for EF (0.806). This closeness indicates that while EF and SMEG are distinct to some extent, there might be overlapping elements or shared facets between the two constructs.

**Table 3.** The Fornell-Larcker criterion

	Digital Transformation (DT)	Environmental Factors (EF)	SME Governance (SMEG)
Digital Transformation (DT)	0,895		
Environmental Factors (EF)	0,363	0,806	
SME Governance (SMEG)	0,251	0,747	0,873

**Source:** Own calculations

Table 4 showcases the evaluation results of the structural model, highlighting the relationships between Digital Skills (DS), Digital Transformation (DT), Environmental Factors (EF), and SME Governance (SMEG).

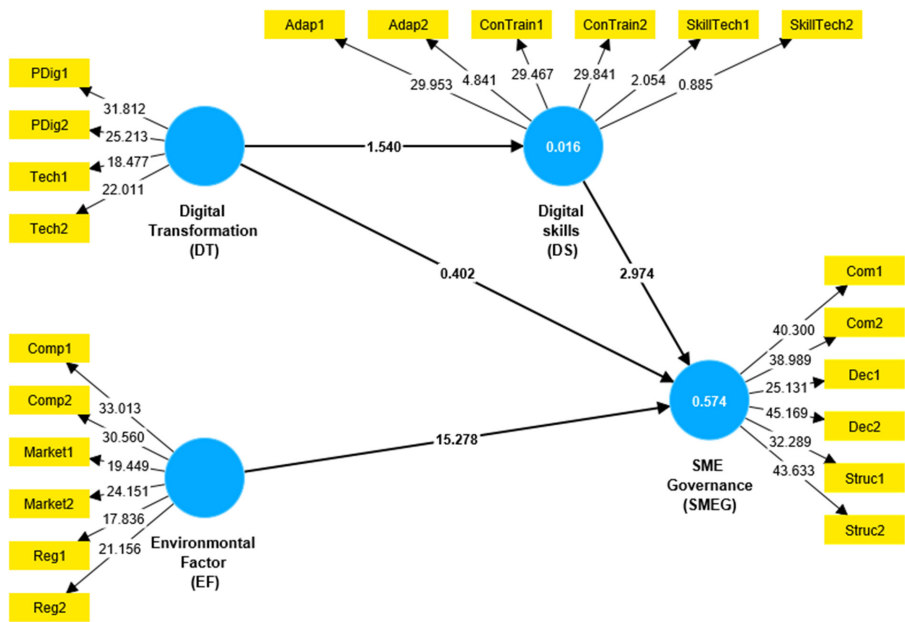
**Table 4.** Structural Model Evaluation Results

	Original Sample (O)	Standard Deviation	T Statistics	P Values
Digital Skills (CN) ► SME Governance (GPME)	0,133	0,045	2,974	0,003
Digital Transformation (TN) ► Digital Skills (CN)	0,125	0,081	1,54	0,124
Digital Transformation (TN) ► SME Governance (GPME)	-0,025	0,061	0,402	0,688
Environmental _Factor _ (EF) ► SME _Governance _ (SMEG)	0,714	0,047	15,278	0,000

**Source:** Own calculations

Beginning with the association between Digital Skills (DS) and SME Governance (SMEG), the data reveals a moderate positive relationship ( $\beta = 0.133$ ;  $t = 2.974$ ). This association's significance is underscored by the p-value of 0.003, suggesting that enhanced digital skills among employees correlate with improved SME Governance.

When examining the impact of Digital Transformation (DT) on Digital Skills (DS), the relationship appears relatively modest ( $\beta = 0.125$ ). Given the t-value of 1.540 and a p-value of 0.124, this relationship isn't statistically significant. This suggests that while digital transformation might influence digital skills to some extent, its effect isn't pronounced enough to be deemed significant in this study.



**Figure 2.** Path diagram model with mediator interaction  
**Source:** Own calculations

Regarding the relationship between Digital Transformation (DT) and SME Governance (SMEG), the association is slightly negative ( $\beta = -0.025$ ). However, with a t-value of 0.402 and a p-value of 0.688, this relationship isn't statistically significant. This implies that digital transformation may not have a marked direct effect on SME Governance in this dataset.

Lastly, a robust positive correlation is observed between Environmental Factors (EF) and SME Governance (SMEG) ( $\beta = 0.714$ ;  $t = 15.278$ ). The p-value of 0.000 affirms the statistical significance of this relationship. This indicates that environmental factors are instrumental in influencing SME Governance, emphasizing the importance of external factors and market dynamics in molding governance practices within SMEs.

**Table 5.** Bootstrapping Results for R2

	Original Sample	Standard Deviation	T Statistics	P Values
Digital Skills (DS)	0,016	0,022	0,692	0,489
SME Governance (SMEG)	0,574	0,050	11,412	0,000

**Source:** Own calculations

Table 5 showcases the bootstrapping results for the coefficient of determination (R2) related to the constructs of Digital Skills (DS) and SME Governance (SMEG). The R2 value provides a perspective on the variance explained by the endogenous constructs and stands as a key metric in gauging the model's predictive strength.

Examining the Digital Skills (DS), the R2 value is notably low at 0.016, suggesting that the model accounts for just 1.6% of the variance in Digital Skills. This assessment is further supported by a t-statistic value of 0.692 and a p-value of 0.489, indicating that the model's predictive accuracy for Digital Skills isn't statistically noteworthy. As a result, there may be additional external factors, not addressed in this model, that have a pronounced influence on digital skills.

Conversely, the R2 value for SME Governance (SMEG) is much more substantial at 0.574. This means that the model elucidates 57.4% of the variance in SME Governance, highlighting its

effective predictive performance for this construct. With a t-statistic of 11.412 and a p-value of 0.000, the data underscores the statistical significance of this relationship, reinforcing the model's reliability in forecasting SME Governance.

**Table 6.** Model Adjustment

	Original Sample (O)	Sample Mean (M)	95%	99%
<b>Saturated Model</b>	0,083	0,049	0,056	0,061
<b>Estimated Model</b>	0,103	0,058	0,080	0,108

**Source:** Own calculations

Table 6 delves into the model's alignment using two different frameworks: the saturated model and the estimated model. The key metric employed for assessment is the standardized root mean square residual (SRMR), which is instrumental in evaluating the congruence of the suggested model with the observed data.

Examining the saturated model first, the SRMR for the original sample stands at 0.083. This figure is beneath the widely recognized threshold of 0.10, signifying a satisfactory fit with the data. The sample mean (M) rests at 0.049, also indicating a favorable alignment. The confidence intervals for this model are 0.056 at 95% and 0.061 at 99%, implying that the SRMR values for this model remain consistent and within recognized boundaries.

Turning to the estimated model, the SRMR for the original sample is marginally elevated at 0.103. Although this measurement surpasses the desired threshold of 0.10, it conveys a modest alignment with the data. The sample mean (M) for this model measures 0.058, akin to the saturated model, signaling an acceptable alignment. The 95% confidence interval settles at 0.080, while the 99% confidence interval reaches 0.108. These ranges are broader relative to the saturated model, indicating increased variability in the estimated model's alignment.

In juxtaposition, both models showcase SRMR values reflective of decent alignments with the data. Yet, the saturated model, accommodating all conceivable correlations among the constructs, seems more harmonized with the observed data. In contrast, the estimated model, grounded in the postulated model structure, exhibits some deviations, notably with its SRMR value marginally exceeding the 0.10 benchmark. This observation infers that while both models align reasonably with the data, the saturated model offers a more harmonious fit, but there's potential for refining both frameworks.

## 5. CONCLUSION

In today's dynamic business environment, the digital era presents a myriad of challenges and opportunities for businesses around the world. The term "digital transformation" is frequently used in modern discussions, but it demands a more profound comprehension, particularly when exploring its direct effects on SMEs. This article aimed to uncover the nuances of digital transformation and its impact on the governance of SMEs, particularly within the thriving service sector of Morocco. Our investigation revealed that digital transformation goes beyond just the introduction of technology; it signifies an organizational shift with the potential to reshape governance frameworks and strategies within SMEs.

The insights from our study are twofold. On one side, digital transformation offers opportunities for improved governance in SMEs. On the other, its success depends on multiple factors. Key among these are external elements like market trends and regulatory structures that have

significant influence. Moreover, expertise in digital domains can act as a bridge, connecting digital transformation to effective governance. While some of our hypotheses received strong empirical support, others highlighted areas ripe for further investigation and understanding.

Focusing on the Moroccan service sector, it's evident that SMEs need to be proactive in their approach to digital transformation. It shouldn't be viewed merely as a tool, but as a strategic imperative. In this context, proficient governance, guided by digitization, can evolve into a powerful competitive asset, enabling SMEs to excel in a fluctuating market landscape.

Expanding the scope, even though our research provides keen insights into the Moroccan context, the broader implications of its findings are globally relevant. This emphasizes the global nature of the digital transformation story. As SMEs navigate the digital waters, a deeper understanding of its influence on governance becomes increasingly vital. Looking ahead, there's a call for more research, especially examining the dynamics between external factors and digital expertise in diverse cultural and economic environments. Such endeavors can further enhance the discourse on digital transformation and its implications for organizations.

**Validation of Hypotheses:** The data indicates that the supposed direct positive impact of digital transformation on SME governance, as stated, is not confirmed. The data strongly supports the assertion, underscoring the significant role of external factors in determining the effects of digital transformation on SME governance. The hypothesis receives mixed support from the data. While digital skills play an essential role in influencing SME governance, the mediating relationship between digital transformation and these skills isn't decisively established.

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# A New Approach to the Logistics 4.0 Measuring Model in SMEs

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**Abstract:** An important source of competitive advantage for logistic functions is to include the processes brought using the Industry 4.0 approach in their business models. The main problem is how to measure the logistics 4.0 levels of enterprises. Therefore, this study aims to develop a model for measuring the degree of logistics 4.0 (DoL\_4.0) in SMEs. This measurement model is based on the usage scores of logistics 4.0 technologies used in businesses, usage scores in logistic activities, and the number of technologies used. Second, the relationship between DoL\_4.0 and firm performance was examined. Our data were collected using the convenience sampling method in Gaziantep, Turkey. Because this research was an exploratory study, data were collected from 57 companies. In order to test the study topics, correlation analyses were conducted. The findings revealed robust correlations among the variables under investigation. The paper concludes with a discussion of the management and theoretical implications of the study's findings.

## 1. INTRODUCTION

Industry 4.0 is a sophisticated infrastructure that leverages the following technologies: robotics, automation, big data, artificial intelligence (AI), the Internet of Things (IoT), additive manufacturing (3D printing), the cloud, and cybersecurity. The notion initially surfaced in a governmental publication in Germany in November 2011, followed by a resurgence of the term “Industry 4.0” in April 2013 during an industrial exhibition held in Hannover, Germany. The notion of Industry 4.0 has been the subject of extensive discussion and implementation in both academic research and corporate operations. The permeation of all business operations has been subject to the digital transformation mandated by Industry 4.0 since the term “Industry 4.0” was first used in 2011. One of the most vital industries, logistics, has incorporated innovations of the new industrial revolution into its procedures ever since the advent of Industry 4.0. [Strandhagen et al. \(2017\)](#) proposed that logistics 4.0 was an approach driven by technology and provided the following illustrations:

- Logistics 4.0 utilizes big data analytics in real time to determine the most efficient routes for transporting materials and products by analyzing vehicles, product volume, and facility locations.
- Logistics 4.0 reduces the amount of stock needed for mass manufacturing by measuring on-site and on-demand.
- In warehouses, autonomous robots and vehicles, along with tracking and decision-making systems, maintain strict control over inventory.
- Logistics 4.0 enables a reduction in the bullwhip effect by real-time exchange of information among different actors.
- Smart products and cloud-supported networks keep the information flow intact.

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Determining the degree of logistics 4.0 (DoL 4.0) in small and medium-sized enterprises (SMEs) is the objective of this research. Exploratory in nature, this study seeks to establish a framework for quantifying DoL 4.0. This measuring model is made up of the ratings of how well logistics 4.0 technologies are used in businesses, how well these technologies are used in logistics operations, and the total number of technologies that are used. Later, an analysis was conducted to investigate the correlation between DoL 4.0 and firm performance.

The subsequent inquiries into research were addressed in order to accomplish the primary aim of this manuscript:

**RQ1:** What are the technological elements of Logistics 4.0?

**RQ2:** How to assess the DoL\_4.0?

**RQ3:** How to assess DoL\_4.0 in SMEs in Turkey?

**RQ4:** What are the effects of DoL\_4.0 on firm performance?

## 2. LITERATURE REVIEW

According to Vargas et al. (2023), Industry 4.0 is distinguished by the intelligent, horizontal, and vertical integration of people, machines, objects, information, and communication technologies (Veile et al., 2020). The digital transformation of production systems constitutes Industry 4.0. This revolutionizes production into a human-free system capable of accumulating and analyzing data, making decisions, and communicating with other systems autonomously (Nantee & Sureeyatanapas, 2021; Sureeyatanapas et al., 2023; Thoben et al., 2017). Technologies such as cyber-physical systems, the Internet of Things, cloud computing, cognitive computing, 3D printers, and the Internet of Services are integral components in the advancement of Industry 4.0. The logistics business has seen a profound transformation as a result of the applications of Industry 4.0. Logistics 4.0 is the result of the Industry 4.0 Revolution, which has prompted logistics organizations to implement novel business models and procedures. Consequently, greater autonomy will prevail in every facet of logistics. “Logistics 4.0 and smart supply chain management in industry 4.0” (i-SCOOP, 2017) presented Figure 1, which depicts the road map developed by UNITY Consulting and Innovation. Winkelhaus and Grosse (2020) proposed a range of technologies, including Big Data, IoT, Cyber Physical Space (CPS), Cloud Computing, mobile systems, and social media-based systems, as potential means to digitalize logistics 4.0. In order to facilitate digital transformation (Vial, 2021), logistics 4.0 employs intelligent trucks, pallets, containers, and transport systems.

Büyüközkan and Göçer (2018) believe that logistics 4.0 is predicated on the implementation of cutting-edge technologies including Big Data, IoT, and AR. Logistics 4.0 is an intelligent, adaptable, flexible, and productive system (Hrouga & Sbihi, 2023).

The Internet of Things (IoT) is a network of physical objects or “things” that can be accessed through the Internet. According to Kubáč (2016), IoT is characterized by the presence of integrated technology that enables these objects to communicate with either internal or external environments. IoT, according to Tran-Dang et al. (2022), has arisen as a revolutionary innovation that transforms the way in which objects are connected and communicate. Enhancing the

operational effectiveness of logistics activities, attaining valuable and real-time data, and optimizing the logistics process with regard to fleet and traffic management, inventory control, asset utilization, safety, and security are all possible with the Internet of Things.

Treiblmaier (2018) provided the following definition of blockchain technology: “A decentralized, distributed, and digital ledger in which transactions are recorded and appended in a sequential fashion, with the intention of establishing immutable and tamper-resistant records.” Liao and Wang (2018) highlighted the advantages of blockchain technology in the logistics industry, including the simplification of product tracking and the interchange of digital documents. Blockchain technology may have a significant impact on certain logistics and supply chain operations, according to Raja Santhi and Muthuswamy (2022). These operations may include the creation of a product traceability mechanism, the detection of counterfeit or gray market goods, the enhancement of product visibility, and the elimination of paperwork and administrative burdens that persist throughout the product life cycle. Implementation of blockchain technology can reduce or eliminate obstacles associated with logistical characteristics, such as delivery delays, documentation loss, product origin obscurity, and errors. Simultaneously, the adoption of blockchain technology offers several advantages, including enhanced sustainability, decreased occurrences of errors and delays, optimized inventory management and transportation, expedited problem detection, heightened confidence (both among consumers and business partners), and improved security (Tijan et al., 2019).

## UNITY Industry 4.0 Roadmap: Logistics

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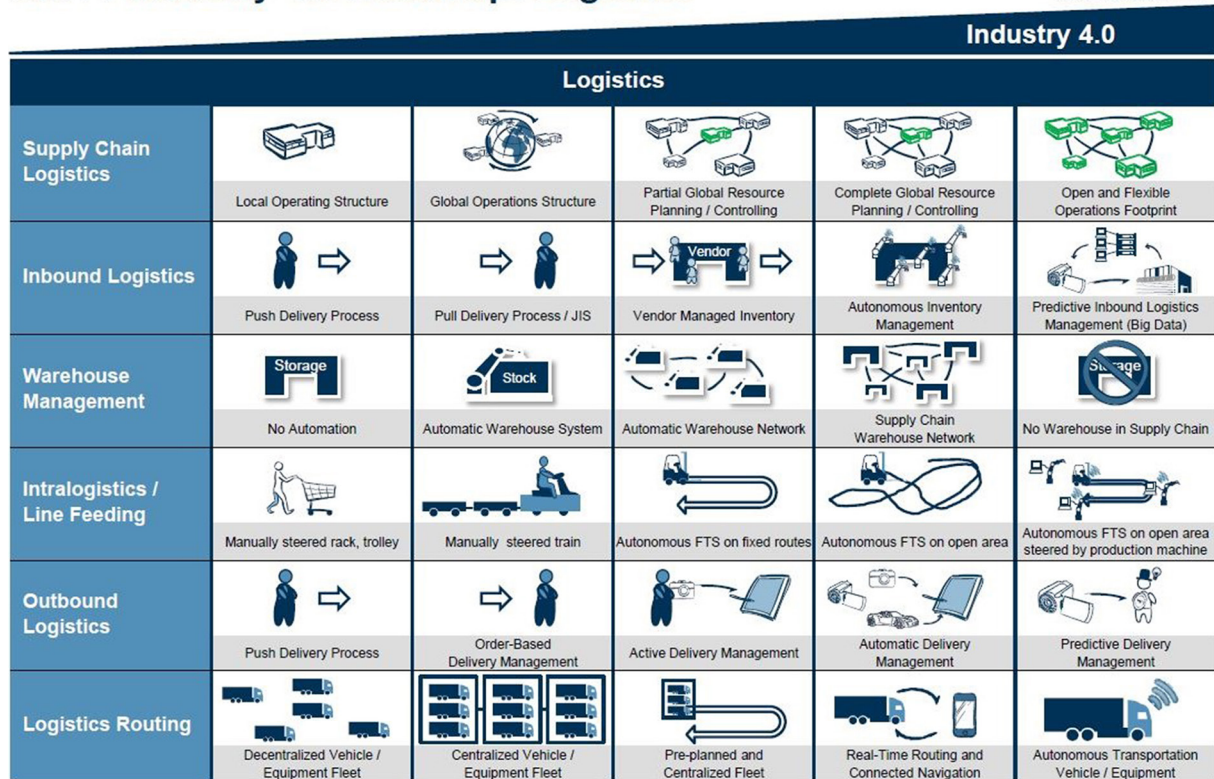


Figure 1. UNITY Industry 4.0 Roadmap: Logistics

Source: i-SCOOP, 2017

Big data is a term coined by Liu et al. (2019) to describe “expanding, heterogeneous data sets in structured, unstructured, and semi-structured formats” (Oussous et al., 2018, p. 433). Additionally, the term “big data” refers to “a collection of data sets that is both substantial and intricate,



rendering conventional data processing applications and database management tools inadequate for their processing” (Furht & Villanustre, 2016, p. 3). The following attributes define big data; they are referred to as 3Vs+1 (Kubáč, 2016):

- Volume – size of data,
- Variety - various data formats,
- Velocity - the speed of generation of data,
- Veracity - The quality of the data, and
- The other V is Value – benefits from data.

Utilizing big data analytics, one can enhance the efficiency of logistics operations, oversee supply chain procedures, mitigate supply chain vulnerabilities, optimize worldwide transportation, and manage client information.

Cyber security systems comprise a collection of technologies, rules, tools, guidelines, security safeguards, security concepts, risk management approaches, training, and best practices. These components are designed to secure the user assets, company, and cyber environment. Cybersecurity is defined by the International Telecommunications Union (ITU) as “a collection of risk management approaches, tools, policies, security concepts, safeguards, guidelines, actions, training, best practices, assurance, and technologies that can be employed to protect the assets of an organization and its users within the cyber environment” (Von Solms & Van Niekerk, 2013). Establishing a secure cyberspace by eliminating or lowering cyber hazards (or cyber threats) in a digital network for the logistics business is the objective of cyber security in logistics management (Cheung & Bell, 2021).

Augmented reality (AR) is a technology within Industry 4.0 that is presently garnering considerable attention from the industrial sector. AR is defined as any endeavor in which the primary objective is to enhance the physical environment by incorporating virtual data that deepens human perception and capabilities (Cirulis & Ginters, 2013, p. 17). Tablets or glasses can be utilized in warehouse operations to assist with AR in logistics, including the verification and tracking of goods received, the storage placement of incoming items, and the routing of storage location information. As a result, it is extensively utilized and offers significant benefits in the domains of shipping and order selection (Lagorio et al., 2022). An additional application domain encompassing augmented reality applications is the education of logistic operators.

Robotization: The utilization of robots to perform (a portion of the) labor that was formerly performed by employees in business processes is the definition of roboticization (Berkers et al., 2023). This has been an ongoing practice for decades. An autonomous robot is classified as an intelligent machine that executes designated duties with a significant level of independence (Shamout et al., 2022). Autonomous robotic vehicles provide the logistics industry with solutions and benefits including a reduction in labor and expense costs, enhanced productivity and dependability, improved job quality and safety, and diminished hazards of human error and damage (Tubis & Poturaj, 2021).

Artificial intelligence (AI) is a technological advancement that enables machines to replicate, learn, and augment human intelligence (Ding et al., 2021). AI enables machines to acquire knowledge through experience, adapt to new inputs, and execute activities resembling those of humans (Ding et al., 2021). The most effective application of AI to increase the operational efficiency of the logistics sector is the intelligent warehouse. Utilizing AI in warehouses has significantly enhanced logistical operations, including storage density, picking accuracy, and



handling speed (Zhang, 2019). The application of AI in transportation and product delivery presents many prospects and obstacles. Furthermore, it is imperative to conduct a thorough analysis of data security and privacy issues while implementing AI in the logistics industry to safeguard the confidentiality and integrity of sensitive data (Richey et al., 2023).

### 3. METHODOLOGY

The research focuses on SMEs based in Gaziantep, Turkey. We communicated with firm executives and explained the purpose and procedures of our study. Then, managers who accepted the research made a face-to-face questionnaire. A total of data<sup>3</sup> was collected from 57 managers. We used the convenience sampling method. We develop a measurement methodology to assess the degree of logistics 4.0 (DoL\_4.0) in SMEs. In the methodology, we first determine about 22 related technologies of Industry 4.0 (IoT, Blockchain, 3D printer, Bigdata, Drone, GPS, Robotization, AR, AI, etc.). Second, respondents graded the degree of use of technology of Industry 4.0 in all business activities on a 10-point scale with anchors ranging from Not Use (=0) to Highly Use (=10). Likewise, finally, we wanted these technologies to be given points for only logistic activities.

We developed DoL\_4.0 using six indicators (Ind):

- Ind<sub>1</sub>: The ratio of a firm's Use Score of Industry 4.0 Technology to Total Score in all business activity *[It refers to the ratio of the score obtained by any company from the use of Industry 4.0 technologies to the total score (total number of measured Industry 4.0 technologies\*highest measurement score)]*.
- Ind<sub>2</sub>: The ratio of firm's use number of vehicles of Industry 4.0 to total vehicles in all business activity *[It refers to the ratio of the number of Industry 4.0 technologies used by any company to the total number of technologies measured]*
- Ind<sub>3</sub>: The ratio of firm's Use Score of Technology of Industry 4.0 to Total Score in only logistic activities, *[In only logistics activity, it refers to the ratio of the score obtained by any company from the use of Industry 4.0 technologies to the total score (total number of measured Industry 4.0 technologies\*highest measurement score)]*,
- Ind<sub>4</sub>: The ratio of firm's use number of vehicle of Industry 4.0 to total vehicles in logistic departments, *[In only logistics activity, it refers to the ratio of the number of Industry 4.0 technologies used by any company to the total number of technologies measured]*
- Ind<sub>5</sub>: The mean of firm's use in all business activity, *[It refers to the mean that their use score of Industry 4.0 technologies to the number of technologies]*,
- Ind<sub>6</sub>: The mean of firm's Use in only logistic activities, *[In only logistics activity, it refers to the mean that their use score of Industry 4.0 technologies to the number of technologies]*.

Finally, DoL\_4.0

$$DoL_{4.0} = Ind_1 + Ind_2 + Ind_3 + Ind_4 + Ind_5 + Ind_6 \quad \text{was calculated.}$$

Firm performance was measured using three components: financial (four items), market (three items), and export (five items) performance. We have adapted the measures of firm performance from Gunday et al. (2011). The Cronbach's alpha of each component was greater than .75. According to Nunnally's (1978) guidelines, all of the factors were reliable, respectively, financial performance (Cronbach  $\alpha=.82$ ) market performance (Cronbach  $\alpha=.83$ ), and export performance (Cronbach  $\alpha=.91$ ).

<sup>3</sup> The dataset was used in the second author's master thesis.

#### 4. ANALYSIS AND RESULTS

The corporate features and profiles of the respondents were evaluated. 3 (5.26 percent) of the 57 firm responses were firm owners, 7 (12.28 percent) were department managers, 27 (47.36 percent) were top managers, and 20 (35.08 percent) were other positions. The age of firms ranges from 3 to 148 years, with an average age of 34.10. The range of personnel employed is from nine to two thousand. Automotive (12), textile (5), civil (5), chemistry (10), and machine (10) are among the principal industries of the companies (15). The industry 4.0 technologies that are most frequently implemented across all business activities are as follows: GPS (56 companies), smart devices (55), e-purchase (54 companies), mobile applications (53 companies), and IoT (49 firms). In all business operations, the mean number of industry 4.0 technologies utilized is as follows: mobile applications (8.50), smart devices (8.29), real time location technology (8.27), warehouse management systems (8.18), and GPS (8.19). In the realm of logistics, the prevailing industry 4.0 technologies are GPS (54 firms), smart devices (51 firms), mobile applications (50 firms), e-purchase (49 firms), and the Internet of Things (IoT) (46 firms). In the domain of logistics, the average utilization of Industry 4.0 technologies is as follows: e-purchase (7.73), GPS (7.40), warehouse management systems (7.34), mobile applications (7.32), and smart devices (7.21). The score for utilized industry 4.0 technology varied between 14 and 198 for firms, while the number of cars utilized in all company activities spanned from 5 to 21. (Max vehicles: 22, Grade: 0-10, Max Score: 220). Similarly, the score for utilized industry 4.0 technology varied from 5 and 157 for businesses, although the number of cars utilized in logistics alone spanned from 2 to 19. (Maximum of 22 cars (grades 0-10, maximum score 220))

Table 1 shows the descriptive statistics of DoL\_4.0 and its six indicators:

**Table 1.** Descriptive Statistics of DoL\_4.0 and its Six Indicators

	Minimum	Maximum	Range	Mean	Std. Deviation
<b>Ind 1</b>	0.06	0.90	Out of -1	0.47	0.19
<b>Ind 2</b>	0.23	0.95	Out of 1	0.65	0.24
<b>Ind 3</b>	0.02	0.71	Out of 1	0.32	0.14
<b>Ind 4</b>	0.09	0.86	Out of 1	0.49	0.19
<b>Ind 5</b>	0.64	9	Out of 10	4.73	1.95
<b>Ind 6</b>	0.23	7,14	Out of 10	3.24	1.45
<b>DoL_4.0</b>	1.52	19.47	Out of 24	9.91	3.98

**Source:** Own calculations

We conducted a correlation analysis between DoL 4.0 and export, financial, and market performance. Bivariate Pearson correlations between the constructs are presented in the correlation matrix found in Table 2. Positive correlations were observed between the variables DoL 4.0 and market performance ( $r=0.45$ ;  $p<0.01$ ), export performance ( $r=0.38$ ;  $p<0.01$ ), and financial performance ( $r=0.46$ ;  $p<0.01$ ).

**Table 2.** Correlation Analyses

	1	2	3	4
<b>1.DoL_4.0</b>	1			
<b>2. Financial Perf.</b>	.46**	1		
<b>3. Market Perf.</b>	.45**	.81**	1	
<b>4. Export Perf.</b>	.38**	.44**	.36**	1

\*\* Correlation is significant at the 0.01 level; \* Correlation is significant at the 0.05 level (2-tailed).

**Source:** Own calculations

## 5. FUTURE RESEARCH DIRECTIONS

Some of the shortcomings of this study indicate potential avenues for further investigation. In the first place, the research data was quite limited and was acquired solely from Turkish companies in Gaziantep, indicating the necessity to examine more sites. Statistical power would be increased for the model with a larger sample size, and future investigations may also consider implementing alternate sampling procedures. The sample was not categorized according to the firm sector (consideration of which could lead to clarified research results). Thirdly, convenience sampling was utilized, which restricts generalizability.

## 6. CONCLUSION

This investigation is conducted for exploratory purposes. While the primary objective of our study is not to investigate causal linkages, it does want to stimulate more conceptual and empirical research on DoL\_4.0. The objective of this research is to construct a model that can quantify DoL\_4.0.

Ali (2019) underscored the notion that organizations can obtain a competitive edge and mitigate supply chain risk with the increased adoption of industry 4.0 technologies. DoL\_4.0 had a mean score of 9.91 out of 24. Our companies were required to invest in Logistics 4.0 technologies, according to the findings.

Correlation analyses indicated important findings. Our findings indicate that the implementation of Industry 4.0 technology will enhance the all three performance of companies. According to a study by Díaz-Chao et al. (2021), the implementation of Industry 4.0 technologies, including flexible production systems and robotics, had a beneficial impact on labor productivity, exports, and sales. Moreover, Oduro and De Nisco (2023) have shown that these technologies have a substantial and favorable impact on performance, encompassing both financial and non-financial aspects.

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# Comparative Analysis of Artificial Intelligence Adoption in Small and Large Companies in Slovenia

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**Abstract:** The paper presents a comparative analysis of adopting artificial intelligence (AI) in small and large companies in Slovenia. The study examines the current landscape of AI usage, including its application in various operational areas such as AI-supported acquiring and retaining talented employees, AI-supported appropriate training and development of employees, and implementation of AI technology in a work environment. A survey was conducted among a sample of small and large companies across different industries in Slovenia. The results provide valuable insights for policymakers, managers, and researchers interested in understanding the dynamics of AI adoption in the Slovenian business context. Ultimately, this research contributes to the growing body of literature on AI adoption by shedding light on the unique challenges and opportunities faced by small and large companies in Slovenia, facilitating informed decision-making and strategic planning for future AI implementation initiatives.

## 1. INTRODUCTION

Artificial intelligence (AI) has become integral to modern businesses (Cao, 2022; Peretz-Andersson et al., 2024), permeating various activities and sectors. The widespread adoption of AI across industries is reshaping traditional business practices and revolutionizing the way organizations operate (Bag et al., 2021). Moreover, in recent years, many enterprises have progressively embraced AI technology, which aids in enhancing operational efficiency and lowering production costs within supply chains (Liang et al., 2024). AI's impact is evident across a spectrum of business activities, ranging from routine tasks to groundbreaking innovations (Dhamija & Bag, 2020). In routine operations, AI is employed to automate repetitive processes, streamline workflows, and improve operational efficiency (Abrokwah-Larbi & Awuku-Larbi, 2023). In the past ten years, the ongoing quest to automate advanced processes in machine learning has gained significant attention, fueled by improvements in optimization techniques and their influence on the selection of machine learning models/algorithms. At the heart of this movement is the ambition to create a computational system capable of identifying and implementing high-performance solutions for a wide range of machine-learning challenges with little to no human involvement (Kedziora et al., 2024; Xu et al., 2023). Tasks such as data entry, document processing, and inventory management can now be executed with greater speed, accuracy, and scalability through AI-powered systems (OECD, 2020; Zhong et al., 2023). This enables employees to focus on more strategic and value-added activities, enhancing overall productivity and effectiveness (Hansen & Bøgh, 2021). Moreover, AI technologies are driving astonishing advancements in data analytics, machine learning, and predictive modeling (OECD, 2020). By analyzing vast amounts of data, AI algorithms can identify patterns, extract insights, and make predictions with remarkable accuracy. This empowers businesses to make data-driven decisions, anticipate market trends, and gain a competitive edge (Szedlak et al., 2021). Organizations are recognizing the growing importance of AI technologies to maintain a competitive

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edge in today's rapidly evolving landscape (Dhamija & Bag, 2020). Businesses that embrace AI can leverage its capabilities to enhance customer experiences, optimize operations, and drive innovation (Wang et al., 2022). From chatbots and virtual assistants that provide instant customer support to AI-powered algorithms that optimize supply chain logistics, the strategic integration of AI technologies is becoming a key differentiator for companies across industries (Upadhyay et al., 2021). To stay ahead in today's competitive landscape, businesses must recognize the importance of AI technologies and invest in their adoption. By harnessing the power of AI, companies can unlock new opportunities, gain insights from data, enhance customer experiences, and drive innovation. Embracing AI is not just a strategic advantage; it has become a necessity for businesses striving to succeed in the digital age (Drydakis, 2022; Hansen & Bøgh, 2021; Papadopoulos et al., 2020).

Artificial intelligence (AI) has emerged as a transformative technology with the potential to revolutionize various aspects of business operations. Its applications range from enhancing customer service and optimizing production processes to enabling data-driven decision-making (Dhamija & Bag, 2020). As AI advances and evolves, companies across industries increasingly recognize its potential and explore ways to integrate it into their operations. However, the adoption of AI is not uniform across all companies (Papadopoulos et al., 2020). Factors such as size, resources, and organizational culture can significantly influence the extent to which AI is embraced and utilized (Basri, 2020). In this context, it becomes crucial to examine and compare the adoption of AI between different company sizes, such as small and large enterprises. There are distinct differences in adopting artificial intelligence (AI) between small and large companies (Hansen & Bøgh, 2021). As AI technologies continue to advance and permeate various industries, the extent to which small and large companies embrace and implement AI differs significantly due to various factors (Drydakis, 2022). One of the primary differences lies in the availability of resources. Large companies often have greater financial capabilities and infrastructure to invest in AI technologies. They can allocate substantial budgets for AI research, development, and implementation (Bag et al., 2021; OECD, 2020). In contrast, small companies often face resource constraints, including limited funding and technological infrastructure, which can hinder their ability to adopt AI on a large scale. Additionally, small and large companies' organizational structure and culture impact AI adoption (Abrokwah-Larbi & Awuku-Larbi, 2023). Large companies tend to have more hierarchical structures and complex decision-making processes, which can slow down the implementation of AI initiatives. In contrast, small companies often have more agile and flexible organizational structures, allowing for quicker decision-making and implementation of AI solutions (Benjamins, 2019). Furthermore, the level of AI expertise and talent within the organization also influences adoption. Large companies often have the resources to attract and retain AI specialists and data scientists, enabling them to develop in-house AI capabilities. In contrast, small companies may face challenges in acquiring AI talent due to competitive hiring environments and limited resources (Drydakis, 2022; Papadopoulos et al., 2020; Szedlak et al., 2021).

This paper focuses on conducting a comparative analysis of AI adoption in small and large companies in Slovenia. Slovenia, as a dynamic European country, provides an interesting context to explore the adoption patterns of AI due to its diverse business landscape. By examining the differences in AI adoption between small and large companies, this study aims to shed light on each category's unique challenges and opportunities, contributing to a deeper understanding of the factors influencing AI adoption in the Slovenian business context. The findings of this research will provide valuable insights for policymakers, managers, and researchers interested in understanding the dynamics of AI adoption in the Slovenian business context. Understanding the discrepancies in AI adoption between small and large companies can help inform decision-making processes,

guide resource allocation strategies, and facilitate the development of tailored policies and initiatives to support AI implementation. By identifying the differences in AI adoption patterns and highlighting the challenges and opportunities faced by each category, this research will aid in fostering a better understanding of AI integration in the Slovenian business landscape and facilitate informed decision-making for future AI implementation initiatives.

## 2. LITERATURE REVIEW AND HYPOTHESIS

Each company has its unique business objectives, priorities, and challenges. The alignment of AI technology with these objectives and priorities can significantly impact its adoption. Companies prioritizing efficiency, customer experience, or innovation may be more inclined to implement AI technology that aligns with their specific goals (Dhamija & Bag, 2020). Variations in business objectives and priorities can influence the differences in AI adoption and implementation across companies. Furthermore, Acquiring and retaining AI talent is crucial for effectively implementing AI solutions (Hansen & Bøgh, 2021). Large companies often have more attractive employment opportunities and can offer competitive salaries and benefits to AI professionals. This gives them an advantage in recruiting and retaining AI experts (Abrokwah-Larbi & Awuku-Larbi, 2023). Due to resource limitations, small companies may face challenges in attracting and retaining highly skilled AI professionals. Large companies typically have a larger workforce and more complex operations (OECD, 2020). AI solutions can be particularly valuable in managing and optimizing large-scale recruitment processes, analyzing vast amounts of employee data, and identifying patterns for effective retention strategies (Bag et al., 2021). Small companies, with smaller teams and simpler operations, may not require the same level of AI sophistication for acquiring and retaining employees. Implementing AI technologies requires investment in infrastructure, data collection, and training (Benjamins, 2019). Large enterprises may have dedicated teams and resources to overcome the initial barriers associated with AI adoption, while SMEs may face challenges in terms of cost, lack of expertise, and resistance to change (Drydakakis, 2022). AI algorithms rely heavily on data for training and decision-making. Large enterprises tend to have more extensive data repositories, providing them with a rich source for AI-driven insights into employee acquisition and retention (Hansen & Bøgh, 2021). Small companies may have limited data availability, which can impact the effectiveness of AI solutions and the ability to draw meaningful conclusions. Also, large companies often can develop AI-supported training programs that are highly customized and personalized (Szedlak et al., 2021). AI algorithms can analyze individual employee data, learning styles, and preferences to deliver personalized training content, adaptive learning paths, and targeted skill development opportunities (Upadhyay et al., 2021; Wang et al., 2022). Moreover, the culture and leadership within an organization play a crucial role in AI implementation. Companies with a culture that values innovation, embraces technological advancements, and encourages experimentation are more likely to adopt AI technology (Dhamija & Bag, 2020). Moreover, strong leadership that champions AI initiatives, promotes a data-driven mindset and supports the necessary investments can drive successful AI implementation. Differences in organizational culture and leadership approaches can lead to variations in the adoption of AI technology (Bag et al., 2021; Basri, 2020; Hansen & Bøgh, 2021). Therefore, we formulated three hypotheses:

- H1:** *There are statistically significant differences in AI-supported acquiring and retaining talented employees between small and large companies in Slovenia.*
- H2:** *There are statistically significant differences in AI-supported appropriate training and development of employees between small and large companies in Slovenia.*
- H3:** *There are statistically significant differences in implementing AI technology in the work environment between small and large companies in Slovenia.*

### 3. METHODOLOGY

A survey was conducted with a random selection of 127 companies in Slovenia. The sample represented 44.1% small companies and 55.9% large companies. The participants in the study included either owners or managers from each company. By gender, there were 58.3% male and 41.7% female. The sectors represented in the survey were as follows: information and communication activities (26.8%), financial and insurance activities (21.3%), professional, scientific, and technical activities (13.4%), real estate activities (11.8%), manufacturing (11.0%), wholesale and retail trade, repair of motor vehicles, and motorcycles (8.6%), and administrative and support service activities (7.1%). For data collection, we employed a closed-type questionnaire. The questionnaire was designed to incorporate statements pertaining to specific concepts, and participants were asked to indicate their level of agreement using a 5-point Likert-type scale. The scale ranged from 1, representing “strongly disagree,” to 5, signifying “strongly agree.” Items for construct AI-supported acquiring and retaining a talented employees were adopted from Kambur and Akar (2022), items for construct AI-supported appropriate training and development of employees were adopted from Pillai and Sivathanu (2020) and items for construct Implementation of AI technology in the work environment were adopted from Bag et al. (2021), Dhamija and Bag (2020). To analyze the data, we employed descriptive statistics and conducted the Mann-Whitney U test to identify statistically significant differences between small and large companies.

### 4. RESULTS

In the following section, the authors present the results of the descriptive statistics and Mann-Whitney Test for three constructs: AI-supported acquiring and retaining talented employees, AI-supported appropriate training and development of employees, and the implementation of AI technology in the work environment.

**Table 1.** Descriptive Statistics and the Mann-Whitney Test for the construct AI supported acquiring and retaining talented employees

AI-supported acquiring and retaining of talented employees	Mann-Whitney U	Asymp. Sig. (2-tailed)	Small companies			Large companies		
			Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
AI helps in conducting primary interviews of bulk candidates using chatbots.	20280.000	0.012	3.39	4.00	1.389	3.74	4.00	1.209
AI helps in a better quality of decisions for recruiting and selecting candidates.	20867.500	0.039	3.41	4.00	1.459	3.72	4.00	1.241
AI technology saves the monotony of the job done while finding candidates.	20047.000	0.006	3.44	4.00	1.436	3.81	4.00	1.273
AI technology reduces the time spent in finding candidates.	20923.000	0.043	3.49	4.00	1.336	3.78	4.00	1.267
With AI technology we gain access to more qualified candidates.	19874.500	0.004	3.39	3.00	1.471	3.75	4.00	1.316
We hire candidates with the right skills to accomplish their work successfully.	21564.000	0.131	3.52	4.00	1.320	3.80	4.00	1.128
We hire candidates capable of using AI technologies (e.g., machine learning, natural language processing, deep learning).	20791.500	0.034	3.43	4.00	1.369	3.79	4.00	1.063



We hire those candidates that are effective in data analysis, processing, and security.	22004.000	0.245	3.55	4.00	1.320	3.76	4.00	1.069
We take care of retaining suitable candidates with help to acquire the necessary skills for their career plans.	21976.000	0.235	3.54	4.00	1.324	3.77	4.00	1.036

Source: Own research

The results in Table 1 indicate that, on average, large companies exhibit higher agreement levels with all statements pertaining to the construct of AI-supported acquisition and retention of talented employees. Particularly, large companies display the highest agreement with the statement that AI technology alleviates the monotony associated with the job by streamlining the candidate selection process. They also demonstrate a stronger inclination towards hiring candidates with the requisite skills for successful job performance and candidates with proficiency in AI technologies such as machine learning, natural language processing, and deep learning. Additionally, large companies emphasize the importance of retaining suitable candidates by providing support in acquiring the necessary skills for their career advancement. Furthermore, AI technology is perceived as reducing the time spent in candidate sourcing and providing access to a broader pool of highly qualified candidates. Based on the results of the Mann-Whitney U test, the authors confirm the hypothesis H1: There are statistically significant differences in AI-supported acquiring and retaining talented employees between small and large companies in Slovenia. In the following, Table 2 shows descriptive statistics and the Mann-Whitney Test for the construction of AI-supported appropriate training and development of employees in Slovenian companies.

**Table 2.** Descriptive Statistics and the Mann-Whitney Test for the construct of AI-supported appropriate training and development of employees

AI-supported appropriate training and development of employees	Mann-Whitney U	Asymp. Sig. (2-tailed)	Small enterprises			Large enterprises		
			Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
AI technology reduces the time spent on in-company training courses.	19820.500	0.003	3.68	4.00	1.161	4.21	4.00	1.093
AI technology reduces the attention deficit experienced by employees in classical in-company training courses.	20109.000	0.047	3.47	3.00	1.374	3.72	4.00	1.220
AI technology increases accessibility to in-company training courses	20657.000	0.025	3.50	4.00	1.344	3.81	4.00	1.135
In-company training courses with artificial intelligence technology lead to a successful training program.	17414.500	0.000	3.57	3.00	0.981	4.02	4.00	0.904
Employee professional knowledge will be kept up to date with in-company training courses through artificial intelligence technology.	15358.000	0.000	3.59	4.00	1.046	4.24	4.00	0.649
When the in-company training courses take place with artificial intelligence technology, the restrictions regarding to place where the training will be given will be removed.	17526.500	0.000	3.53	4.00	0.911	3.95	4.00	0.753
Employees are provided with the required training to deal with AI applications	17844.500	0.000	3.58	4.00	0.849	3.97	4.00	0.734

Source: Own research

The results in Table 2 indicate that, on average, large companies demonstrate higher agreement levels with all statements related to the construct of AI-supported appropriate training and development of employees. Specifically, large companies exhibit the highest agreement with the statement that employee professional knowledge can be effectively updated through in-company training courses facilitated by artificial intelligence technology. Moreover, large companies acknowledge that AI technology contributes to reducing the time required for conducting in-company training courses. Based on the results of the Mann-Whitney U test the authors confirm hypothesis H2: There are statistically significant differences in AI-supported appropriate training and development of employees between small and large enterprises in Slovenia. Moreover, Table 3 presents descriptive statistics and the Mann-Whitney Test for the construct implementation of AI technology in the work environment in Slovenian companies.

**Table 3.** Descriptive Statistics and Mann-Whitney Test for the construct implementation of AI technology in the work environment

Implementation of AI technology in the work environment	Mann-Whitney U	Asymp. Sig. (2-tailed)	Small companies			Large companies		
			Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
We are able to work with data scientists, other employees and customers to determine opportunities that AI might bring to our organization.	20542.000	0.016	3.49	4.00	1.069	3.79	4.00	0.826
Employees have strong leadership to support AI initiatives and are committed to AI projects.	21012.500	0.048	3.48	4.00	1.419	4.28	4.00	0.834
With AI we reduce the burden on administrative staff in a company.	18728.500	0.000	3.46	4.00	1.148	3.93	4.00	0.885
The AI technology applied in our company can take orders and complete tasks which reduces the workload of employees.	19057.500	0.000	3.47	4.00	1.370	3.94	4.00	1.195
The AI technology applied in our company can communicate with users/customers which reduces the workload of employees	18509.500	0.000	3.40	4.00	1.437	3.97	4.00	1.132
Our company uses program and portfolio structures for managing projects.	20197.500	0.010	3.44	4.00	1.170	3.85	4.00	0.996
Our company has a digital transformation strategy, including AI adoption.	20241.000	0.008	3.86	4.00	1.270	4.27	4.00	0.762
Our company uses AI technologies for work design.	20577.500	0.022	3.60	3.00	1.149	4.24	4.00	1.130
Our company uses AI technologies to plan new tasks better.	20666.500	0.026	3.59	3.52	1.214	4.17	4.00	1.045
Our company uses AI technologies in projects to create teams.	19991.500	0.005	3.54	4.00	1.339	4.12	4.00	0.884

**Source:** Own research

The results in Table 3 indicate that, on average, large companies exhibit higher agreement levels with all statements pertaining to the construct of AI technology implementation in the work environment. Large companies display the highest agreement with the statement that employees receive strong leadership support for AI initiatives and demonstrate commitment to AI projects. They also affirm that their company has a digital transformation strategy in place, which includes the adoption of AI. Additionally, large companies express a higher agreement regarding

using AI technologies for work design. This is followed by their utilization of AI technologies for better planning new tasks and creating teams within projects. Moreover, large companies acknowledge that the AI technology implemented in their organization can effectively communicate with users/customers, thereby reducing the workload of employees. Also, based on the results of the Mann-Whitney U test, the authors confirm hypothesis H3: There are statistically significant differences in implementing AI technology in the work environment between small and large companies in Slovenia.

## 5. FUTURE RESEARCH DIRECTIONS

Future research directions for the comparative analysis of AI adoption in small and large companies in Slovenia could explore the following areas: (1) Conduct a longitudinal study to track the evolution of AI adoption in small and large companies over time. This would provide insights into the trends, changes, and challenges organizations face as they progress in their AI implementation journey; (2) investigate the specific factors that influence AI adoption in Slovenian small and large companies. This could include exploring the role of organizational culture, leadership support, technological infrastructure, and resource availability in shaping AI adoption patterns and (3) Conduction industry-specific analyses to understand how AI adoption varies across different sectors in Slovenia. Examine the unique challenges and opportunities faced by industries such as finance, healthcare, manufacturing, and services in adopting and implementing AI technologies.

## 6. CONCLUSION

The results of this study highlight statistically significant differences in the adoption and perception of AI technology between small and large companies in Slovenia. Large companies consistently demonstrate higher agreement levels with statements related to AI-supported acquisition and retention of talented employees, AI-supported appropriate training and development of employees, and AI technology implementation in the work environment. The presence of statistically significant differences between small and large companies in these areas emphasizes the need for tailored approaches and strategies in AI adoption and implementation. From this point of view, the authors provide the following recommendations on how small companies can implement artificial intelligence to increase their competitive advantage: (1) Company should begin by implementing AI in specific areas or processes that can provide immediate value. Thus, the company, identifies tasks that are repetitive, time-consuming, or prone to errors, and explores how AI technologies can automate or optimize those processes. Starting small allows for testing and learning without overwhelming resources or disrupting overall operations; (2) company should take advantage of AI tools and platforms specifically designed for small businesses. These platforms often provide user-friendly interfaces and pre-built AI models that can be easily integrated into existing systems. This reduces the need for extensive technical expertise and minimizes the cost and time associated with AI implementation; (3) partnering with AI service providers or consultants can help small companies overcome technical barriers and navigate the complexities of AI implementation. These experts can offer guidance, assist in developing AI strategies, and provide customized solutions based on the specific needs and goals of the business; (4) company should encourage a culture that embraces learning, experimentation, and innovation. Develop initiatives that promote AI literacy among employees and provide training opportunities to upskill the workforce. Empower employees to contribute ideas and explore AI solutions that can improve efficiency, customer experiences, and overall

business performance; (5) company should identify AI applications to enhance customer experience. This could include implementing chatbots for customer support, personalizing recommendations based on customer preferences, or utilizing AI-powered analytics to gain insights into customer behaviour. By focusing on customer-centric AI solutions, small companies can differentiate themselves and drive customer satisfaction; (5) companies can benefit from collaborating with other businesses, research institutions, and industry associations. Sharing knowledge and experiences with peers can provide valuable insights and lessons learned in AI implementation. Collaborative efforts can lead to joint projects, shared resources, and collective problem-solving, fostering innovation in AI adoption.

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# Application of Large Language Models for Text Mining: The Study of ChatGPT

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## Keywords:

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**Abstract:** The appearance of Large Language Models (LLMs) has brought advancements in natural language processing (NLP), making it more available to everyone. This paper examines the application of LLMs in text mining, with a focus on ChatGPT by OpenAI. The author provides a brief overview of LLMs, highlighting their structure and training techniques, as well as parameter tuning. Utilizing ChatGPT as an example of an LLM, this paper identifies the model's capabilities and constraints in extracting insights from textual data. Based on the author's findings, they suggest several applications of LLMs for text mining that provide better text comprehension and set the tone for further research.

## 1. INTRODUCTION

The concept of generative artificial intelligence has been expanding for the last two years, most notably with the public appearance of large language models. Generative artificial intelligence can be defined as the application of artificial intelligence and machine learning algorithms to generate new content (Goodfellow et al., 2016). The generative artificial intelligence market is expected to reach more than 667 billion USD value, which is a huge increase over 2022 market value of 29 billion USD (Generative AI Market Size, Share and Industry Trends [2030], n.d.).

Besides the ability to generate new content such as bodies of text (de Rosa & Papa, 2021), images (Rombach et al., 2022), or music (Wang et al., 2023), generative artificial intelligence can be used to transform existing content into more manageable forms. This can be useful if we need to digest large amounts of text or get a quick summary of the information at hand. These capabilities in generative artificial intelligence are commonly provided by large language models (LLM) (Radford & Narasimhan, 2018).

Due to the way how large language models work, they are suited to be a good candidate for the process of text extraction. ChatGPT (n.d.) is one of the more popular and most commonly used large language models due to its availability to a wide range of users. Our goal is to see if ChatGPT is a suitable option for the process of extracting data from text.

## 2. CONCEPT OF LARGE LANGUAGE MODELS

Large language models (LLM) represent a relatively new language model based on generative pre-trained transformers (Radford & Narasimhan, 2018). Generative pre-trained transformers represent the application of the transformer neural network (Vaswani et al., 2017) trained with unsupervised learning on large datasets. Training results yield probabilities between tokens

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inside the training dataset, usually words. The resulting model is specialized in supervised learning for specific tasks, such as language translation or text mining.

The first publicly available LLM is the GPT-1 model (Radford & Narasimhan, 2018), followed by the GPT-2 and GPT-3 models (Brown et al., 2020). The key difference between the models is in the amount of parameters used for training. The original GPT-1 model used 117 million parameters, compared to GPT-2 with 1.5 billion parameters and GPT-3 with 175 billion parameters.

An alternative to the GPT language model family is the BERT (Bidirectional Encoder Representations from Transformers) language model from Google (Devlin et al., 2019). The main difference when compared to the GPT family of large language models is in the way how next tokens are predicted in the sentence. BERT utilizes bi-directional context and word masking in order to perform predictions, while GPT is autoregressive and has a unidirectional path for determining context (left-to-right compared to BERT which performs context determination left-to-right and right-to-left).

The use of non-public datasets for training is a common characteristic of GPT and BERT language model families. The lack of public datasets or dataset descriptions keeps models hidden from general research contributions and potential improvements from third parties. The creation of the LLaMA (Touvron et al., 2023) family of models with the collaboration from Meta and Microsoft is a direct response to the problem of dataset availability.

Besides utilizing publicly available datasets, LLaMA utilizes several novel improvements to the transformer architecture, such as the application of the SwiGLU activation function (Shazeer, 2020) and rotary embeddings (Su et al., 2023). LLaMA, with its current iteration LLaMA 2 (Touvron et al., n.d.) provides significantly better performance than GPT and BERT language models.

Even though LLaMA and BERT provide better performance than the GPT language model family due to the improvements to the transformer architecture and larger amount of parameters used for training, the key blocker in public adoption is the accessibility of these models. One of the original goals of OpenAI, the company behind the GPT family of language models, was the benefit of AI for mankind (About, n.d.). ChatGPT (n.d.) is one of their key publicly available solutions that became available in November 2022. It is a front-end to the GPT-3 language model which would allow regular users to harness its capabilities for their day-to-day tasks and language model evaluation.

### 3. CURRENT WORK

Text mining is defined as a process with the goal of extracting meaningful information from text (L. Sumathy & Chidambaram, 2013). Text mining uses many different techniques, most notably natural language processing (NLP) and statistics to perform its goals. Our focus will be on the current state of large language models, both GPT and BERT, applied to the area of text mining.

One of the most common applications of text mining can be seen in the word prediction features of modern text editors. Utilizing text mining, the text editor can predict what would be the next word in the sentence. This is commonly used in programming environments (Allamanis & Sutton, 2013). This has evolved with the advent of large language models, now allowing tools to generate complete computer programs (Nijkamp et al., 2022) from user descriptions.

Another application for text mining is the improvement of text comprehension. Text comprehension is presented as the ability of the language model to answer questions, summarize text and hand and provide definitions of unknown concepts. One of these models is Galactica (Taylor et al., 2022), a large language model trained and focused on retrieving scientific data. This model also has the ability to reason given prompts and generate answers, allowing the end user to gain better insight into the information at hand. Another example regarding text mining with scientific data is the SciBERT (Beltagy et al., 2019) large language model which demonstrates improvements concerning the original BERT model.

Similarly, BioGPT (Luo et al., 2022) is a large language model belonging to the GPT family focused on textual mining and retrieval of biomedical data. The focus of BioGPT is end-to-end relation extraction, question answering, document classification and text generation. It is also worth mentioning that it outperforms the GPT-2<sub>medium</sub> general purpose, large language model. There are similar implementations based on the BERT family of large language models, such as BioBERT (Lee et al., 2020).

#### 4. CHATGPT AND ITS CAPABILITIES

As mentioned before, the concept behind the GPT family of large language models was introduced by Radford and Narasimhan (2018) and its improvements were introduced by Brown et al. (2020). The popularity of the GPT family of large language models has increased with the introduction of ChatGPT (n.d.) by OpenAI (n.d.), an originally GPT-3 large language model specialized for textual conversations. At the time of writing, there have been about 1.7 billion unique visits to the ChatGPT website (Similarweb, n.d.) which offers interaction with the model.

The popularity of ChatGPT comes from an intuitive user interface available via the web and natively on Android and iOS. The additional feature is the tuned GPT-3.5 and GPT-4 models made to represent human interaction, even though the training and model data are proprietary.

Giving additional instructions to the large language model is performed using prompts (Liu et al., 2023). Utilizing prompts we are able to customize the behavior of the large language model by setting baseline points and formatting for the returned answers. The process of utilizing prompts for large language model customization is called prompt engineering. This is an alternative for retraining the model whenever we wish to have a different context, allowing us to have a large model that we can engineer later on for our use cases.

Prompt engineering is one of the key features of using ChatGPT. Applying prompt engineering with ChatGPT allows the end user to get better results and in the required context, without retraining the model. With the application of prompt patterns (White et al., 2023) we are able to further increase the usability of ChatGPT.

Another key feature is the ability to use specialized plugins (Chat Plugins, n.d.), such as specialized search engines (Wolfram Plugin for ChatGPT, n.d.) and web browsing (Browsing, n.d.). This extends the original abilities of ChatGPT with new features that aren't a part of the original trained model, since they depend on outside services.

All of the features above are able to be combined, allowing the creation of complex questions and tasks for ChatGPT, utilizing multiple data sources and contexts.

## 5. TEXT MINING WITH CHATGPT

We have performed experiments on the following three text mining use cases with ChatGPT: sentiment analysis, document summarization and concept extraction in the domains of news articles, scientific papers and technical documentation.

Each experiment started with the following prompt: “Hello ChatGPT, I will need you to perform **text\_mining\_use\_case** on text I will give you in the next prompt” where **text\_mining\_use\_case** are sentiment analysis, document summarization or concept extraction. Prompt engineering was applied later in order to refine the returned results and provide better quality for the end user.

The following data was used for testing – a news article from Forbes (Tucker, n.d.), a scientific paper regarding the discovery of biological nerve conductivity (Hodgkin & Huxley, 1952) and a technical document outlining the extraction methods in Oracle database based data warehouses (Database Data Warehousing Guide, n.d.). Since the scientific text in question is large, we are focusing on the part “Refractory period”.

Sentiment analysis can be defined as a method of extracting emotional sentiment from a body of text (L. Sumathy & Chidambaram, 2013). Sentiment analysis is used to convey the emotional meaning from bodies of text in order to gauge perceptiveness. Before testing, we read and analyzed the texts manually in order to determine the sentiments. The news article had positive sentiments, while the scientific text and technical document had neutral sentiments.

In the case of the news article, the sentiment is mostly positive and it has been presented descriptively. Prompt engineering with the following statement “Format the sentiment analysis by ranking” gives us a numerated list of sentiments identified and references inside the text. Performing advanced sentiment analysis with the prompt “As an analyst, perform advanced sentiment analysis” gives us a detailed breakdown of the discovered sentiments that are positive with further explanation of the referenced text.

Scientific text sentiment was discovered to be neutral, with an explanation about the process that determined its neutrality, compared to a newspaper article where sentiment has been referenced in the text. Similarly, the results were the same for the technical documentation, but with detailed sentiment ranking due to formatted subtitles in text. Asking additional questions regarding advanced sentiment analysis confirms the objectivity of these documents since sentiment is neutral.

**Table 1.** ChatGPT discovered sentiment comparison

Type of document	Expected main sentiment	Discovered main sentiment
News article	Positive	Positive
Scientific text	Neutral	Neutral
Technical document	Neutral	Neutral

**Source:** Own research

Document summarization is another branch of text mining that concerns the processing of text into more manageable parts that convey the same meaning (L. Sumathy & Chidambaram, 2013). This allows the reader to quickly go through large bodies of text and gain better knowledge of the text importance at hand. The key metric used for summarization was the final word count and the subjective measure of the authors about the validity of the summarization.



ChatGPT was able to perform document summarization of the news article by 48.79%, without further prompt engineering. After utilizing the prompt “Summarize the text even more” we were able to summarize it even more, bringing us to a total of 67.63% of summarization.

Due to the nature of scientific texts and technical documentation, document summarization gave us better results than news articles. ChatGPT managed to summarize the scientific text in question by 59.92% and with prompt engineering by 69.08%. The technical document was summarized by 58% and with prompt engineering by 80.21%.

**Table 2.** ChatGPT document summarization results

Type of document	First document summarization	Second document summarization	Author’s subjective validity of summarization
News article	48.79%	67.63%	Valid
Scientific text	59.92%	69.08%	Valid
Technical document	58%	80.21%	Valid

**Source:** Own research

The process of concept extraction focuses on identifying and isolating key concepts from bodies of text in order to increase comprehension and organization of knowledge (L. Sumathy & Chidambaram, 2013).

Because of the way how ChatGPT is organized and the architecture of the GPT model, it is trivial for ChatGPT to perform concept extraction. Using the starting prompt “Hello ChatGPT, I will need you to perform concept extraction on text I will give you in the next prompt”, we are able to summarize all three text’s key concepts and ideas. Prompt engineering can help us with additional concept extraction (such as clarification of extracted concepts or their connections) in the next steps after the original prompt.

## 6. FURTHER RESEARCH

The provided use cases are a balance between the usability and practicality of ChatGPT in day-to-day work. With the complexity of large language models and text mining, there is room for further research in these areas.

One of the main directions would be deeper research into the applicability of ChatGPT as a solution to text mining. The performance of ChatGPT in text mining different kinds of text could give promising results, as well as the ability to set the context with prompt engineering. This can be approached with the applicability of prompt patterns (White et al., 2023) and unlearning (Yao et al., 2023) as a method to improve output.

Another important approach would be the capability of ChatGPT to perform advanced logical reasoning on mined bodies of text. This approach stems from the current research that assumes ChatGPT is a Chinese room and unable to perform advanced logical reasoning (Ling, 2023), but it is worth discovering the threshold of logic that can be applied to the text at hand.

Combining prompt engineering with the process of advanced logical reasoning, we should be able to build data mining pipelines (Wei et al., 2022) that can translate to specific data mining patterns. These emerging patterns can be used for text mining applications on different language models, such as LLaMA, focusing on a multi-model approach to text mining.

## 7. CONCLUSION

We have established that ChatGPT as a solution is a viable tool for text mining of three different kinds of text, most notably newspaper articles, scientific papers and technical documents. Testing was done for sentiment analysis, document summarization and concept extraction. All three use cases gave us positive results for the usage of ChatGPT. Starting prompt was “Hello ChatGPT, I will need you to perform **text\_mining\_use\_case** on text I will give you in the next prompt” where **text\_mining\_use\_case** are sentiment analysis, document summarization or concept extraction”.

ChatGPT is able to perform sentiment analysis with results matching the expected values. With prompt engineering, detailed sentiment descriptions are returned by ChatGPT. Regarding document summarization, word count is lowered on average by 55.57% and by applying prompt engineering these results improve to 72.03%. No additional prompt engineering is required for concept extraction using ChatGPT.

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# How Can Ai-Powered Solutions Improve Communication in Healthcare?

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**Abstract:** *AI, as an integral part of various applications and devices in mHealth, can help establish reliable communication in healthcare. AI Chatbots can understand and respond to patients' language, providing instant answers to common questions. They can conduct initial assessments of patients' physical or mental conditions, assist patients through diverse healthcare processes, and offer support to individuals experiencing adverse health conditions. Additionally, wearables and smartphones can collect vast amounts of information that can be further analyzed using AI and machine learning technologies and used to identify risk factors and potential health patterns that may not be immediately apparent, thus enabling personalized healthcare interventions. This paper aims to point out that Chatbots, being user-friendly and highly accessible, are facilitating online healthcare services and helping patients to self-manage their conditions. Therefore, AI-powered solutions can be an efficient tool for improving communication with patients and easing the pressures faced by healthcare professionals.*

## 1. INTRODUCTION

The field of mobile health has experienced rapid growth, demonstrating the potential to support and assist patients in the diagnosis, treatment, and prediction of health-related events. This rise has undeniably been contributed to by the implementation of AI tools. The synergy of AI and wearable technologies serves as a notable example of AI's contribution to mobile health: wearables generate patient data related to health, and AI tools process this information, leading to conclusions that aid healthcare professionals in making decisions about patient health. Effective communication between patients and doctors is a vital aspect of the healthcare system. The evolution of technologies in mobile health has opened up new possibilities for exchanging health-related messages and providing timely information and alerts in real-time, as observed in the COVID-19 pandemic, through various electronic communication media, such as SMS text messaging (Jelić et al., 2022). In situations where a patient, for any reason, is hesitant to seek assistance from a doctor, chatbots and virtual assistants emerge as a means to bridge the communication gap – anywhere and anytime.

ChatGPT, an AI chatbot developed by OpenAI San Francisco, CA, USA, was launched in November 2022. While currently free to use, OpenAI plans to monetize ChatGPT in the future. Being highly accessible to the public, it has already garnered millions of interactions. When given a query, ChatGPT autonomously generates responses based on information from thousands of internet sources. This functionality underscores the increasing need for strict AI author guidelines particularly in scholarly publishing due to ethical concerns related to copyright, attribution, plagiarism,

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and authorship when AI is involved in producing academic text. Despite its popularity, there are apprehensions about the potential harm caused by generating misleading or inaccurate content, raising concerns about scholarly misinformation. The widespread use of ChatGPT emphasizes the urgency of addressing these issues, prompting questions about the authenticity of the content and the involvement of human authors in what is being read (Liebrenz et al., 2023).

In his study on the current popularity of using Generative AI in healthcare, Pohrebniyak (2023) provides some interesting insights into the statistics based on the survey. According to this article, ChatGPT is ranked highest among healthcare professionals for patient inquiries, while the results of the survey show that more than 10% of healthcare workers currently use this technology, and half are planning to adopt it. Undeniably, Generative AI has many benefits for both patients and healthcare providers, such as speed drug discovery, cost-effectiveness, regulatory compliance, risk mitigation, resource allocation, and enhanced customer experience.

The widespread use of AI-powered conversational chatbots in the healthcare industry has been justified due to their versatile applications. The article titled “Benefits of Chatbots in Healthcare: 9 Use Cases of Healthcare Chatbots” (2023) provides facts stating that “an extensive study by Verified Market Research showed that the healthcare chatbot’s market size is currently valued at USD 194.85 million in 2021 and is projected to reach USD 943.64 million by 2023, growing at a CAGR of 19.16% from 2022 to 2023. It is worth noting that in the age of personalized medicine, AI tools facilitate tailored health solutions and recommendations based on individual patient medical data. In this context, personalized chatbots offer immediate health advice, help in scheduling appointments, and send reminders to patients for their medication. However, despite the undoubtedly numerous advantages such as 24/7 availability, rapid information access, cost savings, shorter wait times, anonymity, and improved patient satisfaction, as stated in the article, chatbots raise some ethical and security concerns, particularly regarding data protection, as well as issues like report validity, the inability to address posed questions, and other related considerations.

## 2. AI LANGUAGE PROCESSING MODEL – A POWERFUL TOOL FOR VARIOUS APPLICATIONS

The use of large datasets and predictive models that enable machine learning is highly significant for doctors as assistance in diagnosing and treating patients (Handelman et al., 2018). These services are facilitated through the use of artificial intelligence tools and natural language processing (NLP). The development of human language has been a goal for AI researchers since the 1950s. This field includes applications such as speech recognition, text analysis, translation, and language-related tasks such as negation detection, context determination, hedging, word tokenization, lemmatization, and various others (Moradi & Samwald, 2022). In healthcare, prominent usages of NLP involve creating, understanding, and categorizing clinical documentation and published research. NLP systems can analyze unstructured clinical notes about patients, generate reports (e.g., on radiological examinations), transcribe interactions with patients, and participate in AI-driven conversations. Harrison and Sidey-Gibbons (2021) pointed out the importance of sentiment analysis (or opinion mining), as one of the common NLP techniques, which is a process of assigning subjective meaning to text units. Recognizing that different forms of text data represent a rich source for clinical research, Kreimeyer et al. (2017) conducted a literature review to identify existing clinical NLP systems capable of converting unstructured texts into interpretable datasets for statistical and machine-learning models.

According to Patel and Lam (2023), ChatGPT could find valuable applications in the creation of discharge summaries. Generating comprehensive discharge summaries can be time-consuming, which can lead to delays in patient discharges or the production of insufficient summaries. The use of ChatGPT could alleviate the burden of writing discharge summaries, and contribute to more efficient and thorough discharge processes. However, even though ChatGPT can serve as an initial step in the writing process, manual verification by a doctor is necessary before finalization. Doctors can utilize ChatGPT by providing specific information, concepts to elaborate on, and guidance for explanation. In return, the system rapidly generates a formal discharge summary. The suitability of this technology for discharge summaries is evident due to the standardized format typically used. The authors further consider the potential consequences of technology failure stating that while asking trivial questions to a home chatbot may have minimal impact, providing incorrect or insufficient information regarding medication changes or follow-up can significantly affect patient care.

Li et al. (2023) investigated radiology reports, highlighting the ability of ChatGPT to simplify complex texts into easily comprehensible summaries, one aspect of ChatGPT that has been somewhat overlooked. The authors also state that to produce high-quality language predictions, resembling human language, the LLM-based chatbot – ChatGPT has been trained on vast text datasets, LLM (Large Language Models) being derived from NLP.

Taking into consideration how extensively medical imaging techniques have been used worldwide for diagnosing illnesses and monitoring patients' progress, Alfarghaly et al. (2021) researched deep learning models capable of automating the report writing process. The aim of their study is twofold: to help radiologists generate confident and accurate reports, as well as to reduce the considerable time it takes for radiologists to draft full-text reports. Automated analysis of medical images would facilitate the composing of a comprehensive textual report describing the findings, and hopefully, avoid uncertain information that might prompt additional tests for patients, or require advanced imaging methods.

However, there are some concerns about using AI chatbots in healthcare. In their recent study on ChatGPT's capabilities in diagnosis and managing patients with new shoulder and elbow complaints, Daher et al., (2023) conclude that although ChatGPT presents a formidable counterpart, its existing form is insufficient to substitute a specialist in the diagnosis and treatment of patients. This limitation arises from factors like potential misdiagnosis, inadequate management, a lack of empathy and direct patient interactions, reliance on magnetic resonance imaging reports, and a deficiency in incorporating new knowledge.

### 3. CASE STUDY

This paper aims to investigate how online communication in the healthcare sector can be improved, focusing on both semantic and linguistic aspects, through the utilization of AI and machine learning technologies, as opposed to online consultations with a doctor via a web portal. To facilitate this analysis and comparison, a query sent by a patient from Macedonia to the [www.stetoskop.info](http://www.stetoskop.info) web portal seeking a dermatologist, whose work she had been following for a while, has been chosen:

*Original query: Dear!!! I am Kate, your follower and admirer, thank you so much for the phenomena content! I forgot to ask you \* Firstly, for a dear friend, she bites her nails, a*

*bad habit... Can you recommend a solution for me? Please!!! Secondly, when our nails are breaking, what should we do? Should we take some vitamins? And also, for vaginal itching, some cream to use? For me, gynecological swabs are negative, but I occasionally experience unpleasant itching.. Thank you in advance for everything!!! Soon we are going to Nis, for an examination with a vascular specialist, and... Let's meet somewhere for coffee/ice cream, whatever you prefer!! Kiss!!!*

(Stetoskop, 2023)

The patient seizes the opportunity to ask three questions: firstly, seeking a solution for a friend who bites her nails; secondly, looking for a recommendation for vitamins to reduce nail breakage; and finally, inquiring about which cream to use for vaginal itching, which persists despite negative gynecological swabs. On the [www.stetoskop.info](http://www.stetoskop.info) web portal, the dermatologist ignores the questions about nails and, in a very concise epistolary form, provides a brief answer recommending PRP treatment for vaginal issues.

*Dear,  
For your vaginal issues, I recommend PRP treatment.  
Warm regards,  
[name and surname of the doctor known to the authors]*

(Stetoskop, 2023)

The same content query was entered into ChatGPT. The introductory and concluding parts of the response, i.e., the greeting and farewell, will be analyzed first.

*Introduction: First of all, thank you for your kind words! Now let's talk about your questions:*

[Body of the response]

*Conclusion: And finally, happy examination with the vascular specialist in Nis! I hope you enjoy your time with coffee and ice cream. If you have any additional questions, I am at your disposal. Kiss and all the best! 🍷*

(OpenAI, 2023)

Upon initial observation, there is a distinct difference in the communicative style of the latter response compared to the online consultation with the doctor. ChatGPT adeptly recognizes and mirrors the tone used by the patient. An informal communicative style is established with a speech act expressing gratitude (Searle, 1969) (*First of all, thank you for your kind words*) and the utilization of the “inclusive we” to self-mention, exemplifying the interactive dimension of metadiscourse (Hyland, 2005) (*Now we will talk about...*). The response concludes in the same amiable tone, extending best wishes for the patient's ongoing treatment, a delightful time with coffee and ice cream, and an invitation to reach out again for any additional questions, concluding with a warm farewell. This example showcases a high level of personalization in human-machine communication. Following the initial greeting, ChatGPT addresses all the questions posed by the patient.

To enhance comprehension of how the formulation of a question influences the scope, style, and content of ChatGPT's responses, the same query will be entered as specific, precise questions but in two different ways:

Test query 1: How can one address nail biting, nail breakage, and vaginal itching?

Test query 2: I have an issue with nail-biting, nail breakage, and vaginal itching. How can these issues be cured?

Due to the scope of this paper, only responses to the question about nail biting will be analyzed. In Table 1, responses to the Original query posed by the patient, Test Query 1, and Test Query 2 are presented for comparison.

**Table 1.** Comparison of responses provided by ChatGPT regarding nail biting

Response to the Original query	Response to Test Query 1	Response to Test Query 2
<p>For nail biting:</p> <ul style="list-style-type: none"> <li>You could use some bitter nail preparations available in pharmacies.</li> <li>Consider taking vitamins and minerals that can support nail health, such as biotin and zinc.</li> </ul>	<p>Nail biting:</p> <ul style="list-style-type: none"> <li>Application of bitter coatings: Use special coatings with a bitter taste and apply them to the nails. This can deter nail biting.</li> <li>Always keep nails neat: Maintain nails regularly groomed and shaped. People often bite their nails less if they are beautiful and neat.</li> </ul>	<p>Nail biting:</p> <ul style="list-style-type: none"> <li>Psychotherapy: If nail biting is a result of stress, anxiety, or other emotional factors, psychotherapy (such as cognitive-behavioral therapy) may be helpful.</li> <li>Application of bitter coatings: Use medications with a bitter taste on the nails to break the habit of nail biting.</li> <li>Holistic approach: Identify triggers leading to nail biting and work on changing those behavior patterns.</li> </ul>

**Source:** Own research

As seen in Table 1, responses to all three differently phrased questions are presented in bullet-ed lists. In the response to the Original query, ChatGPT maintains a less formal communicative style using appropriate language tools, such as the use of potentials (*You could use...*), as well as hedging while giving advice, achieved through the use of verbs like *consider* and the modal verb *might/may* (*Consider taking vitamins and minerals that may support nail health...*). The response to Test Query 1, presented as a simple, specific question without elaboration, starts without any introduction. It is evident that language tools have been altered, adopting a direct approach by using imperative verbs (*Use special coating...apply them...; Maintain nails regularly groomed...*). The impact of how a question is formulated on the response is best illustrated in the answer to Test Query 2, wherein the key term '*issue*' is used. This term triggered a new approach to seeking answers, offering psychotherapy and a holistic approach to addressing the health problem. Unlike the previous two responses, the phrase '*to have an issue*' connected nail biting with stress, anxiety, or other emotional states, as reflected in the use of new lexis, shifting the linguistic register to the fields of psychology.

The small-scale investigation outlined in this paper as a case study implies several key findings. Alongside the significance of the accuracy of input data in ChatGPT and the algorithms processing that data, it is equally crucial how users frame queries directed to ChatGPT. Most importantly, both patients and doctors need to adopt a critical approach to the information they receive.

#### 4. CHALLENGES AND OPPORTUNITIES FOR FUTURE DEVELOPMENT

AI-powered chatbots have been increasingly implemented into various healthcare practices, showing a huge potential to empower healthcare professionals in making predictions and becoming a diagnostic tool and a useful consultation resource for physicians. However, there are also challenges to consider. Exploring the benefits and drawbacks of using ChatGPT for medical imaging diagnosis, [Srivastav et al. \(2023\)](#) highlight significantly improved accuracy and efficiency of AI-supported radiological diagnoses but also emphasize that some challenges, including the necessity for high-quality training data, ethical consideration, and the need for further research and development, should be constantly addressed in future. Radiology is pivotal in treating various medical conditions, offering physicians detailed images of the body's internal structures to assist in diagnosis and treatment planning. Since the interpretation of medical images is intricate, time-consuming, and requires specialized expertise, AI has opened up new possibilities for improving accuracy and patient outcomes. The authors draw further attention to addressing the ethical implications of making healthcare more accessible, in other words, inaccessible and underserved regions and populations should be able to receive adequate attention and medical support, which would significantly reduce health disparities. Furthermore, while improving accessibility, it is crucial to remain committed to protecting patient privacy and confidentiality.

In addition to privacy issues, instances have been documented where AI apps provide risky and detrimental guidance to professionals involved in making decisions in clinical care. It has been noticed that ChatGPT cannot comprehend some complex conditions and subtle distinctions. This can have severe consequences, particularly in fields like mental health. Artificial intelligence systems will unquestionably make mistakes in diagnosis, which can lead to e.g., the misinterpretation of results from medical tests or radiological images, or inappropriate advice for further treatment. Additionally, machine learning systems may be susceptible to algorithmic bias, perhaps predicting a higher likelihood of a disease based on gender or race, when they are not causal factors. All of this raises questions of establishing accountability, transparency, safety, and privacy, regarding who is more responsible: AI developers or the healthcare professionals using it. Moreover, it is crucial for healthcare institutions, as well as government and regulatory bodies, to establish structures for monitoring key issues, to act responsibly, and to establish management mechanisms to limit negative implications. Future work on improving AI systems should focus on ensuring the input of accurate and unbiased data upon which AI-generated predictions and recommendations can be comprehensive to both patients and clinicians.

A paper in the Journal of the American College of Radiology aiming to investigate the potential use of LLMs in radiology identifies the positive and negative aspects of using ChatGPT ("[The Pros and Cons of Using ChatGPT in Clinical Radiology: an Open Discussion](#)", 2023). ChatGPT exhibits versatile applications within the healthcare domain, contributing to the improvement of patient care and medical processes. It can simplify complex medical reports for patients, fostering a more patient-centered approach. Additionally, it aids individuals preparing for radiologic-guided procedures by providing information, assessing readiness, and offering support. Moreover, ChatGPT serves as an effective educational tool for radiologists, enhancing their training experience. However, concerns surround its accuracy and reliability, particularly in addressing the hallucination ([Hallucination, 2023](#)) problem. The transparency of ChatGPT's operations poses a challenge, raising questions about how it generates outputs. Privacy apprehensions also emerge regarding the safeguarding of patient data. Notably, there is a consensus that AI systems, including ChatGPT, should complement rather than replace human expertise and judgment. Additionally, ethical considerations arise regarding the implications of AI-generated content in research and publications.



## 5. CONCLUSION

The implementation of AI presents a notable challenge in the field of communication in healthcare, involving the creation of sound theories and models and providing an opportunity for detailed testing of health communication theories and models that are still unverified. As Galetsi et al. (2023) conclude once individual health data is converted into digital format and handed over to healthcare professionals and app developers who maintain health information systems, inquiries emerge regarding the utilization and safeguarding of this information. In other words, certain concerns have been raised about the potential harm these applications might pose to public privacy, data ownership rights, and the permissible sale or storage of such data by app companies.

This paper aims to illustrate the advantages of using an AI chatbot to alleviate the workload of physicians by reducing the necessity for patients to schedule appointments in clinics, thus easing the strain on the healthcare system. Even online portals, which can assist in facilitating doctor-patient communication, demand additional effort and time from doctors to effectively address patient inquiries. The paper also emphasizes the significance of carefully formulating questions, as large language models can discern the style and tone of a question, and much depends on this in determining the direction in which they generate a response. Analyzing communication skills through the use of email, SMS text messaging, web portals, and social networks, Mamula Tartalja et al. (2023) underline the importance of increasing eHealth literacy. This encompasses the ability to search for, find, understand, and evaluate health information, along with applying it to treatment and the improvement of one's well-being. To increase the prospects for better health outcomes, the authors assert that a specific level of health literacy is necessary for internet users to approach information critically and determine its accuracy.

While acknowledging the immense potential of this technology, it is crucial to steer the future development of AI systems in healthcare towards enhancing the capabilities of healthcare professionals rather than replacing them. The advancement of machine learning should empower doctors to augment their cognitive and reflective abilities, ultimately resulting in improved healthcare outcomes.

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# Digital Trends in the Accounting Profession

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**Abstract:** *The rapid technological changes have profoundly affected the accounting profession. This study aims to systematically explore how digital technology is influencing accounting, examining the forces driving this change. It also investigates crucial educational adaptations needed for future accountants to navigate the evolving technological landscape. The research examines various aspects, including the complex relationship between the accounting profession and global technological changes, the evolving role of technology in accounting, and the necessary adjustments required in accounting education. Through a literature review methodology, the findings highlight a compelling need for a fundamental shift in accounting practices. This transformative process is gradually related within the profession, emphasizing the certain impact of continuous evolution in the accounting field on accounting education. In summary, while technological advances reshape specific aspects of accounting, the discipline's foundational principles persist.*

## 1. INTRODUCTION

The accounting profession is often correlated to the language of business, reflecting the way people think and operate in the financial world (Žager et al., 2016). Despite the accounting profession's renowned traditions and firmly established principles, it is not immune to change within our modern, globally interconnected business environment. This transformation is driven by the convergence of more rigorous regulatory frameworks and a profusion of technological innovations that are fundamentally reshaping the profession. These challenges are manifesting in the necessity for swift adaptation and transformation of business practices and processes, all while ensuring that the fundamental accounting rules and principles remain at the core of the profession (Gulin et al., 2019). In the fields of accounting and auditing, the concept of prudence in decision-making has long been considered a vital aspect of professionalism. Individuals like managers, auditors, financial analysts, accountants, and standard-setters are responsible for making crucial judgments and decisions. Accountants and managers often choose accounting methods and make decisions that align with their objectives, particularly in the production of accounting information. Within organizations, accountants are concerned with the precision of accounting policies and estimates, while auditors focus on ensuring the accuracy of the provided accounting information (Mala & Chand, 2015).

Traditional accounting has primarily relied on historical cost conventions, emphasizing past and somewhat present business performance while neglecting the future (Hales, 2018). However, modern business places great importance on the future, and this shift in thinking is expected to bring significant changes to the accounting profession in the next three decades (Islam, 2017). These anticipated changes in the accounting profession will be driven by three key factors: the integration of digital, smart, and intelligent technologies; the globalization of reporting standards and the introduction of new regulatory approaches; and the major challenges that the profession will confront (Islam, 2017). Association of Chartered Certified Accountants (ACCA) research—Drivers of Change and Future Skills—has explored these important changes, expected

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to be encountered by the year 2025. Founded in 1904, ACCA is an authority on the profession, but even this organization remains unsure about the exact nature of accounting's future. The organization has repeatedly stressed the need for accountants to future-proof their livelihoods by keeping an eye on the horizon (Galarza, 2017). Routine tasks like bookkeeping and process-driven auditing are becoming increasingly automated, creating space for accountants to focus on non-routine aspects such as tax and business strategies. Technological innovation presents both opportunities and challenges for accountants, necessitating their preparedness for this evolving landscape (Galarza, 2017). The accounting profession is facing potential challenges due to the rapid advancement of technology, as highlighted by Malviya and Lal (2022). As new technologies emerge, it becomes imperative to acquire fresh skills for professional adaptation and success. Consequently, this paper aims to investigate how the profession is transforming in response to current technology trends, framing the following research questions (RQ):

**RQ1:** How is technology reshaping accounting, and what drives this change?

**RQ2:** What educational adaptations are essential for preparing future professionals to navigate the evolving technological landscape in the field of accounting?

The primary objective of this paper is to systematically examine and analyze the significant changes in the accounting profession resulting from digitalization. This research is based on a comprehensive review of relevant professional and academic literature. The paper is organized into five main sections. The initial section serves as the introduction, setting the context for the study. The second section is the literature review, providing a thorough overview of existing knowledge in this field. The third section outlines the methodology employed in this research. The fourth section of the paper focuses on clarifying the impact of digitalization on accountants' roles and responsibilities, along with an exploration of the key digital solutions available to accountants in this evolving landscape. Furthermore, within the fourth section, a comprehensive elucidation of essential adaptations to accounting education is provided. Lastly, the paper concludes by summarizing the main findings and acknowledging the research's limitations. Additionally, it suggests potential directions for future research in this area.

## 2. LITERATURE REVIEW

Many jobs traditionally performed by humans are at risk of being replaced by automation. Frey and Osborne (2013) indicated that slightly less than half of the jobs in the United States face the risk of redundancy due to digitalization, as robots can handle not only routine tasks but also sophisticated ones. While the digitalization era presents opportunities for those who embrace it, it also poses considerable challenges to traditional professions, including accounting. According to Kumar (2018), the accounting industry is undergoing significant digital transformation and is poised for further growth. Similar to numerous other industries, it is adapting to the changing landscape driven by digital technologies.

Technology has significantly transformed the field of accounting. In the past, accountants relied on physical ledger books or ordinary hardbound books with neatly drawn T-shaped lines created using a ruler. Manual calculations or electronic calculators were used for computations. However, over time, software developers introduced accounting software that automated a significant portion of accounting tasks. This automation greatly enhanced the accuracy of financial reports. Due to technological advancements, many companies are undergoing restructuring

to eliminate administrative roles and are increasingly adopting artificial intelligence (AI) for managing accounts payable and receivable (Malviya & Lal, 2022). As a result, the next generation of accountants must possess a comprehensive understanding of business operations, not limited solely to the functions of the accounting department.

Vetter (2018) suggests four key strategies for accountants to remain relevant in the age of technology. The first strategy highlights the significance of adopting cloud computing in accounting, recognizing that much of the future data will reside in the cloud. This move enhances data management efficiency and accessibility to resources. The second strategy emphasizes understanding automation as artificial intelligence becomes more prevalent in routine accounting tasks. Accountants must comprehend automation technologies and their implications. The third strategy stresses the consideration of cryptocurrency and blockchain technologies, which have a potential influence on financial markets. Lastly, the fourth strategy underscores the importance of continuous learning and communication for accountants, given the rapid technological evolution. To remain agile in this changing landscape, accountants must prioritize ongoing learning and effective communication within their professional networks, as complacency in knowledge and skills can be detrimental as technology evolves.

In the contemporary professional landscape, accountants are expected to possess proficiency in areas such as business transformation, digital strategy, and innovation to effectively embrace the digital era (Kokina & Blanchette, 2019; Mosteanu & Faccia, 2020). Accounting practices profoundly depend on technology (Junger da Silva et al., 2020), enabling accountants to perform precise calculations. To maintain their employability, accountants must enhance their skill set and adapt to evolving technological advancements (Kruskopf et al., 2020).

The rapid advancement of technology offers significant opportunities to enhance work efficiency, but it also presents challenges, especially for professionals like accountants, in adapting to digital technology (Ghani & Muhammad, 2019). Despite the growth of digital-based and artificial intelligence-driven businesses, the need for accountants' professional judgment remains critical to ensure compliance with standards in transaction recording. As these technological changes are disclosed, accountants have the potential to evolve into valuable business advisors, emphasizing their role as effective communicators (Solikhatus et al., 2023). To thrive in this evolving landscape, accountants should be prepared to meet future challenges, including technical knowledge, adaptability, learning abilities, a positive mindset, and resilience (Jackson et al., 2020). This shift positions accountants as integral partners in a company's main support system, moving away from the traditional perception of a back-office role (Solikhatus et al., 2023).

According to Frey and Osborne (2013), technological advancement is expected to affect a variety of job positions. The Internet of Things (IoT) has led to changes in accounting and accountability practices within companies (Arnaboldi et al., 2017). Although it doesn't directly alter the fundamental nature of accounting, IoT influences the accounting field in three ways: affecting reporting and disclosure standards, introducing new forms of regulation, and potentially challenging the role of accountants (Islam, 2017). Moreover, IoT is transitioning business models from manual to automatic, impacting the roles of accounting professionals. Accountants now use AI and robotic technology for recording, processing, and generating transaction reports (Sever Mališ et al., 2021; Sumarna, 2020). Basic accounting tasks are becoming more efficient with computer assistance, reducing the need for direct human involvement. This transition also promotes the creation of mobile applications to access data on mobile devices, tablets,



and virtual reality (VR). Real-time financial statement audits are enabled, ensuring data transparency and accuracy (Solikhatun et al., 2023). Accountants and auditors lacking IT expertise may risk losing their roles to other professions.

Stoica and Ionescu-Feleagă (2021) conducted a review of the most recent literature in the field of accounting digitalization using a structured literature review. Their study's findings emphasize that researchers predominantly concentrate on three key aspects: accounting education, professional regulation, and accounting information systems. These three key aspects are the focus of this article.

### 3. METHODOLOGY

This paper utilizes a literature review methodology to investigate the history and potential future of the accounting profession, with a specific focus on the Croatian context. The reviewed literature spans from 2013 to 2023 and encompasses sources from various global regions. According to rigorous scientific methodology, the following databases were searched: the Web of Science platform, EBSCO Host, and Google Scholar. The considered selection of databases was motivated by its vast repository of scholarly content and the invaluable citation analysis tools it provides, significantly enhancing the depth and precision of the research.

The primary subject of investigation pertained to *digitalization \* accounting*, encompassing a comprehensive exploration of articles covering diverse aspects of digitalization within the accounting discipline. The research inquiry was precisely tailored to specific Web of Science categories, exclusively "Business" and "Education - Educational Research" aimed at targeting scientific articles related to the educational aspects of digitalization in the accounting field. Moreover, to facilitate accessibility and comprehension, the search was confined exclusively to articles published in the English language. The chosen academic and professional papers underwent a rigorous evaluation, utilizing a diverse array of scientific research methodologies, which encompassed both inductive and deductive reasoning. Furthermore, these methodologies encompassed techniques involving analysis and synthesis, generalization, and abstraction, collectively constituting a robust framework for a systematic and comprehensive exploration of the available literature.

Finally, as a result of these research activities, a total of 40 articles were successfully identified and retrieved, each of which impeccably met the exacting criteria established for the study. This diligent and methodical approach ensured the selection of literature that was highly pertinent and instrumental in advancing the research objectives.

### 4. RESULTS AND DISCUSSION

**RQ1:** How is technology reshaping accounting, and what drives this change?

Digital technology profoundly impacts a company's strategy, competitiveness, business models, and market approach. It also significantly influences accounting information and management control systems (Mancini et al., 2017). While accounting principles remain stable over time, the accounting industry is evolving due to technological advancements. This transformation is reshaping accountants' roles and client expectations, with technology and digitalization enabling rapid updates and reducing the workload through modern computer systems. Rapid technological advancements, globalization, and increased competition are driving constant change across

professions. The accounting profession is particularly susceptible to the effects of technological developments and globalization, with many new digital systems now integral to the field. Research by Frey and Osborne (2013) identifies 702 job titles at risk of automation, with the accounting profession topping the list as highly likely to be automated and digitalized in the near future. Automation in accounting and auditing follows pre-programmed rules, streamlining processes using workflow automation software. This includes tasks like transaction processing, payroll, and accounts payable, enhancing internal controls, compliance, and fraud detection. Examples of automation in accounting encompass paperless invoicing, cloud accounting, and automated document testing. Major companies like Amazon, Wal-Mart, Nestle, DHL, and Adidas are already incorporating automated accounting into their operations (Akhter & Sultana, 2018). The evolution of the accounting profession is defined in Table 1.

**Table 1. Accounting Evolution**

Activities	Past, present and future situation
Data Entry	Historically performed by accountants, it now involves operators or accountant assistance and is gradually shifting towards automation using artificial intelligence.
Bookkeeping	Previously the domain of accountants, it currently relies on software, and the future trend is a combination of software and artificial intelligence
Compliance Work	In the past, accountants and auditors managed compliance work. Today, software is the primary tool, with the expectation of a more prominent role for artificial intelligence in the future.
Handling Client Documents	Account staff used to physically collect documents, but today, electronic documents and email are common. In the future, cloud technologies will streamline this process.
Preparing Bills and Requisitions	Historically an accountant's responsibility, it's now assisted by software, and machine learning will further enhance it in the future.
Preparing Ledgers	Accountants traditionally used spreadsheets for this task, and this practice will persist with the assistance of software in the future
Preparing Tax Documents and Calculations	Accountants previously handled this, and software is currently the norm. However, in the future, machine learning will play a more significant role.
Preparing Financial Statements	In the past, accountants prepared financial statements with the help of ERP and SAP software. In the future, there will be a greater reliance on XBRL for automated annual reports.

Source: Akhter and Sultana, 2018; Solikhatus et al., 2023

**Table 2. Key digital advancements in accounting**

Digital solutions	Key advancements in technology usage	Researcher
Artificial Intelligence (AI) and machine learning	<ul style="list-style-type: none"> <li>enhance businesses through real-time data and task automation, boosting efficiency and advisory services for accountants</li> </ul>	Zhang et al. (2020) Hasan (2022) Malviya and Lal (2022) Cazazian (2022) Ranta et al. (2023)
Blockchain	<ul style="list-style-type: none"> <li>enhance data access, security, and process efficiency, potentially revolutionizing auditing, compliance, and reconciliation beyond cryptocurrency uses</li> </ul>	Brandon (2016) Wu et al. (2019) Mosteanu and Faccia (2020) Cazazian (2022) Zhang et al. (2020)
Big data and analytics	<ul style="list-style-type: none"> <li>improving processes, data quality, efficiency, and reporting while influencing financial, managerial, and auditing practices</li> </ul>	Arnaboldi et al. (2017) Witkowski (2017)
Internet of things (IoT)	<ul style="list-style-type: none"> <li>improved real-time data access, enhanced automation of financial processes, and increased accuracy in asset tracking and inventory management.</li> </ul>	Hatane et al. (2019) Yilmaz and Hazar (2019) Wu et al. (2019) Karmańska (2021)
Cloud technology	<ul style="list-style-type: none"> <li>enhanced data security and accessibility, improved collaboration among remote teams, and cost-effective scalability for businesses of all sizes.</li> </ul>	Dimitriu and Matei (2014) Mauricette et al. (2022)

Source: Own research

In the past, various accounting activities were primarily carried out by accountants. Today, many of these tasks are automated or assisted by technology. Table 2 shows key digital advancements that will significantly impact accounting professions in the future, according to researchers.

Zhang et al. (2020), Malviya and Lal (2022), Hasan (2022), Cazazian (2022), and Ranta et al. (2023) collectively emphasize how artificial intelligence (AI) is reshaping accounting. They analyze the challenges and opportunities, including the rising demand for IT professionals with accounting knowledge. These studies highlight the need for interdisciplinary collaboration in response to disruptive technologies and discuss the implications for education, regulation, and professional readiness, all pointing to significant changes in the accounting field.

**RQ2:** What educational adaptations are essential for preparing future professionals to navigate the evolving technological landscape in the field of accounting?

‘As automation and technology continue to drive changing business models, the role of accountants and auditors will need to rapidly evolve and adapt’ (Vitale, 2020). Gulin et al. (2019) emphasize that educational reform is imperative, with a specific focus on cultivating critical and systemic thinking in students to enhance their creative abilities. This transformation is deemed necessary due to the evolving responsibilities of accountants, who are expected to play a proactive role in the management and operation of companies. Such a role requires close collaboration with professionals from diverse functional areas, notably IT experts, to ensure the effective execution of a company’s business processes.

According to Birt et al. (2023), the evolution of technology is expected to impact the digital skills needed by accounting graduates, which may require transforming accounting and finance education: Graduates will be solution architects, problem solvers, data analyst, design thinkers and storytellers. As highlighted by Berikol and Killi (2021), students pursuing accounting education should receive training in several key areas. This includes acquiring skills in data analytics to effectively analyze extensive datasets, gaining knowledge about data and cybersecurity, and being well-prepared for the continuing digitalization trends. The accounting profession is undergoing significant transformation as the world rapidly transitions into a digital era. Therefore, it is crucial to equip accounting students with the latest technology and tools to ensure their readiness for these changes.

Future accountants will focus more on more specific things because previously manually operated activities are operated by technology (Kruskopf et al., 2020). The accounting profession’s expertise needed in the future includes IT knowledge, forensic IT, audit IT and data analytics (Pan & Seow, 2016). Meanwhile, Kruskopf et al. (2020) predict the jobs available for accountants in the future as blockchain accountants, healthcare accountants, cybercrime accountants, fintech accountants, cloud accounting specialists, fintech city planning accountants, data security accountants, historical accounting analyst, system integrator, and strategic accounting analyst. These jobs do not only require knowledge but also skills, both hard and soft. Hard skills include the ability to understand software, analytical skills, data visualization, international standard knowledge of accounting, knowledge of specific industrial regulation, basic coding, fintech knowledge of software, data warehouse management and enterprise resource planning. Meanwhile, soft skills include communication, conflict management, leadership, risk management, decision-making strategies, emotional quotient (EQ), adaptability, creativity, and customer orientation (Kruskopf et al., 2020). Therefore, a curriculum that teaches these skills is needed for prospective accountants to compete in the future.

## 5. CONCLUSION

The accountancy profession is shifting away from routine data entry duties and moving towards more complex tasks that involve advanced analysis and judgment-based accomplishments. As technology continues to advance, accountants must work together to adapt and thrive in the era of digitalization. This paper demonstrates that technology is not eliminating the accounting profession but rather transforming it with new and challenging responsibilities. The rise of robotics automation and drones is likely to replace certain manual accounting tasks, while artificial intelligence will redefine the role of accountants. Despite these changes, there is an expectation of a growing demand for highly skilled accountants.

Future accounting professionals must receive an education that integrates technological advancements. This includes comprehensive training in data analytics, artificial intelligence, and emerging software. Additionally, fostering critical thinking and adaptability in the face of technological shifts is crucial. Practical experiences in handling these technologies within educational settings will be fundamental in preparing these professionals to navigate the evolving landscape of accounting.

Finally, a limitation of this study stems from its limited coverage of the analyzed literature, as it is not comprehensive. While the adoption of digitalization and automation is a global phenomenon, there remains a lack of professional and academic research on the implementation of digitalization in accounting. Future research should focus on conducting primary research using surveys and in-depth interviews. This approach will provide valuable insights into the evolving role of accountants in the context of digitalization and automation.

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# Cryptocurrencies as a Risk Management Tool – Legal and Economic Perspectives

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**Abstract:** *The development of law is faced with many challenges, including the creation and testing of new information and communication technologies. At the same time, the law must quickly react with a set of legitimate means of regulation to guarantee legal certainty in relations. Cryptocurrencies are a manifestation product of rapidly developing technology entering civil turnover at an increasingly rapid pace. The paper aims to examine the various legal aspects of cryptocurrencies in the EU and to reveal the relationship between the stock market, investors' decisions, and cryptocurrency. It clarifies the concept of cryptocurrency, comparing it to the millennia-old fiat money. In addition, the research traces the cryptocurrencies and their status as essential legal assets in the EU market. To test the relationship between the capital market, the investors' behavior, and cryptocurrency, we apply the regression model, correlation analysis, and Granger Causality Test. The explored variables include the Crypto Index (CRIX), the Sentix sentiment index, and the capital market index. We prove that the cryptocurrency market influences the stock market, which may be explained by the fact that the investors in the crypto markets are better informed than those in the traditional financial markets.*

## 1. INTRODUCTION

The international turnover is developing in the digital environment. It has created the need for an adequate legal and economic response to the new technological assets. The growth of new trends in legal and economic sciences are inextricably linked. Their compatibility and interaction guarantee the protection of the rights and legitimate interests of individuals as part of society. This convergence is one of the main tasks that underlie every legal system. Law and economy face a new challenge – crypto assets. They are also known as cryptocurrencies or digital assets and are a form of digital or virtual currency that uses cryptography for security. Unlike traditional currencies issued by governments and central banks, crypto assets operate on decentralized networks based on blockchain technology. The development of digital trade (European Commission, 2021) and commodity exchange makes the market increasingly dynamic, and so do the capital markets. There is a need to transfer to innovative and faster methods of exchange. Thus, money as a particular form of generic obligation for the transfer of fungible things is shifting from electronic money to cryptocurrencies in the current digital era. Fulfilling monetary obligations requires greater flexibility and speed to adapt to the pace at which the exchange of goods circulates. Cryptocurrencies are the response to the intensity of trade exchange. They are a complex of developed technologies, rapidity, and efficiency in transaction execution. These currencies are created based on cryptographic technology, dating back to the 19th century, for transmitting coded messages between various military agencies and national leaders (Chen, 2021, pp. 4-6). This technology later evolves into blockchain technology (Narayanan, 2016, pp. 1-336). Its main goal is to use

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algorithms, codes, and symbols to preserve certain information from unwanted subjects. Blockchain, also known as a chain of blocks, represents a database (a recorded sequence of information) that is not subject to manipulation, accessible to a specific set of subjects. The three main characteristics of blockchain are decentralization, transparency, and immutability.

Cryptocurrency began to be discussed for the first time in the 1980s. However, it was only in the early 1990s that cryptographic protocols and software were developed to allow the creation of a truly decentralized digital currency. The emergence of cryptocurrencies is likened to the discovery of the automobile by Henry Ford and is presented as something safer than the vault at Fort Knox (United States government, 2023). Bitcoin, Ethereum, and even Dogecoin are just part of the different types of currencies that are entirely based on blockchain technology. Questions arise as to whether they are carriers of a financial revolution, a striving for a more democratized society, or simply a breakthrough in technologies. Even some researchers consider different speculative scenarios of potential systemic risk in the traditional financial system (European Systemic Risk Board, 2023, pp. 51-57). All the above justifies the need to explore crypto assets' essence and significance for the law and economy. The convergence of legal aspects, the digital economy, and risk management in the context of crypto assets involves navigating a complex landscape. Considerations for each of these elements include clarification of their nature based on a comparison with fiat money and their legal framework defined by EU legislation. Navigating the legal aspects of crypto assets (Crumbley et al., 2023, p. 2) in the digital economy requires a multi-faceted approach that includes compliance with regulations, risk assessment, and adapting to technological advancements. The research paper also attempts to test the relationship between the capital market, the investors' behavior, and cryptocurrency, applying the regression model, correlation analysis, and Granger Causality Test'. Nowadays investors are willing to risk in the volatile and often unpredictable cryptocurrency markets, so it is important to carefully assess their legal aspects and function as a risk management tool.

Nguyen (2022) found evidence of volatility spillovers from the stock market to Bitcoin prices. These effects are existing during periods of high uncertainty. The correlation between both markets is increasing during periods of turmoil and the COVID-19 pandemic.

## 2. COMPARATIVE ANALYSIS OF CRYPTOCURRENCIES WITH FIAT CURRENCIES AND EXTRACTION OF THEIR NATURE

The definition and clarification of the concept of crypto assets are in direct relation to their place and significance in global monetary affairs and their connection with fiat money. In literature, the concept of money (Kitamura, 2022) is considered in both a broad and narrow view. From a broad perspective, monetary symbols are regarded as internal payment instruments. In a narrow one, these are the legal tender of a country. This includes banknotes and coins in circulation as payment and exchange instruments. In summary, on one hand, money is encountered as a means of economic exchange. From a legal perspective, money (banknotes and coins) is movable, indivisible, consumable, and fungible property. The term 'currency' (Online Britannica Dictionary, n.d.) denotes both foreign currencies and the monetary unit and system of a given country. With the development of technologies and because of their implementation, the term 'electronic money' begins to be discussed.

Electronic money is a monetary value stored electronically, including in magnetic form, representing a claim on the issuer, issued upon receipt of funds to make payment transactions,

and accepted by a natural or legal person other than the electronic money issuer. This definition fully corresponds to the definition in Article 2, point 2 of Directive 2009/110/EC ([Directive 2009/110/EC on the taking up, pursuit, and prudential supervision of the business of electronic money institutions and for the purpose of amending Directives 2005/60/EC and 2006/pp. 7-8](#)). Electronic money is divided into two main groups depending on the mechanisms for their issuance, control, and supervision – centralized and decentralized. Centralized electronic money represents fiat currency in digital form. Their issuance, circulation, and withdrawal are managed and controlled by the respective central bank (a centralized financial institution). Decentralized electronic money is known as “digital money,” encompassing all monetary assets in digital form under the control of specific economic entities other than a sovereign authority. This category includes virtual currencies, which are digital expressions of value available solely in electronic form, used both as an instrument of exchange and a store of value. Virtual currencies possess all the functions of money except for the status of legal tender.

Centralized virtual currencies are issued and maintained by specific organizations or groups of people united by a common goal or interest. Examples of such virtual currencies are the so-called ‘simulated currencies’ (game currencies) created for purchasing goods or services within a specific simulated system owned by a particular commercial company or non-governmental organization. Many online computer games also use virtual currencies solely for the purposes of the respective game. They are created and managed by the companies that developed the given game and are applicable only within the virtual environment of the game. A specific example of a centralized virtual currency is E-gold, founded in 1996. E-gold is a digitally traded currency backed by gold, tradable for national currencies, with issuance and currency trading managed by the Gold & Silver Reserve company.

Decentralized virtual currencies, also known as crypto assets, are any form of electronic money created using cryptographic technology that regulates their creation and ensures the legitimacy of transactions conducted using these currencies. Cryptographic technology is the essence of decentralized virtual currencies. Cryptocurrencies have no administrative body exercising centralized control. Payments in cryptocurrencies are made using cryptographic public and private keys, enabling the transfer of funds between legal and physical entities. Security, integrity, and balance in the cryptographic registry are ensured by a network of interconnected, equal participants (peer-to-peer) who manage and protect the integrity of the network, receiving specific rewards in return.

In summary, it can be concluded that all cryptocurrencies are a type of virtual currency. However, the reverse statement is not true – not all virtual currencies are cryptocurrencies, as there are also so-called digital tokens. Digital tokens (crypto tokens) represent a type of crypto asset or rights with specific uses and purposes, applied and located only within their own blockchain. They are used in initial coin offerings (ICOs) for investment purposes, storing value, making purchases of goods and services, and acquiring rights to purchase specific existing digital assets. Crypto assets encompass the concept of both cryptocurrencies and digital tokens. They are defined as cryptographically secured digital representations of value or contractual rights using ‘distributed ledger technology’ that can be transferred, stored, or traded electronically. Also, cryptocurrency can be defined as an unregulated and decentralized virtual currency created using cryptographic blockchain technology, controlled and used by members of a specific virtual community. It is essential to generalize that cryptocurrency is not identical; on the contrary, it differs from fiat money, i.e., national currencies that have physical carriers (banknotes



and coins). It also differs from centralized electronic money, which represents a digital mechanism for transferring value measured in national currency. It can be concluded that fiat money and cryptocurrencies differ only in the absence of state sanctions. (Noneva-Zlatkova, 2023). So, the following definition of cryptocurrency should be made a digital representation of value that is not issued or guaranteed by a central bank or public authority, is not necessarily linked to a legally established currency, and does not have the legal status of currency or money but is accepted by natural or legal persons as a means of exchange and can be transferred, stored, and traded electronically.

### **3. NEW LEGAL ASPECTS OF CRYPTO ASSETS IN THE REGULATION (EU) 2023/1114 (Regulation (EU) 2023/1114 on Markets in Crypto-Assets)**

During the last years regulatory environment in the different EU countries has been dynamic. Cryptocurrencies and digital assets are subject to various regulations that differ by jurisdiction on the EU level. Understanding and complying with local, national, and international regulations is crucial. Regulatory frameworks may cover issues such as taxation, anti-money laundering (AML), and customer due diligence (CDD), but the focus of this paper is only the Regulation (EU) 2023/1114. Legal challenges may arise in defining the legal status of smart contracts (Gietzmann & Grossetti, 2021) and enforcing them in traditional legal systems. Legal frameworks need to adapt to innovations, addressing issues such as contract enforcement, liability, and dispute resolution. So does the tokenization of assets, where real-world assets are represented by digital tokens on a blockchain, raises legal questions regarding ownership, transferability, and regulatory compliance. On the other hand, crypto assets are known for their price volatility. So, educating stakeholders, including businesses, investors, and users, about the legal aspects of crypto assets is essential. This includes awareness of regulatory requirements, rights and responsibilities, and potential legal risks. All mentioned factors need to be underlain in the legal framework of cryptoassets.

The new regulation outlines the regulatory framework for crypto assets within the EU. Here are summarized some of the key elements envisaged by the Regulation. The regulation includes the crypto assets that do not qualify as financial instruments, deposits, or structured deposits according to EU legislation in the field of financial services, requirements for issuers of crypto assets, requirements for providers of crypto assets, regulation of crypto assets that will be offered publicly or admitted to trading on a trading platform in the EU, prohibitions, and requirements to prevent market abuse.

The legal definition of a crypto asset in the EU law is: *“Digital representation of value or rights that can be transferred and stored electronically through distributed ledger technology or similar technology.”* It also presents definitions of new categories of crypto assets such as tokens, asset-backed tokens, tokens for electronic money (stablecoins), and tokens for goods or services. The proposed regulatory framework in the Regulation on Crypto-Assets Markets includes various levels of regulation determined based on the risks associated with different types of crypto-assets. These types encompass regular crypto assets, tokens secured by assets, and tokens for electronic money.

Regarding regular crypto assets that are not tokens secured by assets or tokens for electronic money, various obligations are envisaged. Firstly, these crypto assets can be traded on crypto asset platforms without the issuer holding a prior license. Instead, the issuer must be a legal entity and prepare a whitepaper specifying the parameters of the crypto asset. This document is

sent in advance to the competent authority in the respective member state and must be publicly published. The whitepaper obliges the issuer to take responsibility in case of inaccurate or misleading information and to provide compensation to investors.

Additionally, a procedure for updating the whitepaper in case of changes in the characteristics of the crypto asset is outlined. For crypto assets not traded on platforms, the right of withdrawal from the purchase is provided as an additional guarantee. The issuer must provide honest and professional information, avoid conflicts of interest, and adhere to restrictions on preferential treatment not explicitly defined in the whitepaper. However, these rules do not apply to crypto assets provided for free or as a reward for maintaining distributed ledgers or validating transactions. Furthermore, the regulation does not apply to unique crypto assets that cannot be replaced, as well as those offered only to qualified investors or with a total value of 1,000,000 euros over a 12-month period in which they are publicly offered. It is crucial to note that providing crypto assets against personal data is not considered free, under European legislation on personal data protection.

The regime is significantly more restrictive for tokens secured by assets – i.e., crypto assets whose value is tied to multiple fiat currencies, or one, as well as more commodities, other cryptocurrencies, or combinations of assets. Issuing such tokens requires the issuer to obtain a license. The obligations imposed on the issuer in these cases are more stringent – the whitepaper must include information about its management, the asset reserve securing the tokens, mechanisms for deriving the value of these tokens from the reserve assets, or other liquidity assurance mechanisms, etc. The whitepaper and its changes in these cases must be approved by the competent authorities. Additionally, issuers of tokens secured by assets are required to provide information to token holders at least monthly and establish a procedure for addressing their complaints. Furthermore, detailed rules for ongoing management, capital requirements, and maintaining an asset reserve are outlined for issuers of such tokens.

The Regulation on Crypto Asset Markets introduces separate regulations for another type of crypto asset – electronic money tokens, intended as an instrument of exchange and linked to the value of a fiat currency, representing legal tender. Issuing such tokens also requires a license, and in this case, certain rules for electronic money institutions apply. The issuer is obligated to provide a specific value to the token holder upon request. While a whitepaper is still a vital element of the regulatory requirements, it does not need prior approval from competent authorities in these cases. Additional obligations are specified for tokens secured by assets and electronic money tokens due to their widespread use, making them significant according to the project's definition. The Regulation on Crypto Asset Markets also includes specific rules for entities providing services related to crypto assets, which must be legal entities established in the EU and hold a corresponding license. These providers are subject to requirements regarding fairness, impartiality, professionalism, maintaining a specified capital or insurance, organizational requirements for their activities, including governing body members, individuals holding over 20% of capital or voting rights, and staff, protection of client crypto assets, complaint resolution procedures, and prevention of conflicts of interest. Specific rules are outlined for certain types of services, such as custody, management, exchange for other assets, operating a trading platform, and consultancy. Moreover, all entities are obligated not to engage in actions that may be considered market abuse. Explicit requirements for disclosing internal information that may influence investor decisions are introduced, alongside a prohibition on abusing such information. Actions that could lead to market manipulation, including fictitious transactions, media communications, etc., are also prohibited.

In conclusion, in the regulatory framework, there is a lack of legal issues regarding the approach to decentralized networks that operate without adhering to predefined rules. The regulation focuses on regulating legal entities that issue crypto assets or provide related services, but there is no mechanism for applying the rules to a network of individual entities simply using protocols for handling crypto assets. The regulation emphasizes the need for clear identification of the beneficiary of providing crypto assets or related services, but in many cases, this may pose a significant challenge. In general, decentralized networks and autonomous organizations that may form within these networks pose a serious challenge to the legal domain, particularly due to the large number of participants who often are not united by common interests. As a result, applying measures to all participants is challenging, and the Regulation of Crypto-Asset Markets, at least for the moment, does not offer solutions in this direction.

The results of the research of Mužić and Gržeta (2022) will help investors to develop a more in-depth understanding of the impact of macroeconomic announcements on Bitcoin's prices compared to those of traditional assets and to build successful strategies in a more mature digital assets ecosystem. Their findings suggest that Bitcoin's high risk is an asset class, and it should be regulated in a way that protects the end investor, who is not necessarily a professional investor, but wants to be part of this new and exciting investment opportunity. Qian et al. (2021) prove that the CRIX can serve as a hedge asset against the world stock market. The high (low) level of EPU has a significantly positive (negative) effect on the optimal hedge ratio of CRIX, which increases significantly during the COVID-19 period.

#### 4. METHODOLOGY

Cryptocurrencies are establishing themselves as an investment asset and are often named the New Gold (Walther et al., 2018). According to Haq et al. (2021), they differ from traditional financial assets due to: (i) a lack of association with higher regulatory authorities or a decentralized nature, (ii) infinitely divisible, (iii) not collateralized (backed by the economy, asset, or firm) but securitized by an algorithm. However, some interesting features of cryptocurrencies are the lower cost of a transaction, direct peer-to-peer or one-to-one transactions, and independence from the involvement of the government of the state. The literature about cryptocurrency and its relationship with capital markets is gaining more research interest. The current study contributes to this context by exploring the connection between these two types of markets and the influence of investors' behavior. A panel data approach is applied, and the explored variables are Crypto Index (CRIX), Sentix Sentiment Index (SSI), German stock market index (DAX), French stock market index (CAC 40), Bulgarian capital market index (SOFIX), Romanian stock market index (BET), Turkish stock market index (BIST 100). The uniqueness of the crypto market is described by Trimborn and Härdle (2018) by applying the CRIX index. The CRIX index is applied because it permits treating cryptocurrencies as a united pool (Imtiaz, 2021).

The explored period in the current research is July 31, 2014, to October 20, 2023. The conclusions of Imran and Shoaib (2021) reveal that during the COVID-19 period, all hedge ratios were found to be higher, implying higher hedging costs during the COVID-19 period compared to the pre-COVID-19 period. Their research offers valuable insights to fund managers, investors, and policymakers regarding diversification opportunities, hedging, optimal asset allocation, and risk management. Based on their results, the explored period is divided into three sub-periods: pre-COVID-19 pandemic, COVID-19 pandemic, and post-pandemic conditions. The aim is to estimate if the relationship is influenced by high levels of uncertainty. It is important to check if cryptocurrencies

may be included in investors' portfolios as instruments for diversification and hedging risk during periods of turmoil (Ganchev & Paskaleva, 2024). We divide the stock market indexes into two groups: developed and emerging markets - according to the market capitalization:

**Table 1.** Explored countries are divided into two panels

Developed markets (DM)	Market capitalization	Emerging markets (EM)	Market capitalization
Germany (DAX)	1.882 505 USD bn	Turkey	374.852 USD bn
France (CAC 40)	3.473.340 USD bn	Romania	58.738 USD bn
		Bulgaria	16 886.84 USD bn

**Source:** Own classification

The data of the explored variables is available from [Royalton-Crix \(n.d.\)](#), [Sentix \(n.d.\)](#), and [Yahoo \(n.d.\)](#). The data is with daily frequency.

The rates of change of the explored data series are calculated as their logged first differences. We apply the Argument Dickey-Fuller test to estimate stationarity. We prove that all variables are stationary in the form  $dlog(x)$  i.e., variables were integrated of order 1.

To reveal the correlation between the explored markets we apply correlation analysis.

$$\hat{\rho}(X, Y) = \frac{\hat{\sigma}(X, Y)}{(\hat{\sigma}(X, X) \hat{\sigma}(Y, Y))^{\frac{1}{2}}} \quad (1)$$

To test the direction of the relationship between capital markets and the crypto market, the Granger Causality Test is applied. We aim to reveal the direction of information transmission before applying regression analysis. Granger Causality test allows us to estimate if one variable can predict the fluctuations of another or to show if the interdependence is bidirectional.

For the aims of the regression analysis, the Ordinary Least Squared Model is applied. It has the following form:

$$\text{Return of CRIX}_t = \alpha + \beta_1 \cdot \text{Return of Stock market indices}_t + \beta_2 \cdot \text{Return of Sentix}_t + \varepsilon_t \quad (2)$$

To conduct calculation the dummy variable takes two values – (0) for the pre-COVID-19 pandemic and post-pandemic periods and (1) for the COVID-19 pandemic period.

## 5. RESULTS AND DISCUSSIONS

[Akhtaruzzaman et al. \(2021\)](#) find lower dynamic conditional correlations between Bitcoin and industry portfolios and bond indexes, allowing investment in Bitcoin to hedge the risk against industry portfolios and bonds. The most effective hedge in a Bitcoin/industry (bond) portfolio is to short-term Utilities sector. Results are robust to the use of US industry portfolios and a cryptocurrency index instead of global industry portfolios and Bitcoin, respectively. Our results can help investors make informed decisions about risk management and portfolio analysis. Most theories claim that correlation is essential if the investor aims to diversify his portfolio. If the diversification strategy is successful, the investing risk will decrease, and we will be sure that it will not doom if the price of a single variable decreases rapidly. The correlation matrix helps us to visualize which assets are appropriate for combining as trading pairs. If the correlation coefficient is strong and positive, it means very risky, and on the other side if the correlation is strong and

negative the investment is meaningless because the decrease in one variable will be compensated with an increase in another. If we choose assets that are law-correlated it is possible to have a profitable and well-managed portfolio. The estimated positive correlation coefficients mean that both markets move in the same direction. However, during a period of high uncertainty, the stock markets of developed economies (France and Germany) and crypto markets are negatively correlated with a coefficient equal to (-0,831765). Based on the results in Table 2 we observe an increasing correlation between the explored markets during the COVID-19 pandemic – a period which is characterized by increasing investors' fear. These results correspond to the understanding that during turmoil investors can consider cryptocurrencies as risky assets because they are not reliable instruments for portfolio diversification. It may be considered that the increased correlation during the COVID-19 pandemic, raises the probability of spillovers of investors' sentiment and proves that both markets are interconnected which proves the results of [Lingling et al. \(2021\)](#). These results confirm the findings of [Chen and Hafner \(2019\)](#) who prove that volatility increases as the sentiment index decreases, which is analogous to the commonly called leverage effect.

**Table 2.** Estimated correlation coefficients between the explored sub-periods.

	Pre-COVID- 19 pandemic period	COVID-19 pandemic	Post pandemic period
Estimated correlation coefficient between developed stock markets and CRIX	0,534151	-0831765      ↑	0,628105      ↓
Estimated correlation coefficient between emerging stock markets and CRIX	0,010348	0,214501      ↑	0,345808      ↓

**Source:** Own calculations

The results from the applied Granger Causality Test are exposed in Table 3. We observe that during the COVID-19 pandemic, the CRIX index influences the returns of the stock market indices of both explored groups of countries. This causality also reveals some evidence that cryptocurrencies can play the role of stock market predictors. We must mention that CRIX Granger caused the indices of developed capital markets during the pre-COVID-19 pandemic and post-pandemic period, so we may conclude that its influence is permanently independent of shocks and turmoil. What is interesting is the fact that during the coronavirus pandemic stock markets of France and Germany are in a casual relationship with the crypto market.

**Table 3.** Granger Causality Test for establishing the relationship between the returns of stock market indices of the explored panels and the CRIX index.

Null hypothesis	F-Statistic	p-value	Decision
<b>Pre-COVID- 19 pandemic period</b>			
DM does not Granger Cause CRIX CRIX does not Granger Cause DM *	0.50712 2.51713	0.8420 0.0052	Do not reject Reject
EM does not Granger Cause CRIX CRIX does not Granger Cause EM	0.58421 0.03915	0.2575 0.5842	Do not reject Do not reject
<b>COVID-19 pandemic</b>			
DM does not Granger Cause CRIX* CRIX does not Granger Cause DM *	3.05215 2.05145	0.0251 0.0158	Reject Reject
EM does not Granger Cause CRIX* CRIX does not Granger Cause EM	2.81862 1.56921	0.0369 0.1528	Reject Do not reject



Post pandemic period			
DM does not Granger Cause CRIX CRIX does not Granger Cause DM *	0.05183 2.48510	0.4815 0.0008	Do not reject Reject
EM does not Granger Cause CRIX CRIX does not Granger Cause EM	1.08482 0.78524	0.7851 0.5942	Do not reject Do not reject

Source: Own calculations

The results of the applied linear regression, estimated by the OLS model are presented in Tables 4 and 5. The Sentix Sentiment Indices shows investors' market expectations. It represents their emotions which corresponds to fear or greed. Negative values of the indices represent a price recovery, whereas the investors' optimism is usually a warning signal of an upcoming price decrease. This is the reason why the expected sign of their influence is negative because Sentix must be interpreted oppositely. We observe that for both developed and emerging markets the influence on the crypto market is negative, this means that decreasing values of Sentix lead to an increase in the prices of the crypto market. For the panel data containing developed markets, the positive sign of the stock market indices not only increases the value of CRIX but also affects the influence of investor expectations in the model. From the results in Table 4, capital markets of developed economies have a positive impact on the crypto market, especially the CRIX index, but their specificity of influence is neutralized by the impact of the investors' expectations. These conclusions support the results of López-Cabarcos et al. (2021) which suggest that Bitcoin investors are more "technological", and therefore pay more attention to the information that comes from media and the investors' sentiment. In periods where stock markets have high volatility, Bitcoin can be used as a safe haven, but when stock markets are stable, Bitcoin becomes attractive to speculative investors.

**Table 4.** Results from OLS Regression for Developed Countries with Dependent Variable-CRIX

Variable	Coefficients	St. Error	T - statistic	p-value
C	3.015820	0.845972	4.281546	0.0001
DM	0.511004	0.241562	2.018752	0.0008
Sentix	-0.281546	0.184625	-2.584102	0.0015
R- squared	0.782564			
Adj.Rsquared:	0.684952			

Source: Own calculations

Table 5 reveals the results from OLS for emerging markets. Stock market indices of Bulgaria, Romania, and Turkey (EM) are not statistically significant. This indicates that this variable does not have a significant impact on the dynamics of the crypto market during the explored period. The fluctuations of CRIX are determined by the investors' expectations.

**Table 5.** Results from OLS Regression for Emerging Countries with Dependent Variable-CRIX

Variable	Coefficients	St. Error	T - statistic	p-value
C	4.158202	0.980515	3.815081	0.0001
EM	0.125812	0.015027	1.815402	0.8152
Sentix	-0.108015	0.184502	-2.805216	0.0005
R- squared	0.512805			
Adj.Rsquared:	0.481542			

Source: Own calculations

Based on the results in Tables 4 and 5, we can conclude that for developed economies, capital markets can predict crypto market dynamics. The Sentix index has a weaker negative impact on CRIX for Bulgaria, Romania, and Turkey compared to the same interaction for developed countries. The difference may be explained by the fact that more capital markets correspond to more optimistic investors who operate on both: capital and crypto markets.

## 6. CONCLUSION

Cryptocurrency is a form of virtual currency that is unregulated and decentralized, developed through cryptographic blockchain technology. It is managed and utilized by members within a specific virtual community. It is crucial to emphasize that cryptocurrencies are not uniform; instead, they distinguish themselves from fiat money, which refers to national currencies with physical forms such as banknotes and coins. Even though they hide many risks for individual investors, so the legislative framework is crucial. Individuals and businesses involved in the digital economy need to manage market risks associated with price fluctuations. The decentralized nature of blockchain networks doesn't make them immune to security threats. Risks include hacking, fraud, and vulnerabilities in smart contracts. Implementing robust cybersecurity measures is essential. Non-compliance with regulatory requirements can lead to legal consequences. Effective risk management involves staying informed about evolving regulations and adapting business practices accordingly. The global nature of the digital economy and crypto assets means that legal and regulatory considerations often extend beyond national borders. International coordination and compliance are crucial. So do, educating stakeholders, including businesses, investors, and users, about the legal aspects of crypto assets is essential. This includes awareness of regulatory requirements, rights and responsibilities, and potential legal risks. All mentioned factors need to be underlain in the legal framework of crypto assets, but unfortunately, most of them are not included in the new EU Regulation 2023/1114 framework. By the applied methodology, it is proved that during turmoil investors can consider cryptocurrencies as unreliable instruments for portfolio diversification. It may be considered that the increased correlation during the COVID-19 pandemic, raises the probability of spillovers of investors' greed and fear and proves that capital and crypto markets are interconnected. We prove that the cryptocurrency market influences the stock market, which may be explained by the fact that the investors in the crypto markets are better informed than those in the traditional financial markets. Investors' sentiment has effects on the crypto markets for developed and emerging economies but their influence is neutralized by the increasing significance of stock markets for developed economies – France and Germany.

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# The Relationship between the Number of Cryptocurrency Acceptance Sites and the Intensity of Tourism in Terms of Legal Regulation

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**Abstract:** *The research delves into the nexus between cryptocurrencies and tourist activity, with a special focus on the facet of legal regulations. The study's objective is to fathom how cryptocurrencies influence the tourism sector, and how legal standards bear on transactions involving cryptocurrencies within the tourism industry.*

*The principal aim is to unravel the interconnection between the employment of cryptocurrencies in tourist services and its concurrent legal governance in four handpicked countries: Spain, France, Croatia, and the Netherlands.*

*Clustering was achieved through SOM and PCA methodologies, which, in unison, proffer profound insights into the data's architecture and interconnectedness. The data was collected through scraping with an API key. The research underscores that blockchain technologies, including but not limited to Ethereum's advancements that extend beyond just Bitcoin, are steadily gaining a more influential role in tourism. Moreover, legal guidelines, especially within the EU, wield significant influence over transactions and operations associated with these digital assets.*

## 1. INTRODUCTION

Since Önder et al. (2017) stated that „most academic communities have been slow in picking up the blockchain and investigating its potential implications”, the topic has grown and it is the focus of tourism research. The tourism industry is a dominant sector in worldwide economic development.

While the technological environment has had a significant impact on both the supply and demand sides of the touristic system, the recent digital revolution has fundamentally transformed the way the tourism sector operates (Rátz, 2023) while the sector's digital transformation is now an ongoing process, enhanced by a set of disruptive innovations that changed the industrial panorama and are starting to be transferred into the tourism sector (Rodrigues et al., 2023, p. 1).

The COVID-19 epidemic generated huge changes in this sector and broke the trends discussed by Nam et al. (2021). According to Önder and Gunter (2022), this period of our history made contactless payments particularly important and that has driven also cashless economies. Not only hygiene but also quick and secure solutions, and sustainability became prior. The possibility to use the internet and electronic devices adds to the improvement of tourism significantly. It ensures that visitors (tourists) can look for and create their trips by themselves (Erceg et al.,

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2020), meanwhile, real-time information makes decisions easier and adds not only to planned, but also to impulse spending of tourists.

Technologies like Blockchain belong also to the newest digital solutions for spending money through their device. Erceg et al. (2020) mentioned “app-capitalism” has a strong effect on financial decisions as well. The cryptocurrency, mostly Bitcoin has triggered a lot of media attention and so put blockchain technology in focus of interest of various industries. As tourism is a dynamically developed industry where modern technological solutions add extremely to competitiveness, the touristic sector started to adopt possibilities ensured by Blockchain technology first.

Thanks to this technology the creation of decentralized currencies (like Bitcoin) can be created and security is ensured by digital contracts, which are called smart contracts. According to the definition by the Court of Justice of the European Union (2015), “Bitcoin is a virtual currency used for payments between private individuals over the Internet and in certain online shops that accept it; users can purchase and sell the currency on the basis of an exchange rate.” In Judgment in Case C-264/14 the Court stated, that “The exchange of traditional currencies for units of the ‘bitcoin’ virtual currency is exempt from VAT”. That decision ensures an important legal background on the tourism market and helps travellers to buy more and higher levels of services. Furthermore, it minimizes the need for a central authority, banks, or other third parties (Valeri & Baggio, 2021), like online travel agents (Önder & Treiblmaier, 2018).

Our research focuses on **France, Spain, the Netherlands, and Croatia**. The delimitation was made on the following basis: France and Spain as classic tourist destinations and Croatia as one of the most dynamically developing countries, are typical tourist destinations. The Netherlands has strong tourism as well but with other characteristics. The Netherlands is rather a sending country where domestic tourism also plays an important role.

## 2. BLOCKCHAIN, THE TECHNOLOGY

Blockchain technology is a decentralized and secure system with data management, made up of a list of transaction bundles called blocks, that is the information and hash collection. These blocks contain every transaction secured before on the chain, a given transaction could supersede every ‘blocks’ substances. Blocks are linked together and they form a secure chain (Erceg et al., 2020; Nakamoto, 2008; Önder et al., 2017; Thees et al., 2020).

*“A world with little or no intermediaries where there is no need to build trust between people and transactions are completed in seconds. This is the promise of Blockchain Technology.”* (Dogru et al., 2018, p. 1)

Blockchain provides not only data integrity but also security, anonymity (Thees et al., 2020), transparency, trust, privacy (Erceg et al., 2020), and collaboration among stakeholders (Balasubramanian et al., 2022) but it is decentralized and can be used without the control of a third-party organization or government.

The tourism industry has seen a slow but growing influence of blockchain technology since 2008 (Nam et al., 2021). From a tourist point of view, it enhances the tourism experience, rewards sustainable behaviour, ensures benefits for local communities and reduces privacy concerns (Tyan et al., 2020), builds trust among parties, and helps to solve problems firsthand.

### 3. SMART TECHNOLOGY, SMART CONTRACT AND SMART CITIES – SUSTAINABILITY IN TOURISM

*“Bringing smartness into tourism destinations requires dynamically interconnecting stakeholders through a technological platform on which information relating to tourism activities could be exchanged instantly.” (Buhalis & Amaranggana, 2015, p. 378).*

Blockchain as a distributed database can guarantee the reliability and validity of information. Erol et al. (2022) noted that *“this is highly critical in building sustainability in tourism”*. WTO also stated that the installation of environmentally efficient new technology can ensure sustainability goals (UNWTO, 2005). It has three generations (BTCWires, 2019; Nam et al., 2021). The newest, third generation of technology made smart contracts enabled through applications.

Touristic experience requires digital opportunities. The use of information and communication technologies (ICTs) is unavoidable.

Real-time information is crucial in the decision-making of tourists. Koo et al. (2019) stated that new realities in tourism are caused by ICTs over destinations, travellers, and businesses. Smart tourism destinations are able to offer authentic travel experiences thanks to real-time information about all tourism services, like tracking tourists, managing lost luggage, providing fast check-in procedures, and facilitating travel insurance so it can enhance the tourism experience (Dogru et al., 2018; Tyan et al., 2020).

### 4. IMPORTANCE OF BLOCKCHAIN TECHNOLOGY FOR THE EUROPEAN UNION

One of its pillars is the European Blockchain Partnership (EBP), launched before the COVID-19 pandemic.

*“The EU wants to be a leader in blockchain technology, becoming an innovator in blockchain and a home to significant platforms, applications and companies.” (European Commission, 2023).* EBP’s main focus has been building the European Blockchain Services Infrastructure (EBSI). According to the website of EBSI at the beginning of 2021, 21 projects from 18 European countries participated in the first pilot programme (European Commission - EBSI, 2021). EBSI is a peer-to-peer network of interconnected nodes running a blockchain-based services infrastructure. Until October 4, 2021 (the latest update on the official EBP site), there are 30 members of the program (European Commission, 2022). The Netherlands, France and Spain signed the Declaration of EBP on the Digital Day in 2018. Croatia joined the partnership in 2019 according to the European Commission (2021).

### 5. TOURISM IN THE SURVEYED COUNTRIES

Thanks to Regulation (EU) No 692/2011 of the European Parliament and the Council of the European Union (Official Journal of the European Union, 2011) and the Council Directive 95/57/2011 (EUR-lex, 2011), it is required in the EU that the Member States provide a regular set of comparable tourism statistics. According to these data, the tourism sector is a dynamically growing sector in terms of nights spent in tourist accommodation (Eurostat, 2023). The data show that the number of nights spent in tourist accommodation increased between 2017 and 2019 in the countries surveyed, except in Spain, where there was a slight decrease. According

to the [Eurostat \(2022\)](#) statistics, for international tourists, Spain was the top destination in 2021 with 114 million nights spent in tourist accommodation establishments, which is 19.5 % of the EU total. Half of the nights spent in Spain were concentrated in five NUTS 3 regions: Mallorca, Tenerife, Gran Canaria, Barcelona, and Malaga.

Croatia (63 million nights) was the third most popular tourist destination, and France was the fifth with 57 million nights. Despite the above-mentioned percentages the highest international travel receipts in 2021 were recorded in France (€34.5 billion) followed by Spain (€29.2 billion).

From this point of view (nights spent by domestic and international guests at tourism accommodation establishments per inhabitant), tourism in the Netherlands is also intensive and it is above the average of the EU ([Eurostat, 2022](#)). Tourism in the Netherlands has been decreasing since 2019 ([Eurostat, 2022](#)). The Netherlands has ambitious objectives for sustainable development and digital transformation. The agenda, Perspective Destination Netherlands 2030, states that travellers use more and more digital resources and platforms for inspiration and information, so they can more easily and faster book a trip. Digital solutions ensure transparency when it comes to prices and products, while big data offers new insights into tourism planning ([UNWTO, 2023a](#)).

Spain declared also that one of the most important initiatives of its tourism development is the preservation of cultural and natural values. The country has the Sustainable Tourism Strategy 2030, for the challenges of the sector in the medium and long term, pushing the three pillars of sustainability: socio-economic, environmental, and territorial ([UNWTO, 2023b](#)).

Croatia also has The Sustainable Tourism Development Strategy until 2030 and is in the process of developing a new Tourism Law, which will be in line with the Sustainable Development Strategy ([UNWTO, 2023c](#)).

## 6. REGULATORY BACKGROUND OF CRYPTOCURRENCIES IN TOURISM ACTIVITY IN THE SURVEYED COUNTRIES

The Regulation of the European Parliament and of the Council on Markets in Crypto-assets, and amending Directive (EU) 2019/1937 (further defined as MiCA) defines a crypto asset as any digital representation of rights or values that can be transferred and stored electronically using distributed ledger technology (DLT) or similar technology. The MiCA distinguishes between three types of crypto assets:

1. **asset-based tokens:** designed to maintain stable value by referencing the value of multiple fiat currencies that are legal tender, or one or more commodities, or one or more crypto-assets, or a combination of these assets;
2. **electronic money token:** the main purpose of which is to be used as a medium of exchange and to maintain a stable value by referencing the value of a fiat currency that is legal tender;
3. **user token:** provides digital access to a good or service available on a DLT and is accepted only by the issuer of the token in question. NFTs are excluded from MiCA's scope.

The digital opportunities offered by blockchain technology and smart contracts affect public administrations and bring with them the need for regulation. It comes from the fact that major economies have been contentious about blockchain technology and regulation, specifically cryptocurrencies ([Kwok & Koh, 2019](#)).

**France** enacted a new genre of regulation, the PACTE-law (Law n° 2019-486 - Plan d'Action pour la Croissance et la Transformation des Entreprises). Furtherly France decided to provide an optional visa for initial coin offerings (“ICO”) and a mix of mandatory registration for some intermediaries coupled with a voluntary licence for all intermediaries. This optional regime (or so it seems) is a new type of regulation: neither soft law, nor a default rule, nor totally hard law. Most provisions require an opt-in but once the option is exercised, there are constraining rules that will apply.

**The Netherlands** has an innovation-friendly approach under a liberal, yet cautious relationship between regulatory, supervisory and governmental entities and market players. The Netherlands has a three-headed regulatory power: the Authority of Financial Markets (AFM), the Dutch Authority for Consumers and Markets (ACM) and The Dutch Central Bank (DNB), which together regulate the financial sector and markets (DNB, n.d.).

AFM and DNB have adopted a taxonomy that distinguishes between three overlapping categories of cryptocurrencies: transaction crypto(s); utility crypto(s); and investment crypto(s). These categories are highly interconnected, as these “cryptos” could have multiple functions simultaneously, and their function may change over time. The Dutch regulatory approach to the possibility of creating regulatory arbitrage through blockchain experiments, by attracting projects and competing with others, needs to be seen in terms of the country’s competitiveness in a European - but global - financial and economic context.

**In Spain**, cryptocurrency is largely unregulated because cryptocurrencies are not financial instruments under Spanish law, except that they cannot be treated as legal tender, which is exclusively reserved for the euro as the national currency. However, some main regulations are regarding the issue of cryptocurrencies. The Fifth Money Laundering Directive (5MLD) was transposed into Spanish Law through the Royal Decree-Law 7/2021. Also, Law No 10/2010 on the Prevention of Money Laundering and Terrorist Financing mandates that virtual currency exchangers and e-wallet providers are included among the entities required to comply with its regulations. The Spanish National Securities Market Commission’s (CNMV) proposal provides a normative definition of crypto assets, stating that a crypto asset is a “*digital representation of an asset or right that can be electronically transferred or stored by using distributing ledger technologies or other similar ones*”.

Regardless of their nationality, if services relating to “Virtual Currency Exchange for Fiat Currency” or “Services for the Custody of Electronic Wallets” are offered or provided in the Spanish territory, these individuals or entities will have to be registered with the Registry of the Spanish Central Bank (“SCB”) created for these purposes.

**In Croatia**, virtual currencies are defined as “*a digital representation of value that is not issued or guaranteed by a central bank or a public authority, is not necessarily attached to a legally established currency, and does not possess a legal status of currency or money, but is accepted by natural or legal persons as a means of exchange and which can be transferred, stored and traded electronically.*”

Since “virtual currency” is a synonym for “cryptocurrency”, the Croatian government has implicitly provided cryptocurrencies with a legal definition.

The fact that the Croatian government does not explicitly regulate cryptocurrency raises two considerations. First, Croatian authorities do not issue licences to cryptocurrency firms. Cryptocurrency

investors must be aware that cryptocurrency trading is considered a simple “financial transaction” in Croatia. It is unclear just how big the crypto market is in Croatia, but the Blockchain and Cryptocurrency Association counts a few hundred people as members. Ascertainable, there are 18 crypto companies registered with the Croatian authorities. One of those companies is Electrocoin, an exchange that reported €72 million in revenue last year.

## 7. RESEARCH RESULTS

In order to conduct an in-depth investigation and establish stronger correlations in which aggregated data do not distort the relationships, the authors determined the level of each of our regional statistical studies at the NUTS 3 level. In this research, tourism intensity is interpreted based on the number of nights spent in tourist accommodations according to NUTS 3, for which data was provided by Eurostat (2023). Consequently, a total of 221 NUTS 3 regions across four countries were included in the analyses.

The number of cryptocurrency acceptance locations was collected through scraping methodology using an API key. This was based on the CoinMap database, accessed through their official API key. The data collection occurred in September 2023, using Python code within the Jupyter framework. This process gathered information about the names, categories, dates, countries, states, localities, and geocodes of the cryptocurrency acceptance locations. To obtain accurate location data, an instance of Geolocator was implemented in the code. Additionally, it checked the validity of coordinates using Geolocator and handled incorrect coordinates.

A total of 20,012 data points were collected for the selected four countries. The NUTS 3 divisions were deduced from the settlement level using Eurostat’s LAU list, allowing both tourism and cryptocurrency-related data to be interpreted at the same level – the NUTS 3 level.

In examining the relationship between cryptocurrencies and tourism, this paper found it worthwhile to begin by conducting a relevance test. Specifically, the authors sought to answer the question: *Q1 - are cryptocurrencies primarily used for tourism services in the four selected countries, and if so, to what extent?*

*The following hypotheses were put forward in the study:*

*H1: they are primarily used in the tourism sector.*

*H2: the number of nights spent at tourist accommodations correlates with the number of cryptocurrency acceptance locations in the examined regions.*

For the four selected countries, establishing a clustering neural network was justified to explore whether there are specific patterns in the grouping of categories at the settlement level. The clustering neural network analysis method, through SOM (Self-Organizing Maps) and PCA (Principal Component Analysis), is suitable for examining the research question - whether there are groupings of categories at the settlement level.

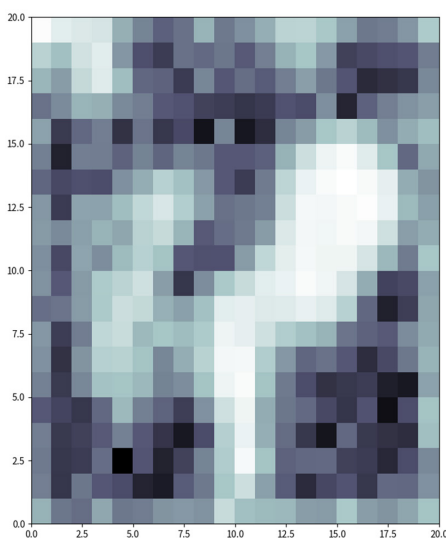
In this context, SOM and PCA serve as complementary methods in data analysis, particularly in this case, where the data is provided by a big data file. The authors found both methods justified because SOM allows for the clustering of data in a lower-dimensional space, aiding in the



visual identification of patterns and groupings while preserving the topological properties of the data. This is reinforced by the linear transformation technique of PCA, which repositions the data in a new coordinate system where the variables (principal components) are independent. This enables dimensionality reduction without significant loss of information. In the PCA process, data is transformed to maximise variance, so the first principal component represents the greatest variance, the second the second greatest, and so on. This helps identify the most significant patterns and trends in the data. For the neural network analysis, data was normalised, upon which the SOM was trained. During the training process, typographical errors were collected to examine how the error changes over iterations.

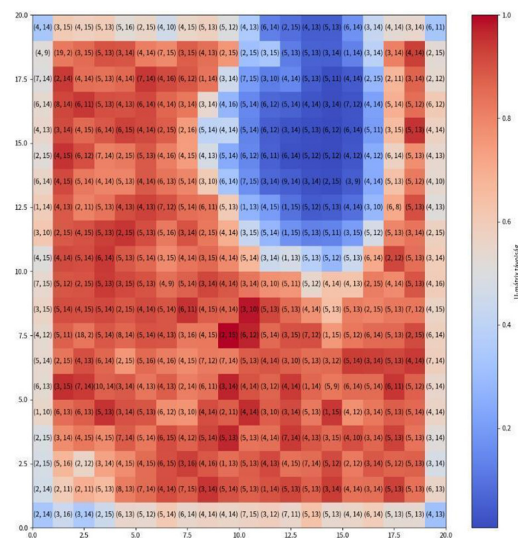
The Self-Organizing Map (SOM) was trained on the normalised data over 1000 iterations. The following Figure 1 illustrates the SOM map, where distances between different cells are represented by colour intensity (darker areas indicate greater distances). To interpret this, the authors also created a U-matrix that represents the distances between neurons of the SOM, as shown in figure 2, to which the authors added the centroids of the clusters. These two maps help identify different clusters and their distances from each other. Identifying clusters aids in understanding the data structure and the relationships between different categories.

During the categorization process, the neural network model divided data into 120 distinguishable categories. As evident from the data, the trio of nightlife, food, and lodging – categories directly related to tourism – collectively have the most significant influence in the clusters. This influence is not distorted by the shopping category, as both locals and tourists utilize the opportunities it presents. This is reinforced by the fact that typical local services – like groceries and sports, and the categories with negligible presence, such as ATMs and local services – greatly underperform in weight compared to the other categories. Reflecting on the Q1 research question, the authors can conclude that, based on the examined data and the methods used in the study, cryptocurrencies are utilized in tourism in the examined regions with considerable intensity.



**Figure 1. The SOM Map**

Source: Own research



**Figure 2. The U-Matrix**

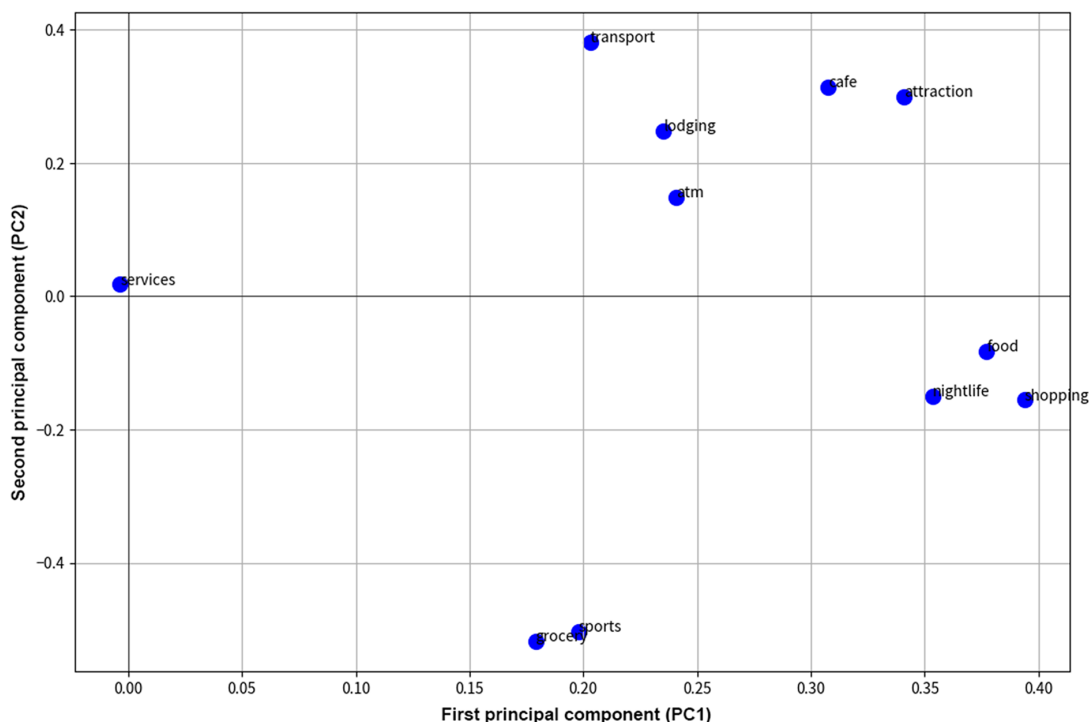
Source: Own research

During the SOM clustering, input data (settlements and categories) were organised on a two-dimensional map, creating a data table with X and Y coordinates, where similar data points are located close to each other. Different parts of the map represent clusters, which denote groups of

data. The most prominent groupings in terms of categories are as follows: Nightlife: 44 clusters; Shopping: 38 clusters; Food: 34 clusters; Lodging: 31 clusters; Transport: 5 clusters; Sports: 1 cluster; Grocery: 1 cluster.

The notation “Nightlife: 44 clusters” signifies that the “Nightlife” category is the dominant category in 44 distinct clusters. A deeper examination of the data reveals that, according to the methods used in this study, cryptocurrencies are predominantly used in tourism in the examined regions, thereby validating the hypothesis (H1).

To gain a better understanding of the clustering neural network, Principal Component Analysis (PCA) was employed, which involves creating linear combinations of the original variables. In our analysis, the first few principal components account for a significant portion of the data’s variance. As we increase the number of principal components, the cumulative variance also increases, albeit at a diminishing rate. The first principal component alone explains a substantial part of the data’s variance. However, as we increase the number of principal components, the increase in cumulative variance decreases, indicating that each additional principal component contributes less to the total variance.



**Figure 3.** Loadings of the Categories in the First Two Principal Components

**Source:** Own research

Figure 3 illustrates the loadings of categories in the first two principal components. Categories located close to each other on the figure, such as “nightlife” and “cafe,” show similar patterns across settlements, suggesting that places with vibrant nightlife likely also have numerous cafes. This observation indicates regions where cryptocurrencies are more widely accepted in tourism. Categories situated further from the origin demonstrate greater loadings in a particular principal component. For instance, the “shopping” category shows a substantial loading in the first principal component (PC1), indicating that shopping is a critical factor across settlements. This has implications for the tourism sector, suggesting that shopping opportunities with cryptocurrency play

a significant role in tourists' choice of cities. Categories near the origin exhibit lower loadings in both principal components, implying they contribute less to the explanation of variance in the data, such as sports or groceries. The wide distribution of categories on the figure indicates that settlements offer unique experiences in different categories. For the tourism sector, this means cities should diversify their offerings to attract various types of tourists.

Based on PCA results, the tourism sector might benefit from diversifying offerings and leveraging connections between categories. For example, in a city where nightlife is popular, investing in cafes and restaurants could be advantageous. Similarly, enhancing shopping opportunities can be crucial, as they significantly influence tourists' city choices. Cities should also identify unique or outstanding categories to use in their tourism marketing.

*This analysis not only strengthens the answer to our research question but also confirms that, according to the examined data and methods, cryptocurrencies are intensely used in tourism in the studied regions.* To demonstrate the correlation between cryptocurrency acceptance locations and tourism intensity, and to examine our hypothesis *H2 – that the number of nights spent at tourist accommodations correlates with the number of cryptocurrency acceptance locations in the regions* – correlation analyses were conducted. The authors interpreted the data at the NUTS 3 level, considering the number of guest nights spent at tourist accommodations as the dependent variable (Y) and the number of cryptocurrency acceptance locations in the NUTS 3 region as the independent variable (X).

The consolidated data analysis yielded the following results: The correlation coefficient value of 0.458693 indicates a moderately strong positive relationship between the number of nights spent at tourist accommodations and the number of cryptocurrency acceptance locations within a country's NUTS 3 regions. It can be concluded that as the number of cryptocurrency acceptance locations in a region increases, the number of guest nights generally increases as well.

The 95% confidence interval indicates the level of certainty we have in the value of the correlation coefficient. In this case, the authors can say with 95% confidence that the true correlation coefficient value lies between 0.332622 and 0.568658. This means that even under the most pessimistic estimate, there is a positive correlation between the two variables.

The p-value "<.0001" suggests that it is highly unlikely that the observed correlation coefficient occurred by chance. This implies a probable genuine relationship between the two variables, and not merely due to random fluctuations in our sample.

The positive covariance value indicates that as one variable increases, so does the other, consistent with the positive correlation value.

Based on these results, the authors can say that the number of nights spent at tourist accommodations is positively correlated with the number of cryptocurrency acceptance locations in the country's NUTS 3 regions. As the number of cryptocurrency acceptance locations in a region increases, the number of guest nights typically increases as well.

With these findings, the authors consider our hypothesis *H2 to be validated, confirming that the number of nights spent at tourist accommodations correlates with the number of cryptocurrency acceptance locations in the examined regions.*

## 8. CONCLUSION

In our research, the authors conducted a detailed analysis of the current status and potential impacts of cryptocurrency applications in the tourism industry across four examined countries. Our study paid special attention to key aspects highlighted in the literature, such as the application of digital payment tools in tourism and the economic impacts of tourism.

During our literature review, the authors tracked the global trends in cryptocurrency applications in tourism. Digital payment tools like cryptocurrencies are increasingly gaining traction in the tourism sector, as supported by several studies. The application of cryptocurrencies in tourism not only diversifies payment methods but also offers new opportunities for the hospitality industry, such as reducing transaction costs and speeding up payment processes.

Our research concluded that there is a moderate positive correlation between the number of cryptocurrency acceptance points and the intensity of tourism in the four countries studied. Through the use of Self-Organizing Maps (SOM) and Principal Component Analysis (PCA) methods, the authors determined that cryptocurrencies in tourism primarily appear in accommodations, nightlife, and shopping centres. This correlation is particularly pronounced in Spain, France, the Netherlands, and Croatia.

The application of cryptocurrencies in tourism signifies not just a diversification of payment methods but also opens new opportunities in the tourism sector, such as faster and simpler service for guests and promoting sustainable tourism. Additionally, cryptocurrencies allow for transactions without intermediaries, reducing costs and increasing transaction security.

According to our research, the increase in the use of cryptocurrencies correlates with an increase in the number of nights spent at tourist accommodations, indicating that this payment method is becoming increasingly accepted in the tourism sector. This trend could be particularly important for the digitalization and sustainable development of tourism, especially in the countries the authors studied, where tourism is a significant economic factor.

In conclusion, the growing acceptance of cryptocurrencies in tourism opens up new opportunities for the sector, particularly in terms of digitalization and sustainability. Our research highlights that the use of cryptocurrencies in tourism not only emerges as a new payment tool but also contributes to the transformation of the tourism sector.

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# Wine Tourism: A New Emerging Segment in Albania

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**Abstract:** *In the last four decades, tourism has received greater attention from researchers in several sciences. Wine regions can attract tourists who, in their turn, will be a source of revenue for the wine producers in that region. Though considered to be a niche segment, the interest in wine tourism research has grown because the wine sector is not just about producing a beverage; it's a multifaceted industry with significant economic, cultural, and social importance both in wine-producing regions and on a global scale. It contributes to job creation, international trade, tourism, and the preservation of cultural heritage, making it a vital sector for many countries around the world.*

*Overall, wine tourism has the potential to be a catalyst for regional development by attracting visitors, creating jobs, spurring investments, and supporting local businesses. As a result, many regions around the world actively promote and invest in wine tourism as a means of enhancing their economic and cultural vitality.*

*Albania is new to the wine sector, so this paper aims to provide some useful insights related to the possibilities that wine tasting, wine tours, or wine-related events present to local businesses and for the creation of destination image.*

## 1. INTRODUCTION

Wine tourism represents a major segment of culture tourism, and it is widely believed to be an effective driver of local development. Today's tourists are looking for forms of tourism that bring unique experiences and they are paying tourism operators to help them find the best experience within a limited period. The typical tourist of the twenty-first century seeks emotional stimulus and would fundamentally like to purchase feelings and not products (Opaschowski, 2001). These alternative tourist activities, which include sports, wine, culture, painting, adventure, opera, etc., can be categorised as special-interest tourism (Mckercher & Chan, 2005; Trauer, 2006).

There is a symbiotic relationship between wine and tourism. People travel to the so-called tourist destinations to visit some attractions. As attractions provide activities and experiences, they constitute a reason for visiting a specific destination. Many wine-producing regions are trying to become new tourist destinations. For the tourism industry, wine is an important component of the appeal of a particular destination, and it can even be the major motivation for visitors (Hall et al., 2009).

Thus, wine tourism has the potential to provide wine regions with a competitive advantage, and to generate profitable business for wineries, wine-related products and various services. It is therefore necessary for wine tourism to develop a customer-oriented commercial strategy, with the participation of all stakeholders such as wine firms and institutions, cultural institutions, and social entities, as well as the residents who earn a living, directly or indirectly, from the wine industry.

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The very nature of wine tourism principally involves the indulging of the senses in the wine product itself and its immediate aesthetic surroundings, and therefore an experiential view of the consumption of wine tourism seems justified (Dodd & Gustafson, 1997). The consumption of wine tourism occurs in the rural countryside where agriculture is normally practised, including vineyards, landscapes, tasting rooms, tourist facilities, etc., in other words, the ‘winescape’ (Johnson & Bruwer, 2007a).

Wine production and consumption have a long history in Albania, deeply rooted in its cultural heritage starting with the Illyrians and beyond. Albania has favourable climatic conditions and a rich tradition of wine production, as such it has the opportunity to position itself as an important element in the wine industry, not only in the Balkans and Europe but also beyond.

Despite these obvious advantages, the Albanian wine market remains relatively undeveloped and unexplored. The main objective of this paper is to contribute to the emerging wine tourism research and investigate the potential of wine tasting as a new market in Albania. Is it a growing market? Is it an industry that offers opportunities? What does it require to develop further and what does it offer to those who want to become part of this industry?

Answering these questions will provide valuable knowledge to entrepreneurs, investors, policymakers and other actors interested in taking advantage of the opportunities offered by wine tasting in Albania. Moreover, this paper will be a good motivation and a new window in increasing awareness of the heritage of wine production in Albania, and why not also give its help in the general image and branding of the country in the world community of wines.

## 2. LITERATURE REVIEW

Wine tourism has the potential to provide wine regions with a competitive advantage, and to generate profitable business for wineries, other products related to wine, and various services. It has been proved that the wine tourism industry is known as a recognized cluster within the regional development context. It is directly related to attracting new investments as well as increasing economic development investments due to the current number of wineries and cellar doors and the increasing number of new ones (Sanders, 2004). Wine tourism plays an important role in the economic development of the rural zones that are wine producers, given that it positively affects the generation of employment, the growth of business, and corporate investments (King & Morris, 1997)

Getz (2000) argues that wine tourism is a “form of consumer behaviour, a strategy by which destinations are developing and selling the image of wine-growing region and also a marketing opportunity for producers to sell products directly to the consumer”. Wine tourism consists of an activity directly related to wine which provides a dynamic and versatile experience that integrates wine culture and heritage to create emotions, sensations, attachment and sensory impressions throughout the visit, allowing the wine tourist to become an advocate of that particular cellar, brand or wine region (Santos et al., 2019, p. 683). Winemakers manipulate particular geological, hydrological, and climatic characteristics and related microclimatic effects that significantly influence the quality of the grapes highlight wine characteristics and produce a fermented masterpiece.

The wine industry has experienced significant globalization, with the emergence of new wine markets, including China, India and other parts of Asia, contributing to the increase in wine consumption worldwide.

The world vineyard surface area is estimated to be 7.3 mha in 2022, only -0.4% marginally lower compared to 2021. World wine consumption and exports have suffered severely in 2022 due to the war in Ukraine and the associated energy crisis, and together with the global supply chain disruptions, have led to a spike in costs in production and distribution, increasing the average price by +15% compared to 2021 and a global wine exports value estimated at 37.6 bn EUR, even though the global wine exports amount to 107 mhl, 5% lower compared to 2021 and a world wine consumption, estimated at 232 mhl, with a decrease of 2 mhl compared to 2021 (OIV, 2023).

Wine regions can attract tourists who, in their turn, will be a source of revenue for the wine producers in that region. Wine is becoming an enticing element for tourism, given that it increases the tourist flow to production areas, creates an image of a quality tourist destination, and serves to develop a production area (Szivas, 1999). Certainly, new employment opportunities can be created in the tourism and wine industry (Hall et al., 2009).

Wine tourism offers a multi-faceted experience that combines cultural, historical, and gastronomic elements with the enjoyment of high-quality wines. It has become increasingly popular as people seek immersive and educational experiences related to food and beverages. In addition to wine tastings, wine tourism typically includes visits to various establishments related to winemaking including visits to wine museums, cellar tours, harvest events, wine festivals, etc. As Madeira et al. (2019) argued, the wine tourism experience typically consists of the simultaneous modelling interplay of wine, staff, cellar door, entertainment, education and aesthetics.

The “new” tourist is more experienced and therefore more demanding, expects to receive additional value, strives for individuality, is more flexible at short notice, is economically independent and is more price sensitive (Pikkemaat et al., 2009). The wineries’ visitors are rarely interested simply in wine tasting but seek a total tourism experience (Getz et al., 2008). This includes activities closely related to tourism, like exploring the rural landscape and natural environment, local hospitality and gastronomy, communicating with local people, participating in cultural traditional festivals and with wine like meeting the winemakers and learning about wine (Alant & Bruwer, 2004; Mitchell et al., 2009). According to Quadri-Felitti and Fiore (2012), wine tourists seek other kinds of wine-related activities such as dining, shopping, and recreational and cultural outlets, and these components should be additional parts of the wine tourism supply chain.

Wine tourism experiences are the reason *why* for wine tourism and wine destination selections. Wine experiences and winescapes also contribute to the image, appeal, and attractiveness of wine destinations (Bruwer et al., 2016). Wine tourism experience plays a crucial role in wine companies achieving a set of strategic and competitive advantages and opportunities for continuous growth, development and consolidation of wine tourism vacations and wine trips that occur, especially in wine tourism products and destinations (Duarte Alonso et al., 2014; Santos et al., 2021).

In marketing wine tourism, it is the specific experiential benefits that must be stressed, and carefully targeted. Bruwer (2003) identified ten specific visitor motivations for visiting a wine route and among the primary reasons are wine purchasing, wine tasting/sampling, country setting/vineyards and winery tour.

Wineries are the core attraction (Getz, 2000), but cannot stand alone (Getz & Brown, 2006). Pikkemaat et al. (2009) suggest that the initial interest (wine) is not on top of the experience

driving factors. Instead, the aesthetic components, such as landscape and information about wine are success factors of high relevance in staging experiences. These results underline the existing potential to create experiences in wine tourism by creating an ideal atmosphere, guiding tourists and theming wine and wine production. **Croce and Perri (2010)** advocate a sustainable and profitable relationship among wineries, local suppliers and the local community. Factors such as the friendliness of winery staff, service provision, courteousness, knowledge, professional attitudes and believability are considered important by tourists (**Hashimoto & Telfer, 2003**) because the service provided by the winery was found to be the most enjoyable aspect of a visit to a winery (**Hall & Mitchell, 2002**).

Even though wine tourism is an emerging field of research in the tourism literature, most of the studies have captured the wineries' perspective (**Mitchell et al., 2009; Tassiopoulos et al., 2004**) or have occurred at the cellar door, neglecting the potential consumer at home (**Getz & Brown, 2006**) so there is no definitive profile of wine tourist. Winery visitors are much more highly educated and have higher household incomes (**Dodd, 1995**) so it can be expected that high-yield wine tourists will not be on cheap package deals (**Dodd & Bigotte, 1997**). **Mitchell and Hall (2001a, p. 69)** state "most authors suggest that winery visitors are typically middle-aged, highly educated, professional or managerial, with above average income". Whereas **Charters and Ali-Knight (2002)** identified four segments of wine tourists: the Wine Lover, (the 'highly interested'), the Wine Interested (those who self-classify as 'interested'), and Wine Novice (those with limited interest) and the 'Hanger On', (who goes to the winery with no apparent interest in wine, but as part of a group which has decided to visit).

### 3. METHODOLOGY

The main objective of this paper is to contribute to the emerging wine tourism research and investigate the potential of wine tasting as a new market in Albania. This paper adopts secondary research as a research method. Data were collected through reports, bulletins, and an extensive literature review available on Google, Google Scholar and the websites of institutions, organizations and other entities engaged somehow in the wine tourism industry.

### 4. ANALYSIS OF RESULTS

Related to the times of winemaking, Albania belongs to the old world of wine-producing countries and has one of the oldest wine-making traditions which dates back at least 3000 years ago to the Bronze Age Illyrians. Its geographical position enables a favourable climate and the fertile soil of the mountainous areas of the country is well suited to viticulture.

Albania has a long tradition of wine production dating back to ancient times. The first wine made by the Illyrians was made from honey and it was strong but very sweet (Aristotle 832 a,22 as cited in Shpuza, 2007). The Illyrians, an ancient civilization in the region, were known for growing grapes and making wine. The Illyrians' knowledge of winemaking techniques and the use of clay vessels/amphoras influenced early winemaking practices in the region.

The Turkish invasion and the expansion of the Ottoman Empire caused the wine evolution process to slow down a bit. The Muslim faith did not favour the use of the drink, therefore in all the countries conquered by the Ottoman occupation, this drink was prohibited, and heavy taxes were imposed on its producers, pushing many farmers to stop making wine.



During the communist regime, some wineries were built, but most of their production was aimed at export. Nowadays, large quantities of wine are produced by a few wineries, which have had traditions and have used the arsenal and technology of the past, such as the “Skenderbeu” Winery in Durrës, the “Rilindja” Winery in Korce, Winery “Luani” in Berat, the Librazhdi canteen, the Gjirokastra canteen and some smaller ones. A large part of the amount of wine is made in newly created private wineries in different cities of Albania. Besides the investments in facilities and wineries, they are investing in human capital. By attending adequate education in Western Europe universities they bring a new breeze and approach to the wine industry. They have brought the Western experience and adopted it in the Albanian context. Some of them have opened a restaurant on their farms and offer the customer fresh vegetables, meat and wine from their wineries. Also, the customers can visit the winery or ask for a tour (available upon previous request).

The most important regions for wine production are Berat, Elbasan, Vlora, Fieri, Lezha, Durrës, and Kavaja. The areas with the best reputation for quality wines are Berati, Përmeti and Lezha. Berat is the most important region for wine production in Albania where most wineries are located. Lezha is an area with several wineries, and it is closely related to the “Kallmet” grape variety, the main area to produce which is located in this region and is highly valued by Albanian consumers. Albanian territory can be divided into six wine-production regions: Zadrima, Sukthi, Narta, Myzeqeja, Korça and Përmeti. The main varieties of Albanian autochthonous grapes for red wine are Shesh i Zi, Kallmet, Vlosh, Serinë, Debina e Zeze, while among the white wines we rank Shesh i Bardhë, Debina e Bardhë, Pulës, Therepelë, etc., appreciated for their fruity aroma and flowers.

Most wine tourists are surprised by the flavours, nuances, and quality of the wine they encounter in local wineries. The history of winemaking in Albania dates back thousands of years, with a rich history and a recent resurgence in quality and production.

During the communist regime, Albania was closed to foreigners, but in 1990, after the fall of the regime, the country was looking for foreign investors and tourists. The number of tourists grew slowly, until 2018-2019, the years marked by steady growth. In 2021 the country experienced an increase in incoming tourism, followed by a boom in 2023. According to the [Albanian Ministry of Tourism \(2023c\)](#), 9,53 million foreign tourists visited Albania until November 2023. Compared to the period January-November 2022 there is an increase of 33%.

According to the latest report published by the Albanian Ministry of Tourism, the number of tourists entering Albania in the period January - October 2023 was 8,986,199, approximately 2,200,000 more than the same period in 2022. 99% of foreign visitors who have entered Albania have stated that their purpose of travel is for vacations, visiting relatives and health reasons ([Ministry of Tourism, 2023b](#)).

Regarding the average daily expenditure for the first 6 months of 2023 for non-resident foreign nationals visiting Albania for business purposes, the average daily expenditure is 121.5 Euros, which is 20 Euros more compared to the same category a year ago. While foreign citizens who stayed in Albania for personal reasons spent a daily average of 68 euros per day. The increase is 3 Euro per day more than the daily average spent for personal reasons, in the same period of the previous year ([Ministry of Tourism, 2023a](#)). The net income from travel/tourism in these first 6 months has increased compared to the previous year. Net income has increased 82% compared to 2022 ([Ministry of Tourism, 2023a](#)).

Regarding the average length of stay for non-residents, the figures show that foreign visitors coming for personal purposes during the first six-month period of 2023 have an average of 5.5 nights of stay. While the non-residents who declared the purpose of their visit to Albania for business reasons had an average of 4.5 nights. Overnight stays for personal reasons are the same as the previous year, while overnight stays for business reasons have decreased by 0.5 nights compared to the average overnight stays of the same period a year ago (Ministry of Tourism, 2023a).

All these statistics suggest that there are a lot of opportunities for different businesses in Albania, especially those involved in accommodation and gastronomy. Following the global trends, inbound travel agencies, are offering wine tours as part of other travel activities or as the main activity.

Telfer (2001) examines the Niagara wine route by qualitative in-depth interviews conducted at 25 local wineries. The author finds that strategic collaborations between wineries, food industries and tour operators located in the region as well as aggressive marketing policies were crucial for additional on-site wine and related merchandise sales. A successful wine route exerts a twofold effect on farms: on the one hand, existing activities become more profitable simply because the area and its products get more appealing to consumers (*localization effect*); on the other hand, it opens up new opportunities for their business (*synergy effect*) (Brunori & Rossi, 2000 as cited in Brandano et al., 2020). Following this rationale, the Albanian Government in collaboration with international organizations has invested in creating and improving the wine tourism infrastructure by initiating, implementing and founding projects, supporting agricultural farms, organizing contests and awarding best practices/wines/approaches.

The Regional Development Agency (RDA2) with the support of the Ministry of Tourism has created the agrotourism project “Wine and Olive Road”. The purpose of this project is to highlight quality wineries producing extra virgin olive oil and wine, and to promote them as destinations for tourists to visit. Many of the wineries and farms included in this project are already part of these tours, sometimes separate and individual and sometimes organized by tourist agencies (Agjensia për Zhvillimin Rajonal 2 & Ministria e Turizmit dhe Mjedisit, 2023).

In the Western Balkans, Albania occupies the fourth place related to the vineyard surface area, but as can be seen in Table 2, there is a slight decrease in Albania’s vineyard surface area, along with Romania, Croatia and Bosna and Herzegovina. As OIV (2023) reports the world vineyard surface area is only -0.4% marginally lower compared to 2021. Also in 2022, there is a slight decrease of 1% in world wine production compared to 2021 which is estimated at 258 mhl.

**Table 1.** Vineyard surface area in the Balkans

Year	2021		2022	
Country	world ranking	vineyard surface area	world ranking	vineyard surface area
Croatia	37 <sup>th</sup>	22804	30 <sup>th</sup>	22142
Serbia	39 <sup>th</sup>	20113	31 <sup>st</sup>	20113
North Macedonia	36 <sup>th</sup>	25559	N/A	N/A
Albania	53 <sup>rd</sup>	11339	37 <sup>th</sup>	11322
Bosna and Herzegovina	62 <sup>nd</sup>	4873	40 <sup>th</sup>	3387
Montenegro	70 <sup>th</sup>	2825	N/A	N/A

Source: OIV, 2023

Though wine tourism is an attractive segment, it would be difficult to appeal to the desired tourist as they have a myriad of alternatives within the country neighbour to Albania, and to a larger extent countries within the Western Balkans. Differentiating the offer by providing more value and adapting the marketing communication according to the desired segment is imperative.

**Table 2.** Production/consumption/imports/exports in Western Balkans

Country	Production value 1000 hl	World ranking as producer	Consumption value 1000 hl	World ranking as a consumer	Import value 1000 hl	World ranking as importer	Exports value 1000 hl	World ranking as exporter
North Macedonia	936	21 <sup>st</sup>	265	58 <sup>th</sup>	2	159 <sup>th</sup>	685	22 <sup>nd</sup>
Croatia	765	25 <sup>th</sup>	1003	32 <sup>nd</sup>	276	41 <sup>st</sup>	43	48 <sup>th</sup>
Serbia	705	27 <sup>th</sup>	829	37 <sup>th</sup>	232	45 <sup>th</sup>	102	34 <sup>th</sup>
Albania	295	41 <sup>st</sup>	291	54 <sup>th</sup>	55	84 <sup>th</sup>	N/A	N/A
Montenegro	70	54 <sup>th</sup>	37	98 <sup>th</sup>	30	98 <sup>th</sup>	61	41 <sup>st</sup>
Bosna and Herzegovina	69	55 <sup>th</sup>	119	71 <sup>st</sup>	84	68 <sup>th</sup>	32	51 <sup>st</sup>

Source: OIV, 2023

According to OIV (2023), the Republic of North Macedonia is the largest wine producer and exporter in the WB, followed by Croatia, Serbia and Albania in fourth place. The country with the largest consumption and importing value is Croatia.

Law nr.86\_2022 regulates the registration of a wine with specifications: a) appellations of origin; b) geographical indicators; c) protected designations of origin; and d) protected geographical indications. Albania can enlarge its vineyard surface area and invest more in infrastructure and exports, both will help in creating a favourable image.

## 5. CONCLUSION

Wine tourism represents a major segment of culture tourism, and it is widely believed to be an effective driver of local development. All Balkan countries are wine producers and engage in wine tourism activities. In order to attract tourists, Albanian wineries should differentiate their offer and create more value for local and international tourists. Beyond the logistical challenges of growing the industry, Albania wine must also place itself into the wider world of wine. In marketing wine tourism, it is the specific experiential benefits that must be stressed, and carefully targeted. Wineries are the core attraction (Getz, 2000), but cannot stand alone (Getz & Brown, 2006).

In Albania, government entities, have proven relevant stakeholders as partnerships in the whole wine tourism sector, specifically in the cocreation and promotion of events and festivals and solving the lack of infrastructures and resources, facilitating information between business and marketing strategies or staff formation.

Government entities are organizing events that aim to promote and attract the attention of potential tourists to Albania, such as sports marathons, artistic festivals, concerts, fairs, meetings etc. They are building the infrastructure to support the wine and winery owners.

There are 43 wineries in Albania that are part of the wine road and offer different wine tour experiences. Wine routes are a fundamental engine for linking wine tourism, activities and traditions, working as a privileged tool to disseminate and promote regional tourism (Getz, 2000).

The wine route – either as a spontaneous partnership or as a policy-induced joint initiative among winegrowers, rural tourism businesses and public bodies or both – has emerged as the most relevant vehicle for linking wine and tourism, combining both the tangible and intangible dimensions of the wine tourist experience (Brandano et al., 2020).

Tourism agents play an important role in the growth of the segment and are crucial partners in the value-delivering chain. Tourism agents are provided with data for successfully developing wine tourism. Besides elements that can be controlled by the provider, they have data related to elements that cannot be controlled by them such as a tourist's interest in wine. This makes it necessary to develop communication strategies that increase interest in the wine product and related activities.

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# The COVID-19 Pandemic and Its Effects on the United States Housing Market

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**Abstract:** *This research examines the impact of the COVID-19 pandemic on the housing market in the United States, with a specific focus on housing prices and their relationship with COVID-19 infection rates. The study utilizes a panel-data regression model, using monthly county-level data spanning from January 2020 to December 2022. Two separate models were employed, one for urban counties and another for rural counties, determined by population data. These models employ a fixed effects regression approach with robust standard errors and incorporate various independent variables to explore the association between county-level economic activity, unemployment rates, long-term interest rates, COVID-19 infection cases, and national housing market prices. The findings of this investigation reveal that the prices of homes in the United States were influenced by both the number of COVID-19 infection cases and the economic factors under consideration. Interestingly, urban counties experienced more pronounced fluctuations in housing prices compared to their rural counterparts. Moreover, there was a noticeable shift in housing demand, with a preference for less densely populated areas over densely populated ones. The outcomes of this study offer insights into spatial disparities and their implications for the real estate market.*

## 1. INTRODUCTION

Shelter, a fundamental necessity for all living beings, stands as one of humanity's most essential needs. In the context of modern living standards, the demand for space, comfort, and amenities in our homes continues to rise (Balemi et al., 2021). Yet, in today's complex world, everything comes at a cost. Beneath the apparent simplicity of this statement lies a multifaceted web of factors that influence housing prices. Countless studies have delved into this subject, yielding a plethora of related factors that underpin the dynamics of housing costs. These factors range from macroeconomic indicators, such as the well-being of the population, the state of the national economy, and the impact of large-scale social and political events (Ansell, 2019; Bratt, 2002; Coates & Matheson, 2011; Davis & Heathcote, 2005; Piazzesi & Schneider, 2016; Shamsuddin & Campbell, 2022). At the local level, housing prices can fluctuate due to buyer preferences, regional regulations that either stimulate or hinder housing demand, and the specific location and surrounding amenities of the housing units, all influenced by population density and social and cultural factors (Aladangady, 2017; Glaeser et al., 2012).

The outbreak of COVID-19 ushered in a period of global economic turbulence as societies worldwide grappled with the profound challenges posed by the pandemic. Numerous studies have explored the ramifications of COVID-19 across various economic domains, including the surge in the U.S. unemployment rate, which peaked at 14.7% in April 2020 as the pandemic took

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hold (Couch et al., 2020; Gallant et al., 2020). The impact of COVID-19 was also keenly felt in the housing market, as it ushered in price fluctuations, shifts in housing demand, and alterations in consumer preferences (Chetty et al., 2020; Guerrieri et al., 2020).

This paper's principal objective is to scrutinize the interplay between the all-transactions U.S. house price index, population well-being, interest rates, and the state of the country's economy during the implementation of COVID-19 protective measures. The authors also aim to investigate whether the aforementioned independent variables exert a substantial influence on the U.S. house price index, the dependent variable. Moreover, the study also focuses on analyzing the presence of spatial patterns in the effects of the pandemic across different regions. Hence, the topic will shed light on the geography of housing market changes during times of crisis. The examination of the impact of the COVID-19 outbreak on the housing market will provide insights into how unforeseen events can disrupt and reshape this critical sector of the economy. By comparing the impact of the outbreak on urban and rural counties, the study will illuminate how the housing market's response differs based on population density and location.

The remainder of this paper is organized as follows. In Section 2, the literature review presents and discusses concepts from prior research. Section 3 elaborates on the presentation of data and the methodology employed in the preparation of this work. Section 4 provides the results of our model. Lastly, section 5 concludes.

## 2. LITERATURE REVIEW

Adams and Füss (2010) examined the long-term impact and short-term dynamics of macroeconomic variables on international housing prices. The authors resorted to the application of a panel data analysis due to the lack of adequate and frequent data on the housing market resulting in a low number of observations for each country, thereby bypassing the data restrictions faced during analysis of single-market time-series data. The authors based their choice of variables for the estimation process on the static equilibrium model of Dipasquale and Wheaton (1996). The three variables chosen were as follows: economic activity, long-term interest rate, and construction costs. The dataset used consisted of quarterly real house prices from 1975Q1 to 2007Q2 for 15 countries: Australia, Belgium, Canada, Denmark, Finland, France, Great Britain, Ireland, Italy, Netherlands, New Zealand, Norway, Spain, Sweden, and the USA. The authors conducted a cointegration analysis on their panel data as follows: First, using panel unit root tests, the variables are tested for any possible stationarity. Next, the authors made use of panel cointegration tests to detect the long-term equilibrium relationships. Finally, the short-term dynamics of the data were estimated using cointegration-vector estimation methods. The authors concluded that macroeconomic variables have a significant impact on house prices, particularly stating that for a 1% increase in economic activity, the housing prices in the long-run increase by 0.6%. Tripathi (2019) examined the global relationship between macroeconomic factors and housing price increases, utilizing a panel dataset with data primarily sourced from the OECD and the World Bank. The study covered 43 countries from 1970 to 2017, employing random-effect models and feasible generalized least squares regression. The analysis considered various macroeconomic variables, such as rent price, price-to-income ratio, price-to-rent ratio, urban population, GDP per capita, inflation, total population, real interest rate, annual GDP growth, broad money, real effective exchange rate index, and employment in services. The model incorporated country and year-fixed effects, utilizing five regression models. The findings indicated that several factors, including rent, price-to-income ratio, price-to-rent ratio, urbanization, per-capita GDP, inflation, population aged 15-64,

GDP growth rate, broad money, and real exchange rate, had a positive and statistically significant impact on real house prices.

Li and Zhang (2021) studied spatial patterns in U.S. real estate market price changes, analyzing data such as Zillow Home Value Index (ZHVI), U.S. County and ZIP code data, data on major cities, and a COVID-19 cases dataset. ZHVI, a seasonally adjusted measure of home value, was used. The research employed Spatial Autocorrelation Analysis, Cluster and Outlier Analysis, and Hot Spot Analysis using Moran's I and Getis-Ord's Gi. The study compared housing price changes pre-COVID (2011 – May 2020) with those during the COVID-19 pandemic (May 2020 – May 2021). The findings revealed varied spatial impacts, with changes influenced by Americans' cautious approach, particularly avoiding densely populated areas with higher COVID-19 infection levels. Yörük (2020) examined the early impact of the COVID-19 pandemic on the U.S. housing market using daily data from fifty major cities from February 15 to April 19, 2020. The data included daily confirmed coronavirus cases and deaths, county population data, 2016 Presidential election results, and daily housing data. The study employed event study and difference-in-difference models, with separate analyses for counties with a Democratic majority due to potential differences in compliance with COVID-19 policies. The findings revealed a significant decline in new home listings and pending home sales, reaching over a 60% drop in mid-April 2020 compared to the same period in the previous year. Liu and Su (2021) investigated how the COVID-19 pandemic affected housing demand locations. The study utilized monthly data on home sales, listings, inventory, home price index (HPI), and rent data. Their regression analysis incorporated spatial and time variables, including interactions between time and neighborhood characteristics. The logarithm of the average case rate was also considered. The findings revealed a shift in housing demand away from densely populated areas, attributed to decreased need for proximity to telework-compatible jobs and the waning appeal of consumption amenities. The study also noted that cities with higher pre-COVID-19 home values experienced a more significant decline in housing demand.

Apergis (2003) investigated the impact of macroeconomic variables—money supply, employment, and mortgage interest rates—on real housing prices of new house sales in Greece. The study aimed to test the hypothesis that interest rates significantly influence housing prices. Using an error correction vector autoregressive (ECVAR) model, the analysis incorporated Greece's national quarterly data from 1981 to 1999. Key variables included the housing price index, a mortgage interest rate proxy, a consumer price index, and an employment index. The results indicated that real housing prices do respond to specific economic factors. Apergis found, through variance decompositions, that the housing mortgage rate had the highest explanatory power over the variation in real housing prices, followed by inflation, supporting his hypothesis on the relationship between interest rates and housing prices. Andrews (2010) examined the impact of housing supply rigidity, tax relief on mortgage debt financing, and transaction costs on real house prices. The study utilized panel data from OECD member countries spanning 1980-2005. The model incorporated variables like real house prices, long-term interest rates, household disposable income, inflation, construction costs, real rents, and housing stock. Structural factors included a Financial Reform Index, NAIRU for structural unemployment, and immigration/natural population increase. The findings indicated that real house prices correlate positively with real household incomes while having a negative correlation with structural unemployment and real interest rates. Ferrero (2015) aimed to demonstrate that domestic credit and preference shocks caused the U.S. housing boom in the 2000s. The research also sought to establish that a combination of expansionary monetary policy and controlled exchange rates globally explained low global real interest rates. The study

employed a two-country model with time-series data for the “home” (US) and “foreign” countries for the 2001-2011 period. The author’s study came to the conclusion that domestic factors can explain the full increase in US housing prices (2001-2006), as well as result in substantial current account deficits. However, the author’s analysis concluded that the euro area’s housing prices and loan rates were more sensitive to monetary policy changes.

Hsu et al. (2018) investigated the impact of unemployment insurance (UI) on the housing market using time-series and cross-sectional data on UI benefits from 1991 to 2010. Their study concluded that more generous UI benefits correlate with a decline in mortgage delinquency and default rates, acting as a stabilizer for the U.S. housing market. Head and Lloyd-Ellis (2012) explored the relationships between geographical mobility, unemployment, and the value of owner-occupied housing. Employing a multicity stationary equilibrium model, their complex dataset included panel data from 1999-2000 and the 2008-2010 periods for 274 cities, categorized as large or small. The study revealed that the illiquidity of owner-occupied housing negatively influenced owners’ willingness to move for distant job opportunities, leading to significant variations in house prices, rents, and unemployment rates across cities. Mohan et al. (2019) assessed the impact of macroeconomic indicators on housing prices using data from 1999 to 2017 in the Town of Amherst, New York. The indicators included crude oil price, 30-year mortgage interest rate, Consumer Price Index, Dow Jones Industrial Average, and unemployment rate. Housing prices were measured using the Home Price Index (HPI), treated as a self-affecting variable. The study employed a vector autoregression model, conducting unit root and cointegration tests. Results indicated that current changes in house prices significantly influenced expectations of future changes. Unemployment rate was the second-largest contributor, explaining 5.8% of the variation in housing prices after 12 months.

Based on the literature, our hypotheses are as follows:

**Hypothesis One:** Economic activity has a significant positive impact on US housing market prices.

**Hypothesis Two:** The number of COVID-19 infection cases has a significant positive impact on US housing market prices.

**Hypothesis Three:** Unemployment has a significant negative impact on US housing market prices.

**Hypothesis Four:** The level of COVID-19 influence is different in urban and rural county areas.

### 3. DATA AND METHODOLOGY

This study aims to identify factors influencing changes in the U.S. housing market, with a specific focus on the impact of the COVID-19 outbreak. The research analyzes spatial patterns of the pandemic’s effects on housing markets, comparing urban and rural areas. Monthly data from January 2020 to December 2022, obtained from various online sources, is used at county levels in the United States. Two regression models are employed: A U.S. county-level panel data model, further categorized into urban and rural counties based on population data from the U.S. Census Bureau (2023). Both models use the Zillow Home Value Index as a dependent variable, along with proxies for economic activity, new COVID-19 cases, long-term interest rates, and unemployment rates. Both urban and rural county models use the same variables, which are explained thoroughly in the following table.



**Table 1.** Data Summary

Data	Data Type	Measurement Scale	Data Source
Zillow Home Value Index	Quantitative	Weighted Average	Zillow
County Economic Impact Index	Quantitative	Index	Argonne National Laboratory
New COVID Confirmed Cases	Quantitative	Total New Cases	USA Facts
County Unemployment Rate	Quantitative	Ratio	U.S. Bureau of Labor Statistics

**Source:** Own processing

A multiple regression analysis was conducted to find the regression equation and draw conclusions about the effects that the selected independent variables have on the dependent variable, the Zillow Home Value Index. The US county model's regression equation is presented as follows for both the urban and the rural model:

$$ZHVI_{it} = \alpha_i + \delta_t + \beta_1 CEII_{it} + \beta_2 COVID_{it} + \beta_3 UNRATE_{it} + \varepsilon_{it} \quad (1)$$

Based on all the diagnostic tests, the study uses a fixed model with robust standard errors.

Lastly, counties were *categorized as urban or rural* based on their resident population as of April 2020. The categorization was conducted based on the following criteria:

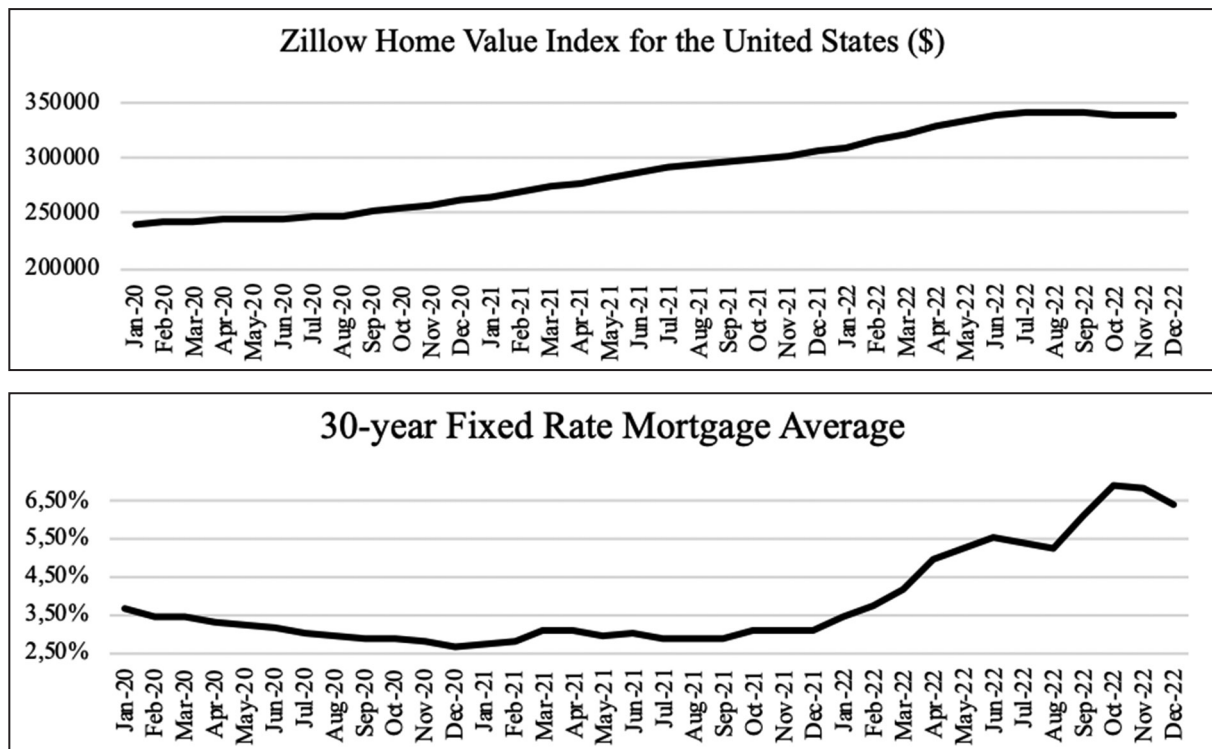
1. The 5 most populous (top 5) counties in each state were included in the urban county model (urban group).
2. Counties with a resident population of over 1 million were included in the urban county model, ignoring the limit of 5 counties per state.
3. The 5 least populous (bottom 5) counties in each state were included in the rural county model (rural group). However, when data was unavailable for a bottom 5 county, the next least populated county was taken.
4. The population cutoff point for counties to be categorized as urban or rural was set at around 125,000. This would aid in lowering heteroskedasticity in the model.
5. Categorization as urban or rural is mutually exclusive.
6. For states with less than 10 total counties, the same rules apply.
7. In cases where any of the top 5 counties had a resident population under 125,000, the authors used their own discretion to either include or exclude the county from the rural group. Post-exclusion, the state could be represented by 4 or less urban counties.
8. In cases where any of the bottom 5 counties had a resident population over 125,000, the authors used their own discretion to either include or exclude the county from the rural group. Post-exclusion, the state could be represented by 4 or less rural counties.

After the categorization of approximately 3000 US counties, a total of 461 counties were chosen between the two groups: with the urban group containing a total of 229 counties, and the rural group containing 232 counties.

#### 4. RESULTS AND MECHANISMS

This section of the paper will be heavily focused on the descriptive analysis of the dependent variable and the independent variables for the United States model during the specified period of January 2020 to December 2022. The authors will observe the statistics to identify themes and patterns in the data, to ultimately conclude whether a correlation between the factors exists.

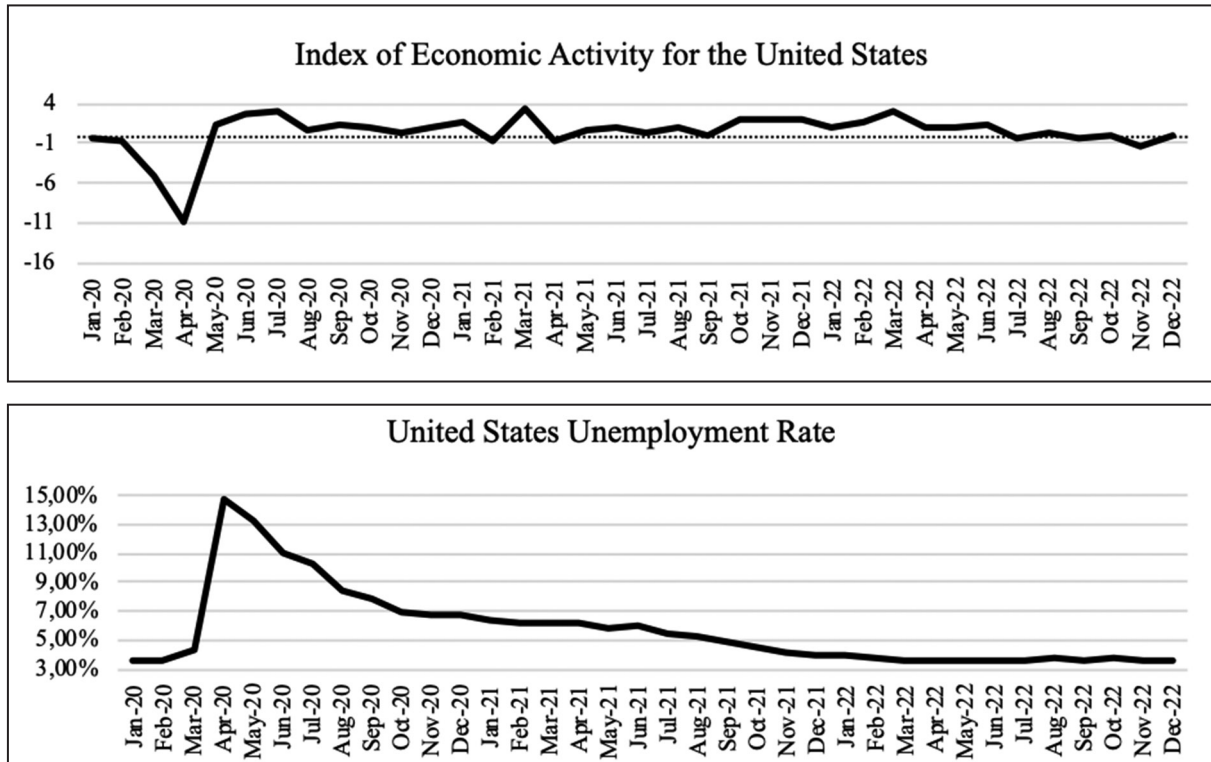
By observing Figure 1, it is apparent that the ZHVI in the US housing market between January 2020 and July 2022 has been steadily on the rise, thereafter suffering a slight drop until December 2022. The constant increase in the value of ZHVI can be interpreted as an effect of the COVID-19 outbreak and pandemic, as well as the various policies undertaken to ensure public health and safety. The authors also show the average interest rates for 30-year fixed rate mortgages in the United States for the January 2020 to December 2022 period. Interest rates slowly decrease from January 2020 to December 2020, reaching a low of 2.68% in the latter month. For the next year, that is, until December 2021, interest rates hover around 3%. It is only at the beginning of January 2022 that they suffer a drastic spike, reaching 5.52% in June 2022, then falling during the summer months, only to increase at a faster pace starting from August 2022, reaching the highest point (6.90%) in October.



**Figure 1.** Zillow Home Value Index data and Mortgage Rate for the United States

**Source:** Own processing

The Index of Economic Activity shows the month-to-month variation of 15 Census Bureau economic indicators. By observing Figure 2, it can be concluded that there was a sudden decline in economic activity during April 2020. This coincides with the beginning of the COVID-19 pandemic and the period when the US started taking drastic measures to ensure public safety, such as the nation-wide quarantine of non-essential workers and businesses. This temporary drop in the working population was without a doubt, a factor for the major decrease in economic activity observed. The rest of the data points are mostly positive, meaning that economic activity was able to recover over time, slowly but surely. Simultaneously, the figure shows that the unemployment rate starts at a low of 3.5% in January and February 2020. This was followed by a sudden spike in the unemployment rate in April 2020 to an extreme high of 14.7%. This drastic increase can be attributed to the fight against COVID-19, which was especially straining for both the population and the economy at the time (Falk et al., 2021). The graph shows that unemployment has been on a steady decrease since its spike and is now back at the lowest 3.5% it has been during the last three years.



**Figure 2.** Economic Activity and Unemployment Rate for the United States

Source: Own processing

### Urban County Regression Model

Based on all diagnostic tests, the urban county model must be adjusted to be a fixed effect model with robust standard errors. Furthermore, the data on the variables ZHVI and COVID must be converted to their logarithmic form to avoid heteroskedasticity. The urban county model includes data on 229 US counties over 31 monthly periods, ending up with a regression comprised of a grand total of 6526 observations. The rural county model includes data on 232 US counties over 31 monthly periods, ending up with a regression comprised of a grand total of 6081 observations. The results of both models are as shown below.

**Table 2.** Rural County Model Regression Results Using Robust Standard Errors

	(1)	(2)	(3)	(4)
	log(ZHVI)	log(ZHVI)	log(ZHVI)	log(ZHVI)
<b>CEII</b>	1.254547***	-0.7373339***	0.1810034***	0.0218516
	(0.1081069)	(0.1619337)	(0.0878663)	(0.1340244)
<b>log(Covid)</b>	0.0128799***	0.0544534***	0.0120562***	0.067882***
	(0.0009672)	(0.0035490)	(0.0013191)	(0.0045700)
<b>UNRATE</b>	-0.007241***	-0.0144012***	-0.0218581***	-0.0041309
	(0.0011855)	(0.0023942)	(0.0016420)	(0.0035608)
<b>N</b>	229	229	232	232
<b>R<sup>2</sup></b>	0.5327	0.0469	0.3573	0.0381

**Note:** Standard errors in parentheses \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

(1) and (2) are the fixed effect with robust error and pooled OLS regressions for the urban model, meanwhile (3) and (4) are the fixed effect with robust error and pooled OLS estimation for the rural model.

Source: Own processing

The study anticipates that all independent variables have a significant tendency to affect home values. Regarding the independent variables, every single of them: the county economic impact index, the logarithm of COVID-19 infection cases, and the unemployment rate are all significant at any level.

Regarding the urban model, the independent variables explain 53.27% of the variation of the dependent variable. The County Economic Impact Index, representing the level of economic activity within each county, has a significant positive impact on house values, increasing ZHVI on each side, both urban and rural. However, there is a higher effect of economic activity on the urban scenario rather than the later, due to the fact that the spatial economic differences in the US case are huge and the value of a house in an urban area is worth tenfold compared to a house in the rural area (Garriga et al., 2021; Nygaard & Parkinson, 2021). Hence, the authors conclude that the level of economic activity somehow affects US market house values as supported by the previous literature's findings (Adams & Füss, 2010). The COVID variable, representing the logarithms of the new monthly COVID-19 infection cases, also has a positive statistically significant impact on the dependent variable, with an estimated increase of 0.013% to ZHVI and with a 1% increase to the independent variable (c.p.) for both scenarios. This observation pleads the case of the pandemic having a positive effect on house prices, similar to other researchers' claims (Li & Zhang, 2021; Liu & Su, 2021). On the contrary, the unemployment rate was observed to have a negative impact on US housing market prices, seemingly decreasing ZHVI by 0.007% and 0.004% respectively, for a 1% increase in unemployment rates (c.p.). This impact was foreseen by previous studies, including Andrews (2010); a work which concluded that structural unemployment had a negative correlation with real house prices. These findings support this study's hypotheses 1, 2 and 3.

## 5. CONCLUSION

This study investigates the impact of the COVID-19 pandemic on U.S. housing market prices, considering economic indicators like proxies for economic activity, long-term interest rates, and unemployment rates. Utilizing panel data regression techniques, two county regression models were developed for urban and rural areas based on U.S. Census Bureau population data. The analysis reveals similar coefficient signs for both urban and rural models, indicating consistent effects of independent variables. The study observes that economic activity, measured as CEII, has over 10 times more impact in urban counties than in rural areas. This difference may result from pandemic-related policies and circumstances. Additionally, the findings support the notion that changes in Americans' preferences for less population-dense areas impact housing prices. The study concludes that economic activity and COVID-19 cases positively impact housing prices, while unemployment negatively affects prices in both urban and rural areas. However, urban areas exhibit greater volatility in response to economic activity changes, while rural areas are more sensitive to unemployment shocks. This study is valuable for policy-makers and real estate stakeholders as it provides detailed insights into how the COVID-19 pandemic has influenced U.S. housing markets, offering a nuanced understanding of urban-rural dynamics and the different impacts of economic indicators. The findings contribute to informed decision-making, enabling tailored policy interventions and strategies for navigating post-pandemic real estate landscapes.

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# Exploring the Influence of Corporate Governance on the Financial Performance. Case Study of the Energy Sector

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**Abstract:** *Given the region's commitment to sustainable and renewable energy sources as well as its reliance on conventional fossil fuels, the energy industry in Europe shines in the light of contemporary economies. The European energy industry is at a turning point and is prepared to change in response to new environmental concerns and shifting market dynamics. This paper aims to investigate whether the corporate governance score (GOV) of companies operating in the energy sector is associated with their corporate financial performance (CFP). The research covered data from 103 companies in the energy sector collected from Thomson Reuters Eikon for the period 2017-2021. The research used the regression and correlation analysis between GOV performance and its components and an accounting-based measure of profitability: total revenue. The data used in this study were analyzed using SPSS Software. The results show a partial but positive correlation between the management mechanisms on financial performance and a full positive influence of CSR strategy on financial performance; the shareholder score shows no impact. The energy sector is an environmentally sensitive yet understudied industry, and the present research helps to determine what has to be improved from a sustainability point of view.*

## 1. INTRODUCTION

In recent years, industries and researchers have come to place greater emphasis on corporate sustainability. Corporate sustainability strategies and activities are essential for today's organizations, especially those whose success depends largely on their sustainability initiatives, to address these concerns. The whole world is currently facing several social and environmental challenges due to global population growth and the increasing risk of climate change.

Corporate governance is the third pillar of ESG (environmental, social, and governance) factors and can be defined as a set of methods and mechanisms that when applied, streamline the management and control of a company to improve its performance and value (Pintea et al., 2020, p. 2). This definition underlines the indispensability of corporate governance within a company. A similar definition mentions that it is a structure that not only improves the relationships between various parties (shareholders, managers, and investors) but also ensures the appropriate distribution of resources among competing parties, providing structures for formulating the company's objectives and determining how to achieve them, as well as assessing whether or not the objectives are being met (Al-ahdal et al., 2020, p. 2). In assent to the previous statement, it can be added that effective corporate governance enables shareholders to exercise appropriate oversight of a company to maximize the value of the company and ensure that its investments generate returns. Managers may take excessive risks due to the lack of effective corporate governance processes, thereby increasing the chances of insolvency (Liang et al., 2020, p. 137). The purpose of this article is to determine whether and under what conditions corporate governance performance impacts financial performance.

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## 2. LITERATURE REVIEW

The literature provides a vast amount of research exploring the sensitive relationship between governance performance and financial performance; however, the results of current studies continue to differ. Considering the number of publications referring to the relationship between financial and corporate governance performance, it can be stated that the interest is continuously growing in the last twenty years (Wahyuningrum et al., 2023, p. 2). To support sustainable economic growth and business sector development, corporate governance has become a crucial factor for both developed and emerging countries. Rodriguez-Fernandez (2015) argues that good corporate governance performance leads to financial benefits and the relationship between the two is bi-directional, and given that the way the two performances correlate depends on the degree of sustainability sensitivity of the industry. Mixed results can also be driven by the lack of interest of companies to invest in sustainability, and one of the reasons why companies do not invest in corporate governance mechanisms is because the cost of implementation outweighs the results achieved (Freire et al., 2020, p. 150).

Remo-Diez et al. (2023) analyze the relationship between ESG issues and financial performance in a sample of 185 companies, concluding that the governance score does not influence the evolution of return on assets. On the other hand, Gonçalves et al. (2023) obtain mixed results on the governance score, but argue that the adoption of corporate governance mechanisms does indeed influence financial performance. Their findings are supported by a large study of 252 companies listed on the London Stock Exchange in 2014, where Kyere and Ausloos (2021) analyze corporate governance components concerning return on assets obtaining statistically significant results for governance components: board size, board independence and audit committees and statistically insignificant results for CEO duality and insider shareholder. Another mixed result is obtained by Haque and Arun (2016) who claim the existence of a positive and significant relationship between corporate governance quality and companies' net marginal return despite determining a statistically insignificant result in the research on the relationship between the overall governance indicator and ROA and ROE.

Another perspective in analyzing the relationship between the two performances is obtained by authors Naeem et al. (2022), who use sustainably sensitive companies from emerging and developed countries in their analysis, suggesting that good governance can positively affect ROE in developed countries. Siminică et al. (2019) studied the relationship between corporate governance and financial performance, represented by ROA and ROE, on a sample of 614 companies in the European Economic Area, establishing a clear relationship between the two, agreeing with the results obtained by Mahrani and Soewarno (2018). According to authors Temba et al. (2023), the financial performance of commercial banks in Tanzania is positively influenced by corporate governance performance, especially components such as board gender diversity, board size, director shareholding and audit presence. Considering other component variables of governance performance, Zelalem et al. (2022) analyze the relationship in insurance companies using ROA and ROE as determinants of financial performance and find a positive and significant impact when it comes to board size, transparency, board remuneration and management soundness.

Affes and Jarboui (2023) use multivariate regression to analyze the impact between the two performances on a sample of 160 companies from different sectors over the period 2005-2018 and find that the implementation of good governance mechanisms leads to an improvement in financial performance when measured by ROE. Also, Statovci et al. (2023) analyze the impact of the two

performances and find, using linear regression, fixed-effects, random effects and trend analysis, that financial reporting transparency has a positive effect on financial performance. Considering also the time variable, Nawaz and Ohlrogge (2020) take a longitudinal approach, with a focus on Deutsche Bank in 1957-2019, and state that the presence of gender diversity on boards of directors, a component of corporate governance, has a positive effect on financial performance. Analyzing the present issue also from the point of view of the degree of sensitivity to sustainable factors of the analyzed industry, Bigioi & Bigioi (2023) and Zehir et al. (2023) observe the existence of an impact between governance performance on financial performance for companies in the energy sector.

This research aims to examine the relationship between corporate governance performance and financial performance of energy companies in Europe, based on the assumption that improving or implementing corporate governance can affect the efficiency of these companies' operations.

### 3. RESEARCH METHODOLOGY

The purpose of this paper is to determine whether there is a relationship between corporate governance performance and financial performance, and the total corporate governance pillar percentage score will be used. Given the relational differences between the two performances when the governance components are also analyzed, the constituent variables such as management score, shareholder score and CSR strategy score will also be considered independently. By obtaining and aggregating the scores of 56 variables from the published information of public companies, Refinitiv Eikon generates the governance score (Environmental, Social and Governance Scores from Refinitiv, 2022, p. 6), and this is the independent variable in the chosen calculation models. The normalization of score weights occurs using percentages that range from 0 to 100, where the maximum value of 100 indicates high reporting transparency and excellent governance performance. The high degree of uniqueness and plausibility of the information used to calculate these scores is given by the fact that they are disclosed directly by companies. Financial performance plays the role of the dependent variable and is determined through total revenue, also information about this is collected from the Thomson Reuters Eikon platform for companies with accessible Governance Scores.

The statistical analysis, which covers a data range from 2017-2021, is based on a sample of 103 listed companies in the European energy sector, and the data presented in the tables are expressed in US dollars, which is also one of the world's major currencies. The variables used in the statistical analyses are described as follows:

**Table 1.** Variable description

Variable name	Symbol variable	Type of variable	Significance
Total revenue	TR	dependent	the total income a business generates from all of its goods and services
Governance Score	GOV	independent	establishing an operational structure that is in line with the goals of the company's shareholders and guaranteeing reporting transparency
CSR Strategy Score	CSRS	independent	incorporates data regarding the CSR strategy developed and the ESG reporting and transparency
Management Score	MS	independent	incorporates data regarding the structure of the management and the compensation
Shareholder Score	SS	independent	incorporates data regarding the shareholder rights and the takeover defense

**Source:** Own processing

The subsequent analysis is based on the following main hypotheses to investigate whether governance score and financial performance in energy sector companies are correlated:

**Hypothesis One:** There is a link between corporate governance performance and financial performance in companies operating in the energy sector.

The primary hypothesis leads to a series of supporting hypotheses such as:

**Hypothesis Two:** The component variable - CSR strategy score has a significant effect on the financial performance of companies in the energy sector.

**Hypothesis Three:** The component variable - Management score has a significant effect on the financial performance of companies in the energy sector.

**Hypothesis Four:** The component variable - Shareholder score has a significant effect on the financial performance of companies in the energy sector.

Whereas, if the above hypotheses prove to be true, then companies with high governance performance result in better financial performance than companies with low or no such performance, leading to a subsidiary hypothesis:

**Hypothesis Five:** The intensity of the relationship between corporate governance score and financial performance increases as a result of the increase in governance factors.

The validation or invalidation of the above-mentioned hypotheses is conducted through regression analysis and correlation analysis between the two performances.

## 4. RESULTS AND DISCUSSION

### 4.1. Results of Correlation Analysis

Assuming that the data are normally distributed, the Pearson correlation coefficient, representing the basis of the correlation analysis, is determined for the corporate governance and financial performance score components using SPSS software (Table 2). Data analysis is performed for each year of the 2017-2021 period. The last matrix presents the data analysis for the whole period.

Correlation analysis is a statistical technique used to assess the type and degree of relationship between two or more independent variables. Correlation analysis reveals significant relationships between several variables and financial performance. The correlation matrix (Table 2) indicates that there is a direct and positive correlation of low intensity between the MS and CSRS variables, and the 1% and 5% significance levels of the Pearson correlation coefficient indicate that the relationship is statistically significant. Also, no statistically significant relationship was observed between total revenue and shareholder score, thus hypothesis three becomes invalid; hypotheses one and two are validated by determining a Pearson correlation coefficient with a positive and statistically significant value. It is found that the total revenues of energy companies in Europe are influenced by the implementation of sustainability strategies, transparency, and non-financial reporting that provide confidence as well as by the structure of management through management decisions and less influenced by shareholder rights and actions.



**Table 2.** Pearson Correlation

2017	MS	SS	CSRS	TR	2018	MS	SS	CSRS	TR
MS	1				MS	1			
SS	0.133	1			SS	.320**	1		
CSRS	.445**	-0.021	1		CSRS	.493**	0.071	1	
TR	0.154	-0.123	.278*	1	TR	0.199	0.095	.331**	1
2019	MS	SS	CSRS	TR	2020	MS	SS	CSRS	TR
MS	1				MS	1			
SS	.371**	1			SS	0.134	1		
CSRS	.506**	0.000	1		CSRS	.512**	0.077	1	
TR	.299*	0.080	.377**	1	TR	.336**	0.170	.375**	1
2021	MS	SS	CSRS	TR	Total	MS	SS	CSRS	TR
MS	1				MS	1			
SS	0.147	1			SS	.238**	1		
CSRS	.552**	0.093	1		CSRS	.517**	0.063	1	
TR	.328**	0.153	.373**	1	TR	.261**	0.077	.337**	1

Note: \*\*significant at the 1% level, \*significant at the 5% level.

Source: Own calculations

**Table 3.** Evolution of Pearson correlation coefficient. between GOV score and CFP

Year	2017	2018	2019	2020	2021	Total
Pearson corr. coeff.	0.151	.238*	.321**	.386**	.372**	.289**

Note: \*\*significant at the 1% level, \*significant at the 5% level.

Source: Own processing

The results shown in Table 3 validate hypothesis one (there is a link between corporate governance performance and financial performance for companies operating in the energy sector) with a weak and positive but statistically significant link between corporate governance performance and financial performance. There is a significant increase in the intensity between the two performances over the period under analysis, and considering the increase in the intensity of the link between some component variables and total revenues, observable in Table 2, it can be stated that the intensity of the relationship between corporate governance score and financial performance increases as a result of the intensification of governance factors, thus hypothesis five is partially validated.

## 4.2. Results of Linear Regression Analysis

The type of relationship between the independent variables (governance score and its components) and the dependent variable (financial performance as measured by total revenue) is reflected in the linear regression analysis, and the SPSS statistical software is used to run the regression models for the selected sample. The governance performance score, GOV, is derived from the MS, SS and CSRS scores, which is why only the three component variables are used as independent variables and total revenue, TR, as the dependent variable in the linear regression to determine the variation in financial performance through governance performance.

For the whole period analyzed, the results of the regression analysis show that 12.5% of the total variation in total revenues of energy companies can be explained by the component variables of the governance score, resulting in the validation of the primary hypothesis and its derivatives. According to Table 4 and Table 5, the p-value results confirm the linear relationships between total governance performance composed of the three dimensions (MS, SS, CSRS) and total revenues, being well below the acceptance level ( $p < 0.05$ ), except for the results of 2017, which do not reject the null hypothesis.

**Table 4.** Multiple linear regression of GOV and CFP variables

Year of analysis	Regression Weights	R <sup>2</sup>	F	p-value	Hypothesis supported
2017	MS, SS, CSRS → TR	.094	2.349	0.080	NO
2018	MS, SS, CSRS → TR	.115	2.954	0.039	YES
2019	MS, SS, CSRS → TR	.159	4.271	0.008	YES
2020	MS, SS, CSRS → TR	.184	5.120	0.003	YES
2021	MS, SS, CSRS → TR	.171	4.675	0.005	YES
Total	MS, SS, CSRS → TR	.125	16.910	0.000	YES

Source: Own processing

**Table 5.** Multiple linear regression coefficients

2017						
Term	Coeff.	SE Coeff.	t	p	Collinearity sts.	
					Tolerance	VIF
Constant	0.044	2.314	.191	.849		
MS	0.118	0.260	.456	.650	.782	1.279
SS	-0.270	0.250	-1.077	.285	.974	1.026
CSRS	0.479	0.249	1.923	.059	.795	1.258
2018						
Term	Coeff.	SE Coeff.	t	p	Collinearity sts.	
					Tolerance	VIF
Constant	-1.969	1.763	-1.117	.268		
MS	0.036	0.220	.165	.869	.675	1.480
SS	0.125	0.233	.538	.592	.888	1.127
CSRS	0.507	0.211	2.393	.019	.749	1.335
2019						
Term	Coeff.	SE Coeff.	t	p	Collinearity sts.	
					Tolerance	VIF
Constant	-3.457	1.696	-2.039	.045		
MS	0.310	0.222	1.392	.168	.728	1.373
SS	0.249	0.219	1.133	.261	.982	1.018
CSRS	0.474	0.022	2.150	.035	.737	1.356
2020						
Term	Coeff.	SE Coeff.	t	p	Collinearity sts.	
					Tolerance	VIF
Constant	-1.751	1.266	-1.383	.171		
MS	0.389	0.166	2.342	.022	.703	1.423
SS	0.044	0.169	.263	.794	.815	1.227
CSRS	1.508	0.165	.910	.366	.606	1.650
2021						
Term	Coeff.	SE Coeff.	t	p	Collinearity sts.	
					Tolerance	VIF
Constant	-3.103	1.905	-1.629	.108		
MS	0.530	0.256	2.066	.043	.695	1.439
SS	0.252	0.273	.925	.358	.978	1.022
CSRS	0.317	0.260	1.216	.228	.686	1.458
Total period						
Term	Coeff.	SE Coeff.	t	p	Collinearity sts.	
					Tolerance	VIF
Constant	-1.979	0.780	-2.534	.012		
MS	0.018	0.010	1.817	.070	.691	1.448
SS	0.006	0.010	.665	.506	.938	1.066
CSRS	0.047	0.009	4.798	.000	.729	1.372

Source: Own processing

The regression model calculated for the whole period is as follows:

$$TR_{TOTAL} = -1.979 + 0.018 * MS_{TOTAL} + 0.006 * SS_{TOTAL} + 0.047 * CSRS_{TOTAL} \quad (1)$$

where TR represents the total revenues of companies measuring financial performance, MS represents the management score, SS refers to the score on shareholder characterization and actions, CSRS determines the score on the companies' sustainable strategies, and TOTAL refers to the analysis of total scores and revenues over the entire period analyzed.

Since the values in the correlation matrix table are greater than 0.60, the explanatory results obtained for the corporate governance variables have a unique contribution to the model and are not strongly correlated with each other. The results indicate that multicollinearity is not an issue.

In the energy sector, governance performance is crucial for risk mitigation, confidence building, compliance, as well as long-term sustainability and business success in a dynamic and rapidly changing market, as evidenced by the evolution of R-square over the period under review. According to the results, among energy companies, better financial performance is directly correlated with a higher governance score. The conclusion is based on several factors, such as transparency in board appointments leading to the selection of highly qualified individuals, the implementation of risk management systems increasing efficiency, and specialized committees such as the audit committee improving corporate decision-making. Investor confidence is enhanced by employing statutory auditors, along with greater transparency in financial reporting.

## 5. CONCLUSION

The close relationship between corporate governance and a company's financial performance has been intensively studied in recent decades. To ensure good governance, the importance of fundamentals such as fairness, responsible management, and transparency must be emphasized. These principles are the essential pillars on which any effective corporate governance system should rest. This research provides valuable insights into the link between the two performances, with specific application to the energy sector market. The sustainability of a company's operations depends on improved financial performance, which in turn contributes to strengthening corporate governance procedures. Improving financial performance thus becomes a key catalyst for competitive companies in this market, positively influencing their long-term evolution. Limitations should be set on the fact that the current study is constrained by the period in which it was conducted; longer-term studies will be designed to examine the relationship between the two performances more thoroughly.

Future research should also include adding additional variables such as size, age and leverage, or further analysis of governance factors such as board characteristics. These factors, especially those related to ESG activities, are considered critical in explaining variations between governance configurations adopted.

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# Connecting the Dots: Crises' Influence on Persistence and Financial Integration in Southeast Asian Capital Markets

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**Abstract:** *This study aimed to assess risk diversification in the capital markets of nine Asian countries, including Hong Kong, Indonesia, Malaysia, South Korea, Japan, the Philippines, Thailand, China, and Taiwan. The research posed two main questions: (i) Did events in 2020 and 2022 create inefficiencies in these markets? (ii) If so, did autocorrelation of returns lead to increased linkages among these markets? The findings revealed the presence of autocorrelation, conditional heteroscedasticity, and nonlinear elements in the sample, suggesting persistence in returns during both tranquil and stressful periods. Consequently, the first research question was refuted, indicating that market (in)efficiencies were not significantly influenced by these events. Additionally, the analysis using the rhoDCCA method did not suggest integration between the markets, leading to the rejection of the second research question. These results have implications for investors, regulators, and supervisors in these markets, suggesting a need to consider measures that align with the random walk and martingale hypotheses in stock price creation.*

## 1. INTRODUCTION

During periods characterized by uncertainty, both individual and institutional investors exhibit a heightened desire to possess enhanced predictive capabilities regarding the returns on their investments. This is driven by their intention to identify market inefficiencies and potential valuation errors, thereby enabling the implementation of investment strategies that can yield returns surpassing the market average. Furthermore, this can assist regulators and policymakers in formulating policies that foster financial stability, mitigate systemic risk, and uphold the principles of fairness and transparency in markets (Dias, Pardal, et al., 2022; Dias, Pereira, et al., 2022; Pardal et al., 2022; Teixeira, Dias, & Pardal, 2022; Teixeira, Dias, Pardal & Horta, 2022).

In recent research investigations, it has been noted that during times of stress and global instability, there is a tendency for markets to exhibit a certain level of integration. Additionally, there is evidence of persistence in returns, suggesting that price changes are not independent or identically distributed. This implies that market prices may not fully reflect all the available information. When markets exhibit an overreaction to information, it signifies a delay in the adjustment of this information, granting investors the opportunity to obtain abnormal returns without assuming additional risk (Guedes et al., 2022; Zebende et al., 2022).

The objective of this study is to assess the risk diversification potential of two significant phenomena observed in recent years: the examination of (in)efficiency in its weak form and the investigation of financial integration in the capital markets of Southeast Asia. Specifically, this research focuses on the stock indexes of Hong Kong (HSI), Indonesia (JKSE), Malaysia (KLSE),

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South Korea (KOSPI), Japan (NIKKEI 225), the Philippines (PSEi), Thailand (SET), China (SSE), and Taiwan (TSEC). The study period spans from 2 January 2018 to 10 November 2022. The findings indicate the presence of persistence in returns. However, when employing the Detrended Fluctuation Analysis (DFA) model to quantify this persistence in two distinct subperiods, we observe that it is evident during the subperiod characterized by market stability, as well as during the events of 2020 and 2022. Consequently, we are compelled to reject the initial research question. To address the second research question regarding the impact of persistence on integration within regional markets, an examination of the *rhoDCCA* coefficients for two distinct subperiods was conducted. The analysis revealed a transition from anti-persistence to weak persistence in the majority of cases. Consequently, the findings prompt the rejection of the second research question.

In terms of contributions to existing research, this is the first study, as far as we know, to analyze the predictability of returns and tie it to the level of integration in Southeast Asian capital markets during the 2020 and 2022 events. Furthermore, we know that the authors' studies [Pardal et al. \(2022\)](#), [Dias, Pardal, et al. \(2022\)](#), [Dias, Pereira, et al. \(2022\)](#), and [Teixeira, Dias, Pardal, and Horta \(2022\)](#) evaluated the international financial markets during the events of 2020 and 2022, but the research issues, methodology used, and markets examined were fundamentally different from the following in this investigation.

This article is divided into five sections. The current section is the introduction. Section 2 includes a bibliographic review with references to empirical studies that investigated efficiency in its weak form and international financial market integration. Section 3 shows the sample data as well as the methods used. Section 4 details the discovered results. Section 5 summarizes the investigation's overall findings.

## 2. LITERATURE REVIEW

### 2.1. Market Efficiency, in Its Weak Form, in International Capital Markets

Many scholars contend that they encounter efficient financial markets wherein the prices of traded securities accurately reflect all pertinent information and promptly adjust to new information. Furthermore, this perspective assumes that the market's information is readily accessible without any associated costs ([Fama, 1965a, 1965b, 1970, 1991](#)). The efficient market theory posits that investors are unable to achieve abnormal returns when accounting for risk. However, previous research has presented contrasting findings, indicating that investors have the potential to achieve returns beyond the market average ([Fama & French, 1988, 1993](#)).

In the study conducted by [Lin \(2012\)](#), the efficient market hypothesis was examined on Asian stock exchanges from January 2003 to December 2011. The author employed Ljung-Box autocorrelation models and variance ratio tests for this purpose. The results indicate that the Hong Kong (Hang Seng) and India (BSE) markets exhibit efficiency in their weak form, whereas the Singapore (STI) market displays indications of (in)efficiency. Furthermore, [Rizvi and Arshad \(2016\)](#) employed the MF-DFA economic model to analyze weak-form efficiency in the capital markets of Malaysia, Indonesia, Singapore, and South Korea. Their study aimed to compare the Asian crisis with the subprime crisis. The obtained results suggest that there are indications of (in)efficiency in the markets, and the rejection of the random walk hypothesis differs depending on the economic structure of the countries in which the stock market operates.

Recently, [Zebende et al. \(2022\)](#) used intraday data to quantify market efficiency in the G20 capital markets using the DFA and DCCA methods. The results of the DFA demonstrate that, in the pandemic times of COVID-19, stock exchanges tend to be efficient for deadlines less than 5 days but inefficient for terms more than 10 days. The DCCA data demonstrates a variety of patterns for each stock market. Furthermore, [Guedes et al. \(2022\)](#) investigated if the financial crises of the recent 20 years (2000–2021) impacted efficiency, in its weak form, in 19 G20 stock markets. The results of the study indicate (in)efficiency in each sliding window (1000 days), and the DFA exponents have values greater than 0.5, indicating long memories in their profitability.

## 2.2. International Capital Market Integration

According to conceptual understanding, financial integration in markets occurs when assets exhibiting equivalent levels of risk yield comparable returns and are exchanged within distinct market domains. The term “integration” can be described empirically as the phenomenon wherein non-stable individual series achieve stability when joined linearly ([Pardal et al., 2020](#); [Teixeira, Dias, & Pardal, 2022](#)).

In their study, [Qizam et al. \(2015\)](#) investigated the long-term interconnectivity dynamics between the capital markets of Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The authors discovered that these markets had a high level of integration from September 2007 to October 2012. Furthermore, they discovered that these links frequently involve bidirectional shocks, which make portfolio diversification efforts difficult. [Gulzar et al. \(2019\)](#) examined the integration of emerging capital markets in Asia, notably India, China, Pakistan, Malaysia, Russia, and South Korea, with the United States in their study. The study looked at the time before, during, and after the 2008 financial crisis. The study’s findings demonstrated long-term financial integration between the US market and emerging stock markets, particularly in the post-crisis era.

The authors, [Stevanius and Sukamulja \(2020\)](#), emphasize the significant level of integration observed in 2020 between the Indonesian market and the capital markets of Malaysia, Thailand, South Korea, Japan, Singapore, and Hong Kong. [Habiba et al. \(2020\)](#) analyzed the co-integration of the stock markets in the United States and South Asia, specifically focusing on the markets of India, Pakistan, and Sri Lanka. The study examined the period before, during, and after the global financial crisis of 2008. The authors emphasize notable degrees of interconnectedness, hence raising doubts regarding the feasibility of portfolio diversification.

Subsequently, [Song et al. \(2021\)](#) conducted a study examining the effects of economic integration between India’s stock market and prominent Asian markets, including China, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore, and Thailand. The study encompassed the period from September 1999 to December 2017. The authors provide evidence and argue, based on their findings, that the potential for portfolio diversification may be undermined by the significant levels of financial integration observed in the examined capital markets.

In a recent study, [Shi \(2022\)](#) examined the integration and co-movement dynamics between China’s stock market and 12 trading partners in the Asia-Pacific area subsequent to the global financial crisis of 2008. The empirical findings indicate that there has been an upsurge in the shocks experienced by China’s stock markets and its trading partners, primarily attributed to recent occurrences like the Shanghai stock market crisis, the US-China tariff war, and the COVID-19 pandemic. The authors [Teixeira, Dias, Pardal and Horta \(2022\)](#) evaluated the synchronizations

between the capital markets of Germany, the USA, France, the United Kingdom, Italy, Russia, Japan, Canada, and China and the oil markets in the US, Asia, Canada, Emirates, China, Nigeria, and the United Kingdom during the events of 2020 and 2022, highlighting that long-term relations between the financial markets did not help to explain short-term movements, suggesting that the oil indexes can be considered safe ports for efficient portfolio diversification.

### 3. DATA AND METHODOLOGY

#### 3.1. Data

The daily price index data for the capital markets of Hong Kong (HSI), Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 225), the Philippines (PSEi), Thailand (SET), China (SSE), and Taiwan (TSEC) were collected from the Thomson Reuters Eikon platform. The data covers the period from January 2, 2018, to November 10, 2022. To enhance the robustness of the study, the sample was partitioned into two distinct subperiods: “Tranquil” (January 2, 2018, to December 31, 2019) and “Stress” (January 1, 2020, to November 10, 2022). In order to address exchange rate distortions and avoid distortions of achieved outcomes, quotes are expressed in the local currency.

#### 3.2. Methodology

To address the research questions, the approach employed will be established through a series of sequential steps. To initially assess the stationarity of the time series, a panel unit root test of [Levin et al. \(2002\)](#) will be employed. This test aims to determine if the series adheres to a white noise process characterized by a means of zero and constant variance. In order to assess the potential occurrence of structural breaks as a consequence of the heightened volatility observed over the periods of 2020 and 2022, the methodology proposed by [Clemente et al. \(1998\)](#) will be employed. To address the initial research question, an assessment will be conducted to determine if the time series exhibit autocorrelation in their returns. To achieve this objective, we will use autocorrelation econometric tests, namely the [Ljung and Box \(1978\)](#), ARCH-LM test proposed by [Engle \(1982\)](#), to estimate the presence of conditional heteroscedasticity. Furthermore, the BDS test developed by [Brock and de Lima \(1996\)](#) will also be used to evaluate the linearity of the time series. However, it should be noted that this particular model artifact lacks the ability to accurately measure the degree of autocorrelation. As a result, we will need to employ the Detrended Fluctuation Analysis (DFA), which is an econophysical model, in order to estimate and analyze this aspect. To address the second research question, the methodology employed will involve the application of the Detrended Cross-Correlation Coefficient  $\rho DCCA$  ( $\rho DCCA$ ). This method will enable the assessment of whether there exists a discernible tendency towards financial integration during periods characterized by stress and uncertainty in the capital markets of Southeast Asia, which are the focus of the analysis. The objective is to examine the plausibility of portfolio diversification in light of these findings.

The explanation of the exponents  $\alpha_{DFA}$  and  $\rho DCCA$  can be found in Tables 1 and 2.

**Table 1.** Detrended Fluctuation Analysis  $\alpha_{DFA}$

Exponent	Signal Type
$\alpha_{DFA} < 0.5$	long-range anti-persistent
$\alpha_{DFA} \approx 0.5$	uncorrelated, white noise
$\alpha_{DFA} > 0.5$	long-range persistent

Source: Own elaboration



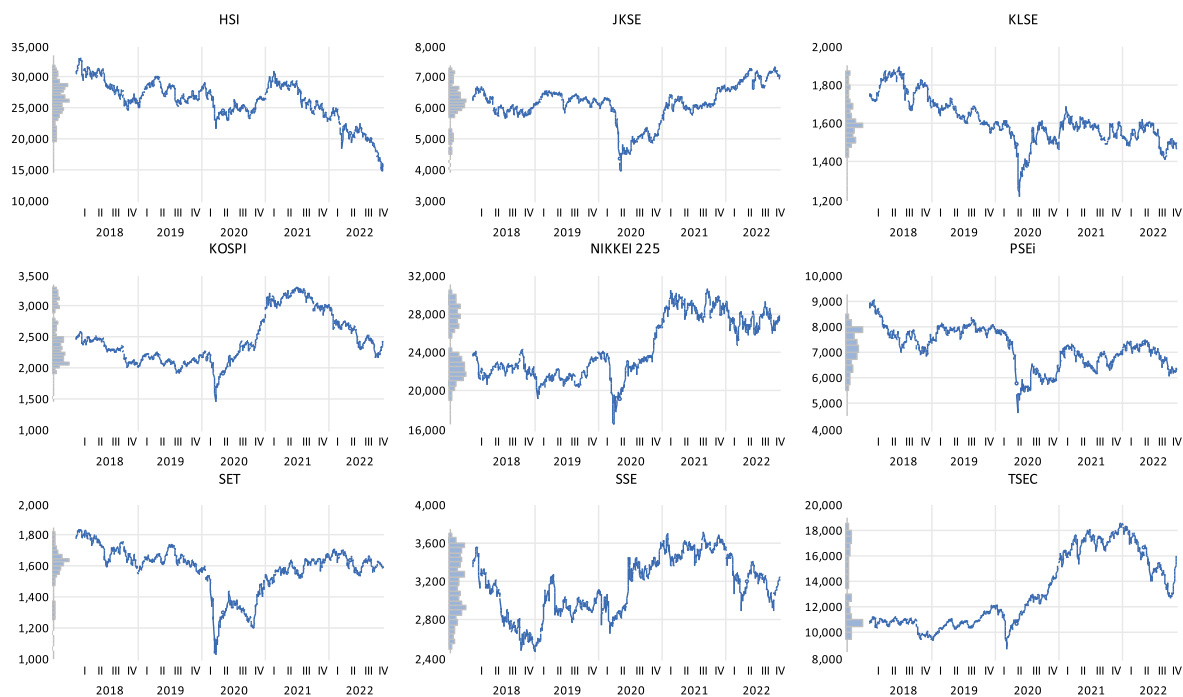
**Table 2.** Detrended Cross-Correlation Coefficient pDCCA

Weak	Medium	Strong
$\cong 0.000 \rightarrow \cong 0.333$	$\cong 0.333 \rightarrow \cong 0.666$	$\cong 0.666 \rightarrow \cong 1.000$

Source: Own elaboration

#### 4. RESULTS AND DISCUSSION

Figure 1 depicts the evolution of levels in the nine capital markets under consideration over the whole study period. The investigated stock indexes clearly indicate structural breaks in the time series, indicating the volatility to which these stock markets were subjected, particularly in the first months of 2020, which coincides with the occurrence of the first wave of the COVID-19 pandemic. Fluctuations in the time series can be seen as early as 2022, primarily in the first and third quarters of the year, implying structural breaks, a situation that may eventually be explained by the impact of Russia's invasion of Ukraine and subsequent concerns about rising associated inflation.



**Figure 1.** Evolution, in levels, for the 9 capital markets under analysis  
from January 2, 2018, to November 10, 2022

Source: Own elaboration

The evaluation of time series concerning their stationarity is significant as it enables the comprehension of underlying trends and patterns in the data while also facilitating the identification of potential fluctuations. Table 3 presents the outcomes derived from the LLC (2002) test, which examines the null hypothesis that posits the existence of a unit root (inconsistent variance) inside the panel data's time series. Based on the information supplied, it can be inferred that throughout the specified period, at a significant level of 1%, there is an absence of a unit root, indicating the rejection of the null hypothesis in the first differences.

The findings of the unit root test of Clemente et al. (1998), with structural breaks, applied to the 9 capital markets under analysis for the two subperiods under examination are provided in table

4. During the tranquil subperiod, it is feasible to see that the Asian markets had the most significant structural breakdown in 2018. There were concerns that year that the US Fed would raise interest rates more than expected, producing a collapse trend in international markets, with the Asian region bearing the brunt of the impact. The most severe structural breaks in the Stress subperiod are due to the global pandemic of 2020, except the HSI stock index, which has its most substantial fall in 2022, coinciding with Russia's invasion of Ukraine. These conclusions are supported by the authors [Pardal et al. \(2022\)](#), [Dias, Pardal, et al. \(2022\)](#), [Dias, Pereira, et al. \(2022\)](#), highlighting structural breaks caused by events in 2020 and 2022.

**Table 3.** Panel unit root test, applied to 9 capital markets under analysis for the full-time period sample

Method					Statistics	Probability**
Levin, Lin & Chu t*					-132.424	0.0000
	Coefficient	t-Stat	SE Reg	mu*	sig*	Observations
Pooled	-0.99857	-100.558	1.001	-0.500	0.707	10736

**Note:** \*\* Probability is assumed as asymptotically normal.

**Source:** Own elaboration

**Table 4.** Unit root test from Clemente et al. (1998), with structural breaks, concerning the capital markets of Southeast Asia

	Tranquil Period		Stress Period	
	02/01/2018 a 31/12/2019		01/01/2020 a 10/11/2022	
Stock Exchange	t-stat	Break Date	t-stat	Break Date
HSI	-22.45790 (0)***	06/02/2018	-27.58790 (0)***	23/03/2022
JKSE	-22.56739 (0)***	18/09/2018	-27.15514 (0)***	12/05/2020
KLSE	-22.06478 (0)***	27/07/2018	-28.60787 (0)***	15/05/2020
KOSPI	-21.88841 (0)***	29/01/2018	-27.06296 (0)***	19/03/2020
NIKKEI 225	-23.80133 (0)***	02/02/2018	-27.63558 (0)***	01/04/2020
PSEi	-38.03594 (0)***	10/01/2018	-42.20247 (0)***	14/01/2020
SET	-21.80880 (0)***	20/06/2018	-50.70630 (0)***	18/12/2020
SSE	-22.59823 (0)***	24/04/2019	-27.13685 (0)***	17/01/2020
TSEC	-24.53457 (0)***	06/02/2018	-25.41780 (0)***	20/10/2020

**Notes:** Lag Length (Automatic Length based on SIC). Break Selection: Minimize Dickey-Fuller t-statistic. The lateral values between parentheses relate to lags. The asterisks \*\*\*, \*\*, \* represent the significance of the statistics at 1%, 5% and 10% respectively.

**Source:** Own elaboration

The findings of the Ljung-Box test, applied to the 9 capital markets examined for the entire sample period, are presented in Table 5. To assess the level of autocorrelation, the original returns were examined for 4 and 12 lag days. The analysis revealed that when the lags increase, the autocorrelation exhibits a higher level of persistence. In order to verify the findings, an identical model was employed, incorporating squared returns as well as lagged values at intervals of 4 and 12. The analysis demonstrated an increase in the persistence of autocorrelation, except for the Hong Kong Index (HSI), which exhibited a comparatively smaller rise in autocorrelation, particularly to the original returns.

In order to verify the findings of the Ljung-Box test, an assessment of conditional heteroscedasticity in temporal data was conducted using Engle's Lagrange Multiplier test (ARCH-LM test) as proposed in 1982. The ARCH-LM tests were conducted on residuals from a first-order autoregressive process for a lag of 10 days. Table 6 presents evidence indicating that the residuals

of autoregressive processes in the capital markets of Southeast Asia exhibit conditional heteroscedasticity, which aligns with the common occurrence of this characteristic in financial assets. The findings of this study confirm the validity of the Ljung-Box tests conducted on squared returns with lag periods of 4 and 12, as presented in Table 5.

**Table 5.** Ljung and Box's (1978) test results applied to the time series residues pertaining to the financial markets under study from January 2, 2018, to November 10, 2022

Stock Exchange	LB (4)	LB (12)	LB <sup>2</sup> (4)	LB <sup>2</sup> (12)
HSI	4.8393	16.041	222.63***	279.59***
JKSE	11.720**	28.847***	312.79***	789.85***
KLSE	12.056**	22.067**	311.69***	623.91***
KOSPI	8.0097*	21.881**	511.98***	621.29***
NIKKEI 225	9.7543**	23.065**	249.58***	557.53***
PSEi	11.887**	15.807	118.01***	476.94***
SET	15.906***	69.989***	196.83***	696.98***
SSE	9.8237**	21.939**	23.826***	49.090***
TSEC	11.704**	18.187	305.28***	392.01***

**Note:** The asterisks \*, \*\*, and \*\*\* indicate the statistical significance at 1%, 5%, and 10%, respectively.

**Source:** Own elaboration

**Table 6.** ARCH-LM test applied to the residues of the time series, relating to the financial markets under review, from 2 January 2018 to 10 November 2022

Stock Exchange	ARCH-LM (10 lags)
HSI	18.22159***
JKSE	28.31304***
KLSE	44.95503***
KOSPI	45.79618***
NIKKEI 225	183.4122***
PSEi	5.501505**
SET	40.08408***
SSE	3.352062***
TSEC	20.94755***

**Note:** The asterisks \*, \*\*, and \*\*\* indicate the statistical significance at 1%, 5%, and 10%, respectively.

**Source:** Own elaboration

To verify the outcomes of the Ljung-Box tests conducted on the squared returns, specifically for lag days of 4 and 12, and the ARCH-LM tests performed on the residuals of first-order autoregressive processes, specifically for a lag day of 10, the Brock and de Lima (1996) BDS test was employed to detect the existence of nonlinear components. The results of the BDS test can be seen in Table 7, indicating that the hypothesis of independent and identically distributed (i.i.d) returns is rejected at a statistical significance level of 1% from dimension 2. These findings provide more support for the assumption that stock index returns exhibit nonlinearity or possess a substantial nonlinear element. The present findings provide support for the outcomes obtained by Ljung-Box's autocorrelation test and the ARCH-LM's examination of conditional heteroscedasticity. The above evidence has been substantiated by Revez et al. (2022) and Guedes et al. (2022), indicating the existence of persistent trends in returns throughout global capital markets.

Table 8 validates the results of the Detrended Fluctuation Analysis (DFA) exponents applied to the time series of the 9 capital markets under consideration for the two subperiods: Tranquilo and Stress. Long memories may be observed in the stock indexes KLSE (0.59), SSE (0.56), KOSPI (0.57), SET (0.55), Nikkei 225 (0.54) and TSEC (0.54) during the Tranquil subperiod, while markets

in the Philippines (PSEi - 0.48), Indonesia (JKSE - 0.47) show signs of anti-persistence, i.e., short-term memories, and Hong Kong (0.51) shows signs of some balance. Already in the stress subperiod, it can be observed that the stock markets of SET (0.65), KOSPI (0.59), JKSE (0.58), KLSE (0.58, TSEC (0.56) and Nikkei 225 (0.55), show signs of (in) efficiency quite significant, while the HSI stock index (0.47) shows some anti persistence, as the markets in the Philippines (PSEi - 0.51) and China (SSE - 0.49), suggest some balance during the events of 2020 and 2022. These findings highlight that the global pandemic of 2020 and the Russian invasion of Ukraine in 2022 did not increase the persistence of returns in these regional markets, even though this autocorrelation was already present in the Peaceful subperiod. As a result of these findings, the first research question is rejected, namely, that the events in 2020 and 2022 did not accentuate the persistence of returns.

**Table 7.** The BDS test applied to the residues of the time series relating to the financial markets under review from January 2, 2018, to November 10, 2022

Stock Exchange	Dimension (2)	Dimension (3)	Dimension (4)	Dimension (5)	Dimension (6)
HSI	1.789176*	2.625399***	3.561366***	4.373404***	5.171091***
JKSE	9.231350***	10.91309***	11.30731***	11.69457***	12.16552***
KLSE	7.213532***	7.765237***	8.265813***	9.186513***	10.05533***
KOSPI	7.997180***	10.11833***	11.31711***	12.18097***	13.03395***
NIKKEI 225	5.188243***	7.292188***	8.474536***	9.414761***	9.974192***
PSEi	4.284193***	4.981881***	5.974118***	6.797873***	7.490943***
SET	6.037695***	8.130050***	9.433205***	10.01199***	10.58819***
SSE	2.823340***	4.585408***	5.409197***	6.001483***	6.322955***
TSEC	5.146626***	7.339224***	8.658569***	9.853241***	10.71121***

**Note:** The method considered in the BDS test was the fraction of pairs, for a value of 0.7. The second to last column relates to the size of the diving (embedding dimension). The values shown in the table refer to z-Statistic. The asterisks \*\*\*, \*\*, \*, represent the significance of statistics at 1%, 5%, 10%, respectively.

**Source:** Own elaboration

**Table 8.** Detrended Fluctuation Analysis (DFA) results

Indexes	DFA Exponent (Tranquil) 02/01/2018 a 31/12/2019	DFA Exponent (Stress) 01/01/2020 a 10/11/2022
HSI	$0.51 \pm 0.0013$ ( $R^2 = 0.98$ )	$0.47^{**} \pm 0.0048$ ( $R^2 = 0.99$ )
JKSE	$0.47^{**} \pm 0.0075$ ( $R^2 = 0.99$ )	$0.58^{***} \pm 0.0018$ ( $R^2 = 0.98$ )
KLSE	$0.59^{***} \pm 0.0020$ ( $R^2 = 0.98$ )	$0.58^{***} \pm 0.0081$ ( $R^2 = 0.98$ )
KOSPI	$0.57^{***} \pm 0.0010$ ( $R^2 = 0.98$ )	$0.59^{***} \pm 0.0010$ ( $R^2 = 0.98$ )
NIKKEI 225	$0.54^{***} \pm 0.0088$ ( $R^2 = 0.99$ )	$0.55^{***} \pm 0.0011$ ( $R^2 = 0.98$ )
PSEi	$0.48^{**} \pm 0.0022$ ( $R^2 = 0.97$ )	$0.51 \pm 0.0219$ ( $R^2 = 0.97$ )
SET	$0.55^{***} \pm 0.0012$ ( $R^2 = 0.98$ )	$0.65^{***} \pm 0.0023$ ( $R^2 = 0.97$ )
SSE	$0.56^{***} \pm 0.0029$ ( $R^2 = 0.99$ )	$0.49 \pm 0.0207$ ( $R^2 = 0.97$ )
TSEC	$0.54^{***} \pm 0.0011$ ( $R^2 = 0.98$ )	$0.56^{***} \pm 0.0063$ ( $R^2 = 0.99$ )

**Note:** The hypotheses are  $H_0 = 0.5$  and  $H_1 \neq 0.5$ . The asterisks \*\*\*, \*\*, \*, represent the significance of the statistics at 1%, 5%, 10%, respectively.

**Source:** Own elaboration

Table 9 shows the Detrended Cross-Correlation Coefficient ( $\rho DCCA$ ) coefficients for the 9 capital markets studied over two subperiods: Tranquil and Stress. The  $\rho DCCA$  coefficients for the Tranquil subperiod reveal 19 anti-persistent (negative autocorrelation) correlation components, 8 mean correlations ( $\cong 0.333 \rightarrow \cong 0.666$ ), 6 weak correlating factors ( $\cong 0.000 \rightarrow \cong 0.333$ ), and 3 cross-correlation factors without strong trends ( $0.666 \rightarrow \cong 1.000$ ). These findings indicate that the markets under consideration are not integrated, implying that risk mitigation through diversification may

be a smart approach for investors operating in these Southeast Asian regional markets. During the Stress subperiod, there are 18 weak correlation coefficients ( $\cong 0.000 \rightarrow \cong 0.333$ ), 10 mean correlations ( $\cong 0.333 \rightarrow \cong 0.666$ ), 7 anti-persistent correlated coefficients (negative autocorrelation), and 1 strong correlating coefficient ( $0.666 \rightarrow \cong 1.000$ ). When the two subperiods were compared, it was discovered that the  $\rho DCCA$  climbed from anti-persistent to weak and medium non-trend correlation coefficients in the majority of cases. To answer the second research question, which is whether the persistence of returns drove the integration of these regional markets, the answer is no, which means that the second investigation question is rejected due to a lack of evidence.

**Table 9.** A summary of the  $\rho DCCA$  coefficients, applied to the 9 Asian capital markets, regarding the Tranquilo and Stress subperiods

Índices	Tranquilo 02/01/2018 a 31/12/2019			Stress 01/01/2020 a 10/11/2022		
	$\rho DCCA$	Period (days)	Trend	$\rho DCCA$	Period (days)	Trend
KOSPI   HSI	0.68	n > 35	Strong	0.36	n > 29	Médio
KOSPI   JKSE	-0.18	n > 43	Anti-persistent	0.16	n > 136	Weak
KOSPI   SSE	0.33	n > 29	Medium	0.21	n > 112	Weak
KOSPI   TSEC	0.64	n > 4	Medium	0.39	n > 112	Medium
KOSPI   NIKKEI	-0.01	n > 53	Anti-persistent	0.63	n > 92	Medium
KOSPI   SET	0.67	n > 63	Strong	0.58	n > 63	Medium
KOSPI   PSEi	0.13	n > 76	Weak	0.18	n > 43	Weak
KOSPI   KLSE	-0.13	n > 63	Anti-persistent	-0.02	n > 63	Anti-persistent
HIS   JKSE	-0.11	n > 43	Anti-persistent	-0.07	n > 76	Anti-persistent
HIS   SSE	0.33	n > 29	Medium	0.17	n > 112	Weak
HIS   TSEC	0.39	n > 29	Medium	0.15	n > 112	Weak
HIS   NIKKEI	0.44	n > 35	Medium	0.38	n > 35	Medium
HIS   SET	0.67	n > 52	Strong	0.21	n > 52	Weak
HIS   PSEi	0.11	n > 76	Weak	0.05	n > 24	Weak
HIS   KLSE	-0.11	n > 63	Anti-persistent	0.03	n > 29	Weak
JKSE   SSE	-0.11	n > 24	Anti-persistent	-0.01	n > 24	Anti-persistent
JKSE   TSEC	-0.23	n > 43	Anti-persistent	0.07	n > 43	Weak
JKSE   NIKKEI	0.19	n > 35	Weak	0.06	n > 35	Weak
JKSE   SET	-0.11	n > 52	Anti-persistent	-0.29	n > 76	Anti-persistent
JKSE   PSEi	0.42	n > 24	Medium	0.67	n > 136	Strong
JKSE   KLSE	-0.10	n > 29	Anti-persistent	0.47	n > 112	Medium
SSE   TSEC	0.43	n > 20	Medium	0.39	n > 76	Medium
SSE   NIKKEI	-0.18	n > 29	Anti-persistent	0.18	n > 112	Weak
SSE   SET	0.35	n > 52	Weak	0.16	n > 52	Weak
SSE   PSEi	0.07	n > 24	Anti   persistent	0.19	n > 76	Weak
SSE   KLSE	0.05	n > 29	Anti   persistent	0.04	n > 92	Weak
TSEC   NIKKEI	0.11	n > 29	Anti   persistent	0.22	n > 112	Weak
TSEC   SET	0.38	n > 35	Medium	0.50	n > 112	Medium
TSEC   PSEi	0.11	n > 16	Anti   persistent	0.16	n > 136	Weak
TSEC   KLSE	0.07	n > 52	Anti   persistent	0.12	n > 92	Anti   persistent
NIKKEI   SET	0.03	n > 16	Anti   persistent	0.48	n > 92	Medium
NIKKEI   PSEi	0.16	n > 17	Weak	0.02	n > 13	Weak
NIKKEI   KLSE	0.03	n > 52	Anti   persistent	0.15	n > 76	Anti   persistent
SET   PSEi	0.12	n > 52	Weak	0.02	n > 52	Weak
SET   KLSE	0.13	n > 63	Anti   persistent	0.38	n > 112	Anti   persistent
PSEi   KLSE	0.12	n > 43	Anti   persistent	0.39	n > 136	Medium

Source: Own elaboration



## 5. CONCLUSION

The objective of this research was to examine the phenomenon of risk diversification within the capital markets of various Asian nations, namely Hong Kong, Indonesia, Malaysia, South Korea, Japan, the Philippines, Thailand, China, and Taiwan. The study focused on the period spanning from 2 January 2017 to 31 December 2017. The findings of the analysis indicate that the occurrences in 2020 and 2022 did not exert a noteworthy influence on the persistent nature of returns within these markets. This suggests that the state of market efficiency was already established during times characterized by relative tranquility. Moreover, the findings of the study indicate that the existence of persistence and long-term memories did not result in increased financial integration across the regional capital markets. On the contrary, these markets appeared to remain separate and distinct from one another. In conclusion, investors, regulatory authorities, and supervisors have the potential to use these findings to influence their supervisory policies and actions, thereby maintaining stability and efficiency within capital markets. In conclusion, this study provides significant insights for all parties involved in Asian financial markets, offering assistance for their future decision-making and strategic endeavors.

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# Efficiency in the Market Structure of the Banking Sector in Croatia

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**Abstract:** The purpose of this paper was to determine the market structure of the banking sector in Croatia and the characteristics of its technical efficiency for the period from 2009 to 2022 by applying descriptive statistics and data envelopment analysis (DEA). It was determined that the banking sector in Croatia is characterized by a relatively high and persistent technical efficiency of an oligopolistic market structure with a trend of growing consolidation. On average, managers use resources efficiently and are successful in exploiting economies of scale, with scale efficiency surpassing pure technical efficiency. The aforementioned efficiencies generally grow and are achieved more frequently with the increase in the size of banks, i.e., credit institutions. The results imply that small banks could increase efficiency by more rational use of inputs, and, assuming growing returns to scale, by exploiting economies of scale through internal growth or further sector consolidation.

## 1. INTRODUCTION

Different characteristics of individual market structures determine differences in their economic efficiency in general, and technical efficiency specifically. Technical efficiency (TE) or input efficiency is achieved when companies combine inputs in a way that minimizes the costs of a certain amount of output (Pindyck & Rubinfeld, 2005) or achieve maximum output with available inputs (Primorac & Troskot, 2005). Technical efficiency includes scale efficiency (SE) and pure technical efficiency (PTE). Pure technical efficiency reflects (in)efficiency of operation, whereas scale efficiency reflects operating conditions (Cooper et al., 2007). In other words, the first refers to the manager's ability to use resources, and the second refers to utilizing scale economies by operating at the point where the efficiency frontier manifests the characteristics of constant returns to scale (Sufian, 2011).

Given that the banking sector is the backbone of financial markets in Central and Eastern European (CEE) countries, its efficiency influences their costs of financial intermediation as well as the general stability of the financial system (Novickytė & Drożdż, 2018). As a result, there is a growing number of studies on the efficiency of the banking system in the aforementioned countries (Andrieş & Ursu, 2016; Belke et al., 2016; Cevik et al., 2016; Diallo, 2018; Erina & Erins, 2020; Kozak & Wierzbowska, 2019; Kutsomanoli-Filippaki et al., 2009; Řepková, 2014; Roghanian et al., 2012; Stavárek, 2006; Yildirim & Philippatos, 2007; among others), in Croatia (Davidovic et al., 2019; Gardijan Kedžo & Tuškan Sjaus, 2021; Hunjak & Jakovčević, 2003; Jemrić & Vujčić, 2002; Jurčević & Žaja, 2013; Peša et al., 2021; Primorac & Troskot, 2005; Tuškan & Stojanović, 2016; Učkar & Petrović, 2021; among others), but of course also wider. Domestic studies (Gardijan Kedžo & Tuškan Sjaus, 2021; Jemrić & Vujčić, 2002; Peša et al., 2021; Tuškan Sjaus, 2020; Učkar & Petrović, 2021) indicate that the banking sector's efficiency

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generally grew from the 1990s to the present, and that larger banks are more efficient than small or medium-sized ones. At the same time, scientific and practical considerations point to an oligopolistic market structure (Tipurić et al., 2002), i.e., high concentration (Tuškan Sjauš & Zubanović, 2021) of the Croatian banking industry.

The general goal of the paper is derived from the introductory consideration of the paper's subject, and it consists of the analysis and identification of the market structure of the banking sector in Croatia and the characteristics of its technical efficiency from 2009 to 2022, using descriptive statistical analysis and the DEA method. Based on the empirical findings so far, the specific goals derived from the stated general goal have been shaped into the following hypotheses:

**Hypothesis One:** The banking sector in Croatia has an oligopolistic market structure in the period from 2009 to 2022.

**Hypothesis Two:** The market structure of the banking sector in Croatia is technically efficient in the period from 2009 to 2022.

**Hypothesis Three:** The levels and accomplishments of complete technical efficiency of credit institutions in the banking sector in Croatia increased with their size in the period from 2009 to 2022.

Continuing from the introduction, the findings of the research are elaborated in the next chapters of the paper. Starting with the development and structural-business features of the banking sector in Croatia, the state and trend of its market structure are outlined in the second chapter. The third chapter introduces the methodological framework, and the fourth chapter gives the findings of the banking sector's technical efficiency in Croatia in connection to its identified market structure. The fifth chapter presents future research directions and the conclusion highlights the main findings and implications and discusses the contributions and limitations of the paper.

## 2. CROATIA'S BANKING SECTOR DEVELOPMENT AND STRUCTURAL-BUSINESS FEATURES

In the period from 2009 to 2022, there is a noticeable trend of consolidation of the banking sector, which is manifested by a decrease in the number of credit institutions (2009: 39; 2022: 22) and net entry rates, as well as an increase in the minimum efficient scale and the share of entities that meet it, especially in terms of number of employees (2009: 20.51%; 2021: 29.17%; 2022: 27.27%), which consequently results in the growth of market concentration (HHI 2009: 1,319.75, HHI 2012: 1,654.30). Although in the observed period all types of credit institutions recorded a decline in their number, the intensity of these declines varies. The credit institution structure by type illustrates banks' growing dominance, i.e., the fall in the role of savings banks and house savings banks in Croatia's banking industry over time. The foregoing is a direct result, first and foremost, of the expansion of financial markets and the introduction of new methods of meeting housing and other needs (Leko, 2012). As a result, 22 credit institutions existed in Croatia at the end of 2022, 21 of which were banks and one was a house savings bank, whereas no savings bank operated as of March 2018. The banking sector's size structure<sup>4</sup> was dominated by small credit institutions, i.e.,

<sup>4</sup> The size of banks is determined based on the share of their assets in the total assets of the banking sector. Small banks have a share of assets in the banking sector that is less than 1%, medium-sized banks have a share that is greater than 1% but less than 5%, and large banks have a share that is greater than 5%. (Šverko et al., 2012)



banks, whose number declined from 23 in 2009 to 13 in the most recent year, 2022, due to bankruptcies, liquidations, and mergers and takeovers. The number of medium-sized banks ranged from two (from 2018 to 2022) to four (2008; 2013; 2014), while the number of large banks stayed constant at six. Finally, in terms of credit institution ownership structure, foreign banks dominate throughout the period, although their proportion in the structure reduces over time (Hrvatska narodna banka [HNB], 2023a, 2023b). According to data from the end of 2022, 12 credit institutions are foreign-owned, while 10 are domestically owned, seven of which are privately owned and three of which are state-owned (Hrvatska narodna banka [HNB], 2023c).

The banking sector in Croatia in the observed period, but in the preceding periods, is also characterized by the linking of credit institutions into national (Croatian Banking Association (CBA) since 1999) and international (e.g., European Banking Federation (EBF) since 2013) associations and by the differentiation of substitutable services (Rupčić & Superina Gudelj, 2021), particularly driven by the progressive application of advanced information and communications technology (ICT). The rising usage of ICT, along with other variables, undoubtedly has an impact on the profitability of Croatia's banking sector. Profitability during the period in consideration, measured by Return on Assets (ROA) and Return on Equity (ROE), ranged from -1.14% and -9.00% in 2015 to 1.37% and 9.82% in 2019, with fourteen-year averages in the observed period of 0.75% and 5.41%. Banks and credit institutions mainly are generally deemed profitable if their ROA values are at least 1% and their ROE values are greater than 10% (Jurčević & Žaja, 2013). Accordingly, it can be concluded that on average the mentioned traditional requirements are not met. However, what is positive is that in the last five years, except for 2020, the ROA values are in line, and the ROE values are almost in line with the stated requirements.

Following the presented development and structural-business features, it can be concluded, according to Tipurić et al. (2002) and Tuškan Sjauš and Zubanović (2021), the existence and strengthening of the oligopolistic market structure of the banking sector in Croatia during the period from 2009 to 2022 and, accordingly, the hypothesis one is accepted.

### 3. METHODOLOGICAL FRAMEWORK FOR ANALYSING THE EFFICIENCY OF CROATIS'S BANKING SECTOR

Data Envelopment Analysis (DEA) is used to examine the technical efficiency of the banking sector's market structure in Croatia from 2009 to 2022. The method was chosen based on the rare analyses of banking efficiency in Croatia using the aforementioned method, which they carried out in their papers Jemrić and Vujčić (2002), Jurčević and Žaja (2013), Tuškan and Stojanović (2016), Davidović et al. (2019), Peša et al. (2021), Učkar and Petrović (2021), Tuškan Sjauš (2020) and Gardijan Kedžo and Tuškan Sjauš (2021).

In order to determine the TE, PTE, and SE for the banking sector in Croatia for each year, this paper, based on similar domestic (e.g., Gardijan Kedžo & Tuškan Sjauš, 2021; Jemrić & Vujčić, 2002; Peša et al., 2021; Tuškan Sjauš, 2020; Učkar & Petrović, 2021) and foreign studies (Řepková, 2014; Sufian, 2011; among others), both the Charnes-Cooper-Rhodes (CCR) and the Banker-Charnes-Cooper (BCC) input-directed models (CCR-I and BCC-I) were used. Both models were chosen precisely to enable the decomposition of TE into PTE and SE, and their focus on inputs was chosen because, although the banking market is not competitive, management in the banking sector has a greater ability to influence input minimization than output maximization (Učkar & Petrović, 2021). Therefore, the decision-making units (DMUs) included in the analysis

are (managers of) credit institutions (banks, savings banks, and housing savings banks) that operated in Croatia throughout certain years of the observed period.

Based on the literature review in the field of bank efficiency research, four equivalent approaches to identifying input and output dominate - the production, the intermediation, the added value and the operating or profit-oriented approach (Drake et al., 2006; Sufian, 2011). While the first two approaches apply the traditional microeconomic theory of the company to banking and differ only in the specification of banking activities, the last two approaches go a step further and modify the classical theory by incorporating some specific banking activities. The suitability of each approach varies depending on the circumstances (Sufian, 2011). Based on the fact that banks in Croatia are of a universal type and perform a variety of activities, as well as for practical reasons of ensuring comparability with previous studies (e.g., Jemrić & Vujčić, 2002; Jurčević & Žaja, 2013; Peša et al., 2021; Tuškan & Stojanović, 2016; Tuškan Sjaus, 2020; Učkar & Petrović, 2021), the inputs and outputs are determined using the operating approach. Following the operating approach's cost and income management perspective, each decision maker, i.e., credit institution has four inputs: (I1) interest costs, (I2) commission and fee costs, (I3) other non-interest costs, and (I4) general administrative costs and depreciation, and three outputs: (O1) interest income, (O2) commission and fee income, and (O3) other non-interest income.

Annual data on defined inputs and outputs of all credit institutions in Croatia during the observed period were used, which were extracted from the Croatian National Bank's Bulletin on Banks for individual years from 2010 to 2019 and from financial statements of credit institutions for years 2018 to 2022. The descriptive statistics of the input and output variables used to build the DEA model are available upon request.

#### 4. TECHNICAL EFFICIENCY OF THE CROATIA'S BANKING SECTOR

The results of applying the CCR-I model (Table 1), which assumes constant returns to scale, show that the banking sector's average annual global TE ranged from 0.8793 (2016) to 0.9725 (2022), with a fourteen-year average of 0.9283. As a result, the period's average relative inefficiency, that is average surplus of inputs in relation to the need for inputs when operating at the limit of efficiency, is 7.84%. Large banks have the highest average TE, whereas small banks have the lowest. The number of credit institutions operating on the efficiency limit, i.e., those that are technically efficient, as well as those whose TE is at or above the TE average, ranges from 15 (2016) to 24 (2011) and on average accounts for more than half (58, 65%) of the total number of credit institutions during the observed period. The size of credit institutions determines their representation in the set of technically efficient credit institutions. Based on fourteen-year averages, large banks dominate the set of technically efficient credit institutions (79.76%), followed by medium-sized banks (68.45%), and finally small banks (43.39%). Savings banks (72.22%) and housing savings banks (78.10%) have comparable participation rates. In terms of the coefficient of variation, the volatility of credit institutions in the covered period does not exceed 20%. The year 2016 was the most volatile (19.29%), characterized by the already mentioned, least favourable remaining efficiency indicators.

Although the results of the local PTE analysis revealed by the BCC-I model (Table 2) based on the assumption of variable returns to scale inherently show higher levels of efficiency, the main findings are consistent with those of the CCR-I model. From 2009 to 2022, the banking sector's average annual local PTE fluctuated between 0.8997 (2015) and 0.9972 (2022), with a

fourteen-year average of 0.9505. In comparison to operations at the efficiency limit, this implies that the period's average relative inefficiency or the average excess of inputs is 5.31%. On average, the largest PTE is achieved by large banks, and the smallest by small banks. Except in 2015 (48.48%), the number of credit institutions operating on the efficiency frontier, characterized by PTE, is larger than 50%, with a period average of 2/3 (66.95%). This figure, as well as the number of credit institutions with PTEs equal to or higher than the PTE average, fluctuates between 16 (2015) and 26 (2011). As with TE, the presence of efficient credit institutions is highest in the large bank group (fourteen-year average: 90.48%), followed by medium-sized banks (fourteen-year average: 82.14%), and lowest in the small bank group (fourteen-year average 50.33%). Savings banks and housing savings banks are represented by 88.89% and 84.29% of their total number. Considering the elimination of SE effects, PTE volatility is consistently lower than TE volatility, implying that more credit institutions are closer to the average PTE than to the average TE. The highest PTE volatility was recorded in 2014 when it was 14.47%.

Finally, the findings of the SE analyses (Table 3), as a quotient of TE and PTE, identify the movement of the average SE of the banking sector in the examined period in the range of 0.9573 (2016) and 0.9876 (2017) and, correspondingly, with a high temporal average of 0.9758. Large banks achieve the greatest average SE ratings, whereas small banks achieve the lowest. Higher SE values compared to PTE, along with other measures, imply that the SE impact, while not by much, outperforms the local PTE effect in determining the total, that is, the global TE. Specifically, compared to the achievement of economies of scale and reaching the optimum point characterized by constant returns to scale, the average relative inefficiency in the covered period is only 2.48%. Although SE is generally more favourable, compared to TE and PTE, it is achieved by a smaller number of credit institutions. Specifically, from 43.59% to 79.17% of them, depending on the year, that is, on average 58.27% in total, 49.46% in the category of small banks, 66.67% in the group of medium-sized banks, and 73.81% large banks. And the frequencies of savings banks (44.44%) and housing savings banks (63.81%) are consistently lower. Parallel with TE and PTE, the variability of SE is in overall the lowest, with a maximum of 15.25% in 2016.

In all observed years, two credit institutions achieve full TE, full PTE, and therefore full SE: Hrvatska poštanska banka d. d. and Zagrebačka banka d.d. Accordingly, these credit institutions are considered absolutely technically efficient. Similarly, for the period from 2009 to 2018, Gardijan Kedžo and Tuškan Sjauš (2021) detected the dominance of Erste&Steiermärkische Bank d. d. and Zagrebačka banka d.d. Furthermore, the temporal trends of TE, PTE, and SE are broadly consistent with one another, as well as with the movements of ROA and ROE during the observed period. The above points to the agreement between the results of the efficiency evaluation using the non-parametric DEA method and traditional (profit) efficiency measures.

Based on the presented results of the analysis of the technical efficiency of the banking sector in Croatia for the period from 2009 to 2022, hypotheses two and three are accepted. Also, the results are consistent with the findings of Peša et al. (2021) and Učkar and Petrović (2021), and in the context of hypothesis two, to a greater extent, with the findings of Gardijan Kedžo and Tuškan Sjauš (2021), and in the context of hypothesis three, predominantly with the findings of Jemrić and Vujčić (2002).

**Table 1.** Summary results of the application of the CCR-I model for the TE analysis of the banking sector in Croatia for the period 2009–2022

measure	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	average
average efficiency	0,9250	0,9221	0,9339	0,9151	0,9145	0,8839	0,8806	0,8793	0,9482	0,9425	0,9369	0,9707	0,9717	0,9725	0,9283
standard deviation	0,0915	0,1209	0,1133	0,1177	0,1368	0,1451	0,1258	0,1696	0,0788	0,0920	0,1093	0,0580	0,0727	0,0814	0,1081
coefficient of variation (%)	9,89	13,11	12,13	12,86	14,96	16,42	14,28	19,29	8,31	9,77	11,67	5,98	7,48	8,37	11,75
maximum	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
minimum	0,5705	0,5500	0,5884	0,5749	0,5217	0,5496	0,6383	0,1895	0,7085	0,7099	0,6468	0,7696	0,7196	0,6139	0,5965
number of DMUs	39	38	37	36	35	33	33	31	29	25	24	24	23	22	30,64
number of effective DMUs	17	21	24	19	18	16	16	15	16	16	16	16	19	16	17,50
%	43,59	55,26	64,86	52,78	51,43	48,48	48,48	48,39	55,17	64,00	66,67	66,67	82,61	72,73	58,65
from that	small	8	9	12	8	6	4	4	5	6	5	8	9	10	7,14
	%	34,78	39,13	54,55	38,10	31,58	23,53	31,25	40,00	38,46	46,15	61,54	69,23	76,92	43,39
	medium	1	2	2	1	3	2	3	2	1	2	1	2	2	1,86
	%	33,33	66,67	66,67	33,33	75,00	50,00	100,00	66,67	50,00	100,00	50,00	100,00	100,00	68,45
	large	3	5	5	5	4	5	5	5	6	6	5	5	3	4,79
	%	50,00	83,33	83,33	83,33	66,67	83,33	83,33	83,33	100,00	100,00	83,33	83,33	50,00	79,76
	savings banks	1	1	1	1	1	1	0	0	0	0	0	0	0	0,50
	%	50,00	100,00	100,00	100,00	100,00	100,00	0,00	0,00						72,22
	housing savings banks	4	4	4	4	4	4	2	3	4	2	2	3	1	3,21
	%	80,00	80,00	80,00	80,00	80,00	80,00	40,00	60,00	100,00	66,67	66,67	100,00	100,00	78,10
number of DMUs with efficiency at or above average	21	26	27	23	24	19	17	17	20	17	18	17	20	17	20,21
number of inefficient DMUs	22	17	13	17	17	17	17	16	13	9	8	8	5	6	13,21
average inefficiency	0,0811	0,0845	0,0707	0,0927	0,0935	0,1313	0,1356	0,1373	0,0547	0,0610	0,0674	0,0302	0,0291	0,0283	0,0784

Source: Own calculations

**Table 2.** Summary results of the application of the BCC-I model for the PTE analysis of the banking sector in Croatia for the period 2009–2022

measure	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	average
average efficiency	0,9487	0,9411	0,9479	0,9347	0,9372	0,9021	0,8997	0,9201	0,9596	0,9703	0,9708	0,9904	0,9877	0,9972	0,9505
standard deviation	0,0652	0,0925	0,0951	0,0999	0,1121	0,1305	0,1097	0,1074	0,0700	0,0590	0,0648	0,0395	0,0420	0,0106	0,0784
coefficient of variation (%)	6,87	9,82	10,03	10,69	11,97	14,47	12,19	11,68	7,29	6,08	6,68	3,98	4,26	1,06	8,36
maximum	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
minimum	0,7851	0,7074	0,6670	0,6292	0,5650	0,5768	0,6505	0,7081	0,7280	0,7589	0,7728	0,8040	0,8015	0,9501	0,7217
number of DMUs	39	38	37	36	35	33	33	31	29	25	24	24	24	22	30,71
number of effective DMUs	20	23	26	21	19	17	16	18	19	18	19	22	21	20	19,93
%	51,28	60,53	70,27	58,33	54,29	51,52	48,48	58,06	63,33	72,00	79,17	91,67	87,50	90,91	66,95
from that	small	7	12	13	10	6	4	6	7	6	8	11	10	11	8,21
	%	30,43	52,17	59,09	47,62	31,58	23,53	37,50	46,67	46,15	61,54	84,62	76,92	84,62	50,33
	medium	2	1	3	1	3	2	3	3	2	2	2	2	2	2,21
	%	66,67	33,33	100,00	33,33	75,00	66,67	100,00	100,00	100,00	100,00	100,00	100,00	100,00	82,14
	large	5	5	5	5	5	5	5	6	6	6	6	6	6	5,43
	%	83,33	83,33	83,33	83,33	83,33	83,33	83,33	100,00	100,00	100,00	100,00	100,00	100,00	90,48
	savings banks	2	1	1	1	1	1	1	0	0	0	0	0	0	0,64
%	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	0,00					88,89	
housing savings banks	4	4	4	4	4	4	4	3	3	4	3	3	3	1	3,43
%	80,00	80,00	80,00	80,00	80,00	80,00	80,00	60,00	60,00	100,00	100,00	100,00	100,00	100,00	84,29
number of DMUs with efficiency at or above average	23	26	27	24	26	20	16	19	22	19	19	22	21	20	21,71
number of inefficient DMUs	19	15	11	15	16	16	17	13	10	7	5	2	3	2	10,79
average inefficiency	0,0541	0,0625	0,0550	0,0698	0,0670	0,1085	0,1115	0,0868	0,0421	0,0306	0,0301	0,0097	0,0124	0,0028	0,0531

Source: Own calculations



**Table 3.** Summary results of the SE analysis of the banking sector in Croatia for the period 2009–2022

measure	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	average			
average efficiency	0,9738	0,9782	0,9850	0,9779	0,9725	0,9778	0,9773	0,9573	0,9876	0,9710	0,9636	0,9798	0,9836	0,9753	0,9758			
standard deviation	0,0553	0,0702	0,0624	0,0574	0,0583	0,0484	0,0492	0,1460	0,0248	0,0685	0,0795	0,0386	0,0585	0,0832	0,0643			
coefficient of variation (%)	5,68	7,17	6,34	5,87	6,00	4,95	5,04	15,25	2,51	7,06	8,25	3,94	5,95	8,53	6,61			
maximum	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000			
minimum	0,6789	0,6268	0,6208	0,7249	0,7483	0,8369	0,8095	0,1895	0,8847	0,7099	0,6468	0,8406	0,7196	0,6139	0,6894			
number of DMUs	39	38	37	36	35	33	33	31	29	25	24	24	24	22	30,71			
number of effective DMUs	17	21	24	19	18	16	16	15	16	16	16	16	19	16	17,50			
%	43,59	55,26	64,86	52,78	51,43	48,48	48,48	48,39	53,33	64,00	66,67	66,67	79,17	72,73	58,27			
from that	banks	small	7	14	15	14	1	3	7	4	5	6	5	6	8	9	11	8,36
		%	30,43	60,87	68,18	66,67	31,58	41,18	22,22	31,25	40,00	38,46	46,15	61,54	84,62	49,46		
		medium	1	1	3	1	3	3	2	3	2	1	2	1	2	1	1,86	
		%	33,33	33,33	100,00	33,33	75,00	75,00	66,67	100,00	66,67	50,00	100,00	100,00	50,00	50,00	66,67	
	large	3	3	5	3	4	4	5	5	5	6	6	5	5	3	4,43		
		%	50,00	50,00	83,33	50,00	66,67	66,67	83,33	83,33	100,00	100,00	83,33	83,33	50,00	73,81		
	savings banks	2	1	0	0	1	0	1	0	0	0	0	0	0	0	0,36		
	%	100,00	100,00	0,00	0,00	100,00	0,00	100,00	0,00	0,00						44,44		
	housing savings banks	4	2	1	1	4	2	4	2	3	4	2	2	3	1	2,50		
	%	80,00	40,00	20,00	20,00	80,00	40,00	80,00	40,00	60,00	100,00	66,67	66,67	100,00	100,00	63,81		
number of DMUs with efficiency at or above average	29	33	31	30	27	27	28	26	20	20	17	16	21	19	24,57			
number of inefficient DMUs	22	17	13	17	17	17	17	16	13	9	8	8	5	6	13,21			
average inefficiency	0,0270	0,0223	0,0153	0,0226	0,0283	0,0227	0,0232	0,0446	0,0126	0,0299	0,0377	0,0206	0,0167	0,0253	0,0249			

Source: Own calculations

## 5. FUTURE RESEARCH DIRECTIONS

Given the extent of this paper, it is suggested to channel future research in the direction of analysing other dimensions of efficiency: dynamic efficiency, inherent in oligopoly and monopoly markets, and allocative and cost efficiency. Furthermore, it is suggested that future research take into account other limitations of this study, particularly the sensitivity of the results to the methodological approach (choice of method and input and output) and the absence of identification of the character of returns to scale. Also, this research can be extended temporally, sectorally and geographically, by analysing an even longer period in order to comparatively monitor changes in efficiency over time within the same and between different sectors in one or more countries. Finally, there are numerous possibilities for extending the research on the relation to market structure — efficiency — business and economic performance.

## 6. CONCLUSION

The banking sector is the backbone of financial markets and economies of CEE countries, including Croatia. Consequently, the efficiency of its market structure affects the performance of the financial and economic system in general. For this reason, the purpose of the paper was to determine the market structure of the banking sector in Croatia and the characteristics of its TE for the period from 2009 to 2022 using descriptive statistical analysis and the DEA method. Based on the descriptive analysis, consistent with hypothesis one, an oligopolistic market structure with characteristics of growing consolidation was established. The results of the technical efficiency analysis using the DEA method reveal the persistence of a relatively high average TE, as well as its components: PTE and SE. Full total TE (58.65 %), PTE (66.95 %) and SE (58.27 %) were achieved on average in the observed period by more than half of the credit institutions. It is concluded, following hypothesis two, that on average managers use bank resources efficiently and are more successful in exploiting economies of scale, which synergistically determines a relatively high average TE. At the same time, as assumed by hypothesis three, the aforementioned efficiencies generally grow and are achieved more frequently the larger the size of the bank, that is, the credit institution. Thus, large banks achieve the highest levels and most often achieve full PTE, SE and overall TE. The opposite is true for small banks. Additionally, the results of the analysis reveal relatively low to moderate volatility of average (in)efficiencies (TE, PTE and SE) and equal degrees of homogeneity between PTE and SE of credit institutions.

The findings imply that small banks in Croatia could increase efficiency by using inputs more rationally and assuming growing returns to scale, by exploiting economies of scale. With the aforementioned assumption, positive effects on efficiency can be achieved by changing the volume of operations through internal growth or further consolidation in the sector. The study suggests that to take advantage of cost advantages due to the use of economies of scale, efficient banks should absorb inefficient banks. In addition to the aforementioned implications aimed at improving static TE, long-term efficiency improvements can also result from innovative banks that develop and introduce new technologies.

Despite the detected limitations, this research is valuable because it stands out among the rare existing related studies in Croatia in its spatial and temporal coverage, covering the entire banking sector for the longest period. In this way, it contributes to existing studies on the efficiency of the banking sector in Croatia and beyond, while providing a foothold for future research. The practical contribution of the paper is in the implications of the research results for the bank's management, the central bank, the association of banks, the government, and other bodies in the financial market.

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# Project Sustainable Economy: The Significance of Project Teams

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**Abstract:** *Project Sustainable Economy is a unique project approach to business that balances and solves the project's environmental, social, and economic aspects with the primary objective of effectively addressing the current requirements of stakeholders, according to the authors from two Project Management Institute definitions. For all projects aimed at business growth, development and sustainability, the quality of teams is crucial. This research aims to investigate the factors within project teams that have an impact on the success of sustainable business projects. The research identifies success-contributing factors in the Project Sustainable Economy, such as decision time, team dynamics, acceptance of proposed methods, a defined plan, quality of relationships, successful project managers, and constructive conflict resolution. The paper's substantive contribution lies in empirical research conducted on a sample of 102 project team members. The findings underscore that enhanced communication and interpersonal relationships among team members emerge as pivotal factors fostering success within the ambit of the sustainable economy project.*

## 1. INTRODUCTION

Today, there is a growing emphasis on environmental preservation, sustainable development, and investments directed toward projects and initiatives that have a positive impact on the environment and society. The **United Nations (2015)** adopted the Sustainable Development Goals as a roadmap for achieving a sustainable and inclusive society by 2030. Sustainable projects have become essential elements in developing modern entrepreneurship and economic prosperity. The **European Commission (2018)** published its first Action Plan for a Greener and Cleaner Economy. The European Union established the European Green Deal as a foundation for a green transition, with goals including climate neutrality by 2050, strengthening the economy through green technology, creating a sustainable industry, and reducing pollution (**European Commission, 2019**). The European funds distributed financial assets in seven-year financial periods or perspectives. Various EU funds enable the financing and initiation of numerous projects in renewable energy sources, energy efficiency, nature conservation, recycling, and many other ecologically sustainable initiatives.

Therefore, society's economy and economic development are moving toward a project-based business model. *A project represents a temporary endeavour to create a unique product, service, or result with a defined start and end, specified goals, costs, and deadlines (Project Management Institute, 2021). The Project Economy is described as a fundamental paradigm shift in business, moving toward using projects to handle work and solve problems (Project Management Institute, 2021).* In the Project Economy, it is crucial to have individuals with the skills and

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capabilities to turn ideas into reality. *Sustainability involves balancing different concerns: environment, such as climate change; society, such as community; economy, such as affordability; and administration, such as health and safety* (Project Management Institute, 2021).

From the mentioned definitions, the authors create the following definition: Project Sustainable Economy is a unique project approach to business that balances and solves the project's environmental, social, and economic aspects with the primary goal of meeting the current needs of stakeholders.

To achieve a Project Sustainable Economy, well-organized project teams are necessary. The main goal of this paper is to investigate the factors within project teams that have a crucial impact on the success of a project sustainable economy. Based on data collected through primary research, the paper analyses team members' crucial communication and relationship factors, which are essential for success in the project sustainable economy. Empirical research allows the analysis of the significance of the communication and relationship factors in a project sustainable economy.

## 2. LITERATURE REVIEW

If society wants to reach the goals of climate neutrality by 2050, it needs to develop many sustainable projects. In a situation where the product life cycle has shortened due to a constant need for innovations and changes, the use of project management models for the development of a society focused on a project sustainable economy becomes necessary. Achieving strategic goals is essential for aligning with the management of sustainable projects realizing enhanced value for individuals and organizations. Concepts and models of green development (Borodina et al., 2022) are essential for sustainable development.

The effects (positive or negative) of climate change are global and local (Naseem & Abbas, 2022). A clean, sustainable, carbon-free economy poses challenging goals for project managers and teams. The EU Biodiversity Strategy for 2030 aims to enhance the protection and restoration of nature (European Commission, 2020). Marine Strategy provides legal protection and obligations for restoring carbon sinks in wetlands, forests (Ohmura & Creutzburg, 2021), and other carbon-rich habitats. The biodiversity of the oceans, or Blue Economy (Proczek & Garbarczyk, 2023), is subject to human activity and climate change effects. Taxonomy (Agarwala et al., 2021) can help trace climate change's physical and transition impacts. Climate projects require an unprecedented structural transformation of the global economy over the next few decades. Managing or participating in multiple projects simultaneously is the main reason for delays (Gordon et al., 2021) and the failure to achieve set goals. The relationship between complexity and seniority (Barbalho et al., 2022) is essential for the project schedule. The study by Chadi and Homolka (2023) confirms that increasing team size does not change team performance.

A project's success depends on the characteristics and interaction of the individuals forming project teams. Behind every successful project is a team of members with unique skills, experiences, and perspectives collaborating to overcome challenges and achieve set goals. Integrating soft skills (Shkoda et al., 2022) and hard skills is crucial for project success. Projects must contribute to companies' strategy and stakeholders' benefits (Castro et al., 2022).

Project managers must possess well-developed soft skills: communication, teaching, motivation, etc., essential in the profession (Podgórska & Pichlak, 2019) to engage their team and keep

the project focused on set objectives. A project manager's emotional intelligence can contribute to creating project team satisfaction (Zhang et al., 2018), improve the company's climate (Castro et al., 2022), boost collaboration satisfaction (Zhang et al., 2018), increase job engagement (Qureshi et al., 2020), minimizing team turnover (Rehman et al., 2020), increasing trust toward their team and vice versa (Rodrigues & Rebelo, 2021) or solve a coordination problem (Duijf, 2021). Despite being above-average in quality, many projects or project teams fail due to a lack of leadership.

Project team members with a higher level of involvement and influence, promote learning, creativity, and adaptation within the project team's environment (Shafique et al., 2023). The project team needs the freedom to focus on delivery, value, and experimentation. Trust positively influences team performance and project success (Imam & Zaheer, 2021). The influence of trust and its impact on project execution and outcomes is confirmed (Guo et al., 2021). Team efficacy is based on trust, cooperation, and knowledge sharing (Imam & Zaheer, 2021).

Projects are drivers of innovation, growth, and success, which is crucial for business. Better transmission of information leads to shorter and more frequent rest periods, impacting faster project completion. The Project Management Institute (2017) forecasts that the value of project activities worldwide will reach \$20 billion by 2027, creating jobs for an estimated 88 million people. It is vital for construction projects to establish the idea of complexity and identify the elements that influence it (Abdullahi et al., 2022). The latest trends in using digital platforms for remote work, various artificial intelligence applications, and data analysis pose new challenges for project teams. As indicated by Corrocher and Lenzi (2022), knowledge diversity is positively associated with innovation. The digital economy (Skvarciany et al., 2023) is essential to sustainable development. Digital project teams (Liu et al., 2023) are facing challenges in improving performance in the interactive era of the knowledge economy and digital technologies.

Effective management of project stakeholders in terms of cost, time, and quality, as emphasized by Khalilzadeh et al. (2021), is crucial. Balancing stakeholder interests with project objectives is crucial for resolving conflicts (Bahadorestani et al., 2020). Stakeholder management aids project managers in selecting strategies to maximize project value.

The agile nature of project teams must align with the growing needs of a sustainable project economy. Organizations undergo changes ranging from minor adjustments to internal processes to complete structure and business strategy revisions. Project teams consist of individuals with diverse skills, knowledge, and experiences selected according to project needs, including a project manager, team members, sponsors, and users. Project teams should have individuals in various roles, such as Isaac Adizes' Roles (Andonovic et al., 2014, p. 6): producer, administrator, entrepreneur, and integrator. No one in project teams can fulfil all roles. The fundamental elements of a project include an excellent manager, a good team, effective work organization, and quality communication (Šimović & Varga, 2011).

This study formulates two hypotheses based on the literature review:

**Hypothesis One:** The success of projects in the project sustainable economy depends on better-improved communication and relationships among team members, satisfying team characteristics such as decision time, team dynamics, acceptance of proposed methods, defined plans, quality of relationships, successful project managers, and constructive conflict resolution.

**Hypothesis Two:** There is a statistically significant difference in respondents' opinions regarding their position in the project team on the impact of communication and relationships among team members on the project's success in the project sustainable economy.

### 3. METHODOLOGY

The main goal of this study is to investigate the communication and relationship factors within project teams and whether they have a crucial impact on the success of sustainable business projects. The empirical research was conducted on 102 members of project teams with an on-line survey from August to November 2023.

The questionnaire consisted of two parts. The first part of the questionnaire included general questions related to the respondents, the company, the activities, the company's ownership and the respondent's position within the organization, and other general questions. In the second part, the respondents evaluated the success of the project implementation through the main characteristics of the project team, with ratings from the offered options on the Likert scale: 1- do not agree at all, 2 - do not agree, 3 - neither agree nor disagree, 4 - agree and 5 - completely agree.

The hypotheses tested by the Kruskal Wallis Test for H1 and Correlation for H2 between the positions in the team of respondents and communication and relationships of team members in the SPSS program. From 102 respondents, internal project team members participated 67.6%, project managers 26.6% and external team members 11.8%. 56.9% of respondents were men, and 43.1% were women. In the sample, 57% of the respondents are in the age group of 36-55 years, 28% are in the age group of 18-35 years, and 15% are in the age group older than 55 years. Regarding years of service, the largest group (63.7%) consists of respondents with 10-35 years of work experience, 30.4% of respondents with less than ten years of experience, and 5.9% of respondents with more than 35 years of work experience.

Communication and relationships of team members serve as the primary grouping variable in Kruskal Wallis Test. Communication and relationships of team members is average of four variables such as: project team relationship, project team responsibilities (both common and individual), respect of differences among project team members and the significance of open communication in project team members.

Table 1 presents the descriptive statistics for the main variable, communication, and relationships. The average score for Communication and relationships is 3.67. Notably, respondents assigned the highest score, 4.01, to the respect of differences among project team members. On the other hand, the lowest score of 3.5 was attributed to project team relationships.

**Table 1.** Descriptive statistics of main variables

	N	Range	Min.	Max	Sum	Mean		Std. Dev.
		Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
<b>T. Relationship</b>	102	4.00	1.00	5.00	357.00	3.50	.12207	1.233
<b>T. Responsibilities</b>	102	3.00	2.00	5.00	361.00	3.54	.07461	.753
<b>Team Differences</b>	102	3.00	2.00	5.00	409.00	4.01	.08975	.906
<b>Open comm.</b>	102	3.00	2.00	5.00	372.00	3.65	.09818	.991
<b>Communication and relationships</b>	102	2.50	2.50	5.00	374.75	3.67	.05785	.584

**Source:** Own calculations

**Table 2.** Descriptive statistics of the tested variables

	Mean	Std. Deviation	Percentiles		
			25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>
Decisions time	3.59	1.229	2.75	4.00	5.00
Teams' dynamics	3.72	1.238	3.00	4.00	5.00
Acceptance of proposed method	4.16	1.158	3.25	5.00	5.00
Defined plan	4.36	1.124	4.00	5.00	5.00
Quality of relationships	4.16	0.962	4.00	4.00	5.00
Successful project managers	4.16	0.829	3.00	4.00	5.00
Constructive conflict resolution	4.17	0.924	4.00	4.00	5.00
Communication and relationships of team members	3.67	0.584	3.25	3.75	4.00

**Source:** Own calculations

Descriptive statistics of the tested variables are presented in Table 2. Variables in Table 2 indicate the following statements: (i) decision time - within the team, decisions are made on time (ii) teams' dynamics - Dynamics within the team have a positive effect on the work of the team, (iii) acceptance of proposed method - The project team members accept the proposed methods for teamwork, (iv) defined plan - A clearly defined execution plan affects the success of the project, (v) quality of relationships - Good relations in the project team have a positive effect on the success of the project, (vi) Successful project managers - A successful project manager is essential, (vii) Constructive conflict resolution - Constructive resolution of conflicts is necessary. The highest score was 4.36 for a well-defined projects plan, and the lowest was 3.59 for decision time.

#### 4. RESEARCH RESULTS AND DISCUSSION

From a financial perspective, the Republic of Croatia will have access to nearly €25 billion from 2021 to 2027. These funds, sourced from various EU programs, enable the financing and initiation of numerous projects in renewable energy sources, energy efficiency, nature conservation, recycling, and other various ecologically sustainable initiatives.

Communication and relationships within project teams are crucial for project success, and this aspect is precisely the focus of this research segment.

A non-parametric Kruskal-Wallis H-test was used to compare multiple independent data groups based on an ordinal scale. Cronbach's Alpha is greater than 0.8 for all variables, signifying excellent reliability of the sample results. Given that the conditions for parametric tests were not met (due to non-normality of data distribution), the non-parametric Kruskal-Wallis (H-test) was used to test the set hypothesis. Results of the Kruskal-Wallis H test indicate a significance level of less than 0.01 for the variables: decision time, team dynamics, acceptance of proposed methods, defined plan, quality of relationships, successful project managers, and constructive conflict resolution (sig = 0.000).

**Table 3.** Kruskal Wallis Test

Test Statistics <sup>a,b</sup>							
	Decisions time	Team dynamic	Accep. Pr. methods	Defined plan	Quality of relationships	Successful PM	Constructive conflict resolution
Chi-Square	38.103	34.794	37.762	39.997	41.055	38.779	52.186
Asymp. Sig.	.000	.000	.000	.000	.000	.000	.000

**Note:** a. Kruskal Wallis Test. b. Grouping Variable: Communications and relationships of team members

**Source:** Own calculations



According to the Kruskal-Wallis H test, the alternative hypothesis is accepted. According to the results of the analysis, hypothesis One: *The success of projects in the project sustainable economy depends on better-improved communication and relationships among team members, satisfying team characteristics such as decision time, team dynamics, acceptance of proposed methods, defined plans, quality of relationships, successful project managers, and constructive conflict resolution* is accepted.

Table 4 presents the Chi-Square Test of the second hypothesis.

**Table 4.** Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
<b>Pearson Chi-Square</b>	51,633 <sup>a</sup>	18	,000
<b>N of Valid Cases</b>	102		

**Note:** a. 24 cells (80,0%) have expected count of less than 5. The minimum expected count is ,35.

**Source:** Own calculations

There is a statistically significant difference ( $\chi^2(18) = 51.633, p = .000$ ) in the opinions of respondents in different positions regarding the impact of project team communication and relationships on the success of the project (table 4).

**Table 5.** Crosstab position and communication and relationships

		Communication and relationships					
		1	2	3	4	5	Total
POSITION	<b>INTERNAL MEMBER</b>	0.0%	13.0%	56.5%	30.5%	0.0%	100.0%
	<b>EXTERNAL MEMBER</b>	0.0%	0.0%	25.0%	50.0%	25.0%	100.0%
	<b>PROJECT MANAGER</b>	0.0%	0.0%	57.1%	42.9%	0.0%	100.0%

**Source:** Own calculations

Among internal team members (Table 5), 56,5% rated communication and relationships with a score of 3, while 30.5% assigned the highest rating of 4. In contrast, for external members 25% gave the highest mark of 5, and 50% rated it as 4. Project managers gave 57.1% a score of 3, and 42.9% rated it as 4 regarding the impact of communication and relationships among team members.

According to the results of the analysis, Hypothesis Two which states that *There is a statistically significant difference in respondents' opinions regarding their position in the project team on the impact of communication and relationships among team members on the project's success in the project sustainable economy*, is accepted.

The significance of a strong leader is emphasized as more critical than the pleasurable emotional state of job satisfaction (Castro et al., 2022). Trust is a crucial factor influencing project performance, both within the team and for project managers.

The factors influencing communication and relationships explored in this paper include decision time, team dynamics, acceptance of proposed methods, a defined plan, and quality of relationships. These factors are confirmed by Juras's research (2019) involving 83 project team members.

The factors influencing communication and relationships researched in this paper include decision time, team dynamics, acceptance of proposed methods, defined plan, quality of relationships, successful project managers, and constructive conflict resolution.

Research further affirms the importance of project management, as indicated in the study by [Castro et al., \(2022\)](#) on a sample of 101 project professionals, highlighting the significant impact of project managers' emotional intelligence and their team members' trust in project success.

The examined factors, such as decision time, team dynamics, acceptance of proposed methods, a defined plan, and quality of relationships are again confirmed in Juras's research ([Juras, 2019](#)) on 83 project team members. Project team dynamics, characterized by strong goal orientation and highly efficient decision-making ([Juras, 2019, p. 279](#)) play a significant and boosting role in positively affecting project success.

The research not only confirms that communication and relationships within the team facilitate better collaboration, communication, and mutual understanding among team members, but also impact the improvement of innovation, motivation, and conflict-resolution abilities. This confirmation is found in [Fung's study \(2013, p. 147-148\)](#) with a sample of 201 project team members, where team trust directly predicts project performance and effectiveness. Project complexity, impacting project success, and team performance requires mitigation strategies to overcome project failure ([Shafique et al., 2023](#)), as confirmed by 420 respondents. Consequently, constructive conflict resolution is deemed necessary.

Project managers must possess the ability to motivate their team, stimulate cooperation between team members, encourage knowledge transfer, and promote open discussion of problems and conflict resolution to enhance project results ([Capaldo et al., 2021](#)).

However, overall, research confirms that good communication and relationships within a project team have a positive impact on project success.

## 5. FUTURE RESEARCH DIRECTIONS

The global economy has struggled to address the challenges of climate change, artificial intelligence, and unfavorable demographic trends. The first proposal for further research is to specialize in investigating factors that can accelerate the successful implementation of sustainable development projects. The second proposition for future research involves expanding the research sample, not only in Croatia but also in other EU countries.

Managing the risk of sustainable projects requires long-term solutions, as it increases business uncertainty and demands constant adaptation to change.

## 6. CONCLUSION

Understanding project management and studying different approaches and methodologies are essential for a sustainable project economy. The paper defines priorities, explores challenges in forming project teams and analyses how communication and relationships within project teams impact project success.

The study confirmed that communication and relationships significantly impact the success of Project Sustainable Economy. The research identifies success-contributing factors, including a clearly defined plan, decision time, team dynamics, acceptance of proposed working methods, assigned individual and collective responsibilities of project team members, optimal

communication in the project, the role of a constructive approach to solving potential problems, and management of resources and project risks. In a project sustainable economy, successful project management enables organizations to navigate necessary changes and seek opportunities for sustainable, socially, and environmentally efficient management of global resources. The goals of all project stakeholders must be considered because what one group or individual perceives as success may be considered a failure by others, and vice versa.

This research can contribute primarily to project managers and team members, but also to all other project participants, as they all play a crucial role in achieving the goals and success of sustainable projects. The main limitation of this study is the small and country-limited sample.

A project sustainable economy helps to overcome existing uncertainties and efficiently manage risks in all economic and social aspects. This is achieved thanks to the skills and abilities of project teams using utilizing various project management knowledge areas to fulfil project goals.

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# Engagement of Computer Professionals (On the Example of Bulgarian Companies in the IT Sector): Incentives as Moderator

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**Abstract:** *Employee engagement is linked to enthusiasm and passion about the job, identification with the company's values and loyalty to the employer. It is directly dependent on the incentives applied by the management. We have conducted a study in Bulgarian IT companies to analyze how certain incentives affect the engagement levels of computer professionals. Our main hypothesis suggests that intangible incentives have a stronger impact on employee engagement than tangible ones. The means of collecting empirical data from respondents are surveys and in-depth interviews, and the statistical method used is  $X^2$  analysis.*

## 1. INTRODUCTION

The IT sector in Bulgaria is extremely unpredictable and dynamic. Many organizations have faced the problem of finding talented, highly educated professionals and retaining them, which seems equally difficult. The issue of employee engagement, especially highly skilled employees, is becoming more and more relevant. If they don't feel committed to their job, an experienced IT professional will look for another company.

Employee engagement is directly related to the degree of satisfaction with specific incentives management hands out. Rewards, material, and social benefits are traditionally perceived as important to employees, but they usually lose their motivational power quickly. In our view, due to the complex and creative nature of the work performed in the IT sector, intangible incentives outweigh tangible ones and it is these that engage employees. In addition to attractive remuneration and excellent working conditions, the manager must provide interesting and stimulating tasks for his staff, provide opportunities for the realization and development of their ideas, and create an environment of satisfying team relationships. All the below leads to higher employee productivity, customer satisfaction, and a good reputation for the company.

## 2. LITERATURE REVIEW

### 2.1. Employee Engagement

Employee engagement is a complex concept, with various theoretical frameworks exhibiting different constructs. Key terms include “employee engagement,” “work engagement,”

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“organization engagement,” and “job engagement.” The first two, according to [Schaufeli and Bakker \(2010\)](#), “are typically used interchangeably”.

[Kahn's \(1990\)](#) influential study found that meaningfulness, safety, and availability were the three psychological factors connected to employee engagement or disengagement at work. This model was empirically tested in a study ([May et al., 2004](#)), which found a significant relationship between meaningfulness, safety, and engagement. Additionally, [May et al. \(2004\)](#) discovered that meaningfulness was positively correlated with job enrichment and role fit; safety was positively correlated with rewarding coworker and supportive supervisor relations; self-consciousness and adherence to coworker norms were negatively correlated with safety.

Other researchers rely on the five-factor model of personality (FFM) - a set of five personality trait dimensions, often referred to as the Big Five: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experience ([McCrae & Costa, 1989](#)), conduct independent research, discovering that extraversion and agreeableness were found to be positively correlated with vigor; conscientiousness was found to be positively correlated with absorption and dedication; neuroticism was found to be negatively correlated with dedication; and openness to new experiences was positively correlated with vigor and absorption. The results point to the following relationships: (i) extraversion is negatively related to absorption, (ii) agreeableness is negatively correlated with dedication; (iii) neuroticism is positively correlated with vigor; (iv) openness to experience is negatively correlated with dedication. This study shows that the effects of personality characteristics on employee engagement vary across the five dimensions ([Narayanasami et al., 2023](#)).

[Schaufeli \(2016\)](#) describes employee/work engagement as a positive, fulfilling state of mind characterized by vigor (e.g., being highly energetic), dedication (e.g., being highly involved in work), and absorption (e.g., being highly concentrated in work). Job engagement is defined as the extent to which an individual is psychologically present in a work role ([Saks, 2006](#)). Something more - [Jia and Hou \(2024\)](#) argue that work engagement is the result of a complex dance between an individual's innate qualities and the larger organizational environment, which includes structural subtleties and HR procedures. [Myrden and Kelloway \(2015\)](#) consider employee engagement as an employee's enthusiasm, passion, and commitment to their work and the organization, the willingness to invest their discretionary effort to help the employer succeed. In an interesting study, [Nissinen et al. \(2023\)](#) look for the relationship between job crafting profiles of public sector employees and how they differ in terms of employees' work engagement, workaholism, and approach to learning.

According to [May et al. \(2004\)](#), employee engagement is most closely associated with job involvement and “flow”. “Flow” is defined as the “holistic sensation that people feel when they act with total involvement” ([Csikszentmihalyi, 1975](#)), without external rewards or goals.

Employee engagement is a cognitive, emotional, and behavioral state directed toward desired organizational outcomes ([Shuck & Wollard, 2010](#)), which not only results in higher productivity, talent retention, and increased loyalty but also brings customer satisfaction and company reputation ([Lockwood, 2007](#)). Engaged employees come to work every day feeling a connection to their organization, have high levels of enthusiasm for their work ([Buckingham & Coffman, 1999](#)), and consistently produce at high levels ([Meere, 2005](#)).

According to some recent studies, employee engagement is the enthusiasm and commitment a person has towards their work, which is crucial for job satisfaction and staff morale and can lead

to increased efficiency and better performance within a company (Kerdpitak & Jermstittiparsert, 2020; Johansen & Sowa, 2019), as cited in Arokiasamy et al., 2023). After analyzing the most popular definitions of employee engagement in the literature, Pincus (2023) concludes that they can all be reduced to a core set of human motives. These motives are arranged in a comprehensive model of twelve human motivations. Other authors focus on the role of leadership in engagement development: the relationship between workplace engagement and the growth mindset in a professional setting. Through investigation, managers can get specific guidance on how to encourage concept-related thinking and behavior in their workforce (Lyons & Bandura, 2023); incorporating organizational culture as a moderating factor (Sharafizad et al., 2020); technology impacts employee engagement, and the leadership during the Covid-19 pandemic (Woods, 2021). Additionally, some researchers (Mudannayake et al., 2024) looked at how team conflict and work engagement interact to affect role innovation and career commitment. It clarifies the role that motivated staff members play in encouraging creativity. Celebi Cakiroglu and Tuncer Unver (2024) are testing a conceptual model that integrates the relationships between psychological well-being, work engagement, and toxic leadership. It's an intriguing point of view. Research on social media use in the workplace and the effects of "doomscrolling" on occupational well-being, which is defined as work engagement (Hughes et al., 2024) is incredibly interesting.

Since each study looks at employee engagement using a different protocol, it is challenging to assess the state of knowledge regarding employee engagement due to disparate definitions. For the purposes of our study, we assume that *employee engagement is linked to enthusiasm and passion for work, identification with the company's values, and loyalty to the employer. It is directly dependent on the incentives applied by the management.*

## 2.2. Incentives as Determinants of Employee Engagement

Incentives are seen as a social factor that more or less determines human behavior, incites it and defines its direction. Incentives have been the object of analysis and research for many scientists in the area of classical behaviorism; neo-behaviorism and social behaviorism (Pierce & Cheney, 2008, as cited in Koleva, 2016). Incentives motivate or determine behavior in two ways, by either creating necessary conditions to respond to some basic needs (indirectly) or by excluding any other behavior than that induced by the external environment. Managers apply diverse motivation instruments that ought to be adequate to the environment and conditions and which can provoke a motivated and committed behavior of people within an organization.

Different types of incentive typology can be distinguished from one another according to their respective formal and substantive criteria and characteristics. We consider incentives and their categorization into material and non-material factors to be the most important from both a theoretical and practical standpoint. The purpose of material incentives is to meet material needs. These can be financial, and technological, linked to hygienic and temporal conditions, incentives concerning safety and working conditions, social and living benefits, sports, etc. One could argue that financial incentives are crucial. Conversely, non-material or spiritual needs are intended to be met by moral and spiritual (intangible) incentives. This category can also include other incentives, such as those that are moral, legal, political, artistic, social and psychological, cognitive, etc. (Koleva, 2016).

## 2.3. Study Hypotheses

For the study, we explore a specific set (10 in number) of incentives and their impact on the engagement of IT professionals (the tangible incentives are written in the *Italic font style*, while the intangible ones are in the regular font style).

- *High salaries (high labor costs) including social security*
- *Extra forms of reward (bonuses, perks) at successful project completion, financial bonuses (every three or six months or yearly), payment for overtime, percentage of profit, paid annual leave, etc.*
- *Social benefits such as a place to rest, food vouchers, excursions, cell phone, fuel coupons for own transport, etc.*
- Work on dynamic and interesting projects and tasks.
- Opportunities to be creative and take independent action when executing tasks.
- *Work with modern technological devices, including the latest state-of-the-art (innovative) technologies.*
- *Work in cozy and well-appointed offices.*
- Opportunities for self-advancement and recognition (inspiring talent, high achievement, knowledge, expertise)
- Participative leadership style, the role of the charismatic leader.

The **research hypothesis** is that due to the complex and creative nature of the work performed in the IT sector, non-material incentives have a greater influence on employee engagement than material incentives.

## 3. METHODOLOGY

The sample size of (148) firms was determined by simple random sampling with an initial maximum variance of two leading attributes - location and number of employees, a confidence probability  $P(z)=0.95$  and a maximum marginal error of 5.5%. We are interested in firms with the number of employees distributed according to the Small and Medium Enterprises Act, namely: micro firms (with up to 9 employees); small firms (with 10 to 49 employees), medium firms (with 50 to 249 employees) and large firms (over 250 employees).

On the principle of random selection, the sample includes 76 firms in the city of Sofia and 60 firms in Varna. The sample consisted of 60 companies in Varna and 60 companies in Sofia, which have computer programming as their economic activity. Respondents were selected from the respective firms on a random basis.

The survey was the primary means of collecting empirical data from respondents. Due to the particularities of the industry and to refine the questionnaire, preliminary discussions were held with representatives from the IT sector, in the form of in-depth interviews, as well as document analysis. On this basis, the questionnaire was already structured in detail to reflect certain specificities of the industry. After conducting a pilot study and adjusting the questionnaire, the process of the actual research was launched. It was carried out via the web-based OptiS platform. It allowed the sending of emails to respondents with an individual web link through which each interviewee filled in the questionnaire, after which the answers were automatically allocated to the database. The system thus ensured the anonymity of the respondents as well as the security of the data collected.

After processing the results to deepen the analysis, we conducted in-depth interviews, expert assessments of senior management on “problem areas”, and content analysis of documents.

All data from the survey were processed using Microsoft Excel 365 and SPSS for Windows 10 and represented by frequency distributions, the most commonly used way to summarize data in an array. We work with bivariate distributions (crosstabs) on the specific variables. The statistical methods we use are chosen depending on the type of variables representing the dependence.

#### 4. RESULTS AND ANALYSES

Below are the results of the correlation analysis between satisfaction with incentives and engagement with the organization.

**Table 1.** Correlation between satisfaction with incentives and engagement with the organization

	Incentive	Theoretical characterization of X <sup>2</sup> distributions	If	Pearson's X <sup>2</sup>	Relation/ Dependency	Cramér's V	Strength of connection (if any)	Statist. Signific. $\alpha = 0,05$
1	High salaries (high labor costs) including social security	16,919	<	56,487	Yes	0,357	Medium	0,000
2	Extra forms of reward (bonuses, perks) at successful project completion, financial bonuses (every three or six months or yearly), payment for overtime, percentage of profit, paid annual leave, etc.	16,919	<	41,892	Yes	0,307	Medium	0,000
3	Social benefits such as a place to rest, food vouchers, excursions, cell phone, fuel coupons for own transport	16,919	>	15,218	No	0,185	-	0,085
4	Work on dynamic and interesting projects and tasks	16,919	<	59,487	Yes	0,366	Medium	0,000
5	Opportunities to be creative and take independent action when executing tasks	16,919	<	56,649	Yes	0,357	Medium	0,000
6	Work with modern technological devices, including latest state-of-the-art (innovative) technologies	16,919	<	55,731	Yes	0,354	Medium	0,000
7	Work in cozy and well-appointed offices	16,919	<	29,778	Yes	0,259	Weak	0,000



9	Opportunities for self-advancement and recognition (inspiring talent, high achievement, knowledge, expertise)	16,919	<	81,584	Yes	0,429	Medium	0,000
10	Participative leadership style, the role of the charismatic leader	16,919	<	71,282	Yes	0,401	Medium	0,000

Source: Own research

From a statistical perspective, of the ten stimuli examined, nine had a medium-strength connection with the engagement. Only social benefits do not lead to employee commitment. Each of the others is directly related to employee engagement.

To prove our research hypothesis, we use Cramer's ratio. The values are more significant for non-material incentives, which we will discuss below:

- Opportunities for self-improvement and recognition (inspiring talent, excellence, knowledge, experience) (*Cramér's V* - **0,429**) is the incentive whose satisfaction leads to the highest degree of engagement of professionals. Recognition from management, the opportunity to gain knowledge and develop professionalism are some of the strongest motivators for them.
- Participative leadership style, the role of the charismatic leader (*Cramér's V* - **0,401**) is the second most important incentive that leads to professionals' commitment. Team relationships are largely determined by the leadership style and qualities of the leader - collegial, direct and personalized relationships combined with charismatic leadership create commitment and loyalty. Employees are engaged when they like their leaders. Leadership is not just about earning the trust of your colleagues but being able to engage them to achieve your goals. Effective leaders can model appropriate engagement behaviors, starting with their team.
- Work on dynamic and interesting projects and tasks (*Cramér's V* - **0,366**) leads to diversity and dynamism, and stimulates the creativity of computer professionals, which in turn increases their motivation and commitment.

All the incentives mentioned are intangible. **Our research hypothesis is proven.**

## 5. FUTURE RESEARCH DIRECTIONS

The study of engagement is part of a larger study by the authors related to the motives for the behavior of IT professionals in Bulgaria. Our future research focuses on opportunities to prevent turnover and build loyalty through new forms of job design, especially in the wake of the changes in jobs following the COVID-19 pandemic.

## 6. CONCLUSION

The study proved the role and place of intangible incentives in the organization as a factor of employee engagement. They are particularly important for computer professionals in the IT sector. With high salaries, good bonuses and working conditions, i.e. when basic needs are satisfied, employees turn to their higher needs of self-realization and expression, proving abilities, creativity, and forming positive team relationships.

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# Consumer Reactions to Sustainable Consumption Content – An Eye-Tracking Experiment

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Sustainable consumption



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**Abstract:** *Within the framework of the project “Sustainable Urban Consumption – Regional Differences” a website and Facebook profile have been created to disseminate the results. However, these platforms alone do not guarantee the effective reach of its web audience. The main purpose of this paper is to present the results of an eye-tracking experiment to assess the potential of the tested website to effectively disseminate information regarding sustainable consumption. The survey is based on data on the movement of the gaze, but in addition, are used data on heart rate and galvanic skin reaction of the respondents. Using eye-tracking techniques and tactile reactions analysis the authors formulate conclusions about web usability and the elements engaging the attention of the target web audience.*

## 1. INTRODUCTION

The problems of Sustainable Consumption in the context of UN Sustainable Development Goals, in particular, Goal 12 “Sustainable Production and Consumption”, require action from all stakeholders. It is necessary to develop policies and programs by governments and local authorities, but they would not be realized if they failed to involve in their implementation a large part of the participants in society. Their success is possible only after the realization of the part of all individuals and organizations that it is their actions that ensure the environmental, social, and economic sustainability of living on the planet and in particular of the specific settlements where they live or function.

Within the project „Sustainable Urban Consumption – Regional Differences“, funded by the Bulgarian National Science Fund (BNSF Contract Nr. KP-06-H35/7), a website and a Facebook profile have been created. They aim to disseminate project information in the context of Sustainable Consumption in several specific areas: housing; food; mobility in urban environments and product exemptions. The starting position of the project team is that the larger dissemination of information provides conditions for people to think about the problems related to excessive consumption; ways in which the waste is recovered; efficient consumption of water and electricity; and the way they move around in cities.

Considering the importance of disseminating this type of information to change people's behavior, a key point is to pay attention to the means that would ensure the effectiveness of communication channels. In this regard, it is necessary to take measures in the direction of the communication behavior of the subjects of management. How the target audience is communicated

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depends on whether the achievement of the communication goals is ensured. If the vocabulary of communication patterns is used, the message will be understood in cases where it is coded correctly. This would ensure its visibility within the target audience.

Speaking of content marketing management, a key point is knowing the mechanisms of perception, in particular visual ones, such as: which signals (words, color, image) are perceived; which elements of content engage the attention of the audience; are their positions that focus attention to the greatest extent, regardless of the content; how quickly content users get their bearings.

This paper aims to assess the usability of the developed project site by analyzing the visual and Tactile Reactions of a young audience. To achieve this goal, an experiment was conducted using a gaze-tracking technique and a research-grade biometric signal tracker for capturing heart rate and galvanic skin response with students.

## 2. LITERATURE REVIEW

The evaluation of audience response is a concept that was introduced in the mid-19th century, and Hermann von Helmholtz can be cited as the founder of such tests (Holden et al., 2020). In 1849, he conducted his studies using electrical stimulation to study nerve conduction speed. In the following years, approximately 150 years of such assessments were extended widely to medical research related to neurological disorders or insults (Holden et al., 2020), such as TBI/mTBI, PTSD, pharmaceuticals, aging, Parkinson's, dementia, schizophrenia, ADHD, sleep deprivation, caffeine, alcohol, autism spectrum disorders, and diabetes. According to the developed timeline for the development of tests to assess audience reactions by Holden et al. (2019) they began with the measurement of "Visual Reaction Time" and "Auditory Reaction Time" (reporting Human Performance in the 150-200 MSEC Range), and after the middle of the 20th century began the reporting of "Tactile Reaction Time", as already by 2000 the reporting of reactions extends from 150 to 400 msec. The advent of computer technology in more and more areas of public life has led to the expansion of opportunities for testing reactions. Developed technologies help to get such assessments of respondents out of laboratory conditions and conduct tests in an environment close to nature.

Technological innovation in the field makes it possible to use Eye-tracking technologies to test the reactions of the observed audience to changes in variables in the viewing experience (Dahmen, 2016). "Using an eye-tracking device, a researcher can analyze the respondent's eye movements and know exactly which area the respondent is focusing his or her visual attention on at any given moment" (Mičík & Kunešová, 2021). Ehmke and Wilson (2007) define Eye-tracking as a "technique whereby eye movement is recorded whilst the user is looking at a stimulus". The basic concepts that we need to be familiar with when using and are:

- Fixation – a moment when the eye rests on a certain part of the screen;
- Saccade – the moment of moving the gaze between two separate fixations;
- Gaze plot – show the moments of fixations and saccades for each of the respondents;
- Heat map – marks the time for which each screen area has been viewed.

A review of the scientific publications shows that eye-tracking is used in some areas of marketing research, which are presented by authors in Table 1.



**Table 1.** Eye-tracking in marketing research

	Authors	Problem
2018	Bartels et al. (2018)	Information at the point of purchase optimizing.
2019	Țichindelean et al. (2019)	Usability testing.
2019	Höhne (2019)	A/D (Agree/Disagree) questions testing.
2020	Xie et al. (2020)	<ul style="list-style-type: none"> <li>• Enhance online advertising effectiveness;</li> <li>• Improve the online purchasing process.</li> </ul>
2021	Van Der Lans et al. (2021)	Online advertising – visual context.
2021	Mičík and Kunešová (2021)	Website optimizing: <ul style="list-style-type: none"> <li>• Usability</li> <li>• Credibility;</li> <li>• Accuracy;</li> <li>• Appearance.</li> </ul>
2021	Orzeł (2021)	Product package testing.
2021	Gómez-Carmona et al. (2021)	Testing the effect of packaging and label format on Google Ads in e-commerce sites.
2022	Muñoz-Leiva et al. (2022)	<ul style="list-style-type: none"> <li>• At the point of sale – improve the product position and presentation; increase visual prominence;</li> <li>• Online store design or Web Usability;</li> <li>• Helping to attract traffic to websites or landing pages;</li> <li>• Achieving striking packaging design;</li> <li>• Analysis of advertising effectiveness in offline or online contexts;</li> <li>• Education in the marketing area.</li> </ul>
2022	Chocarro et al. (2022)	E-Commerce Site Design Improvement - Product Area Visual Content Testing.
2023	Casado-Aranda et al. (2023)	Evaluating communication effectiveness online.
2023	Xie et al. (2023)	Analyzing eye-tracking data in the context of: <ul style="list-style-type: none"> <li>• Print advertising;</li> <li>• Social interaction;</li> <li>• Face-to-face interaction;</li> <li>• Video viewing;</li> <li>• PC and mobile advertising.</li> </ul>
2023	Martinovici et al. (2023)	Decision making - accumulation and prediction of brand choice.

**Source:** Own research

A number of the authors point to Eye-tracking as a Technique for identifying usability problems. In this connection Ehmke and Wilson (2007) present a relatively comprehensive summary of the metrics used for these purposes, grouping them into four groups, namely:

- Fixation-related – Time to first fixation on target; Fixation spatial density; Fixation duration, Fixation length; Fixations on target divided by the total number of fixations; Number of fixations overall; Repeat fixations (post-target fixation); Fixations per area of interest; Percentage of participants fixating on the area of interest; Fixations per area of interest adjusted for text length; Saccade/fixation ratio;
- Saccade-related – Number of saccades; Saccades revealing marked directional shifts; Saccade amplitude; Regressive saccades (backtracks/regressions); Saccade duration;
- Scanpath-related – Longer scanpath duration; Scanpath direction; Longer scanpath length; Small spatial density of scanpath; Scanpath regularity; Transition matrix (back and forth between areas); Transition probability between AOIs<sup>3</sup>;
- Gaze-related – Gaze (dwell); Gaze orientation; Gaze duration on AOI; Number of gaze per AOI; Spatial coverage calculated with convex hull area.

<sup>3</sup> AOI – Area of Interest

In recent years, Eye-tracking has been defined as an element of the overall UI or UX design process (Igorova & Ilchenko, 2022). In addition to identifying usability problems, the authors' attention is also focused on site ergonomics. In the context of web applications, Chmal et al. (2022, p. 330) define ergonomics as “interfaces that are structured according to the user's characteristics”. Interfaces should be close to what users expect and they should not need to be further trained to be able to work with them. In the context of this, the authors also derive the key metrics to be monitored, namely: 1. Time to first fixation in AOI; 2. Duration of first AOI fixation; 3. Total duration of AOI visits and 4. Number of AOI visits.

One such research aimed at creating an interface for a Web site close to its Web Audience is also considered by Rozova et al. (2022). They also look at a combined usability test approach on a website. In addition to the qualitative study based on fixations, gaze plots, and head maps, an additional qualitative study is added in the form of an in-depth interview after completing an Eye-tracking experiment. This second survey aims to enable respondents to argue their behavior during the first survey.

Regardless of the approach applied and the metrics that are included in it, it is necessary to take into account the reactions of individuals to different stimuli there is a certain error due to the time it takes for the body to react. Kim et al. (2020) indicate that in the Tactile Test, the response time is 16 ms, while in the Visual Test is 81 ms.

### 3. METHODOLOGY

For the purpose of this paper In the period April – May 2023, an experiment was conducted with 33 students aged between 20 and 22 years (9 males and 24 females). The experiment was conducted in controlled settings. The respondents browsed a tested website and worked on 6 different tasks, and in the end – free surfing. All participants have worked without time limitations. The individual's tasks are:

**Task 1:** Getting to know the home page;

**Task 2:** To find something about the creators of the site;

**Task 3:** Open publications on the site;

**Task 4:** Search by keyword;

**Task 5:** View the blog part of the site;

**Task 6:** Find contacts to contact the creators of the site;

**Free surfing:** Free viewing of the page to open things that impressed them while performing other tasks.

All tasks end with a decision of the respondents, and they notify the moderator to move further.

The experiment was conducted according to the four stages proposed by Rozova et al. (2022): **Stage 1:** Acquaintance and instructions; **Stage 2:** Calibration; **Stage 3:** Realization of the experiment scenario, and **Stage 4:** Post testing.

The experiment was carried out by GP3 HD Eye Tracker 150Hz and a research-grade biometric signal tracker. All data are recorded with Gazepoint Analysis UX Edition software. In addition to eye movement data, heart rate, and galvanic skin response data are also registered. Some data are summarized and imported into JASP for statistical data processing.

#### 4. RESULTS

The mean time taken by the participants in the experiment to complete the main 6 tasks was 388 sec. (368 sec. for males, and 395 sec. for females). The minimum mean time is 175 sec. (male) and the maximum is 1068 sec. (female). Men worked between 176 and 580 sec. and women worked between 185 and 1068 sec. Respondents went through the six main tasks of the experiment with a mean of 632 fixations (mean 720 fixations for males and 598 for females). The minimum number of fixations is 352 (female), and the maximum is 1400 (male). Men complete 6 tasks with fixations between 401 and 1400, and females – fixations between 352 and 1175.

In JASP we conduct the Shapiro-Wilk Test of Normality<sup>4</sup> of these two variables. The null hypothesis ( $H_0$ ) in both is rejected (tasks time  $p$ -value < 0,001; number of fixations  $p$ -value < 0,001), which means the data in the observed variables are not normally distributed. This requires a non-parametric test to be used when testing for a difference between the average on a given basis. Based on the Mann-Whitney U tests, we can conclude that there are no significant differences in the mean values (tasks time/gender  $p$ -value = 0,984; number of fixations/gender  $p$ -value = 0,176) of the time to work on the tasks and the number of fixations in a gender section.

##### Task 1: Getting to know the home page

Approximately 97% of the participants in the experiment declared that they had familiarized themselves with the home page after actually looking at the entire page. The mean time to complete the task is 109 seconds (min. 36,7 sec., max. 235,4 sec.). When performing the task, a mean of 244 fixations are reported (min. 102, max. 573). The T-Test performed shows that there is no difference between the mean work time between men and women (Shapiro-Wilk  $p$ -value = 0,066; T-Test  $p$ -value = 0,111), and as a result of the Mann-Whitney U test, it is found that there is a difference between the mean number of fixations women (Shapiro-Wilk  $p$ -value = 0,003; Mann-Whitney U test  $p$ -value = 0,044). Women go through this task with a mean of 123 fixations less than men.

One of the key things that is monitored within Task 1 is whether the information that is intended to be presented attracts enough attention. Figure 1 shows that the part of the home page with the icons of the main four categories that are presented on the website has a relatively good level of fixations in the respective Fixation Map.

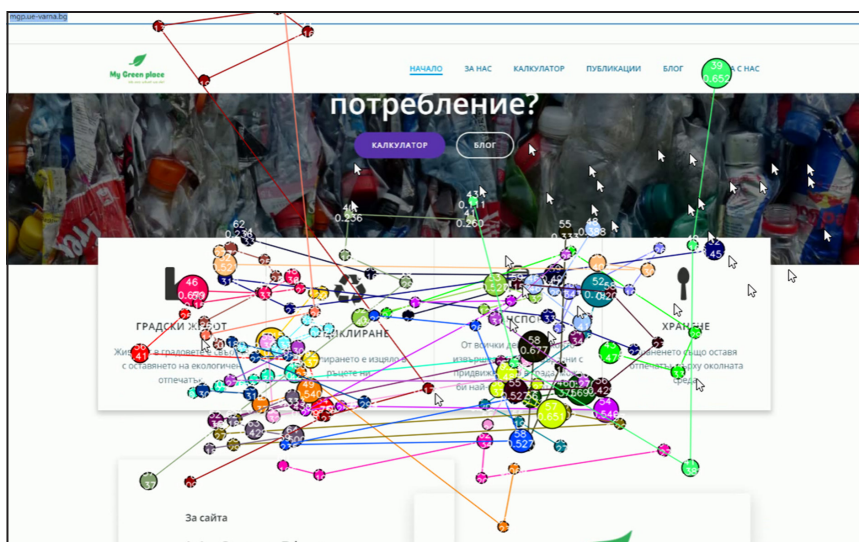
With the help of a Heat Map, we can easily visually show what attention is paid to individual categories (Figure 2.). At this stage, it can be said that three of the four categories used attract the attention of the participants in the experiment: 1. Transport; 2. City life and 3. Recycling.

The next main point and whether respondents devote sufficient attention to the definitions of the categories themselves. Here, thanks to the visual examination, a relatively good balance of

<sup>4</sup> Shapiro-Wilk Test of Normality has been conducted for the purpose of determining the correct Independent Sample Test, but will not be described in the main text in order to optimize its volume.

engagement of the gaze about the leading image and the corresponding text box is concerned. Due attention is also paid to the part of the home page presenting the last 3 blog posts on the website.

To decide to get acquainted with the home page, approximately 18% of respondents have opened two additional pages on the website, 24% have opened one additional page, and the remaining approximately 58% have not clicked on an additional page. Most often click on the posts from the Blog part in the categories “Nutrition”, “Recycling”, and “Transport”.



**Figure 1.** Fixation map of the presented categories icons  
Source: Own research



**Figure 2.** Heat map of the presented categories icons  
Source: Own research

## Task 2: To find something about the creators of the site

To decide that they had completed the task, respondents took a mean of 60.19 sec. (min. 17.06 sec., max. 167,97 sec.). Mean fixations are 89 (min. 40, max 197). Approximately 18% of the participants in the conducted Eye-tracking experiment did not open the required page with the

names of the scientific project team within the task. All of them remain on the main page and do not click on the correct one. A chi-square test was conducted for the presence of a statistically significant relationship between the variable sex and whether they were able to meet the condition correctly, but none has been established ( $p\text{-value} = 0,167$ ).

A one-third of respondents click the first time on the correct page, and this is enough for them to complete the task. Approximately 30% open one additional page, 24% - two, 9% - three, and 3% - four. In 12% of cases, the additional pages opened are external, which is a problem because it can lead to leaving the page.

### Task 3: Open publications on the site

There are two types of publications on the website: scientific and blog articles. The purpose of this task is to determine to what extent the target Web Audience distinguishes between the two. The opening of the part with the scientific publications of the project is considered a successful final. Approximately one-quarter of the participants in this Eye-tracking experiment did not complete this task.

To decide that they had completed the task the respondents took a mean of 50 sec. (min. 6.5 sec., max. 304.45 sec). The mean fixations are approximately 55 (min. 12, max. 313). Approximately 24% open only one page, 30% click on one additional page, 39% open two, and the remaining approximately 6% open three and six pages. A Heat Map review of this task clearly shows that the majority of respondents at the very beginning are heading to the right place to reach the scientific publications. This and relatively quickly within the first 4-6 seconds of starting the task. It should be borne in mind, however, that 42% open the part with scientific publications and blog articles at the same time, which shows the need to take additional measures to identify both types of information.

### Task 4: Search by keyword

None of the participants in the Eye-tracking experiment used the intended functionality to search by keyword. The main place where respondents search is a Home page on the website (72.27%). 18% direct to search directly on the Blog page.

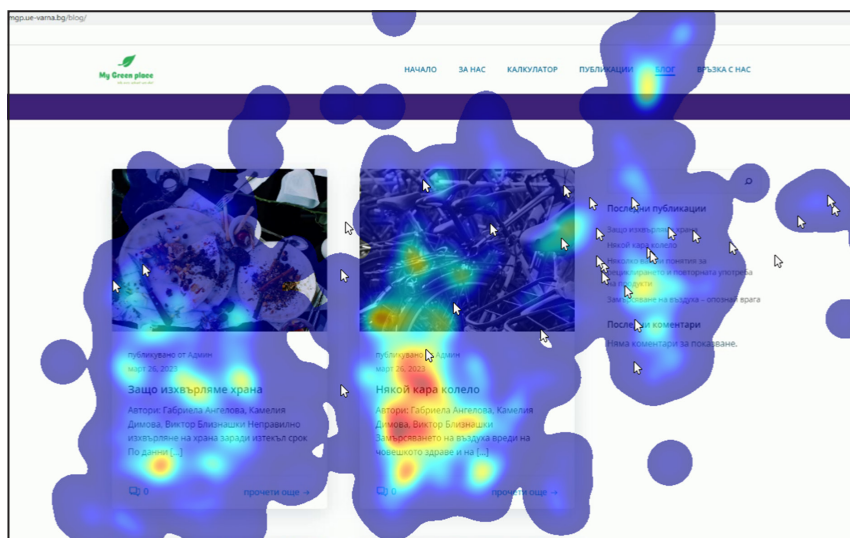
### Task 5: View the blog part of the site

Before requesting termination of the task, respondents spent a mean of 112.93 sec. on the website (min. 28.47 sec., max. 710.66 sec.). An average of 153 fixations are recorded (min. 72, max. 674). Unfortunately, approximately 60% open only one of the four tested posts. All four blog articles were opened by only 6% of respondents.

Figure 3 shows that the most attention on the blog page is paid to the title of the tested article from the category “Transport”. This is actually the only title that stands out from the others, as it makes an association with a relatively famous song. However, this is not enough to make the participants open and read the material. Two-thirds of respondents opened the blog article, related to the category “Nutrition”. Approximately 33% open up the material associated with air pollution. Equally are the clicks in terms of “Recycling” and only 9% - “Transport”. In 3% of participants, no publication aroused interest<sup>5</sup>.

<sup>5</sup> Percentages Exceed 100 Because Study Participants Opened Multiple Articles on Blog page.





**Figure 3.** Heat map of the Blog page

**Source:** Own research

### **Task 6: Find contacts to contact the creators of the site**

Approximately 94% click in the right place in no more than 12 seconds. The remaining 6% do not reach the contact form.

### **Free surfing: Free viewing of the page to open things that impressed them while performing other tasks**

The calculator for assessing one's own level of Sustainable Consumption is the most visited part of the website at this stage in an Eye-tracking experiment. Approximately 55% of respondents open it. The Heat map for this part of the study shows that the additional graphic layout (a button in a different color in a central place) makes the necessary impression and stimulates the opening of this link. There are many cases when the task ends on the Home page.

Within the entire Eye-tracking experiment, there is registered a single emotional response (a registered increase in skin reaction) and it is linked to a blog article in the "Nutrition" category. Emotion is registered in a woman.

## **5. FUTURE RESEARCH DIRECTIONS**

In this paper, attention is paid mainly to the number of fixations and the time that the relatively tested site manages to keep the attention of its users. An important aspect, however, is what is the time that the individual elements of the site manage to engage within the interaction. There is enough data that after further processing can serve these purposes and, accordingly, reach conclusions, in the context of the AOI.

## **6. CONCLUSION**

Based on the conducted research, some of the elements that make an impression on potential users of the website can be displayed. As a result of the Eye-tracking experiment, it can be said that the created site manages to attract some attention from the Web Audience. The homepage manages the attention

on the categories of information. A relatively good balance between visual elements and text boxes has been achieved. It can certainly be said that in a significant proportion of respondents there is confusion between publications (scientific) and blog articles. This makes it necessary to consider a way to make them clearer. Young people do not use the built-in search option on the site. They browse, read, and even open multiple pages to find a keyword. In this regard, it is necessary to find a place all that is considered key yet on the Home page. Most respondents pay attention to an element that is designed to evaluate their behavior (the Sustainable Consumption calculator), and the corresponding Heat map clearly shows that the given emphasis on the access point manages to attract attention.

The results can be used as a starting point to assess the usability of websites through the analysis of visual and Tactile Reactions, as well as to improve content about Sustainable Consumption in households.

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# Consumption of Digital Content – Positive and Negative Aspects of Impact on Consumers

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**Abstract:** *The digital environment provides innovative ways to attract potential customers in the market by sharing content through different channels. Content marketing shared daily by companies, paid advertisers, influencers, bloggers, or anonymous individuals in the digital environment shapes consumer habits and directs consumer activities. Therefore, ubiquitous effective digital content marketing and tempting offers can drastically influence consumer behavior and cause positive and/or negative aspects to impact them. The paper presents the theoretical framework as well as the results of the conducted research, which aims to examine how often consumers encounter content marketing, how often they agree to buy under its influence, and determine whether there are positive and/or negative aspects of digital content consumption. The results indicate that consumers encounter content marketing daily, mostly on social networks or digital platforms managed by companies or influencers, bloggers, and others. Consumers receive discounts or promotional offers and codes at different time intervals and they use them while buying. However, the negative aspect of the influence of digital content marketing on the consumer is more pronounced than the positive one.*

## 1. INTRODUCTION

In recent years, content marketing in the digital environment has evolved dramatically to increase the reach and awareness of the product and/or service (Matin et al., 2022; Mendoza-Moreno & Turriate-Guzmán, 2022). By observing customers in the digital environment and analyzing the collected data, companies strive to know every detail of the customer's life to fully customize the offer and provide a memorable customer experience (Saura et al., 2020). Companies use various strategies to present and distribute content in the digital environment. Marketing experts, influencers, or ordinary users with their own experience create different content that finds its way to potential customers. Content that is engaging, interactive, educational and entertaining prompts customers to buy products or services and constantly creates new needs for them, which can be discussed in the positive and negative context of the impact on customers.

The literature certainly tends to emphasize the positive aspects of the influence of digital content on consumers and their purchasing decisions. Through content in a digital environment, consumers are provided with benefits such as discounts, campaigns, prize games, sharing experiences and recommendations, and more (Gümüş, n.d.). In addition, digital content enables access to a wide range of products and/or services from any part of the world, availability of detailed information about products and/or services, insight into reviews, comparison of different brands and more (Ahmad & Rosli, 2023; Hamdan et al., 2021). Although negative aspects are neglected in scientific circles, they do exist and can be described by certain reactions of

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customers and their behavior as a result of contact with certain digital content. The negative aspect of digital content in consumer behavior can be manifested in increased consumption and impulsive shopping (Hrustek, 2023).

The main goals of the research paper are:

- examine how often consumers encounter content marketing,
- examine how often they agree to buy under its influence,
- determine whether there are positive and/or negative aspects of digital marketing.

The next chapter presents the theoretical foundations of qualitative research, explaining the forms of distribution of content marketing in the digital environment and their influence on consumer behavior. The third chapter provides an insight into the methodology of the research conducted and collected data. The fourth chapter presents the results of the research, highlighting the positive and negative aspects of the influence of content marketing on consumer behavior. Finally, the research is concluded with a discussion, and the limitations of the research as well as future research plans are outlined.

## 2. CONTENT MARKETING IN DIGITAL ENVIRONMENT

Content marketing includes textual and/or graphic information whose purpose is to present products or services in an entertaining, informative, educational and attractive way to attract, retain and bring back customers (Ansari et al., 2019; Munsch, 2021; Vinerean, 2017). The development of digital technologies has enabled the creation, sharing and distribution of content via platforms or social media, opening paths to potential consumers of all ages, preferences and interests. As consumers spend more and more time in the digital environment in their daily lives, they engage with a variety of products and services (Matin et al., 2022; Mendoza-Moreno & Turriate-Guzmán, 2022). Such enticing offers can have both positive and negative effects on consumers and their behavior.

The types of content marketing distribution in the digital environment are:

- Content marketing and offers distributed on official social networks or platforms by the company;
- Content marketing and offers distributed on search engines, portals, radio and television in the engagement company;
- Content marketing and offers distributed on social networks or platforms of influencers, bloggers or other influential persons;
- Content marketing and offers distributed on social networks, platforms or portals based on experience, reviews, and content created by consumers;
- Content marketing and offers distributed by e-mail, mobile messages or directly to consumers through platforms (e.g. Viber...) (Dobrinić, 2023; Hrustek, 2023; Saura et al., 2020).

Content marketing on the company's social networks and platforms implies the official distribution of content by the company. This includes various forms of content such as video material, audio content, storytelling, images and more (Chanpaneri & Prachi, 2021; Vinerean, 2017). Through this form of content sharing, companies not only collect feedback from their customers but also observe their behavior in the digital environment to identify key touchpoints that determine their lifestyle habits and interests. The content and offers distributed via portals, radio



and television are also created on behalf of the company and represent a paid form of content distribution. As a rule, this type of content is aimed at a wider audience and the company wants to increase its brand awareness. The distribution of content marketing and offers via social networks or platforms by influencers, bloggers or influential people is a form of content distribution that has characterized recent years. Content shared on Instagram, TikTok, YouTube, Facebook and other platforms is a very enticing and widespread form of information sharing that influences people. Recently, consumers have questioned the authenticity and sincerity of content shared by influencers and other influential people (Figueiredo et al., 2021). In contrast, content shared by unpaid individuals is becoming more desirable, and customers are basing their purchasing decisions on recommendations from unknown individuals. Content distributed via e-mail, mobile messaging, or directly via communication platforms is a common way of sharing information about products and services, although it is not as attractive to customers. They are often used to inform customers about discounts, discount codes, special offers, benefits, competitions and more.

## 2.1. Consumer Behaviour Influenced by Content Marketing

The presence of digital technologies has significantly changed people's behavior by creating new lifestyle habits and needs. People spend a large part of their time in the digital environment and use various types of digital solutions. A large part of this time is spent by individuals researching various content related to the promotion and offering of products and/or services. Such content is very interesting and attractive, it draws users' attention and encourages them to immerse themselves as deeply as possible in the world of a particular brand (Chanpaneri & Prachi, 2021; Gregurec & Hrustek, 2022). In addition, the attractiveness of the digital environment is convenient for customers for several reasons. Quick and easy access to all information about products and services, user-friendly and customized shopping options and benefits are just some of the reasons why customers are increasingly taking advantage of the opportunity to shop in a digital environment. Digital technologies have enabled customers to get a more realistic picture of products and services.

Consumer behavior is an interesting research area of particular importance, especially in the online environment, where there are interesting discussions about how and why consumers choose to purchase products or services (Prasetya & Susilo, 2022; Solomon & Lowrey, 2017). Consumer behavior is not constant, it changes over time and depends on numerous factors. Since consumers are different individuals, it is difficult to generalize their habits as their behavior can be influenced by factors such as personal, psychological, social, cultural, lifestyle, geographical and other factors (Hopper, 2020). Customer behavior in the digital environment can be described by certain new habits and activities. Consumers are not only spending more time online and searching for a product or service but are also emotionally connected to a brand. In addition to analyzing consumer behavior through the activities of purchasing, using and disposing of products and services, it also includes the emotional, mental and behavioral responses of the consumer that precede, determine, or follow these activities (Hrustek, 2023).

## 2.2. Positive and Negative Aspects of Consumption Digital Context

Marketing in the digital environment has strengthened the relationship between the brand (the company) and the customer and enabled innovative ways of communicating, collaborating and sharing information. The role of content in the impact on customers is related to visibility and

awareness of content, customer satisfaction, the return of loyal customers and the acquisition of new customers (Jami Pour & Karimi, 2023).

Customers are no longer co-creators of products or services but become an extended hand in enriching and promoting the brand (Geng et al., 2020). Content generated by users and companies receives more attention than content that is available in the physical environment (Müller & Christandl, 2019).

The positive aspects include access to social knowledge and experiences that help customers better understand the purpose of online shopping and make more informed and accurate purchasing decisions. Interaction takes place between consumers, but also between consumers and companies (Geng et al., 2020). Interactions facilitate the creation of product reviews, and as products become more popular, customers create their own content and objective product reviews (Hrustek, 2023).

However, there are also some negative aspects of the impact of content marketing on customer behavior. The main ones are impulse buying, increased consumption and uncontrolled consumption (Hrustek, 2023). With the advancement of technologies such as artificial intelligence, big data and analytics, additional concerns arise. In particular, concerns about unethical content design in digital environments and the compulsion for content marketing strategies to be developed solely for economic and profitability reasons leave many questions unanswered (Barbosa et al., 2023). The privacy of customer data is a sensitive issue and there is debate about how customers can be protected (Anand & Lee, 2023).

### 3. METHODOLOGY

The previous chapter provided an insight into the theoretical implications of the field of content marketing and its influence on consumer behavior as well as its positive and negative aspects, based on qualitative research of secondary literature sources.

The quantitative research conducted to collect and analyze the primary data is described below. A questionnaire was created that included three groups of questions:

- Demographic characteristics of respondents (4 questions);
- The impact of content marketing on consumers (4 questions);
- Positive and negative aspects of content marketing on consumer behavior (2 questions).

The questionnaire was distributed via social networks LinkedIn and Facebook avalanche method and the sample was purposive.

A total of 54 people took part in the survey, answering all questions in full (Table 1). According to demographic characteristics, 85.2 % of the participants were female, the remaining 14.8 % were male. Most respondents (64.8%) were between 25 and 34 years old, and not a single respondent between the ages of 15 and over 55 took part in the survey.

The respondents were largely a population with a completed specialist professional or university graduate studies/ integrated undergraduate and graduate university studies, (50% of respondents), 22.2% of respondents had completed professional or university undergraduate studies, and 18.5% of respondents had completed four-year high school. The vast majority of respondents, 74.1%,

were in permanent employment, while 9.3% of respondents were in fixed-term employment, as were the students. Two unemployed people and one housewife took part in the survey, while one person stated that they were in part-time employment. The results of the research, according to the demographic characteristics of the observed control variables are shown in Table 1.

**Table 1.** Demographic characteristics of respondents

Variables	Characteristics	Frequency	Percentage
<b>Gender</b>	Female	46	85,2%
	Male	8	14,8%
<b>Age</b>	> 15	0	0%
	15 – 24	8	14,8%
	25 – 34	35	64,8%
	35 – 44	10	18,5%
	45 – 54	1	1,9%
	55 – 64	0	0%
	< 65	0	0%
<b>Education</b>	Unfinished Elementary School	0	0%
	Finished Elementary School	0	0%
	Finished Two- or Three-Year High School	1	1,9%
	Completed Four-Year High School	10	18,5%
	Completed vocationally or university undergraduate study	12	22,2%
	Completed specialist vocationally or university graduate study/ integrated undergraduate and graduate university study	27	50%
	Completed postgraduate specialist study	1	1,9%
	Completed postgraduate scientific master's study	1	1,9%
<b>Employment Status</b>	Completed university postgraduate doctoral study	2	3,7%
	Primary and high school student	0	0%
	College student	5	9,3%
	Part-time job	5	9,3%
	Full-time job	40	74,1%
	Housewife	1	1,9%
	Unemployed	2	3,7%
	Retired	0	0%
	Other: honorarium job	1	1,9%

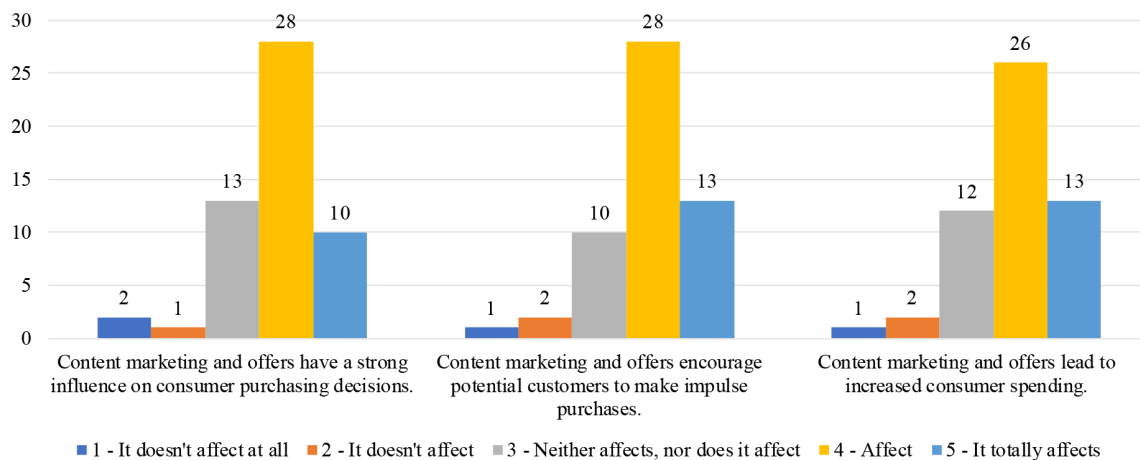
Source: Own research

## 4. RESEARCH RESULTS

The analysis of secondary sources found that content marketing and offers have an influence on customers' purchasing decisions, which was confirmed by the analysis of the data collected from respondents with an average grade of 3.8 (Figure 1). A large number of respondents agreed that content marketing and offers encourage impulse purchases, with an average grade of 3.93. Respondents also confirmed that content marketing and offers increase spending, with an average grade of 3.89.

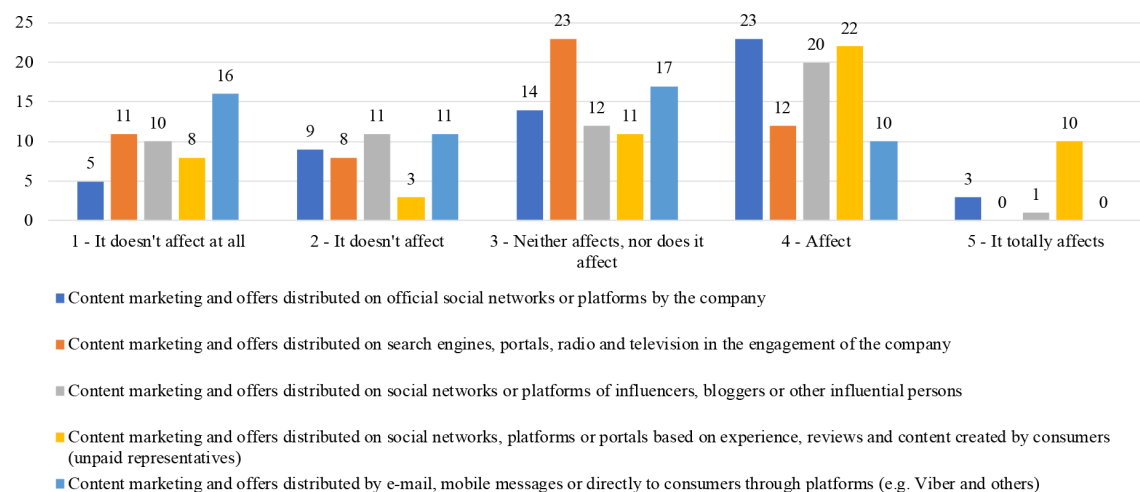
Figure 2 shows the influence of the different types of content marketing in the digital environment on consumers (respondents). Content marketing that is distributed via e-mail, mobile messages or directly via platforms such as Viber and others has the lowest impact. Content marketing that is distributed via portals, radio or television also has a lower impact.

The content marketing that has the greatest impact on respondents is that created by customers or unpaid people on social networks or platforms. In addition, half of the respondents confirmed that they are influenced by content marketing available on professional social networks or corporate platforms and influencers are still noticeable with their content.



**Figure 1.** The impact of content marketing

Source: Own research



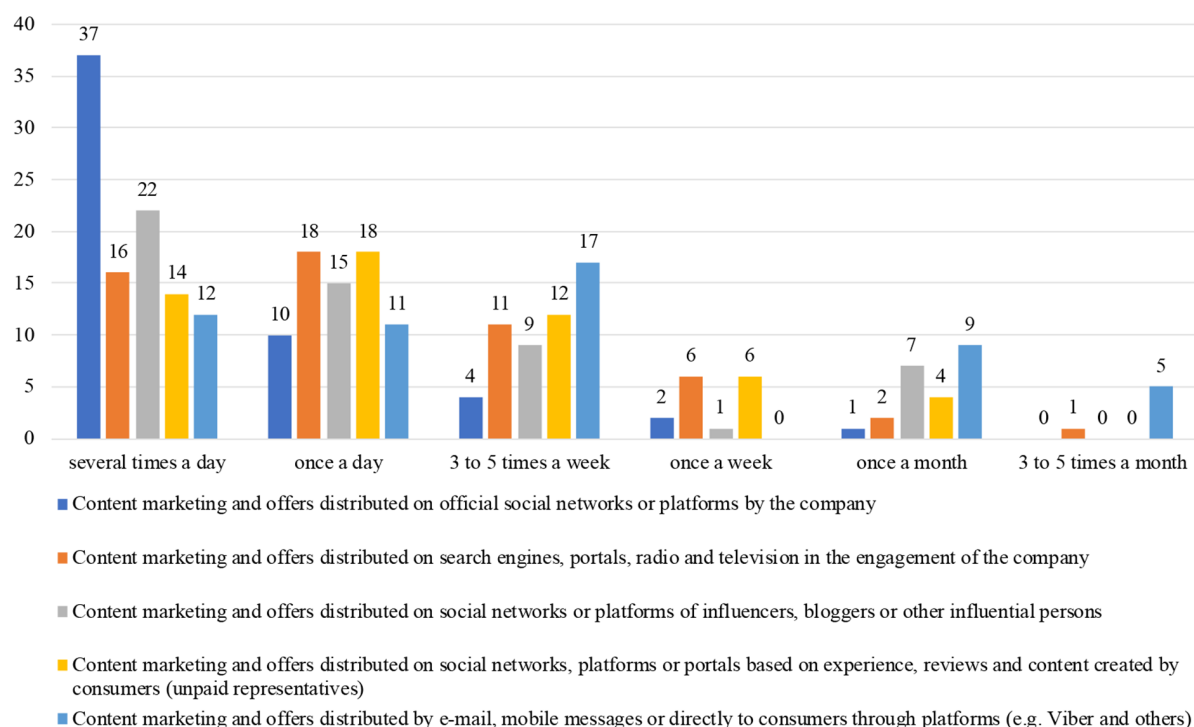
**Figure 2.** The impact of different content marketing on the purchase decision

Source: Own research

Figure 3 shows that a large number of respondents come across content in the digital environment several times a day, especially content that is distributed on the company's platforms and social networks, as well as content from influencers, bloggers and other influential people. Only a small proportion of respondents emphasized that they came across this content in more than a week (less than 10 of them).

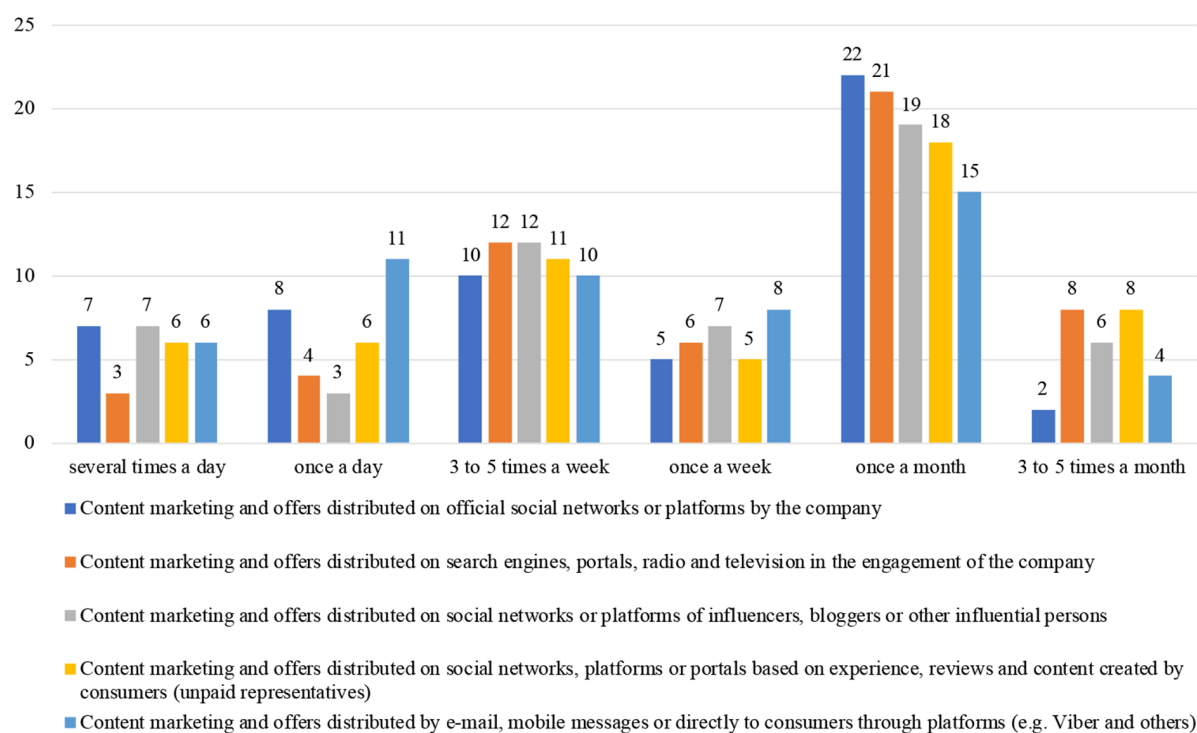
Figure 4 shows the frequency with which respondents receive discounts, promotional codes and other benefits through content marketing. For all forms of content distribution, most often this offers to be once a month. However, some respondents stated that this is the case 3 to 5 times a week. It is interesting to note that a proportion of respondents, 11, receive special offers directly via e-mail, mobile messages, or platforms once a day.

Figure 5 refers to the negative aspects of the effects of content marketing. Respondents had to express their agreement with two statements, the first relating to unnecessary consumption and the second to borrowing. The data analysis revealed that content marketing encourages customers to make unnecessary purchases. The average score was 3.87, and most customers agreed that such content encourages unnecessary purchases. Slightly fewer respondents, with an average score of 3.30, believe that content marketing influences their borrowing of money.



**Figure 3.** The frequency of respondents' encounters with content marketing

Source: Own research



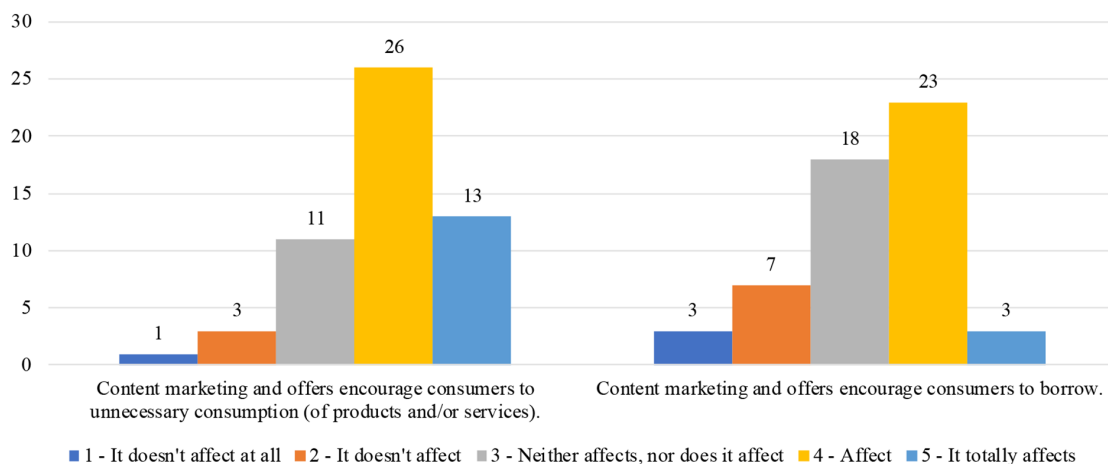
**Figure 4.** Frequency with which respondents receive discounts and promotional coupons/codes in addition to marketing content and offers

Source: Own research

Figure 6 shows the respondents' agreement with the positive aspects of content marketing. The majority of respondents (23 of them) neither confirmed nor denied their agreement with the numerous benefits of content marketing in connection with discounts and other advantages when

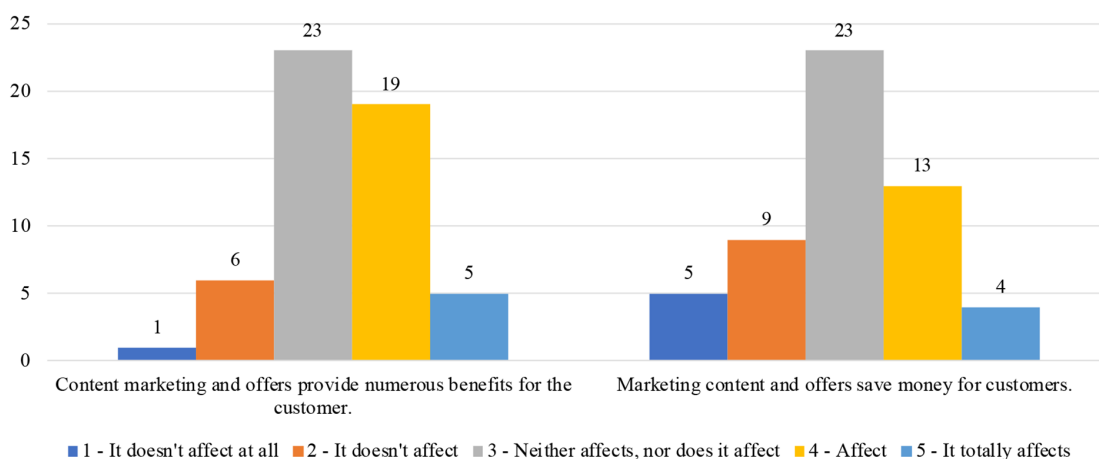


making a purchase. The average score was 3.38. Respondents' opinions on content marketing enabling more favorable offers available to customers, i.e. the opportunity to save money, were divided. With an average score of 3.03, some respondents agreed with this statement, while others felt that the cost savings had not been achieved.



**Figure 5.** Negative context of content marketing

Source: Own research



**Figure 6.** Positive context of content marketing

Source: Own research

## 5. LIMITATIONS AND CONCLUSION

The constant development of technologies opens up new initiatives to offer customers products and/or services and improve the customer experience. Content marketing and offers are reaching potential customers more easily than ever via various media and channels. This is done in an attractive, exciting and user-friendly way. Customers are not only co-creators of value but their active role is expanded and they become partners in sales and reaching awareness of the company's brand.

Alongside influencers, bloggers, marketing experts and other marketing influencers, the customer is becoming a creator, sharer and disseminator of content. All generations of people are actively pursuing different content in the digital environment, which is changing their behavior. Research has shown that content marketing and offers in the digital environment influence consumer behavior and purchasing decisions. The effects of content marketing can be divided into positive and negative aspects.

The conducted research provided an insight into the impact of marketing content on consumer behavior, focusing on the positive and negative aspects of the impact of content marketing, however only a small sample of respondents took part in the research and therefore some broader and clearer conclusions were missing.

The marketing content in the digital environment influences consumers in their purchasing decisions, encouraging them to make impulse purchases and increase consumption. The influence on consumer behavior is most evident in the content distributed via social networks and corporate platforms, by customers and then by influencers, bloggers and others. However, it can be seen that customers trust the experiences and reviews of other customers the most. It can be seen that customers follow the content daily, while most receive certain benefits once a month.

Ultimately, however, it can be stated that the respondents are unanimous and confirm the negative aspects of the influence of marketing content (unnecessary purchases and borrowing), while they are divided on the positive aspects, i.e. most of them stated that they didn't achieve benefits and save money. Another limitation relates to the research of positive and negative aspects, where only the two most frequently mentioned aspects from each group were included, while more are mentioned in the literature.

Future research will include analyzing positive and/or negative content marketing by content type (educational/entertaining/informative) and assessing content value according to customer expectations.

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# Impact of COVID-19 Pandemic on Use of ICT in Marketing in Montenegro

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**Abstract:** COVID-19 caused significant changes in daily lives, including, but not limited to the limitation of movement and working from home. As a consequence of spending more time at home, more time is spent in front of internet-enabled devices. This paper is trying to address whether the COVID-19 pandemic caused accelerated application of ICT in marketing in Montenegro. One of the findings presented in the paper is that micro-companies had a significant increase in internet marketing budget, while mini-companies reduced spending on it. Using data from original research, the clear conclusion is that the pandemic had such influence in Montenegro, especially in the field of e-commerce through increased presence in its own online shops.

## 1. INTRODUCTION

Novel Corona Virus Disease 2019 (COVID-19) became a worldwide pandemic, as stated by the World Health Organization, in March 2020, affecting all aspects of human life, including business activities (Craven et al., 2020) and the global economic situation (Carlsson-Szlezak et al., 2020). More research in health science will be preferred, but in the area of economic, management, and business studies, the impact of COVID-19 is also important to be analyzed (Manajemen, 2020).

The main method of this research was a scientific research (survey) based on an original questionnaire, created for this research. Based on the survey, respondents present data on the use of ICT technologies in marketing (advertising on digital media, use of influencers, online sales, etc.) before the pandemic and during 2021. By comparing the responses “before” and “after” the pandemic, an attempt is made to determine the increase in the use of ICT technologies in marketing as a consequence of the COVID-19 pandemic. The assumption is that the growth is a consequence of the pandemic, given that the “before” and “after” periods are relatively short, and no significant increase in the use of these technologies is expected as a result of the passage of time.

The sample in this research is a non-probability convenience/volunteer one. The author had access to a limited number of contacts (email addresses) of companies to whom he sent an invitation to participate in the research (convenience sample). Those companies that were interested in participating in the research responded to the invitation (volunteer sample). Considering that there is no central database with contacts of all companies, the author of the paper could not apply probability sampling.

The anonymous survey was created on the Google Forms survey platform and consisted of 28 questions, including classification questions. The questions were closed-ended with suggested

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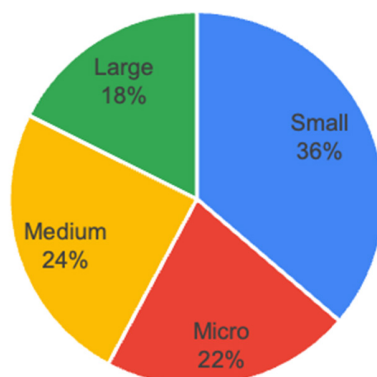
answers. The survey questions, in addition to the information needed to classify the sample, were focused on comparing the use of information and communication technologies before and during the pandemic for the purpose of sales and advertising and concluded with questions about post-pandemic plans.

The adequacy of the sample could have been affected by the fact that the survey was distributed via email, so it preferred companies that are more oriented towards the use of ICT technologies in their daily business. Nevertheless, the number of companies to which the survey was sent is significant (about 5% of the total set), and 12% of the companies to which it was delivered responded to the survey.

According to the data of the Statistical Office of Montenegro (MONSTAT), there were 37,255 registered business entities in Montenegro in 2020, while according to the data of the Central Bank of Montenegro on December 31, 2020, in Montenegro, there were 18,846 blocked legal entities and entrepreneurs, that is, there were 18,409 active companies. The survey was sent to more than 850 email addresses (that is, 4.6% of active companies), and was conducted in the period from August 30<sup>th</sup> until September 23<sup>rd</sup>, 2021. The survey has been answered by 102 respondents, i.e., the sample consists of 12% of addressed companies or 5.54‰ active companies (0.54%).

Also, according to the data of the above-mentioned statistical office in Montenegro in 2021, 99.4% of companies used computers in their operations, of which 100% had access to the Internet. According to the same survey (Maltez, 2021), 84.6% of companies had their internet portal, 62.5% of companies had links or company references on social network profiles, and 73.0% provided access to product catalogs or price lists.

The geographical analysis of the sample shows that 89 are companies from the central region of Montenegro (the municipalities of Podgorica, Nikšić, Danilovgrad, and Cetinje), 9 from the south (municipalities of Bar, Budva, Herceg Novi, Kotor, and Tivat) and 4 from the north region (Pljevlja, Berane and Bijelo Polje).



**Figure 1.** Analysis of the sample by company size

**Source:** Own research

The classification by size of the company, as shown in Figure 1., was done according to the definition of small and medium-sized companies published in the Recommendation of the European Commission number 2003/361/EC, as summarized in Table 1, which classified companies into micro, small, medium and large companies. According to the EU classification, the sample included 22 micro, 37 small (micro and small enterprises make up 60% of the sample),



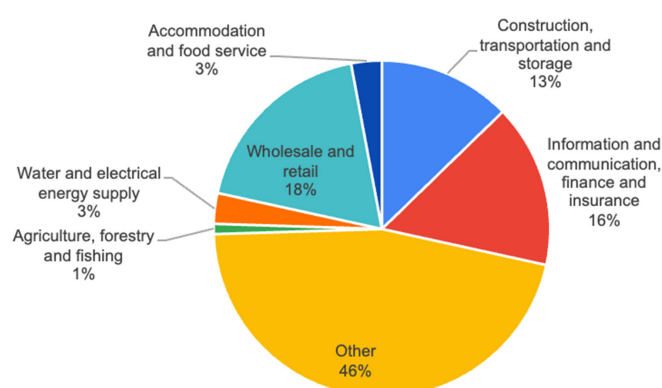
25 medium (22% of medium enterprises in the sample) and 18 large enterprises (or 18% of the sample). For comparison, the structure of companies by size in Montenegro in 2020, according to MONSTAT data (Raičević, 2021), was 98.9% of small companies, 0.9% of medium, and 0.2% of large companies. It is important to note that in its statistics, MONSTAT recognizes only small, medium and large enterprises.

**Table 1.** Definition of company size

Category	No. of employees	Revenue
<b>Large</b>	over 250	over 50 mil. €
<b>Medium</b>	50 to 250	10 mil. € to 50 mil. €
<b>Small</b>	10 to 50	2 mil. € to 10 mil. €
<b>Micro</b>	up to 10	up to 2 mil. €

**Source:** Own research

The survey questions for the classification of the sample by activity sector, as shown in Figure 2, were done following the simplified Classification of Activities KD 2010, which fully corresponds to the Classification of Activities NACE Rev.2 used in EU countries (Eurostat, 2008). Simplification was done to simplify the questionnaire and the classification was reduced from 21 sectors to 7.



**Figure 2.** Analysis of the sample by industry

**Source:** Own research

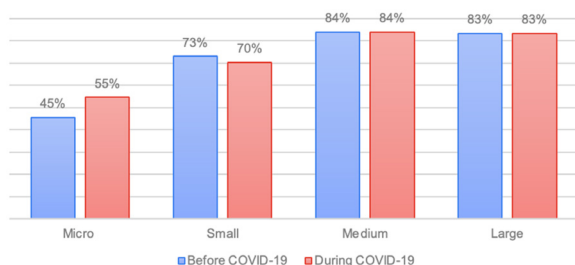
The analysis of the research results was carried out in the Microsoft Excel software, while the statistical processing of the results was done in the IBM SPSS software.

## 2. RESEARCH HYPOTHESIS

The hypothesis of the work is defined as “the COVID-19 pandemic and the measures used to suppress it have significantly accelerated the digitization of the service-trade sector through the increased use of ICT technologies in marketing”. This will represent an alternative hypothesis in statistical hypothesis testing.

## 3. RESEARCH RESULTS

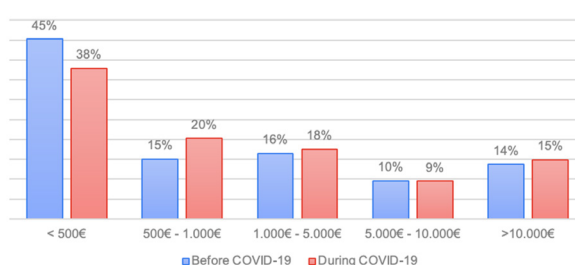
The results of the research indicate a significant growth in the number of companies that invested in internet advertising only among micro-enterprises, as shown in Figure 3. In contrast to micro-enterprises, small enterprises reported a decline in the use of the Internet for advertising, while there were no changes in medium-sized and large enterprises.



**Figure 3.**

Internet use for advertising by company size

Source: Own research

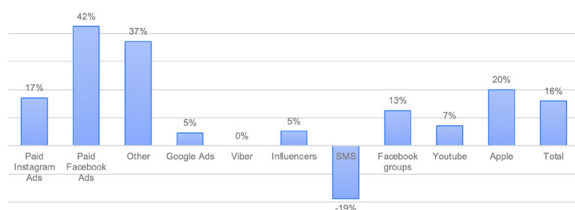


**Figure 4.**

Internet marketing budget

Source: Own research

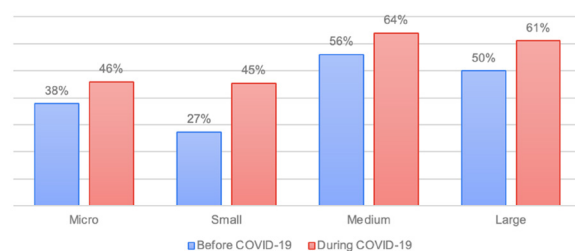
Based on the answers to the question on the budget used for internet advertising, as well as the number of companies that used the internet for advertising before and during the pandemic, it is concluded that companies that recognized the advantages of internet advertising before the pandemic itself, invested additionally in this type of advertising during the pandemic through increasing the budget, while companies that had no experience with internet advertising had a hard time deciding to invest in this type of advertising, not wanting to risk a potential loss of investment, which is shown in Figure 4.



**Figure 5.**

Comparison of the use of individual ICT channels for advertising before and during the pandemic

Source: Own research



**Figure 6.**

Use of Internet for sales by company size

Source: Own research

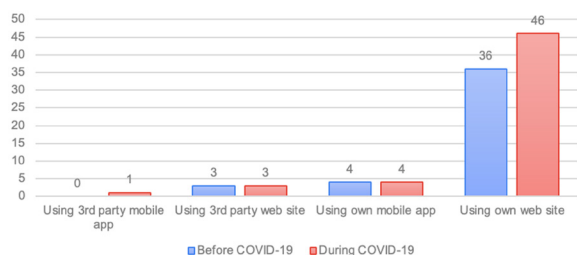
The aforementioned conclusion is supported by the data from Figure 5, which illustrates a significant increase in the use of various digital communication channels, with the only exception being the usage of SMS.

A significant result of the research, in terms of proving the hypothesis of the work, provides an answer to the question of using the Internet to sell products before and during the COVID-19 pandemic, which is shown in Figure 6. In contrast to the use of ICT technologies, where growth was noted practically only in the segment of micro enterprises, the answers to the question about the use of the Internet for selling products before and during the pandemic show growth in all categories of enterprises.

Based on this data, it can be concluded that the restrictions on the movement of the population as well as the shortening of the working hours of shops have forced companies to offer their products on the digital market, which in the virtual world can work 24 hours a day, 7 days a week.

This conclusion is aligned with the data showing an increase of 28% in the number of companies that sold products through their internet portal, indicating a large fragmentation of online

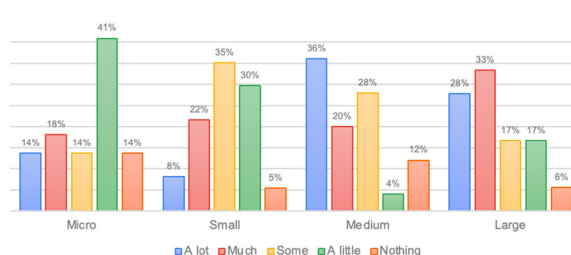
stores, where practically every company has its store, as depicted in Figure 7. This approach makes it difficult for consumers to buy products of different categories because they cannot do it in one “virtual” place.



**Figure 7.**

Ways to use Internet for sales

Source: Own research



**Figure 8.**

Perception of benefits

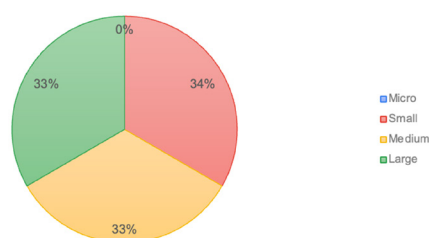
from internet advertising by company size

Source: Own research

There is a clear conclusion that the popularity of online shopping in Montenegro would improve significantly with the introduction of multi-brand online stores such as, for example, Amazon.

Questions about the perception of the importance of Internet advertising and Internet sales differ significantly depending on the size of the company. Companies that used these types of ICT marketing had the option to answer the question about importance with “none” (1), “a little” (2), “some” (3), “much” (4) and “a lot” (5).

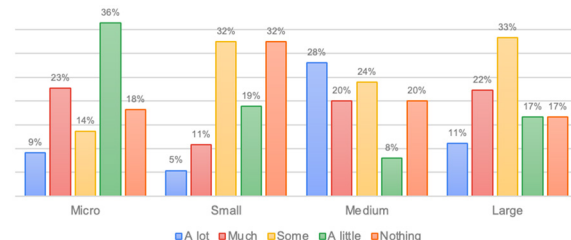
From Figure 8, it can be concluded that the perception of the importance of Internet advertising increases with the increase in the size of the company. It can be assumed that this perception is in direct correlation with the funds invested in digital marketing, as can be seen in Figure 9, that is, that micro-enterprises do not invest enough in digital marketing to experience its benefits.



**Figure 9.**

Division of entities with digital marketing budget over 5,000€ per year

Source: Own research



**Figure 10.**

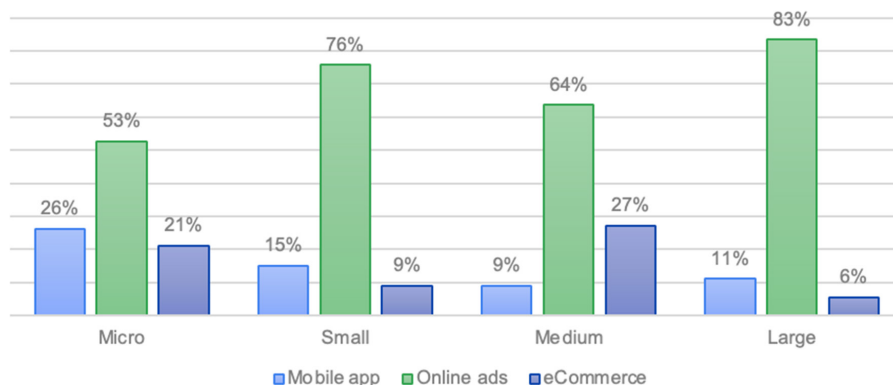
Perception of benefits from internet sales by company size

Source: Own research

The size of the company also influenced the perception of the importance of the impact of sales using ICT technologies on the company’s business, with the same trend as with the use of digital marketing, as shown in Figure 10.

As shown in Figure 11., the rating of the most useful ICT channel for accessing customers by company size generally corresponds to the perception of the term “benefit” from Internet advertising, where we have an increase in the rating of usefulness with the increase in company size.

When evaluating the most useful channel for accessing customers, a significant percentage of micro-enterprises rated the mobile application as the most useful channel. However, it should be emphasized that most of the surveyed micro-companies answered the question “Which mobile application did you use?” with “Instagram”, which is a digital advertising platform.



**Figure 11.** Evaluation of the most useful ICT approach for customers

Source: Own research

#### 4. RESEARCH IMPLICATIONS

According to [Abiad et al. \(2020\)](#), the coronavirus has forced consumers to stay at home, causing a change in customer behavior ([Zwanka & Buff, 2021](#)), which has forced retailers to modernize and offer their products online, which is in line with this research and research by [Vázquez-Martínez et al. \(2021\)](#), which shows an evident shift in purchasing habits of customers from physical to online stores. Also, this research states that especially micro and small, companies that have not previously used ICT technologies in advertising and sales were cautious and unwilling to invest in, for them, new and unproven technologies, which is in line with research by [Vuřa et al. \(2022\)](#).

#### 5. PERSPECTIVES IN THE APPLICATION OF ICT TECHNOLOGIES IN MARKETING

The survey showed that the majority of surveyed companies used their internet portal for online sales. However, statistics in Montenegro and around the world show that consumers prefer a different approach.

**Finding One:** In Montenegro, as many as 68% of consumers buy via smartphone ([Investitor, 2021](#)), which indicates that the correct approach to consumers in Montenegro would be through a mobile application, not an internet portal. This is, perhaps, partially reflected in the intention of an additional 20% of surveyed companies to use their application for mobile phones in the near future.

**Finding Two:** According to the information from [Statista \(2019\)](#), the most popular trading platform in the United States by far is Amazon (80.64%), followed by Walmart with 46.08% and eBay with 33.28%. Customers prefer multi-brand platforms for many reasons, such as delivery security, return of defective products, product quality, as well as reviews from other customers. If we comprehend the primary causes of this connection, it becomes evident that Montenegro's online sales could experience significant growth with the presence of a multi-brand trading platform. According to [Lazaroiu et al. \(2020\)](#), such a platform would facilitate client access and build greater trust in online shopping. In addition to the mentioned advantages, such a platform

would allow more companies to access clients using ICT technologies, eliminating the need to invest in the necessary prerequisites for starting such sales.

It is clear from the research that, although they follow modern trends in the use of ICT technologies in the world, marketing and sales managers in companies in Montenegro need a little more education and information about the needs of the market, i.e., consumers.

Looking further, technological disruptions such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data Analytics (BDA) have offered digital solutions to attract and maintain a user base (Anshari et al., 2019). New technologies provide a competitive advantage (Rouhani et al., 2016) by enabling users access to the offer of products and services (Balaji & Roy, 2016). According to Gans (2016), in the current business scenario, fierce competition and technological disruptions have changed the way companies operate. A globally oriented approach to clients focused on customers' needs, plays a key role in the company's growth (Vetterli et al., 2016). Artificial intelligence is a widely used new technology that helps organizations monitor real-time data to analyze and quickly respond to customer requests (Wirth, 2018). It offers companies insight into consumer behavior essential to attracting and retaining customers. One such example is the online service Netflix, in which movie and series recommendations are one way of encouraging users to continue using that service. AI prompts the customer to take the next step and redefines the overall experience (Verma et al., 2021).

## 6. DISCUSSION AND CONCLUSION

For the purposes of statistical analysis of this research, Student's t-test and McNemar's test were used, while McNemar's test is recognized as more adequate for "YES/NO" surveys (Pembury Smith & Ruxton, 2020). McNemar's test is a test for evaluating the significance of the difference in the frequencies of a dichotomous characteristic of two dependent samples and is often called the Test of Independence in two dependent samples.

If we compare the results of the same group "before" and "after", as shown in Table 2, or if we compare the same group in two different activities, then it is likely that there is a correlation between the first and second result (Petz et al., 2012, p. 264).

**Table 2.** Results on a sample of 102 surveyed companies

		During COVID-19 pandemics		
		Use	Do not use	Total
Before COVID-19 pandemics	Use	41	2	43
	Do not use	13	46	59
Total		54	48	102

Source: Own research

We define the null hypothesis as  $H_0$ : **the COVID-19 pandemic did not influence the increase in the use of ICT technologies in marketing in Montenegro**, while the alternative hypothesis is defined as  $H^a$ : **the COVID-19 pandemic influenced a significant increase in the use of ICT technologies in marketing in Montenegro**.

In this particular case, by using a statistical tool the p-value (the probability that the results from the sample data occurred by chance) was determined as  $p=0.0098$ , leading to the conclusion that the null hypothesis can be rejected, that is, that the COVID-19 pandemic did influence the



increase in the use of ICT technologies in marketing in Montenegro, which confirms the hypothesis of this research.

In order to further confirm whether the mean values of these two groups of data (before and during the COVID-19 pandemic) are statistically significantly different from each other, the Student's t-test was used. The null and alternative hypotheses were set, similar to the previous test, that there will be no increase in the use of ICT technologies in marketing in Montenegro, as a result of the COVID-19 pandemic, or alternatively, that there will be an increase.

To quantify the results of the research, the answers "yes" and "no" are reduced to "1" and "0". In the statistical tool, the value of t (ratio of mean difference and standard error) is 2.16, and the degrees of freedom  $df = 101$ .

Using Student's t-distribution table, it is concluded that the p-value is between 0.025 and 0.01. Since the p-value is also below 0.05 in this case, we again conclude that the initial hypothesis can be rejected in favor of the alternative hypothesis.

Following this research, and based on the presented results of the same, theoretical knowledge and opinions regarding digital marketing and the impact of the COVID-19 pandemic on it, it is possible to conclude that **"There is an evident increased growth in the use of ICT technologies in digital marketing during the COVID- 19 pandemic. This is particularly reflected through the use of the Internet for the purchase of goods and services, but also a greater online presence in advertising."**

Social networks Instagram and Facebook are especially popular for advertising on the internet in Montenegro with SME companies, through paid ads, while large companies prefer to use influencers on social networks. Online sales are mostly done through their internet portals, although micro-enterprises prefer the use of social networks as a kind of combination of advertising and sales.

Companies in Montenegro adapted to the social specifics of the market during the COVID-19 crisis through an increased presence on the Internet, either in the form of promotional activities on social networks or through online sales platforms.

There is obvious room for progress in the use of ICT technologies on the Montenegrin market through greater representation of applications for smart mobile phones and the eventual creation of multi-vendor online stores.

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# Unveiling the Experiential Dimensions Driving Local Producers, and the Potential Ways of Transmitting the Experience to Consumers

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**Abstract:** *Most studies related to sustainable small-scale local producer life-styles focus on producing healthy foods. Research that integrates other aspects of mental and spiritual well-being into the holistic concept of a healthy lifestyle is mostly missing. The study examines the motives behind the lifestyle choices of farmers engaged in sustainable production in Western Hungary and draws attention to aspects that are beyond the preference for environmentally conscious (sustainable) production of foods. The authors are looking for an answer to what motivates local producers to carry out their activities and what relatable elements of experience can be identified.*

## 1. INTRODUCTION

In recent times, the field of sustainable consumer trends has garnered substantial interest, centered on the capacity and potential for altering food consumption patterns. Scientific literature about health-conscious consumers primarily emphasizes physical health as a crucial component of overall well-being. Researchers examining the motivations of eco-friendly food consumers also highlight aspects such as trust, way of life, and self-actualization.

In this study, the authors shift their focus to the motivations of sustainable production among producers, with the goal of demonstrating that the attributes of sustainable production are not limited to environmental sustainability and healthy lifestyles but can also be interpreted in a social context.

The authors begin with the premise that responsible production involves considering social, environmental, and ethical factors in both the short and long term. This underscores the importance of holistic research and supports the argument that the concept of sustainable production cannot be reduced to health consciousness alone. Therefore, sustainability research should explore the dimensions of the inner experience of the production.

The study examines the intrinsic motives behind and the lifestyle choices of local producers engaged in sustainable production in Western Hungary, drawing attention to aspects and components

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of this choice that go beyond the preference for environmentally conscious (sustainable) production of healthy food, naturally taking into account the effects of recent market and technological changes which influence the evolution of producers' beliefs, perceptions and habits.

According to the authors, responsible production cannot be solely determined by goal-oriented and profit-oriented motives. Instead, it may also be influenced by components such as absorption, environmental connection, and social stimulation. The authors aim to examine how the 'choice of path' (i.e., the production processes) and the 'goals to be achieved' relate to each other from the producer's perspective.

## 2. METHODS

Prior to delving into the subject matter, the authors found it essential to clarify the concepts of local production and local products, along with their unique attributes.

**Table 1.** The unique attributes of local production and local products

Attributes	Sources of information
<b>Geographical proximity</b> (production, processing, distribution, and consumption occur geographically close to each other or within the same region within a 20 to 100 km radius)	(Beke, 2021; Cvijanović et al., 2020; Kneafsey et al., 2013; Lang et al., 2014; Mesić et al., 2021; G. Fekete, 2009; Szomi, 2022; Nemes et al., 2019)
<b>Subjective</b> (depends on factors such as the size of the population and whether the settlement is rural or urban in nature or the closeness of cities)	(European Commission, 2013)
<b>Social proximity</b> (closeness of the relationship between and the familiarity with the producers, trust, transparency, information sharing)	(G. Fekete, 2009; Kiss et al., 2020; Kovács et al., 2022; Schlett, 2021)
<b>Perceived traits</b> (authenticity, freshness, better quality and taste, uniqueness, cultural heritage preservation)	(Sántosi & Böröndi-Fülöp, 2014; Szente et al., 2014, Nagy, 2018; Szegedyné Fricz et al., 2020; Kovács et al., 2022; Lisányi et al., 2022)
<b>Positive social impacts</b> (health consciousness, environmental considerations, uniqueness, and a desire to support local economies)	(G. Fekete 2009; Skallerud & Wien, 2019; Cvijanović et al., 2020; Kiss et al., 2020; Koncz et al., 2021; Mesić et al., 2021)

**Source:** Own research

It is important to note that local production operates on different principles than other sectors producing for the global market. As human labour inputs or other costs may be higher, it is necessary to identify the characteristics that may result in a positive shift for small-scale farmers to then examine their role in sustainable production attitudes and farming strategy choices.

The smallholder lifestyle and life management practices have their specific character traits. In contrast to large-scale production, the producer is connected to the product. They do not merely specialize in a single operation but oversee the whole production process. The position of the owner is, therefore, active. The owner is present, exercising actual control over the enterprise and its physical assets. In addition to these, intellectual values may also be attached to ownership. Ownership is a direct source of pleasure in addition to the income. The enterprise thus contributes to fulfilling the small producer's personality. It thus represents a subjective value for the business owner, regardless of its market value.

Profitability is a measure of the effectiveness and efficiency of work. In modern culture, individuality and privacy are highly valued, and people value themselves according to what they have achieved in life as individuals (Scitovsky, 1990).



There is a wealth of psychological research that shows that the most important source of human experience is social stimulation. However, a common effect of a rational, utilitarian, work-centred attitude to life is that it leads to having less time and attention to others. Although the quality and richness of interpersonal relationships increase the sense of happiness to a much greater extent than increasing income or consumption (Hellmich, 2020; Schlett, 2021; Wärneryd, 1988).

Therefore, in our research, we attached great importance to examining the relationship between the importance and depth of profitability decisions as well as interpersonal relationships. We aim to understand how local agro-entrepreneurs in a sub-region that still retains traditional characteristics view interpersonal relationships and social embeddedness. The other focus of our research was the inner experience of the activity. Psychological studies in the realm of work have primarily concentrated on enhancing individual productivity and reducing friction.

However, work is often characterized by a sense of alienation. Many work-related challenges can be traced back to this sense of alienation, which arises from extreme specialization. Classical and neoclassical economics assumed that people's decisions were solely influenced by rational expectations. However, the rise of behavioral economics was prompted by the need to analyze the distortions caused by rational expectations, using psychological and other social science disciplines (Thaler, 2016). Our paper, however, does not focus on human biases in 'rational choice', but instead asks how the intrinsic nature of local producers' activities contributes to their behavioral attitudes.

Focusing solely on the objective of an activity may diminish the very essence of participation and involvement. A range of human activities, including sports, play, and the fine arts, serve to enrich our lives with pleasure and provide joyful experiences. In these autotelic activities, satisfaction is derived from the activity itself, without the need for external rewards or motivations (Csíkszentmihályi, 2014a, 2014b, 2014c; Pugno, 2014; Scitovsky, 1990).

Building on the theoretical foundations, the authors opted for using the in-depth interview technique in the first phase of the research project, as these interviews provided them with more in-depth knowledge to explore:

- the main motivations for local producers to carry out their activities;
- the level of autotelic factors; and
- the role of the autotelic factors as driving forces.

The target area of the study was the West-Transdanubia. It is one of the NUTS-2 statistical regions of Hungary, surrounded by the Slovenian, Austrian and Slovakian borders. The region is relatively fragmented due to its topography, which gives the region its unique appearance. This geographical feature has influenced the local communities and their way of life. The fragmentation of the landscape has provided an ideal environment for small-scale production. Ten local producers (cheese makers, wine producers, horticulturists, meat processors, jam and syrup producers, fruit producers, beekeepers, pasta makers, and essential oil producers) were interviewed. Data collection took place between September 20, 2023, and November 15, 2023.

### 3. RESULTS – THE PREFERENCES OF LOCAL PRODUCERS

In our in-depth interviews, we set out to uncover the key attitudes defining sustainable small-scale producers, looking beyond the obvious profit motive. The psychological needs arising

from the conditions of human existence go beyond material considerations. We looked beyond the satisfaction of these needs to identify the determinants of psychological and mental health. Our goal was to understand not only which attitudes are most significant but also how they interconnect and influence one another.

From our review of the psychological tableau of well-being during the in-depth interviews, it quickly became apparent that economic activity, or economic success in the narrow sense, is only one source of well-being. In our research, we explored the aspects of small producers' attitudes that they perceive as determinants.

In our research, we identified two main groups of attitudes:

Social - cultural attachments:

- importance of **human-social ties**,
- the importance of **local community ties**,
- organic **landscape-people relationship**,
- attachment to a distinctive **local product** (local exotic) or local production processes,
- the importance of local **cultural tradition**.

Autotelic attitude:

- need to be **involved**.
- within the group, an **escapist** orientation has become clearly distinguishable, where the escape from a modern, mechanized, and crowded world, the immersion in an activity, is the dominant experience.

Of course, while considerable overlaps exist, their dominance may vary widely (Rützler, 2021). Nonetheless, it's crucial to pinpoint that the most stimulating phenomena are fundamentally rooted in human action, imagination, and local culture.

### 3.1. Social Embeddedness

While mutual stimulation is generally not framed as an economic phenomenon, the 'background experience' associated with economic activity and resources is highly valued among the benefits generated. Most of the stimulating effects were observed within human connections and their reciprocity. Our research shows that the stimulus was provided to producers by the infinite variety and unpredictability of human interactions and the myriad challenges they posed.

The research has revealed that one of the main sources of satisfaction for local producers is social stimulation, much of which is mutual stimulation.

### 3.2. Autotelic Attitude

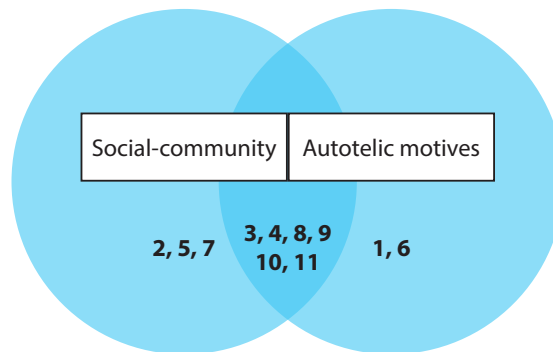
Based on Csíkszentmihályi's flow theory (Csíkszentmihályi, 2014a, 2014b, 2014c) and the works of Csíkszentmihályi and Nakamura (2014) and Csíkszentmihályi et al. (2014), the authors identified several components of autotelic attitude. It is important to emphasize that we can speak of autotelic activity when we do something not for further gain, but simply because we like doing it. If a given activity is autotelic in nature, then the health benefits associated with that activity, or even the benefits of being free from stress, are irrelevant (Schlett, 2021).

The authors of this paper identified the following autotelic characteristics:

- **Hobby:** work as a hobby;
- **Talent** in the field, but at least a balance between the individual's abilities and the difficulty of the task;
- **Present-oriented:** focus on the present rather than the unpredictable future;
- **Self-serving/Intrinsic:** the activity should be intrinsically rewarding;
- **Absorption:** to be completely immersed in what someone is doing, to identify with it.

### 3.3. Experience Motives Based on the Results of the In-depth Interview Surveys

The responses from the in-depth interviews helped to identify the main local producer motivations, and these can be put in parallel with the two key dimensions identified in the literature. Figure 1. shows the main mentions and reflections of local producers in relation to the socio-occupational and autotelic motives.



**Figure 1.** Social Embeddedness and Autotelic Attitudes - the main mentions and reflections of local producers in relation to the socio-occupational and autotelic motives

**Source:** Own research

The following main responses were given by the local producers interviewed:

1. "The product and the activity that I do is me."
2. "To do something I believe in, something that is good and works, because years of experience and tradition give it strength."
3. "I get pleasure from the activity I do, and I give pleasure to others."
4. "It is a good feeling to teach others something, and it's nice to see that they are happy to take the created product away."
5. "The strength and cooperation of the local community is a huge motivation." (see for example Zala Völgyi Nyitott Porták).
6. "My hobby gave me the idea, and this is where I can really feel complete."
7. "It's important for me to be natural and to incorporate that into the products."
8. "It is a good feeling when I come up with something new and it pleases my customers."
9. "The smile and feedback of a returning customer is what gives me the real experience."
10. "There's nothing like the experience and atmosphere of a local fair."
11. "For me, it's the community programmes that give the real experience."

(Source: own research, 2023).

Both the social and community and the autotelic factors can be delineated from the responses. However, as shown in Figure 1., the responses classified in the intersection of the two circles deserve special attention, as they combine the power of both dimensions to create a more profound

emotional imprint. The landscape-people relationship, local community cooperation and consumer involvement play a key role in this system. It is no coincidence that producers are becoming increasingly active in organising experiential programmes, such as tastings, wine tours, excursions, educational presentations, and product demonstrations. The experience is perceived by both producers and consumers, and the entertainment environment creates a good atmosphere. At the same time, tastings, fairs, and demonstrations enable information to be obtained directly from producers, thus creating a more personal relationship between producers and consumers, deepening trust and bonds, and developing consumer awareness.

Other benefits include the marketing value for local producers to showcase their products, promoting local products and strengthening the local brand. The programmes revitalize local traditions and can positively impact community building, local cohesion, knowledge sharing and the attractiveness of local tourism. All this is extremely important, as it is an increasingly evident challenge and opportunity for local producers to provide consumers with something extra that they will experience and then tell their friends and acquaintances about, remember positively, and even cherish in their memories.

#### 4. FUTURE RESEARCH DIRECTIONS

The findings of this study open further research opportunities that may contribute to a more complete exploration of the underlying determinants of producers' flow experience. The results provide a sound basis and pave the way for examining the extent to which authentic producer experiences can be transferred, transformed, and communicated to consumers.

Based on the results of the in-depth interviews, the authors plan to deepen the analysis of producer attitudes in the Zala Valley and other regions using quantitative methods. The study may also provide an opportunity for comparative studies, exploring consumer perceptions, and identifying producer-consumer linkages.

#### 6. CONCLUSION

The research has shown that the small entrepreneurial mindset is rooted in needs beyond the physical, such as involvement, the socio-cultural attachment to the past, tradition, nature, place, local culture, and transcendence. In terms of self-acquisition, self-perception and the building blocks of experiencing, for local producers, the close connection with their products and their markets, their environment and local traditions has great potential.

The results of the in-depth interviews showed that both social and autotelic factors are present in the motivations for production. However, at the intersection of the two circles in Figure 1., a new dimension is clearly visible, which can lead to an even higher level of producer experience. In this, collaboration, human involvement, interaction, co-creation, and knowledge transfer play a vital role. And these factors can lead us towards an even richer producer experience that is "entertaining, enriching, aesthetically pleasing and totally immersive" (Pavluska, 2014, p. 384).

Our research also shows that:

- "If we can find ourselves, anything can create a flow, we can enjoy the energy flowing through us almost continuously, without having to waste our energy on side trips." (Csíkszentmihályi, 1997).

- “We are looking for meaning in our lives, something we believe in, something that goes beyond us.” (Horváth, 2020).
- When an experience is shared with others, it becomes sustainable and becomes a shared memory. Shared memories have a longer lifespan than individual memories (Ásványi, 2022). This increases trust and attachment, which links the experiential dimensions studied in this article even more intensively.

It can be concluded that the most intense experiential driving force is the combination of the social and community and the autotelic factors and their intersection point, which can create a deeper emotional imprint.

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# Differences in Household Intentions for Sustainable Food Consumption

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**Abstract:** *The main purpose of this paper is to present part of the results of a survey carried out on the territory of Bulgaria among the households of three Bulgarian cities. The research was conducted in two waves and covered 2,117 Bulgarian households, with the data collected through a survey. The focus of the presented results falls on examining the relationships between some demographic characteristics such as income, education, dwelling size, place of residence, household size, household life cycle, and intentions to consume sustainably produced food. The results of the study show the existence of relationships that can be analyzed.*

*The revealed, albeit weak, regional differences in the intentions of households from the three cities to consume sustainably produced food and food products can be used in the construction of marketing strategies and tools aimed at stimulating the consumption of sustainably produced food products.*

## 1. INTRODUCTION

Stimulating the production and consumption of sustainably produced food is one of the EU's development priorities for two main reasons. The first is related to EU strategies for improving people's quality of life, including their health status, and the second one - with programs for the use of public resources to support sustainably produced foods. In this sense, the role of households as an object and participant in the implementation of strategies is of particular importance. On the one hand, it is related to their inclusion in the achievement of the global goals of sustainable development, and on the other - to the pressure on the economy that they can exert through the demand for sustainably produced food and other products. Several opinions are also advocated, according to which the promotion of sustainable food consumption helps to the achievement of the United Nation's Sustainable Development Goals (Nguyen et al., 2021). On the other hand, the thesis advocates that although the popularity and consumption of sustainable food are growing globally, in peripheral areas where production and realization are not so developed, the intentions and attitudes of individuals are not sufficiently well studied and require special attention (Feil et al., 2020). It should also be noted that according to some scientists, the modern food system is not sustainable and the impact of food consumption on the climate crisis is significant (Ammann et al., 2023). This, in turn, shows the importance of researching intentions for sustainable food consumption as part of the processes related to achieving the goals of sustainable development, as well as the social and psychological dimensions that condition it (Lema-Blanco et al., 2023).

## 2. LITERATURE REVIEW

The starting point in the research is the definition of sustainable consumption. According to this, we can define it as the consumption of goods and services produced in a sustainable way. This scope includes such goods and services, in the production and realization of which the use

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of natural resources and pollutants is minimized, so as not to harm the consumption of the next generations. But, as we can see, sustainable consumption is a very large topic, so we can focus our interest only on food consumption. On the other hand, scientific interest in sustainable food consumption is very large. Only one search using that combination of keywords (sustainable, food, and consumption) gives us a huge result in scientific publications. If we take one of the bibliometric databases – Medeley.com – we can find more than 16,000 results. More than 10,000 of them are in academic journals. In the last four years, we can find about 1,500 results averages by year. This short example shows that sustainable food consumption is a hot topic in the field of marketing research and, of course, in marketing practices. A bibliometric analysis of publications in the Web of Science from 1975 to 2019 shows that the number of topics included in the consideration of sustainable food consumption is constantly growing within the framework of the two possible perspectives - of the individual and society and this trend has become stronger in the last five years of the analysis carried out (Diaconeasa et al., 2019).

In researching sustainable consumption, there are different possible approaches. One of them, widely advocated in the literature, is related to the search for a theoretical framework to explain the motives and values behind sustainable behavior in general. In this connection, the theory of planned behavior (TPB) can be mentioned (Ajzen, 1991). This theory, developed by Ajzen, and based on his previous research works, tries to explain human behavior as reasoned action (Hill et al., 1977). Concerning these theories, conducted empirical studies show the presence of relationships between sustainable food consumption and social norms, perceived value, perceived consumer effectiveness, and consumer attitudes (Alam et al., 2020). This gives us reason to conclude that sustainable food consumption is a complex process that is determined by external and internal factors. Some of these factors are revealed in the already cited bibliometric analysis, such as involvement, health care, knowledge, and attention focused on sustainable development and the environment, and also such as climate change and environmental impact (Diaconeasa et al., 2019).

Another bibliometric analysis of papers, related to sustainable food consumption covering the period from 1990 to 2023 shows the presence of several sub-themes connected to the consumption of organic products, waste disposal, sustainable development, and consumer behavior (Kristia et al., 2023). In this sense, sustainable food consumption intentions can be seen as a function of personal attitudes towards personal health care and environmental protection - two areas that refer to the already outlined personal and social perspectives of consumer behavior. In support of such a statement, other studies can be cited that link sustainable food consumption to four groups of factors - cultural, social, economic, and related to environmental care (Mensah et al., 2023).

Alam et al. (2020) defined sustainable food consumption intention as something that reflects the future behavior of individuals. Based on the adapted TPB model, they underlined five factors that can determine intentions – Perceived Value, Attitude, Social Norm, Perceived Availability, and Perceived Effectiveness. The results of the conducted empirical study show a strong relationship between intention and sustainable food consumption. In this sense, the study of the intentions of households to consume sustainable food can be seen as a predictor of their future behavior as buyers. The same approach can be seen in other studies. For example, when studying recycling intentions, part of the sustainable behavior of individuals, Pathak et al. (2023) used the TPB model and found a relationship between intentions and two other factors - the place of residence and the existing subjective and moral norms of human behavior (Pathak et al., 2023). In this sense, the specific characteristics of the region, such as the social and ethical norms of the population, cannot be excluded as factors that influence the intentions of sustainable food consumption.



Other studies discuss the relationship between green self-identity, self-congruity, and sustainable food consumption (Gravelines et al., 2022). Based on a study that included 837 respondents from Lithuania, the researchers concluded that sustainable food consumption, in addition to functional benefits such as good taste and health care, is also associated with symbolic benefits such as identification with the ideas of sustainable development and green Lifestyle. Based on a literature review conducted, these factors cannot be excluded from the study of sustainable food consumption intentions. For example, a study focused on the influences on sustainable food consumption behavior of students found links with their healthy lifestyle and outlined the areas that influence consumer choices (Aguirre Sánchez et al., 2021). According to Aguirre Sánchez et al. (2021), these factors can be divided into five main groups – 1) how the food is produced, 2) the impact of food transport on the environment, c) the materials from which the packaging is made, 3) specific food choices (such as limiting meat consumption or using legumes and grains) and 4) food waste. This means that when designing a scale to assess intentions for sustainable food consumption, the variables should be grouped into separate zones that take into account the influence of different groups of factors.

Other studies have highlighted the relationship between rational and emotional aspects that influence the intention to purchase organic food. The attention of the researchers is also directed to the feeling of guilt when buying conventional food by individuals sensitive to environmental protection and at the same time to the financial barriers that reduce purchase intentions (Nguyen et al., 2021). Based on this, it can be argued that the influence of demographic and psychographic variables such as income, attitudes towards environmental protection topics, and feelings of guilt should also be included in the study of intention for sustainable food consumption. A similar relationship is seen in other literature studies that identify sociodemographic characteristics such as gender and level of education as key to choosing sustainable food (Ammann et al., 2023). The influence of knowledge about sustainability and the willingness to pay a higher price for sustainable foods compared to conventional ones should also be noted. At the same time, the influence of values on intentions for sustainable food consumption cannot be ignored. Some of the studies on the subject show the existence of a relationship between values and eating habits and the different degrees of influence of these relationships in the short and long term (Olsen & Tuu, 2021).

As there are different motives, values, and attitudes behind the consumption of sustainable food, the presence of consumer segments should also be taken into account when researching intentions (Verain et al., 2015). Among the factors that influence these intentions can be pointed out the daily routine of the individuals and the habits related to eating out (Pfeiffer et al., 2017). In this sense, the role of social contacts and communication in social networks, a function of these habits, should also be included in the framework of influence research (Schubert et al., 2021). The following clarification should be made here. When we consider eating habits as part of the socio-cultural environment of individuals, in the context of sustainability they must be tied to individual assessments of the state of the environment, the ability to distinguish the expected from the actual state, which in turn act as a trigger, to change eating habits following the individual's desired state (Vermeir et al., 2020). Only then can the intention for sustainable food consumption be linked to motives that condition behavior aimed at achieving sustainability goals.

In other studies, as the main motives behind the intentions for sustainable food consumption, the diet, social values, environmental attitudes, and the desire for individuals to stimulate the development of local economic communities through their behavior are indicated (Lema-Blanco

et al., 2023). Of course, the environment in recent years has been extremely dynamic and the changes reflect on the formation of intentions for sustainable food consumption and the factors that condition them. In this direction, studies of the influences of online shopping habits (Hedin et al., 2019) and related changes after the COVID-19 pandemic (Zanatta et al., 2022) can be indicated.

In connection with the studies and publications reviewed so far, related to the study of intentions for sustainable food consumption, one more clarification should be made. It is related to the supposed gap between positive attitudes toward sustainable foods and the intention to purchase such foods, which differences can be explained by the degree of development of their distribution in specific markets (Vermeir & Verbeke, 2006). In this sense, it should be emphasized that the degree of development of the sustainable food market in different regions can reflect the presence or absence of purchase intention. Based on the literature review, it can be summarized that in scientific studies and publications, intentions for sustainable food consumption are considered as a construct composed of different groups of factors. In examining these intentions, it is common practice to group the factors into different areas related to the impact of values, attitudes, knowledge, and personal and social influences. From this point of view, the design of a scale for researching sustainable food consumption intentions should include variables arising from the indicated different areas of influence. Of course, as already emphasized, the influence of demographic characteristics on these intentions must also be taken into account.

### 3. RESEARCH METHODS AND RESULTS

The main task of this paper is to present the research results of one aspect of sustainable household consumption. This is the influence of demographic factors on the intentions of households to consume sustainable food. The research thesis is that demographic factors such as the number of persons in the household, number of children under 18 years, education of the household head, household income, size, and type of dwelling can influence intentions to consume sustainably produced foods. Accordingly, two sets of variables are presented here and the relationships between them are tested. The first is related to gathering data on those demographic characteristics that are hypothesized to influence household intentions to consume sustainable food. The second group of variables is designed for the creation of a scale for measuring intention for sustainable food consumption.

The conducted study covers the period 2019 - 2022. Based on a literature review, a theoretical frame of sustainable household consumption is derived. A survey is developed and primary data is collected from 245 households. The first wave of the survey is conducted in February – April 2021, and the second – in October – December 2022. The survey covered a total of 2117 in both waves. The demography of respondents is presented in Table 1.

**Table 1.** Respondent's demographic characteristics

	Frequencies	Percentages
<b>Gender</b>		
Male	875	41.3
Female	1242	58.7
<b>City</b>		
Sofia	779	36.8
Varna	719	34
Svishtov	619	29.2

<b>Level of education</b>		
<b>High school</b>	791	37.4
<b>Bachelor or master</b>	1242	58.8
<b>PhD</b>	81	3.8
<b>Income</b>		
<b>&lt;1500 BGN</b>	306	29.5
<b>1500 – 2000 BGN</b>	301	14.2
<b>&gt;2000 BGN</b>	804	38
<b>No answer</b>	706	18.3

**Source:** Own research

The survey is representative of the three cities. When designing the sample, quota indicators are used: such as the number of persons in the household, gender of the household head, age of the household head, and number of children in the household under 18 years of age. In addition to demographic variables, three separate blocks are included in the survey based on the prepared conceptual frame. Through them, data is collected on the three groups of factors that determine the sustainable behavior of households - that is, their knowledge, attitudes, and actions. The focus is on the search for differences or absence in the three studied regions.

To describe the intention for sustainable food consumption, a scale with a total of 18 variables is constructed (table 2). These variables cover several sets of intentions aimed at purchases of organic products and products taken directly from local producers, requirements for the composition and packaging of food products, the quantities of food purchased by the household, and food waste.

**Table 2.** Variables in the scale of household intentions for sustainable food consumption

No.	Variable	What it measures
1.	We strive to buy more organic or natural foods	Intention to purchase sustainably produced food
2.	We buy food produced by local producers or suppliers	Intention to stimulate the local economy
3.	We mainly buy food produced in our country	Intention to stimulate regional sustainable food production
4.	We strive to consume products and food, our own production	Intentions to engage in sustainable food production processes
5.	We eat home-cooked food as a priority	Intentions to reduce the cost and environmental footprint of food preparation and distribution
6.	We prefer to buy food in organic or recyclable packaging	Intention to reduce the environmental footprint of food packaging production
7.	We mainly consume seasonal foods	Intention to reduce the ecological footprint of food transport
8.	We avoid buying semi-finished products	Intentions to consume healthy food
9.	We try not to eat meat every day	Intention to reduce the environmental footprint of industrial meat production
10.	We are trying to consume more fish and seafood that is not industrially harvested	Intention to reduce the environmental footprint of industrial fish production
11.	We include more fruits and vegetables in our diet	Intention for a healthy lifestyle
12.	We strive to consume more grains and legumes	Intention to stimulate agricultural food producers
13.	We check the food we buy for preservatives and colorings	Intention to avoid consuming foods with harmful ingredients
14.	When buying food, we use reusable bags	Intention to avoid the use of single-use bags
15.	We try not to stock up on food at home	Intention to reduce the volume of food purchased
16.	We try to reuse plastic bags	Intention to reuse single-use products
17.	We try to avoid using plastic bags	Intention to be part of the process to reduce the production of plastic bags
18.	We try to compost organic waste	Intention to reduce the use of chemical fertilizers and pesticides
19.	None of the above correspond to our usual behavior concerning food	Lack of intentions for sustainable food consumption

**Source:** Own research

To investigate whether the 18 questions of the sustainable food consumption intentions scale form a reliable scale, Cronbach's alpha coefficient is measured. The reliability of the scale is 0.815 for the entire sample  $N = 2117$ . The correlation coefficients between the individual questions and other questions range between 0.311 and 0.500, which indicates that the individual questions are well correlated with the others and are good components of the scale.

Confirmatory factor analysis (CFA) is performed using the principal components method and orthogonal rotation using the Varimax method with Kaiser normalization. The results of the tests of the assumptions for the application of the CFA show that the Kaiser-Meier-Olkin measure of adequacy is greater than 0.60 ( $0.939 > 0.6$ ), which means that the number of included variables in each factor is sufficient. Bartlett's test of sphericity is significant because there are values less than 0.05 ( $0.000 < 0.05$ ) indicating that the variables are sufficiently highly correlated. Three factors are assigned, with Factor 1 accounting for 37.7%, Factor 2 7.1%, and Factor 3 5.6% of the variables' variance before rotation. The eigenvalues for the three factors are 6.783, 1.281, and 1.003. Ten variables refer to Factor 1, four to Factor 2, and three to Factor 3 (table 3). In Table 3, the variables forming the three factors are given with the numbers with which they are described in Table 2. Within each of the factors, the variables are ordered according to the magnitude of their factor weights in the Rotated Component Matrix. This sequence is also preserved in Table 4.

**Table 3.** Factors for sustainable food consumption

Factor	Variables	Eigenvalues	% of variance
<b>F1: Specific food choices and diets</b>	2,10,12,3,7,9,13,11,4,6,15	6.783	37.7%
<b>F2: Eating and shopping habits</b>	5,16,14,8	1.281	7.1%
<b>F3: Food disposal and recycling</b>	1,18,17	1.003	5.6%

**Source:** Own research

The influence of demographic variables such as household size, number of children under 3 years, age of the household head, household income, gender of the household head, etc. on these intentions (table 2) is investigated. The collected data is analyzed using a series of chi-square tests, bivariate distributions, and analysis of variance.

The analysis of the frequency distributions of the respondents' answers shows that a total of eight of the eighteen variables in the scale measuring food habits are the most common. These are habits related to the consumption of local food or food, own production as well as home-cooked food. The second group of habits is related to the use of home-cooked food and avoiding the consumption of semi-finished products. The third group of habits is related to the desire to reduce the use of single-use plastic bags, food waste, and recycling. The analysis conducted looked for significant relationships with a set of demographic variables. These are Place of living, Number of members in the household, Number of workers in the household, Children under the age of 13, Gender of the head of the family, Education of the head of the family, Type of housing, and Income. Table 4 shows the statistically significant relationships between these demographic variables and the variables included in the intention scale for sustainable food consumption at  $p < 0.05$ ,  $N = 2117$ . The numbering of the variables for the three factors is given according to their numbers in Table 2.

As we can see from the empirical data analysis, demographic characteristics, albeit weakly, have an impact on sustainable food consumption intentions. The values of the Phi and Kramer's

V correlation coefficients range between 0.149 and 0.289. This indicates the presence of weak relationships but gives us reason to investigate them. Several relations can be commented on from the results in Table 3. There are significant relationships between three of the demographic characteristics and variables in the intention for sustainable food consumption scale - these are Place of living, Children under the age of 3 years, and Income. It can be outlined that among the surveyed respondents, these demographic characteristics have the strongest influence on the intentions for sustainable food consumption. It is between these three demographic characteristics and the intentions for sustainable food consumption that the correlation coefficients have the largest values. At the same time, weak relationships are found between three other demographic characteristics and respondents' intentions - these are the Number of members in the household, Gender of the head of the family, and Type of housing.

**Table 4.** Statistically significant relationships between tested variables

Demography	Factor 1	Factor 2	Factor 3
Place of living	2,10,12,3,7,9,13,11,4,6,15	5,16,14,8	1,18
Number of members in the household	7,13,4	5,16,14,8	none
Number of workers in the household	2,10,12,7,9,13,11,4	5,14,8	1,17
Gender of the head of the family	10,3,9	none	17
Education of the head of the family	2,10,3,7,13,11,4,6,15	16,14	1,18,17
Children under the age of 3	2,10,12,3,7,9,13,11,4,6,15	5,16,14,8	1,18,17
Type of housing	2,3,4,15	5,16,8	18
Income	2,10,12,3,7,9,13,11,4,6,15	5,16,14,8	1,18,17

**Source:** Own research

A series of chi-square tests conducted show other interesting results. For example, statistically significant relationships are found between place of residence and some of the household habits related to the use of sustainable food. Such are, for example, those related to the use of organic foods. The fact that other demographic factors, such as the gender of the head of the household or the size of the dwelling, do not influence the intentions of using organic products is indicative. At the same time, significant relationships are found between the respondents' answers and the survey waves. On the other hand, significant relationships are also found between food habits and the type of housing. As well as whether the household owns its housing. At the same time, the presence of significant relationships between the gender of the head of the household and the use of sustainable foods can be commented on.

It should be noted, that such relationships are not significant for all the variables tested, but only for some of them. For example, the gender of the head of the household does not influence the use of seasonal fruits and vegetables, unlike the intention to use food produced by the household itself. The relationships between demographic variables and intentions to use sustainable food are also tested by one-way analysis of variance, which confirms the conclusions drawn.

Based on the collected data and the analysis conducted, several important conclusions can be drawn. First of all, the differences found between the first and second waves of the survey show that the observed processes are dynamic. Second, the presence of relationships between the type of settlement and intentions to consume sustainable food indicates the presence of regional



differences. Third, the significant relationships between these intentions and demographic variables such as housing type, home ownership, and income indicate that sustainable food consumption can be conditioned by the material status of the household.

#### **4. FUTURE RESEARCH DIRECTIONS**

The role of intentions for sustainable food consumption is important in terms of understanding the motivations that determine the sustainable behavior of households in general. If the demographic characteristics of individuals have a weak influence on the intentions determining their sustainable behavior, then the task of further research is to find out which other factors have a stronger influence. Based on the research done, such factors may be related to respondents' attitudes and values formed during parenting and caring for young children. The same can be assumed about income if it is considered not as an indicator of social status, but as a resource that ensures the development of personal interests and a set of opportunities. Last but not least, the role of the place of residence in forming the intentions for sustainable food consumption and in general for sustainable behavior should be investigated.

Also of particular importance is the finding that intentions for sustainable food consumption change over time. The dynamics of these processes show that through the formation of correct and aimed at changing the intentions, values, and attitudes of individuals, this process can be managed. Here it is important to highlight the growing role of cities as institutions that provide not only stimulating policies to the population but also infrastructure to promote sustainable behavior.

The results of the research connected to the influence of demographic characteristics can serve in the formation of regional policies aimed at stimulating sustainable food consumption, as well as in the segmentation of consumers. This is of extreme importance both for the institutions that implement such policies and for the businesses related to the production and sale of sustainable foods.

#### **5. CONCLUSION**

The supply and production of sustainable food in Bulgaria are still less developed compared to most EU member states. The fact that the incomes of the population lag behind those in the EU is also not without importance. This means that the barriers to buying sustainable food are relatively higher for Bulgarian consumers. From this point of view, the promotion of sustainable food consumption, which, as shown in this study, is determined to a stronger degree by income, place of residence, and parentage, needs to be directed in a different direction. In this sense, it can be argued that policies aimed at stimulating sustainable food consumption and sustainable behavior of households in general in the EU should be adapted to the specific features of different markets. Some of these adaptation opportunities can be discovered by examining the factors that influence and determine households' intentions for sustainable behavior.

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