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The Role of Blockchain Technology in Reducing Transaction Costs: An Economic Analysis

Irada Baghirova

Abstract. *Transaction costs are considered one of the key factors determining the efficiency of market mechanisms in modern economic systems. Contract enforcement, data collection and verification, trust assurance between parties, and monitoring mechanisms generate additional costs for economic agents. In particular, in the context of global trade and the digital economy, the increase in these costs can limit the efficiency of market operations. In recent years, the rapid development of blockchain technology has created new institutional and technological opportunities to reduce transaction costs. This distributed ledger technology minimizes the need for intermediaries, ensures data immutability, and enhances transparency in economic relations. This paper analyzes the role of blockchain technology in reducing transaction costs based on economic theory and existing scholarly approaches. Within the research framework, the mechanisms through which blockchain technology addresses information asymmetry, automates contract enforcement, and strengthens trust mechanisms are examined. The main objective of this study is to evaluate the potential efficiency benefits of blockchain technology and scientifically demonstrate its strategic importance in reducing transaction costs.*

Keywords: *Blockchain technology, transaction costs, digital economy, institutional economics, distributed ledger, smart contracts, economic efficiency*

Introduction

The acceleration of globalization and the expansion of international economic relations have significantly increased the strategic importance of managing transaction costs. The concept of transaction costs, put forward by Ronald Coase, includes the costs associated with concluding, implementing and monitoring contracts, as well as ensuring trust between parties. These costs directly affect the efficiency of market mechanisms and determine the allocation of resources, as well as the performance of both firms and the overall economic system. In the context of global trade, transaction costs are further increased by factors such as the geographical distance of the parties, legal and institutional differences, and the difficulty of tracking cross-border transactions. These factors lead to increased transaction costs, reduced efficiency, and increased uncertainty in economic interactions. Traditional transaction management mechanisms rely on intermediaries, lengthy verification processes, and centralized registration systems, which increase costs and slow down decision-making. In recent years, the development of digital technologies, especially blockchain technology, has provided innovative approaches to solving these problems. Blockchain, as a technology based on a distributed registry system, reduces the need for centralized intermediaries, provides an immutable record of transactions, and increases transparency in economic relations.

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This enables direct interaction between parties, minimizes verification costs, and makes transaction processes faster and more reliable.

Literature Review. Digital Transformation and Transaction Costs: The literature has widely emphasized that transaction costs are an important factor in economic efficiency and market performance (Coase, 1937; Williamson, 1985). Transaction costs include the additional costs associated with the preparation of contracts, the collection and verification of information, the provision of trust between parties, and the implementation of control mechanisms. Especially in the context of global trade and the digital economy, the high cost of these costs negatively affects the operational efficiency and market efficiency of firms (North, 1990; Alicke et al., 2016). Recently, blockchain technology has provided institutional and technological opportunities to reduce these costs (Catalini & Gans, 2016). Based on a distributed registry system, blockchain minimizes the need for intermediaries, ensures data immutability, and increases transparency in transactions. This technology also allows for further optimization of transaction costs through the automation of contracts and the application of smart contracts (Christidis & Devetsikiotis, 2016).

Research

Blockchain and economic efficiency: Research shows that blockchain technology eliminates information asymmetry, reduces the costs of monitoring and controlling transactions, and strengthens trust mechanisms between parties (Kouhizadeh et al., 2019). These features allow firms to use resources more efficiently, speed up transactions, and reduce the number of errors. At the same time, blockchain technology facilitates integration into global value chains and strengthens the competitive position of firms in international markets (Wang et al., 2019). Thus, the existing literature shows that blockchain technology plays a crucial role at the strategic and operational levels in reducing transaction costs. The application of this technology contributes not only to the optimization of transaction costs, but also to increasing economic efficiency at the national and international levels.

Research questions and hypotheses: The main objective of this study is to systematically investigate the impact of blockchain technology on reducing transaction costs and improving the operational efficiency of firms. Given that the topic is both theoretical and practical, the study is structured around two main questions:

TS1: How does blockchain technology affect transaction costs? This question examines how blockchain technology contributes to optimizing transaction costs by eliminating information asymmetry, automating contracts, implementing smart contracts, and increasing the transparency of transactions.

TS2: Through what mechanisms does blockchain technology enhance the operational efficiency and competitive advantage of firms?

This question aims to determine the strategic role of blockchain through mechanisms such as accelerating transaction processes, efficient use of resources, minimizing errors, and deepening integration into global markets.

Based on the above research questions, the following hypotheses were put forward:

F1: The application of blockchain technology has a positive effect on reducing transaction costs. This hypothesis assumes that costs are minimized by eliminating information asymmetry, automating contracts, and tracking transactions.
F2: Blockchain technology increases the operational efficiency and competitive advantage of firms.

According to this hypothesis, through the implementation of blockchain, firms accelerate operational processes, use resources more efficiently, and strengthen their competitive positions in global markets.

Methodology

The main objective of this study is to systematically assess the impact of blockchain technology on transaction costs and operational efficiency of firms. For this purpose, a qualitative systematic literature review method was chosen. A systematic literature review allows for the systematic collection, analysis, comparative evaluation and generalization of existing scientific knowledge. At the same time, this method allows for a more accurate understanding of the effects of blockchain technology at the operational and strategic levels (Tranfield et al., 2003). The study analyzed high-impact articles indexed in international academic databases such as Scopus and Web of Science. In addition, reports and analytical materials from international organizations such as OECD, World Bank, World Economic Forum (WEF) and UNCTAD were examined. The selection of sources was carried out taking into account their scientific reliability, relevance to the topic, publication in the last 10 years and citation indices. The collected literature was grouped using thematic analysis. During the analysis, the following main categories were identified: reducing transaction costs, implementing smart contracts, automating operations, efficient resource management, competitive advantage of firms and opportunities for integration into global markets. This approach allows researchers to assess the potential advantages of blockchain technology in terms of economic efficiency within a conceptual framework. In addition, the methodology covers both theoretical and practical aspects. Based on the data obtained, it is possible to identify the main mechanisms that reduce transaction costs, such as eliminating information asymmetry, automating contracts, transparency of transactions, and strengthening trust mechanisms. The analysis also allows us to assess the factors that affect the operational efficiency and strategic advantages of firms. Thus, this methodology ensures that the research is built on a reliable and systematic basis from both theoretical and practical points of view and allows us to comprehensively analyze the role of blockchain technology in reducing transaction costs.

Conclusion

The results of the study show that blockchain technology plays a crucial role in reducing transaction costs and increasing the operational efficiency of firms. In modern economies, transaction costs include processes such as concluding contracts, collecting and verifying information, ensuring trust between parties, and implementing control mechanisms, and these costs significantly increase the overall costs of enterprises, especially in the context of global trade and the digital economy (Williamson, 1981; Bowersox et al., 2013). The implementation of blockchain technology minimizes the need for intermediaries, ensures the immutability of data, and increases transparency in economic relations. This technology automates contract execution through smart contracts, facilitates the tracking of transactions, and creates conditions for reducing risks. As a result, transactions are carried out faster, more reliably, and in a cost-effective manner (Tapscott & Tapscott, 2017). According to the findings, blockchain technology significantly reduces the operating costs of firms by eliminating information asymmetry and strengthening trust mechanisms. In addition, this technology provides transparency in financial, logistics and supply processes, which leads to more efficient management of resources and a reduction in errors. Blockchain implementation at the firm level allows for the optimization of operations, the effective use of warehouse and transportation resources, and a more flexible response to customer demands. This strengthens the market position of firms and increases their competitive advantage (Kouhizadeh et al., 2021). Analyses conducted at the national and global levels show that the application of blockchain technology deepens the integration of countries into global value chains and ensures their participation in segments that create higher added value in international trade. At the same time, the application of the technology accelerates economic growth

and strengthens the structural foundations of national competitiveness. Thus, the study proves that blockchain technology is not only sufficient to reduce transaction costs, but also a key tool for firms to increase their operational efficiency, strengthen their competitive advantage, and more actively participate in global economic integration. These results confirm both the theoretical and practical significance of blockchain technology and indicate the importance of its application in economic policy and management strategies.

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Development Directions and Perspectives of Modern Telecommunications Systems

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Abstract. *In recent years, artificial intelligence technologies have demonstrated significant success in solving a number of tasks in various telecommunications systems. The application of artificial intelligence for predicting the load of telecommunications networks and modeling their future development allows for timely decision-making and improving the quality of service for subscribers. The article reveals the essence, nature, and characteristics of artificial intelligence technologies, presenting the results of substantiating and systematizing the trends in the development of artificial intelligence and its application areas in the field of telecommunications systems. It also highlights the main directions of development of generative artificial intelligence and the key areas of its application in the globalizing world. The article also outlines the tasks for applying artificial intelligence in telecommunications systems in the Republic of Azerbaijan. In the field of telecommunications, artificial intelligence approaches are briefly outlined, traditional methods and modern approaches are compared, and how they are applied in wireless communication is discussed. These methods include fuzzy logic, neural networks, reinforcement learning, and artificial intelligence techniques used in mobile communication. Some key and terminological issues are addressed, and it is explained how these issues will contribute to the stable operation of 5G and 6G mobile networks in the future, as well as the provision of various services through numerous mobile devices and data. An analysis of artificial intelligence methods used to improve the performance of mobile communication has been conducted.*

Keywords: *Artificial Intelligence, mobile communication, neural network, complex network, resource, mobile traffic*

Introduction

Artificial Intelligence (AI) is one of the methods for adapting the human brain or thought processes, the activities of other animals, biological systems, and species. In particular, artificial intelligence plays a significant role in mobile communication systems and is a promising approach for optimizing their productivity. Overall, artificial intelligence methods make substantial contributions to mobile communication through dynamic adaptation to the environment. Currently, the transition from traditional exploitation and management methods of complex network infrastructure to an intellectual approach is essential for increasing efficiency and scalability (Artvel, 2020).

Next-generation wireless networks are more complex and require more resources due to the increasing service demands of various devices, complex networks, and diverse applications. Additionally, network engineers must optimize systems and provide accessible resources to improve service quality. Artificial intelligence is aimed at creating an adaptive system that ensures better performance of both the system and the environment.

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With the advent of big data, a larger and more extensive dataset derived from mobile and wireless systems emerges. In other words, artificial intelligence applied to mobile communications will enhance the effectiveness of communication systems, increase productivity, and improve key performance indicators (KPI). As the network infrastructure and the hardware of mobile devices and their applications grow, the demand for mobile stations, as well as mobile traffic and the volume of processed data, will also rise (Zyuzin, 2023).

Research

Main Section. Approaches and Applications of Artificial Intelligence in Mobile Communications . Artificial Intelligence (AI) has several classical approaches, such as uncertainty and neural networks. Subsequently, the neural network will be expanded with more effective methods, such as machine learning and deep learning approaches. Machine learning is the process where systems analyze data and learn to make accurate predictions based on that data. The primary approach is uncertainty, where various values are processed to obtain correct and incorrect results. The second term is *learning through refinement*, which involves designing a computer or machine to learn on its own without precise programming (Bolyapkin, 2021). One of these methods is neural networks. Neural networks are used to process data, recognize patterns, and learn. For example, they are widely used in tasks such as image recognition, speech command understanding, and text interpretation. This technique allows problem-solving using a computer or machine with the ability to learn by itself. This process is based on mimicking the system and behaviors of the human brain. Currently, deep learning, as an advanced form of machine learning, is very popular. Deep learning is an interesting approach for managing mobile network traffic and future mobile communications. Two main types of learning are used in artificial intelligence in mobile communications: supervised learning and unsupervised learning (Borisova, 2019).

Decision Making in Mobile Communications. In mobile communications, when artificial intelligence makes decisions, not only the quantity but also the quality of the experience for various types of services should be considered. To achieve this, by using neural networks, the key indicators of mobile internet are combined and classified. That is, the indicators are analyzed and classified in a qualitative manner. In general, the artificial intelligence “assistant” used in content search offers a personalized content search service with a quality experience, which is divided into two types: 1. To accurately capture users' interests and experiences; 2. The process of accessing availability and appropriate recommendations.

Data analysis, machine learning, and artificial intelligence methods can be used in analog, digital, and hybrid beamforming techniques for creating optimal directional diagrams, dynamically selecting the most suitable beam, and performing beam management operations (Kolesnikov, 2020).

Resource Optimization in Mobile Communications. For resource optimization, numerous mobile-specific networks have utilized multi-addressed branching algorithms. Additional objectives for this optimization include minimizing handover delay and improving energy efficiency. Furthermore, neural networks and various methods are applied in solving the task of reducing PAPR (Peak-to-Average Power Ratio). This is used for online learning. One of the key components for enhancing the efficiency of OFDM (Orthogonal Frequency Division Multiplexing) channel estimation can be solved using artificial intelligence methods (Boychenko, 2020).

The cognitive radio system is discussed, where several secondary users work together to ensure proper spectrum allocation and attempt to achieve efficient and reliable spectrum access. Additionally, artificial intelligence methods are proposed for eliminating inter-cell interference between independent networks, which can negatively affect the performance of wired communication users in mobile networks. Existing artificial intelligence algorithms enhance performance in

peripheral computing by integrating Graphics Processing Units (GPU) and Central Processing Units (CPU) (Kuzovkova, 2021). The application of artificial intelligence for mobile communications is related to complex statistical methods, taking into account devices, infrastructure, end users, technologies, and other resources.

Network Management in Mobile Communications. An example of applications for network management in wireless communications can be seen in routing within the communication section. Artificial intelligence has already been applied in some studies on this topic. For instance, both the self-tuning and self-optimization of radio resources and routing are handled using neural networks (Muzata, 2021). Muzata, in other studies, machine learning methods have been used to solve various routing problems from the past. These include routing based on the shortest path, adaptive routing, and multicast routing.

Another method of network management in wireless communication networks is the monitoring of network activities and the detection of anomalies (such as unusual activities, for example, viruses), meaning events that deviate from the network's normal behavior. Artificial intelligence has also been used for traffic forecasting in communication networks (Rustamov, 2023). Artificial intelligence technologies can minimize interventions in traditional network traffic management and ensure greater network reliability, more adaptive systems, and higher performance. Other Applications of Artificial Intelligence. In general, the artificial intelligence methods applied in mobile communications can be seen in table 1. (Volodina, 2023).

Table 1

Mobile Communication Technology	**Applications of Artificial Intelligence**
Autonomous vehicles and medical assistance devices	- Automation and its associated artificial intelligence. - Modern and core algorithms in the specific field of artificial intelligence for autonomous vehicles. Such systems are particularly suitable for high-level decision-making, as they inherently need to perceive the environment and respond to it to achieve certain objectives.
Internet of smart devices	Network solutions for utilizing the artificial intelligence methods used to create such intelligence and the benefits provided by this capability.
Mobile cloud computing	Applications with high resource demands, such as augmented reality, artificial intelligence, computer vision, object tracking, image processing, and natural language processing, are becoming increasingly popular in the management of mobile cloud computing systems.
5G Network	Artificial intelligence and its subcategories, such as machine learning and deep learning, are developing as a scientific field, enabling these mechanisms to be predictive and proactive in fifth-generation (5G) wireless networks, which is of great importance for the implementation of the 5G concept.
Wireless sensor networks	- Artificial intelligence tools are used to assist in intellectual radio channels. The tool known as machine learning is considered an important means in solving the aforementioned problem.

	- Machine learning methods for localization using the signal level indicator received in WSNS.
Mobile heterogeneous networks (HetNets) (networks that integrate various types of technologies, devices, or network protocols)	Machine learning, algorithms based on biological structures, abstract neural networks, etc., as artificial intelligence methods, can naturally solve the problems of large-scale complex systems.
Detection of covert communications in mobile malware	Artificial intelligence tools, such as neural networks and decision trees, are used as two detection methods to identify malicious programs exchanging data.
Mobile and wireless networks	Deep Learning
Vehicle mobile networks	Cache boundaries based on artificial intelligence
Next-Generation wireless networks	- Machine learning, artificial neural networks. - Big data analytics to analyze user activity and detect user anomalies (a situation that deviates from normal patterns).
Mobile multimedia	Deep learning has become the most important technology for multimedia computing.
Wi-Fi-based indoor positioning system	Artificial neural networks
Cognitive radio networks. These networks provide significant advantages, especially in environments where the spectrum is congested and resources are limited.	The development of cognitive routing protocols refers to routing protocols that are intended to fully incorporate artificial intelligence-based methods in their own development.
Artificial intelligence and data science for communication	Artificial intelligence, machine learning, and innovations in network data analysis present significant opportunities to revolutionize global communication systems and enhance user experience.
Mobile Network Systems	The concept of artificial intelligence and its application in the design, operation, and optimization of mobile networks.

Challenges of Artificial Intelligence in Mobile Communications. The challenges of artificial intelligence in mobile communications are based on various technical and practical issues. These problems arise from the integration of (Zyuzin, 2020). AI development and applications into mobile communication systems:

- The data used in mobile communication networks is often inaccurate. This makes it difficult for AI models to operate correctly. Additionally, the diversity of data types and formats across the network (e.g., voice, video, IoT data, etc.) creates further challenges for AI applications (Rustamov, 2025).

- Implementing AI requires powerful computational resources, especially in areas such as deep learning and machine learning. The limited computational power and energy capacity of mobile devices make it difficult for such systems to function effectively.

- AI applications in mobile communication networks require real-time data processing and response. However, network latency, long data processing times, or connection interruptions can prevent these processes from functioning properly.

- Privacy concerns become even more critical when using AI in mobile communication systems. The data used by AI, particularly users' personal information, can potentially be leaked or manipulated.

- Mobile communication networks collect large volumes of data. Effectively analyzing this data and converting it into useful insights can be challenging. Additionally, the quantity and diversity of the data can complicate the model's learning process.

- The simultaneous sharing of the same frequency channel by numerous users in mobile communication networks can create additional problems for AI systems. In particular, network congestion and interference can make it difficult for AI applications to function properly (Klausman, 2017).

The application of artificial intelligence in mobile communications offers a wide range of possibilities, from network optimization to enhancing user experience. However, resolving the challenges outlined above is crucial for this technology to function effectively and sustainably. With further development of artificial intelligence and mobile communication technologies, these issues can be addressed over time.

Artificial intelligence will play a key role in the management of big data, advanced data analytics, and the organization of various communication devices in future mobile or wireless networks (Rustamov, 2025). On the other hand, it is essential for the mobile communication infrastructure to be adaptable to different services, efficient, and reliable. This means that it should help increase the productivity of mobile broadband communication, minimize the peak-to-average power ratio (PAPR), improve quality through multiple access methods (Orthogonal Frequency-Division Multiplexing, OFDM), and enhance overall communication quality (Volodina, 2023).

Other challenges of artificial intelligence in mobile communication systems include decision-making, network management, and resource optimization. As for mobile intelligent communication, it is characterized by a proactive system, self-management, self-regulation, forecasting, and economic efficiency. Another important aspect of mobile communication is the application of artificial intelligence in wireless communication for various scenarios, such as energy management, radio frequency management, mobile communication, and interference management (Rustamov, 2024).

Conclusion

Artificial intelligence plays a significant role in enhancing the performance of mobile communication systems: predictive systems, self-awareness, self-adaptation, forecasting, efficiency, and optimization. Several classical artificial intelligence methods and modern approaches are reviewed and analyzed for their applications in the mobile communication field. These methods include uncertainty logic, neural networks, reinforcement learning, and some artificial intelligence techniques applied in mobile communication. Some key challenges between artificial intelligence and future mobile communication, such as big data, how to manage data through exploration, ensuring transmission at higher frequencies, communication between devices, reliable architecture, high-density networks, and 3D beamforming, are addressed. These challenges are related to the existing difficulties of 5G fifth-generation technologies. The issues of how 6G mobile networks will be used in the provision of stable networks and service types are brought to the forefront.

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Protection Against the Effects of FPV Drones

Vagif Azizov[1], Rahman Quliyev[1*], Rauf Hasanov[1]

Abstract. *In the modern era, the high efficiency of using various types of drones in conducting aerial reconnaissance of territories, correcting artillery fire, destroying armored vehicles and personnel, as well as executing numerous combat missions, must be taken into account. The direct destruction of drones through fire and their complete neutralization without causing any damage to them using electronic warfare (EW) means are of particular importance. As we know, since it is not possible to fully protect unmanned aerial vehicles (UAVs) from the effects of EW (Electronic Warfare) means, in wartime conditions, anti-drone weapons such as guns, mobile laser devices, and other weapons are practically used to disable FPV drones. The simplest method to avoid these effects is changing the control frequency of the drone, which makes it impossible for EW systems to affect the drone. It should be noted that since this method provides only temporary protection, work should be carried out to develop EW devices capable of monitoring and effectively jamming non-typical frequencies.*

Keywords: *Drone, control channels, electronic warfare tools, frequency range, satellite navigation signals, video signal, navigation system*

Introduction

Until recently, drones were mainly used for aerial photography at low altitudes during prestigious sports events and other mass gatherings. Currently, they are extensively utilized in the military sphere, particularly in the Ukraine-Russia conflict, for reconnaissance of the area, correction of artillery fire, destruction of armored vehicles and personnel, and the execution of numerous other combat missions.

Considering the high effectiveness of various types of drones in combat operations and their direct impact on combat tactics, different methods have been developed to combat them. Among these methods, the direct destruction of drones with fire and the use of EW (Electronic Warfare) tools that disable drones without causing any damage are particularly significant. It is precisely these EW tools that are considered more effective means of countering drones in warfare.

EW (Electronic Warfare) tools can interfere with the control channels of drones, capturing them, disrupting their radio signals, or creating artificial radio jamming signals to impair their control systems.

Main Section: FPV (First Person View) drone is a type of unmanned flight vehicle where the operator uses special glasses or video cameras mounted on the drone to see the area in real-time on a screen. This allows the operator to perform various tasks in real-time, such as area surveillance, reconnaissance, striking different targets, and executing precise maneuvers with the drone. These drones, especially in recent times, are being widely used for tasks such as reconnaissance, surveillance, and striking targets.

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FPV drones, compared to manned flight vehicles such as fighter jets and helicopters, have some significant advantages: they are cost-effective, very inexpensive, durable, highly resilient, and pose almost no risk to the operator. Their small size allows them to perform agile maneuvers in confined spaces and quickly evade enemy countermeasures. Since analog video transmission systems are used in such UAVs, they are more resistant to jamming by electronic warfare tools. However, it should be noted that this factor (analog communication) also enables the enemy to determine the drone's launch location (Makarenko, 2020; FPV-drony: sfery primeneniya, tipy i printsip raboty, 2024).

Research

The structure and components of FPV drones are shown in Figure 1.

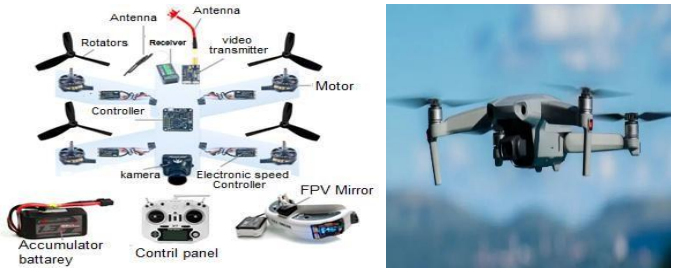

Figure 1
Model of the FPV drone

The main threat to drones from REM is the loss of control by the operator. In many cases, control is taken over by others, control signals are completely blocked, or GPS coordinates are altered.

Primarily, the method of completely jamming the drone is used. In this method, the drone loses the signal received from the satellite, the operator cannot see the image on the screen, and manual control becomes impossible. In such cases, the drone is practically lost (Rustamov et al., 2024; Mashinnoe zrenie, 2018). The method of spoofing or changing GPS coordinates is also an effective way to quickly bring down a drone. Many drones are programmed with the coordinates of airports and other strategic sites. When the drone enters these zones, it automatically lands. When GPS coordinates are altered, the drone "thinks" according to the security protocol and performs an immediate landing, which can then be taken over by others (Slyusar, 2010).

The following methods are used to protect drones from the effects of REM devices:

- Signal encryption – this method uses complex encryption algorithms that are very difficult or impossible to crack or decipher;
- Frequency hopping – in this method, the control frequency of the drone changes hundreds or thousands of times per second, making it impossible for REM devices to jam within the frequency range;
- Autonomous mode – in this mode, the drone operates without using GPS coordinates, following a pre-planned route stored in its onboard computer. In this method, the drone is not affected by any spoofing systems (coordinate manipulation).
- Currently, additional devices are being developed to enhance the resilience of drones against various threats. For example, SIM card-based GPS trackers (navigation devices capable of tracking the drone's location remotely) enable drones to operate with accurate coordinates. Additionally, there are devices called anti-jammer (which protect navigation signals from malicious or accidental interference) that feature their own antennas synchronized with the drone's main antenna. When obstacles occur, the anti-jammer isolates these obstacles and increases the drone's resistance to external influences.

- An anti-jammer uses directional antennas during electronic interference, employing CRPA (Controlled Reception Pattern Antenna) technology to filter out interference, ensuring precise and reliable navigation.

Anti-jammers:

- Detect obstacles – identify unwanted radio signals that interfere with useful signals received from satellites;
- Counter obstacles – focus solely on satellite signals to actively jam or disrupt signals from REM devices;
- Preserve the useful signal – ensure the drone's navigation system continues to receive and process data transmitted solely from satellites, allowing for precise navigation.
- and process data transmitted solely from satellites, allowing for precise navigation.

Additionally, to reduce the impact of REM devices, it is advisable to orient drones according to the following recommendations (Internet resources).

- Minimize flights or refrain from flying near strategic and military facilities equipped with 100% REM devices;
- Plan the flight route in the maximum open area possible;
- Considering the height influence boundary of REM devices, it is not recommended to plan flights above 30 meters altitude. It should be noted that simple jamming devices at 200-300 meters altitude can block the drone's signals.
- If the number of satellites "seen" by the drone is fewer than 6, the flight should be canceled.

Anti-jamming techniques:

- Detect obstacles – identify unwanted radio signals that hinder the reception of useful signals from satellites;
- Overcome obstacles – primarily focus on satellite signals and actively suppress or jam the signals of REM devices;
- Preserve the useful signal – ensure that the drone's navigation system continues to receive and process data only from satellites, allowing for precise navigation.

FPV drone components. FPV drones consist of a complex control system, including a camera, receiver, transmitter, four motors, and a frame housing the drone's control controller (Internet resources).

The camera, typically with a viewing angle of 90° to 180°, is mounted on the front part of the drone and transmits real-time images and video to the operator's screen via a transmitter.

Transmitter – An essential component of the FPV drone that sends the video signals (video data) from the camera to the operator's receiver. The transmitter operates at a 5.8 GHz frequency, ensuring high-quality image transmission and high-speed data transfer. In intensive REM environments, an additional transmitter operating at 1.3 GHz can also be installed.

Receiver – A device that receives the video signals from the drone and displays them on the screen. The display can be integrated into goggles or control controllers. The receiver operates at the same frequencies as the transmitter (5.8 GHz and 1.3 GHz).

FPV drone motors – FPV drones are controlled with the help of an ESC (Electronic Speed Controller). The ESC is connected to the operator's control unit and manages the rotational speed of each motor, allowing the operator to precisely control the drone's flight direction and speed.

When using an FPV drone, the operator wears goggles or connects a screen to the receiver to receive real-time video feed.

The visual signals (video streams, data) that the drone "sees" are transmitted via a transmitter from the drone's camera, enabling the operator to see where the drone is flying. In other words, the operator feels as if they are inside the drone, and due to this characteristic, FPV – First Person View – refers to video footage captured from the first person's perspective, showing what the drone's camera sees (Rustamov et al., 2023).

FPV drone goggles and control transmitter

Control transmitter – The main device for operating the drone. It provides a connection between the operator and the drone and allows the drone to be controlled via a device equipped with joysticks and other buttons (Internet resources).
Goggles – Used to receive video signals from the drone's camera. To see what is happening in real-time in front of the drone, a receiver and screen are installed in the goggles. As an alternative, an external screen can also be connected to the drone. This screen is used by the operator as an assistant and is connected as soon as it is linked to the receiver and goggles. The drone control team usually consists of two people (operator and assistant).

Application of FPV drone. Before using an FPV drone, its intended purpose (such as for launching or as a kamikaze) must be determined. Additionally, attention should be paid to the size of the drone, as its dimensions affect its payload capacity. Currently, drone models are produced with the ability to carry loads of 720 grams, 1 kg, 1.5 kg, 2 kg, and 3 kg. If the drone is intended for launch purposes, it is also necessary to know which combat ammunition will be used and what platform will be installed (Optovolokno dlya upravleniya dronom, n.d.; Vasilyev, 2015).

One of the main important characteristics of an FPV drone is the transmission of video signals in active RF environments at frequencies of 5.8 GHz or 1.3 GHz. For this purpose, an additional antenna can be installed on the operator's side within a distance of up to 30 meters (BPLA: klassifikatsiya, tipy, sfery primeneniya, n.d.; *FPV dron: S chego nachat novichku*, n.d.; Rustamov et al., 2024).

In case of losing contact with the drone due to RF interference, the following precautions are recommended for operator training:

- Before deploying drones in combat, operators must practice controlling the drone in simulators provided by the drone manufacturer. Additionally, it should be noted that FPV drone operation significantly differs from the control of civilian Mavic and Autel drones, so training on FPV drone simulators only should be conducted for FPV drone control skills.
- Enemy equipment such as antennas, observation cameras, and movement parts of the enemy's attacking vehicles can be disabled using the FPV drone.
- FPV drones are the most cost-effective means to eliminate enemy personnel and combat equipment.
- If a drone is “jammed” or its control is completely lost, it can only be recovered using a GPS tracker (if equipped).
- If the drone loses GPS signals, do not activate the “return to home” program, as the drone’s location will be unknown without GPS coordinates. In such cases, since it is possible to see the surrounding area through the camera, efforts should be made to land the drone manually.

- When controlling the drone becomes impossible, attempts should be made to disconnect its engines; in this case, the drone is likely to fall and break apart.
- When GPS signals are lost, the drone switches from normal mode to ATTI mode, but it is essential to know how to fly in this mode.
- It should be kept in mind that when GPS signals are lost, the drone will be dragged, so avoiding obstacles is crucial.

Conclusion

The article analyzes the combat application of FPV drones, and certain practical recommendations have been proposed for their effective deployment in potential future combat operations.

Due to the rapid development of modern technology, it is currently impossible to fully protect unmanned aerial vehicles (UAVs) from the effects of RF interference. At present, counter-drone systems such as anti-drone rifles, mobile laser devices, and other weapons are practically used to disable FPV drones. This application has become particularly prominent in the context of ongoing combat operations in Ukraine. For example, anti-drone rifles can generate “white noise” (a stochastic process with spectral density across all frequencies) within the control signal frequency range and specific frequencies, causing the operator to lose control of the drone.

The simplest method to avoid the effects of RF interference (REM) is to change the drone's control frequency. In this case, no REM can affect the drone. However, it should be noted that this method is also temporary, as work is underway to develop REM devices that can track and effectively block these non-standard frequencies quickly.

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From Burden to Efficiency: Enhancing the Listening Lesson Planning Process through AI Integration in Algerian Secondary Schools

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Abstract. *The inherent complexity of teaching listening comprehension places a significant burden on teachers to create effective lesson plans. To mitigate these hurdles, the integration of AI tools into the lesson-planning process has been suggested. Yet, most studies on AI in education focus solely on its impact on students' learning outcomes, overlooking instructors' experiences and attitudes toward it. This research aims to unveil the challenges faced by Algerian secondary school English language teachers during the design stage of listening lessons, evaluate the impact of implementing AI tools in the lesson-planning experience, and further explore teachers' attitudes toward using such smart technologies. For the sake of this study, a mixed-method approach with an experimental design was employed. A closed-ended questionnaire, answered by 34 English language secondary school teachers, identified the most common challenges in planning listening lessons. An experiment, conducted with four teachers, assessed the potential of AI tools, like ChatGPT and voice generators, by comparing two self-evaluation checklists completed by the participants. Then, individual interviews were conducted to gain in-depth information. The findings revealed significant challenges, such as time constraints and content adaptation. The experiment demonstrated that AI tools have the potential to improve the lesson-planning experience by enhancing time efficiency, enabling content customization, and supporting material creation, including audio scripts and adaptable listening activities. However, concerns were raised about AI's inability to fully contextualize lessons to fit the Algerian education system and its lack of consideration for the scarcity of technological resources, which remain limited in many schools. Hence, policymakers and school administrators should consider strategies to integrate AI related courses into teachers' development programs while addressing infrastructural constraints.*

Keywords: *Artificial Intelligence, AI tools, lesson planning, listening skills*

Introduction

In the realm of English as a foreign language (EFL) education, listening comprehension is pivotal, yet it remains one of the most complex and least understood skills. It has often been overshadowed by reading, writing, and speaking (Rost, 2011). Recent studies, however, have increasingly focused on the effective teaching of this skill, placing significant demands on teachers to design creative, engaging, and effective lesson plans that cater to the different needs of all their classes. To mitigate these challenges, educators are required to stay informed and capable of embracing new cutting-edge technologies that can offer a great deal of assistance.

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Artificial Intelligence (AI) has revolutionized various sectors, and education is no exception. The development of AI tools, such as chatbots and natural language processing applications has the potential to revolutionize the listening lesson planning experience by enhancing several key elements. Despite the promise of AI in education, existing studies primarily focus on its impact on students' learning outcomes, with limited attention given to the perspectives of educators who utilize this advanced technology. In the Algerian context, research usually concentrates on meeting students' needs through AI, particularly in enhancing their writing skills (Labidi, 2022; Aliouch & Mezghich, 2022). However, there is a significant gap in understanding how AI can assist teachers in the most daunting task of planning lessons for complex skills like listening. This gap is particularly pressing given the increasing trend of digitalization of education in Algeria, where teachers are expected to incorporate technology into their teaching practices in spite of the limited training or institutional support. Therefore, exploring how AI can support teachers is crucial; not only to enhance the listening lesson planning efficiency but also to promote a more balanced approach to using technology in pedagogy.

This research aims to enhance teachers' lesson planning experience of listening skills through the integration of AI tools. Particularly, it explores the challenges faced by secondary school English language teachers during the design stage of listening lessons, evaluates the impact of AI tools on lesson plan efficiency, and investigates teachers' attitudes toward using AI technologies as assistants in their lesson planning experiences. Hence, the core questions of this study are:

- What are the challenges faced by secondary school English language teachers during the design stage of listening lessons?
- To what extent do AI tools enhance the listening lesson planning efficiency?
- What are the teachers' attitudes towards using AI tools as assistants in their listening lesson planning process?

Attempting to answer these questions, it is hypothesized that:

- Some of the challenges teachers encounter during the design stage of listening lessons can be related to managing time, adapting content, finding suitable resources, and manipulating audio material characteristics.
- AI tools have the potential to address these issues and enhance the lesson planning efficiency.
- Teachers hold both positive and negative attitudes towards using AI-assisted lesson plans.

To understand the complexity of designing listening lesson plans and unveil the power of AI in EFL teaching, this research draws on multiple theoretical perspectives. On the one hand, Osada (2004) and Yukselci (2003) offer key insights about the challenges associated with teaching listening, such as difficulties in processing spoken input and selecting appropriate listening materials, emphasizing issues that educators frequently face during the lesson planning stage. These theories help in the identification and analysis of the specific challenges discussed in the current study. On the other hand, Wolff and Koraishi's (2023) views on using AI tools as assistants in the lesson planning process offer a strong foundation for understanding how such technologies can support pedagogy, particularly by providing customized assistants. Their work is highly relevant to this research, as it suggests AI-assisted strategies in lesson planning as practical solutions to lesson design difficulties. The integration of these perspectives shapes the scope of this research by grounding its investigation in both established listening pedagogy and emerging technological tools.

The present paper is divided into three sections. The first section reviews recent literature regarding the theoretical underpinnings of teaching listening and the associated challenges, as well as the role of AI and its applications in EFL pedagogy. The second outlines the methodology adopted in this study, including the study approach, target population, and data collection instruments. The final section presents the analysis and discussion of the findings.

Listening as a Complex Skill. Listening comprehension is a crucial skill that plays a significant role in the process of learning English as a Foreign Language (EFL). Many scholars have made attempts to define listening and state its components. According to Wolvin and Coakley (1996), listening is "the process of receiving, constructing meaning from and responding to spoken and or/non-verbal messages" (389), emphasizing the importance of interpreting non-verbal cues such as frowning and smiling.

Long time ago, listening was considered as a passive skill, a competence that "would develop without assistance" (Osada, 2004). As noted by Flowerdew & Miller (2005), we spend over forty percent of our daily communication time listening, thirty five percent speaking, sixteen percent reading, and only nine percent is occupied by writing. With this opinion, it may seem quite absurd that listening skills did not receive adequate acknowledgement as a skill in its own right (p. 22-23). Research on listening comprehension started to be explored until the turn of the 1970s (Osada, 2004), introducing a transition in listening skill being viewed as a passive skill to seeing it as something that students should *actively* learn. This recent accreditation came about rather late, making listening the "least researched of all four language skills" (Vandergrift, 2007) and remains "one of the least understood processes" (Osada, 2004). Therefore, the effective teaching of this skill is still a grey area. It is frequently seen as a "somewhat neglected and poorly taught aspect of English" (Osada, 2004). Moreover, the complex nature of such skill also makes its instruction a challenging affair for EFL educators.

Rusadze (2018) opines that active listening is a skill that may be improved with practice. It implies to actively listening. A learner should be completely focused on what is being said, and most importantly, a learner should attempt to comprehend the entire content being delivered. This requires the student to pay close attention to the speaker. Active listening entails listening with all of your senses. Learners should attempt not to become bored or lose track of what the other person is saying.

To better grasp the challenges of teaching listening, it is important to first recognize the obstacles that students face when learning this skill. Listening comprehension is a difficult skill to acquire for the majority of EFL learners owing to the distinctive features of spoken discourse (Rost, 2002). Learners' comprehension of spoken language is influenced by several factors that are beyond their control. According to Vandergrift, one obvious obstacle is the fact that listening requires immediate processing with limited access to the spoken material again, making the skill arguably more complex than, for example, reading (2004). Furthermore, "in most cases, listeners must process the text at a speed and an accent determined by speakers, which is generally quite fast" (Osada, 2004), which means students have no control over the speaker's pace or accent.

Osada explains that "vocabulary and grammar also tend to be far more colloquial and much less formal", meaning that students may be unfamiliar with informal language (2004). This can lead to confusion if the listener's simple and relevant vocabulary overlaps with the difficult vocabulary of the passage.

Interestingly enough, teachers encounter significant obstacles when tasked with teaching or arranging listening lessons. While students struggle to comprehend the audio information, educators find it challenging to gain control over these materials. EFL teachers often struggle when trying to find suitable materials for teaching listening because of lack of resources. Additionally, available materials can be too challenging for learners to understand, this can be due to the speaker's characteristics in the listening material, such as accent, speed, intonation, etc. complicating the selection and editing process (Yukselci, 2003). This scarcity of resources stands in the way of teachers who are striving to provide student-friendly and high-quality material.

Sahin and St. Sule (2016) stress the significance of thoroughly reviewing the vocabulary, grammar, and content of selected materials. This process is proved to be crucial for ensuring that the chosen material aligns with the learning objectives and is suitable for students' level. Yet, it can be a daunting task for teachers to effectively conduct this evaluation.

The study conducted by Slamet et al. (2019) highlights that the obstacles faced by educators when teaching listening are due to time constraints and limitations in lesson planning. Such constraints hinder teachers from creating effective listening lesson plans that can cater to the different learners' needs, thus, impacting their role as instructors. Given these challenges, it becomes essential for teachers to embrace the potential of emerging technologies to enhance the lesson planning experience.

AI in EFL Teaching/Learning. Numerous interpretations of AI exist since scholars attempted to give their own perspectives depending on their understanding of the word "intelligence". John McCarthy, the university professor who coined the phrase, defined AI as "the science and engineering of making intelligent machines" or "a machine that behaves in a way that could be considered intelligent if it was a human being" (2007). McCarthy's understanding of AI was hinged on the idea that mathematical logic might foster computers to achieve human-level intelligence through translating and encoding knowledge and then reasoning about it. This explains that AI is not really limited to biological methods but can also make use of mathematics, algorithms and other related approaches. Russel and Norvig (2010) opine that AI includes creating smart systems capable of thinking and acting like humans. Their belief prioritizes rationality and efficiency. These systems are designed to optimize decisions based on their environment, goals, and knowledge. They are then evaluated depending on their capability to achieve optimal objectives.

The use of technology in education dates back to the introduction of first-generation computers and subsequent updates (Schindler et al., 2017). Educators were seen utilizing computers to lecture, research, record student grades, and accomplish other tasks. Similarly, students used computers to learn, investigate, and solve problems. Computers have also been utilized as an instructional resource and to maintain student information databases (Jones, 1985). Current research in the field of AI is gaining attention from experts as it is having a positive impact on educational practices.

It is anticipated that AI applications for teaching and learning will expand dramatically in the coming years (Alexander et al., 2019). One Key issue mentioned by UNESCO (2019) stresses on the fact that AI in education (AIEd) contributes to increased scientific output. In this sense, various AI applications that incorporate analytical techniques, such as Machine Learning (ML), Natural Language Processing (NLP), and Deep Learning (DL) have been widely used in the EFL context and are having a significant impact. During the COVID-19 epidemic, video conferencing tools (e.g., Zoom) and learning management systems (e.g., Blackboard) powered by AI technologies were widely used to implement online EFL teaching and learning (Layali & Al-Shlowiy, 2020). A significant body of literature suggests that AI can improve language teaching and learning as well as ameliorate the quality of instruction (Gao, 2021; Pikhart, 2021; Klimova et al., 2022).

Because of the ever-increasing demand for skilled English speakers in our modern society, a great deal of pressure is placed on the shoulders of EFL teachers to give effective instruction that meets the different needs of their students. In the context of teaching listening, educators are required to stay informed and capable of embracing new cutting-edge AI-technologies. It is essential to consider leveraging such tools as novel means of support to improve the efficiency of lesson planning for listening activities (Rudolph et al., 2023). There exists a plethora of AI-tools that are capable of assisting teachers in creating effective listening lesson plans:

AI chatting robots or chatbots are AI-powered computer-based programs that can provide an intelligent human-like conversation experience. This promotes a smooth user experience by updating

their knowledge and perception from previous conversations (Haristiani, 2019). One example is ChatGPT, a natural language processing tool developed by OpenAI. Studies have confirmed the effectiveness of this chatbot in EFL teaching and learning. According to Koraishi (2023), ChatGPT has the ability of assisting teachers in multiple ways. With the right prompts, lesson planners in collaboration with ChatGPT can manipulate vocabulary integration. ChatGPT can generate texts or listening scripts that incorporate target vocabulary words which allows teachers to address their different students' needs and meet the lesson objectives. Furthermore, this chatbot may provide teachers with different types of comprehension questions related to the text suggested by the teacher. This collaborative approach between the teacher and ChatGPT not only saves time but also allows teachers to design engaging lessons plans that cater to specific instructional needs, thus, enhancing effective teaching practices. However, lesson planners need to master prompt design by providing necessary parameters and details related to their target lesson. This includes specific vocabulary set, learning objectives, students' proficiency level, etc.

Recently, AI voice generators have advanced dramatically, moving from simple text-to-speech tools to complex and advanced systems capable of producing humanlike and natural-sounding voices. These systems rely on deep learning algorithms. Its process consists of analyzing voice recordings to teach the algorithm to identify speech patterns such as intonation, accents and pace. When a user enters a script, the system is trained to break it down into phonetic components. It then combines these components to generate words and phrases. To make the audio sounds real, some advanced AI speech generators use techniques such as Natural Language Processing (NLP) as it enables the system to recognize and interpret language nuances, therefore, allowing it to customize its speech output accordingly. Adjusting for sarcasm, questioning, or excitement helps the synthetic voice sound more natural and human-like (Staniszewski, 2023). Educators often make sure that the material they adapt is suitable for their students' different needs. AI-voice generators like NaturalReader or Speechify act like allies in this. These tools offer teachers unique flexibility options over voice customization. Whether it is altering the pitch for emphasis, managing the pace for greater comprehension, or adding strategic pauses for effect, instructors can edit the narration according to the mood and aim of the lesson. Furthermore, pronunciation feature allows teachers to ensure that words are pronounced accurately, contextually, and correctly. Moreover, the option to convert text to audio on the fly allows teachers to save time and effort while focusing on curriculum updates, development, and student interaction (https://murf.ai/resources/text-to-speech-for-teachers/2023).

Ethical Considerations and Limitations of AI in EFL Teaching and Learning: The integration of AI in EFL teaching and learning has sparked a blend of anticipation and concern. Despite the multifarious advantages of this emerging technology in pedagogy, it raises a cascade of ethical considerations and limitations that warrant careful consideration. One pressing issue linked to the integration of AI into teaching practices is its potential to mechanize and dehumanize the teaching-learning process (Alghamdi, 2023), thereby undermining the inherently human element. For instance, the incorporation of AI algorithms in creating educational material and delivering lessons can pose significant difficulties for some students in keeping up with the swift pace introduced by automated tools. In language education, the emotional support and personalized guidance offered by human teachers are essential to cater to the unique strengths and challenges of each learner. Thus, the absence of the human element in the teaching learning process poses risks to students who tend to benefit more significantly from direct interaction with their teachers (Baidoo-Anu & Ansah, 2023), necessitating a balanced approach between AI applications and human engagement.

In addition to these concerns, excessive dependence on AI can result in more passive teaching and learning environments. Johinke et al., (2023) posit that the overuse of AI technologies by both teachers and students may risk suppressing their natural creativity, problem-solving, and critical thinking skills. Using AI to generate new lesson ideas, while considered efficient, can gradually limit teachers' ability and willingness to engage in creating authentic lesson planning and adapt materials

in novel ways. Likewise, students who depend heavily on generative AI tools can struggle with their learning, especially for tasks that require higher-order thinking and independent thought, such as writing or problem-solving activities. This overdependency may hinder the development of several 21st century soft skills like creativity, innovation, problem solving, critical thinking, and autonomy.

Another drawback concerns technological limitations and accessibility problems that may arise when using AI in EFL classrooms. The effective use of AI systems requires specialized infrastructure, including fast internet connections and suitable hardware, which may not be equally available in all educational institutions. This lack of technological accessibility can create a sense of inequity in terms of AI-enhanced experiences among educators or learners. Furthermore, using AI technologies necessitates proper training for instructors and students to fully harness their benefits. For instance, a grasp of how to communicate with AI chatbots effectively involves developing skills in prompt engineering, which is the process of designing and optimizing prompts to guide AI models, like ChatGPT, towards generating the desired responses (Genkina & Dina, 2024). Nevertheless, acquiring such skills requires time and effort to become used to these novel tools and adapt teaching strategies (Vera, 2023). Without sufficient training and institutional support, these challenges may lead to negative attitudes like frustration and resistance towards integrating AI in pedagogical practices.

Research

Method. The present study aims to boost teachers' lesson planning experiences of listening skills through AI implementation. Specifically, it attempts to explore challenges faced by secondary school English language teachers related to planning listening lessons, investigate how incorporating AI tools into the lesson planning process can reduce teachers' workload and enhance planning efficiency, and discover teachers' attitudes towards using AI-assisted lesson plans. In this respect, a mixed-method approach is employed to gather the data. Amalgamating quantitative and qualitative approaches offers an effective way to critically conduct a solid study and draw valid conclusions. In this study, various tools were employed to ensure comprehensive data collection. These included a closed-ended questionnaire, an experiment supplemented with self-evaluation checklists, and individual interviews.

Initially, to identify the most frequent issues faced by secondary school English teachers during the lesson planning experience of listening skills, an online questionnaire was used. Employing such data collection tool in this study is of utmost importance to ensure that the responses are carefully structured and standardized, allowing an efficient data gathering from a larger sample size. The questionnaire was created using Google Forms and designed to cover different aspects of the lesson planning process of listening lessons. To enhance the user experience, the questionnaire was divided into seven sections, the first section aimed at extracting demographic information from the participants, whereas the other six focused on the challenges, each focusing on a specific difficulty. It included closed-ended questions with multiple-choice answers, aiming to quantify the frequency of specific challenges. The questionnaire was administered to 34 secondary school English language teachers from different Algerian towns. A purposive convenience sampling criterion was used to recruit the participants. This approach to sampling combines the intentional selection of participants based on relevant characteristics with the practical consideration of their availability and willingness to participate in the study. The participants included both male and female teachers, aged between 22 and 40 years old. Their teaching experience ranged from one to ten years. All participants worked in public secondary schools and had previously considered using AI tools in their teaching practices. This initial data collection served as the basis upon which further experimental and qualitative methods were built.

Secondly, a within-subjects experimental design was employed to evaluate the extent to which AI tools can boost the lesson planning experience of listening skills. Four participants were selected from

the same pool of teachers who completed the questionnaire, chosen based on their availability across different Algerian towns. Teachers were given a detailed experiment guide that included step-by-step instructions, outlining the goals of the experiment, the required tasks, the allocated time for completing the experiment, and suggested AI tools to be used. The experiment was based on a sample lesson objective for a third-year class (“Discover how the universe /outer space is organized") and emphasized using specific language points (e.g., "both…and," "whereas," "unlike") and unit-related vocabulary (e.g., "astronomy," "rocky planets," "gas giants").

To further explain the content of the experiment guide, teachers were asked to create two listening lesson plans: one using traditional methods of lesson planning and one with the suggested AI tools as assistants, focusing particularly on the second phase of the PDP lesson framework, which is the during- listening stage. The total time allocated for completing both tasks was ten days. The traditional lesson plan required selecting audio material, adapting it to meet the lesson’s objective, designing two student-focused activities, while noting the time taken to complete it. For the AI-assisted lesson plan, teachers were expected to use the suggested AI tools, including chatbots like ChatGPT, Perplexity, and Copilot, as well as text-to-speech voice generators such as Eleven labs, PlayHT and, Natural Reader, to complete the same task. They were encouraged to use these AI tools creatively to enhance engagement strategies. The participants were provided with two online self-evaluation checklists to be completed after each phase of the experiment. Implementing such tool helped in measuring various aspects of the lesson plans, such as the time taken, manipulating the content of the listening material, their satisfaction with their final product, etc. These checklists were analyzed through a comparative method to evaluate the impact of integrating AI tools in the listening lesson planning process. A Likert scale was used in the checklists, where teachers rated their experiences on a scale from 1 (strongly disagree) to 5 (strongly agree). For each element, the mean score was calculated by summing the individual ratings and dividing by the total number of participants. This method offered a structured way for teachers to track their progress and also reflect on their experiences. Furthermore, this tool played an important role later on in facilitating a direct comparison of average scores between the two lesson plans, thus, determining the effectiveness of using AI tools as assistants in the lesson planning process.

To understand a complex concept like AI in the context of lesson planning, one-on-one interviews were conducted after the experiment. The design of these interviews was fully unstructured, aiming at retrieving the information directly from the participants rather than being determined by the questions asked. The interviews were conducted with the same four participants from the experiment via phone calls right after receiving the results. Each interview lasted approximately twenty minutes. To analyze the qualitative data from the interviews, a thematic approach was adopted. After recording the calls, the audio files were reviewed to begin transcription and gain familiarity with the content. The data were then coded by highlighting specific areas of the texts and creating shorthand labels to describe the content. Four potential themes were identified to help in addressing the research aims. The themes are further discussed in the next section of the paper.

Findings and Discussion. Following the process of collecting data, the results of the study questionnaire were analyzed quantitatively using descriptive statistical analysis. The analysis was done as follows:

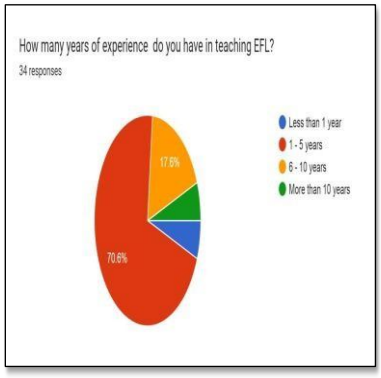

Figure1
Participants' Years of Experience in Teaching EFL

Figure 1 chart depicts the distribution of the participants' years of experience in teaching EFL. The majority of participants have an average level of experience, from 2 to 5years, representing 71% of the whole sample. Another significant portion of participants, comprising 18% of the sample, have years of experience ranging from 6 to 10 years. However, only a small portion of 6% has more than 10 years of experience. Finally, participants who have less than 1 year of experience represent the rest 6% of the sample.

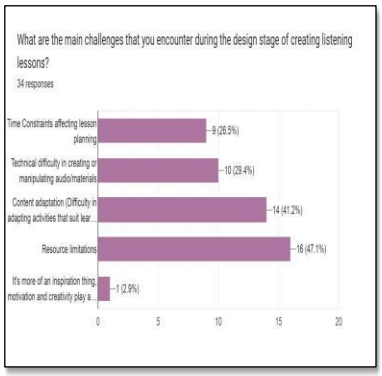

Figure 2
Participants' Main Challenges during the Design Stage of Listening Lessons

The bar chart in Figure 02 illustrates the distribution of participants' answers regarding the challenges they face during the design stage of creating listening lessons. Most participants consider resource limitations as their main obstacle, representing 47% of the sample. Another significant portion of the sample encounters difficulties in adapting the content of the listening material, constituting 41% of the whole sample. Additionally, 30% of the participants find it challenging to create or manipulate a listening material, selecting technical difficulty as their main concern. Furthermore, 26% of the participants chose time constraints as one of the challenges they face during the planning stage. 3% indicate a new challenge, suggesting the lack of motivation and inspiration among the difficulties they face.

The pie chart in Figure 3 represents the distribution of the second challenge answers which is about the effect of time constraints on teachers' ability to design effective listening lessons. 56%, which is the majority, of participants said that time limitations prevented them from exploring new teaching methods or technologies. Other participants said they struggled to allocate sufficient time for planning and preparation, representing 41% of the sample. An additional answer was suggested by one of the teachers, saying that "an overloaded syllabus is what hinders the use of listening lessons as they should have been used", comprising 3% of the sample.

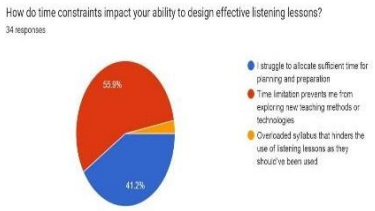

Figure 3
The Impact of Time Constraints on Designing Effective Listening Lessons

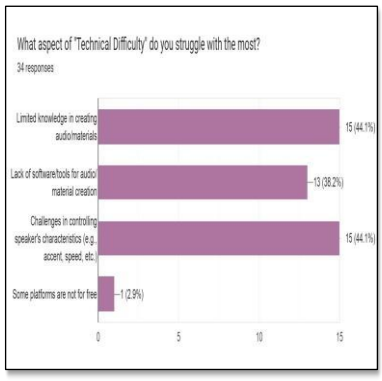

Figure 4
Aspects of Technical Difficulty Most Struggled With

The bar graph above (Figure 4) visualizes the distribution of participants' answers regarding which aspect of "Technical Difficulty" they struggle with the most. Interestingly, two aspects were equally represented, with both limited knowledge in creating audio/materials and challenges in controlling speaker's characteristics, cited by 44% of the participants for each answer. 13% of participants selected the aspect of lack of software/tools for audio/material creation. Another aspect which suggested that "some platforms are not for free", was mentioned by 3% of the sample.

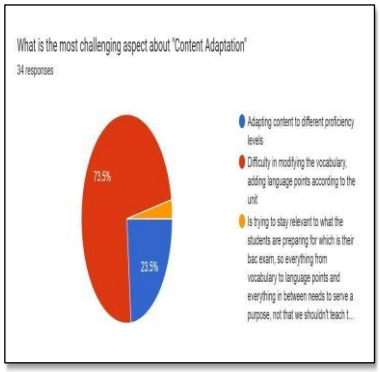

Figure 5
Aspects of Content Adaptation Most Struggled With

The pie chart in Figure 05 represents the distribution of participants' answers concerning the most challenging aspect about "Content Adaptation". The majority of participants find it difficult to modify the vocabulary and add language points according to the unit, representing 73% of the whole sample. 24% of participants struggle with adapting content to different proficiency levels. Finally, 3% of the sample added another aspect which suggests the most challenging thing is "trying to stay relevant to what the students are preparing for which is their BAC exam".

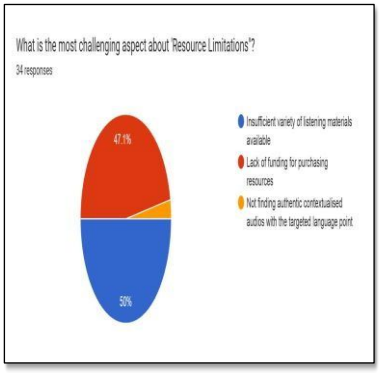

Figure 6
Aspects of Resource Limitations Most Struggled With

The pie chart in Figure 06 shows the answers distribution of the most challenging aspect about "Resource Limitations". Half of the participants struggle with the insufficient variety of listening materials available; While, 47% of the sample consider the lack of funding for purchasing resources as their main obstacle. 3% suggested another challenging aspect which is not finding authentic contextualized audios with the targeted language point.

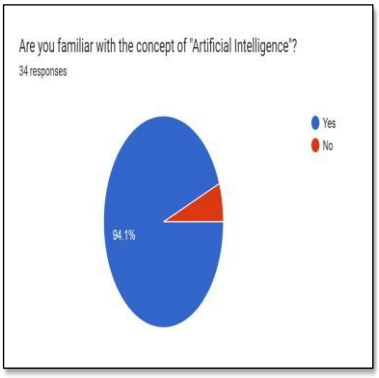

Figure 7
Participants' Familiarity with Artificial Intelligence

Figure 7 illustrates the distribution of participants' answers regarding their familiarity with the concept of Artificial Intelligence. The majority of the sample, 94%, was familiar with the concept of AI, while only 6% were not acquainted with it.

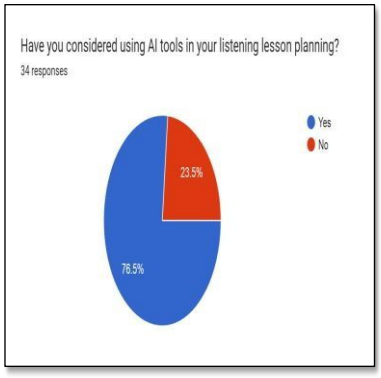

Figure 8
Participants' Consideration of Using AI Tools

This pie chart in Figure 8 represents the distribution of participants' answers about their consideration of using AI tools in their listening lesson planning. Most of the participants,77% were open to using

AI technologies in their listening lesson planning process. The remaining 23% of the sample declined the suggestion. This will add great value to our discussion.

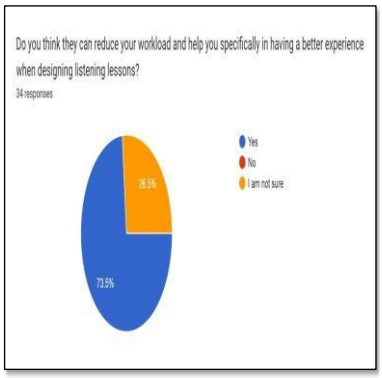

Figure 9
Impact of AI Tools on Workload and Designing Listening Lessons

The last pie chart in this analysis (Figure 9) shows the distribution of participants' answer about their opinion on whether AI tools can reduce their workload and help them specifically in having a better experience when designing listening lessons. The majority have a positive opinion towards incorporating AI tools, representing 74% of the whole sample. Yet, there were still some participants, 26%, who were not sure about that.

The Experiment Self-Evaluation Checklists' Analysis. This analysis focuses on comparing the self-evaluation checklists that the teachers completed before and after using AI tools. This comparative analysis is shown below through a graphical representation of the mean self-evaluation scores for each element of the lesson plan, both before and after implementing AI tools. Additionally, a table is accompanied with the graph to provide a detailed and transparent data breakdown alongside the calculations of mean scores:

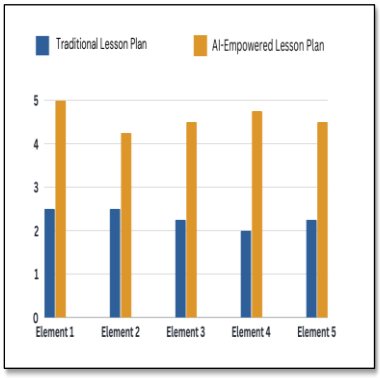

Figure 10
Comparison of Mean Self-Evaluation Scores Before and After AI Implementation

The bar graph in figure 13 displays the comparison of mean self-evaluation checklists' scores of five elements of the lesson plan, before and after AI implementation. Each element is represented by two adjacent bars: the first bar indicates the mean score of the element without the implementation of AI, whereas the second one shows the score of the element with AI.

Table 1
Mean Scores Calculation for Self-Evaluation Checklists by Element of Lesson Plan

Element of the lesson plan	Mean Score without AI	Mean Score with AI
Element 1: Completing the lesson plan in a short time	3+ 3+ 2+ 2=10/4=**2.5**	5+5+5+5=20/4=**5**
Element 2: Finding suitable materials easily	4+3+1+2=10/4=**2.5**	5+5+5+2=17/4=**4.25**
Element 3: Editing the audio Characteristics easily	2+2+4+1=9/4=**2.25**	5+5+5+3=18/4=**4.5**
Element 4: Customizing the audio script easily	3+3+1+1=8/4=**2**	5+5+5+4=19/4=**4.75**
Element 5: Satisfaction with the final product	2+2+2+3=9/4=**2.25**	4+4+5+5=18/4=**4.5**

Initially, the mean score of completing the lesson plan in a short time increased from 2.5 to 5 which indicate that the implementation of AI helped in saving time. Next, the score for the second element, which concerns the easiness of finding suitable materials, rose from 2.5 to 4.25, suggesting that AI tools facilitated the process of locating appropriate materials. Regarding the third element, which is about the easiness in editing and adjusting the audio characteristics, the mean score showed a notable boost from 2.25 to 4.5, highlighting the enhancement of material editing with the help of AI. The fourth element, which pertains to the customization of audio scripts, saw an improvement as well, moving from 2 to 4.75. Finally, the last element, participants' satisfaction with their final product of the lesson plan, increased from 2.25 to 4.5, reflecting a high level of satisfaction with the AI-empowered lesson plan.

The Individual Interview Analysis. The data gathered from the individual interviews provided valuable and in-depth insights into the teachers' perspectives and attitudes towards using AI tools in their listening lesson planning process, with the aim of increasing efficiency. Through the thematic analysis, recurring patterns were identified and used to develop emergent themes that highlight key aspects of the participants' experiences and viewpoints. The themes are explained in details below:

AI Tools as Creativity Boosters. This theme explores how participants perceive AI technologies in relation to creativity. Contrary to the common belief that AI limits human creativity, the participants highlighted the capabilities of this advanced technology in improving, completing and organizing creative ideas, especially when it comes to planning lessons. They described their creative ideas as the base, and when presented to an AI tool, like a chatbot, they become more refined. One participant stated: *"Sometimes, you have creative ideas but you don't know how to apply them, so you get lost. But, when you make use of AI tools, they will shape your idea to come up with a better and a complete one, ready to be applied in reality or in the classroom context" (B. Merriam, personal communication, June 06, 2024).* Discussing this theme resulted in another sub-emergent topic which highlights the potential of using AI technologies in the context of planning lessons.

The Skill of Improvisation. This sub-emergent theme highlights a key quality of humans, particularly teachers: the skill of improvisation. Improvisation can be regarded as an intrinsic human quality, representing all daily communication and human attributes (Dehlin, 2008). To demonstrate that AI cannot limit teachers' creativity, one participant opined that AI tools, such as ChatGPT, enhance our ideas but do not replace the human element in the classroom. "We have the opportunity to be creative

in our own way when delivering the lesson. As teachers, of course we have the skill of improvising which in its own end needs creativity. For example, if a student does not understand something that was AI-generated, you have to find a creative way to re-explain the idea". (B. Merriam, personal communication, June 06, 2024)

This viewpoint emphasizes that teachers must be creative in the classroom. Even if the lesson is AI-assisted, they should creatively deliver the lesson plan.

ChatGPT as an Inspector. This theme emphasizes the role of AI chatbots, ChatGPT in particular, as novice teachers' inspector. One participant suggested that ChatGPT works like an inspector somehow in the way it can provide teachers with constructive feedback. *"People in general do not like feedbacks; however, when they hear it from a robot that doesn't have feelings, this will be less offensive, and they are going to take it actually in to consideration, they wouldn't think that they do know better than robots and they do not think that 'no! this is a generational gap, this inspector is a boomer and we are the Gen Z which give us the ability to create more fun lesson plans".(Z. Sarah, personal communication, June 01, 2024)* This discussion highlighted the necessity of using ChatGPT to provide feedback for novice teachers who are still in their first years, struggling with making fun and engaging lesson plans properly.

Local Contextualization Issues. This interviewee highlighted one of the major concerns about AI tools, which is the inability of AI chatbots to contextualize lesson plans to fit the Algerian education system. Specifically, they fail to align the suggested lesson tasks with grammar or competency-based approaches which are used in the Algerian Baccalaureate exam. Instead, these smart chatbots often generate content-based activities, which are not relevant to our educational system. *"What I like less about ChatGPT is when it doesn't contextualize the lesson plan because it doesn't really know how, for instance, our baccalaureate exams are designed, so whenever I paste a text...it gives me tasks that are content-based which is something we do not use..." (G. Narimene, personal communication, June 01,2024)* This particular theme sheds light on one of the deficiencies of AI chatbots that needs to be taken into consideration by teachers to avoid unwanted results. This will add great value to our discussion.

Technology Constraints. Another major concern that was put in forefront by the interviewees is AI's inability to take into consideration the layout of Algerian classrooms in terms of technological equipment. *"ChatGPT doesn't take somehow into consideration how Algerian schools are built, what we have and what we don't, because it doesn't know that we don't have the bare minimum. The only technologies used inside the classroom are data show, a phone and an amplifier." (K. Leyla, personal communication, June 2, 2024).* The participants highlighted that the scarcity of technological resources makes it challenging for teachers to incorporate some listening lesson plans suggested by AI. This particular point will be discussed in detail in the discussion section.

To encapsulate the whole findings, the closed-ended questionnaire revealed multiple key obstacles faced by teachers, including resource limitations, content adaptability, time constraints, and technical difficulties. These findings align with Osada (2004), Yukselci (2003), and Slamet et al. (2019), who highlighted similar issues about the reality of teaching listening lessons. For instance, 47% of respondents reported serious difficulties in finding suitable listening material. The latter urged the need to find alternative ways for more efficient lesson planning experiences.

In line with our hypothesis, which suggested that AI tools can increase lesson planning efficiency and reduce teachers' workload, it was clearly shown in the comparative analysis of the self-evaluation checklists that using these smart tools enhanced key areas in the lesson plan. The first noteworthy element is saving time, as participants could design a lesson plan in a short amount of time without hindering the quality of the lesson activities or the audio material. This mirrors findings by Wolf

(2020) on the capability of NLP programs to free up our time. Time constraints can deeply impact the role of the instructor, yet AI has proven to be worthy because of its effectiveness in generating content in a matter of minutes. Another area of improvement concerns material availability, as participants could adapt existing material and were even able to create their own audio script from scratch using ChatGPT. Additionally, a high score for content adaptation is noted. Participants found that AI tools allowed them to easily tailor the lesson content to meet their lesson objectives. Through the use of chatbots and voice generators, audio manipulation has finally become possible by adjusting audio speed, accent, content, and clarity. This finding is consistent with previous research done by Koraishi (2023), which suggested that lesson planners in collaboration with ChatGPT can manipulate vocabulary and grammar integration. This proves AI's ability to overcome some of the most challenging aspects of planning and teaching listening lessons. These quantitative findings were further supported by qualitative data retrieved from the interviews, in which participants elaborated on the reasons behind their responses, which offered richer and deeper insights into their attitudes and experiences.

The interviews revealed quality themes about the potential of AI in enhancing the lesson planning experience, reflecting both positive and somehow negative attitudes. AI tools are viewed by the participants as creativity boosters when it comes to refining and shaping initial ideas, contradicting common beliefs on the risks of AI. While this cutting-edge technology can provide structured suggestions, it can never replace the human element of the instructor's creativity as it remains critical in adapting and delivering the lessons effectively. Interestingly, chatbots, like ChatGPT, were seen as valuable for giving objective feedback, especially for novice teachers. Their confidence can be boosted in several ways. Receiving non-judgmental feedback may improve their lesson plans without the fear of being personally criticized. In the time of constant evaluation, new teachers can address their weaknesses to be more prepared to meet their inspectors and demonstrate their teaching competencies. Nevertheless, concerns were raised about AI tools inability to contextualize lesson plans according to the Algerian education system. Such technologies may offer general content, but lack awareness of the Algerian local curricula objectives, textbook guidelines, and exam formats such as those of the Baccalaureate. Consequently, this may mislead novice teachers, especially the ones who are not fully acquainted with what, for example, official exams focus on. Moreover, it was noted that it is impossible to fully adapt AI-generated lesson plans as they require advanced technological resources, which are not available in Algerian secondary schools. Yet, this reveals that teachers' concerns may stem from their lack of awareness about prompt engineering. This technique, as Koraishi (2023) highlighted its importance, is the act of providing crafted and extra-detailed prompts to AI tools in a way that we can take the most relevant answers out of them. If the participants were more familiar with it, they could provide ChatGPT with a sample of the Baccalaureate exam layout or the technological resources available in their classrooms to potentially receive valid responses.

Conclusion

Practitioners can embrace AI as a new cutting-edge technology which acts like an assistant in the lesson planning process. AI has the potential to enhance several elements of the listening lesson plan, reducing workload and increasing efficiency. Nevertheless, to fully leverage the capabilities of AI, proper training in prompt engineering and understanding of these intelligent tools are highly required. Additionally, to ease the transition to using emerging AI technologies, teachers are advised to start with simple AI-assisted tasks such as creating customized vocabulary lists and adapting generated scripts. They can then collaborate with colleagues to exchange their creations. This not only facilitates the use of AI tools but also helps avoid overreliance. At a broader level, the findings of this study emphasize the need for Algerian educational policymakers to integrate AI literacy workshops into pre-service teacher training programs and ongoing professional development, aiming to equip teachers with skills necessary to navigate the ethical issues associated with AI. Future research should focus on the long-term impact of AI-empowered lesson plans on students' learning outcomes to have

a fuller picture. This study contributes to the limited body of research on overcoming the challenges associated with teaching listening and applications of AI in EFL education by offering valuable nuances from the perspectives of educators, thus filling an important research gap that can serve as a strong foundation for future studies in this domain.

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Digital Financial Tools and Economic Transformation: Global Changes in the Financial Sector

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Abstract. *This research explores the impact of digital tools on economic transformation, with a particular focus on global changes within the financial sector. As the world increasingly shifts towards digital finance, the study examines how financial innovations such as blockchain, cryptocurrencies, and fintech applications are driving significant economic shifts. The research investigates the relationship between these digital advancements and economic growth across developed and developing economies, analyzing how they influence key economic indicators such as market stability, investment behavior, and policy development. By employing empirical data and case studies, the study reveals that digital financial tools play a pivotal role in reshaping financial markets, increasing accessibility to financial services, and accelerating economic development. The findings indicate that while digitalization offers immense opportunities for economic growth, it also presents challenges related to market regulation, data security, and financial inclusion. Ultimately, the study proposes policy recommendations to foster the positive impact of digital finance while mitigating its risks, especially in emerging markets.*

Keywords**:** *Digital tools, economic transformation, financial sector, blockchain, cryptocurrencies, fintech, economic growth, market stability, policy development*

Introduction

Over the past decade, the global economy has witnessed profound transformations, largely driven by the advent of digital technologies. Among these innovations, digital finance has emerged as a pivotal force in reshaping economic systems across both developed and developing nations. The accelerating adoption of digital financial tools such as fintech applications, cryptocurrencies, and blockchain technologies has significantly altered traditional financial structures and has become a key driver of economic modernization, expansion, and inclusion. In this context, digital finance represents not just a technological evolution but also a fundamental shift in how financial transactions, investments, and trade are conducted across borders.

The rise of fintech has introduced innovative services that provide consumers and businesses with alternative financial solutions, increasing the accessibility and efficiency of financial products. Cryptocurrencies and blockchain technologies, in particular, have disrupted conventional banking and financial systems by providing decentralized, transparent, and secure means of conducting financial transactions. These innovations have paved the way for more inclusive financial systems, offering opportunities for individuals and businesses in underserved regions to participate in the global economy. As digital financial tools become more embedded in economic systems, they have unlocked new avenues for investment diversification, enhanced liquidity, and greater efficiency in global trade, marking a new era for financial markets.

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However, the proliferation of these digital tools has not come without its challenges. As the financial sector undergoes rapid digitization, the associated risks – such as market volatility, regulatory gaps, and cyber threats – have become prominent concerns. The absence of uniform regulatory frameworks and the lack of financial security protocols have made digital finance susceptible to misuse, fraud, and speculative market behaviors. Furthermore, these challenges are particularly acute in emerging economies, where the adoption of digital finance is often outpaced by regulatory development, creating vulnerabilities in the financial ecosystem.

The interplay between digital finance and economic transformation is particularly notable in how it influences economic policies, financial market dynamics, and investment strategies on a global scale. In both developed and developing countries, the integration of digital financial technologies is reshaping the landscape of global trade and investment, and it poses unique challenges to national regulators and financial institutions alike. Emerging economies, which are striving to keep pace with technological advancements, face the dual challenge of leveraging the benefits of digital finance while mitigating the risks inherent in its adoption. The rapid growth of digital finance in these economies highlights the need for policies that can ensure financial stability while fostering innovation and inclusivity.

This research aims to investigate the role of digital financial tools in economic transformation, with a particular focus on the impact of fintech, cryptocurrencies, and blockchain technologies on global financial systems. The study will explore how these digital tools are reshaping financial practices in both developed and emerging economies, considering their potential to drive economic growth, promote financial inclusion, and diversify investment opportunities. Additionally, the research will examine the regulatory challenges and risks associated with the integration of digital finance into existing economic frameworks. The findings of this study will contribute to the broader understanding of digital finance's role in shaping future global markets and will offer policy recommendations aimed at optimizing the integration of digital financial tools to enhance their positive impact while addressing potential risks.

By providing a comprehensive analysis of the digital finance ecosystem, this research will offer valuable insights into the changing dynamics of global economies and the future of financial markets. Ultimately, the study aims to inform policymakers, financial institutions, and stakeholders about the economic implications of digital finance and to propose strategies for navigating its integration into the global economic fabric.

Literature Review. Digital Financial Tools and Economic Transformation. The role of digital financial tools in transforming economies has become a focal point of recent research. Arner et al. (2016) highlight that fintech has revolutionized the financial sector, especially by increasing access to financial services in underserved markets. Digital tools, including blockchain technology, cryptocurrencies, and digital wallets, have facilitated financial inclusion, offering previously unbanked populations access to essential financial products and services (Narayanan et al., 2016; Ozili, 2020). These innovations have shown substantial promise in enhancing economic transformation, with studies from the World Bank (2018) indicating that digital finance contributes to economic growth by improving efficiency, reducing transaction costs, and stimulating investment. This is particularly true in emerging markets, where digital tools have enabled more people to participate in economic activities. However, Mazzucato (2018) warns that while digital finance holds growth potential, it also brings challenges. Regulatory oversight remains a significant concern, particularly around financial security and the vulnerability of digital platforms to cyber threats.

Research

Impact of Cryptocurrencies on Financial Markets. Cryptocurrencies, such as Bitcoin and Ethereum, have garnered considerable attention for their potential to disrupt traditional financial systems. Catalini and Gans (2016) argue that cryptocurrencies provide a viable alternative to conventional banking systems by enabling cheaper and faster cross-border transactions. Their research shows that cryptocurrencies can reshape financial markets by reducing transaction fees and offering secure methods of transferring money globally. However, Zohar (2019) offers a more cautious perspective, emphasizing the risks associated with cryptocurrencies, including their volatility and the potential for their use in illicit activities. He underscores the regulatory challenges that cryptocurrencies pose, particularly with respect to taxation, fraud prevention, and consumer protection. As digital currencies gain traction, governments and financial institutions face increasing pressure to develop comprehensive regulatory frameworks that address these concerns without stifling innovation.

Blockchain and Financial Market Stability. Blockchain technology, the foundation of cryptocurrencies, has been hailed as a revolutionary innovation in the financial sector. Tapscott and Tapscott (2016) emphasize that blockchain's decentralized and transparent nature provides a secure way to record transactions, reducing the risk of market instability. Several studies suggest that blockchain technology could significantly enhance the transparency and efficiency of global financial markets, thus improving their stability (Narayanan et al., 2016; Vives, 2019). Despite its potential, Liu and Narayanan (2017) note that integrating blockchain into traditional financial markets remains a considerable challenge. Issues such as the lack of interoperability between blockchain systems and legacy financial infrastructures, as well as the high energy consumption of blockchain networks, must be addressed for the widespread adoption of blockchain technology. These hurdles prevent blockchain from being seamlessly integrated into mainstream financial systems, limiting its full potential for market stability.

Digital Finance and Economic Policy Development. As digital financial tools continue to shape the global economic landscape, their influence on economic policies has become an essential area of study. Chiu and Koeppl (2017) argue that digital finance could significantly impact monetary policy, particularly by influencing interest rates, inflation control, and overall financial stability. The rise of digital currencies and blockchain technology calls for a reassessment of traditional policy frameworks by governments and central banks. Gabor and Brooks (2017) further emphasize that policymakers must strike a delicate balance between fostering innovation and ensuring financial stability. They stress the importance of developing robust regulatory frameworks that protect consumers while encouraging the growth of digital finance. As digital finance continues to evolve, policymakers will need to adapt their approaches to maximize the benefits of these technologies while safeguarding the stability of financial systems.

Challenges in Implementing Digital Financial Tools in Developing Economies. While digital finance holds significant promise for economic growth, its implementation in developing economies faces numerous challenges. Kauffman and Riggins (2015) identify barriers such as inadequate digital infrastructure, poor internet connectivity, and low levels of digital literacy in many developing countries, which hinder the widespread adoption of digital financial tools. Additionally, regulatory frameworks in many developing nations are not designed to accommodate emerging technologies, further limiting access to digital finance. Mendelson and Lustig (2019) stress the importance of financial literacy and education for the successful integration of digital finance in these economies. They argue that public awareness campaigns and training programs are essential to equip individuals and businesses with the knowledge needed to fully leverage the benefits of digital finance. Addressing these challenges is critical for ensuring that developing economies can capitalize on the potential of digital finance to promote economic growth and inclusion.

Methodology

This research employs a quantitative research design to examine the impact of digital financial tools on economic transformation, particularly within the financial sector. The study integrates empirical analysis and econometric modeling to explore the causal relationships between digital finance adoption and economic outcomes, such as economic growth, market stability, and financial inclusion. The use of panel data facilitates the analysis of both cross-sectional and temporal variations, allowing for a comprehensive examination of digital finance's role in shaping economic dynamics across countries and time periods.

Data Collection. The data for this study is primarily obtained from secondary sources, which include international financial reports, databases from financial institutions, and government statistical offices. This approach allows for an extensive analysis of a variety of economic variables and digital finance adoption rates. The time frame for the data spans from 2010 to 2024, covering both short-term fluctuations and long-term trends in the adoption of digital financial tools. This period is selected to capture the rapid evolution of digital finance technologies and their increasingly significant role in economic systems.

The study will analyze a set of key variables that are directly related to digital finance adoption and its effects on economic transformation. The specific variables are:

Digital Adoption Index (DAI): The DAI serves as a central measure in this research, representing the extent to which firms and individuals in a given economy have adopted digital financial tools such as blockchain, cryptocurrencies, fintech applications, and mobile payments. This index will be based on a combination of quantitative indicators, including the number of fintech startups, the percentage of the population using digital wallets, and the volume of transactions involving digital currencies.

Economic Growth Indicators: The analysis will focus on traditional economic growth metrics, such as GDP growth, productivity rates, and investment levels in digital infrastructure. These indicators will help to understand the macroeconomic effects of digital finance adoption, as well as its contribution to overall economic development. Special attention will be given to investment in digital infrastructure, as it directly correlates with the capability of economies to integrate digital tools effectively.

Market Stability: This variable will be measured through indicators such as financial volatility, liquidity, and the occurrence of financial market crashes. Market stability is critical for understanding how digital finance impacts the overall resilience of financial markets. By analyzing these factors, the study will assess whether the adoption of digital finance tools has led to increased stability or exacerbated volatility in the markets.

Financial Inclusion: This aspect will be measured by factors such as access to banking services, mobile payments penetration, and digital wallet usage. Financial inclusion is a key aspect of economic transformation, as it provides previously underserved populations with access to essential financial products and services. This variable will help to gauge the extent to which digital financial tools contribute to broader economic inclusion, especially in regions with traditionally low access to banking services.

Sample Selection. The research focuses on a cross-country analysis that compares a select group of emerging economies, with a particular emphasis on countries in Eastern Europe and Central Asia. These regions have experienced varying degrees of digital finance adoption, making them ideal candidates for examining the broader economic impacts of digital finance tools. The countries selected for this study represent diverse levels of digital infrastructure, financial development, and

economic performance, providing a comprehensive sample for assessing the influence of digital finance on economic outcomes.

The sample will consist of 15 countries, chosen based on their relevance to the research question, availability of data, and the degree to which they have embraced digital financial tools. These countries include:

Kazakhstan: As a rapidly developing economy in Central Asia, Kazakhstan has been at the forefront of digital finance adoption, especially in terms of mobile payments and fintech innovations.

Türkiye: Türkiye has made substantial strides in fintech development and has seen widespread adoption of mobile payment systems. Its unique position as a transcontinental country allows for insights into both European and Asian markets.
Ukraine: Ukraine's digital finance sector has seen significant growth, particularly in the area of cryptocurrency adoption and blockchain applications.
Georgia: Known for its growing digital economy and significant progress in digital governance, Georgia offers a unique case study in a smaller, fast-developing market.

Other countries in the sample will include Bulgaria, Serbia, Uzbekistan, Armenia, Moldova, Azerbaijan, Bosnia and Herzegovina, Belarus, Kyrgyzstan, Albania, and Montenegro. These countries have been selected based on the availability of digital finance-related data and the variation in their digital finance adoption levels. This diversity allows for a more robust understanding of how digital financial tools influence economic outcomes in different contexts.

Econometric Modeling and Statistical Analysis. The study employs panel data econometrics to analyze the relationships between digital finance adoption and the key economic variables. The use of fixed-effects or random-effects models will be considered, depending on the nature of the data. The primary goal is to identify both short-term and long-term relationships between digital finance adoption and economic transformation.

Econometric techniques such as Ordinary Least Squares (OLS), panel regression analysis, and Granger causality tests will be used to assess the impact of digital adoption on economic growth, market stability, and financial inclusion. These methods will allow for the identification of both direct and indirect effects, as well as the estimation of causal relationships between the adoption of digital financial tools and various economic outcomes.

By combining statistical analysis, panel data techniques, and econometric modeling, this research aims to provide a comprehensive and data-driven understanding of the role that digital financial tools play in transforming economies. The findings will offer valuable insights for policymakers, financial institutions, and businesses in emerging markets, helping them to navigate the opportunities and challenges posed by the digital financial revolution.

Conclusion

This study has provided valuable insights into the relationship between digital financial tools and economic growth, with a particular focus on emerging economies. The research highlights the transformative role that digital finance, including cryptocurrencies, blockchain technologies, and fintech applications, plays in driving economic performance. It is clear from the findings that digital adoption is a significant driver of economic development, particularly in countries that are embracing these technologies. The evidence supports the notion that nations with higher levels of digital finance adoption, such as Türkiye, Georgia, and Kazakhstan, exhibit consistently higher GDP growth, improved financial inclusion, and greater market stability when compared to countries that have not

integrated digital tools to the same extent. The increased access to financial services in these countries, particularly for underserved populations, has enhanced overall economic participation and fostered sustainable growth.

The research also reveals that digital finance is a catalyst for market stability, as blockchain technologies and digital currencies offer more secure and transparent mechanisms for conducting transactions. This has been especially crucial for developing economies that have historically struggled with financial instability. Moreover, fintech applications have democratized access to capital and financial products, fostering entrepreneurship and innovation across different sectors of the economy. Despite the immense potential, the study emphasizes that the digitalization of financial systems also brings challenges, including the risks associated with regulatory gaps, cybersecurity threats, and market volatility. It is essential that these challenges be addressed to ensure the long-term sustainability of digital finance in economic growth.

Recommendations. Based on the findings of this research, several key recommendations are proposed for policymakers, financial institutions, and businesses aiming to foster economic growth and stability through digital finance:

Promote Digital Financial Literacy: To fully leverage the potential of digital finance, governments should prioritize the implementation of nationwide education programs to raise awareness and understanding of digital financial tools among the general public. This is particularly important in emerging economies, where digital finance may still be relatively new to the population. By increasing digital literacy, individuals and businesses will be better equipped to adopt these tools, leading to greater financial inclusion and improved economic outcomes.

Enhance Digital Infrastructure: One of the most critical factors for the successful implementation of digital finance is the availability of digital infrastructure. Governments and private sector players should increase their investments in building and upgrading the necessary infrastructure, including improved internet access, mobile network coverage, and digital payment systems. Ensuring that digital financial tools are accessible to all, particularly in rural or underserved areas, will be key to maximizing the reach and impact of digital finance.

Strengthen Regulatory Frameworks: While digital finance presents significant opportunities, it also brings about new risks. Therefore, strong regulatory frameworks are essential to mitigate the potential downsides of digital finance, such as fraud, cybersecurity threats, and money laundering. Governments should develop and enforce regulations that ensure data security, fraud prevention, financial transparency, and consumer protection. This will create a safer environment for individuals and businesses to engage in digital finance, fostering trust and encouraging further adoption.

Encourage Innovation while Ensuring Financial Stability: Policymakers should focus on fostering innovation within the digital finance sector while ensuring financial stability. While promoting the growth of cryptocurrencies and fintech applications, governments need to provide clear and balanced guidelines that safeguard market integrity and prevent market instability. Regulatory frameworks must encourage the development of new technologies without compromising the security of the financial system. This involves carefully navigating the challenges posed by rapidly evolving digital financial tools, such as the potential for market bubbles and the integration of new technologies into existing financial infrastructures.

Foster Public-Private Partnerships: The successful integration of digital finance into the broader economy requires collaboration between the public and private sectors. Governments, financial institutions, and tech companies should work together to create synergies that facilitate the adoption and integration of digital finance. Public-private partnerships (PPPs) can help to bridge gaps in

infrastructure, technology, and education, making digital finance more accessible and impactful. Additionally, these partnerships can support financial innovation and inclusive economic development by ensuring that digital finance reaches the most vulnerable populations and sectors.

Final Thoughts. The integration of digital finance into the global economy offers both immense opportunities and significant risks. On the one hand, digital financial tools have proven to be powerful drivers of economic growth, market stability, and financial inclusion. They have revolutionized access to capital and financial products, empowered businesses to innovate, and facilitated cross-border transactions in more efficient and cost-effective ways. On the other hand, the rapid growth and adoption of digital finance also pose challenges related to regulation, security, and the sustainability of digital financial systems.

To fully harness the potential of digital finance, governments, businesses, and financial institutions must work collaboratively to address the challenges that come with this transformation. By focusing on improving digital literacy, infrastructure, and regulatory frameworks, as well as encouraging innovation and public-private partnerships, the benefits of digital finance can be maximized while mitigating the associated risks. It is crucial that policymakers adopt a forward-thinking approach that fosters inclusive economic development while ensuring the stability and security of financial systems. Only through careful planning, effective regulation, and a commitment to financial literacy will digital finance continue to serve as a catalyst for global economic transformation.

In conclusion, the role of digital finance in shaping the future of global markets cannot be overstated. As the world increasingly moves towards digital financial systems, it is essential for all stakeholders to understand the dynamic opportunities and challenges these tools present. By addressing these challenges head-on and taking proactive steps to ensure the successful integration of digital finance, governments and businesses can help ensure that these technologies contribute to sustainable and inclusive economic growth in the years to come.

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