THE MACROECONOMICS OF AI AND BLOCKCHAIN IN THE CIRCULAR ASPECT OF SUSTAINABLE TOURISM: A SYSTEMATIC THEORETICAL REVIEW

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ABSTRACT
The contribution of global tourism to GDP increased to 10%, and significantly affected the actuality of transitioning the tourism sector from 'take-make-dispose' models to a circular economy. The study explores how artificial intelligence and blockchain are evolving beyond speculative trends into tangible macroeconomic drivers. Within a narrative literature review and conceptual analysis, it is examined how these technologies impact productivity, change labour market demands, and affect monetary frameworks. The paper addresses the scientific problem on how artificial intelligence and blockchain strengthen circularity in the development of sustainable tourism from a macroeconomic perspective. Consequently, the purpose of the study is to analyse the effects of digitalisation on economic productivity, labour market dynamics and monetary policy through the lens of the circular economy. Also, the study highlights the fact that interrelatedness between digitalisation and macroeconomic dynamics has the long-term sustainability potential of implementing digital technologies in sustainable tourism circularity.
KEY WORDS: *digitalisation, AI, blockchain, circular economy, sustainable tourism development*

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Introduction

Relevance of the research topic. Digitalisation is the process of exploring and integrating digital technologies that affects the way businesses operate and deliver value to their customers. The integration of advanced digital technologies caused the transformation of economic systems from different perspectives (Vărzaru, Bocean, 2024). Everyday business operations and financial transactions step into the new era of macroeconomic dynamics through the integration of artificial intelligence (AI) and blockchain technology (Rane, 2023). This evolution is driving a renewed focus on sustainable practices across various sectors worldwide. Such a focus on sustainable practices is increasingly recognised as influential in fostering economic resilience and ensuring environmental stewardship in the digital age (One Planet, 2025). A prominent example of such a shift is the emergence of circular tourism which emphasises resource efficiency and waste reduction in the travel industry. It is important to study the macroeconomics of AI and blockchain in the circular aspect of sustainable tourism, because the global circular economy is expected to reach $4.5 trillion by 2030, and adopting circular principles specifically within tourism can lead to a reduction in waste generation and a decrease in carbon emissions, as the tourism sector contributes 10% of global GDP (World Economic Forum, 2025; Strippoli et al., 2024; Sharma et al., 2024). So the scientific problem to be explored is how the integration of artificial intelligence and blockchain technologies enhance circularity in sustainable tourism from the perspective of macroeconomics.

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Rather than acting as basic automation tools, AI provides the predictive intelligence and learning algorithms necessary to optimise complex tourism operations (European Parliament, 2020). With a forecast $15.7 trillion contribution to the global economy by 2030, AI-driven systems are already reshaping labour markets: displacing traditional roles, while automatically creating demand for new, high-value skills (Wang, Lu, 2025). In the tourism sector, such a shift towards AI-enhanced efficiency allows for real-time resource allocation and superior waste management (Zhang, Deng, 2024). Going with AI, blockchain serves a secure, unchangeable ledger that ensures transparency across financial and supply chains (European Parliament, 2017). As the blockchain market grows at a compound annual growth rate (CAGR) of 67%, from 2021 to 2028, its potential extends into the reform of monetary policies and regulatory frameworks (Grand View Research, 2021; Javaid et al., 2022). For circular tourism, blockchain's value lies in its ability to trace the entire life cycle of services, fostering a trust economy that encourages tourists and travellers to choose ethically sourced and sustainable options (Rejeb et al., 2022; Erol et al., 2022).

The scientific problem is the unresolved tension between the tourism industry's important role in global GDP and its traditionally linear take-make-dispose consumption model. Despite the theoretical potential of artificial intelligence and blockchain, there remains a critical knowledge gap in how these technologies are seen to be integrated as macroeconomic drivers to facilitate a transition towards circularity without compromising economic productivity or labour market stability. The study establishes the extent to which artificial intelligence is primarily seen in the optimisation of the resource loop, when blockchain's influence is most profound in the trust and transparency loop, and both of them are required to decouple tourism growth from environmental degradation.

The purpose of the study: to analyse the macroeconomic impacts of AI and blockchain on circularity in sustainable tourism, specifically examining their influence on the productivity dynamic, workforce shifts, and monetary frameworks.

Research tasks: 1) to synthesise the theoretical foundations of how AI and blockchain redefine macroeconomic variables, specifically economic productivity, labour market dynamics, and monetary policy; 2) to evaluate the conceptual dynamics of the circular economy within sustainable tourism, focusing on resource revaluation and systemic resilience; 3) to analyse the specific macroeconomic channels through which AI-driven optimisation increases circularity in the development of sustainable tourism; 4) to investigate the role of blockchain as a macroeconomic driver of transparency and ethical resource tracking within the circular tourism paradigm.

Research methods: narrative literature review, conceptual analysis.

1. A theoretical analysis of the impact of digitalisation on macroeconomics

Digitalisation is the process of integration of digital technologies into everyday life at all levels. It reshapes traditional business models and operations processes across most sectors. It is not only about adopting technologies and digitising, but its significance is also in changes of business interactions with customers, resource management, and competition in the global market. The macroeconomic impact of digitalisation and its technological advances influences various aspects of economic performance and social structures, such as economic productivity, the labour market and monetary policies.

Research method

The methodology chosen for the current research employs narrative literature review and conceptual analysis. The systematic approach is to gather, analyse and synthesise relevant academic works, such as articles, reports and publications from respected sources. The narrative literature review serves as the first step in synthesising the importance of digitalisation in macroeconomics, and to define CE principles in the tourism industry. At the same time, the conceptual analysis assists in examining specific macroeconomics aspects such as productivity, labour and monetary policy, because through them, technologies, AI and

blockchain influence the development of sustainable tourism. To ensure the comprehensive exploration of the intersection between digitalisation and sustainable tourism practices, the research keywords were *circular economy*, *AI*, *blockchain*, *macroeconomic productivity*, *labour market dynamics*, *monetary policy* and *sustainable tourism development*. It helped to move beyond general digitalisation, and focus on the nature of the influence of digital drivers on the economic transition from linear to circular models.

The literature search was conducted primarily using academic databases such as Scopus, ScienceDirect and Google Scholar to access peer-reviewed articles and research papers. To learn the most recent trends in macroeconomic and policy perspectives, it was chosen to analyse strategic reports from the European Commission, the IMF (2024), the World Bank, the WTTC (2024), and the OECD (2024; 2025). The sources were selected based on their credibility and direct relevance to the research problem. The inclusion criteria focused on publications dating from between 2020 and 2025, in order to be sure that analysis accounts for the post-generative AI era and the most recent shifts in the circular economy (World Economic Forum, 2025). Within this, the conceptual analysis was applied in order to map thematic dimensions such as the mechanism of AI-driven resource optimisation (Al Naqbi et al., 2024), the transformative impact of digitalisation on labour and skills (Bone et al., 2025), and the regulatory and monetary implications of blockchain in financial transparency (Thanasi-Boçe Hoxha, 2025).

The evaluation of source credibility and the use of a diverse range of international datasets helped to mitigate availability bias. This integrative approach ensured a robust conceptual analysis of the macroeconomic drivers, allowing for the construction of a theoretical model that defines the specific causal pathways within the circular tourism paradigm.

Economic productivity

Operational efficiency is one of the key impacts of digitalisation on macroeconomics, as companies and other types of organisation can automate and digitise routine tasks, reduce errors and defect rates, as well as optimising workflows through the adoption of digital tools (Chenic et al., 2023). Firstly, the automation of processes reduces the time required for production processes, by minimising human intervention. It leads to faster output rates and lower operational costs (Haque, 2023). Secondly, organisations can leverage big data analytics to reach insights into consumer behaviour and market trends, achieving more efficient decision-making results, resource allocation, supply chain optimisation and improved service delivery, contributing to higher overall productivity levels in a variety of industries (Vasilopoulou et al., 2023). Thirdly, countries that are adaptable to digital technologies and tend to integrate them experience faster economic growth compared to countries that are not yet open to digitalisation (Afonasova, Panfilova, Galichkina, Ślusarczyk, 2019). To sum up, the relationship between digitalisation and economic productivity is important, as it improves both knowledge-sharing production processes through digital tools and automation (Arsić, 2020). The evidence suggests that the relationship between digitalisation and productivity is built on a foundation of improved knowledge sharing. However, it is important to recognise that this is not a guaranteed outcome for all nations. The data implies that productivity gains are heavily dependent on a country's openness to integration; therefore, digitalisation functions less as a stand-alone tool, and more as a multiplier of existing economic adaptability. The shift from manual to automated represents a fundamental change in how value is generated, moving from labour-intensive processes to data-driven efficiency.

Labour market and employment dynamics

The impact of digitalisation on the labour market is significant, as it leads to both job displacement and job creation (Mizaev et al., 2025). On one hand, the job displacement refers more to the low and medium-skilled jobs that are more easily replaced by automation processes, increasing the unemployment rate as a result, as companies find automation is more efficient and timesaving, even if expensive (Popelo et al., 2021; Назарова, et al., 2024). On the other hand, there are a lot of new job opportunities that arise in technology and innovation-driven sectors, and require advanced skills and knowledge; there is a growing demand for technical expertise that balances the employment rate (Popelo et al., 2021; Назарова, et al., 2024; Schislyae-

va, Saychenko, 2022). The tension between job loss and job creation highlights a transformative period for the global workforce. While the literature points to a balance in the employment rate, the balance is fragile. The transition is not seamless: there is a clear friction where the speed of technological replacement may outpace the speed at which workers can acquire advanced skills. This creates a workforce in transition, where the macroeconomic stability of a country depends on its ability to bridge the gap between disappearing routine roles and emerging high-tech opportunities.

Monetary policies

The impact of digitalisation on monetary policy requires central banks to rethink their strategies for effective economic management, due to the changes in consumer behaviour (Fiedler et al., 2019). First, digitalisation has changed consumer preferences and behaviour, as people adapt to new technologies and find them easy to use, as well as timesaving, which is very important in the dynamic world they live in and with the intense lifestyle they have (Uribe-Linares et al., 2023). Second, the impact of digitalisation on financial intermediation leads to a shift from traditional banking systems to fintech solutions. This transformation alters how banks operate and conduct financial transactions, as well as reflecting in the monetary policy tools that rely on circulation of cash (Dhangu, 2025). As a result, the introduction of Central Bank Digital Currencies (CBDCs), which provides a new form of central bank money accessible to the public, is a critical development in the context of the digitalisation era (Mishchenko, Naumenkova, 2021; Molina, 2023). This evolution suggests that monetary policy is no longer just about controlling the money supply, but about adapting to a landscape where financial intermediation has been fundamentally digitised. As consumers move away from cash, the very mechanics of how money moves through the economy change. The rise of CBDCs is not just a technological upgrade, but a necessary reaction to ensure that monetary policy remains effective in a world where traditional banking boundaries are being blurred by fintech innovation.

The relationship between variables

The main variables affected by digitalisation in the macroeconomic context are labour market dynamics (employment rates, job types, wage levels), productivity (efficiency of labour and capital), economic growth (GDP growth rates), and income distribution (wealth disparity between different socioeconomic groups) (Arsić, 2020; Wang et al., 2024). Digitalisation has a significant influence on the various macroeconomic variables creating interdependencies (Tudose et al., 2023). Firstly, it changes employment rates and job types; automation and artificial intelligence displace traditional jobs and create new opportunities in tech-driven sectors. This shift also leads to changes in wage levels, where the highly skilled may get wage increases on demand, while low skilled jobs may experience stagnation or decline (Počepavičiūtė, Kiaušienė, 2025). Secondly, the impact of digitalisation is important to productivity, enabling better resource allocation, which is closely connected to economic growth and an increase in GDP growth rates (Arsić, 2020). Lastly, there is a complex relationship between digitalisation and income distribution, because those who have better access to digitalisation and technology, as well as high-demand skills, are disproportionately compared to those who do not have such access, leading to unequal income distribution (Perveen, Majeed, 2025). Ultimately, the synthesis of these variables reveals that the relationship between digitalisation and macroeconomics is rarely linear. The presence of a digital divide introduces the risk of divergence, where the gains of the digital era may remain concentrated in those who already have access and the skills to navigate the new landscape. This results in a two-sided macroeconomic outcome: increased national wealth paired with rising income inequality. For digitalisation to be a positive force, it has to be supported by inclusive frameworks that ensure that these variables work in harmony, rather than creating deeper social divides.

While Chapter 1 has established that digitalisation acts as a powerful macroeconomic catalyst for productivity and growth, its true value is often realised when applied to specific sectors facing urgent sustainability challenges. One such sector is tourism, where the rapid growth in the contribution to global GDP has

been secured at high environmental costs. As the digital tools discussed previously enabled better tracking and efficiency, they created the necessary infrastructure to move away from traditional linear models towards the circular economy. Chapter 2 explores how circular principles provide a transformative framework for achieving sustainability in the tourism industry.

2. A theoretical analysis of the circular economy in sustainable tourism

The tourism sector is an important and growing contributor to global GDP and employment, but it also has an increasingly negative environmental impact, such as high consumption of resources, carbon emissions and waste generation (Daga et al., 2025). The circular economy proposes a transformative approach to achieve sustainability in the tourism industry through changes in the model, from the linear 'take-make-dispose' to circular economy principles that prioritise resource efficiency, waste reduction and regeneration (Manniche et al., 2021; Moroz, Labanauskaite, 2025). Some of the key principles of the circular economy in tourism are resource efficiency, waste reduction and valorisation, longevity and reuse, as well as systemic thinking and collaboration (Renfors, 2022).

Resource efficiency

In sustainable tourism, which prioritises the circular economy, resource efficiency focuses on reducing waste and improving the statistics on the utilisation of resources, moving towards regenerative practices and sustainability. Resource efficiency involves redesigning tourism products and services for circularity and durability; they should be easily repaired, reused and recycled (Sharma et al., 2025). One of the goals of resource efficiency under the guise of circularity in sustainable tourism is to create regenerative tourism that can actively restore and improve natural and cultural capital, support local ecosystems, and preserve the heritage (Songklin, 2025). Another goal is to encourage the shared use of resources and infrastructure to reduce redundancy, environmental impact and operational costs. The achievement of goals is possible with water-saving technologies, the adoption of renewable energy, repurposing old furniture, efficient supply chain management, life cycle assessment, material flow analysis, resource consumption assessment, and the implementation of smart technologies and innovations (Eelager et al., 2025; Moroz, Labanauskaite, 2025). The shift towards resource efficiency suggests that sustainability in tourism is moving from a passive goal to an active, regenerative one. With such a focus on life cycle assessments and materials flow analysis, the industry is beginning to view resources as continuous assets rather than consumable costs. However, the reliance on smart technologies mentioned in the literature highlights a critical dependency: the success of circular resource management is linked to the digital maturity of the destination.

Waste reduction and revaluation

Waste reduction and revaluation as the key principle of the circular economy in sustainable tourism is the prevention of waste generation and transforming unavoidable waste into valuable resources through composting, upcycling and recycling (Renfors, 2022; Moroz, Labanauskaite, 2025). Some of the main initiatives in waste reduction are energy efficiency and using natural and recyclable materials. Waste reduction and revaluation strategies include the comprehensive assessment of energy, water and waste flow, and then preparing plans for improvement (Hariyani et al., 2025b). Practical examples range from repurposing cork stoppers to creating employment opportunities in waste management, contributing not only to environmental, but also to social and economic sustainability as well (Ramos et al., 2020). Waste revaluation represents a shift in the economic perception of rubbish. By transforming waste into a resource, tourism businesses can create a closed-loop system that reduces operational costs, while fostering local social development. The evidence indicates that waste management is no longer just an operational concern, but a core component of the brand's value proposition and community impact.

Longevity and reuse

The longevity and reuse principles in the circular economy are fundamental to achieving sustainable tourism, because the key focus is on keeping resources in use for as long as possible, and getting maximum value from them (Manniche et al., 2021). This shift towards longevity and reuse protects ecosystems, and offers economic benefits through cost savings, innovations, and enhanced resilience against supply chain disruptions, based on reduce-repeat-recycle principles (Khaenamkhaew, 2025). The tourism sector is now in the process of rethinking traditional products and services for a sustainable and continuously cycled design. Digital innovations are seen to accelerate these goals, through the better tracking of materials, and fostering collaboration consumption models (Vărzaru Bocean, 2024). This focus on longevity challenges the disposable nature of traditional tourism. The move towards collaborative consumption models suggests that the industry is beginning to value access over ownership. This transition not only protects natural capital, but also enhances economic resilience, as businesses become less vulnerable to the fluctuating costs of raw materials, by maintaining a circular inventory of high-quality, reusable assets.

Systemic thinking and collaboration

Systematic thinking and collaboration are important aspects for integrating the principles of the circular economy into sustainable tourism; this involves resource flows, governance, business activities, infrastructure and user practices (Sorin, Einarsson, 2020). Recognising that tourism operates within such complex ecosystems requires collaboration between stakeholders, such as tourists, businesses, local communities and policymakers (Luongo et al., 2023). Successful systematic thinking and collaboration lower operating costs, strengthen brand credibility, and stimulate sustainable finance. The principles of the circular economy in sustainable tourism move beyond reductionist viewpoints, to consider wider systemic impacts, ensuring that economic, environmental and social aspects are equally respected (Moroz, Labanauskaite, 2025). Ultimately, systemic thinking reveals that circularity is not achievable by a single business in isolation. It is a collective effort that requires a simplifying viewpoint to be replaced by a holistic understanding of environmental and social impacts. The literature suggests that the future of the industry lies in these shared-value ecosystems, where the economic health of a business is viewed as inseparable from the health of the local community and the environment.

To synthesise the core differences between the traditional macroeconomic approach to tourism and the circular approach, a summary was prepared in Table 1. The table bridges the concept from both digitalisation and circular economy sections.

Table 1. Linear versus circular tourism models

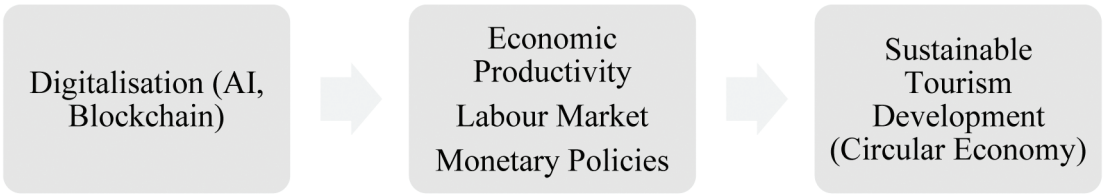
Feature	Linear tourism model (take-make-dispose)	Circular tourism model (regenerative)
Resource philosophy	Resources are consumable costs to be minimised	Resources are continuous assets to be maintained
Environmental focus	Passive ‘do no harm’ or simple waste management	Active restoration of natural and cultural capital
Product design	Disposable or short-life cycle products	Designed for durability, repair and recycling
Economic logic	Driven by volume and high turnover	Driven by value retention and resource longevity
The role of digitalisation	Used for marketing and basic automation	Used for material tracking and smart resource management
Stakeholder interaction	Fragmented, individual business goals	Shared-value ecosystems and collaboration

The contrast between the linear and circular models, as summarised in the comparison above, clarifies that the transition to a regenerative tourism sector is not a change in philosophy, but a fundamental shift in operational logic. Moving from a model of 'take-make-dispose' to one of systemic resource longevity requires a level of oversight and data transparency that traditional manual systems cannot provide. As the industry moves towards valuing access over ownership and restoration over consumption, it becomes increasingly clear that the CE remains a theoretical ideal, unless it is supported by an advanced technical infrastructure. This necessity leads directly to Chapter 3, where there is an analysis of the scientific roles of artificial intelligence and blockchain. These technologies act as the primary engines of the proposed theoretical model, providing the intelligence and transparency required to turn circular principles into measurable macroeconomic outcomes.

3. An analysis of scientific approaches

The theoretical model for the current literature review article proposes a framework to analyse the scientific approaches based on the synthesis of the trends and tendencies on the macroeconomic effect of digitalisation. The theoretical model specifically focuses on AI and blockchain, on economic productivity, the labour market, and monetary policies, all contextualized within sustainable tourism development through a circular economy lens.

Table 2. The theoretical model



Variable category	Component	Nature of influence	Mechanism of influence	Key supporting evidence
Independent	AI blockchain	Driving force (technological disruption and optimisation)	High (serves as the foundational infrastructure for data-driven circularity)	Yusuf, 2025; Rane, 2023
Mediating	Economic productivity	Positive (resource efficiency and predictive maintenance)	Significant (reduces operational leakage and maximises asset lifecycle)	Al Naqbi et al., 2024; Hariyani et al., 2025b
Mediating	Labour market	Transformative (skills shift automation)	Moderate to high (replaces routine tasks with high-value digital/sustainability monitoring roles)	Bone et al., 2025; Wang Lu, 2025
Mediating	Monetary policy	Stabilising (transparency lower transaction friction)	Moderate (reduces cost of green financing and improves traceability of circular incentives)	Thanasi-Boçe, 2025; Ogunrinde, 2025
Dependent	Sustainable tourism (circular tourism)	Outcome (systemic resilience and waste reduction)	Ultimate goal (achieved when macroeconomic variables reach a threshold of digital maturity)	Siddik et al., 2025; Mansi et al., 2025

In the proposed theoretical model, digitalisation represents the independent variables of economic productivity, labour market and monetary policies are mediating variables that represent the direct macroeconomic impact, and the development of sustainable tourism (circular economy) is a dependent variable, reflecting the ultimate contextualised outcome.

As in Table 2, the model functions as a primary macroeconomic catalyst, because it reshapes the traditional linear tourism model. The nature of the influence that artificial intelligence has is optimisation-driven. It exerts a significant influence on economic productivity, as it shifts the production frontier through predictive maintenance and real-time resource allocation. Such a mechanism reduces the waste of resources and capital effectively and increases the total factor productivity in the CE tourism framework. At the same time, the extent of the influence of mediating variables such as labour market and monetary policy shows a structural transformation. In the labour market, the influence is transformative, and based on skills. It automates routine and low-value hospitality roles, and creates a moderate to high demand for a specialised workforce capable of managing circular digital assets. From a monetary perspective, blockchain's stabilising influence provides the transparency required to lower transaction friction and facilitate sustainable finance. In this way, a secure trust economy is created, where circular incentives are tracked with high precision. Ultimately, the model demonstrates that the transition to sustainable tourism (a dependent variable) is not a direct result of technology alone, but a byproduct of how these digital drivers successfully optimise productivity, reskill the workforce, and stabilise the financial frameworks governing the tourism ecosystem.

3.1. AI and its macroeconomic impacts on circularity in the development of sustainable tourism

AI is the capability of computer systems to perform tasks and solve problems that typically require human intelligence and decision making. AI learns from the synthesis of data, and improves its performance automatically and constantly. It can be general AI or designed for specific tasks, but its purpose stays the same, to replicate human cognitive abilities, and a variety of functions, as well as to provide rational intelligent decision support (Xu et al., 2021). AI is a transformative force in the global economy that reshapes traditional economic paradigms, so it is important to explore the macroeconomic effects it has on economic productivity, labour market and monetary policy (Passi, Vorvoreanu, 2022; Yusuf, 2025).

AI's economic productivity

AI affects productivity growth positively, as it helps to decide rationally how to produce more with the same number of resources, as a result multiplying wealth and life quality of the people around (Filippucci et al., 2024). Firstly, AI benefits economic productivity through the robotic automation and machine learning of routine tasks, streamlining operations and reducing errors, leaving and developing more creative tasks for the human workforce, and higher quality for lower costs for businesses (OECD, 2025). Secondly, AI can generate new products and services, bringing new ideas to the market, increasing the competition, becoming the driver of innovation, and leading to new opportunities in the area of research and development (Russel, 2025). Thirdly, AI helps in efficient and optimised resource allocation, as it analyses patterns in consumption, production processes and supply chain dynamics, bringing lower input costs as a result (Chen et al, 2024). Moreover, AI allows companies to operate without concentrating on high investment in physical infrastructure or a corresponding increase in costs, but rather on cloud-based AI solutions that help to expand the capabilities by leveraging shared resources (Rashid, Kausik, 2024). As a result, organisations maintain a much higher level of productivity, as they respond fast to changes in demand and market conditions (Al Naqbi, Bahroun, Ahmed, 2024; Lu, 2021). This evolution suggests that AI is transitioning industry from a model of estimated efficiency to one of precise circularity, where the ability to process data becomes as economically important as the physical assets themselves. By bridging the gap between general economic theory and industry-specific application, these intelligent systems provide the necessary infrastructure to implement circular principles directly in the travel sector.

The integration of AI into the development of sustainable tourism has significant implications for economic productivity, primarily through enhanced efficiency and optimised resource allocation (Siddik et al., 2025). AI-powered analytics, for instance, can process vast datasets relating to tourist behaviour, environmental impact and operational costs, leading to more informed decision making. This capability allows tourism enterprises to predict demand more accurately, thereby reducing waste from over-provisioning, and optimising staffing levels (Zhang Deng, 2024). Furthermore, the AI-driven automation of routine tasks, such as booking management, customer service inquiries, and even certain aspects of waste sorting and energy management, frees human capital to focus on higher-value activities requiring creativity, empathy and complex problem solving (Sundari et al., 2024). This shift not only boosts individual firms' productivity, but also contributes to the overall economic output of the tourism sector by fostering innovation and improving service quality, which can attract a larger and more diverse tourist base (Sundari et al., 2024). Such reallocation of human capital suggests that AI acts as a structural catalyst, transforming the labour-intensive nature of traditional tourism into a high-value, knowledge-driven service model. Beyond simply streaming human operations, these intelligent systems provide the granular oversight necessary to manage the physical life cycle of tourism resources.

AI's contribution to the tourism sector is through its unusual ability to promote circularity by mitigating environmental externalities, which indirectly secures long-term economic viability. Also, through the careful monitoring of resources such as water, energy and materials, AI-driven systems identify inefficiencies and suggest actionable improvements. This leads to cost savings and a reduced ecological footprint (Siddik et al., 2025; Song Chen, 2025). It is visible in practice when AI algorithms optimise supply chain logistics to minimise transport emissions, or when personalised eco-friendly suggestions guide tourists and travellers to prefer choices and behaviours that are sustainable. This data-driven approach to sustainability aligns with global environmental goals, and creates new economic opportunities in sustainable tourism, strengthening the sector's resilience and competitiveness (Siddik et al., 2025; Chen et al., 2024; Song Chen, 2025). The systemic optimisation demonstrates that AI is not an additional tool for green branding, but a fundamental driver of a new economic logic, where ecological preservation and profitability are mutually reinforcing. However, the transition to such a technology-dependent circular model needs a radical reevaluation of the human workforce required to sustain it.

The AI labour market

The integration of AI into work processes creates both threats and opportunities, having a dual effect on the labour market. As AI systems increasingly automate time-consuming routine tasks that once required human intelligence, it is witnessing a significant shift in human resource requirements (Sundari et al., 2024). On one hand, it leads to job losses in many sectors; on the other hand, it brings new opportunities, demanding professionals that can manage, lead and improve AI systems (Lane Saint-Martin, 2021). According to the World Economic Forum (2020), the forecast loss of 85 million jobs by 20230 is likely to offset the emergence of 97 million new roles in technology-driven fields. This suggests a systematic restructuring, rather than a simple rise in unemployment remaining susceptible to automation, which could exert downward pressure on future wages (Lane Saint-Martin, 2021; Georgieva, 2024). Ultimately, this structural shift shows that while AI enhances productivity, it risks deepening the global digital divide if emerging economies lack the infrastructure to reskill their workforces at the same pace as advanced economies (Cramarenco, Burcă-Voicu, Dabija, 2023; Popelo et al., 2021; Назарова, et al., 2024; Schislyaeva, Saychenko, 2022). Consequently, the tourism sector has to navigate this broader macroeconomic changeability, by identifying exactly which roles can be augmented by technology and which have to remain human-centric.

The integration of AI into the development of sustainable tourism has a multifaceted impact on the labour market, balancing efficiency-driven displacement with the creation of specialised roles (Siddik et al., 2025). AI-powered tools, ranging from predictive maintenance to customer service chatbots, streamline repetitive tasks in hospitality and resource management, potentially reducing human involvement in front-desk operations and scheduling (García-Madurga, Grilló-Méndez, 2023; OECD, 2024). This shift necessitates a pro-

active focus on upskilling, moving the human workforce towards soft skills that AI cannot easily replicate. Specifically, emotional intelligence, complex problem solving and authentic cultural storytelling set new priorities for delivering personalised sustainable tourism experiences (Çolak, 2023; OECD, 2024). This evolution suggests that the value of human labour in tourism is shifting from operational execution to experience curation, where empathy and cultural nuance are the primary drivers of competitive advantage. Beyond the transformation of existing service roles, AI's capacity for circular resource management is simultaneously opening up entirely new professional frontiers.

AI's role in the circular development creates new options and elevates traditional roles to high-skilled technical positions (Siddik et al., 2025). There is an urgent demand for data scientists and ethical AI specialists to build systems that check waste and optimise resource management (Rashid, 2024). By automating routine burdens, AI allows the workforce to pivot towards strategic and creative tasks, which inherently improves service quality and depends on institutional engagement with sustainable practices (Kassa, Ketema, 2025). This shift suggests that the key macroeconomic challenge is not the loss of work, but the pace at which institutional education can adapt to the technical demands of a circular service model. However, as the labour market restructures around these new digital efficiencies, the resulting shifts in productivity begin to exert pressure on the broader financial system, requiring a new approach to monetary policy and value valuation.

AI-driven consumer insights require human expertise to design and market next-generation eco-friendly tourism products. Such a relationship, where technology serves to augment rather than replace human labour, is the foundation for just transitioning to the circular economy (Bang-Ning et al., 2025; Botta, 2024; Oladapo et al., 2024). The shift suggests the key macroeconomic challenge is not the loss of work, but the way at which institutional education can adapt to the technical demands of a circular service model. However, as the labour market restructures around these new digital efficiencies, the resulting shifts in productivity and distribution begin to exert pressure on the broader financial system.

AI monetary policies

Governments and central banks need to adjust monetary policies due to the dynamic changes and influence AI has on economics (European Central Bank, 2024). Reflecting previous technological revolutions, the traditional response for central banks has been to facilitate growth through lower interest rates over extended horizons; however, the effectiveness of this approach today remains contingent on how AI adoption reshapes inflation and market competition (Challoumis-Κωνσταντίνος Χαλλουμής, 2024). Such an environment suggests that traditional monetary tools may face diminished predictability. As AI-driven productivity gains begin to decouple economic growth from historical inflationary triggers, the tourism sector emerges as a vital sectoral laboratory for observing the new macroeconomic realities. The industry serves as a testing ground for how digital circularity stabilises prices and resource flows simultaneously.

The integration of AI into sustainable tourism creates a sophisticated interplay with monetary policy, particularly regarding its influence on circularity and resource efficiency (Siddik et al., 2025; Bang-Ning et al., 2025). By leveraging advanced analytics and predictive modelling, AI significantly sharpens the application of circular principles, reducing supply chain waste, optimising energy use in hospitality, and extending product lifecycles (Vărzaru Bocean, 2024). This heightened efficiency translates into lower operational costs, a trend that could exert downward pressure on inflation and impact the price stability targets managed by central banks (Gailhoffer et al., 2021). Furthermore, as AI-powered platforms refine carbon pricing and incentivise sustainable behaviour, they catalyse broader economic transitions that monetary authorities must account for when managing liquidity or adjusting interest rates (Bang-Ning et al., 2025; Bibri Huang, 2025; Zhou, 2025). It seems that AI turns environmental externalities into measurable data, and monetary policy may increasingly need to move beyond traditional prices to address the structural shifts of the decarbonising economy. In this way, these shifts in operational efficiency and sustainability data directly reshape the broader landscape of national productivity and investment.

From a monetary policy perspective, the macroeconomic effects of AI-driven circularity in sustainable tourism reach far into productivity growth and shifting investment patterns (Siddik, 2025). By automating routine processes, AI boosts labour productivity in the sector, which may foster higher overall growth rates. This enhanced efficiency, combined with the lower resource intensity inherent in circular models, helps to create a more reliable economic environment (Filippucci et al., 2024). Accordingly, central banks have to evaluate these structural shifts that influence the natural rate of interest and the potency of traditional policy instruments (Hartmann, Maver, 2025). Furthermore, the substantial capital required for AI adoption and circular transitions could redirect global capital flows and credit demand, requiring monetary authorities to safeguard financial stability while supporting a policy environment that encourages both innovation and sustainability (Siddik et al., 2025; OECD, 2025). This suggests that the green transition is becoming a digital transition as well, where the cost of capital is increasingly tied to aligning incentives, and the focus shifts from purely economic management to the operational challenges of handling data.

The integration of AI into sustainable tourism suggests that circularity is increasingly evolving into a data-management challenge. Current research highlights the fact that AI's primary value is in its power to transform unstructured environmental data into rational, strategic actions. However, this shift presents a technical paradox: while algorithms optimise resource use, they risk devaluing human roles that do not pivot towards high-level problem-solving. Ultimately, macroeconomic success in this field relies on a coevolutionary model, one where technology manages resource logistics, while human labour focuses on the creative and empathetic nuances of the guest experience. In summary, the rapid expansion of AI is fundamentally altering economic productivity across sectors, triggering a dual wave of labour market challenges and opportunities that demand an agile response from central banks to develop new, digitally driven monetary frameworks.

3.2. Blockchain and its macroeconomic impact on circularity in the development of sustainable tourism

The decentralised digital ledger technology is blockchain. It records securely (each record is a 'block' that contains transaction data) transactions across a network of computers. The blockchain structure is done in such a way that when data is recorded, it cannot be changed without the network participants, which provides security and transparency. Blockchain was developed to secure bitcoin in 2009, but nowadays it is integrated not only into cryptocurrencies but also into supply chain management, healthcare and finance systems. Blockchain is very useful, reduces costs, and guarantees efficiency through the automation of systems and processes (Habib et al., 2022).

Blockchain economic productivity

Blockchain affects economic productivity from different perspectives: the speed, cost and efficiency of transactions, driving innovation, transparency and decreasing fraud and corruption, and the improvement of supply chain management (Hariyani et al., 2025). Firstly, blockchain impacts economic productivity through transactions. Traditional transaction methods involve intermediaries, but blockchain gives an opportunity for peer-to-peer transactions, where transactions are recorded automatically on a decentralised digital ledger. This method of transactions reduces transition costs, as transitions occur directly between parties, without international banking fees; as a result, blockchain transactions become especially useful when talking about cross-border payments that in traditional methods are associated with high fees, processing charges and losses on currency conversion (Thanasi-Boçe Hoxha, 2025). Advantages also come from the speed of the transaction process, as blockchain allows it in minutes or seconds, while traditional banking systems need several days for it: quicker access to money leads to better economic productivity (Ogunrinde et al., 2025). Secondly, due to the transparent work of blockchain, it can positively affect the reduction of fraud and corruption.

When there is an automatised and digitalised transaction history, it is difficult to manipulate data for individual gain. Transparent transactions increase stakeholders' loyalty, and positively affect investment decisions (Rane et al., 2023). Thirdly, blockchain improves supply chain management, as it provides the

opportunity for the real-time tracking of all processes: from production to the delivery of goods. Such visibility leads to optimised operations and identifying inefficiencies on time, before external quality failures. Improved blockchain supply management reduces waste and increase customer satisfaction (Hariyani et al., 2025; Habib et al., 2022; Kurpjuweit, Schmidt, Klöckner, Wagner, 2021; Kwok Treiblmaier, 2024). Fourthly, blockchain fosters innovation, as it encourages different sectors to implement innovation due to its efficiency and usefulness (Ogunrinde et al., 2025). To conclude, blockchain has a multifaceted and positive effect on economic productivity.

The integration of blockchain into sustainable tourism represents a profound macroeconomic shift, positioning the technology acting as a vital engine for boosting economic productivity (Upadhyay et al., 2021). By leveraging algorithms to optimise resource allocation, forecast demand shifts and manage dynamic pricing, blockchain particularly minimises food waste (Oluwafemi et al., 2021; Wolfs, 2025). This technology amplifies macroeconomic stability, by offering a transparent, immutable and secure ledger. Such a system does more than record data; it builds the trust necessary to verify circular practices and bolster overall efficiency (Thanasi-Boçe, Hoxha, 2025).

In the sustainable tourism sector, blockchain provides a reliable way to trace the origin and entire life cycle of producers, ensuring that they follow strictly circular principles, such as fair trade, local sourcing and waste reduction. This level of transparency creates a powerful dual effect: it empowers consumers to make informed choices, while providing businesses with a clear incentive to go green, as their sustainability efforts become both verifiable and auditable (Thanasi-Boçe, Hoxha, 2025; Baydeniz, 2024). Furthermore, the use of smart contracts can automate complex payments and agreements, slashing transaction costs, and streamlining operations within these circular tourism economies, which can attract new investment and secure long-term economic growth (Oluwafemi et al., 2021; Wolfs, 2025). This shift towards automated verification suggests that blockchain fundamentally lowers market entry barriers for smaller, ethical enterprises, by replacing traditional brand reputation with transparent, auditable proof. However, the macroeconomic impact remains contingent on cross-border protocol standardisation, as fragmented digital ledgers could accidentally create new silos that stall systemic collaboration.

Blockchain labour market

Blockchain technology affects market labour from the perspective of employment dynamics, skills requirements, job displacement and the creation of new job roles (Počepavičiūtė, Kiaušienė, 2025). Like other types of technology, the automation of processes and digitalisation displace some existing jobs, but increase the demand for professionals who are skilled in blockchain development, programming and cybersecurity, reminding us that after the successes of the service economy comes the knowledge economy era. Among new job roles are blockchain developers, smart contract auditors, blockchain consultants and data analysts (European Parliament, 2021). Talking about the shift in skills demand, technical skills and soft skills are in high demand. Also, additional training and upskilling are already required for different types of employees in traditional roles, as in the current dynamic world, even to stay at the same place we must run as fast as possible. Colleges, schools and universities around the world have already responded to this shift, and developed a lot of study programmes and courses connected to blockchain technologies and the blockchain-driven economy (Bone et al., 2025). To sum up, although a lot of job roles disappear, new opportunities arise. Talking about low-skilled workers, they may face a higher risk of being replaced by automated systems powered by blockchain technologies (Li Lee, 2025; Popelo et al., 2021; Назарова, et al., 2024; Schislyaeva, Saychenko, 2022).

The intersection of AI and blockchain in sustainable tourism marks a significant shift in global macroeconomics, particularly where circularity and labour dynamics are concerned. This technological pairing does more than just update old systems; it actively bolsters resource efficiency and curbs environmental externalities, ultimately providing a much-needed safety net for regions whose economies rely heavily on tourism (Upadhyay et al., 2021; Bang-Ning et al., 2025; Bashynska Prokopenko, 2024). This evolution implies that the financial stability of a destination is becoming inseparable from its digital maturity, as the capacity to

automate circular processes now directly underpins long-term fiscal health. Because these technologies operate in tandem, their combined effect is already beginning to rewrite the professional requirements of the tourism workforce.

The relationship between AI, blockchain and the labour market is far from simple. When these tools work together, they create a level of accountability, through immutable records of resource flows and supply chain origins, that was previously impossible, giving businesses a genuine reason to invest in verifiable sustainability (Omar et al., 2024; Thanasi-Boçe Hoxha, 2025). But this transition is a double-edged sword; while it rewards transparency, it also fuels legitimate anxiety regarding job displacement and the widening skills gap (Thanasi-Boçe Hoxha, 2025; Baydeniz, 2024). We are seeing a shift where routine tasks are phased out by automation, only to be replaced by high-level roles in data forensics and blockchain oversight. For this shift to be a 'just transition', macroeconomic policy must step in to bridge the gap through targeted education, ensuring that the workforce is equipped for a circular, tech-driven future (Omar et al., 2024; Thanasi-Boçe Hoxha, 2025). Ultimately, the 'just transition' to this circular economy hinges on whether governments can treat human capital as a dynamic asset that evolves alongside, rather than competes with, algorithmic systems.

Blockchain monetary policies

The integration of blockchain into the financial sector caused a fundamental rethinking of monetary policy, focusing on solutions to stabilise markets and manage the money supply (Fiedler et al., 2019). Traditional systems have always relied on the command of centralised institutions; however, the rise of decentralised finance allows value to move through frameworks that exist (Javaid et al., 2022). This creates a challenge for stability, as digital assets often fail to respond to the standard interest rate or liquidity adjustments used by central banks. In response, policymakers have to shift from a stance of simple restriction to one of active adaptation, finding ways to mitigate systemic change without stifling the efficiencies blockchain provides (Slatvinska et al., 2022). Ultimately, this transition suggests that the future of monetary authority may rest less on total control and more on the ability to oversee a hybrid landscape of centralised and decentralised value. However, the true power of this financial evolution is most visible in how it converges with AI to solve the data-management crises inherent in sustainable tourism.

In the tourism sector, the synergy between AI, blockchain and monetary policy is rapidly becoming the primary engine for circular growth (Bang-Ning et al., 2025; Oncioiu et al., 2025; Tileagă, 2024; Bashynska, Prokopenko, 2024). By acting as a transparent, immutable ledger, blockchain allows for the precise tracking of a resource's entire journey, from initial sourcing to final disposal, ensuring that sustainability claims are rooted in verifiable fact rather than marketing rhetoric. When this trust layer is paired with AI's capacity to parse massive datasets, it generates the consumer and investor confidence required to drive serious capital into circular tourism models (Thanasi-Boçe, Hoxha, 2025). Furthermore, AI can scan these blockchain records to pinpoint supply chain waste and suggest smarter methods for resource reuse, effectively shrinking the industry's ecological footprint (Bang-Ning et al., 2025; Tileagă, 2024; Mansi et al., 2025). This suggests that green credentials are maturing from vague branding promises into verifiable financial assets, fundamentally changing the way we measure risk in sustainable investment.

The analysis of AI and blockchain in the preceding chapter clarifies that these are not merely peripheral tools, but the fundamental drivers required to power a circular tourism model. However, the integration of these technologies does not occur in a vacuum. As the theoretical model has demonstrated, the shift towards smart circularity needs a parallel evolution in labour market skills, productivity measurements and monetary frameworks. To wrap up the inquiry, the following conclusion synthesises the study's findings to assess the overall macroeconomic viability of a digitally driven, circular tourism sector.

Conclusions

The synthesis of digitalisation and the circular economy in the tourism sector represents more than a technical upgrade; it signals a profound structural transformation of modern macroeconomic dynamics. This study demonstrates that the transition from a 'take-make-dispose' model to a regenerative framework is only a workable solution when it is supported by a parallel technological architecture. In this paradigm, artificial intelligence serves as the engine of resource optimisation, and blockchain functions as the infrastructure for institutional trust. The research proposes a way to resolve the scientific tension between industrial growth and ecological preservation by synthesising these elements, suggesting that economic stability in the digital age is fundamentally predicated on the intelligent management of resource loops.

Redefining economic productivity in this context requires moving beyond simple labour-capital models. Today, economic efficiency is increasingly a product of digital multipliers, such as AI-driven systems and blockchain, that lower the marginal cost of sustainability by automating waste reduction and optimising complex supply loops. However, these gains are not guaranteed, and depend heavily on the digital maturity and openness of specific nations and destinations. The findings indicate a growing risk of digital stratification, because the macroeconomic resilience of a destination depends heavily on its technological development and its openness to algorithmic governance.

Regarding the labour market, the impact reveals a structural realignment rather than a simple job displacement. While automation threatens routine roles, the transition to circular tourism creates a specific demand for circular human capital, high-value skills in tech-management and sustainable service delivery. Macroeconomic stability during this transition process is very dependent on how effectively national policies can bridge the gap between disappearing traditional roles and the emerging opportunities in the innovation-driven sector.

Furthermore, the stability of monetary frameworks is being challenged by the rise of decentralised finance and digital transactions. For circular tourism to move from theory to practice, financial systems must evolve to support the transparency provided by blockchain. Consequently, monetary policy may need to incentivise green digital investment, ensuring that the financial architecture of the digital age is fundamentally aligned with environmental preservation.

Taken together, the findings suggest that the synergy between AI and blockchain acts as the primary catalyst for circularity. AI provides the predictive intelligence necessary for waste reduction and resource efficiency, while blockchain establishes the trust economy required for ethical resource tracking and transparency. Ultimately, the interrelatedness between these digital technologies and macroeconomic variables offers a long-term potential for sustainable tourism development. The realisation of this long-term potential is, however, contingent upon the establishment of inclusive governance frameworks. Such measures are important to prevent a digital divide and ensure that the transition to a circular economy benefits all socioeconomic groups equitably.

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DIRBTINIO INTELEKTO (DI) IR BLOKŲ GRANDINĖS MAKROEKONOMIKA TVARIOJO TURIZMO ŽIEDIŠKUMO ASPEKTU: SISTEMINĖ TEORINĖ APŽVALGA

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Santrauka

Skaitmenizacijos ir žiedinės ekonomikos sintezė turizmo sektoriuje pristato ne tik techninį atnaujinimą, ji rodo esminę šiuolaikinės makroekonominės dinamikos struktūrinę transformaciją. Šis tyrimas atskleidžia, kad perėjimas nuo linijinio „imk–gamink–išmesk“ modelio prie regeneracinės sistemos yra gyvybingas sprendimas tik tuo atveju, jei jis remiasi lygiagrečia technologine architektūra. Šioje paradigmoje dirbtinis intelektas (DI) veikia kaip išteklių optimizavimo variklis, o blokų grandinės technologija (angl. *blockchain*) atlieka institucinio pasitikėjimo infrastruktūros funkciją. Sintezuojant šiuos elementus, atlikus tyrimą siūlomas būdas, kaip išspręsti mokslinę įtampą tarp pramonės augimo ir ekologinės pusiausvyros išsaugojimo, teigiant, kad ekonominis stabilumas skaitmeniniame amžiuje iš esmės grindžiamas pažangiu išteklių ciklo valdymu.

Ekonominio produktyvumo pervertinimas šiame kontekste verčia atsisakyti elementarių darbo ir kapitalo modelių. Šiandien ekonominis efektyvumas vis dažniau tampa „skaitmeninių daugiklių“ (tokių kaip DI sistemos ir blokų grandinė) produktu, kurie mažina marginalines tvarumo sąnaudas automatizuodami atliekų mažinimą ir optimizuodami sudėtingas tiekimo grandines. Visgi ši nauda negarantuota, ji tiesiogiai priklauso nuo konkrečių valstybių bei vietovių skaitmeninės brandos ir atvirumo. Tyrimo rezultatai rodo augančią skaitmeninės stratifikacijos riziką, nes destinacijos makroekonominis atsparumas labai priklauso nuo jos technologinio išsivystymo ir pasirengimo algoritminiam valdymui.

Darbo rinkos požiūriu poveikis rodo struktūrinį persitvarkymą, o ne tiesioginį darbo vietų praradimą. Nors automatizacija kelia grėsmę kasdieniams vaidmenims, perėjimas prie žiedinio turizmo formuoja specifinę „žiedinio žmogiškojo kapitalo“ paklausą – aukštos vertės technologijų valdymo ir tvaraus paslaugų teikimo įgūdžius. Makroekonominis stabilumas šiuo pereinamuoju laikotarpiu ypač priklauso nuo to, kaip efektyviai nacionalinė politika sugebės užpildyti atotrūkį tarp nykstančių tradicinių profesijų ir naujai atsiveriančių galimybių inovacijų valdomame sektoriuje.

Be to, iššūkių monetarinių sistemų stabilumui kelia decentralizuotų finansų ir skaitmeninių operacijų plėtra. Kad žiedinis turizmas iš teorinio modelio taptų praktine realybe, finansų sistemos turi evoliucionuoti, integruodamos blokų grandinės teikiamą skaidrumą. Atitinkamai pinigų politika gali būti nukreipta skatinti žaliąsias skaitmenines investicijas, užtikrinant, kad skaitmeninio amžiaus finansinė architektūra iš esmės derėtų su aplinkos išsaugojimo tikslais.

Apibendrinant tyrimo įžvalgas galima teigti, kad DI ir blokų grandinės sinergija veikia kaip pirminis žiediškumo katalizatorius. Šios technologijos ne tik automatizuoja procesus, bet ir suteikia nuspėjamąją analitiką bei etinį skaidrumą, būtiną atskirti turizmo augimą nuo ekologinės degradacijos. Tačiau šio ilgalaikio potencialo realizavimas tiesiogiai priklauso nuo įtraukiojo valdymo sistemų kūrimo. Tokios priemonės yra būtinos siekiant išvengti skaitmeninės atskirties ir užtikrinti, kad perėjimas prie žiedinės ekonomikos teiktų teisingą naudą visoms socioekonominėms grupėms.

RAKTINIAI ŽODŽIAI: *skaitmenizacija, dirbtinis intelektas, blokų grandinė, žiediškumas, tvariojo turizmo plėtra.*

JEL KLASIFIKACIJA: J24, E52, Z32, Q01