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Article

Investigation of the relationship between cryptocurrency acceptance points and tourism in EU regions

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Abstract: This study examined the role of cryptocurrencies in tourism and their acceptance across EU regions, with particular attention to the digital transformation precipitated by the COVID-19 pandemic. The analysis focuses on the relationship between cryptocurrency acceptance points and the intensity of tourism, highlighting that the acceptance of cryptocurrencies is significantly correlated with tourism services. The literature review highlighted that Web 3.0, especially blockchain technology and decentralized applications, opens new possibilities in tourism, including secure and transparent transactions, and more personalized travel experiences. The research investigated cryptocurrency acceptance points and the intensity of tourism within the EU. The study illuminates that the acceptance of cryptocurrencies significantly correlates with tourism services. The data and methodology demonstrated the analysis methods for examining the relationship between cryptocurrency acceptance points and tourism intensity, including the use of clustering neural networks and Eurostat data utilization. The results showed a positive correlation between the number of cryptocurrency acceptance points and tourism intensity in the EU, affirming the research hypothesis. According to the regression analysis results, each additional cryptocurrency acceptance point is associated with an increase in tourism intensity. The significance of the research lies in highlighting the growing role of digital payment solutions, especially cryptocurrencies, in tourism, and their potential impacts on the EU economy. The analysis supports that the intertwining of tourism and digital financial technologies opens new opportunities in the sector for both providers and tourists.

Keywords: cryptocurrency-tourism; digital transformation; tourism services; payment innovations; blockchain technology

1. Introduction

As I have dealt with in my several previous articles, the genesis of the internet, the initial phases of the web, then the definitions and toolsets of web 2.0, and their intertwinement with tourism. To this end, I created the following **Figure 1**, which summarizes all web 2.0 resources employed in tourism. The characteristic of Web 2.0 is that the evolution of blogs and other social media platforms has facilitated interaction among all users, with online travel communities and social networks revolutionizing communication (Kupi and Bakó, 2024).

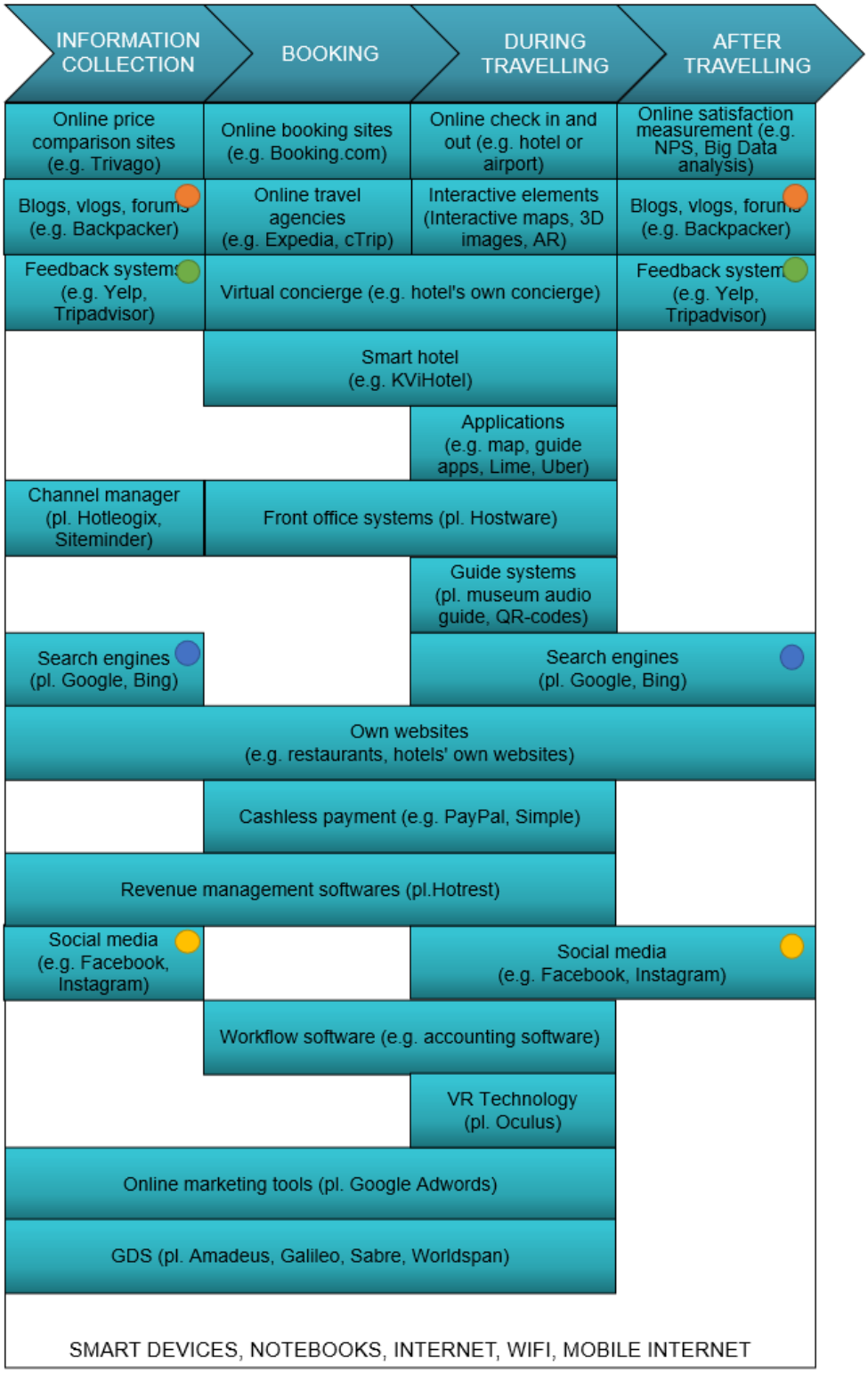

Figure 1. The web 2.0 toolset in tourism (Kupi and Bakó, 2024).

Building upon this concept, the present article shifts the focus to web 3.0, discussing its legitimacy in tourism, with a particular emphasis in this research on blockchains and cryptocurrencies, as one significant aspect of digital tourism is cashless payment. In this context, the correlations between cryptocurrency acceptance points and tourism within the EU are examined, employing cluster neural network

analysis to ensure that the tourism-related correlations and characteristics are identified with the highest possible accuracy.

The justification for this research lies in the continuous development of tourism and digitalization. The COVID-19 pandemic had a substantial impact on tourism, and this is especially true for the change in payment habits, where cashless transactions came to the fore. During the pandemic, both tourists and service providers aimed to minimize physical contact, which accelerated the adoption of digital payment solutions. Cashless payment methods, such as credit cards and mobile payment platforms, not only served to reduce the risk of infection but also offered convenience and efficiency benefits for both tourists and businesses.

The study by Rahmawati et al. (2023) examined the significance of financial and digital literacy in the performance of micro-, small-, and medium-sized enterprises and highlighted that the adoption of digital transformation significantly influences entrepreneurs' performance (Rahmawati et al., 2023). Another study, according to Upadhyaya (2023)–examining the COVID-19 accelerated impact on digital payment services–shed light on how the pandemic brought significant changes to digital payment services, with a marked increase in the demand for digital payments, which was also observable in tourism (Upadhyaya, 2023).

The COVID-19 pandemic and the proliferation of cryptocurrency acceptance points are correlated phenomena that had a significant impact on the global economy and financial markets. During the pandemic, interest in cryptocurrencies greatly increased due to the declining trust in traditional financial systems and the growing demand for digital transactions (Tarchella et al., 2023).

In their study, Chowdhury and Damianov (2023) demonstrated that cryptocurrencies served not only as investment instruments but also functioned as an alternative payment method during the era of digital transactions and social distancing. Cryptocurrencies have enabled rapid transactions and helped to reduce social contact and cash use (Chowdhury and Damianov, 2023).

The spread of cryptocurrencies among tourists has also become more efficient in recent years. In tourism, the use of cryptocurrencies has several advantages, such as simplifying cross-border payments, reducing transaction costs and currency exchange costs, and providing payment security. Cryptocurrencies offer decentralisation and anonymity, which can be attractive to tourists looking for both convenient and secure payment options (Calderon-Monge and Ribeiro-Soriano, 2023).

This research aims to uncover the correlations between cryptocurrency acceptance points and the intensity of tourism within the European Union. Furthermore, it seeks to understand the impact these correlations between cryptocurrency acceptance points and tourism intensity have on the tourism observed in the regions of the European Union, with a particular focus on the digital transformation accelerated by the COVID-19 pandemic, the proliferation of digitalization, and changing demand dynamics. The justification for this study is rooted in the ongoing development of tourism and digitalization. Based on a preliminary literature review, which underscores the novel opportunities in tourism presented by blockchain technology and decentralized applications—such as secure and transparent transactions, alongside more personalized travel experiences—the research is directed towards examining how the quantity of cryptocurrency acceptance

points correlates with tourism density in the EU, aiming to provide a comprehensive snapshot of the current state of these two factors.

However, it's prudent to explore related research through a literature review to familiarize ourselves with Q1: what benefits the application of cryptocurrencies might bring to tourism and the general attitude towards cryptocurrencies in the EU. To investigate the research objective, a multi-step methodology was implemented, combining data collection, data analysis, statistical modeling, and the execution of robustness tests to yield reliable and pertinent results. The relationship between the number of cryptocurrency acceptance points and the density of tourism in various EU regions is examined through the analysis of data sourced from the Eurostat and CoinMap databases. The essence of our methodology enables us to gain an in-depth understanding of the role cryptocurrencies play in tourism and their economic impacts. The precision of the statistical models used and the execution of robustness tests underpin the reliability and validity of our research. Not only do the research findings offer new insights into the relationship between cryptocurrencies and tourism, but they also provide practical recommendations for stakeholders in the tourism sector regarding the integration of digital payment solutions, especially cryptocurrencies. The research scrutinizes two hypotheses, underpinned by a linear regression analysis, K-means clustering, and Principal Component Analysis (PCA). The linear regression analysis determined that each additional cryptocurrency acceptance point is significantly and positively related to tourism intensity. The estimated 'Intercept' value was 1,986,037.1, with the parameter value for the number of cryptocurrency acceptance points being 11,336.568, both significant at *p*-values less than 0.001. This indicates that our model can reliably predict tourism intensity based on the number of acceptance points. To ensure the robustness of the research, various tests were conducted, including outlier analysis, comparison of different models, and clustering of cryptocurrency acceptance point categories. The application of K-means clustering and Principal Component Analysis (PCA) corroborated the correlations within the data, while the utilization of the Self-Organizing Map (SOM) provided more detailed insights into the data structures. These tests confirmed the robustness of our methodology and the trustworthiness of our research findings.

2. Literature review

The differences between Web 2.0 and Web 3.0 show significant changes in the evolution of the Web, the most striking aspects of which are the duality of user interaction and data management. Web 2.0 is often described as the "social" or "interactive" Internet, where users can generate and share content. By contrast, the "intelligent" (or semantic) Web 3.0 includes artificial intelligence, machine learning, decentralised data management, and blockchain technology (and associated cryptocurrencies) (Riaz et al., 2022). The era of Web 2.0 was characterised by the dominance of user-generated content and social media platforms through its tools such as blogs, informative sites and social media. This has enabled users to engage with each other more interactively (Onete et al., 2017).

In contrast, the paradigm-shifting tools of Web 3.0 focus on decentralised networks and user data. Using blockchain technology (and the specific platform for

decentralised applications), users now own and manage their data directly, reducing the influence of centralised actors and increasing data security (Silva, 2022). Web 3.0 also embraces the concept of the semantic web, which makes the content of websites accessible and understandable to machines, enabling the application of machine learning and artificial intelligence to automated data analysis and, more importantly for tourism, to maximise personalised user experiences.

A specific element of Web 3.0 is the decentralisation of content generation and social networks, opening up new opportunities for digital content creators and online communities (Rahmawati et al., 2023). The use of decentralized networks and blockchain technology enables users to partake in the revenues generated from the content they create without the need for intermediaries. This is inconceivable on the centralized platforms of Web 2.0, where the platform owners have complete control over the users' data and the revenue it generates.

In the context of tourism within the consumer-oriented world of Web 3.0, tourists (digital tourists) are at the forefront, utilizing this technological framework to gain deeper and more personalized information about destinations, attractions, and sights. Moreover, it allows them to make the travel experience much more interactive.

Furthermore, blockchain technology facilitates tourists to conduct more transparent and secure transactions during the booking of tourism services and accommodations (Önder and Treiblmaier, 2018).

The transition from Web 2.0 to Web 3.0 is an evolutionary process that facilitated the emergence of Web 2.0 from Web 1.0. However, this time the change encompasses not just technological advancements, but also the dissolution of centralized actors, alterations in user interactions, and a noticeable shift in the interpretation of internet content. In tourism, this shift could be particularly significant as tourists have already been deeply involved through their digital devices in organizing tourism activities. Now, they are increasingly relying on digital tools for making travel-related decisions, planning their journeys, and sharing their tourism experiences.

2.1. Blockchain technology

The array of technologies that define Web 3.0 composes a sophisticated and diverse ecosystem. At its core is the move towards decentralization and the enhanced interpretation of data through semantics, supplemented by advanced developments in artificial intelligence and machine learning, as well as the pivotal blockchain technology. This includes the adoption of smart contracts and the concept of tokenization. Together, these elements contribute to forming a network that facilitates the secure and decentralized automation of user-centric actions, engagements, and financial exchanges, all underpinned by community-driven validation protocols (Riaz et al., 2022).

Blockchain technology represents an innovative approach to data organization that ensures secure, transparent, and immutable recording and exchange of information. Fundamentally, blockchain is a public, distributed ledger that records transactions in "blocks," which are linked together using cryptographic methods, thus ensuring the integrity and immutability of the data (Guo and Yu, 2022).

The most well-known application of blockchain technology is Bitcoin (and other

cryptocurrencies), although its uses go far beyond that. Blockchains are used, for example, in supply chains to track products, to execute smart contracts, for identity management, in voting systems, and in many other areas (Andoni et al., 2019).

One of the key features of blockchain is that it's decentralized. This means there is no central location where data is stored or where transactions are processed. Instead, every participant in the network maintaining the blockchain (also known as a "node") has a copy of the ledger, and each transaction must be validated by the majority of the network before it is added. This consensus-based approach enhances the security of the system and makes it resistant to falsification and service interruptions (Zheng et al., 2017).

Security is therefore a key element of blockchain due to the use of cryptography. Each block contains a cryptographic "hash," which is a unique digital code that links the previous block's hash with the transaction data. If any block's data is altered, the hash changes, thereby making the manipulation evident (Guo and Yu, 2022).

Another important application area of blockchain technology is smart contracts. These are programs that automatically execute the terms of a contract when specified criteria are met, thus eliminating the need for third parties and reducing the risk of fraud (Saberi et al., 2019).

The further development of blockchain technology includes addressing scalability and privacy issues, as well as developing new types of consensus algorithms that allow for higher transaction speeds and energy efficiency (Andoni et al., 2019).

Thus, blockchain technology is a versatile and powerful tool whose applications culminate in cryptocurrencies.

Cryptocurrencies represent a form of digital currency that rely on cryptographic protocols to maintain the security of transactions, to create new units, and to verify transactions. Cryptocurrencies typically rely on decentralized systems (Sebastião and Godinho, 2021).

The cryptocurrency market is rapidly evolving, and alongside Bitcoin, many other currencies have emerged, such as Ethereum, Ripple, and Litecoin. These currencies are based on various technologies and algorithms, and have different features, such as transaction speed, security, and the degree of decentralization. One of the newest developments in cryptocurrencies are so-called non-fungible tokens (NFTs), which represent ownership rights to unique digital assets and are recorded by smart contracts on the blockchain (Dowling, 2022).

The transformation of the financial structure surrounding cryptocurrencies has a significant impact on the global financial system. Fintech innovations, such as cryptocurrencies, create new challenges and opportunities for traditional financial institutions and promote the development of central bank-issued digital currencies (CBDCs) (Allen et al., 2022).

2.2. Cryptocurrencies in tourism

The application of cryptocurrencies in the tourism industry opens up new possibilities for payment methods and transactions, potentially enhancing the efficiency and competitiveness of the sector.

Currently, the role of cryptocurrencies in tourism is becoming increasingly prominent, especially in terms of simplifying payment methods and transactions. Examining the challenges associated with their use in tourism, Zrnić et al. (2022) found that there is growing interest among tourism market participants in cryptocurrencies, with more and more willing to accept them in business and travel transactions. Research suggests that the use of cryptocurrencies can facilitate a better understanding of the operation of digital currencies in tourism and overcoming the challenges associated with their use (Zrnić et al., 2022).

Investigating the immediate payment function of cryptocurrencies in tourism, Laptevaitė et al. (2022) discuss the risks, opportunities, and solutions associated with their use in the industry. The study highlights that cryptocurrencies enable fast and efficient transactions, which can be particularly beneficial in the field of tourism, where rapid and straightforward payment methods are crucial (Laptevaitė et al., 2022).

Looking into their application in health tourism, Çapar (2020) concluded that the use of cryptocurrencies could significantly contribute to minimizing risks, improving accessibility and security, and reducing concerns related to civil litigation procedures. This type of transaction can be advantageous for patients traveling to different countries for medical care, who need secure and efficient payment solutions (Çapar, 2021). Investigating the effects of the volatility of cryptocurrencies on tourism, Kanoujiya et al. (2023) determined that the volatility of cryptocurrencies correlates with the performance of the tourism sector. The research indicates that fluctuations in the exchange rates of cryptocurrencies can affect the arrival of foreign tourists and the foreign exchange earnings from tourism (Kanoujiya et al., 2023). Examining the application of cryptocurrencies in the tourism value chain, Thees et al. (2020) concluded that the application of blockchain technology could transform the structure of the tourism sector and simplify time-consuming background processes, thus providing added value to travelers (Thees et al., 2020).

Several examples and studies have emerged in recent years regarding the specific use of cryptocurrencies in tourism. One such example pertains to Moldova, where the application of blockchain technology was examined to promote tourism, particularly health tourism (Pilkington, 2017). Although Moldova is still relatively unknown in this area, the study suggests that the application of blockchain technology could provide new momentum. Another example is related to Australian cities, where the introduction of cryptocurrencies was studied as a means to invigorate regional tourism (Chen and Tham, 2023). The research identified three main factors influencing merchants' acceptance of cryptocurrencies: the novelty effect, low barriers to entry, and the lack of direct costs during transactions. Another study examining the application of cryptocurrencies in tourism discusses the potential benefits identified within the tourism value chain (Thees et al., 2020). According to researchers, blockchain technology can transform the structure of tourism and simplify time-consuming background processes, thereby providing additional value to travelers.

2.3. The cryptocurrencies and the EU

The European Union (EU) is increasingly moving towards transparency, financial stability, and consumer protection in the regulation of cryptocurrencies,

while striving to facilitate technological innovation and the development of the digital economy.

The relationship between cryptocurrencies and the EU is a complex and dynamically evolving area that raises numerous legal, economic, and regulatory questions. In the EU, efforts to regulate cryptocurrencies are focused on preventing money laundering and the financing of terrorism, as well as protecting consumers and investors (Panfilova, 2020). In the European Union, a key component of the regulatory framework for cryptocurrencies is encapsulated in Directive 2018/843, often called the 5th Anti-Money Laundering Directive. This regulation broadens the scope of anti-money laundering measures to encompass cryptocurrencies. It compels entities providing cryptocurrency services to conduct essential identity verification processes for their clients and to flag any transactions that raise suspicions of illicit activities. Despite this directive, consistency in the legal recognition and treatment of cryptocurrencies across EU member states has not been achieved. There is a diversity in how the legal provisions of the directive are applied, with some nations enacting supplemental oversight mechanisms that exceed the requirements of the directive. (Panfilova, 2020).

Additional regulatory measures at the EU level for overseeing cryptocurrencies incorporate the MiCA regulation, which stands for Markets in Crypto-Assets. This regulation is designed to oversee the crypto-asset market sphere, addressing the issuance and circulation of cryptocurrencies, as well as the governance of cryptocurrency service providers' operations. One of the biggest challenges for cryptocurrency regulation within the EU is the rapid development of technology and the diversity of crypto-assets. Regulators must find a balance between supporting market innovation and protecting consumers, while also being mindful of the risks of money laundering and the financing of terrorism (Laucius, 2023).

The use of cryptocurrencies in tourism within the European Union is a dynamically developing area that offers numerous opportunities for diversifying payment methods and improving customer experience. When examining the aspect of tourism in relation to cryptocurrencies and the European Union (EU), several factors need to be considered. The legitimacy of cryptocurrencies in EU tourism can primarily be examined from the perspective of diversifying payment methods and simplifying cross-border transactions. In terms of their intensity of use in tourism, reports indicate that digital payment solutions, such as cryptocurrencies, are gaining increasing ground (Sovani, 2022).

In the EU, tourism is a significant economic sector that handled nearly half of global tourism before the COVID-19 pandemic. However, the pandemic caused a significant downturn, in response to which interest in digital solutions, including cryptocurrencies, has increased among tourists. As mentioned earlier, the use of cryptocurrencies enables fast and efficient payments, reducing transaction costs and increasing financial inclusivity, which is particularly beneficial for international tourists (Melnychenko et al., 2021).

The strength of cryptocurrencies lies in their decentralization, so they are not dependent on any single institution or state, which can be advantageous during touristic activities between different countries within the EU (Fornari and Allis, 2022). Within the EU, the intensity of the use of cryptocurrencies in tourism is made possible

in many places due to innovative businesses and tourism service providers (Cvijanović and Pantić, 2021).

2.4. Tourism and innovation

The tourism industry is at the forefront of innovation and technological development, often setting trends across various domains. According to Pantano and Stylidis (2021), innovation in tourism is not only focused on improving services but is also linked to an increase in patenting activities. The application of innovative technologies in tourism opens up new possibilities for tourists and aids in enhancing the industry's competitiveness (Pantano and Stylidis, 2021). Tailored services and products are becoming increasingly important in tourism, as Gkoulgkoutsika et al. (2022) have noted. The development of personalized experiences and tourist products in the industry requires targeted application of technological innovations, which cater to consumer needs and trends (Gkoulgkoutsika et al., 2022). Zheng (2023) suggests that innovation in tourism marketing is related to the evolution of social media, where the use of new communication methods and technologies is indispensable for enhancing the effectiveness of tourism marketing. Social media offers new opportunities for tourism and assists in improving service quality (Zeng, 2023). Ramos and Brito (2020) argue that innovation in tourism is not only related to services but also to technological foundations that are essential for ensuring the industry's competitiveness. The introduction of the Industry 4.0 concept in tourism creates new challenges and opportunities that tourism service providers need to leverage (Ramos and Brito, 2020).

Suyunchaliyeva et al. (2020) state that the digital economy and information technology have brought about significant changes in tourism over the past decades, where digitalization and innovation represent two distinct eras. New technologies, such as mobile devices, drones, smart devices, sharing options, and large data sets, create new research directions and challenges in tourism (Suyunchaliyeva et al., 2020). According to Zhou et al. (2020), the tourism industry is a leader in the digital transformation of cultural heritage, where new technologies play an important role in the protection and sustainable development of cultural heritages (Zhou et al., 2020).

These literatures highlight that the tourism industry plays an innovative and trend-setting role in technology and that through continuous technological advancement, it can renew itself and increase its competitiveness.

3. Materials and methods

Based on the literature review, a complex and comprehensive picture emerges concerning the interrelations of tourism, cryptocurrencies, and the EU's regulatory environment. The COVID-19 pandemic and digital transformation have accelerated the spread of digital payment solutions, including cryptocurrencies. In relation to my research question, I can identify the key points indicating that attitudes towards cryptocurrencies vary within the EU; some member states actively support and regulate these technologies, while others are still assessing potential risks and opportunities. The EU strives to balance the promotion of technological innovation with consumer protection and financial stability. However, the undeniable advantages

of using cryptocurrencies in tourism may encourage the EU, as cryptocurrencies offer lower transaction costs and faster payment processing, which can reduce costs for tourism providers and improve service efficiency. Cryptocurrencies enable tourists to easily make cross-border payments without concern for currency exchange fees or traditional banking restrictions. Furthermore, blockchain-based transactions are secure and transparent, thereby reducing the risk of fraud and money laundering. In this context, the following hypotheses are worth investigating in the research:

H1: Primarily, cryptocurrency acceptance points are directed towards tourist services in the European Union.

As indicated by the studies and case examples presented in the literature review, the role of cryptocurrencies in tourism is increasingly coming to the forefront, especially in terms of simplifying payment methods and transactions. Tourism has always been considered an innovative sector, and cryptocurrencies allow for quick and efficient transactions, which are advantageous in tourism, where rapid and straightforward payment methods are crucial. Furthermore, cryptocurrencies offer tourists anonymity and decentralization, which can be attractive for those seeking secure and convenient payment options. Based on these factors, it can be presumed that the specific, physical cryptocurrency acceptance points may primarily target tourism services in the EU.

H2: The number of cryptocurrency acceptance points and the intensity of tourism are correlated in the European Union.

Studies examining the relationship between cryptocurrencies and tourism, such as those by Zrnić et al. (2022) and Laptevaite et al. (2022), suggest that there may be a correlation between the number of cryptocurrency acceptance points and the intensity of tourism in the EU. Cryptocurrencies can aid in better understanding the operation of digital currencies in tourism and reducing challenges associated with their use. When examining the application of cryptocurrencies' instant payment function in tourism, quick and efficient transactions can be particularly beneficial in this distinctively innovative sector. Examples from Moldova and cities in Australia demonstrate that the application of cryptocurrencies and blockchain technology opens up new opportunities in tourism. Based on this, it is worth examining whether there is a correlation between the number of cryptocurrency acceptance points and the intensity of tourism in the EU and how they may influence each other. Investigating these hypotheses requires further in-depth research, including examining the relationships between cryptocurrency acceptance points and tourism intensity.

For this purpose, the number of cryptocurrency acceptance points was collected through scraping methodology via an API key. The basis for this was the CoinMap database (CoinMap, 2023), which I accessed through their official API key. Data collection occurred in September 2023 using a Python code within the Jupyter framework, collecting the following parameters:

fieldnames = ['Name', 'Category', 'Created', 'Country', 'State', 'County', 'Town', 'Latitude', 'Longitude']

To obtain precise location data, a Geolocator instance was created using the 'myGeocoder' user agent. To ensure the code did not break due to external influences, server responses, or other technical issues, the script was capable of handling GeocoderTimedOut, GeocoderServiceError, and RequestException errors.

Furthermore, it was designed to verify the validity of coordinates with the Geolocator and to manage incorrect coordinates, thus reducing the limitations of the research. A total of 446,653 data points were collected for the selected 27 countries, examining a total of 61,585 cryptocurrency acceptance points.

The first hypothesis (H1) was investigated at the settlement level with the help of a clustering neural network. The "Settlement" and "Category" columns were used for clustering through the following steps:

1) Data Preprocessing: The data had to be converted to a numeric format for the neural network. One-hot encoding was applied for this purpose.
2) Autoencoder Creation: A simple autoencoder network was established, capable of creating a compressed representation of the data.
3) Training: The autoencoder was trained using the preprocessed data.
4) Creation of Compressed Representation: Using the encoder part of the autoencoder, I created a compressed representation of the data.
5) Clustering: The compressed representation was clustered using clustering algorithms: K-means, SOM, PCA. In defining the variables, we distinguished two main categories: 'Tourism' and 'Non-tourism'. Based on these, the cluster analysis was conducted. For the formation of clusters, the K-means algorithm was applied, aimed at identifying natural groupings within the dataset. To test robustness, the Jackknife method was utilized, which allowed us to evaluate the stability of our model by omitting various data points.

The second hypothesis (H2) was investigated at the NUTS3 level using linear regression analysis. To conduct a thorough examination and to identify strong correlations where the aggregated data does not distort the relationships, the regional statistical examination level was defined at the NUTS 3 level. In this research, tourism intensity is interpreted based on the number of nights spent at tourist accommodations, the data for which was provided by Eurostat (Eurostat, 2023). Thus, a total of 769 NUTS 3 regions across the 27 countries were included in the analysis runs (since not every region has a cryptocurrency acceptance point, it was not necessary to include all). Since the Geolocator is not capable of assigning Eurostat's own NUTS 3 categorization, I reverse-engineered the collected data from the settlement level using Eurostat's LAU list for the NUTS 3 assignments. Thus, both tourism and cryptocurrency-related data could be interpreted at the same level of regional statistics.

Two indicators were expressed on a ratio scale: the number of guest nights spent at tourist accommodations, and the number of cryptocurrency acceptance points.

The research methodology's strength lies in its ability to directly investigate the correlations between cryptocurrency acceptance points and tourism intensity. The data collection and analysis methodologies applied in this research, such as API data collection techniques, the use of neural networks for clustering, and linear regression analysis, enabled me to uncover significant correlations between cryptocurrency acceptance points and tourism intensity in the EU. The strength of the methodology was that it could extract valuable insights from large datasets suitable for examining hypotheses. The technological advancement, especially the application of neural networks, allowed for a novel perspective on the data, highlighting correlations that might have remained hidden with other methodologies. However, naturally, the methodology is not without its limitations. The data collection process could have been

subjected to certain levels of bias, especially due to the limited filtering of the cryptocurrency acceptance points database. Moreover, while the application of neural networks and clustering methods was innovative, it could carry a degree of subjectivity in selecting the optimal parameters.

4. Results

The distribution across categories is evident within the sample itself, as illustrated by **Table 1**.

Table 1. Distribution of cryptocurrency acceptance points by category, own editing.

Category	**%**
Shopping	37.02%
Food	17.11%
Lodging	15.33%
Grocery	8.51%
Cafe	5.97%
Nightlife	4.77%
Sports	4.41%
Transport	3.78%
Attraction	2.88%
Trezor retailer	0.12%

Compilation Among the categories, numerous services directly related to tourism are found. These categories include:

- Lodging (15.33%): This category encompasses accommodations such as hotels, guesthouses, and apartments.
- Food (17.11%): Restaurants, diners, and other dining options.
- Cafe (5.97%): Coffee shops and tea houses.
- Nightlife (4.77%): Nighttime entertainment venues like bars, clubs, and discos.
- Attraction (2.88%): Tourist attractions, museums, historical monuments, and other points of interest.

The combined proportion of all tourism-related categories amounts to 46.06%, signifying that nearly half of the cryptocurrency acceptance points are comprised of tourism services. This substantial proportion indicates significant interest in cryptocurrencies within the tourism sector, with many providers offering the option to pay with cryptocurrencies. This is further reinforced by the “shopping” category, which, although as a limitation of the study does not distinguish between tourists and locals, can be inferred to not primarily illustrate everyday shopping due to the existence of the separate “grocery” category. Hence, it can be treated as an overlap used by both tourists and locals. Therefore, the adoption of cryptocurrency in tourism gains additional confirmation.

The remaining 53.94% of cryptocurrency acceptance points fall into other categories, including retail stores (37.02%), grocery stores (8.51%), as well as sports and transportation services, which together represent an additional share. This indicates that while tourism holds a significant portion of cryptocurrency acceptance

points, numerous other service sectors are beginning to recognize and integrate digital payment solutions.

However, to demonstrate the actual characteristics and affirm or refute the dominance of cryptocurrency use in tourism, constructing a clustering neural network was justified. Based on the "Elbow Method," it was feasible to create 3 K-means clusters, a method suitable for determining the optimal number of clusters where inertia measures the "goodness" of a particular clustering in K-means. The Elbow method calculates the value of inertia as a function of the number of clusters. As the number of clusters increases, inertia decreases, but beyond a certain point, the rate of decrease substantially slows down. This point is referred to as the "elbow." The cluster number at which this "elbow" is identified is often considered the optimal number of clusters, as increasing the number of clusters beyond this point only marginally improves the quality of clustering. The elbow value was identified to be 3.

The clustering results identified three distinct clusters with the following characteristics:

1) Cluster: Primarily consists of cryptocurrency acceptance points at grocery stores (Category_grocery) and cafes (Category_cafe).
   The food category (Category_food) is also a feature but not in high numbers within the cluster.
2) Cluster: This cluster is dominated by lodging establishments (Category_lodging) that accept cryptocurrency. It also has significant representation from the nightlife and food categories, albeit in smaller numbers (which may result from their generally lower occurrence), with attractions and cafes also characteristic.
   The shopping category (albeit with a small value) is present, confirming that shopping is a category utilized by tourists.
3) Cluster: Shopping centers (Category_shopping) and sports facilities (Category_sports) are most prevalent here, with attractions (Category_attraction) minimally present.

Cluster 2 is dominated by activities suggestive of tourism-related activities. Tourism, however, comprises not just lodging but also other categories such as restaurants, attractions, museums, etc. Among them, this is the most dominant cluster, indicating that cryptocurrency acceptance points are primarily geared towards tourist services. Examining cluster 3, we can reasonably infer domestic tourism, as shopping and sports can often be combined motivations even for day trips. Conversely, the smallest cluster, cluster 1, is unequivocally made up of local residents within this distribution.

The cluster analysis was augmented with a clustering neural network, also known as a Self-Organizing Map (SOM), which is a type of neural network capable of clustering data without requiring supervised learning. The SOM creates a map based on the input data where similar data points are located in close proximity to each other. Since SOM is an unsupervised learning method, only numerical variables were applied, thus all categorical variables were converted to numerical form. Subsequently, the data were normalized to ensure that each variable contributed equally to the clustering process.

The Self-Organizing Map (SOM) is a type of self-organizing network that is capable of creating spatial representations of data, thus enabling the simultaneous

examination of urban structures and the interplay of categories. Specifically, based on the input data, the SOM generates a map where similar data points are positioned in proximity to each other.

Figure 2 illustrates the SOM U-matrix, which represents the distances between different neurons: tourism services, shopping, dining, accommodation, and regions. Darker areas indicate greater distances, signifying that the data points in these areas belong to different clusters. Conversely, lighter areas represent shorter distances, suggesting that the data points are similar and belong to the same cluster.

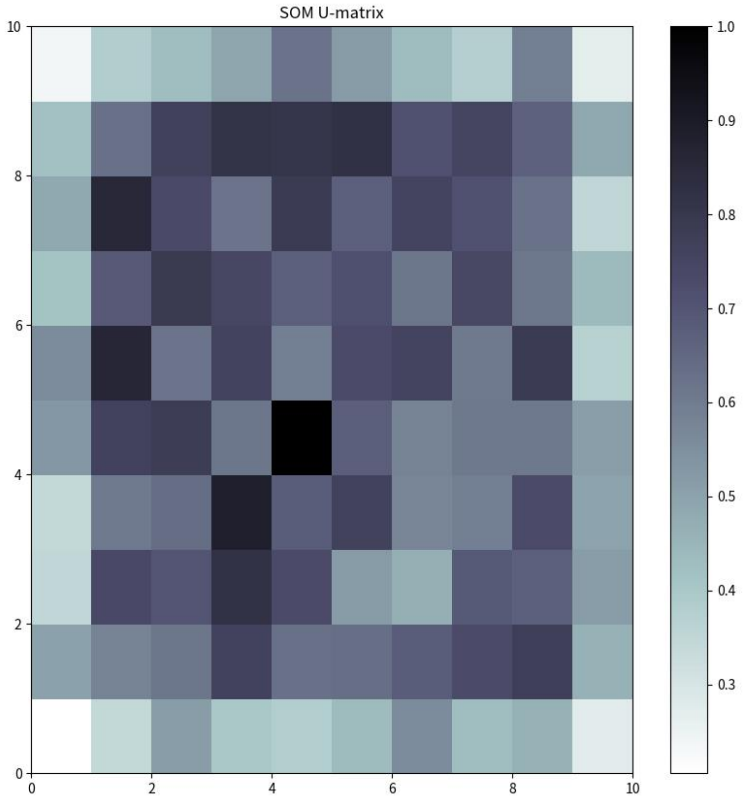

Figure 2. SOM U-matrix from own analysis output.

The clustering through neural networks provides a capacity for assessing more profound and detailed uniqueness. Accordingly, on the SOM U-matrix, dark areas indicate greater distances between neurons, meaning that the data points in these regions belong to different clusters. In other words, dark areas denote the boundaries of clustering, while light areas, indicating shorter distances, suggest that the data points are similar and belong to the same cluster. Based on the SOM U-matrix, it is evident that multiple distinct sub-clusters have formed within the data. These clusters can be categorized based on the original data table. A deeper examination of these data revealed that the light areas surrounding the dark regions contain data points related to touristic activities, as these areas form distinct clusters.

This further reinforced the assumption that cryptocurrency acceptance points are primarily directed towards tourist services, as reflected in the spatial organization of related activities (Lodging, food, shopping, cafe, nightlife, attraction) when examined in relation to settlements.

In the third step, I performed a Principal Component Analysis (PCA) on the data, aiming to create new variables as linear combinations of the original variables, which retain the maximum amount of information from the original dataset while reducing the number of variables. These new variables are referred to as "principal components." The principal components are ordered by the amount of variance they account for, that is, the first principal component contains the greatest variance of the data, the second contains the second greatest, and so forth.

Figure 3 illustrates that the data segregate into several clusters, suggesting distinctive characteristics in the grouping of categories at the settlement level. In the figure's PCA analysis, the categories 'tourism', 'shopping', 'dining', and 'accommodation' were considered, forming distinct clusters during the analysis. The 'Country' category showed no differentiation, suggesting that cryptocurrency acceptance is not limited to any specific country or region.

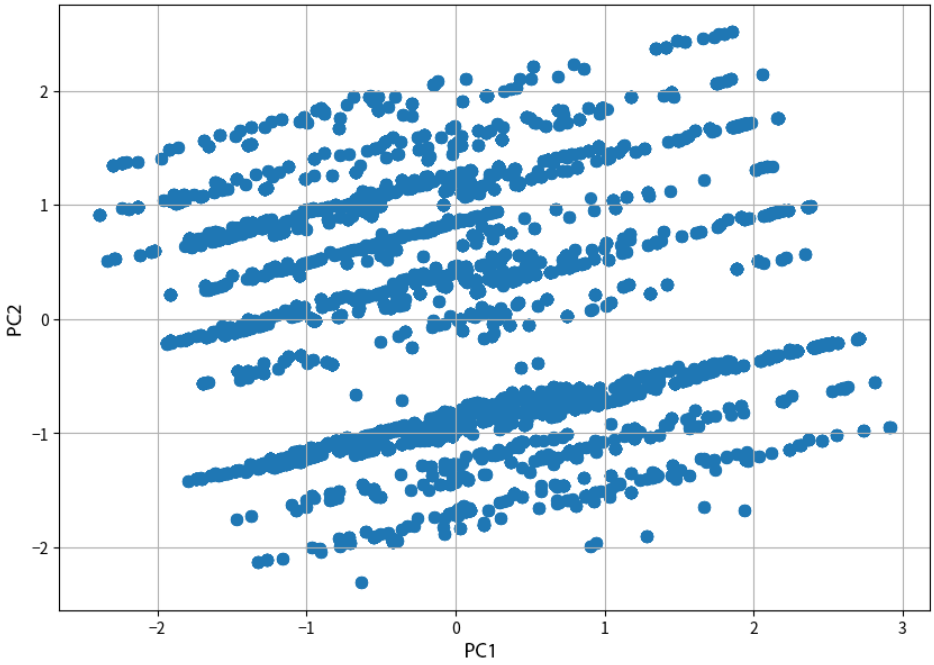

Figure 3. PCA analysis on the full sample, from own analysis output.

- The first principal component (PC1) has a positive loading on the "Category" variables while bearing a negative loading on the "Country" variable. This indicates that PC1 is strongly influenced by the "Category" variables.
- The second principal component (PC2) also has a positive loading on both "Country" and "Category" variables but is less sensitive to the "Name" variable.

Based on the negative correlation with the "Name," the potential distorting influence of franchises or national/international chains can be ruled out, thereby confirming that the principal components predominantly reflect the strong dependency of the "Country" and "Category" variables within the data, with "Category" being the more influential. From this information, it is inferred that the "Country" and "Category" variables significantly affect the groupings and clusters within the data.

Consequently, it was deemed appropriate to categorize the data according to the "Category" variable, given its dominance, and to examine the number of data points

within each category, as well as their distribution along the first principal component.

The following **Figure 4** displays the results of a "unifactorial" PCA analysis, where only the values of the single principal component are plotted. The various colors denote the categories, with color intensities representing dominance. As only one principal component is utilized, the representation on the graph is one-dimensional, meaning that the presentation on the PC1 axis indicates that only one principal component, carrying the largest variance in the data, was considered during the analysis. This approach allows for a simplified visualization of the data but provides limited information on the complexity of the data, which, at this point, does not pose a problem considering the context.

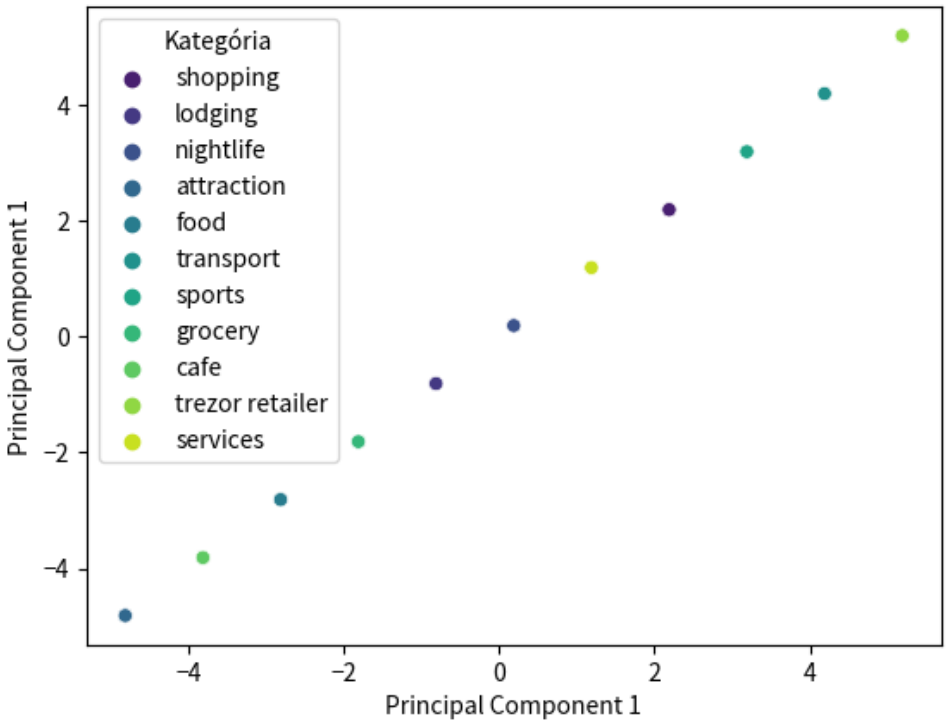

Figure 4. PCA Analysis on the Category Component, output from own analysis.

Based on the results of the PCA analysis, it can be determined that tourism-related categories (e.g., hotels, restaurants) cluster closely together on the graph. This suggests that these categories follow a similar pattern along the examined variables. It also implies that businesses based on tourism exhibit similar characteristics in the studied area regarding the acceptance of cryptocurrency. Additionally noticeable on the graph is a series of local service-related categories (e.g., grocery stores, services) which also display a similar distribution but differ from the tourism-related categories. This may indicate that local services have a different dynamic and characteristics compared to tourist services, suggesting a clear distinction between the two, while the dominance in color intensity clearly peaks within the tourist services. However, one should not overlook the plane on which the data are organized in the graph, indicating a correlation. Since there is observable overlap between categories, this could also mean that there is a strong correlation among the categories. Thus, our PCA analysis yields an unexpected partial result, which points back to the "Country" variable; besides confirming that cryptocurrency acceptance points are primarily focused on

tourism, a regional peculiarity is also observable: For instance, if an area has many tourist providers that accept cryptocurrencies, it is likely that many local services will do the same. Therefore, the growth of tourism probably has a positive impact on local services as well.

Observing the category ratios, the results of the K-means clustering, the findings of the SOM analysis, and the outcomes of the PCA analysis, it can be stated that my Hypothesis 1 has been validated. Specifically, cryptocurrency acceptance points in the European Union are primarily directed towards tourism services, according to the data examined in this current sample.

It can thus be declared in this research that cryptocurrencies are utilized by acceptance points within the tourism sector in a regional context. However, this does not yet prove the proposition that there is a correlation between the intensity of tourism and the number of cryptocurrency acceptance points.

For this purpose, regression analysis was applied at the NUTS3 level.

In the subsection describing the methodology, it was mentioned how I aggregated the municipal data to the NUTS3 level, thereby essentially interpreting two ratio scales. One included the number of guest nights spent at commercial accommodations, while the other reflected the number of cryptocurrency acceptance points.

My study aimed to determine whether the number of cryptocurrency acceptance points influences the intensity of tourism in a given region. In this case, the dependent variable is the intensity of tourism, as we wish to understand how it changes with the variation in the number of cryptocurrency acceptance points. The independent variable is the number of cryptocurrency acceptance points, since I aimed to demonstrate its effects on the intensity of tourism.

The regression line depicted in **Figure 5** indicates that there is a positive upward trend between the two variables, suggesting that with the increase in the number of cryptocurrency acceptance points, the values of tourism intensity also rise. Although the dispersion of points is not perfect, hence I examined this in concrete numbers as well.

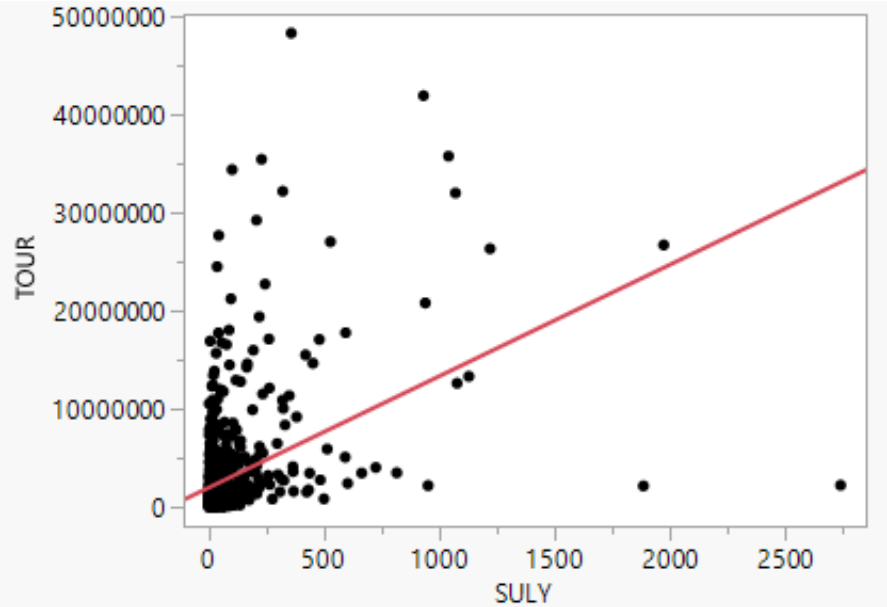

Figure 5. Regression graph, output from own analysis.

In the linear regression model, the presence of outliers does not significantly affect the model's overall validity, although the concentration of observations towards the center of the axes suggests that while there is a relationship between the variables, further studies are required to define the correlations more accurately. The terms 'tour' and 'suly' denote tourism services and the weight of cryptocurrency acceptance points, respectively.

During the analysis, the estimated value for the "Intercept" was 1,986,037.1, with an associated *p*-value (<0.001) indicating that this value is significant. This means that if the number of cryptocurrency acceptance points were zero, the expected value for tourism intensity would be approximately 1,986,037. The estimated parameter value associated with the number of cryptocurrency acceptance points is 11,336.568, which is significant based on its *p*-value (<0.001). This implies that with every unit increase in the number of cryptocurrency acceptance points, the intensity of tourism also rises, taking into account the other variables in the model. Although the data shows that the model does not explain all variance, the ANOVA results demonstrate that the number of cryptocurrency acceptance points has a significant effect on the value of tourism intensity. The parameter estimates corroborate these findings, allowing for the assertion that Hypothesis 2 is verifiable. That is, there is a correlation between the number of cryptocurrency acceptance points and the intensity of tourism in the European Union, according to the methods examined in the current sample.

5. Discussion

The research focused on examining the role of cryptocurrencies in tourism and the impact of digital transformation within the European Union region. The digital transformation accelerated by the COVID-19 pandemic has evidently sped up the adoption of cryptocurrencies, particularly in the tourism sector, bringing fundamental changes to the industry. The findings highlight that a portion of tourism services now transact using cryptocurrencies, reflecting the increasing adoption of digital payment solutions and the growing role of cryptocurrencies in tourism.

This trend could be particularly important for regions where the economy is significantly influenced by tourism. The correlation between the increasing number of cryptocurrency acceptance points and tourism intensity suggests that cryptocurrencies could substantially contribute to the competitiveness of tourism services and the convenience of tourists. The use of cryptocurrencies can reduce transaction costs, increase the efficiency and security of financial transactions, and promote transparency and an enhanced user experience.

However, there are challenges associated with the application of cryptocurrencies, such as volatility, regulatory uncertainties, and gaining user trust. Stakeholders in the tourism sector need to consider these factors and develop strategies for integrating cryptocurrencies while proactively managing risks and educating users about the benefits and challenges of using cryptocurrencies.

The current study also shows that cryptocurrencies are not merely an isolated financial innovation but are part of a broader digital transformation reshaping economic interactions and consumer behavior. As the convergence of Web 3.0 and blockchain technologies with everyday activities intensifies, so does the likelihood of

cryptocurrency utilization. Their deployment within the realm of tourism could pave the way for novel, customer-focused services, potentially catalyzing advancement and ingenuity within the industry.

Nonetheless, ongoing studies should persist in tracking the dynamic function of cryptocurrencies within the tourism landscape, especially against the backdrop of shifting consumer patterns, technological progress, and regulatory landscapes. Stakeholders in the tourism sector should strategically engage with these evolving digital finance technologies, aiming to harness these fresh prospects whilst navigating the accompanying complexities and securing enduring expansion.

The analysis conducted during the research discussed the relationship between cryptocurrency acceptance points and the intensity of tourism within the European Union. Comparing the results with previous literature, it is apparent that new dimensions and perspectives can be uncovered in understanding the correlations between tourism and cryptocurrencies. For instance, the research of Zrnić et al. (2022) and Laptevaitė et al. (2022) on the application of cryptocurrencies in tourism highlights the benefits of digital payment solutions and their increasing acceptance in the tourism sector. In contrast, this research advances the discourse by examining the physical distribution of cryptocurrency acceptance points and their relationship with tourism intensity in the EU through specific data, thus filling the research gaps identified in previous studies. The novelty of this paper lies in its comprehensive data analysis methodology, which enables the precise examination of the correlations between cryptocurrency acceptance points and tourism intensity across various regions of the EU. Furthermore, our research contributes to a deeper understanding of the application of digital payment solutions, especially cryptocurrencies, in tourism, and analyzes the dynamics of their acceptance in the post-pandemic period. This study fills the research gap that examines the direct correlation between the geographical distribution of cryptocurrency acceptance points and the intensity of tourism in the EU.

The associations and patterns deciphered through this research shed light on the burgeoning impact of cryptocurrencies in the tourism domain. As digital transformation progresses unceasingly, it’s imperative for those in tourism to adapt to and exploit the prospects cryptocurrencies bring to the fore, all while tackling the hurdles associated with tech innovation and upholding consumer confidence.

The limitations of the research include the methodology of the sampling and the number of territorial units examined. Further research is necessary to gain a deeper understanding of the relationships and to analyse the temporal changes in adoption trends.

6. Conclusions

This study offers an in-depth examination of cryptocurrencies’ impact within the tourism industry and the ongoing trends in digital transformation. The COVID-19 pandemic has accelerated the adoption of digital payment solutions, among which cryptocurrencies are increasingly becoming prominent in the tourism sector. The analysis confirms that the majority of cryptocurrency acceptance points in the EU are linked to tourist destinations, supporting the research hypothesis H1.

The data examined and the analytical methodology employed reveal that

approximately half of the acceptance points are comprised of tourism services, indicating that industry stakeholders are actively seeking the benefits offered by cryptocurrencies. These benefits include, among others, the reduction of transaction costs, facilitation of cross-border payments, and enhancement of the security of financial transactions. The results clearly indicate that the growth in the number of cryptocurrency acceptance points within the EU aligns with tourism intensity, corroborating the research hypothesis H2.

The findings illuminate that the digital transformation, further amplified by the pandemic, has a significant impact on the interrelation between tourism and the use of cryptocurrencies. The positive correlation between cryptocurrency acceptance points and tourism intensity suggests that regions more open to digital payment solutions exhibit higher tourist activity. This correlation not only signals an increase in the use of cryptocurrencies in tourism but also aids in a deeper understanding of the interplay between digital financial technologies and tourism.

Future research should continue to focus on the evolution of the relationship between cryptocurrencies and tourism, taking into account technological advancements and changes in the regulatory environment. It is imperative that enterprises operating within the tourism sector and policymakers monitor these trends to devise appropriate strategies for the more effective use of cryptocurrencies and to advance digital transformation. The industry must prepare to capitalize on the benefits offered by cryptocurrencies while managing the challenges associated with new technologies.

This research contributes to a better understanding of the role of cryptocurrencies in tourism and facilitates the integration of digital financial technologies. The results can provide a foundation for policy planning, economic decision-making, and determining future developmental directions for the tourism industry.

Conflict of interest: The author declares no conflict of interest.

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