A STUDY OF THE INTENTION TO ADOPT A BLOCKCHAIN TRACEABILITY SYSTEM IN BEEKEEPING SECTOR

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ABSTRACT

This study empirically analyzes the factors influencing beekeeper's intention to adopt a Blockchain traceability system (BCT) using a theorical framework based on the integration of Unified Theory of Acceptance and Use of Technology (UTAUT) model and the Theory of Planned Behavior (TPB). Data was collected through a quantitative survey involving 159 beekeepers across three mediterranean countries (Tunisia, Turkey and Spain). We used Partial Least Square Structural Equation Modelling (PLS-SEM) of SmartPLS 4.0 for data analysis. The study found that two factors of UTAUT, along with two constructs of TPB are promoting blockchain adoption among beekeepers. Positive attitudes toward BCT, perceived behavioral control, effort expectancy and performance expectancy can explain intention to adopt the blockchain.

The findings of this study offer valuable practical guidance for both technology developers and government agencies. By highlighting the factors influencing blockchain adoption, the study assists in informed decision-making concerning technology investments aimed at improving traceability throughout the honey value chain in mediterranean countries. This study is expected also to provide significant theoretical contributions to the research field of acceptance and use of innovant technologies.

Keywords: *Intention to adopt; Blockchain; beekeepers, Theory of Planned Behavior (TPB); Unified Theory of Acceptance and Use of Technology (UTAUT); PLS-SEM*

1. INTRODUCTION

Despite its great ecological and socio-economic importance, the Mediterranean beekeeping sector is facing major problems. The beekeeping sector is impacted by global and detrimental effects of climate and environmental changes (López-i-Gelats et al., 2024; Van Espen et al., 2023). Moreover, honey fraud is a critical concern for honey sector. In fact, honey is a primary target for food fraud and adulteration (Gustafson et al., 2024; García, 2018; Johnson, 2014). Fraudulent practices in beekeeping sector are causing harmful economic and social impacts. From the beekeepers' stand of view, honey fraud is decreasing honey prices and undermining trust in high quality and authentic products. Furthermore, the challenges associated with honey fraud extend beyond the mere economic impact (Almiani et al., 2024; Gustafson et al., 2024, Strayer et al., 2014). They jeopardize the reputation of beekeepers and may also lead to more serious environmental problems associated with the loss of bee colonies. Honey fraud also raises public health concerns, as the consumption of adulterated honey can lead to health risks for consumers.

The lack of traceability and effective systems for tracking products from hives to the consumers is exposing the market to major challenges. In this context, the implementation of a traceability system based on blockchain technology is emerging as a strategic solution to these challenges. Blockchain was found to improve the supply chain transparency and traceability (Mukherjee et al., 2022). It further offers added promising benefits including cost-savings and sustainability improvement (Kshetri, 2018). In the beekeeping sector, this innovative technology offers the possibility of guaranteeing transparency, authenticity, and quality of honey, while also constituting an essential measure in the fight against fraud . Despite promising potential benefits, blockchain adoption and application is still at a nascent stage worldwide and most identified use cases discussed in the literature are stalled at the pilot use (Lavaei Adaryani et al., 2024; Kouhizadeh et al., 2021). In this context, there is an urgent need to conduct studies on main drivers (and barriers) of adoption and use of this technology mainly in food supply chain.

This study aims to answer the following two key questions: What factors are likely to influence the beekeepers' intention to adopt blockchain ? How integration of different technology acceptance mechanisms theories and models can perform better in predicting intention to adopt blockchain product.

2. HEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

For a better comprehension of technology acceptance, researchers suggest a combination of more than one theoretical model instead of single-theory studies since integrated studies produced improved fitting (Subedi et al., 2025). Therefore, the research framework used to study the intention of beekeepers to adopt blockchain technology (BCT) is mainly based on an integrated model of the Theory of Planned Behavior - TPB (Ajzen, 1991) and the Unified Theory of Acceptance and Use of Technology UTAUT (Venkatesh et al., 2003) frameworks. The integration of the two models only aims to provide insightful results in both academic and practical aspects regarding blockchain technology adoption in food sector.
Based on TPB and UTAUT models, we developed an integrated conceptual framework keeping the following hypotheses:
H1*: Performance expectancy has positive impact on behavioral intention to adopt BCT.*
H2: *Effort expectancy has positive impact on behavioral intention to adopt BCT.*
H3: *People's subjective norms have positive impact in behavioral intention to adopt BCT.*
H4: *Attitudes have positive impact on behavioral intention to adopt BCT.*
H5*: The perceived behavioral control has positive impact on behavioral intention to adopt BCT.*

3. METHDOLOGY

This study investigated beekeepers' intention to adopt the BCT in three Mediterranean countries (Spain, Tunisia, and Turkey) using a face-to-face survey. A structured questionnaire, designed based on TPB and UTAUT frameworks, comprised sections on beekeeping characteristics, honey fraud awareness, BCT perception and intention, and socio-demographics. For BCT adoption determinants, 22 adapted constructs related to UTAUT's performance expectancy and effort expectancy, and TPB's attitudes and perceived behavioral control were included. Subjective norms, a common construct, and intention were also measured using a five-point Likert scale. The questionnaire, initially in English, was translated and cross-checked by bilingual experts and pre-tested with beekeepers, with modifications made accordingly. Beekeepers unfamiliar with BCT received a brief definition before answering relevant questions. Data collection occurred from November 2023 to March 2024 via the Qualtrics platform, yielding 159 valid responses for data analysis. To predict and explain BCT adoption intention, PLS-SEM procedures in SmartPLS 4.0 were employed, chosen for their ability to handle complex models with less stringent data assumptions and smaller sample sizes. Both measurement and structural models underwent validation in SmartPLS 4.0, involving the assessment of reliability and validity metrics prior to testing hypothesized relationships.

4. RESULTS

4.1. Descriptive sample information

The study reveals that 86.8% of participating beekeepers are men. Notably, nearly 39% of the sample had completed university studies, while 37% had attained secondary education. Analyzing the age distribution, the most represented group is 36-49 years old, accounting for nearly half of the respondents (49.7%), followed by beekeepers aged 50-65 years old (27.58%). The findings suggest that most surveyed beekeepers are young men with a high level of education, likely due to beekeeping's appeal as an attractive employment opportunity for young entrepreneurs. In contrast, beekeepers aged over 65 represent only 4.92% of the sample, which may be attributed to the physically demanding nature of beekeeping.

4.2. Measurement Models for blockchain adoption: Constructs Validity and Reliability

The measurement model's constructs underwent validity and reliability assessment (Kock, 2014). Reliability analysis, evaluating indicator consistency used to measure constructs (Hair et al., 2021), led to excluding items with loadings below 0.708. The retained indicators exhibited loadings 0.757 to 0.960, and internal consistency was confirmed by Cronbach's Alpha (above 0.7) (Hair, 2017) and Composite Reliability. Convergent validity, representing the degree to which a measure aligns with other measures of the same concept,was established as the Average Variance Extracted (AVE) surpassed 0.50 (Hair et al., 2017). Discriminant validity assumes that a set of indicators represents a single construct. (Hair et al., 2021), was evaluated using the Fornell–Larcker criterion (Fornell and Larcker, 1981) and cross-loadings (Vaithilingam et al., 2024), confirming satisfactory outcomes where indicator loadings exceeded cross-loadings (Chin, 1998), indicating that no construct indicator valued more on an opposing construct (Hair et al., 2017), and thus, discriminant validity appeared satisfactory across all constructs.

4.3. Structural model

After assessing the measurement model, the structural model was tested for evaluation. A standard bootstrapping method with 5000 subsamples (Hair et al., 2021) was applied to calculate path coefficients and test hypotheses across the TPB-UTAUT integrated model. To identify the model with the best predictive power, the coefficient of determination (R^2) and the Bayesian information criterion (BIC) were

assessed (Hair et al., 2021). The integrated model exhibited a higher R^2 (0.657) and a lower BIC (-140.804), confirming its superior predictive capability compared to the individual TPB and UTAUT models. This suggests that the considered constructs from UTAUT and TPB models can explain about 66% of the variance in the intention to adopt blockchain among beekeepers. Consequently, the analysis focused on the integrated structural model, where a multicollinearity check using VIF indicated that collinearities between predictors of endogenous variables are not problematic. Furthermore, the Standardized Root Mean Square Residual (SRMR) value of 0.070 below the 0.10 threshold (Hensler et al., 2015) confirmed the model's robustness.

Table 1. ***The Structural Model***

Hypotheses	Path estimates	β	T statistics	P values	Decision
H1	PE -> BI	0,255	3,243	0,001	Supported
H2	EE -> BI	0,238	3,095	0,002	Supported
H3	SF -> BI	0,112	1,367	0,172	Rejected
H4	PBC -> BI	0,190	2,364	0,018	Supported
H5	ATT -> BI	0,239	3,501	0,000	Supported

The study's findings revealed significant positive relationships between adoption intention and performance expectancy, effort expectancy, perceived behavioral control, and attitudes, supporting four out of five hypotheses (H1, H2, H4, H5). However, subjective norms showed no significant impact, leading to the rejection of H3. These results confirm the pertinence of the integrated UTAUT-TPB models in predicting beekeepers' intention to adopt blockchain technology in their apiary activity.

5. DISCUSSION AND CONCLUSIONS

Studies on blockchain adoption are still limited even if they represent an emerging research topic (Lavaei Adaryani et al., 2024; Kouhizadeh et al., 2021). In this context, the current work aims to contribute to this field by studying the main determinants of blockchain technology acceptance among beekeepers in three mediterranean countries.

The findings of our study confirm the pertinence of the integrated UTAUT-TPB models in predicting beekeeper's intention to adopt blockchain technology in their apiary activity. The study proves that two constructs from the TPB model and two from the UTAUT model are significantly predictive of beekeepers' intention to adopt blockchain technology.

Following the TPB model, our results reveal that attitudes and perceived behavior control are significant predictors for beekeepers' intention to adopt BCT. With respect to attitudes, our findings suggest that beekeepers with a positive outlook on BCT are more likely to adopt it. Therefore, raising awareness and enhancing knowledge of this technology is essential to fostering favorable attitudes toward its adoption.

Regarding the perceived behavioral control, the results show a significant and positive effect on intention to adopt BCT. This suggests that beekeepers with greater knowledge of BCT and confidence in their ability to adopt it are more likely to embrace its use.

Moreover, the performance expectancy of adopting BCT has a significant and positive influence on beekeepers' intention to adopt blockchain technology. Thus, expectations regarding cost and time savings, improved efficiency, and increased income will further strengthen their willingness to adopt BCT. These findings are consistent with those of Lavaei Adaryani et al. (2024) for blockchain adoption in the poultry supply chain; Kapnissis et al. (2022) for the BCT adoption in the case of Greek bulk shipping companies and Chang et al. (2022) for the BCT acceptance in the tourism sector in Korea.

With respect to effort expectancy defined in the UTAUT, as the perceived ease of using a particular technology, our results reinforced the positive and significant role of EE in beekeeper's intention to adopt a BCT to enhance the traceability of their products. This finding conforms to earlier findings of studies about the blockchain (Lavaei Adaryani et al., 2024; Alazab et al., 2021; Li et al., 2021). According to this finding, beekeepers will not adopt BCT unless the expected benefits outweigh the effort needed to use it. However, Latha Lavanya et al. (2023) didn't report a significant effect of effort expectancy on behavioral intention for using blockchain in the retail supply chain in India. Authors explained this result by a potential negative belief that blockchain usage will be challenging and demanding expertise.

In contrast, our study reveals an unexpected insignificant relationship between subjective norms (or social influence) and the intention to adopt BCT. This suggests that beekeepers' decision to adopt blockchain technology is not influenced by their social network or the opinions of friends, family members, and peers about its adoption. Although previous studies on BCT adoption, emphasized the impact of social networks on BCT acceptance (Lavaei Adaryani et al., 2024; Kapnissis et al., 2022;

Khazaei, 2020; Kamble et al., 2019), AI acceptance (Choudhury, 2022) and ChatGPT uses (Menon and Shilpa, 2023), our results conform to the study of Chang et al. (2022) who dismissed the influence of social factor in BCT acceptance .

Given the findings of this study, raising awareness about the practical advantages of BCT is essential to encouraging its adoption in the beekeeping sector. As suggested by Lavaei Adaryani et al. (2024), specialized training and sessions for presenting the benefits of blockchain and example of successful implemented BCT can increase the intention to use this technology.

Moreover, the meaningful relationship between Effort Expectancy and the intention to adopt BCT suggests that a user-friendly blockchain application can enhance its perceived ease of use and accessibility while maximizing its utility. Therefore, the more intuitive, convenient, and flexible the developed BCT is, the stronger the intention to adopt it among beekeepers. Although this study is based on a small sample of beekeepers per country, it offers valuable insights and practical implications for blockchain adoption in the beekeeping sector. It broadens the comprehension of key factors that facilitate the adoption of blockchain within stakeholders of the honey value chain, thereby enriching our understanding of blockchain adoption in the broader context of the food supply chain.

Furthermore, the findings of this study offer valuable practical guidance for both technology developers and policymakers. By finding the key factors influencing blockchain adoption, this research supports informed decision-making regarding technology investments aimed at enhancing traceability across the honey value chain in Mediterranean countries.

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