Original Article

THE ROLE OF DIGITAL PLATFORMS IN ENHANCING CUSTOMER RELATIONSHIPS AND BUILDING STRATEGIC ADVANTAGE IN BEEKEEPING

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Abstract

This study examines how beekeepers perceive the benefits of digital platforms for customer relationships and strategic outcomes, and whether these perceptions differ based on their digital experience. Using a mixed-method approach, data were collected in 2024 in Poland through a survey of 949 beekeepers and 30 expert interviews. Quantitative results show that digitally experienced beekeepers reported higher perceived benefits across all customer relationship dimensions and most strategic ones, particularly in transparency and honey quality, as confirmed by Mann-Whitney U tests and a random forest model. No significant difference was found for customer loyalty, indicating that loyalty depends more on long-term relationships than digital proficiency. Qualitative insights revealed that digital platforms foster trust, support quality improvement, and strengthen beekeeper–customer connections. The study enhances our understanding of how digital experiences shape perceived benefits, and it also provides practical guidance for prioritizing platform features that promote transparency, quality monitoring, and effective communication.

Keywords: beekeeping, digital platforms, customer relationships, strategic benefits, honey quality, agriculture

INTRODUCTION

The ongoing digitization of agriculture, commonly referred to as Agriculture 4.0, is reshaping contemporary agri-food systems by integrating advanced digital technologies across all stages of production, processing, distribution, and marketing (Maffezzoli et al., 2022; Dong et al., 2023). As modern agri-food systems become increasingly data-driven and interconnected, Agriculture 4.0 provides the overarching framework within which the agricultural sector evolves. Beekeeping, although traditionally considered a small-scale and low-tech activity forms an integral component of agri-food systems due to its essential role in pollination, food security, and the production of high-value food products (Richardson, 2023). Consequently, it is now influenced by the same technological trends that transform agri-food systems more broadly, including IoT, AI, data analytics, and digital platforms (Abdollahi et al., 2022; Huet et al., 2022; Ornelas Herrera et al., 2025). However, despite growing awareness, the actual level of digital adoption among beekeepers remains low. Recent studies indicate that between 70% and 80% of beekeepers do not use any digital solutions, and among those who do, applications are typically limited to basic monitoring devices such as electronic hive scales (Verbeke et al., 2024; Karmańska et al., 2025). In broader agri-food systems, digital tools have been shown to enhance productivity, transparency, and communication across the value chain (Dong et al., 2023). To a large extent, these benefits translate directly into the beekeeping context, where digital platforms can support hive monitoring, work organization, financial control, marketing, and direct-to-consumer sales. Digital platforms can be broadly defined as socio-

technical systems that enable data exchange, coordination, and interaction between different stakeholders through integrated digital tools and communication channels (Gao et al., 2022; Finlay-Smits et al., 2023). Such platforms combine operational and relational functions - facilitating not only the management of apiary activities but also the development of trust-based relationships with customers and partners. They integrate multiple digital solutions, allowing beekeepers to collect and share data, plan activities, and communicate effectively with customers within a single technological environment.

Digital platforms also serve as communication and marketing tools - helping beekeepers reach consumers, build brand identity, and promote transparency through information sharing about production methods, locality, and quality standards (Schiro et al., 2020; Sparacino et al., 2024; Taktakidze, 2024). Such activities enhance the beekeeper's credibility, strengthen customer trust, improve the profitability and efficiency of honey production, and contribute to product differentiation in competitive markets (Geng et al., 2024; Yeo & Keske, 2024; Paudel et al., 2025). Moreover, platforms that provide such traceability features as QR-code product tracking or online disclosure of production practices can further support transparency and consumer confidence (Ornelas Herrera et al., 2025).

Existing research has primarily focused on the technical capabilities of digital tools in beekeeping, for instance, sensor accuracy or data management systems (Catania & Vallone, 2020; Guruprasad & Leiding, 2024). Nevertheless, little is known about how beekeepers themselves perceive the benefits of using digital platforms, particularly in terms of customer relationships and broader strategic outcomes. Understanding these perceptions is crucial, as uptake of digital tools depends not only on technical performance but also on beekeepers' subjective evaluation of their usefulness.

This study addresses the research gap by exploring how beekeepers evaluate the effectiveness of digital platforms in managing customer relationships and achieving strategic objectives. Specifically, it examines whether these perceptions differ between beekeepers with and without prior experience using digital technologies for apiary management.

Accordingly, the study is guided by the following research questions:

RQ1: How do beekeepers perceive the customer relationship benefits of digital platform use?

RQ2: How do beekeepers perceive the strategic benefits of digital platform use?

RQ3: How do these perceptions differ between beekeepers with and without experience using digital technologies?

MATERIAL AND METHODS

This study was conducted as part of the international project TOP4Honey Chains: Trustable and Sustainable Open Platform for Smart Honey Value, funded by the National Centre for Research and Development (NCBR) in Poland under the ERA-NET CO-FUND ICT-AGRI-FOOD initiative. The project aims to develop the concept and architecture of a reliable, sustainable, and adaptive digital open-data platform to enhance traceability, transparency, and trust within honey value chains. The platform is designed to enable the efficient implementation of smart honey value chains by integrating advanced digital technologies and supporting end-to-end visibility and trustworthiness across the entire chain.

Research hypotheses

Previous research has shown that utilizing digital platforms in the food sector can enhance customer communication, increase operational efficiency, improve transparency, and strengthen customer relationships (Fu et al., 2017; Camilleri, 2019; Dong et al., 2023; Marzi et al., 2023). Regarding strategic benefits, digital technologies have been linked to higher profitability, competitive advantage, improved customer loyalty, and better product quality management (Dong et al., 2023; Marzi et al., 2023; Ornelas Herrera et al., 2025; Paudel et al., 2025).

Building on these insights and the study's research questions, a series of hypotheses was formulated to examine whether beekeepers' experience with

digital technologies influences their perception of the benefits of using digital platforms. The hypotheses are grouped into two main categories: customer relationship benefits and strategic benefits.

The first set of hypotheses (H1.1-H1.4) concerns customer relationship benefits. It is hypothesized that beekeepers with experience using digital technologies perceive greater benefits in this area than those without such experience. Specifically:

H1.1: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in improving customer communication speed than those without such experience.

H1.2: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in enhancing the quality of customer relationships than those without such experience.

H1.3: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in improving the efficiency of customer relationships than those without such experience.

H1.4: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in increasing the transparency of customer relationships than those without such experience.

The second set of hypotheses (H2.1-H2.4) focuses on strategic benefits. It is assumed that beekeepers who use digital technologies in apiary management perceive greater strategic value from digital platform use than those who do not. Specifically:

H2.1: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in increasing apiary profitability than those without such experience.

H2.2: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in strengthening potential for competitive advantage than those without such experience.

H2.3: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in increasing customer loyalty than those without such experience.

H2.4: Beekeepers with experience using digital technologies perceive greater benefits of digital platforms in emphasizing honey quality than those without such experience.

Research instrument

We employed a mixed-methods approach, integrating both qualitative and quantitative methods. The qualitative component consists of semi-structured interviews with beekeeping experts, while the quantitative aspect involves administering structured questionnaires to beekeepers.

The qualitative instrument - a semi-structured interview guide with open-ended questions - was developed based on both scientific literature (e.g., Schouten, 2021; Day & White, 2022; Wakgari & Yigezu, 2021) and grey literature (e.g., FAO, 2020), and subsequently validated by beekeeping experts. Participants were asked to share their perspectives on the types of digital data considered critical for honey value chains, as well as their experiences and opinions regarding the use of digital technologies in apiary management.

The quantitative instrument - a structured survey questionnaire, was developed based on a review of relevant literature. To ensure content clarity and conciseness, three experts in apiculture reviewed the initial version of the questionnaire. Based on their feedback, ambiguous or unclear items were revised. Subsequently, a pre-test was conducted with twenty beekeepers to assess the clarity and comprehensibility of the questions. Additional refinements to wording were made following this pilot study.

The questionnaire items were originally derived from research on the perceived benefits of digital technologies and were subsequently adapted to the food sector context. These were further tailored to reflect potential digital platform usage in beekeeping. The adaptation process was informed by studies on digital technology benefits in business operations and customer relationship management (Camilleri, 2019; Marzi et al., 2023), strategic advantages in the food industry (Dong et al., 2023), along with studies addressing relationship dynamics in both the food (Fu et al., 2017) and beekeeping sectors

Table 1.

Measurement scale

Indicators	Description	Source
Customer relationships benefits (CR)		Camilleri, 2019 Dong et al., 2023 Fu et al., 2017 Marzi et al., 2023
CR1	Using the digital platform **can increase the speed of communication with customers**	
CR2	Using the digital platform **can improve the quality of relations with customers**	
CR3	Using the digital platform **can increase the efficiency of relations with customers**	
CR4	Using the digital platform **can increase the transparency of relations with customers**	
Strategic benefits (SB)		Dong et al., 2023 Marzi et al., 2023 Ornelas Herrera et al., 2025 Paudel et al., 2025
SB1	Using the digital platform **can increase the profitability of the apiary**	
SB2	Using the digital platform **can help gain a competitive advantage**	
SB3	Using the digital platform **can enable an increase in customer loyalty**	
SB4	Using the digital platform **can enhance attention to good honey quality**	
EXD	**Experience in using electronic devices and applications for apiary management** (e.g., GPS, hive scales, 24-hour hive monitoring, applications for registration and organization of work in the apiary)	

(Engebretson et al., 2022).

A detailed overview of the measurement scale is provided in Table 1.

Data collection and sample

The study was conducted in Poland, a country with a long beekeeping tradition and a predominance of small- and medium-scale apiaries, making it an ideal context for examining technology adoption (Semkiw, 2025). Poland is also among the top EU honey producers, contributing 4-6% of total output and ranking 5th-7th within the Union (Pawłowska-Tyszko et al., 2024). This combination of strong tradition, sectoral fragmentation, and market relevance makes it a suitable context for examining how digital platforms enhance customer relationships and strategic advantages.

The qualitative phase consisted of thirty semi-structured interviews with beekeeping experts (N=30), conducted between March and May 2024. Respondents were selected using purposive sampling to identify individuals highly knowledgeable about or experienced with technology adoption and perceived benefits in apiculture. Strict selection criteria were applied: (i) at least five years of experience in apiculture; (ii) professional roles as apiculturists, researchers, or specialists affiliated with various institutions or government bodies; and (iii) recognition through awards or publications related to apiculture. The resulting expert sample, comprising twenty-four male and six female long-term practitioners from Poland, was highly diverse. The interviewees' ages ranged from 22 to 75 years (average, 48 years), with an average of 22 years of experience in beekeeping. They represented a wide spectrum of professional roles, including commercial beekeepers, apiculture researchers, beekeeping educators, advisors at the Agricultural Advisory Centre, and specialists from the Ministry of Agriculture and national Beekeeping Associations. This diversity in roles, educational backgrounds (including vocational, secondary, and higher formal education related to beekeeping), and years of practice ensures comprehensive and rich insights from multiple perspectives within the sector. Further comprehensive information on the qualitative research protocol and analysis procedures can be found in the previous publication (Ziemba et al., 2025b).

The quantitative phase was based on data

from a structured survey of 949 beekeepers conducted between August and October 2024. Participants were recruited using a combination of online (Google Forms) and paper-based formats, administered primarily through Polish beekeepers' associations. This approach achieved a statistically robust sample size (N=949), which yields a margin of error of approximately 3.5% at a 97% confidence level (significantly better than the target 5% margin for N=383). Participants were selected using purposive sampling to ensure heterogeneity across key variables, while also reflecting the general structure of the Polish beekeeping population (Semkiw, 2025). The sample, therefore, was largely male (84.8%) and comprised mainly hobbyist-amateur practitioners (75.3%), consistent with national data. Crucially, the sample exhibited significant diversity across other characteristics: a broad range of experience (e.g., 36.6% with 6-10 years, 28.3% with 11-20 years, and 14.0% with over 20 years), varied educational backgrounds (e.g., 44.6% vocational, 22.1% higher education), and high organizational involvement (61.5% belonged to an association). This ensures the robust and comprehensive nature of the insights gathered.

Data analysis

To test the research hypotheses, quantitative data from the structured survey were analyzed to compare beekeepers with and without experience in using digital technologies. Due to unequal group sizes, the Mann-Whitney U test with the Bonferroni correction was applied to assess differences between groups, as it was suitable for non-parametric comparisons with unequal sample sizes (Mann & Whitney, 1947).

To complement the statistical analysis, a supervised machine learning approach using a random forest classifier was employed to identify patterns distinguishing 271 technology-experienced (EXD=1) and 678 non-experienced (EXD=0) beekeepers. Eight predictors (CR1-CR4 and SB1-SB4) representing customer relationship and strategic benefits were used as input variables. The dataset was balanced through resampling and split into training (80%) and test (20%) sets. Model performance was evaluated with the use of accuracy, precision, recall, and F1-score (both macro and weighted), as described by Sokolova and Lapalme (2009). Feature importance was analyzed to determine which perceived benefits most strongly differentiated the two groups.

All analyses were performed in Python with the use of the scikit-learn, pandas, and matplotlib libraries.

RESULTS

Perceived customer relationship benefits of digital platform use

Beekeepers with experience using digital technologies (EXD=1) consistently reported higher mean scores across all dimensions of customer relationship benefits (CR1-CR4) compared to those without such experience (EXD=0). The differences were particularly evident for communication speed (CR1: 3.78±1.11 vs. 3.53±0.99) and relationship transparency (CR4: 3.72±1.09 vs. 3.47±1.00). As illustrated in Fig. 1, response distributions were relatively symmetrical, with slightly higher frequencies of top-scale ratings among digitally experienced beekeepers. These findings suggest that digital experience enhances perceived effectiveness and trust in beekeeper-customer interactions. The detailed descriptive statistics are presented in Table S1 in the Online Supplementary Material (Ziemba et al., 2025a).

The Mann-Whitney U tests (Tab. 2) confirmed significant differences across all four dimensions of customer relationship benefits, supporting hypotheses H1.1 through H1.4. The results indicated that beekeepers with experience using digital technology perceive significantly greater benefits in terms of communication speed, relationship quality, transparency, and overall customer interaction. These findings further suggest that digital technology experience has a positive correlation with more favorable perceptions of its usefulness in managing and improving customer relationships within the beekeeping sector.

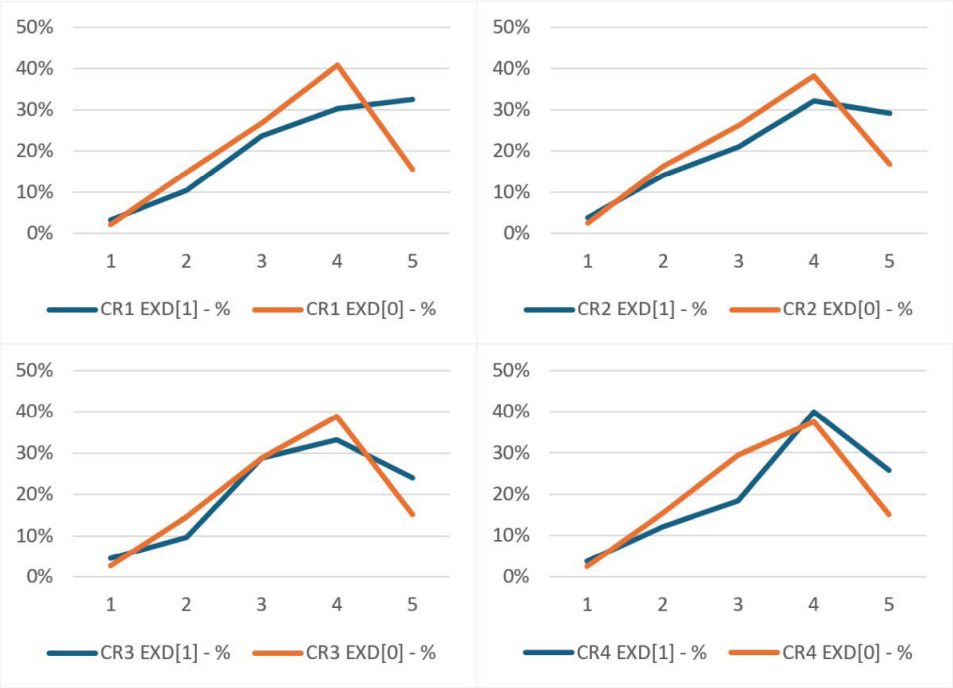

Fig. 1. Distribution of responses for perceived customer relationship benefits among beekeepers with and without digital technology experience.

Table 2.

Statistical comparison of perceived customer relationship benefits among beekeepers with and without digital technology experience

Hypothesis	Variable	Statistic	Std. err.	Sig.	Adj. sig.	Result
H1.1	CR1	105416.50	3676.88	<.001	<.001	H1.1 is supported
H1.2	CR2	102124.50	3684.22	0.005	0.022	H1.2 is supported
H1.3	CR3	106667.00	3687.28	<.001	<.001	H1.3 is supported
H1.4	CR4	107038.00	3662.92	<.001	<.001	H1.4 is supported

Perceived strategic benefits of digital platform use

Beekeepers experienced in using digital technologies (EXD=1) also reported higher mean scores across all strategic benefit dimensions (SB1-SB4) compared to those without such experience (EXD=0). The most notable differences were observed for apiary profitability (SB1: 3.66 ±1.10 vs. 3.50 ±1.01) and honey quality (SB4: 3.62 ±1.14 vs. 3.44 ±1.00). As shown in Fig. 2, response distributions were relatively symmetrical, with slightly higher frequencies of top-scale ratings among digitally experienced beekeepers. These findings suggest that digital engagement supports both economic and product-quality improvements. Comprehensive descriptive statistics are presented in Table S2 in the Online Supplementary Material (Ziemba et al., 2025a).

The Mann-Whitney U tests (Tab. 3) revealed statistically significant differences for SB1 (apiary profitability), SB2 (competitive advantage), and SB4 (honey quality), with higher scores among the experienced group (EXD=1), thereby supporting hypotheses H2.1, H2.2, and H2.4. However, no significant difference was found for SB3 (customer loyalty), leading to the rejection of H2.3 and suggesting that digital experience does not substantially affect perceptions of loyalty enhancement. It is worth noting that applying less conservative correction methods than Bonferroni might have resulted in a different conclusion for SB3, potentially revealing a significant group difference in perceptions of loyalty enhancement.

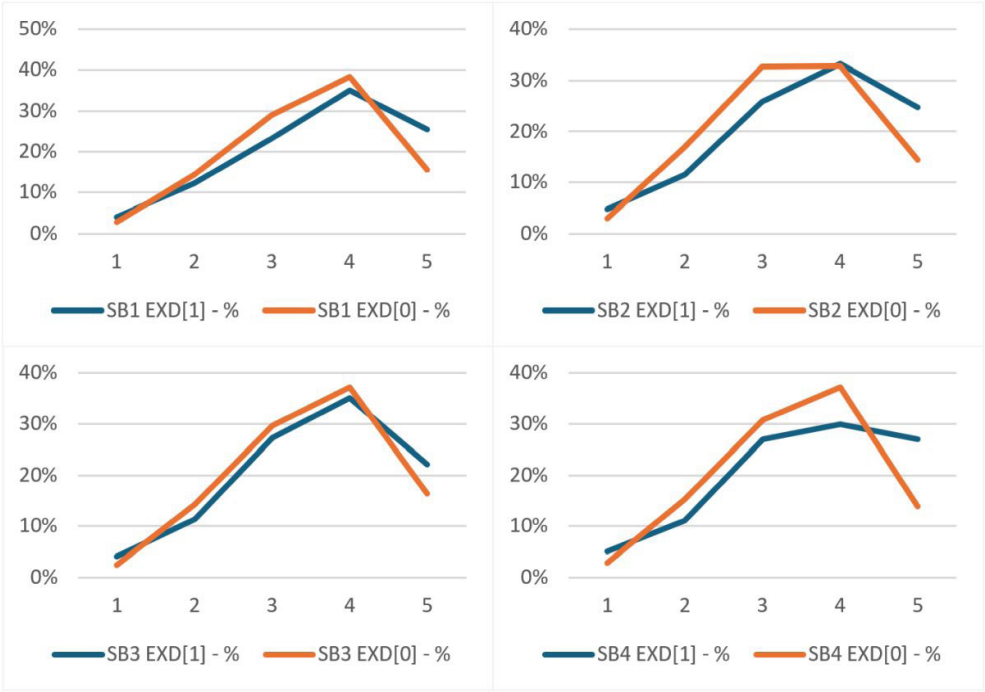

Fig. 2. Distribution of responses for perceived strategic benefits among beekeepers with and without digital technology experience.

Table 3.

Statistical comparison of perceived strategic benefits among beekeepers with and without digital technology experience

Hypothesis	Variable	Statistic	Std.err.	Sig.	Adj. sig.	Result
H2.1	SB1	105609.00	3654.28	<.001	<.001	H2.1 is supported
H2.2	SB2	101993.50	3666.37	0.006	0.023	H2.2 is supported
H2.3	SB3	99231.50	3651.94	0.044	0.176	H2.3 is rejected
H2.4	SB4	105781.50	3652.05	<.001	<.001	H2.4 is supported

Table 4.

Confusion matrix of the random forest model predicting beekeepers' digital technology experience

EXD group	Predicted Group EXD = 0		Predicted Group EXD = 1	
	Cases	Percentage	Cases	Percentage
EXD = 0	48	80.0	12	20.0
EXD = 1	8	16.3	41	83.7

Predictive importance of perceived customer relationship and strategic benefits

A random forest classification model was applied to identify which perceived benefits most strongly distinguish between beekeepers with and without experience in digital technology (EXD). Using customer relationship (CR1-CR4) and strategic benefit (SB1-SB4) indicators as predictors, the model achieved an overall accuracy of 81.7%, indicating robust predictive performance (Tab. 4). Classification metrics (Tab. 5) confirmed balanced performance across both groups, with precision ranging from 0.77 to 0.86 and recall from 0.80 to 0.84. The identical macro- and weighted-averaged

Table 5.

Classification performance metrics of the random forest model predicting beekeepers' digital technology experience

EXD Group	Precision	Recall	F1-score
0	0.86	0.80	0.83
1	0.77	0.84	0.80

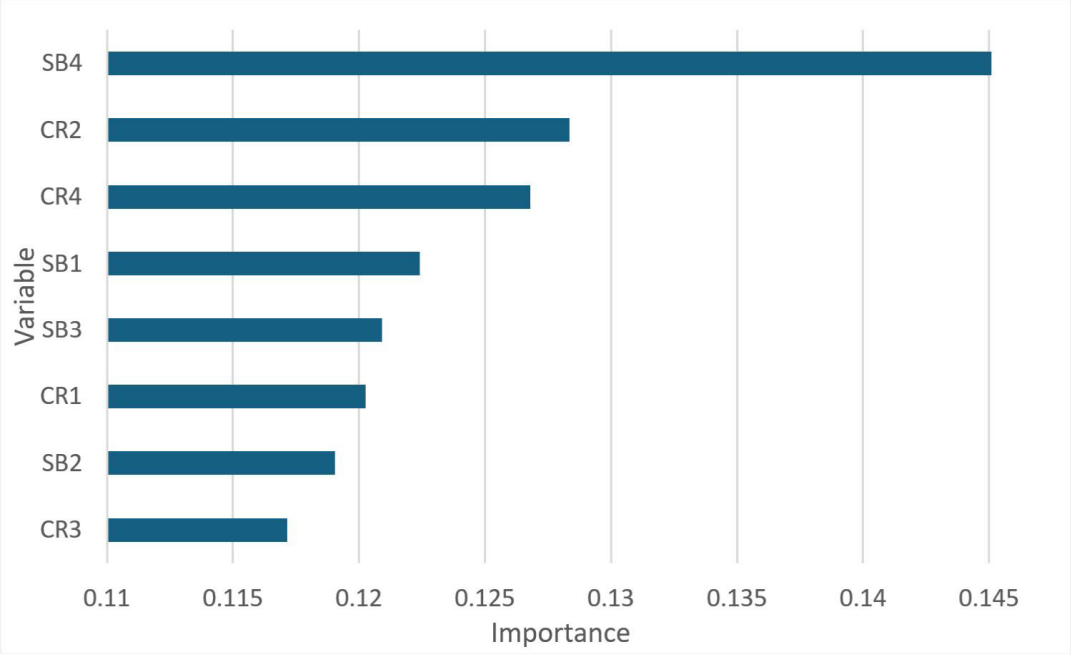

Fig. 3. Importance of perceived benefits in predicting beekeepers' digital technology experience.

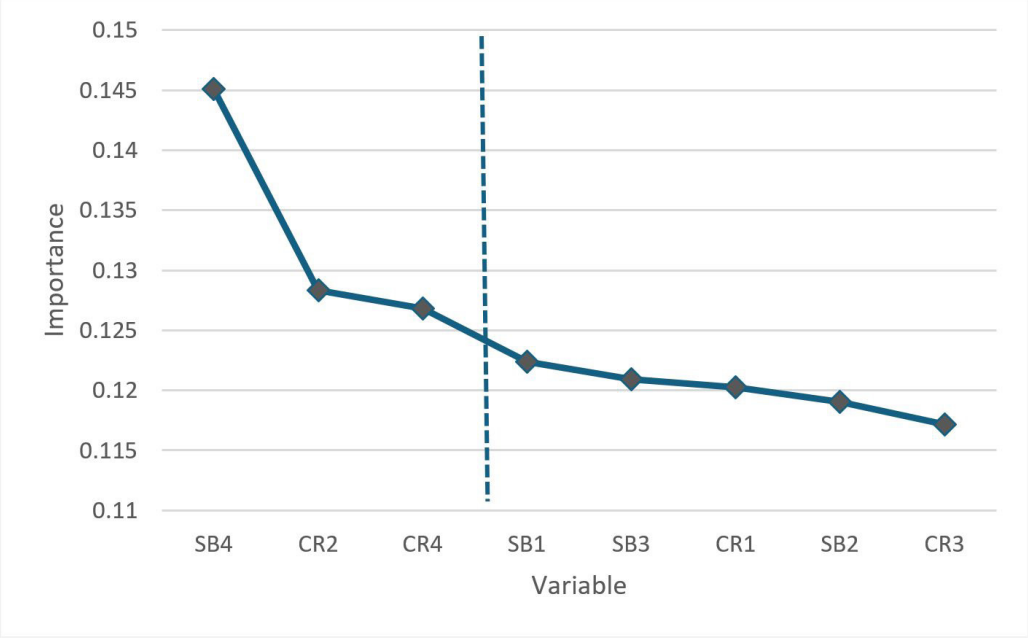

Fig. 4. Elbow plot of perceived benefit importance in predicting beekeepers' digital technology experience.

F1-scores (0.82) further supported the model's consistent reliability.

As shown in Fig. 3, SB4 (honey quality) was the most influential predictor, followed by CR2 (relationship quality) and CR4 (relationship transparency). These three benefits played the strongest role in differentiating digitally experienced and non-experienced beekeepers. The elbow plot (Fig. 4) confirmed the dominant influence of these variables, with the contribution of subsequent benefits gradually declining.

In summary, the classification results indicate that perceptions of honey quality, relationship quality, and relationship transparency most clearly differentiate beekeepers based on their digital experience. These findings highlight that both strategic and relational dimensions of perceived benefits jointly explain patterns of digital technology adoption in beekeeping.

Table 6.

Representative condensed excerpts from expert interviews on customer relationships and strategic benefits of digital platform use

Type of benefits	Experts' opinions
CR1: Communication speed	Digitalization is progressing - our future customers are online, so we need to connect with them quickly. (E5)
CR2: Relationship quality	We build long-term trust with customers through online communication. (E5)
CR3: Relationship efficiency	Online media make selling honey much easier. (E6)
CR4: Relationship transparency	Showing apiary location and production methods online builds customer trust. (E5)
SB1: Apiary profitability	Having an online shop or online platform significantly increases sales. (E23)
SB2: Competitive advantage	We should not be afraid of new technologies - they help monitor and promote our apiary. (E14)
SB3: Customer loyalty	We have customers who have been buying from us online for over 15 years. (E5)
SB4: Honey quality	We use hive monitoring data on weight, temperature, and sound to manage the apiary and improve honey quality. (E11)

Note: Condensed excerpts are presented for clarity; full interview quotations are provided in Table S3 in the Online Supplementary Material (Ziemba et al., 2025a).

Qualitative insights into perceived benefits of digital platform use

To complement the quantitative analysis, qualitative data from expert interviews were examined to gain a deeper understanding of how beekeepers perceive and experience the benefits of digital platforms. The condensed excerpts (Tab. 6) illustrate the perceived influence of digital tools on various aspects of beekeeping operations, grouped into two categories: customer relationship benefits (CR1-CR4) and strategic benefits (SB1-SB4). A full set of interview excerpts is provided in Table S3 in the Online Supplementary Material (Ziemba et al., 2025a).

The excerpts demonstrate that digital platforms are regarded as crucial tools for enhancing communication speed, transparency, and the quality of customer relationships, while also fostering higher profitability, competitiveness, and product quality. Beekeepers emphasized that digital presence enables them to reach younger consumers, build long-term trust, and maintain closer, more transparent connections with buyers. Likewise, the integration of monitoring technologies and online sales channels was described as a key driver of both operational efficiency and market advantage.

DISCUSSION

Regarding **RQ1**, the analysis revealed that beekeepers with digital experience rated the impact of digital platforms significantly higher across all relational benefits - communication speed (CR1), relationship quality (CR2), efficiency (CR3), and transparency (CR4) - than those without such experience. Mann-Whitney U tests confirmed these differences, with particularly pronounced effects observed for communication speed and transparency. Expert interviews further underscored the significance of these two dimensions, highlighting their crucial role in enabling trust and effective collaboration. These findings are consistent with broader research on supply chain transparency (Paunović & Alizadeh, 2022) and align with studies emphasizing the importance of communication and traceability solutions in strengthening consumer trust (Schiro et al., 2020; Ornelas Herrera et al., 2025). However, earlier contributions (e.g., Filippi & Chapdaniel, 2020; Kim, 2020) have rarely examined digital experience as a determinant of transparency perceptions, nor have they consistently recognized

its role as a key relational benefit. Prior research favored efficiency gains and marketing outcomes, often linked to digital communication tools (Mansourian, 2024; Sparacino et al., 2024). In contrast, our results indicate that transparency - manifested through practices such as sharing production data, honey quality information, and working methods - constitutes a cornerstone of customer relationships, and digital platforms appear to reinforce this transparency strongly.

Concerning **RQ2**, the results indicate that beekeepers with digital experience perceived greater benefits of digital platforms across most strategic outcomes, including profitability (SB1), competitive advantage (SB2), and honey quality (SB4). These findings are consistent with prior studies that documented the positive impact of digital technologies on profit generation, product quality, and market positioning in agriculture (Geng et al., 2024; Yeo & Keske, 2024) and in honey production (Paudel et al., 2025). However, these earlier studies did not explicitly examine such benefits through the lens of technological experience. A key contribution of this study is the emphasis on honey quality (SB4) as a central component of digital strategy. This outcome received the highest ratings from beekeepers with digital experience and emerged as the most important differentiator in the random forest predictive model. Expert interviews reinforced this finding, highlighting that digital platforms enable monitoring of production conditions, facilitate quality control, and support the sharing of test results – mechanisms that directly enhance honey quality. This evidence suggests that digitization in beekeeping not only strengthens sales but also reinforces the quality foundations of the product, thereby contributing strategically to competitive advantage. These results extend prior research on brand authenticity and sustainability messaging, where quality was identified as a central element of brand differentiation in digital communication (Bulmer et al., 2024), and suggest that quality can also serve as a strategic axis of differentiation in apiculture.

Interestingly, the only exception among the strategic benefits was customer loyalty (SB3), where no significant differences emerged between beekeepers with and without digital experience. While some experts acknowledged the potential long-term effects of digitization in this area, the quantitative evidence indicates that digital experience alone is not a decisive factor in shaping perceptions of loyalty. Instead, loyalty derives more directly from enduring relationships and consistently high-quality honey, with digital platforms functioning primarily as supportive tools in this process. These observations align with recent findings in the coffee sector, where product quality was found to mediate the relationship between digital engagement and customer loyalty (Taufik et al., 2022).

About **RQ3**, the predictive analysis confirmed that three benefits of digital platforms - honey quality (SB4), relationship quality (CR2), and relationship transparency (CR4) - most strongly differentiate beekeepers according to their level of digital experience. These results reinforce the conclusions drawn from the statistical analyses and align with prior research, which emphasized that higher levels of digital maturity enhance the effectiveness and efficiency of implementing technological innovations (Ladu et al., 2024).

Building on earlier evidence regarding the impact of digital technologies in beekeeping - particularly their role in improving communication, sales efficiency, and product quality (Kim, 2020; Geng et al., 2024; Yeo & Keske, 2024) - this study contributes new insights in four significant ways:

1. Conceptual clarification of benefit categories. By distinguishing between the relational and strategic benefits of digital platforms and empirically validating both in the context of beekeeping, this study provides a structured framework for understanding how digital tools reshape producer–customer interactions, moving beyond the traditional focus on efficiency and marketing outcomes.

2. Transparency as a core relational outcome. The findings highlight relationship transparency - alongside communication speed - as a central relational benefit of digital platforms. This extends existing theories of digital adoption in agriculture by demonstrating that transparency is not merely a by-product of digitization, but a primary driver of trust and relationship quality, especially among

digitally experienced beekeepers.

3. Honey quality as a strategic differentiator. The results position honey quality as a key strategic outcome of digitalization, rated more highly than customer loyalty by digitally experienced beekeepers. In doing so, the study challenges views of product quality as purely operational and instead frames it as a central axis of strategic differentiation in apiculture.

4. Digital experience as a moderating factor. The findings demonstrate that digital experience significantly moderates perceptions of digital platform benefits, amplifying the importance of quality and transparency while leaving customer loyalty unaffected. This refines existing models of digital adoption by showing that perceived outcomes depend on producers' level of digital maturity rather than being homogeneous across users.

The results of this study hold important implications for both beekeeping practice and the design and implementation of digital platforms in the sector. Four key recommendations emerge:

1. Prioritizing quality and transparency. Because honey quality, relationship quality, and relationship transparency are the main differentiators between beekeepers with and without digital experience, platform providers should prioritize features that support continuous monitoring, systematic documentation, and clear communication of product quality and production practices.

2. Targeted capacity building. Support programs for less digitally experienced beekeepers should focus on developing skills in using digital platforms for customer communication, trust-building, and sharing quality-related information, thereby reducing entry barriers and encouraging adoption.

3. Personalized digital strategies. Digitization strategies should be aligned with the beekeeper's level of digital maturity: advanced users can benefit from integrated solutions (e.g., IoT-based monitoring, traceability tools, analytics), whereas beginners require simpler, user-friendly tools that enable gradual skill development.

4. Quality-centered digital marketing. Digital platforms should be viewed not only as sales channels but also as tools for quality-based differentiation, enabling the display of certifications, laboratory test results, and origin information to strengthen consumer trust and enhance competitive positioning.

This study has several limitations. First, its cross-sectional design does not allow for causal inference between digital experience and perceived benefits of platform use. Second, the measures rely on self-reported assessments, which may be affected by perceptual bias and social desirability. Third, the sample is limited to beekeepers operating in a specific national context, which may limit the generalizability of the findings to other regions and levels of digitalization. Future research could therefore employ longitudinal designs, comparative studies across countries, and more fine-grained analyses of specific platform functionalities (e.g., IoT, blockchain, AI) and the skills required to generate different types of relational and strategic benefits.

Despite these limitations, this study addressed three key research questions concerning the perceived benefits of digital platform use among beekeepers. Regarding RQ1, the findings indicate that beekeepers with digital experience perceive stronger relational benefits, particularly in terms of communication speed, relationship quality, and transparency, confirming the central role of trust-building mechanisms in digital environments. In response to RQ2, the study demonstrates that digital platforms generate distinct strategic advantages, with honey quality emerging as the most salient differentiator and strategic resource that reinforces competitiveness. Finally, in addressing RQ3, the results highlight that digital experience moderates these relationships, amplifying perceptions of quality and transparency while leaving customer loyalty unaffected. Overall, the study positions transparency and product quality as core dimensions of both relational and strategic value creation in the honey value chain.

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DATA AVAILABILITY

The empirical material used in this article forms part of a larger mixed-methods research project on the digitalization of beekeeping conducted within a European research consortium. Because the project is still ongoing and the full datasets and research instruments are extensive, the processes of data cleaning, anonymization, and comprehensive documentation have not yet been fully completed at the project level. The de-identified quantitative dataset and the interview guide underlying the analyses reported in this article are available from the corresponding author upon reasonable request, subject to data protection and ethical requirements.

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