Improving Customer Experience Using Smart Technologies in Smart Stores

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ABSTRACT

This study investigates how ethical aspects, safe technology, and customer-friendly technologies influence the customer experience in smart stores. Smart stores are unmanned retail stores that integrate smart technologies and services. An empirical model was proposed and validated using exploratory factor analysis and multiple regression analysis, with n = 402 participants. The results demonstrate that all three constructs have a positive influence on the customer experience in smart stores. However, the results also suggest that store-based interactions (e. g. seamless access and a safe environment) have a stronger influence than product-based interactions. The results highlight the need for retailers to prioritise smart technologies that visibly enhance safety, usability, and ethical transparency. These insights support the development of smart stores that foster customer trust, improve interaction quality, and strengthen long-term customer relationships.

KEYWORDS

Smart store, customer experience, smart technologies, safe technology, ethics, customer-friendly technology

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1. Introduction

The retail sector is confronted with considerable challenges, particularly in terms of staffing shortages and pressure to maintain profitability (Grewal et al., 2023). These challenges have intensified in recent years due to a tightening labor market and increasing demands for operational efficiency (Benoit et al., 2024). Considering these developments, the implementation of smart stores represents a forward-looking response (Netscher et al., 2025). Smart stores are unmanned physical retail stores that rely on smart technologies and services, frequently based on Internet of Things (IoT) and Artificial Intelligence (AI) (Chen & Chang, 2023). Recent regulatory changes, such as court rulings permitting extended opening hours (e.g., in Hesse, Germany), are increasingly enabling the operation of smart stores and highlight the growing relevance of this retail format (Schumacher & Rüschen, 2023).
Existing research has examined the acceptance of smart stores, often drawing on established models such as the Technology Acceptance Model (TAM) or the Unified Theory of Acceptance and Use of Technology (UTAUT) (Netscher et al., 2025; Park & Zhang, 2022). These studies analyse constructs such as perceived usefulness, ease of use, and technology anxiety, providing valuable insights into consumers' willingness to adopt smart stores. Additionally, several studies have examined the perceived value of smart stores by considering utilitarian motivations, such as time efficiency and convenience, and hedonic motivations, such as enjoyment and novelty (Chang et al., 2023; Chen & Chang, 2023).

However, smart stores are progressively incorporating sophisticated smart technologies, such as computer vision, which gives rise to new concerns (Jordan et al., 2023; Jordan et al., 2025). In particular, the role of ethical considerations, perceived technological safety, and customer-friendly technologies remains underexplored (Agbese et al., 2023); and limited research exists on how these concerns influence the customer experience (Benoit et al., 2024).

To address this research gap, the present study builds upon the conceptual framework by Tiutiu & Dabija (2023), which emphasises the importance of safe and ethical technology in smart retail environments. The aim is to explore how these factors shape customer experiences in smart stores and to derive practical implications for retailers. Therefore, the study addresses the following research question: *How do ethical aspects, safe technology, and customer-friendly technology influence the customer experience in smart stores?*

To answer the research question, an empirical model was developed and validated using explorative factor analysis and multiple regression. Section 2 outlines the theoretical basis of the study. Section 3 outlines the development of the hypothesis, and Section 4 describes the methodology. The findings are presented in Section 5. Section 6 discusses the academic and practical implications. Section 7 contains the limitations and future research directions, while Section 8 concludes the study.

2. Literature Review

2.1 Smart Stores

Smart stores are unmanned retail environments that rely on smart technologies and smart services, often based on the IoT and AI, to optimise shopping processes and enable autonomous store operations (Chen & Chang, 2023). Although a universally accepted definition of smart stores is still lacking, the integration of smart technologies and services is widely recognized as a defining characteristic in the academic discourse (Benoit et al., 2024). Central to this understanding is the creation of an immersive in-store customer experience enabled by smart technologies (Alexander & Kent, 2022). The term "smart" refers to the interconnection of those smart technologies to enhance operational efficiency and improve customer experience (Adapa et al., 2020). The degree of smartness within a store is reflected in its implemented smart technologies, which can be divided into front-end and back-end services. Front-end technologies, such as interactive displays or seamless checkout, directly shape the customer experience (Fan et al., 2020). In contrast, back-end technologies support internal operations, such as

inventory tracking, but remain invisible to customers (Shankar et al., 2021).

The shopping journey usually starts with customer authentication at the store entrance. Customers scan either the store's mobile app or a registered credit or debit card at an entry terminal to facilitate a seamless transition into the shopping environment (Benoit et al., 2024).

Smart shelves enhance traditional shelving systems by using radio frequency identification (RFID) technology to enable precise, real-time inventory management (Zhu et al., 2018). RFID technology enables the continuous tracking of product locations and customer interactions within the store. When customers select items, they are automatically recorded and added to a virtual shopping basket (Chen & Chang, 2023). Payment is processed via a seamless checkout system (Jordan et al., 2023). This automated procedure charges the virtual shopping basket upon the customer leaving the store, with the corresponding amount debited from a pre-registered payment method, thus rendering the traditional checkout process obsolete (Netscher et al., 2025). Although this system increases operational efficiency and reduces transaction time, it may also lead to a reduced sense of control and transparency for customers, particularly given the novelty of the system and limited user familiarity with such technologies (Riegger et al., 2021).

Research into the acceptance of smart stores has already examined factors such as expectations and influencing conditions, particularly through established acceptance models (Netscher et al., 2025; Szabó-Szentgróti et al., 2023). These studies indicate that smart stores are generally accepted by customers. Building on this, empirical studies have shown that customers value the utilitarian benefits of smart stores, such as time savings and increased efficiency, as well as the hedonic benefits, such as the entertainment and novelty they offer (Chang et al., 2023). Further research has identified specific motivational factors that reinforce the intention to use. Perceived usefulness and perceived enjoyment have emerged as key factors that positively influence the intention to use smart stores, provided customers feel sufficiently technology-ready (Chang & Chen, 2021). Due to the novelty of smart stores the customer experience in this context has not yet been examined with regard to ethical and safe technology-related aspects. However, existing studies in related fields, particularly those focusing on the customer experience with AI in online retailing, have already incorporated constructs such as ethical considerations, safe technology and user-friendly technology (Tiutiu & Dabija, 2023). While these findings cannot be transferred directly to smart stores as physical retail stores, they clearly highlight the need for empirical research on these constructs within the context of smart in-store experiences.

2.2 Customer Experience (CX) in Smart Stores

Customer experience (CX) is an integral part of marketing and retail research (Lemon & Verhoef, 2016). CX is defined as customers' internal and subjective responses to any direct or indirect contact with a company, including technological interactions within a retail setting (Lemon & Verhoef, 2016). Previous studies have identified four aspects of CX: (a) cognitive (b) emotional, (c) physical and sensorial, and (d) social elements. Customer-friendly technologies are particularly concerned with the cognitive aspect of CX (Ameen et al., 2020). They support information processing, promote an understanding of products and services, and thus contribute to the perceived control and efficiency in the purchasing process (Ameen et al., 2021). In contrast, safe technologies and ethical aspects primarily affect the emotional dimension of the customer experience (Agbese et al., 2023). Data protection, transparency in the handling of personal data and the feeling of being respected and protected are decisive emotional elements that significantly influence the experience in smart stores. Studies show that the perceived protection of personal data in particular is a key factor influencing the acceptance of smart technologies (Budiharseno & Kim, 2023). In the field of human-computer interaction, mainly AI, researching interactive technologies in a tangible retail setting has been demonstrated to enhance comprehension of the CX and its outcomes. These outcomes are linked to constructs such as customer satisfaction, loyalty, reuse intention, customer retention, word of mouth and purchase intention (Chang et al., 2023). Statistics indicate that approximately half of the customers will not return to a store if they have had a poor experience (Kishen et al., 2021). As smart stores rely on smart technologies to shape shopping environments, they offer new

and immersive touchpoints that influence the cognitive, emotional, sensorial, and social dimensions of customer experience (Vadruccio et al., 2024). Additionally, given that smart stores are a novel combination of various technologies and services, it is reasonable to assume that CX will also be redesigned (Ameen et al., 2021). Therefore, it is crucial to prioritize providing a positive CX to retain customers in the long run. Research about online retail indicates that the utilization of ethical technologies can effectively promote customer satisfaction and foster long-term customer loyalty (Tiutiu et al., 2025).

3. Research Framework

We adapted the model developed by Tiutiu & Dabija (2023), which incorporates the constructs of safe technology, ethical aspects, and customer-friendliness, as the findings of their study clearly underscore the need for empirical investigation within the context of smart, technology-driven store experiences. Figure 1 illustrates the research framework. The hypotheses along with its composition are presented below.

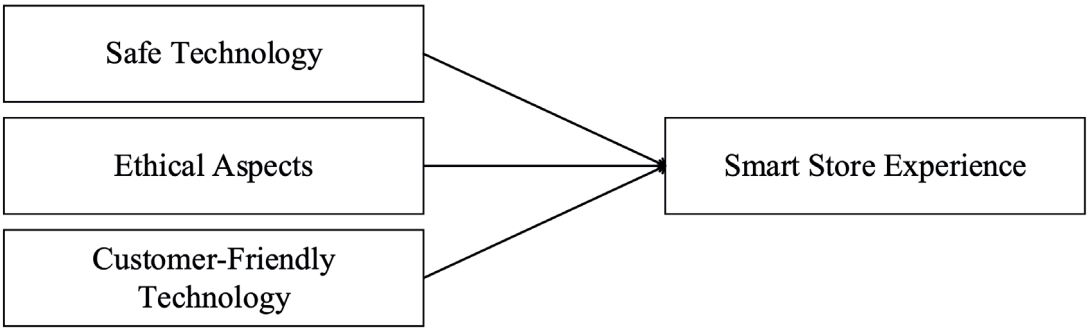

Figure 1: Conceptional research model. Source: According to Tiutiu & Dabija, 2023.

3.1 Safe Technologies in Smart Stores

Advanced smart technologies such as computer vision or customer tracking can analyze customer purchasing behavior, enabling the identification of trends and future purchasing patterns of the smart store customers (Jordan et al., 2025). This technology uses information collected during the purchase process to generate personalized purchase suggestions (Kishen et al., 2021). A major issue arising from the use of customer behavior and purchase analytics in retail is that the implementation of the technology and the resulting commercial benefits to retailers come at a potentially disproportionate cost to privacy (Gregorczuk, 2022). Therefore, apprehensions about misusing digital financial data can increase discomfort (Pillai et al., 2020). Customers may have concerns about how smart technologies are used in a smart store and whether the associated collection and management of their data is transparent and secure. Gregorczuk (2022) shows how monitoring and data collection can undermine customer privacy. Studies in China indicate that a clear and focused communication of secure digital payment methods can enhance trust in them (Qu et al., 2022). Prioritizing customer privacy is crucial given that customers are required to share their personal and financial data with the smart store's integrated technologies. This information must be treated as strictly confidential (Ameen et al., 2020). Smart stores should aim to improve CX by creating seamless, engaging experiences that address customers' concerns about the security of their personal information (Kishen et al., 2021).

Hypothesis 1: Safe technologies have a positive influence on customer experience within smart stores.

3.2 Ethical Aspects in Smart Stores

Following the consideration of safe technology, the question that arises pertains to its alignment with social norms and values. There are various definitions and fields of ethics. Essentially, ethics is the

discipline concerned with distinguishing between right and wrong, and with exploring the moral obligations and duties of individuals (Siau & Wang, 2020). Ethics serve as the basis for all decision-making processes. However, there is no singular universal ethic that can be applied comprehensively; instead, principles must be tailored to specific situations (Ibiricu & Made, 2020). The growing integration of software and associated hardware with AI requires clear regulation to build and maintain trust between customers and technologies (Ibiricu & Made, 2020). In this context, the term "ethical AI" has become widely used. Based on the recommendations of high-level expert groups, the European Union has defined four key principles of ethically sound AI: Respect for Human Autonomy, Prevention of Harm, Fairness, and Explicability (Siau & Wang, 2020). Failing to comply with these ethical principles can cause severe and lasting damage to a vendor's reputation. Moreover, if technology is implemented in a way that is perceived as unlawful or unethical, it can lead to a significant loss of customer trust and to unfavourable experiences (Ibiricu & Made, 2020). Therefore, the positive potential of AI-based technologies integrated into smart stores must be carefully balanced against possible negative consequences arising from insufficient ethical consideration. To ensure fairness and transparency, the benefits of these technologies should be made accessible to all customers, rather than being limited to a select group. In this context, the customer perspective is crucial, as customers ultimately determine whether they accept and use the technology (Budiharseno & Kim, 2023). Their perceptions, concerns, and expectations directly influence the customer experience and play a decisive role in the long-term success of smart stores.

Hypothesis 2: Ethical aspects have a positive influence on customer experience within smart stores.

3.3 Customer-Friendly Technology in Smart Stores

Customers can experience an immersive and pleasurable shopping environment through advanced smart retail technology. According to Chen & Chang (2023), a customer-friendly experience with the technologies in a smart store has two main aspects: ease of interaction and usefulness of interaction. Ease of interaction represents the actual difficulty of interacting with the technologies. Usefulness of interaction describes the degree to which an interaction contributes to generating a more efficient shopping experience (Chen & Chang, 2023). Both aspects have a high influence on the purchase intention and the associated experience with the smart store (Chen & Chang, 2023). However, concerns about consumer acceptance and psychological responses to smart store technologies surface when consumers must cope with advanced technologies (Jordan et al., 2023). Additionally, Khan & Iqbal (2020) highlighted the challenge of replicating human interaction in digitized customer service, suggesting a potential limitation to the positive influence of customer-friendly technology on customer experience (Roy et al., 2018). To overcome the lacking human-to-human interaction, customers at smart stores can enjoy personalized, seamless, and enjoyable shopping experiences facilitated by advanced technology (Chen & Chang, 2023). Based on these findings, it can be assumed that by offering superior and individualized retail services, smart retail technologies have the potential to enhance the customer experience.

Hypothesis 3: Customer-friendly technology has a positive influence on customer experience within smart stores.

4. Research Methodology

4.1 Data Collection

The data collection period spanned from November 15th to December 28th, 2023. During this time, a total of n = 402 complete data sets were collected. The survey was distributed via multiple digital channels, including social media, messaging services, email and online panels in Germany, with a deliberate focus on consumers belonging to Generation Z. This customer segment is considered especially pertinent to the investigation of smart stores owing to its high level of technological affinity, its role as an early adopter of smart technologies, and its growing economic significance (Kim et al., 2022). The behavioral and perceptual patterns of this generation serve as meaningful indicators for anticipating future developments in the retail sector (Kim et al., 2022).

The survey uses a quantitative approach chosen for its advantages in terms of standardization and comparability (Backhaus et al., 2023). Data were collected using an online questionnaire in Lighthouse (Sawtooth) given that online questionnaires are efficient for collecting large amounts of data within a limited timeframe while also reaching a large and diverse number of respondents at low cost (Backhaus et al., 2023). These characteristics render online questionnaires particularly suitable for exploratory research in technology-related fields, where rapid data collection and broad accessibility are essential (Backhaus et al., 2023).

To ensure a consistent and sufficient understanding of smart stores among all participants, the questionnaire commenced with a self-produced explanatory video (see Appendix 1). This video illustrated a typical shopping journey in a smart store, showcasing relevant technologies and service interactions, such as autonomous checkout, digital signage and mobile assistance. The visual-narrative format served to reduce variability in prior knowledge, facilitated cognitive accessibility, and thus contributed to more informed and consistent responses across the sample. Subsequently, participants were asked to indicate their level of agreement with various items, using five-point Likert scales. To minimize order effects, the items were displayed in a randomized sequence. Finally, sociodemographic data were collected to enable ex-post analysis of sample heterogeneity and control for potential biases in subsequent evaluations (see Table 1).

While this broad distribution enabled efficient outreach, it also posed the risk of self-selection bias, as individuals with a greater interest in technology or digital retail concepts may have been more likely to participate. To mitigate this risk, the invitation text was designed to be neutral and accessible, targeting a general audience and not assuming any prior knowledge (Backhaus et al., 2023).

Item	Category	Frequency	%
Gender	Male	143	35.6
	Female	249	61.9
	Diverse	2	0.5
	Not specified	8	2.0
Age	Generation Z	270	67.2
	Generation Y	66	16.4
	Generation X	43	10.7
	Baby Boomers	23	5.7
Highest educational qualification	No high school degree	14	3.5
	High school degree	111	27.6
	Completed apprenticeship	68	16.9
	Bachelor, Master's degree or higher	209	52.0

Table 1: Sociodemographic data of the total sample. Source: Own research, 2023, $n = 402$.

4.2 Scales

The associated items were selected from the scales of Tiutiu & Dabija (2023) and extended by validated scales of Inman & Nikolova (2017) (see Table 4). Each item is constituted by a statement on a five-point Likert scale (1 = total disagreement and 5 = total agreement). Since the online questionnaire has been distributed primarily to German citizen, the English items have been translated into German with the back-translation method by involving independent language experts. The translation process emphasized the necessity to expand the original items with suiting examples to ensure comprehensibility.

To confirm the reliability, consistency and validity of the data, the mean, standard deviation (SD) and

Cronbach's alpha coefficient (> 0.7) were analyzed using SPSS. The Kaiser-Meyer-Olkin (KMO) criterion (> 0.7) and Bartlett's test of sphericity were also analyzed as these are specific to exploratory factor analysis (Kumar et al., 2017). The outcomes are displayed in Table 2 and confirm the reliability and validity of the measurement for all constructs except ethical aspects, which yielded slightly lower internal consistency (Cronbach's α = 0.683). However, this value is considered acceptable for new constructs in exploratory research where thresholds above 0.60 can be considered acceptable (Gliem & Gliem, 2003; Hair Jr et al., 2010). Additionally, the slightly reduced internal consistency may reflect the multidimensional and subjective nature of ethical considerations in the context of smart stores.

Construct	Items	Mean	SD	α	KMO	Bartlett	Eigenvalue	% variance
Safe technology	4	3.538	0.675	0.724	0.805	< 0.001	2.132	16.402
Ethical aspects	4	2.105	0.755	0.683	0.805	< 0.001	1.135	8.735
Customer-friendly technology	5	3.992	0.641	0.794	0.805	< 0.001	3.945	30.347
Smart store experience	11	3.517	0.617	0.864	0.902	< 0.001	4.774	43.402

Table 2: Reliability, consistency and validity tests on the total sample.
Source: Own research, 2023, *n* = 402. KMO: Kaier-Meyer-Olkin; SD: standard deviation.

4.3 Data Analysis

The data analysis was conducted in two steps. First, an exploratory factor analysis (EFA) was performed to examine the dimensional structure and validity of the constructs; second, multiple regression analyses were applied to test the hypotheses and determine the influence of the independent variables on the smart store experience.

Prior to the analysis, incomplete questionnaires were removed to reduce bias and ensure data quality (Backhaus et al., 2023). The constructs safe technology, ethical aspects, customer-friendly technology, and smart store experience were then subjected to an exploratory factor analysis with varimax rotation (Williams et al., 2010). This statistical method is used to uncover latent structures among observed variables and is particularly useful in the early stages of scale development and validation (Williams et al., 2010). Principal axis factoring was selected as the extraction method to identify the common variance among the items. The extracted factors are interpreted as latent variables, which serve as the conceptual basis for the subsequent regression analyses. Table 4 shows the factor loadings, eigenvalues and explained variance for each construct. Only factors with eigenvalues greater than 1 were retained (Backhaus et al., 2023). During the analysis, two items from the customer-friendly technology construct were excluded due to low factor loadings. A semantic review revealed that these items referred to back-end processes that are not directly perceivable by customers. Their removal increased internal consistency and improved the overall model fit.

Based on the factor structure identified in the first step, multiple regression analyses were conducted to examine the influence of three independent variables – safe technology, ethical aspects and customer-friendly technology – on the smart store experience. Prior to conducting the multiple regression analyses, the dataset was tested for the linear relationship between the variables, outliers, the independence of the residuals, multicollinearity, homoscedasticity and the normal residual distribution (Hair Jr et al., 2010; Huber et al., 2007; Velleman & Welsch, 1981). The data showed a good fit for all

conditions; therefore, the prerequisites for multiple regression were met. Each regression model was then evaluated in terms of its fit, statistical significance and the strength of the individual predictors.

5. Findings

The results of the exploratory factor analysis revealed a two-factor structure for the smart store experience construct. Therefore, the original construct was divided into two sub-dimensions: store-based interaction and product-based interaction. A semantic analysis confirmed that the first factor encompasses items related to the overall shopping experience and interaction with the smart store, while the second factor includes items focused on the interaction with and evaluation of individual products (see Table 4). Based on these findings, we re-evaluated the reliability, consistency, and validity of the two new constructs (see Table 4). The analysis indicates satisfactory reliability and validity, supporting the suitability of the revised two-dimensional structure for further analysis.

Construct	Items	Mean	SD	α	KMO	Bartlett	Eigenvalue	% variance
Store-based interaction	6	3.682	0.698	0.849	0.891	< 0.001	4.341	48.233
Product-based interaction	3	3.321	0.807	0.782	0.891	< 0.001	1.218	13.536

Table 3: Reliability, consistency, validity and descriptive parameters on selected constructs.
Source: Own research, 2023, *n* = 402. KMO: Kaier-Meyer-Olkin; SD: standard deviation.

5.1 Exploratory Factor Analysis

The smart store experience treated as a holistic construct reveals that all item factor loadings exceed 0.4 (see Table 4). According to Hair Jr et al. (2010), loadings above 0.3 are considered significant for sample sizes larger than N = 350. With a sample size of n = 402 participants, the observed values are therefore deemed acceptable. Nonetheless, based on the findings from the exploratory factor analysis, the two sub-dimensions were retained for further analysis. Their results were examined individually, compared with one another, and subsequently evaluated in relation to the smart store experience.

Items	Item loading	Reference
Safe technology		
The implementation of new technology is safe despite the considered risk regarding transactions.	0.592	Tiutiu & Dabija, 2023
The use of new technology is safe when it comes to the protection of privacy.	0.586	
Thanks to new technologies such as AI, the shopping experience can be improved.	0.613	
It is of high importance that a certain technology is perceived as pleasant and therefore accepted.	0.524	

Ethical aspects		
It is justifiable that certain technologies do not help customers who are not expected to buy.	0.424	Tiutiu & Dabija, 2023
Is it ethically justifiable to automatically recommend a more expensive product when a cheaper product might be more suitable for the customer.	0.718	
Is it justifiable to prefer certain customers – that only certain customers are eligible to use technologies, for example: Customer classifications in apps which could lead to different discounts.	0.569	
Is it ethically justifiable to put pressure on customers so that they buy as much as possible.	0.699	
Customer-friendly technology		
I believe the use of this specific technology will be clear and easy to understand.	0.576	Inman & Nikolova, 2017
It will be easy for me to use this technology.	0.716	
It would be easy for me to use this technology in the store.	0.770	
This technology helps to provide fast, personalized and qualitative services.	0.403	Tiutiu & Dabija, 2023
This technology includes the transaction process, so everything works out well.	0.577	
Store-based interaction		
I can easily interact with the smart store.	0.532	Tiutiu & Dabija, 2023
The shopping experience seems safe.	0.543	
This technology enables me to enjoy new experiences.	0.585	
I believe it would be useful to use this technology in the store.	0.733	Inman & Nikolova, 2017
I believe this technology will influence my shopping experience positively.	0.778	
I believe this technology will add value to the overall service of the store.	0.754	
Product-based interaction		
It helps me to make better decisions regarding products I might want to buy.	0.654	Tiutiu & Dabija, 2023
It helps me to find the right products.	0.697	
It helps me to evaluate the product.	0.739	

Table 4: Factor loading exploratory factor analysis. Source: Own research, 2023, $n = 402$.

During the analysis, the construct store-based interaction was reduced by one item due to a low factor loading (0.351) leading to an improvement in Cronbach's alpha after its removal. The same procedure was applied to one item in the product-based interaction construct. The results of the exploratory factor analysis can be visualized in the Figure 2.

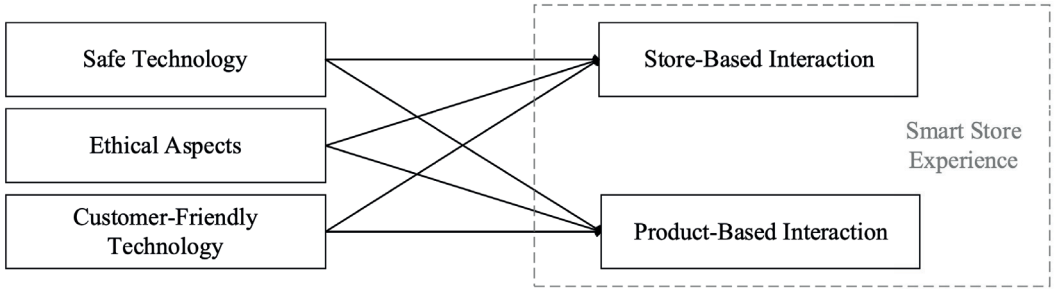

Figure 2: Adjusted conceptual model with two sub-dimensions.

5.2 Sub-Dimensional Multiple Regression Analysis

Multiple regression analyses were conducted using safe technology, ethical aspects and customer-friendly technology as the independent variables. Following the factor structure of the exploratory factor analysis, the dependent variable in the first model was the sub-dimension of store-based interaction. The same analysis was subsequently performed with product-based interaction as the dependent variable (see Table 5). Figure 3 shows the results obtained from these models.

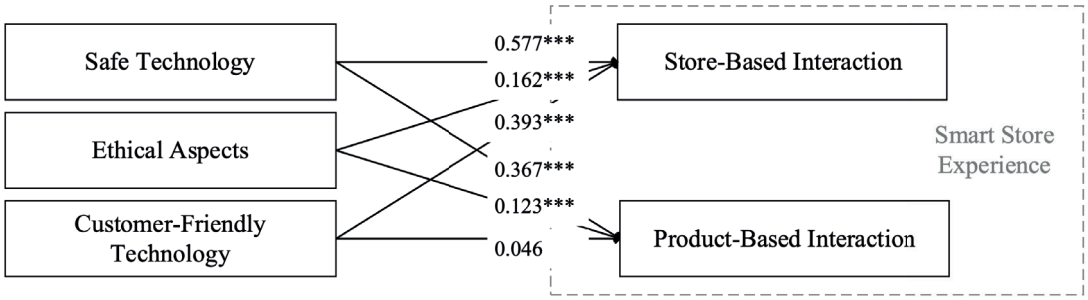

Figure 3: Adjusted conceptual model with two sub-dimensions and regression coefficients.
Source: Own research, 2023, $n = 402$; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

For store-based interaction, the model shows a high goodness of fit, with a coefficient of multiple determination of $R^2 = 0.626$ (adjusted $R^2 = 0.623$) and is statistically significant ($p < 0.001$). All three predictors demonstrate significant and positive effects. Safe technology emerges as the strongest predictor ($\beta = 0.577$, $p < 0.001$), indicating that perceptions of technological safety play a central role in shaping customer experience within smart stores. Customer-friendly technology also exerts a considerable influence ($\beta = 0.393$, $p < 0.001$), suggesting that intuitive and user-friendly features contribute meaningfully to a positive shopping experience. Although the effect is smaller, ethical aspects still have a statistically significant impact ($\beta = 0.162$, $p < 0.001$), underscoring the importance of fairness and transparency in how customers perceive and engage with the store.

In contrast, the product-based interaction model shows a lower fit, with an R^2 of 0.149 (adjusted $R^2 = 0.142$). Nonetheless, the model is statistically significant ($p < 0.001$). The pattern of effects differs from the store-based interaction model. Safe technology again shows a significant influence ($\beta = 0.359$, $p < 0.001$), although the effect is weaker. Ethical aspects also have a significant, albeit smaller, effect ($\beta = 0.115$, $p = 0.008$), indicating that fairness matters even in more task-based interactions. In contrast, customer-friendly technology does not exert a significant effect in this context ($\beta = 0.025$, $p = 0.359$).

The confidence interval for this variable cross zero ([-0.049, 0.135]), suggesting that usability-related features have little to no influence on how customers interact with individual products in smart stores. Overall, these findings highlight safe technology as the most robust and consistent predictor across both interaction levels. While ethical aspects also play a relevant role, particularly in establishing trust, customer-friendly technology appears to be more influential at the overall store level than in product-specific interactions. This is consistent with the exploratory factor analysis results, in which product-based interaction was associated with a comparatively low eigenvalue.

Model	Variable	Beta	Standard error	T-Value	Sig.	95% Confidence Interval
Store-based interaction	Safe technology	0.577	0.025	18.304	< 0.001	[0.408, 0.506]
	Customer-friendly technology	0.393	0.023	12.500	< 0.001	[0.244, 0.335]
	Ethical aspects	0.162	0.023	5.288	< 0.001	[0.076, 0.165]
Product-based interaction	Safe technology	0.367	0.050	7.281	< 0.001	[0.268, 0.466]
	Customer-friendly technology	0.043	0.047	0.918	0.359	[-0.049, 0.135]
	Ethical aspects	0.123	0.046	2.677	0.008	[0.033, 0.213]

Table 5: Sub-dimensional multiple regressions. Source: Own research, 2023, *n* = 402. Sig.: significance.

5.3 Aggregated Multiple Regression Analysis

To address the hypotheses as a whole, multiple regression was performed with the construct smart store experience treated as a holistic concept (see Figure 4). The overall model of the smart store experience shows a high goodness of fit, with a multiple coefficient of determination of $R^2 = 0.570$ (adjusted $R^2 = 0.567$). The model of smart store experience is statistically significant ($p < 0.001$).

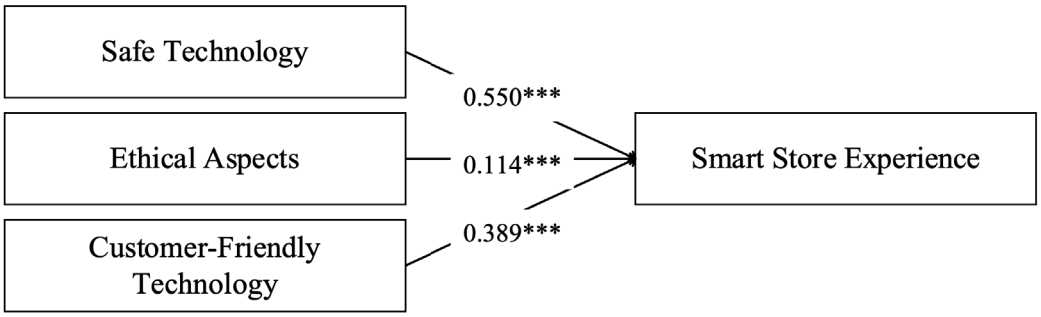

Figure 4: Aggregated multiple regression. Source: Own research, 2023, *n* = 402; * p < 0.05, ** p < 0.01, *** p < 0.001.

Again, safe technology emerges as the strongest predictor ($\beta = 0.550$, $p < 0.001$), indicating that perceived safety in the use of smart technologies plays a key role in shaping the overall customer experience in smart stores, therefore H1 can be accepted (see Table 6). Customer-friendly technology

also shows a substantial and highly significant influence (β = 0.389, p < 0.001), suggesting that intuitive, easy-to-use systems meaningfully contribute to a positive experience, thus accepting H2. Although smaller in effect size, ethical aspects remain a significant factor (β = 0.114, p < 0.001), accepting H3 and highlighting the importance of fairness, and transparency.

Model	Variable	Beta	Standard error	T-Value	Sig.	95% Confidence Interval
Smart Store Experience	Safe technology	0.550	0.038	16.290	< 0.001	[0.543, 0.692]
	Customer-friendly technology	0.389	0.035	11.543	< 0.001	[0.337, 0.475]
	Ethical aspects	0.114	0.035	3.477	< 0.001	[0.052, 0.188]

Table 6: Aggregated multiple regression. Source: Own research, 2023, *n* = 402. Sig.: significance.

6. Discussion and Implications

Considering the increasing implementation of smart technologies in physical retail environments, this study contributes to a deeper understanding of how ethical aspects, and safe and customer-friendly technology influence the CX in smart stores. The findings confirm the significance of all three examined constructs in shaping a positive customer experience (Chang et al., 2023; Chang & Chen, 2021; Netscher et al., 2025; Tiutiu et al., 2025) and reveal important differentiations between store-based and product-based interactions. The distinction between store-based and product-based interactions is grounded in both the results of the exploratory factor analysis and the semantic analysis of the item content. While the factor analysis revealed a two-dimensional structure within the smart store experience, the subsequent interpretation of item meaning confirmed that one dimension captures interactions with the overall store, whereas the other reflects interactions at the product level. This empirically derived distinction provides a differentiated understanding of how smart technologies shape customer experience in smart stores. Safe technology, ethical aspects and customer-friendly technology had a significantly strong influence on the customer experience of store-based interactions. This suggests that customers primarily evaluate smart stores based on how seamless, safe and convenient the environment is perceived to be (Chang & Chen, 2021). In contrast, safe technology and ethical aspects had a weaker, yet still measurable effect on product-based interactions. Surprisingly, however, customer-friendly technology had no effect on the experience of product-based interactions. This may be due to a lower familiarity with such technologies or their limited presence in current smart stores (Park & Zhang, 2022). While store-based technologies in smart stores are already perceived as standard and indispensable, product-based technologies appear to be less pertinent in the current shopping experience and require further development and customer engagement (Grewal et al., 2023). These findings emphasise the importance of retailers first ensuring a smooth and trustworthy in-store environment before focusing on improving product-level interactions.

6.1 Theoretical Implications

This study makes three significant contributions to the theoretical understanding of CX in smart stores. Firstly, it extends existing technology acceptance models, such as the TAM and the UTAUT, by incorporating the concepts of safe technology, ethical aspects, and customer-friendly technology into the analysis of CX in smart stores. Moreover, the study adapts Tiutiu & Dabija's (2023) model for a physical retail context, which has thus far remained unexplored. While these studies are often applied to online retail settings, this study demonstrates their applicability and relevance in smart stores, thereby

expanding the scope of CX research in retail. Secondly, the findings refine the understanding of the dimensionality of CX in smart retail settings. Identifying store- and product-based interactions as distinct sub-dimensions of CX provides a more nuanced view of how customers perceive and evaluate smart stores. This distinction in dimensions aligns with Lemon and Verhoef's (2016) CX framework, further specifying the effect of different types of technological interaction, ranging from holistic, system-level experiences to concrete, product-level support, on customer experiences. Separating these two dimensions suggests that CX in smart stores is structured along multiple interaction layers, each shaped by different technological attributes. Thirdly, this research enhances the understanding of the technology readiness of previous studies by showing that customer experience in smart stores increases when they are perceived as safe and ethical regarding data privacy (e.g. Park, 2020).

6.2 Practical Implications

The findings indicate that retailers do not only have to enhance the quality of in-store interactions but also recognize the importance of fostering seamless customer engagement with products as a distinct objective. In terms of store-based interaction, the objective is to create a physical store that is enhanced by smart technologies which contribute to the store's safety and service. Product-based interaction focuses on product experience, product advice and decision support. To illustrate this, technologies such as interactive digital shelf displays, mobile self-scanning devices, and AI-powered recommendations are examples of solutions that enable engaging and personalized product experiences (Vadruccio et al., 2024). To ensure that the customer has the best possible experience it is essential that both aspects are considered separately in the future.

A more detailed analysis of the topic allows for the identification of differences in the importance attributed to the various constructs. The interest of consumers in customer-friendly technologies is contingent upon their capacity to directly influence the customer experience in a smart store. Consequently, when implementing or improving a smart store, retailers should prioritize customer-facing technologies that visibly and directly enhance the customer experience as back-end technologies are not subject to customer judgement. Examples of such customer-facing technologies include smart mirrors in fashion retail, digital price tags, and real-time queue management systems that improve perceived service efficiency. Furthermore, there is a distinction between customer-friendly technology in product-centric and store-centric interactions. Implementing smart store technologies that prioritize usability, utility, functionality and personalized experiences will significantly improve the in-store experience. For instance, the integration of automated checkout systems (e.g., Amazon Go), or personalized shopping apps that guide customers through the store based on preferences or previous purchases, are concrete implementations that align with these expectations (Jordan et al. 2025). To optimize the customer experience, retailers should refine technologies that have a direct impact on the in-store environment. Customer convenience considerations for product-based interactions can take a back seat to the broader context of smart store implementation strategies. In the context of customer experience in smart stores, the primary focus is on secure technologies, underscoring the necessity for retailers to adhere to security protocols while providing personalized experiences through smart store technologies. It is recommended that future retail strategies should aim to ensure the privacy and confidentiality of personal data. While consumers recognize the importance of secure technologies in the context of smart stores, they do not currently associate inherent risks with existing smart store technologies. Therefore, efforts to explicitly communicate the security measures of these technologies do not need to be intensified. This highlights that the perceived value of these technologies outweighs concerns about their use and privacy, emphasizing the importance of implementing secure technologies while balancing consumer expectations and communication efforts. In both product and business-based interactions, consumers are aware of certain injustices resulting from the use of technologies in the smart store. On average, consumers do not agree that the use of technologies which discriminate between customers or work to a customer's financial disadvantage is justified. Therefore, it cannot be said that customers simply dismiss ethical concerns and have a better customer experience as a result. Rather, it is necessary to consider ethical concerns when implementing smart stores rather than assuming their absence.

7. Limitations and Future Research

This study provided valuable insights into the customer experience in smart stores. Several limitations should be acknowledged, each of which opens avenues for future research. Firstly, the findings are based on a random sample of participants from Germany, which restricts how widely the results can be generalized to other cultural and regional contexts. Future studies should replicate the research in diverse geographic regions to examine potential cultural differences in perceptions of safe technologies, ethical aspects, and customer-friendly technology. Secondly, participants engaged with the concept of a smart store via a video simulation rather than through physical interaction. While this approach ensured consistency, it may not fully capture real-world behavior and perceptions. Further research should be conducted in real or simulated smart store environments, allowing participants to interact directly with the technologies and generate more authentic responses. Thirdly, the study focused primarily on Generation Z, with older cohorts such as the Baby Boomers being less presented. As experience with smart stores may vary by age, future studies should compare generational differences in the evaluation of smart stores, particularly about ethical aspects and safety perceptions. Fourthly, the findings suggest that product-based interaction is less well explained by the applied constructs than store-based interaction. This suggests a need for further exploration into the specific drivers of product-based experiences. Future research should treat product-based interaction as a distinct and specialized field, developing constructs that reflect its unique characteristics and complexity. In summary, these limitations highlight the importance of situationally grounded and customer-centered approaches in future research. While this study is an important step in operationalizing the concept of the smart store experience, it also establishes a basis for further refinement and theoretical development in this emerging field.

8. Conclusion

The study demonstrates that safe technology, ethical aspects and customer-friendly technology have a significant influence on the customer experience in smart stores. By adapting and extending existing models to the context of smart stores, the study addresses a notable gap in the literature and contributes to a deeper understanding of CX in smart stores. The empirical findings emphasize that safe technologies have the strongest influence, followed by ethical aspects and customer-friendliness, particularly regarding store-based interactions. Differentiating between store- and product-based experiences reveals that customers evaluate smart stores on multiple levels. These insights are relevant not only for advancing academic discourse, but also for designing inclusive, trustworthy and customer-oriented smart stores.

Conflicts of Interest Statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Appendix

Appendix

Appendix 1: Online questionnaire

Video introduction with self-produced video					
Five-point Likert scaled items for each construct	**Fully disagree**	**Disagree**	**Neutral**	**Agree**	**Fully sagree**
Safe technology					
The implementation of new technology is safe despite the considered risk regarding transactions. The use of new technology is safe when it comes to the protection of privacy. Thanks to new technologies such as AI, the shopping experience can be improved. It is of high importance that a certain technology is perceived as pleasant and therefore accepted.					
Ethical aspects					
It is justifiable that certain technologies do not help customers who are not expected to buy. Is it ethically justifiable to automatically recommend a more expensive product when a cheaper product might be more suitable for the customer. Is it justifiable to prefer certain customers - that only certain customers are eligible to use technologies, for example: Customer classifications in apps which could lead to different discounts. Is it ethically justifiable to put pressure on customers so that they buy as much as possible.					
Customer-friendly technology					
I believe the use of this specific technology will be clear and easy to understand. Technology is useful to ensure that products are in-stock. I believe that my interaction with this technology will be clear and understandable.					

Technology is useful to provide data extraction solutions for the suppliers. Technology is useful for the customer data extraction solutions for the suppliers. It will be easy for me to use this technology. It would be easy for me to use this technology in the store. This technology helps to provide fast, personalized and qualitative services. This technology includes the transaction process so everything works out well.					
Smart store experience					
I can easily interact with the smart store. The smart store creates an experience similar to that of a real store. The smart store offers me the opportunity to interact with the products. The shopping experience seems safe. This technology enables me to enjoy new experiences. I believe it would be useful to use this technology in the store. I believe this technology will influence my shopping experience positively. I believe this technology will add value to the overall service of the store. It helps me to make better decisions regarding products I might want to buy. It allows me to enjoy being immersed in a new existing experience. It helps me to find the right products. It helps me to evaluate the product.					
Socio-demographic questions					
What is your country of residency?	*Dropdown menu featuring all possible countries*				
What is your current residential situation?	*Single choice question featuring "Rural (<5,000 inhabitants), small city (5,000–20,000), medium-sized city (20,000–500,000) and large city (>500.000)*				
What is your mother tongue?	*Multiple choice with selected languages (German, English, Turkish, Arabic, Spanish, French, Italian and a custom field to put further text answers)*				
How old are you?	*Numeric question design to type respondent's age*				
Please select your highest level of education.	*Single choice question with several answers (Secondary school, A levels, apprenticeship, bachelor's degree, master's degree or higher)*				

Source: Own research, 2023, $n = 402$.