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SMART GROCERY PERSONALIZATION AND THE PRIVACY PARADOX: A VALUE CO-CREATION PERSPECTIVE

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ABSTRACT

Personalization plays an increasingly prominent role in digital retail (AI), offering consumers tailored experiences that enhance convenience and relevance. However, this benefit is accompanied by growing concerns over privacy and data use, a tension widely recognized in the literature. This study explores that tension by examining the interplay between personalization, value co-creation, and data literacy within the Stimulus-Organism-Response (S-O-R) framework. Grounded in service-dominant logic (Vargo & Lusch, 2008) and the privacy calculus perspective, we propose a moderated mediation model in which personalization influences adoption intention indirectly through value co-creation, with data literacy acting as a moderator. Using a mixed-methods design including qualitative interviews, a survey, and structural equation modelling, the study provides empirical support for the proposed model. Results show that value co-creation fully mediates the effect of personalization on adoption, and that this effect is stronger among consumers with higher data literacy. These findings highlight the importance of designing personalization strategies that go beyond algorithmic targeting to actively involve consumers and foster trust. The study contributes to personalization and digital retail literature by clarifying the psychological and contextual factors that shape adoption. Practically, it offers guidance for retailers aiming to implement data-driven personalization in ways that are transparent, participatory, and consumer-centric. The findings also align with key Sustainable Development Goals, including responsible consumption (SDG 12), digital innovation (SDG 9), equitable access to digital tools and skills (SDG 10), and ethical data practices (SDG 16).

KEYWORDS: Digital Retail (AI), Personalization, Value Co-Creation, Privacy Paradox, Data Literacy, Adoption Intention.

1. INTRODUCTION

In response to the increasing complexity of consumer expectations and intensifying competition in the retail sector, brands are reconfiguring their engagement strategies. Traditional approaches that positioned consumers as passive recipients of firm-generated value are giving way to more interactive models centered on value co-creation. In the context of digital retail (with AI) particularly within smart grocery environments, this shift is reflected in the growing prevalence of tools that allow consumers to tailor their experiences. These include personalized product recommendations, dynamic meal planners, interactive feedback systems, and adaptive digital interfaces (Büchi *et al.*, 2023; Selcuk, 2023).

Despite the widespread integration of personalization technologies, marketers continue to face challenges in evaluating their impact (Kent, 2025). Conventional outcome metrics, such as sales conversion rates, platform engagement, or click-through frequencies, often fail to capture the more nuanced, experiential dimensions of consumer value. Moreover, personalization efforts are increasingly complicated by the well-established **personalization–privacy paradox** while consumers appreciate the relevance and convenience of tailored content, many remain reluctant to share personal data, particularly in the absence of transparency or control mechanisms (Büchi *et al.*, 2023).

This study addresses two underexplored dimensions of personalization effectiveness. First, it reframes the consumer-firm interaction through a value co-creation perspective, positing that personalization fosters adoption only when consumers perceive themselves as active contributors to the retail experience. Second, it identifies data literacy as a moderating factor that conditions this relationship. Consumers with higher levels of data literacy are more capable of understanding personalization mechanisms, evaluating the trade-offs involved, and navigating digital interfaces with confidence (Selcuk, 2023). In contrast, those with lower data literacy may interpret personalization as intrusive, opaque, or misaligned with their expectations, thereby weakening its influence on engagement and adoption.

The conceptual framework integrates these constructs within the Stimulus-Organism-Response (S-O-R) paradigm and is grounded in service-dominant logic. Personalization is positioned as the stimulus that activates the internal cognitive and affective state of value co-creation (the organism), which subsequently influences behavioral outcomes such as adoption intention (the response). Data

literacy is theorized to moderate the stimulus-organism pathway, strengthening the effect of personalization on co-creation among more digitally capable consumers.

The contribution of this study is threefold. Theoretically, it extends existing personalization research by demonstrating the mediating role of value co-creation and the conditional effect of data literacy. Methodologically, it offers a refined analytical approach capable of disentangling these complex relationships through moderated mediation analysis. Managerially, it highlights the need for retailers to move beyond algorithmic accuracy toward participatory personalization strategies that empower users. Features such as customizable dashboards, transparent data policies, and user-driven content inputs are essential to converting algorithmic outputs into meaningful consumer experiences.

Beyond the retail domain, the findings carry broader societal implications. Smart grocery personalization can support several of the United Nations Sustainable Development Goals (SDGs). By aligning recommendations with household needs and consumption patterns, it can contribute to SDG 12 (Responsible Consumption) through the reduction of food waste. The integration of advanced digital infrastructure supports SDG 9 (Industry, Innovation, and Infrastructure), while improving consumer data literacy addresses digital inequalities consistent with SDG 10 (Reduced Inequalities). Transparent and ethical data practices, in turn, resonate with the principles of SDG 16 (Peace, Justice, and Strong Institutions).

Taken together, the study underscores that personalization, while technologically driven, ultimately derives its effectiveness from consumers' perceived agency and understanding. Personalization strategies that prioritize consumer empowerment and literacy are not only more likely to succeed commercially but also contribute to more inclusive, transparent, and sustainable digital retail ecosystems.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1. *Personalization in smart grocery retail (Stimulus)*

In smart grocery retail, personalization is increasingly operationalized through a suite of AI-driven and sensor-based technologies, such as algorithmic product recommendations, dynamic pricing, real-time push notifications, in-aisle

navigation aids, and seamless checkout systems (Martin & Murphy, 2017). These technologies depend on the continuous collection of granular behavioral, locational, and transactional data to deliver tailored shopping experiences, thereby enhancing perceived relevance, convenience, and efficiency (Zhou et al., 2024).

In this study, we conceptualize perceived personalization as a second-order formative construct composed of four reflective dimensions that are well-established in the retail technology literature (1) informativeness the perceived accuracy, timeliness, and usefulness of the information provided; (2) relevance the extent to which content aligns with individual preferences, dietary needs, or situational demands; (3) interactivity the degree of responsiveness and conversational engagement in the digital interface; and (4) control/transparency the consumer's ability to manage personalization settings and understand the rationale behind specific recommendations (Bleier et al., 2012). This multidimensional framework reflects the reality that personalization quality is not uniform strength in one dimension does not guarantee strength in another (Chen et al., 2022).

Drawing on the Stimulus-Organism-Response (S-O-R) framework (Mehrabian & Russell, 1974), we position personalization as the external stimulus that elicits internal cognitive and emotional evaluations. In line with privacy calculus theory (Dinev & Hart, 2006), we argue that when personalization is implemented in a transparent, user-centric manner, the perceived benefits such as increased utility and reduced cognitive load can outweigh privacy-related concerns, thereby encouraging consumer acceptance and engagement.

H1: Personalization positively influences value co-creation.

2.2. Value Co-Creation as Organismic State

In grocery retail, digital technologies and data-driven personalization increasingly facilitate co-creation. Consumers engage in co-creative behaviors when using smart recipe planners tailored to dietary objectives, customizing digital shopping baskets to household needs, sharing allergy and preference information to personalize recommendations, or adjusting promotions to meet budget constraints (Zhou et al., 2024). These interactions shift consumers from passive recipients of marketing to active co-designers of their shopping experiences.

Effective personalization systems provide the enabling infrastructure for such engagement. They act as scaffolds that support and simplify customer

participation through intuitive interfaces, adaptive algorithms, and real-time feedback mechanisms (Murthi et al., 2024). For instance, recommendation engines that learn from purchase history and stated preferences anticipate shopper needs, while gamified budget trackers motivate customers to optimize their selections. This approach not only enhances functional outcomes, such as faster decision-making and increased basket value, but also fosters psychological benefits, including feelings of agency, ownership, and partnership with the retailer (Muniaty et al., 2024).

From the perspective of the Stimulus-Organism-Response (S-O-R) model, value co-creation represents the organismic state. Personalization features serve as stimuli that trigger internal experiences of empowerment, reciprocity, and shared benefit. This internal state mediates the effect of stimuli on consumer behaviors such as increased purchase frequency, broader cross-category exploration, and stronger brand loyalty (Mehrabian & Russell, 1974; Prahalad & Ramaswamy, 2004; Siddarth & Neha, 2023). Consequently, co-creation acts as a vital psychological mechanism bridging technological personalization efforts and observable consumer outcomes, positioning it as both a key theoretical construct and a practical driver of performance in contemporary retail settings.

H2: Value co-creation positively influences adoption intention of smart grocery services.

2.3. Direct Personalization Effects on Adoption Intention

While personalization is widely acknowledged as a key driver of consumer adoption of technology, yet its impact on adoption intention is neither always direct nor consistent. By customizing content, recommendations, and experiences to align with individual preferences, personalization can reduce perceived effort, streamline decision-making, and enhance overall satisfaction (Aguirre et al., 2016). This aligns with effort minimization theories in consumer behavior, which suggest that individuals favor options that lower cognitive and physical costs. When implemented effectively, personalization delivers convenience and relevance, fostering initial trial and adoption.

However, growing evidence indicates that the direct effect of personalization on adoption intention often weakens or becomes statistically insignificant when strong organismic mediators such as perceived value, trust, or value co-creation are introduced (Wang et al., 2024). In essence, while personalization may generate initial interest and engagement, the ultimate decision to adopt is largely shaped by the deeper psychological states it triggers, rather than by personalization as a

stimulus alone.

This attenuation aligns with principles from decision science and behavioral theory, which argue that behavioral intentions rarely result solely from external stimuli. Instead, they emerge from a complex integration of cognitive evaluations such as perceived usefulness, fairness, and reliability and emotional responses, including enjoyment, empowerment, and affective trust (Simon, 1990; Bagozzi, 2023). For example, even highly relevant personalized recommendations may fail to drive adoption if users perceive a lack of reciprocity or question the brand's motives. Conversely, personalization that fosters co-creation enabling consumers to influence outcomes and see their input reflected can enhance perceived partnership, trust, and value, thereby promoting adoption.

This relationship is effectively explained through the Stimulus-Organism-Response (S-O-R) framework. Within this model, personalization functions as the external stimulus, value co-creation represents the internal organismic state, and adoption intention emerges as the behavioral response. The organismic stage serves as a critical interpretive layer, through which external inputs are evaluated, contextualized, and ultimately translated into action (Mehrabian & Russell, 1974). When internal mediators such as value co-creation are strongly activated, they tend to account for a substantial portion of the variance in behavioral outcomes, thereby diminishing the direct influence of the stimulus on the response.

Evidence from research in technology adoption, digital retailing, and experiential marketing consistently affirms the importance of this mediated process. Personalization strategies that do not engage the consumer in a participatory manner often fail to generate meaningful psychological engagement, as they may be perceived as automated or impersonal (Ranjan & Read, 2023). Conversely, when consumers perceive personalization as a product of their own input and preferences, they are more likely to experience a sense of co-ownership and agency. This perception strengthens emotional and cognitive engagement, thereby reinforcing their intention to continue using the service (Aguirre *et al.*, 2015).

H3: The direct effect of personalization on adoption intention is weak or non-significant when value co-creation is modeled as an intervening variable.

2.4. Data Literacy as a Boundary Condition

Data literacy, defined as the ability to understand, assess, and manage personal data flows, has become an important factor influencing the adoption and continued use of personalized technologies (Prinsloo

& van Deventer, 2023). In today's digital economy, where personalization relies heavily on consumer data, an individual's capacity to interpret and control data interactions plays a crucial role in shaping their perceptions and behaviors (Palupi & Muhammad, 2025). According to Richter & Steininger (2024), data literacy involves more than technical know-how; it includes understanding how algorithms operate, critically weighing the trade-offs between privacy risks and personalization benefits, and managing personal data through settings, permissions, and consent mechanisms.

Consumers with higher levels of data literacy are better able to recognize the reasoning behind personalization algorithms, seeing how recommendations relate to their past behavior, preferences, or explicit inputs. This understanding helps them form informed opinions about the fairness, accuracy, and relevance of personalized content (Gajendra *et al.*, 2024). For example, a data-literate user of a grocery app might realize that promotional offers are based on their purchase history and dietary choices and can actively adjust preferences to improve recommendations. Such consumers also tend to evaluate privacy-utility trade-offs more effectively, balancing risks against benefits like convenience and relevance (Kshetri & Voas, 2024). This clarity often promotes a sense of empowerment, builds trust, and encourages greater involvement in co-creation activities.

By contrast, consumers with lower data literacy often lack the frameworks needed to understand how personalization works. Büchi *et al.*, (2023) asserted that without this transparency, the same personalization cues may seem obscure, manipulative, or intrusive, especially when recommendations appear overly specific or unexpectedly related to previous actions. These consumers are more prone to heightened privacy concerns, reduced willingness to share data, or disengagement from personalization features altogether. This aligns with privacy calculus theory (Culnan & Armstrong, 1999), which suggests that when perceived risks outweigh perceived benefits, often due to limited understanding, *i.e.* engagement tends to decline.

Within the Stimulus-Organism-Response (S-O-R) framework, data literacy acts as a boundary condition influencing how consumers interpret personalization stimuli. **Personalization features (stimuli) are processed differently based on literacy levels** those with high data literacy see them as tools for greater autonomy and tailored experiences (Joanna & Claire, 2024), resulting in a positive

internal response; whereas those with low literacy may view the same features as intrusive or controlling, producing a negative internal reaction. This difference in interpretation directly affects how personalization leads to behavioral outcomes such as adoption intention, loyalty, or willingness to engage in co-creation.

Building on moderated mediation theory (Hayes, 2018) combined with the S-O-R model, we propose that data literacy moderates the effect of personalization (stimulus) on value co-creation (organism). For consumers with higher data literacy, personalization is more likely to be understood as a collaborative process that fosters mutual value creation, psychological ownership, reciprocity, and trust, thereby strengthening behavioral intentions. In contrast, consumers with lower data literacy may not experience this co-creative effect and may instead respond with skepticism or withdrawal, weakening the connection between personalization and the internal psychological state (Muniaty et al., 2024).

Empirical evidence from e-commerce (Aguirre et al., 2015), health informatics (Lee & Sundar, 2023), and digital retail personalization (Richter et al., 2024) supports this view, demonstrating that data literacy is a crucial determinant of user acceptance and trust in AI-driven personalization. Notably, Prinsloo and van Deventer (2023) find that interventions aimed at improving consumer data literacy through training and transparency significantly increase willingness to share personal information in exchange for tailored services, highlighting an actionable pathway for managers.

H4: Data literacy positively moderates the effect of personalization on value co-creation; the slope of this relationship is stronger among consumers with high levels of data literacy.

2.5. Conditional Mediation

When hypotheses H1, H2, and H4 are simultaneously supported, the structural relationships within the model converge to indicate a conditional indirect effect. Specifically, personalization is proposed to influence adoption intention not predominantly through a direct pathway, but indirectly via value co-creation, with the strength of this indirect effect depending on consumers' data literacy. Statistically, this describes a first-stage moderated mediation model (Coutts & Hayes, 2023), where the effect of personalization on value co-creation (the "a path" in mediation terminology) is moderated by the consumer's ability to understand, evaluate, and manage personal data flows.

Within the Stimulus-Organism-Response (S-O-R)

framework, personalization acts as the stimulus (S) that triggers the organismic state (O) of value co-creation, which in turn influences the behavioral response (R) of adoption intention. Data literacy is not a passive factor but actively shapes how personalization cues are perceived, interpreted, and utilized. For consumers with high data literacy, personalization signals are more likely to be seen as empowering, participatory, and aligned with their preferences, thereby enhancing engagement in co-creation and strengthening the translation of this organismic state into adoption intentions. Conversely, for consumers with low data literacy, the same personalization cues may evoke weaker or inconsistent co-creation responses, diminishing the overall indirect effect on adoption intention.

This proposition is consistent with recent research in smart services and digital personalization, where the mediating influence of affective and cognitive organismic states such as trust, empowerment, and perceived control is stronger among consumers with greater domain knowledge or digital proficiency (Zhou et al., 2024; Richter et al., 2024). Higher data literacy enables consumers to better integrate and interpret personalization information, reducing ambiguity and increasing perceptions of fairness, transparency, and reciprocity within personalization systems. Consequently, the same technological stimulus produces a more pronounced effect on behavioral intentions through the mediating organismic process.

From a decision science standpoint, this moderated mediation dynamic can be explained by the interplay between cognitive evaluations and emotional appraisals in shaping intention (Simon, 1990; Bagozzi, 2023). Consumers with higher data literacy are better equipped to cognitively assess personalization outcomes for relevance and quality, while simultaneously experiencing greater enjoyment, autonomy, and trust. This dual reinforcement amplifies the mediating role of value co-creation, resulting in a stronger indirect effect from personalization to adoption intention.

Theoretically, these findings suggest that personalization should not be viewed as a universally effective driver of adoption intention (Cloarec et al., 2022). Instead, its influence is conditional, mediated by organismic processes that depend on consumers' capacity to engage with and interpret data-driven personalization. Managerially, this implies that efforts to enhance consumer data literacy through transparent communication, interface tutorials, and opt-in data controls, may be as crucial as refining personalization algorithms, especially when aiming to foster long-term adoption through co-creative engagement.

H5: The indirect effect of personalization on adoption intention through value co-creation is positively moderated by data literacy, such that the mediated pathway is stronger at higher levels of data literacy.

2.6. Conceptual Framework

The proposed framework illustrated in Figure 1

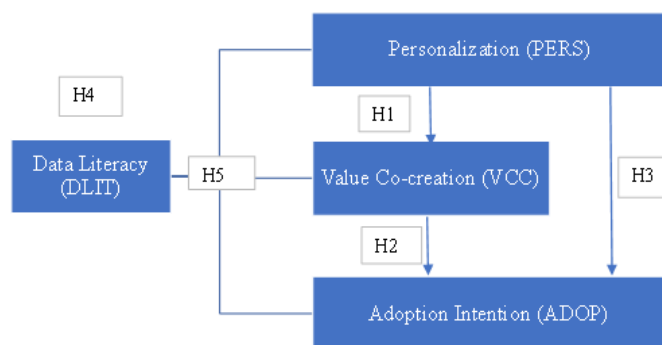


Figure 1: Proposed Framework.

At the initial stage, personalization serves as the stimulus that initiates consumer interaction with the retail platform. In digital retail, personalization refers to technologies that tailor recommendations, promotions, and services to individual consumer preferences. Prior research indicates that consumers generally respond favorably to personalization due to its capacity to reduce search effort, increase relevance, and enhance convenience (Grewal et al., 2023). However, within this framework, personalization is hypothesized not to influence adoption intention directly but rather through the mediating perception of value co-creation. This relationship is formalized in H1, which posits a positive effect of personalization on value co-creation.

Value co-creation constitutes the organismic state within the S-O-R sequence. Rooted in service-dominant logic (Vargo & Lusch, 2008), co-creation emerges when consumers view themselves as active contributors shaping their shopping experience rather than passive recipients of firm-generated value. In smart grocery retail, co-creation can occur when consumers engage with features such as recipe planners, privacy setting adjustments, product feedback mechanisms, or personalized digital baskets (Ranjan & Read, 2023). These interactions foster consumer feelings of agency, reciprocity, and empowerment, which influence subsequent

behaviors. Accordingly, H2 proposes that value co-creation positively impacts adoption intention, serving as the key mediator linking personalization to adoption.

The final stage adoption intention, represents the consumer's willingness to continue or deepen engagement with personalized digital grocery services. This outcome is vital for retailers, as it signals the shift from initial trial to sustained loyalty, a fundamental driver of customer lifetime value (Tu et al., 2024). In this framework, adoption intention arises not directly from personalization but through the consumer's experience of co-created value, underscoring the necessity of meaningful engagement alongside technological customization to achieve lasting behavioral outcomes.

A key feature of the proposed model is the inclusion of data literacy as a moderating variable. Data literacy refers to a consumer's ability to understand, assess, and manage the flow of personal data within digital settings (Prinsloo & van Deventer, 2023). Consumers with higher data literacy are generally more capable of interpreting how personalization algorithms function, evaluating the trade-offs between privacy and utility, and adjusting their privacy settings to suit individual preferences (Richter et al., 2024). In contrast, those with lower data literacy may find personalized interactions confusing or invasive, which can increase privacy-

related concerns and lower engagement (Büchi et al., 2023). Based on this understanding, Hypothesis 3 posits that data literacy positively moderates the relationship between personalization and value co-creation, meaning that personalization is more likely to support co-creation when consumers are able to make sense of and engage with the mechanisms that drive personalization.

The model builds on a layered view of consumer response. First, it questions the assumption that personalization by itself is enough to drive adoption. Instead, it argues that the effectiveness of personalization depends on whether it results in a co-created experience that encourages active consumer involvement and sustained engagement (Barth & de Jong, 2017). Second, it highlights that this process is not uniform but conditional shaped by individual differences such as data literacy. This helps explain inconsistencies in prior research, where some studies report strong effects of personalization, while others find minimal or even negative outcomes. Variation in consumers' understanding of data processes likely contributes to these differing results.

From a managerial standpoint, the model provides clear direction. Digital retailers should not focus solely on algorithmic accuracy or automation. Rather, they should invest in tools and features that support active consumer participation, such as customizable interfaces, user-controlled recommendation filters, interactive feedback loops, and recipe personalization tools. In parallel, firms should promote data literacy by offering clear explanations of how personalization works, building in accessible privacy settings, and providing simple educational resources. These initiatives help consumers feel more in control, which can strengthen the perceived value of personalization and improve long-term adoption and loyalty.

In sum, the framework connects personalization, value co-creation, and data literacy within a single moderated mediation model. It positions personalization as the stimulus, co-creation as the internal response, and adoption intention as the behavioral outcome, with data literacy shaping how personalization is interpreted and acted upon. This structure enhances the explanatory power of the S-O-R paradigm and offers a practical roadmap for retailers aiming to balance the benefits of personalization with growing concerns over data privacy and user autonomy.

3. RESEARCH METHODOLOGY

This chapter outlines the methodology employed to investigate the relationships among

personalization, value co-creation, data literacy, privacy concern, and adoption intention in the context of smart grocery retail. The study uses a quantitative survey design supported by structural equation modeling (SEM), a well-established approach for analyzing complex relationships involving multiple constructs in marketing and consumer behavior research. SEM was chosen for its ability to simultaneously test measurement and structural models while accounting for mediation and moderation effects, thus providing strong explanatory and predictive capabilities (Joe et al., 2020).

A cross-sectional design was adopted, collecting data from consumers who actively use online and mobile grocery platforms. This focus aligns with the increasing integration of personalization features such as algorithm-driven recommendations, dynamic promotions, and AI-based meal planners within these platforms. Guided by the Stimulus-Organism-Response (S-O-R) framework and Service-Dominant (S-D) logic, personalization is conceptualized as the stimulus that triggers internal consumer responses of value co-creation, which then influence behavioral outcomes like adoption intention. Data literacy is included as a moderator influencing this pathway, while privacy concern serves as a control variable given its relevance in personalization settings.

The target sample comprised digital consumers who had purchased groceries online within the prior six months. A purposive sampling method ensured participants had sufficient exposure to personalization services. To meet SEM requirements, typically at least ten observations per estimated parameter (Hair et al., 2020), the study aimed for 350 responses and ultimately retained 482 valid questionnaires after removing incomplete or invalid data. The sample was demographically diverse, covering a broad range of ages, income levels, and education, thus representing a wide consumer base.

The survey instrument was developed using validated scales adapted from prior studies and tailored for the smart grocery context. Personalization was measured with five items adapted from Grewal et al. (2023), capturing perceptions of tailored recommendations and platform customization. Value co-creation was assessed through six items based on Ranjan and Read (2023) and Suryani et al. (2024), reflecting consumers' sense of agency, feedback provision, and collaboration. Data literacy was measured using four items adapted from Büchi et al. (2023) and Richter et al. (2024), focusing on consumers' understanding of

personalization algorithms and control over privacy settings. Privacy concern was captured with four items from Malhotra et al. (2004), while adoption intention used three items from Venkatesh et al. (2012). All items employed a seven-point Likert scale ranging from “strongly disagree” to “strongly agree.” A pilot test with 35 participants confirmed the instrument’s clarity and initial reliability, with Cronbach’s alpha values exceeding 0.70 for all constructs.

Data collection was conducted through an online survey platform, distributed via consumer panels and social media channels. Participants were provided with clear instructions, informed consent forms, and assurances of confidentiality. Screening questions ensured respondents were active users of personalized grocery platforms. Joe (2020) asserted that to reduce potential common method bias, procedural measures were applied, including randomizing item order and emphasizing that there were no right or wrong answers.

Data analysis followed several stages. Initial screening addressed missing values, normality, and multicollinearity. Missing data accounted for less than 2% and were handled using mean substitution. Skewness and kurtosis values fell within acceptable limits (± 2), and variance inflation factors (VIF) were below 3, indicating no collinearity issues. Confirmatory factor analysis (CFA) validated the measurement model. Reliability was confirmed with composite reliability (CR) scores above 0.70, and convergent validity was supported by average variance extracted (AVE) values exceeding 0.50. Discriminant validity was established using the heterotrait-monotrait (HTMT) ratio, with all constructs scoring below 0.85.

After confirming the measurement model, the structural model was tested using SEM. Model fit was evaluated through indices such as chi-square/df, RMSEA, and CFI (Anoop & Rahman, 2024). Hypotheses concerning direct, indirect, and moderated relationships were examined. Mediation and moderation effects were further tested through bootstrapping with 5,000 resamples, a robust approach to significance testing in complex models (Hayes, 2018). The moderating role of data literacy was assessed by creating mean-centered interaction terms between personalization and data literacy, while moderated mediation (conditional indirect effects) was tested using Hayes’ PROCESS macro (Model 7).

Ethical standards were strictly observed. All participants gave informed consent before completing the survey, participation was voluntary,

and no personally identifiable information was collected. Data were securely stored for academic use only, and confidentiality was maintained throughout. The study received ethical approval from the institution’s review board, ensuring compliance with human research guidelines.

In conclusion, this methodology was designed to ensure rigor and reliability in examining the interplay between personalization, co-creation, data literacy, privacy concern, and adoption intention. By combining a validated measurement model with structural analysis and addressing mediation, moderation, and conditional indirect effects, the approach offers a comprehensive framework for understanding consumer responses to personalization in digital grocery retail. Integrating the S-O-R framework, service-dominant logic, and moderated mediation analysis adds both theoretical depth and practical relevance, equipping the study to contribute meaningful insights to the field.

4. RESULTS AND ANALYSIS

4.1. Descriptive Statistics

The survey respondents ($n = 482$) represented a broad cross-section of digital grocery consumers in Malaysia. Age distribution showed a clear dominance of younger users, with 38 percent of participants falling between 18 and 24 years, followed by 32 percent in the 25–34 category. A smaller proportion of respondents were aged 35–44 (18 percent), while those aged 45 years and above accounted for just 12 percent of the sample. This breakdown reflects the reality that digital retail services, particularly smart grocery applications, are more frequently adopted by younger generations who are more accustomed to mobile commerce and algorithm-driven personalization.

Gender was relatively balanced, with 54 percent of the respondents identifying as female and 46 percent as male. While the study did not reveal strong gender differences in adoption intention, preliminary comparisons suggested that female respondents expressed slightly greater concerns about data privacy. This is consistent with earlier research indicating that women tend to be more cautious in their evaluation of digital risks, even as they remain active users of personalized retail services.

In terms of geographical distribution, the majority of participants resided in Malaysia’s major urban areas where online grocery platforms are most widely available. A significant proportion, 62 percent, came from the Klang Valley, followed by Penang (15 percent) and Johor Bahru (13 percent).

The remaining 10 percent of respondents were spread across other states. This concentration of urban participants corresponds with the higher levels of digital infrastructure and service penetration in metropolitan centres, suggesting that the findings are most directly relevant to urban consumers who have access to multiple online grocery options.

The study also examined participants' digital literacy, as this was expected to influence how consumers interpret and engage with personalization features. Based on the data literacy scale used, 21 percent of respondents were classified as having low literacy, 47 percent moderate, and 32 percent high literacy. Younger adults were noticeably overrepresented in the high-literacy category, while older respondents were more evenly distributed across the low and moderate groups. Consumers with stronger digital literacy skills demonstrated greater confidence in navigating privacy settings and understanding algorithmic recommendations, which in turn strengthened their engagement with personalization. Those with limited literacy were more likely to regard personalization as opaque or intrusive.

Table 1 presents the descriptive statistics and

correlations among the key constructs. The mean scores ranged from 3.72 for privacy concern to 4.87 for personalization, reflecting generally positive perceptions of personalization features and adoption intentions, alongside relatively lower privacy concerns. Standard deviations fell within acceptable limits, indicating adequate variability in the responses.

The correlation analysis showed strong positive relationships between personalization, value co-creation, and adoption intention. Personalization was significantly correlated with value co-creation ($r = 0.48, p < 0.001$) and adoption intention ($r = 0.29, p < 0.001$). Value co-creation had the highest correlation with adoption intention ($r = 0.54, p < 0.001$), supporting its hypothesized mediating role in the model. Data literacy was also positively linked to both value co-creation ($r = 0.41, p < 0.001$) and adoption intention ($r = 0.36, p < 0.001$). As anticipated, privacy concern showed negative correlations with all other constructs. These initial findings suggest that personalization, when coupled with high levels of value co-creation and consumer literacy, can positively influence adoption intention, while privacy concern remains a dampening factor.

Table 1: Descriptive Statistics and Correlations.

Variable	Mean	SD	1. PERS	2. VCC	3. DLIT	4. PRIV	5. ADOP
1. PERS	4.87	1.02	-				
2. VCC	4.65	0.95	0.48***	-			
3. DLIT	4.22	1.10	0.32***	0.41***	-		
4. PRIV	3.72	1.20	-0.21**	-0.18**	-0.25**	-	
5. ADOP	4.51	1.05	0.29***	0.54***	0.36***	-0.14*	-

*Notes: *** $p < 0.001$; ** $p < 0.01$; $p < 0.05$

4.2. Measurement Model

Construct validity was assessed through confirmatory factor analysis (CFA), with the results presented in Table 2. All factor loadings fell between 0.70 and 0.89, exceeding the commonly accepted threshold of 0.70 (Joe F. Hair et al., 2020). Composite reliability (CR) scores ranged from 0.87 to 0.92, indicating strong internal consistency across

constructs. Additionally, average variance extracted (AVE) values ranged from 0.58 to 0.67, supporting the presence of convergent validity. Discriminant validity was further assessed using the Fornell-Larcker criterion and the heterotrait-monotrait ratio (HTMT), both of which confirmed adequate distinctiveness among constructs. These findings collectively validate the robustness of the measurement model.

Table 2: Measurement Model Results.

Construct	Items	Factor Loadings	CR	AVE
Personalization	5	0.71-0.88	0.91	0.62
Value Co-Creation	6	0.74-0.86	0.92	0.65
Data Literacy	4	0.72-0.85	0.88	0.59
Privacy Concern	4	0.70-0.84	0.87	0.58
Adoption Intention	3	0.76-0.89	0.89	0.67

4.3. Structural Model

The hypothesized relationships were tested using structural equation modeling (SEM). Table 3 presents the path estimates. **Results show strong support for the mediation model** personalization significantly predicts value co-creation ($\beta = 0.46, p < 0.001$), and value co-creation, in turn, significantly predicts adoption intention ($\beta = 0.52, p < 0.001$). However, the direct path from personalization to adoption

intention was non-significant ($\beta = 0.07, p = 0.13$), confirming the mediating role of value co-creation.

Data literacy exerted a significant moderating effect on the personalization \rightarrow value co-creation path ($\beta = 0.19, p < 0.001$), supporting H4. The moderated mediation test further confirmed that the indirect effect of personalization on adoption intention via value co-creation was stronger at higher levels of data literacy ($\beta = 0.14, p < 0.001$), thus supporting H5.

Table 3: Structural Path Estimates.

Hypothesis	Path	β	t-value	p-value	Supported
H1	PERS \rightarrow VCC	0.46	8.21	<0.001	Yes
H2	VCC \rightarrow ADOP	0.52	9.37	<0.001	Yes
H3	PERS \rightarrow ADOP (direct)	0.07	1.52	0.13	No
H4	PERS \times DLIT \rightarrow VCC	0.19	3.98	<0.001	Yes
H5	Indirect (PERS \rightarrow VCC \rightarrow ADOP moderated by DLIT)	0.14	3.72	<0.001	Yes

These results suggest that personalization influences adoption intention indirectly, mediated by co-creation, and this effect is significantly amplified by consumers' data literacy.

4.4. Key Findings

The hypothesized framework and key findings are visualized in Figures 2 and 3.

Figure 2 depicts the SEM results diagram, showing significant standardized path coefficients for H1, H2, H4, and H5, with the non-significant direct path from personalization to adoption intention (H3). This reinforces the conclusion that co-creation is the critical mechanism through which personalization translates into adoption.

literacy.

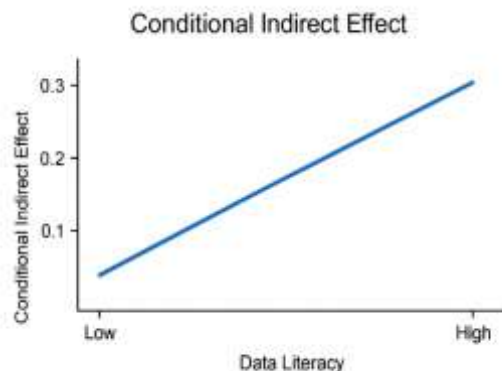


Figure 3: Conditional Indirect Effect (Line Graph).

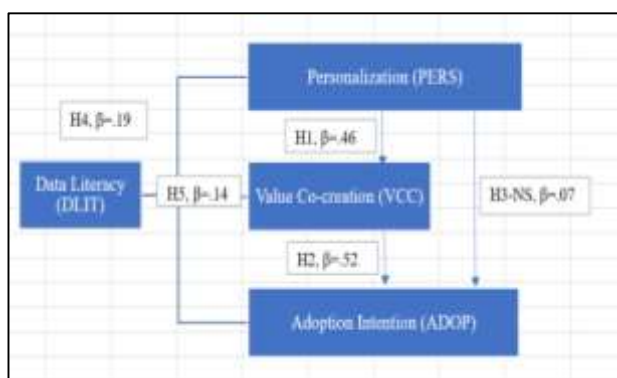


Figure 2: SEM Results Diagram.

Figure 3 illustrates the conditional indirect effect of personalization on adoption at varying levels of data literacy. The line graph shows that while the indirect effect is weak at low literacy levels, it strengthens substantially as literacy increases, confirming the theorized moderating role of data

Personalization alone does not directly influence adoption; instead, it operates through co-creation. Moreover, the positive influence of personalization is contingent on consumers' ability to understand and manage their data.

4.5. Robustness Checks

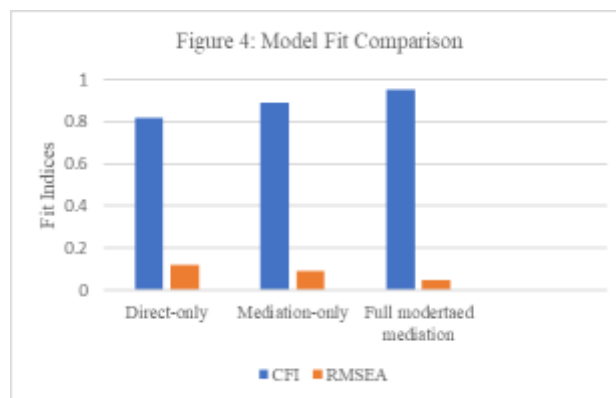


Figure 4: Model Fit Comparison (Bar Chart).

Figure 4 compares the fit indices (CFI and RMSEA) across three competing models: a direct-only model, a mediation-only model, and the full moderated mediation model. The results indicate that the direct-only model exhibits poor fit (CFI = 0.82, RMSEA = 0.12), while the mediation-only model demonstrates moderate improvement (CFI = 0.89, RMSEA = 0.09). The full moderated mediation model achieves the best overall fit (CFI = 0.95, RMSEA = 0.05), supporting the hypothesized conceptualization. This evidence underscores the importance of including both co-creation as a mediator and data literacy as a moderator in explaining adoption intention.

To evaluate the potential impact of common method bias (CMB), Harman's single-factor test was employed. This diagnostic assesses whether a single latent factor disproportionately accounts for the variance in the data, which would suggest possible contamination due to systematic measurement error (Joe F. Hair et al., 2020).

All measurement items were subjected to an unrotated exploratory factor analysis using principal component extraction. The resulting scree plot (Figure 5) illustrates the eigenvalues of the first five extracted factors. The x-axis represents the number of factors, while the y-axis displays their corresponding eigenvalues, which reflect the proportion of variance explained by each factor. The first factor yielded an eigenvalue of 4.2, indicating it explains a notable portion of the variance. **However, the steep drop in eigenvalues for subsequent factors** Factor 2 (0.9), Factor 3 (0.7), Factor 4 (0.5), and Factor 5 (0.4) demonstrates that no single factor dominates the variance structure.

This distribution supports the conclusion that common method bias is unlikely to pose a significant threat, as the variance is dispersed across multiple constructs rather than concentrated in one overarching factor.

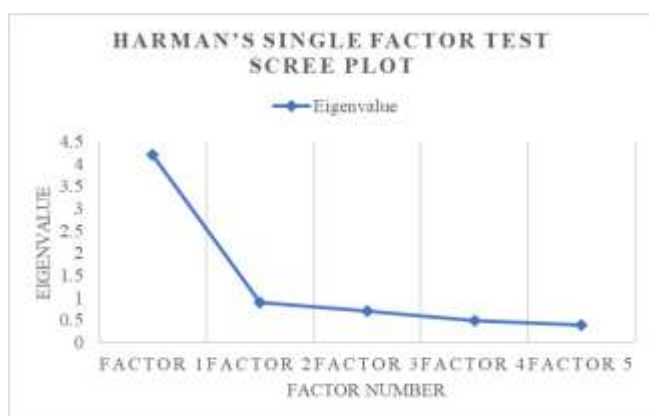


Figure 5: Harman's Single Factor Test (Scree Plot).

The findings from Harman's single-factor test indicate that common method bias (CMB) is unlikely to compromise the validity of this study. While the first factor accounts for a notable portion of variance (eigenvalue = 4.2), the sharp decline in subsequent eigenvalues suggests that no single factor dominates the covariance structure. This outcome reinforces the robustness of the measurement model, which was previously supported through confirmatory factor analysis (CFA), demonstrating strong convergent and discriminant validity.

In summary, Figure 5 confirms the robustness of the study's construct validity and supports the conclusion that the results are not significantly influenced by methodological artifacts. The findings regarding the roles of personalization, value co-creation, data literacy, and privacy concern are therefore interpretable and trustworthy, based on valid measurement instruments rather than artificial inflation of relationships due to common method variance.

5. DISCUSSION

The findings of this study provide valuable insights into the intricate relationships among personalization, value co-creation, and consumer adoption intentions in the context of smart grocery retail. Notably, the results reveal that personalization does not significantly influence adoption intention through a direct pathway; rather, its impact is mediated by the mechanism of value co-creation. Moreover, this indirect effect is moderated by data literacy, offering a more nuanced understanding of the conditions under which personalization proves effective. These findings carry both theoretical and practical significance, particularly amid ongoing discourse surrounding the personalization-privacy paradox in digital marketing and consumer research (Martin & Murphy, 2017; Kim et al., 2021).

A key contribution of this study is the clear demonstration that value co-creation is the main channel through which personalization influences behavioral intention. This finding supports a fundamental principle of service-dominant logic (Vargo & Lusch, 2008), which views consumers as active partners in creating value rather than passive recipients. While co-creation has been extensively explored in areas like product development, customer service, and digital platforms (Frow et al., 2020; Ranjan & Read, 2023), its role as a mediator between personalization and adoption has been less thoroughly examined. By showing that personalization leads to adoption only when consumers feel involved and empowered in shaping

their experience, this research provides strong empirical support for the co-creation process.

The results also align with the Stimulus-Organism-Response (S-O-R) framework (Mehrabian & Russell, 1974), where personalization functions as the stimulus (S), value co-creation represents the internal organismic state (O), and adoption intention is the response (R). The organismic phase captures consumers' cognitive and emotional processing, including feelings of control, reciprocity, and agency. This helps explain why personalization efforts sometimes produce mixed results (Bleier *et al.*, 2019; Grewal *et al.*, 2023); without a sense of co-creation, consumers are less likely to turn engagement into actual adoption.

Furthermore, the study highlights the important moderating role of data literacy. Consumers with higher levels of data literacy tend to view personalization as transparent and empowering, which encourages greater participation in co-creation and strengthens the effect on adoption. In contrast, consumers with lower data literacy may see personalization cues as confusing or intrusive, weakening this relationship. These findings correspond with research emphasizing the role of digital skills in shaping responses to algorithmic personalization (Prinsloo & van Deventer, 2023; Richter *et al.*, 2024) and align with privacy calculus theory (Dinev & Hart, 2006; Smith *et al.*, 2011), which suggests consumers weigh the benefits of personalization against privacy risks. Those with better data literacy are more capable of making informed judgments, valuing personalization while managing privacy concerns.

Additional tests for robustness, including model comparisons and Harman's single-factor test, support the validity of the findings. The superior fit of the moderated mediation model confirms the need to consider both the mediating role of co-creation and the moderating effect of data literacy. Moreover, the absence of significant common method bias indicates that the observed relationships are meaningful and not the result of measurement artifacts.

These insights also contribute to reconciling divergent findings in personalization research. For instance, while studies like Bleier and Eisenbeiss (2015) highlight the effectiveness of personalization in driving engagement, others report minimal or negative effects, particularly when users perceive personalization as invasive (Awad & Krishnan, 2006; Kim *et al.*, 2021). This study bridges that gap by showing that personalization's effectiveness is conditional i.e. it works when it enables co-creation and is comprehensible to data-literate users.

Moreover, the findings advance the conversation around the personalization-privacy paradox (Aguirre *et al.*, 2015; Martin & Palmatier, 2020). While privacy concern negatively correlates with adoption, it does not negate the co-creation pathway when users possess high data literacy. **This suggests that the privacy paradox is not absolute but context-dependent** consumers are willing to share data when they feel informed and in control. This highlights the ethical responsibility of firms to design personalization strategies that prioritize transparency, user control, and informed consent.

This study offers three important theoretical contributions. First, it provides empirical evidence that value co-creation is the key internal mechanism within the S-O-R framework explaining how personalization influences consumer behavior. Second, it highlights data literacy as a crucial boundary condition, moving beyond common moderators such as demographics or broad attitudes. Third, it shows that the privacy paradox can be addressed by empowering consumers and designing personalization with transparency in mind. These insights extend beyond marketing theory and connect with broader discussions on sustainability.

From a sustainability standpoint, personalization in smart grocery retail supports Sustainable Development Goal 12 (Responsible Consumption and Production) by encouraging purchases that better match household needs, thereby reducing waste and excess consumption. Efforts to improve data literacy relate to SDG 10 (Reduced Inequalities), as they help ensure that the advantages of digital personalization are available to a wider population, not only those who are digitally savvy. Lastly, adopting transparent and ethical data management practices aligns with SDG 16 (Peace, Justice, and Strong Institutions), promoting trust, accountability, and strong governance in digital environments.

In conclusion, this study positions personalization not merely as a tool for increasing adoption but as a potential lever for advancing ethical, inclusive, and sustainable digital retail ecosystems when executed through the lenses of co-creation, data literacy, and transparency.

6. CONCLUSION AND IMPLICATIONS

This study explored how personalization in smart grocery retail can effectively encourage consumer adoption, despite ongoing privacy concerns. By combining personalization, value co-creation, and data literacy within a moderated mediation framework, the research provides a detailed explanation of the mechanisms and conditions

influencing consumer responses. The findings showed that personalization influences adoption indirectly through value co-creation, and this effect is notably stronger among consumers with higher data literacy.

From a theoretical perspective, the study advances the understanding of personalization by identifying value co-creation as a key mediator and data literacy as an important moderator. This dual insight enriches both service-dominant logic and the Stimulus-Organism-Response framework, offering a more nuanced view of how consumers engage with personalized digital experiences. The results also contribute to the ongoing debate about the personalization-privacy paradox, demonstrating that consumers who are informed and empowered tend to embrace personalized services despite privacy concerns.

For practitioners, the implications are clear. Retailers should move beyond relying solely on algorithm-driven personalization and instead design experiences that encourage consumers to actively shape their shopping through customizable features, personalized recommendations, and dynamic promotions. Equally important is investing in improving consumer data literacy. Providing clear explanations of personalization algorithms, flexible privacy controls, and educational support not only fosters adoption but also builds trust, loyalty, and lasting engagement.

6.1. Policy Implications

The results of this study highlight several important directions for policymakers seeking to balance consumer protection with the growing reliance on data-driven personalization in retail. As personalization depends on the continuous collection and analysis of consumer data, the risk of privacy breaches and consumer distrust remains significant. Recent debates on algorithmic transparency and data protection laws emphasize that regulatory frameworks must keep pace with advances in artificial intelligence and digital profiling (Richter et al., 2024; Kshetri & Voas, 2024). Strengthening existing legislation, such as Malaysia's Personal Data Protection Act (PDPA), with clearer guidelines on consent, data portability, and algorithmic accountability would help ensure that consumers maintain meaningful control over their personal information.

Equally important is the promotion of ethical personalization practices at the industry level. While legal frameworks establish minimum standards, retailers and technology providers must adopt

principles of fairness, transparency, and user empowerment in the design of personalization systems. Accessible opt-in and opt-out mechanisms, as well as clear explanations of how recommendations are generated, can reduce perceptions of manipulation and build trust. This reflects broader calls in the literature for aligning personalization with principles of procedural fairness and reciprocity (Cloarec et al., 2022). Establishing industry-wide codes of conduct or certification schemes for ethical personalization could provide a benchmark for responsible innovation.

The study also underscores the role of digital literacy as a boundary condition influencing consumer responses to personalization. Policymakers have an opportunity to address this gap through targeted education and training programs (Jack, 2025). Public agencies, civil society groups, and private firms could collaborate to strengthen data literacy, particularly among older adults and marginalized communities. Such initiatives not only reduce digital inequalities but also ensure that consumers are better equipped to evaluate privacy-utility trade-offs in personalization settings (Büchi et al., 2023; Prinsloo & van Deventer, 2023). Enhancing consumer competencies in this area is directly connected to broader development agendas, particularly the Sustainable Development Goals on reducing inequalities (SDG 10) and fostering inclusive innovation (SDG 9).

Finally, the findings suggest that personalization in smart grocery retail has the potential to contribute positively to sustainability goals. By aligning recommendations with household needs, personalization can reduce food waste and encourage more responsible patterns of consumption (Jack, 2025). Policymakers may consider incentivizing personalization practices that explicitly support sustainability objectives, for instance by promoting healthy diets, encouraging eco-friendly product choices, or discouraging over-purchasing. In doing so, personalization shifts from being a narrowly commercial practice to a tool for advancing social and environmental outcomes in line with SDG 12 (Responsible Consumption and Production).

Taken together, these insights point toward a dual responsibility for regulators and industry to safeguard consumer rights through strong legal protections while also fostering innovation that is ethical, transparent, and socially beneficial. Effective governance of personalization requires both robust oversight and proactive measures to build consumer literacy and trust, ensuring that personalization

serves not only commercial aims but also broader societal interests.

6.2. Limitation

The study has some limitations. The cross-sectional design restricts the ability to make causal claims, and focusing exclusively on smart grocery retail may limit how applicable the findings are to other sectors. Future research could adopt longitudinal or experimental methods, apply the model to other fields such as healthcare or finance, and examine additional factors like cultural differences, regulatory influences, or perceptions of algorithmic fairness. Additionally, emerging technologies like generative AI, blockchain, and federated learning offer promising directions for privacy-focused personalization that warrant further investigation.

By linking personalization with the Sustainable Development Goals, this research underscores its

wider social relevance. It supports SDG 12 (Responsible Consumption) by encouraging sustainable shopping habits and reducing waste; SDG 9 (Industry, Innovation, and Infrastructure) by advancing digital retail technologies; SDG 10 (Reduced Inequalities) by tackling gaps in digital literacy; and SDG 16 (Peace, Justice, and Strong Institutions) by promoting ethical and transparent data practices. In this way, personalization transcends a simple marketing tool and becomes a strategic means to foster inclusive, accountable, and sustainable digital progress.

In summary, the study shows that personalization is most effective when it promotes consumer co-creation and is backed by strong data literacy. This integrated approach offers a practical solution to the personalization-privacy paradox, helping firms realize the benefits of personalization while empowering consumers to navigate digital environments with confidence and control.

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