*Sensors and Materials*, Vol. 37, No. 8 (2025) 3595–3608
MYU Tokyo



S & M 4139

# Impact of Brand Image and Perceived Value on Consumer Purchasing Behavior in the Era of Internet of Things: A Study of Cross-border E-commerce in the Thailand Market

Cong Pang,[1] Fen Tan,[1*] Xiaojian Lu,[1] and Cheng-Fu Yang[2,3**]

[1]Business School, Dongguan City University, Dongguan 523419, China
[2]Department of Chemical and Materials Engineering, National University of Kaohsiung, Kaohsiung 811, Taiwan
[3]Department of Aeronautical Engineering, Chaoyang University of Technology, Taichung 413, Taiwan

(Received March 31, 2025; accepted June 20, 2025)

***Keywords:*** IoT, cross-border e-commerce, brand image, perceived value, consumer purchasing behavior, smart retail

The rapid development of Internet of Things (IoT) technology is reshaping the cross-border e-commerce industry. Through applications such as smart logistics, personalized recommendations, and dynamic pricing mechanisms, businesses can enhance their brand image and perceived value, thereby affecting consumer purchasing behavior. In this study, we utilized IoT technology to build a questionnaire platform that allowed consumers to directly respond to surveys and send data back to a collection center. We then combined IoT technology with consumer behavior theory, using Baggo Company in the Thailand market as a case study, to explore how IoT technology impacted brand image and perceived value and analyzed its effects on purchase intention and behavior. A structural equation model was used to verify the influence mechanism of IoT technology, providing empirical evidence for digital transformation in businesses. The results showed that both brand image and perceived value had a significant impact on purchasing behavior, and IoT technology further strengthened consumer loyalty. This research offers strategic recommendations for businesses applying IoT in cross-border e-commerce and explores how policymakers can optimize relevant regulations to promote market development.

## 1. Introduction

The development of Internet of Things (IoT) technology has been widely applied in e-commerce, affecting brand image, perceived value, and consumer purchasing behavior. According to Porter and Heppelmann, intelligent supply chains and real-time customer service systems enhance consumer trust in a brand, which in turn impacts purchasing decisions.(1) Furthermore, smart retail technologies (such as virtual fitting rooms, smart shelves, and self-checkout systems) further improve the shopping experience, making it easier for consumers to accept the integration of IoT technologies into the shopping process.(2) Regarding brand image,

*Corresponding author: e-mail: tanfen@dgcu.edu.cn
**Corresponding author: e-mail: cfyang@nuk.edu.tw
https://doi.org/10.18494/SAM5664

ISSN 0914-4935 
https://myukk.org/

Aaker highlighted that brand image affects consumer perceptions, loyalty, and purchasing behavior.[3] Grewal *et al.* further emphasized that companies can strengthen their brand image through IoT technologies (such as AI customer service and personalized marketing), effectively increasing consumer loyalty and purchase intention.[4] Perceived value is a crucial factor affecting consumer purchasing behavior. Zeithaml suggested that perceived value determines consumer satisfaction and purchase intention.[5] Wang *et al.* showed that IoT technology can enhance consumer perceptions of product price fairness, quality, and shopping convenience, thereby promoting purchase decisions.[6] Additionally, Oliver's theory of brand loyalty indicates that consumers, after accumulating sufficient purchasing experience, develop long-term buying habits driven by brand trust and satisfaction.[7] Therefore, if IoT technology can provide a highly personalized shopping experience, it can effectively enhance brand loyalty and repurchase rates.

With the rapid expansion of the global e-commerce market, IoT technology has become a crucial tool for enhancing consumer experiences and strengthening brand competitiveness. According to the Statista report, the global cross-border e-commerce market is expected to reach $2.1 trillion by 2025, with Southeast Asia showing particularly notable growth, especially in the Thailand market.[8] As an important cross-border e-commerce platform in Thailand, Baggo faces fierce competition from Lazada, Shopee, and other international e-commerce platforms. A key challenge for Baggo is how to leverage IoT technology to enhance brand image and perceived value, in order to attract and retain consumer loyalty. The relationship between IoT and cross-border e-commerce is becoming increasingly interconnected. IoT technologies can significantly enhance operational efficiency, customer experience, and supply chain management in cross-border e-commerce. Here are some key applications and impacts of IoT in cross-border e-commerce:

(1) Optimized supply chain management: IoT technologies help cross-border e-commerce businesses optimize their global supply chains. Through the use of RFID tags, sensors, GPS tracking systems, and other IoT devices, businesses can track the status of products in real time. This enhances supply chain transparency, reduces shipping delays, and helps manage inventory more effectively.
(2) Enhanced customer experience: IoT improves the customer experience in cross-border e-commerce, especially regarding logistics and delivery. Consumers can track the status of their orders anytime via smart devices (*e.g.*, smartphones) and receive real-time notifications throughout the shipping process.
(3) Data-driven personalization: IoT devices collect vast amounts of data on consumer behavior, preferences, and interactions. Cross-border e-commerce businesses can leverage this data for personalized product recommendations, targeted promotions, and enhanced customer service.
(4) Seamless payments and transaction processing: IoT technologies simplify cross-border payments and facilitate faster international transactions. Connected devices can enable automatic payment processing once a product is shipped or delivered, streamlining the purchasing process.
(5) Logistics and last-mile delivery optimization: IoT plays a crucial role in logistics, particularly in cross-border e-commerce. By using intelligent tracking systems, businesses can monitor

international shipments in real time, optimize delivery routes based on data, and even use drones or autonomous vehicles for more efficient delivery.

The integration of IoT in cross-border e-commerce not only improves operational efficiency but also enhances customer experiences, optimizes supply chains, and facilitates smoother international transactions. As IoT technology continues to evolve, its role in cross-border e-commerce will only expand, providing businesses with new opportunities to innovate and streamline their global operations. The primary objective of this study is to explore how IoT technology impacts brand image, consumer perceived value, and purchasing behavior in cross-border e-commerce, using Baggo in Thailand as a case study. In this research, we specifically analyze the effect of IoT technology applications on consumer decision-making, and we will focus on the following key issues:

(1) How does IoT technology affect brand image?
(2) How does IoT technology enhance consumer perceived value?
(3) How do brand image and perceived value affect consumer purchasing behavior?
(4) How does IoT technology improve brand loyalty and affecting repurchase intention?

This research fills the gap in understanding the impact of IoT on brand image and perceived value in cross-border e-commerce and provides empirical analysis to offer strategic recommendations for businesses and policymakers. The specific contributions include the following:

(1) Academic contribution: This study contributes to academic research by integrating IoT technology with concepts such as brand image, perceived value, and consumer behavior into a cohesive theoretical framework, thereby providing a more comprehensive understanding of their interrelationships.
(2) Practical application: The research offers practical implications for businesses by providing concrete suggestions on how to leverage IoT technology to enhance brand competitiveness, specifically through a case analysis of the Thailand market.
(3) Policy impact: This study explores the regulatory needs associated with the use of IoT technology in the e-commerce sector and presents policy recommendations aimed at helping regulators develop appropriate governance frameworks.

By addressing these issues, we aim to provide empirical evidence on the application of IoT in the cross-border e-commerce market and offer valuable insights for business decision-makers and policymakers.

## 2. Research Method

### 2.1 Research framework

We utilized IoT technology to establish a questionnaire platform, allowing consumers to directly respond to surveys on the platform and transmit the data back to the data collection center. The research model is primarily constructed to explore the impact of IoT technology on brand image, perceived value, and consumer purchase behavior. Below is the research framework

of this study, as shown in Fig. 1, which demonstrates the relationships between IoT technology, brand image, perceived value, and consumer purchase behavior.

The core variables of this study include the following:

(1) Independent variable: IoT technology applications (*e.g.*, smart logistics, personalized recommendations, and intelligent customer service);
(2) Mediating variables: brand image (corporate credibility, product quality, and innovation) and perceived value (price fairness, product functionality, and shopping convenience);
(3) Dependent variable: consumer purchase behavior (purchase intention, repeat purchase, and brand loyalty); and
(4) Moderating variables: consumer characteristics (age, purchase frequency, and income).

## 2.2 Research hypotheses

The hypotheses of this study are as follows.

- H1: IoT technology applications have a significant positive impact on brand image. IoT technologies, such as intelligent customer service, real-time tracking systems, and personalized recommendation systems, can enhance the professionalism and reliability of a brand, fostering greater trust among consumers.
- H2: IoT technology applications have a significant positive impact on perceived value. IoT technology can increase product information transparency, improve logistics efficiency, and enhance consumer experience, making consumers feel a higher sense of value. This includes features such as real-time price updates and smart discount strategies.
- H3: Brand image has a significant positive impact on consumer purchase behavior. A positive brand image can increase consumer preference and loyalty toward a product, thereby boosting purchase intention. For example, a brand with a strong corporate image is more likely to attract repeat purchases from consumers.

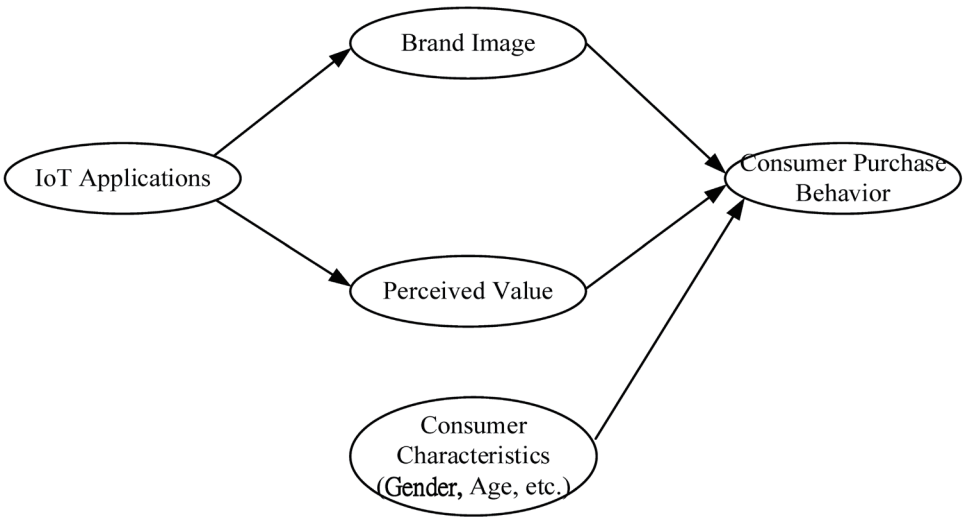


Fig. 1. Research framework diagram.

- H4: Perceived value has a significant positive impact on consumer purchase behavior. When consumers perceive a product as having high cost-effectiveness, superior functionality, and better purchasing experience, they are more likely to make a purchase decision and recommend the product to others.

In this study, we aim to verify the impact mechanisms of IoT technology in cross-border e-commerce through the above four hypotheses and further explore consumer responses to brand image and perceived value.

### 2.3 Research subjects and sampling method

We focused on consumers of Baggo, a company in the Thailand market, as the primary research subjects. Baggo is a company specializing in cross-border e-commerce, primarily selling products through an online platform. The reasons for selecting the consumers of this company as the research subjects are as follows:

(1) Representativeness: Baggo is a representative cross-border e-commerce company in the Thailand market, which can reflect local consumers' views on the application of IoT technologies.
(2) Diversity: The consumer group includes a wide range of age groups, income levels, and shopping behaviors, making it suitable for broad data analysis.
(3) Maturity of IoT technologies: Baggo extensively applies IoT technologies such as smart logistics, personalized recommendation systems, and real-time customer service, providing effective research cases.

The sampling method of this study adopted a stratified random sampling method to ensure the representation of consumers across different age groups, income levels, and shopping behaviors. A total of 669 valid questionnaires were collected. The sampling criterion is that respondents must meet the active consumer conditions of Baggo (having made at least one purchase in the past six months). The survey was distributed primarily through Baggo's online shopping platform, IoT system, and social media to invite consumers to participate. We conducted stratified analysis based on various consumer characteristics (such as age, purchase frequency, and income level) to ensure the representativeness and applicability of the research results.

### 2.4 Questionnaire design

We utilized a structured questionnaire for data collection. The questionnaire design includes the following sections:

(1) Demographic information of respondents: This includes variables such as gender, age, education level, income, and purchase frequency.
(2) IoT technology applications: This focuses on respondents' awareness and usage experiences of IoT applications, including smart logistics, personalized recommendation systems, and intelligent customer service.

(3) Brand image: This measures brand awareness, brand trust, and brand innovativeness.
(4) Perceived value: This assesses the perceived reasonableness of pricing, product quality, and purchase convenience.
(5) Consumer purchase behavior: This evaluates purchase intention, repeat purchase intention, and brand loyalty.

Table 1 shows the background variables of the respondents to ensure that this study covers a sufficient range of variables for further analysis.

We adopted a stratified random sampling method to ensure representativeness across consumer segments categorized by age, income level, and shopping behavior. The inclusion criterion requires respondents to be active Baggo platform users, defined as having completed at least one purchase within the past six months. To facilitate precise targeting and efficient data collection, the Baggo online shopping platform's integrated IoT system was employed. This system collects and processes real-time user data, including login frequency, purchase history, and interaction patterns. On the basis of these data, a pool of 3,582 eligible users was identified. From this pool, 1000 users were randomly selected through the system's automated segmentation algorithm and invited to participate in the online survey via personalized platform notifications, automated email invitations, and social media advertisements. A total of 714 responses were received over a three-week data collection period. After initial screening, 669 valid questionnaires were retained for analysis. The remaining 45 responses were excluded owing to (1) incomplete responses (missing more than 20% of the questionnaire), (2) logical inconsistencies (*e.g.*, contradicting answers across related items), or (3) failure to meet the inclusion criterion (*e.g.*, no recorded purchase in the past six months despite self-claimed eligibility).

The questionnaire was developed on the basis of established consumer behavior and technology adoption frameworks, and it comprises four major dimensions: (1) IoT Technology Applications, assessing consumer interaction with smart features such as personalized recommendations, automated tracking, and responsive interfaces; (2) Brand Image, measuring perceived reputation, trust, and emotional connection with Baggo; (3) Perceived Value,

Table 1
Respondent background variables.

| Variable category | Question content | Response options |
|---|---|---|
| Gender | What is your gender? | □ Male □ Female □ Others |
| Age | What is your age group? | □ Under 18 □ 18–24 □ 25–34 □ 35–44<br>□ 45 and above |
| Education level | What is your highest level of education? | □ High school or below □ Associate's degree<br>□ Bachelor's degree □ Master's degree<br>□ Doctorate degree |
| Purchase frequency | How often do you shop on the Baggo platform? | □ Once a week or more □ Several times a month<br>□ Once a month □ Less than once a month |
| Purchase amount | What is the average amount (in Thailand Baht) spent per purchase on Baggo products? | □ Less than 500 □ 500–1000 □ 1000–2000<br>□ More than 2000 |
| Payment method | What is your primary payment method? | □ Credit card □ Bank transfer/online banking<br>□ Mobile payment (*e.g.* TrueMoney, LinePay)<br>□ Cash on delivery |

evaluating the trade-off between product quality, price, and service efficiency; and (4) Consumer Purchase Behavior, capturing purchasing frequency, decision-making drivers, and behavioral intentions. Each dimension contains multiple items measured on a 5-point Likert scale. The detailed structure and item content are presented in Table 2. Stratified analysis will be conducted on the basis of demographic variables and behavioral data to evaluate differential patterns across consumer segments. This methodological framework ensures the scientific validity, data integrity, and applicability of the results to smart retail environments supported by IoT technologies.

Table 2 shows questionnaire items, and we used a Likert 5-point scale (1–5) to measure respondents' attitudes towards each item, ensuring the accuracy and comparability of the data. In this table, each construct is paired with an item designed to assess the respondents' attitudes, with the 5-point Likert scale ranging from 1 to 5. This approach ensures that the data is consistent and comparable across respondents.

### 2.5 Analytical methods

We employed various statistical analysis methods to ensure the reliability and scientific rigor of the results.

(1) Descriptive statistical analysis: Descriptive statistics were used to analyze the basic demographic information of the sample, including respondents' gender, age, purchase frequency, average purchase amount, shopping methods, and payment methods. This provides an overview of the respondents' basic characteristics.
(2) Reliability and validity testing: To ensure the internal consistency and reliability of the measurement scale, Cronbach's α coefficient was used to assess the reliability of the questionnaire. The validity of the questionnaire was evaluated using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity, ensuring that the questionnaire accurately measures the intended research variables.
(3) Regression analysis: Multiple regression analysis was used to examine the relationships between variables. This method helps explore the impact of IoT technology applications on brand image, perceived value, and consumer purchase behavior, thus testing the validity of the research hypotheses.

Table 2
Questionnaire items.

| Construct | Item content |
|---|---|
| IoT technology application | Have you used the smart logistics service provided by Baggo? |
| | Has Baggo's personalized recommendation system helped with your purchasing decisions? |
| Brand image | Baggo makes you feel that it offers high-quality services. |
| | Do you consider Baggo to be a trustworthy brand? |
| Perceived value | Do you think the prices of Baggo products are reasonable? |
| | The product quality of Baggo meets your expectations. |
| Consumer purchase behavior | Would you be willing to continue purchasing Baggo products in the future? |
| | Would you recommend Baggo to your friends or family? |

(4) Structural equation modeling (SEM) analysis: We used "Analysis of Covariance Structures" (AMOS) for SEM analysis to assess the fit of the research model and test whether the impact paths align with the hypotheses. This approach ensured that the causal relationships between the variables are both reasonable and significant.
(5) Moderating variable analysis: We further explored whether factors such as consumer age, purchase motivation, and brand loyalty play a moderating role in the relationship between IoT technology and brand image/perceived value. We also investigated the differences in IoT technology acceptance and behavioral responses among different consumer groups.

Through these comprehensive analytical methods, we validated the impact of IoT technology on brand image, perceived value, and consumer purchase behavior, providing crucial insights for businesses to formulate effective marketing strategies.

## 3. Results and Discussion

### 3.1 Descriptive statistical analysis

We conducted a descriptive statistical analysis of the basic data from 669 valid questionnaires to understand the respondents' basic characteristics, such as gender, age, and purchase frequency.
(1) Gender distribution: Among the respondents, 54% are male and 46% are female, indicating a balanced gender distribution among Baggo's consumer base.
(2) Age distribution: The largest consumer group is aged 25–34, accounting for 47%, followed by 18–24-year-olds at 29%. This shows that the brand is particularly favored by younger consumers. Consumers aged 35–44 make up 16%, while those aged 45 and above account for 8%, indicating that while the brand primarily attracts younger consumers, there is also a segment of middle-aged consumers.
(3) Purchase frequency: Fifty-eight percent of consumers purchase from the brand 1–2 times a month and 22% purchase more than three times a month, suggesting a relatively high repurchase rate. Additionally, 15% make a purchase once a season and 5% purchase less than once a year, indicating that the brand needs to enhance promotional activities to increase the purchase intention of low-frequency consumers.
(4) Average purchase amount: Twenty percent of consumers spend less than 500 Thailand Baht, indicating that some consumers are price-sensitive. Fifty percent of consumers spend between 500 and 1500 Thailand Baht, which is the primary purchase range, suggesting that the brand's pricing strategy aligns well with market demand. Twenty percent of consumers spend between 1500 and 3000 Thailand Baht and 10% spend over 3000 Thailand Baht, indicating potential in the high-end market.
(5) Shopping methods: Eighty-eight percent of consumers prefer to shop using smartphones, demonstrating that mobile shopping is the predominant trend. Eight percent use computers and 4% use other devices (*e.g.*, tablets), suggesting that the brand should focus on enhancing the user experience on mobile platforms.
(6) Payment methods: Mobile payments (*e.g.*, LinePay and TrueMoney) account for 60%, indicating that mobile payments have become the primary payment method. Credit card

usage is 25%, bank transfer/online banking is 10%, and cash on delivery accounts for 5%, highlighting the high popularity of electronic payments.

The Baggo brand primarily attracts young consumers (18–34 years old) and mobile shopping with mobile payments are the dominant purchasing methods, indicating that the brand should optimize the shopping experience and payment processes on mobile platforms. Furthermore, the high proportion of consumers who make purchases 1–2 times per month suggests that the brand has a relatively high repurchase rate. However, there is a need to strengthen loyalty programs and membership systems to improve long-term consumer retention. The mainstream price range of 500–1500 Thailand Baht shows that the brand's pricing strategy meets market demand, while also revealing potential for growth in the high-end market.

### 3.2 Reliability and validity testing and regression analysis

To ensure the reliability of the measurement scale, we used Cronbach's α coefficient for reliability testing. The results showed that Cronbach's α values for all variables were greater than 0.7, meeting the reliability standard. Additionally, confirmatory factor analysis (CFA) was employed to test the validity.[9] The results revealed a KMO value of 0.82 and a significant Bartlett's Test of Sphericity, indicating that the scale demonstrates good validity. Through linear regression analysis, we examined the impact of IoT technology applications on brand image and perceived value.

H1 Test (IoT Technology → Brand Image): $\beta = 0.65$, $p < 0.01$, indicating that the application of IoT technology significantly enhances brand image.

H2 Test (IoT Technology → Perceived Value): $\beta = 0.72$, $p < 0.01$, showing that IoT technology significantly impacts consumers' perceived value of the product.

Furthermore, the effect of brand image and perceived value on consumer purchase behavior was analyzed, and the results were as follows:

H3 Test (Brand Image → Purchase Behavior): $\beta = 0.48$, $p < 0.01$, suggesting that enhancing brand image contributes to increased purchase behavior.

H4 Test (Perceived Value → Purchase Behavior): $\beta = 0.55$, $p < 0.01$, indicating that perceived value has a significant effect on purchase behavior.

These findings suggest that both IoT technology application and brand image positively impact perceived value, and in turn, affect consumer purchase behavior.

### 3.3 SEM

To rigorously examine the proposed hypotheses and evaluate the interrelationships among core constructs, we employed SEM using AMOS 24.0. The SEM scheme was constructed on the basis of four latent variables derived from the questionnaire (see Table 2): (1) IoT technology applications, (2) brand image, (3) perceived value, and (4) consumer purchase behavior. Each latent construct was measured by 3 to 5 observed variables on a 5-point Likert scale. For example, brand image was assessed through indicators such as trust in Baggo, emotional connection, and perceived brand reputation, whereas IoT technology applications included the

usage frequency of personalized recommendations, automated tracking features, and perceived system convenience. The primary objective of the SEM analysis was to verify the hypothesized causal paths below.

- H1: IoT Technology Applications → Perceived Value
- H2: Brand Image → Perceived Value
- H3: Perceived Value → Consumer Purchase Behavior
- H4: Brand Image → Consumer Purchase Behavior

The model fit indices confirmed the validity and robustness of the hypothesized structure. The chi-square statistic was 125.48 with a $p$-value > 0.05, indicating acceptable model fit. The comparative fit index (CFI) was 0.923 and the Tucker–Lewis index (TLI) reached 0.910—both exceeding the recommended threshold of 0.90. The root mean square error of approximation (RMSEA) was 0.065, which is within the acceptable range of <0.08. These results demonstrate not only the statistical adequacy of SEM but also the theoretical soundness of the model, providing a reliable analytical framework for capturing complex relationships among the consumer perception of IoT functionalities, brand image, and behavioral outcomes. This analytical approach extends beyond descriptive statistics by validating a structured theoretical model using robust multivariate techniques, thus meeting the empirical standards expected in scientific and engineering research contexts.

The path analysis revealed significant and meaningful relationships between key research variables. Specifically, IoT technology application demonstrated a strong positive effect on brand image ($\beta = 0.72$, $p < 0.001$) and perceived value ($\beta = 0.65$, $p < 0.001$). Moreover, both brand image ($\beta = 0.58$, $p < 0.001$) and perceived value ($\beta = 0.60$, $p < 0.001$) exhibited substantial direct effects on consumer purchase behavior. The results underscore that IoT technology application serves as a powerful catalyst, significantly and positively impacting brand image and perceived value, which in turn dynamically shape consumer purchase decisions. Brand image and perceived value emerge as critical mediating mechanisms that translate technological innovation into tangible consumer engagement and purchasing intent, thereby comprehensively validating the study's theoretical framework.

The analysis of the direct and indirect effects reveals a sophisticated mechanism of technological effect on consumer behavior. The total impact coefficient of IoT technology application on consumer purchase behavior is $\beta = 0.78$, with a direct effect of $\beta = 0.50$, complemented by significant indirect effects transmitted through brand image and perceived value. Brand image and perceived value function as critical mediating variables, generating a nuanced mediation effect that illustrates how consumer perceptions of IoT applications strategically reshape brand imagery and ultimately affect purchasing decisions. This intricate pathway demonstrates the transformative power of technological innovation in bridging cognitive perceptions and consumer actions. The SEM analysis provides the robust empirical evidence of IoT technology's pivotal role in cross-border e-commerce markets. By uncovering the complex interrelationships between technological application, brand perception, and consumer behavior, we offer valuable insights that extend beyond theoretical understanding. These findings deliver concrete, data-driven support for businesses seeking to optimize their branding strategies and marketing decisions in an increasingly digital and interconnected marketplace.

### 3.4 Moderated variable analysis

The moderated variable analysis in this study explored the nuanced role of consumer characteristics in mediating the impact of IoT technology on brand image, perceived value, and purchasing behavior. By examining age, purchase motivation, digital literacy, and brand loyalty, we sought to uncover the intricate mechanisms underlying different consumer groups' acceptance and response to IoT technological applications. Age emerged as a critical moderating variable, with significant variations observed across demographic segments. Young consumers aged 18–34 demonstrated heightened sensitivity to IoT technology's effect on brand image and perceived value. This demographic group exhibits greater openness to emerging technological applications and appears more susceptible to IoT-driven purchasing behaviors. In contrast, middle-aged and older consumers (35 and above) displayed lower technological acceptance, with their purchase decisions more heavily influenced by brand trust and pricing considerations. Purchase motivation revealed complex moderating effects that further differentiate consumer behaviors. Price-oriented consumers prioritize promotional discounts and cost-effectiveness, showing minimal interest in IoT technological features. Conversely, technology-oriented consumers exhibit a markedly different behavioral pattern. This segment demonstrates heightened engagement with IoT applications, displaying significant receptiveness to intelligent recommendation systems, personalized shopping experiences, and AI-powered customer service.

Digital literacy emerged as another crucial moderating factor. Consumers with high digital literacy more effectively comprehend the value of IoT technologies and demonstrate greater willingness to engage with digital purchasing platforms. These individuals experience a more profound impact of IoT applications on brand image and perceived value. In contrast, consumers with low digital literacy may struggle to adapt to IoT applications, tending to rely on traditional shopping models. Businesses can address this challenge by implementing educational initiatives and developing user-friendly digital interfaces. Brand loyalty introduced an additional layer of complexity to the analysis. Highly loyal consumers maintain their purchasing behaviors even with limited IoT technological integration, driven primarily by established brand trust. Conversely, consumers with low brand loyalty prove more susceptible to IoT technological influences. By leveraging IoT technologies to enhance shopping convenience and personalization, businesses can effectively strengthen the purchase intentions of this consumer segment. The comprehensive moderated variable analysis reveals the multifaceted role of consumer characteristics in shaping the relationship between IoT technologies and consumer behavior. The findings underscore the critical importance of developing nuanced, segmented strategies that account for demographic diversity, technological receptiveness, and individual consumer preferences. Ultimately, the research provides businesses with a sophisticated framework for understanding and leveraging IoT technologies. By tailoring technological applications to specific consumer characteristics, organizations can optimize brand value, enhance market competitiveness, and create more meaningful, personalized consumer experiences.

The research findings demonstrate the pivotal role of IoT technology in enhancing brand image, strengthening perceived value, and influencing consumer purchasing behavior. A comprehensive comparison with previous research provides nuanced insights into the evolving landscape of technological impact on consumer dynamics. The results align with Zeithaml's seminal work on perceived value's effect on purchase behavior, while extending the understanding by revealing how IoT technology significantly amplifies this relationship.[5] This finding underscores the transformative potential of technological development in reshaping consumer behavior patterns. Compared with Nguyen and Simkin's research, in this study, we demonstrated that IoT technologies' personalized recommendations and intelligent logistics can substantially elevate brand image and directly affect consumer purchase decisions.[10] We went beyond previous investigations by demonstrating how technological innovations create more sophisticated and responsive brand interactions.

Grewal *et al.*'s research highlighted the long-term implications of integrating technology with marketing strategies, a perspective fully supported by the current study's findings.[4] The results confirm that IoT technologies not only impact immediate purchasing behaviors but also play a crucial role in reinforcing brand loyalty through enhanced consumer experiences. By synthesizing these insights, this research provides compelling evidence that IoT technologies serve as more than mere technological tools. They represent strategic mechanisms for businesses to reimagine consumer engagement, brand perception, and purchasing dynamics. The technological applications create a more personalized, intelligent, and responsive consumer journey that transcends traditional marketing approaches. The findings offer a clear strategic imperative for businesses: investing in sophisticated IoT applications can significantly enhance consumer experiences, strengthen brand relationships, and ultimately drive market competitiveness. Companies that successfully integrate these technologies can create more meaningful, adaptive, and consumer-centric business models that respond dynamically to evolving market demands.

Although the empirical data for this study were collected within the context of the Thai e-commerce market, the primary objective was not to derive market-specific conclusions, but rather to construct and validate a generalized structural model that captures the dynamic relationships among IoT technology applications, brand image, perceived value, and consumer purchase behavior. The model is grounded in widely accepted theoretical frameworks, including the technology acceptance model, perceived value theory, and consumer behavior theory, which have demonstrated applicability across diverse cultural and regional contexts. In this study, SEM was employed to test the proposed conceptual framework using the data collected from Baggo's Thai consumer base. The validation of this model serves as a proof of concept, demonstrating that the hypothesized relationships hold under real-world conditions with a statistically significant and well-fitting model structure. Importantly, the constructs used (*e.g.*, perceived value, brand image, and behavioral intention) are not culturally or regionally bound, and the observed indicators (see Table 2) were designed to be modular and adaptable.

Therefore, this research provides a transferable model architecture. Researchers or practitioners aiming to apply it in different geographical or cultural contexts, such as Southeast Asia, Europe, or North America, can do so by recalibrating the questionnaire items to align with

local consumer behavior patterns, language norms, or platform usage habits, without altering the theoretical underpinnings of the model. This approach aligns with cross-context model validation practices common in engineering and systems design, where a core architecture remains consistent, but certain components (*e.g.*, input variables or environmental parameters) are regionally tuned. In summary, the findings from this study are not confined to the Thailand market. Rather, the validated SEM serves as a generalizable analytical framework, offering both theoretical rigor and practical flexibility for international applications in IoT-driven consumer behavior research.

## 4. Conclusions

The development of IoT technology has profoundly impacted the cross-border e-commerce market, not only enhancing consumer trust but also strengthening brand loyalty and purchasing behavior. IoT applications such as smart logistics, real-time customer service, product tracking, and dynamic pricing can optimize the shopping experience and boost market competitiveness. For example, smart logistics can reduce delivery delays, real-time customer service enhances shopping satisfaction, and personalized recommendations and dynamic pricing strengthen consumer perception of value. Transparency technologies in the supply chain (such as RFID and blockchain) further build consumer trust in product origins and quality, fostering brand loyalty. IoT technology has become a core competitive advantage in cross-border e-commerce, especially in areas such as data-driven marketing, smart logistics, intelligent customer service, and payment security. The integration of AI and IoT optimizes marketing strategies, improving conversion and repurchase rates. Smart logistics reduce costs and improve delivery efficiency, while intelligent customer service offers 24/7 real-time support, minimizing customer churn. Additionally, IoT technology enhances payment security, reduces transaction risks, and improves the overall shopping experience. Businesses should further integrate IoT technology with e-commerce platforms to streamline the shopping process while strengthening data privacy protection to enhance market trust. At the same time, leveraging AI and IoT for precise marketing will improve conversion rate and loyalty. Policymakers should improve IoT-related regulations to ensure that technology applications meet international standards, encourage technological innovation, and promote the development of the digital economy. Furthermore, establishing data privacy regulatory mechanisms is crucial to safeguard consumer rights and enhance market trust.

## Acknowledgments

This research was supported by projects under Nos. NSTC 113-2622-E-390-001 and NSTC 113-2221-E-390-011.

## References

1 M. E. Porter and J. E. Heppelmann: Harv. Bus. Rev. **92** (2014) 64.
2 X. Xu, X. He, and Y. Li: IEEE Trans. Eng. Manage. **67** (2020) 1101.

3 D. A. Aaker: Building Strong Brands (The Free Press, New York, 1996).
4 D. Grewal, J. Hulland, P. K. Kopalle, and E. Karahanna: J. Acad. Mark. Sci. **48** (2020) 1.
5 V. A. Zeithaml: J. Mark. **52** (1988) 2.
6 Y. Wang, S. Wang, Y. Yao, and D. Li: SAGE Open **12** (2022) 1.
7 R. L. Oliver: Whence Consumer Loyalty? J. Mark. **63** (1999) 33.
8 https://www.statista.com/study/162268/2023-in-numbers/ (accessed April 2023).
9 D. Goretzko, K. Siemund and P. Sterner: Educ. Psychol. Measure. **84** (2024) 123.
10 B. Nguyen and L. Simkin: J. Mark. Manage. **33** (2017) 1.