Artificial Neural Networks in Marketing:
A Comprehensive Review of Consumer Behavior Applications

İbrahim Halil Efendioğlu[1*]

[1]Business Administration/ Gaziantep University, Gaziantep, Turkey

Abstract

This study aims to provide a comprehensive review of the literature on how artificial neural networks (ANNs) have been applied in consumer behavior research in marketing. The potential of ANNs to enhance the accuracy and effectiveness of marketing strategies is linked to their ability to model complex data relationships. The study highlights how ANNs contribute to marketing processes such as customer segmentation, sales forecasting, and dynamic pricing strategies while also improving customer satisfaction and the effectiveness of loyalty programs. However, it also addresses limitations such as the lack of transparency, high data requirements, and ethical concerns associated with ANNs. By synthesizing the existing body of research, this study examines how ANNs have been used to predict consumer behavior, the challenges encountered, and the directions for future research. Furthermore, it identifies significant gaps in real-time data integration, model transparency, and data privacy. The findings emphasize the transformative potential of ANNs in marketing strategies while shedding light on critical areas that future research should address.

Keywords: Artificial Neural Networks, Consumer Behavior, Marketing

INTRODUCTION

The rapidly evolving intersection of artificial intelligence (AI) and consumer behavior in marketing has garnered significant interest both academically and practically (Abrardi et al., 2022). Among these AI technologies, artificial neural networks (ANNs) stand out as a unique and powerful tool for understanding and predicting consumer behavior. The utilization of artificial neural networks (ANNs) in consumer behavior offers significant advantages in the development of marketing strategies and the management of customer relationships. ANNs can analyze large and complex datasets, enabling more accurate predictions of consumer behavior. This allows for more effective targeting of marketing campaigns (Boozary, 2024). Additionally, ANNs can study consumer behavior to provide personalized recommendations tailored to individual consumers, thereby enhancing customer satisfaction and increasing the effectiveness of loyalty programs. Moreover, ANNs can predict future consumer trends based on past data and behaviors, giving businesses a strategic advantage by anticipating trends (Karim et al., 2024). Furthermore, ANNs help segment consumers into groups with similar characteristics, facilitating the development of optimal marketing strategies for each segment, leading to more efficient resource allocation. ANNs can also optimize customer service processes by learning from customer interactions and feedback, resulting in an improved customer experience (Dang et al., 2023). On the other hand, ANNs enhance the accuracy of sales forecasts through consumer behavior analysis and improve efficiency in inventory management, which contributes to cost reduction and increased profit margins. Therefore, the ability of ANNs to model complex patterns and relationships within data offers businesses unique opportunities to analyze consumer data more precisely and effectively, thereby improving their marketing strategies (Mkedder & Bakır, 2023). The use of ANNs and the research on this subject in predicting consumer behavior is increasing day by day.

In recent years, many studies have used the ANN approach to predict consumer preferences and decision-making processes (Albahri et al., 2022; Ashfaq et aL., 2023; Boozary, 2024; Hajek et al., 2020; Kalinić et al., 2021; Kliestik et al., 2022; Lee et al., 2022; Leong et., 2021; Ma et al., 2023; Mishra et al., 2023; Nica et al., 2022; Sharma et al., 2021; Wang et al., 2023) . However, there is no comprehensive review that synthesizes the findings in these studies and evaluates the combined use of consumer behavior and the ANN approach. This gap in the literature underscores the need for a systematic review that consolidates existing knowledge and identifies the applications and limitations of ANNs in the marketing and consumer behavior context. Therefore, an up-to-date and comprehensive literature review on the various uses of ANNs in consumer behavior will enable the gaps in this area to be seen more clearly.

Accordingly, the aim of this study is to systematically review the literature on the use of ANNs in consumer behavior research, providing a comprehensive overview of the current state of knowledge in this area. The study also aims to identify critical areas in the existing literature, offer suggestions for future research, and provide guidance on how ANNs can be more effectively utilized in the marketing context. Thus, this study will provide valuable insights, aiming to contribute to the development of knowledge in this field.

This study is significant for several reasons: First, by deeply synthesizing research on ANNs and consumer behavior, it contributes to the marketing literature by highlighting key trends, challenges, and opportunities in this field. Second, it identifies gaps in the existing literature, offering valuable insights for future research and guiding new directions and methodologies in this area. Third, the study emphasizes the importance of integrating AI technologies like ANNs into marketing strategies and demonstrates how these tools can enhance the accuracy and effectiveness of marketing efforts.

Ultimately, the study aims to examine how ANNs have been applied in consumer behavior research, systematically review the existing literature in this field, and identify key trends, challenges, and opportunities. Thus, the study seeks to address the following research questions:

RQ1: What are the current trends in the literature regarding the use of ANNs in marketing and consumer behavior?
RQ2: What methodological approaches have been adopted for predicting consumer behavior using ANNs?
RQ3: What are the applications, advantages, limitations, and ethical challenges of ANNs in the literature?
RQ4: What gaps exist in the current literature, and how can future research address these gaps?
The remainder of this paper is organized as follows: First, the literature review section will explain ANNs and examine the existing literature on how ANNs have been used in consumer behavior research. Next, the methodology section will detail how the study was conducted, including the systematic literature review (SLR) method and the research process. The findings section will present the main findings from the literature review, and the use of ANNs together with consumer behavior will be examined. The discussion section will address the theoretical and practical contributions of the findings, discuss gaps in the literature, and offer suggestions for future research. Finally, in the conclusion section, the general findings of the study will be summarized and suggestions for future research will be presented.

LITERATURE REVIEW

Artificial Neural Networks (ANN)

Artificial Neural Networks (ANNs) are a powerful method of artificial intelligence (AI) that models the functioning of biological neural systems. They are particularly useful in data processing, where they process data through a series of interconnected nodes or 'neurons,' mimicking the learning and information processing capabilities of the human brain (Zou et al., 2009). First theoretically proposed by McCulloch and Pitts in 1943, ANNs have evolved over time into a powerful tool used to solve various complex problems, particularly in the field of data processing (Chakraverty et al., 2019).

The theoretical foundation of ANNs is based on how biological nerve cells interact with each other. A biological neuron receives signals from other cells through dendrites, processes them in the cell body, and transmits them to other cells through the axon. Similarly, ANNs receive input data, process this data, and produce an output (Rigby et al., 2019). Each neuron is associated with a specific weight, updated throughout the learning process (Sharma et al., 2017):

Core Components of ANNs:
Layers: ANNs typically consist of an input, hidden, and output layer. The input layer is where data is introduced to the network, the hidden layers process this data, and the output layer generates the final prediction or classification.

Weights: Each connection is associated with a weight that determines the strength of the signal. These weights, not to be underestimated, significantly influence how the network processes data and are optimized during the learning process.

Activation Functions: Activation functions determine how neurons process input data. Standard activation functions include sigmoid, ReLU (Rectified Linear Unit), and tanh.

Learning Process: ANNs learn using techniques such as the backpropagation algorithm. In this process, the difference between the network's prediction and the actual value is calculated, and this error is used to update the weights.
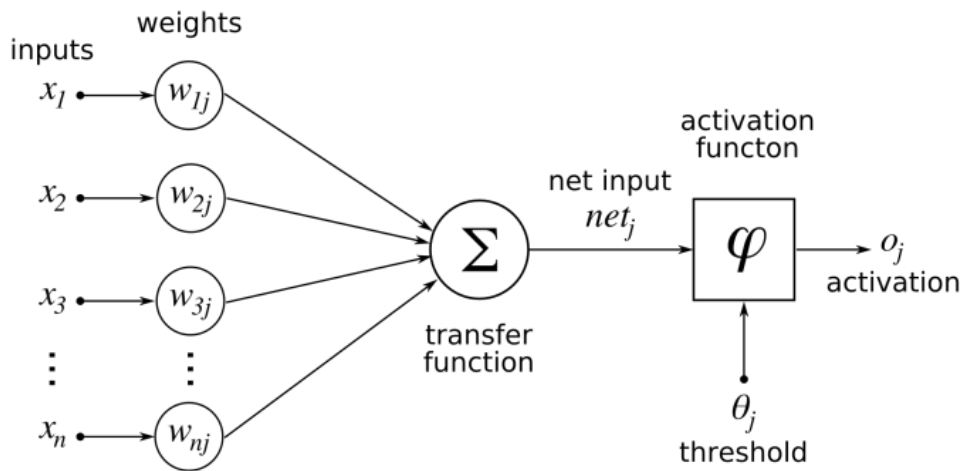

Figure 1. Artificial Neural Networks (ANN)
Source: Salah Alaloul & Hannan Qureshi (2020)

Use of ANNs in Predicting Consumer Behavior

Predicting consumer behavior plays a critical role in the development of marketing strategies. These predictions are used in various applications, such as customer segmentation, personalized marketing, demand forecasting, and enhancing customer loyalty (See Figure 2). ANNs are considered highly effective tools for making these predictions (Kasem et al., 2024):

Customer Segmentation: ANNs are used to analyze consumer data and identify customer groups with similar behaviors. These segments enable the creation of more targeted and effective marketing campaigns. For example, a retail company can analyze customers' purchasing habits to identify different consumer groups and offer customized promotions for each group.

Purchase Prediction: ANNs can analyze past purchasing data to predict future buying behaviors. This provides significant advantages in inventory management, promotional strategies, and supply chain optimization. For instance, an e-commerce platform can use users' previous purchase histories to predict when certain products are likely to be repurchased.

Optimization of Marketing Strategies: ANNs can optimize the effectiveness of marketing campaigns by analyzing consumer feedback, social media interactions, and other data. This process involves analyzing which messages are most effective for different consumer groups and determining which strategies best enhance customer loyalty.
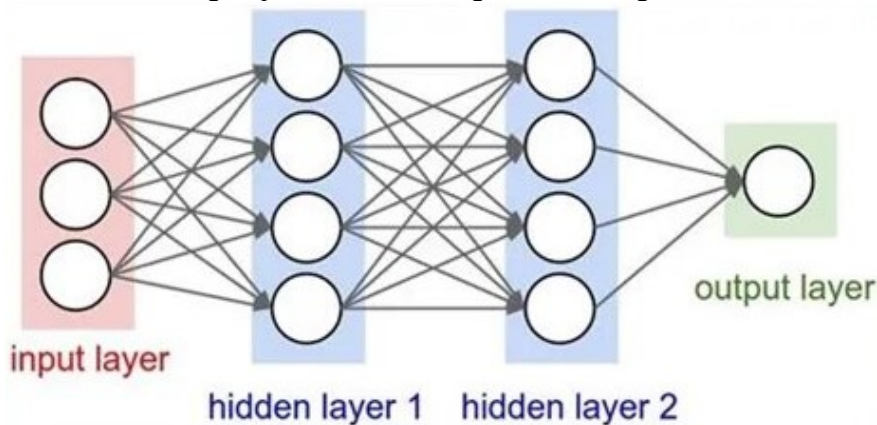

Figure 2. ANN Prediction Layers
Source: Akdagli (2021)

Advantages and Limitations of ANNs

ANNs are highly capable of handling vast and complex datasets. They excel in modeling non-linear relationships and making highly accurate predictions. These qualities make ANNs ideal for solving complex problems such as predicting consumer behavior. However, ANNs require large amounts of data and are computationally expensive techniques (Kurani et al., 2023). Additionally, the network's learning process can be challenging to understand, leading to what is known as the "black box" problem, where the internal workings of the network are not easily interpretable (Fraternali et al., 2023). ANNs have emerged as a powerful tool for predicting consumer behavior. With a theoretical background rooted in biological neural systems, this technology not only plays a critical role but also empowers in developing marketing strategies. However, the challenges and limitations associated with using ANNs must also be considered. Therefore, further research on the applications of ANNs in the field of marketing is necessary.

Methodology

This study employed the systematic literature review (SLR) method to delve into the relationship between ANNs and consumer behavior. The SLR, a method that systematically, transparently, and reproducibly reviews the existing literature in a specific research area, was structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol (Attaoui & Gaber, 2024). This protocol, which sets forth recommended reporting standards for systematic reviews and meta-analyses, is crucial in maintaining the rigor and transparency of the research process, thereby enhancing the credibility of our study. It encompasses four key steps: defining the scope of the literature review, data collection, setting criteria for article selection, and analyzing the findings.

The first step involved outlining the general framework of the literature to be reviewed and identifying relevant studies using specific keywords. In the second step, the data collection process was initiated, and articles meeting the defined criteria were meticulously screened, demonstrating the thoroughness of our research. The third step was dedicated to setting inclusion and exclusion criteria, and studies were meticulously selected from the literature based on these criteria. Finally, the collected data were meticulously analyzed to examine the impact of ANNs on consumer behavior in detail.

The literature review was conducted using the Scopus database, a reliable academic database that includes high-impact publications. Additionally, Scopus is one of the most comprehensive databases in fields such as marketing and business. It also has a large collection of articles from high-quality and peer-reviewed journals.

Thus, a literature search was performed using pre-determined keywords in the detailed database of Scopus. The search strategy employed the following keywords: (consumer behavior) AND (artificial neural networks), aimed at identifying studies that explore the relationship between ANNs and consumer behavior. After the search, only articles were selected, and the review was limited to publications from 2020 to 2024. This limitation was intended to focus on the most recent and high-quality studies evaluating the impact of ANNs on consumer behavior. Finally, articles related to the marketing field were selected, ensuring the credibility and relevance of the literature review.

Specific inclusion and exclusion criteria were used to select the studies from the literature review, ensuring a thorough and objective selection process (see Figure 3).
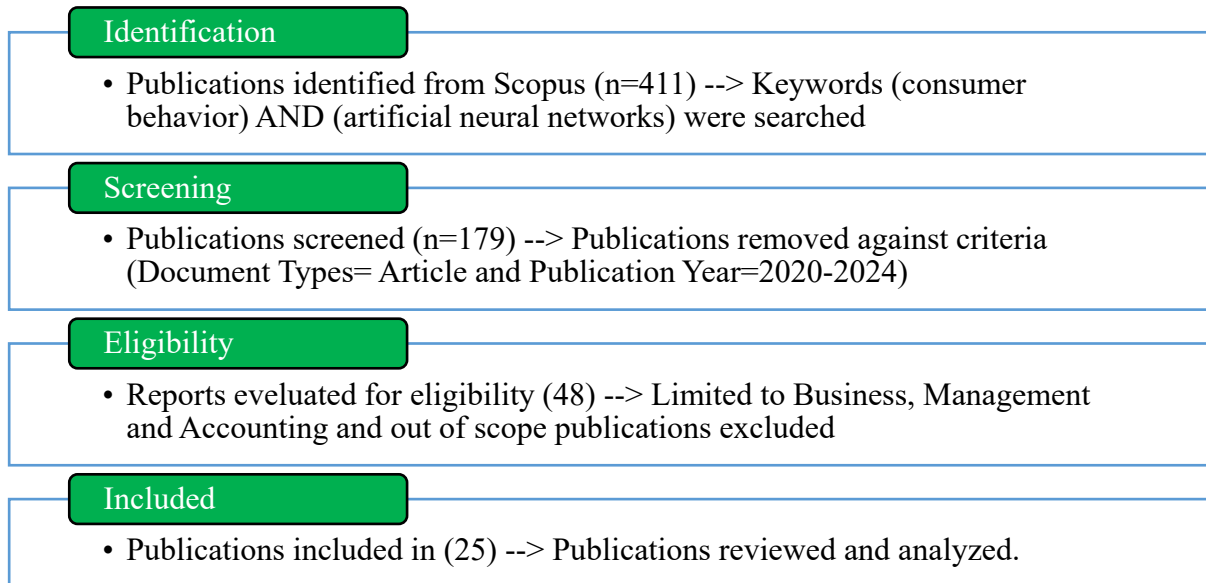
Figure 3. PRISMA Process

Inclusion Criteria

Time Frame: Publications from 2020 to 2024 in the Scopus database were considered. This selection aims to capture the most recent developments in applying ANNs in marketing and consumer behavior.

Type of Publication: Only articles published in peer-reviewed journals were included. Conference papers, book chapters, and other types of publications were excluded. This selection ensures a focus on high-quality research that has been recognized within the field.

Scope: Among the articles, only those related to marketing were selected. Studies that did not focus on consumer behavior or examined ANNs in contexts outside of marketing were excluded.

Exclusion Criteria

Conference Papers and Book Chapters: These publications were excluded, with only journal articles being evaluated.

Studies Not Related to Marketing: Research that did not directly pertain to marketing and consumer behavior was excluded.

Initial Screening Results: **The initial search in the Scopus database identified 411 publications, but this number was reduced to 25 based on the exclusion criteria outlined above.**

The selected articles were evaluated using the SLR analysis method. Each article was analyzed in terms of the main themes and findings related to the impact of ANNs on consumer behavior. The analysis process involved summarizing each article's key findings and methodological approaches and then categorizing these findings under general themes. Additionally, methodological differences between the articles and existing gaps in the literature were identified and discussed. This approach allowed for a thorough understanding of how ANNs influence consumer behavior and highlighted areas within the current literature that are open to further development.**.**

Findings

According to the SLR study, the articles reviewed were published between 2020 and 2024. The number of publications has shown a noticeable increase over the years. In 2020, 2 articles were published, rising to 3 in 2021. The number of articles published in 2022 reached 4; by 2023, 8 articles had been published. For 2024, as of August, eight articles have already been published. Since 2024 is not yet complete, this number is expected to increase by the end of the year. These data indicate that research in this area has risen steadily each year and that academic interest in this topic rapidly grows over time (See Figure 4).
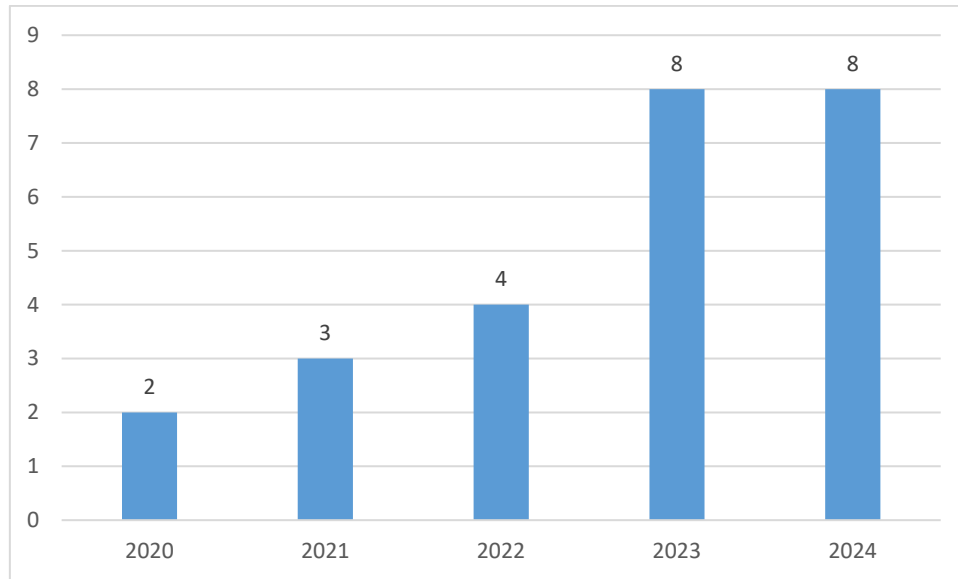
Figure 4. Number of Articles

Among the 25 articles reviewed, empirical studies (20 articles) are predominant. In contrast, literature reviews (4 articles) and case studies (1 article) are fewer in number, indicating a potential gap in terms of theoretical and methodological contributions (See Table 1).

Table 1. Summary of Reviewed Articles: Authors, Study Types, and Titles

Authors	Study Type	Article Title
Zhao et al. (2024)	Empirical	Decoding green food safety information dependency in the digital era: An intelligent validation using SEM-ANN framework
Srivastava and Bag (2024)	Literature Review	Modern-day marketing concepts based on face recognition and neuro-marketing: a review and future research directions
Singh and Ebana-Cabanillas (2024)	Empirical	An SEM-Neural Network Approach for Predicting Antecedents of Online Grocery Shopping Acceptance
Mkedder and Özata (2024)	Empirical	I will buy virtual goods if I like them: a hybrid PLS-SEM-artificial neural network (ANN) analytical approach
Matin et al. (2024)	Empirical	Determinants of Green Smartphone Application Adoption for Sustainable Food Consumption Among University Students
Jin et al. (2024)	Empirical	Forecasting fish prices with an artificial neural network model during the tuna fraud
Chen and Wu (2024)	Empirical	Would you be willing to purchase virtual gifts during esports live streams? Streamer characteristics and cultural traits
Azadravesh et al. (2024)	Empirical	Predicted consumer buying behavior in neural marketing based on convolutional neural network and short-term long-term memory
Zhou et al. (2023)	Empirical	Why do social media users follow tourism-related posts? Roles of bloggers and posts in trip planning

Zambrano-Asanza et al. (2023)	Empirical	Integrating artificial neural networks and cellular automata model for spatial-temporal load forecasting
Ye and Chai (2023)	Empirical	Research and application flow-based live-streaming shopping towards compulsive buying
Storm et al. (2023)	Empirical	Identifying farmers' response to changes in marginal and average subsidies using deep learning
Špicas et al. (2023)	Empirical	Estimating the Acceptance Probabilities of Consumer Loan Offers in an Online Loan Comparison and Brokerage Platform
Ganeshkumar et al. (2023)	Literature Review	Artificial intelligence in agricultural value chain: review and future directions
Arranz et al. (2023)	Empirical	The effect of consumption and production policies on circular economy business models: A machine learning approach
Alaminos et al. (2023)	Empirical	Neural networks for estimating Macro Asset Pricing model in football clubs
Moral-Cuadra et al. (2022)	Empirical	Discovering gastronomic tourists' profiles through artificial neural networks: analysis, opinions and attitudes
Jajić et al. (2022)	Empirical	Deployment of the Microeconomic Consumer Theory in the Artificial Neural Networks Modelling: Case of Organic Food Consumption
Giovanis et al. (2022)	Empirical	Mining the hidden seam of proximity m-payment adoption: A hybrid PLS-artificial neural network analytical approach
Duarte et al. (2022)	Literature Review	Machine Learning and Marketing: A Systematic Literature Review
Sobhanifard and Eshtiaghi (2021)	Empirical	Exploratory modelling and ranking of the trust factors of messages about organic foods in social networks
Senguler and Inel (2021)	Empirical	An Empirical Study Based on Artificial Intelligence for Determining Brand Value Based on Financial Data
Dias et al. (2021)	Empirical	Assessing the Effects of Delivery Attributes on E-Shopping Consumer Behaviour
Peng et al. (2020)	Literature Review	Artificial-Neural-Network-Based Consumer Behavior Prediction: A Survey
Annunziata et al. (2020)	Case Study	Household Food Waste: A Case Study in Southern Italy

Focused Topics

The focused topics include predicting consumer behavior, determining brand value, and developing e-commerce delivery preferences. The potential of ANNs to understand the dynamics and complexities of consumer behavior is particularly emphasized. Studies have shown that ANNs can more comprehensively and accurately model consumer behavior than traditional statistical methods. Additionally, some studies have concentrated on specific application areas such as consumer segmentation, product recommendation systems, and predicting purchase intentions using ANNs. In this context, the contribution of ANNs to making more effective decisions in marketing strategies has been highlighted.

For instance, Zhao et al. (2024) examined the dependency on green food safety information in the digital age and how consumers' psychological perceptions influence their information-seeking behavior and purchase decisions. The study collected data from 630 online users in Guangzhou using PLS-SEM and ANN. It was found that consumers' psychological perceptions significantly affect their information-seeking behavior and purchase decisions regarding green food safety, with reliable information sources playing a critical role in consumer behavior. Using ANNs, the authors could more accurately analyze the relationship between consumers' psychological perceptions, information-seeking behavior, and purchase decisions. The findings provide theoretical and empirical contributions to understanding consumer behavior related to green food safety. The study emphasizes that concerns about green food safety shape information-seeking behavior and purchase decisions, and personalized information delivery based on reliable sources can enhance consumer satisfaction. Future research is recommended to focus on cross-cultural comparisons, long-term effects, and the development of customized strategies to meet the needs of different consumer groups, with a deeper examination of consumer behavior through mixed-methods research.

Srivastava and Bag (2024) explored the potential of facial recognition and neuromarketing in modern marketing strategies, examining data-driven marketing strategies shaped by customer behavior data. The study conducted a systematic literature review on facial recognition marketing and neuromarketing, revealing that the modern market still has not sufficiently explored these areas. The study emphasized that facial recognition and neuromarketing could be significant in understanding consumer behavior and optimizing marketing strategies. ANNs were highlighted as critical in using these advanced marketing techniques more effectively, predicting consumer behavior, and optimizing marketing strategies. The conclusion was that these technologies offer significant opportunities to improve marketing strategies by providing cognitive insights into consumer behavior. Future research should focus on developing predictive models and further exploring the applications of these technologies in marketing strategies.

Singh and Ebana-Cabanillas (2024) examined the factors influencing the acceptance of online grocery shopping in India, such as visibility, economic values, habit, informativeness, and website trust. The study adopted a two-stage PLS-SEM and ANN approach to predict intentions to use online grocery shopping. The findings indicated that habit was the most influential factor affecting user intentions, followed by perceived usefulness, ease of use, and website trust. The ANN model provided flexible and highly accurate results by capturing nonlinear relationships more accurately, supporting the classification of significant predictors identified by SEM. This allowed for more precise predictions of customer behavior and enabled online grocery service providers to tailor their strategies more effectively to customer preferences. Future studies are recommended to cover different demographic regions for broader representation and to enhance the effectiveness of marketing strategies.

In their study, Mkedder and Özata (2024) investigated the functional, emotional, and social values influencing the intention to purchase virtual goods in Free-to-Play (F2P) games. Data from 352 participants were analyzed using PLS-SEM and ANN. The results showed that perceived value positively affects the intention to purchase virtual goods, with quality and social presence being critical factors. ANN supported the PLS-SEM results by capturing nonlinear relationships. The research suggests that F2P game developers focus on social features and high-quality graphics to enhance player experience and increase virtual goods sales.

Additionally, strategies such as time-limited promotions were emphasized as potentially increasing purchase intentions. The study theoretically extended the Theory of Consumption Values in the context of virtual goods and demonstrated the effectiveness of combining PLS-SEM with ANN in understanding consumer behavior. These findings can help F2P game providers optimize their strategies. The study suggests that the model should be tested in different demographics and regions in the future and that the effects of 3D virtual goods and other virtual environments on purchase intentions should be explored.

The study by Matin et al. (2024) investigated the factors influencing the adoption of green smartphone applications for sustainable food consumption among university students. The study employed an integrated model combining the Content Richness Model and the Unified Theory of Acceptance and Use of Technology (UTAUT) with external components such as personalization and environmental concerns. Data collected from 700 participants were analyzed using SEM and ANN, among three machine learning techniques. The results showed that UTAUT, personalization, and environmental concerns positively affected the adoption of green applications. ANN provided the highest accuracy in determining the importance of independent variables, such as performance expectancy, and supported the SEM results. The practical contributions of the study offer significant insights to developers and marketers on how to design and market applications that promote sustainable consumption more effectively. Theoretically, this research contributes to the literature on the factors influencing the adoption of green applications. Although the study's cross-sectional nature, limited to a specific time frame, presents some limitations in generalizing the findings,

it is suggested that further research be conducted in different regions and demographic groups. Additionally, future studies should focus on a more in-depth examination of the role of personalization in adopting green applications.

In their study, Jin et al. (2024) used an ANN model and a threshold vector autoregressive model (TVAR) to predict fish prices during a tuna fraud incident in Spain in 2017. The study found that TVAR offered better short-term predictions for tuna and salmon prices, while ANN performed better in the medium term. The ANN model was particularly effective in capturing nonlinear relationships and hidden structures in the data, making it more accurate in price predictions. This study significantly contributes to the literature on applying machine learning in price prediction during food safety incidents. The practical contributions of the study offer guidance to policymakers and retailers in better understanding market dynamics and consumer behavior during food safety events.

Additionally, the high accuracy rates provided by ANN in agricultural food price prediction present new opportunities for future research and applications. The study's limitations include the inability of social media data to fully represent public engagement and the findings limited to the tuna fraud incident in Spain. Future research should examine food safety incidents in different regions and include additional social media platforms. This study highlights the potential of ANNs in price prediction during food safety events.

In their research, Chen and Wu (2024) examined the factors influencing viewers' intentions to purchase virtual gifts during esports live streams in China. The study investigated how broadcasters' characteristics (expertise, trustworthiness, attractiveness, interaction, and closeness) and Chinese cultural traits shape viewers' social cognition and how this impacts their flow experiences, emotional attachment, and purchase intentions. Viewer behavior was analyzed using SEM, ANN, and Necessity Analysis. The results showed that broadcasters' attractiveness and cultural traits like face consciousness significantly influenced viewers' sense of presence and belonging. ANN provided a higher fit in determining these relationships than SEM. The study recommends developing effective marketing strategies to enhance viewer engagement and promote virtual gift purchases for esports livestream platforms and broadcasters. However, the study notes that the findings must be more generalizable to other cultural contexts due to its focus on Chinese culture. Long-term longitudinal studies are required to track changes in viewer behavior. Additionally, the use of neuroscience technologies to delve deeper into viewers' mental processes in future research is recommended.

In their study, Azadravesh et al. (2024) focused on predicting consumer purchase behavior in neuromarketing using EEG data and machine learning techniques. The study employed a combination of EEG indicators, discrete wavelet transformation (DWT) for feature extraction, and a CNN-LSTM model for classification, which outperformed traditional methods. The proposed CNN-LSTM model accurately predicted consumer preferences by capturing spatial and temporal dependencies from EEG data. The results showed that this model had higher accuracy rates than other classifiers, such as SVM and RF. The study demonstrated that EEG and machine learning techniques could effectively develop neuromarketing strategies, significantly contributing to understanding subconscious consumer behavior and decision-making patterns. Practically, this model has the potential to enhance the accuracy of neuromarketing tools by combining EEG data with biometric indicators such as galvanic skin response and heart rate variability. Future research should focus on improving the data set with a better headset, incorporating eye-tracking, and using more subjects for cross-validation. This study shows that using more advanced machine learning techniques in processing EEG-based neuromarketing data is more effective in predicting consumer behavior than traditional marketing methods.

In their study, Zhou et al. (2023) investigated the factors influencing social media users' intentions to follow tourism-related posts (TRPs) for travel planning. The study identified alignment between bloggers and users and interest in TRPs as critical elements influencing the intention to follow these posts through evaluation and attitude components. The relationships between bloggers' trustworthiness, content quality, attitudes toward posts, and the intention to follow TRPs were analyzed using PLS-SEM and ANN. The findings showed that alignment between bloggers and users and interest in TRPs significantly impacted the intention to follow these posts in travel planning. Strong R2 coefficients supported these relationships. The study contributed to understanding how social media influences travel behavior and provided practical recommendations for bloggers and destination marketing organizations. The results offer valuable insights to social media platforms and bloggers on developing effective marketing strategies.

In the study by Zambrano-Asanza et al. (2023), a novel method was proposed for spatial-temporal load forecasting by integrating ANN and cellular automata (CA) models. This innovative model uses land use preferences, neighborhood conditions, spatial constraints, and random perturbations to predict consumer and electrical load development in small areas. The study emphasizes the importance of normalization and temporal factors in improving error rates in spatial-temporal load forecasting. The proposed method was validated in an electrical service area in

Ecuador, achieving acceptable metrics with spatial error pattern measurements during the training and testing phases. The research highlights the need for strategic expansion planning and understanding consumer behavior in spatial-temporal load forecasting for long-term distribution planning. The study aims to address deficiencies in spatial error prediction in existing forecasting models and shows how crucial spatial-temporal data analytics is in calibration and validation processes. The findings provide an innovative framework for energy demand forecasting with broad application potential in the energy sector.

Ye and Chai (2023) conducted a comprehensive investigation into customer behavior in live-stream e-commerce, focusing on the effects of flow state factors and post-flow state mediators on compulsive buying. The study, which gathered data from 517 individuals who frequently participated in live-stream e-commerce in China, tested hypotheses using the Stimulus-Organism-Response (SOR) model with ANN and SEM. The research identified trust and pleasure as significant flow factors, while loyalty and addiction were found to be post-flow mediators. The study's emphasis on the effects of trust, pleasure, and flow experience on compulsive buying and loyalty provides both theoretical and practical contributions to understanding consumer behavior in live-stream e-commerce. It sheds light on how social influence, trust, and social capital shape consumer experience, offering important insights into understanding and improving consumer behavior in live-stream e-commerce.

Storm et al. (2023) used deep learning methods to examine how farmers in Norway responded to changes in average and marginal subsidies. The study found that farmers responded more to average payments than marginal payments, challenging standard economic theories. The flexible RNN model and multi-year farm-level data used in the study analyzed how subsidies affected farmer decisions by considering cross-product effects on different agricultural activities. The findings highlight the potential contribution of deep learning tools to policymakers' evaluation and prediction processes of the impact of varying farm policy options. The results show the importance of cross-product effects in policy evaluation by illustrating how subsidies for one activity impact others.

Špicas et al. (2023) focused on developing statistical models to predict the acceptance probabilities of consumer credit offers on online credit comparison and brokerage platforms. The study created predictive models using various classifiers such as logistic regression, random forest, XGboost, ANN, and support vector machines, showing high success in predicting the acceptance probabilities of credit offers. The research emphasizes the importance of considering local regulations and information infrastructures in developing predictive models for online credit comparison platforms. The study's findings indicate that platform-specific features and data diversity significantly predict the acceptance probabilities of credit offers.

Ganeshkumar et al. (2023) presented a literature review examining the use of artificial intelligence (AI) in the agricultural value chain. The study underscores that the adoption and implementation of AI in farming can significantly enhance the efficiency and competitiveness of the industry. This has the potential to address the challenge of feeding a growing population by 2050. The research outlines potential applications of AI in the agricultural value chain (AVC), including the use of deep learning algorithms in areas such as water resource management, yield prediction, and personalized consulting. It suggests that increasing AI integration into the agricultural sector can provide benefits such as income growth, competitiveness, and cost reduction. The study concludes that further research in this area is crucial to fully realize the transformative potential of AI in agriculture.

In the study by Arranz et al. (2023), the effects of circular economy (CE) consumption policies on circular economy business models (CEBM) are examined. The study emphasizes the importance of consumption and production policies in developing CEBMs and highlights their complementary and synergistic effects. Using data from the EU, the article combines classical econometric methods with machine learning approaches, revealing that consumption policies directly impact CEBMs. Furthermore, the study concludes that the combined implementation of consumption and production policies contributes to the development of CEBMs. This research provides valuable insights for policymakers in the context of environmental policies by analyzing the interaction between consumption and production policies and their effects on the development of CEBMs.

Alaminos et al. (2023) present a study that uses ANNs to estimate macro asset pricing models for football clubs. The study highlights the importance of using nonlinear techniques for predicting asset pricing models and achieved over 90% accuracy in predictions with ANN techniques like DNDT and QNN. The research points out the significance of the increasing component, which accounts for approximately 40% of the variance in price-dividend ratios, emphasizing the importance of long-term risks and the habit component. The study aims to improve financial asset pricing predictions in football to prepare investors for unexpected crises like COVID-19 better.

Moral-Cuadra et al. (2022) analyze the profiles of gastronomic tourists using ANNs to examine the relationship between the social characteristics of gastronomic tourists and their views on gastronomic tourism. Using data collected from field research in Córdoba, Spain, the study developed an ANN model to create profiles of gastronomic tourists. The research highlights the importance of traditional gastronomy, gastronomic innovation, and the role of gastronomy in social interactions. The results provide helpful information for public institutions promoting gastronomic tourism and professionals in the gastronomy sector. The study found that as tourists age, their appreciation for diversity, desire to taste on-site, and willingness to return increase, while higher income levels enhance interest in gastronomy. The study concludes that traditional gastronomy significantly enriches the tourist experience, especially among those with higher education levels and cultural interests.

Jajić et al. (2022) use the Lancaster approach of microeconomic consumer theory, modeling it with ANNs to analyze organic food consumption. The study examines the relationship between organic food consumption, demographic characteristics, and health consciousness attitudes of individuals living in Croatia. The research highlights the impact of healthy food stores and consumer awareness of organic food consumption. The findings validate the Lancaster approach and show that consumer-defined attributes are significant in organic food consumption. The study successfully models the relationship between consumer awareness and organic food consumption using ANNs. The results reveal that consumers' awareness of health food stores significantly affects organic food consumption. Additionally, the research emphasizes the influence of the availability of health food stores and demographic factors on organic food consumption. It provides various recommendations to public health authorities for developing healthy eating habits.

Giovanis et al. (2022) extend the Theory of Planned Behavior (TPB) to investigate the adoption of proximity mobile payment services (PMPS). The study employs a two-stage hybrid analytical methodology considering linear and nonlinear relationships. This methodology combines partial least squares (PLS) regression with ANNs to identify the critical determinants of PMPS adoption and rank their relative impact. The research reveals that normative and control beliefs play a significant role in PMPS adoption, while some contradictions related to customer attitudes and behavioral intentions are identified. The findings offer important insights for marketing managers to strengthen strategies for promoting PMPS services.

Duarte et al. (2022) provide a systematic literature review examining adopting machine learning (ML) methods in marketing from 2008 to 2022. The study emphasizes the significant growth and maturation of ML techniques, such as deep learning, supervised learning, reinforcement learning, and hybrid methods, in solving various problems in marketing, including consumer behavior, recommendation systems, forecasting, market segmentation, and text analysis. The research shows that ML techniques have matured and developed in marketing, allowing non-experts to use ML effectively in complex data analysis. The study also suggests that ML should be applied more extensively in new and unexplored areas of marketing, highlighting the importance of correctly applying more straightforward ML techniques.

Sobhanifard and Eshtiaghi (2021) conducted a study to model and rank the trust factors of messages about organic foods on social networks. The study consists of four stages: literature review, hypothesis development, data collection, and ANN analysis. The research identifies 31 factors affecting the trust of messages about organic foods and uses exploratory factor analysis (EFA) and ANNs to rank these factors. The findings suggest that Iranian and international organic food producers can increase consumer trust and sales by focusing on these 31 factors. The EFA-based model reveals six factors that positively affect trust levels: valid experiences, content creation, providing guarantees, informing about product benefits, emphasizing naturalness, and communicating with previous buyers. The study also ranks the top five factors affecting the trust of messages about organic foods and significantly contributes to this field.

In the study by Senguler and İnel (2021), artificial intelligence applications were used to determine brand value based on financial data. The study examined how brand value is determined using financial techniques and consumer behavior-based models, evaluating the effectiveness of ANNs in this process. Various models were created and compared based on R-squared, MAPE (Mean Absolute Percentage Error), and RMSE (Root Mean Square Error) values. The research emphasizes the importance of ANNs in objectively determining brand value. The study's findings show that the brand values obtained using ANNs are consistent with those chosen by the 'Brand Finance' firm. The study contributes to the literature on how financial models can be used to determine brand value and demonstrates the effectiveness of ANNs in this area.

Dias et al. (2021) investigate the impact of delivery features on consumer behavior in e-commerce. This study, conducted on Brazilian consumers, analyzes the effects of delivery time, delivery cost, and delivery method on

consumer decisions. The study evaluates consumer behavior using logistic regression and ANNs and finds that these delivery features significantly influence consumer behavior depending on their sociodemographic characteristics. The research highlights that delivery cost plays a decisive role in the behavior of middle-aged consumers, emphasizing the critical importance of this feature in increasing customer loyalty on e-commerce platforms. Additionally, considering the growing importance of e-commerce during the COVID-19 pandemic, the study discusses the importance of delivery features in acquiring and retaining new customers. The study provides significant findings for developing sustainable delivery strategies in the e-commerce sector and suggests further investigation into the impact of delivery features on consumer behavior.

Peng et al. (2020) examined how consumer behavior prediction (CBP) is performed using ANNs. The research compares artificial intelligence (AI) with statistical systems, emphasizing ANN's superiority in CBP due to its high accuracy and learning capabilities. In this study, which reviewed 1,675 articles, ANN was widely used in predicting consumer behavior, particularly effective in analyzing shopping scan data and credit card expenditures. The research highlights that algorithms like ANN-LM achieved high accuracy rates of 94.7%, showing that ANN generally excels in classifying consumer behavior. The study also addresses challenges in ANN training processes, particularly the issue of forgetting older examples, which can negatively impact results. In conclusion, this study significantly contributes to consumer behavior prediction with AI and ANN applications.

The study by Annunziata et al. (2020) investigates household food waste in southern Italy, aiming to understand consumer behavior and reduce food waste. The study explores different consumer profiles that lead to food waste and the factors affecting this waste. Four consumer clusters were identified and classified based on their behavior. The research reveals that consumer awareness, concerns, and intentions influence food waste. These findings emphasize the need for interventions to be tailored based on consumer behavior to prevent food waste. The study highlights the importance of developing targeted anti-waste strategies at the EU and national levels. Increasing consumer awareness, providing education, and collaborating with stakeholders in the food supply chain can contribute to developing effective food waste reduction strategies.

The Techniques Used

The articles reviewed, covering 2020-2024, focus on studies utilizing ANNs in marketing and consumer behavior. These studies emphasize the potential of ANNs to predict consumer behavior and optimize marketing strategies, employing SEM as a critical technique. In addition, various algorithms such as logistic regression, clustering analyses, and backpropagation are used to enhance the accuracy and performance of ANNs. Furthermore, hybrid models and deep learning techniques have been employed to improve the accuracy and generalization capability of ANNs on complex datasets, highlighting the flexibility and strengths of ANNs in marketing applications. These studies demonstrate that ANNs are an effective tool with a broad range of marketing and consumer behavior applications.

Thematic Areas

The reviewed articles focus on various thematic areas in research conducted using ANN in marketing and consumer behavior. These thematic areas highlight the potential of ANN in enhancing marketing strategies and understanding consumer behavior. One of the primary thematic areas has been predicting and modeling consumer behavior. The studies address ANN's ability to predict consumer purchasing decisions, loyalty tendencies, behaviors toward product preferences, and overall consumer segmentation. Insights gained from analyzing consumer data in this area have enabled the development of strategies to optimize marketing campaigns and increase customer satisfaction.

Another significant thematic area is the personalization of marketing strategies and targeting processes. ANN has been used to create targeted marketing messages and campaigns tailored to consumer segments, resulting in more effective targeting. These studies demonstrate that ANN can be used to develop personalized offers based on individual customer profiles and past purchasing behaviors.

Pricing strategies and revenue management have also emerged as prominent thematic areas in the reviewed articles. ANN has been mainly utilized to develop and optimize dynamic pricing models. The studies have explored how different pricing strategies influence consumer reactions and how these reactions can be predicted using ANN. The

findings in this area have allowed companies to implement flexible and dynamic pricing strategies to maximize revenue.

Additionally, customer loyalty and Customer Lifetime Value (CLV) prediction have been common research topics. ANN has been employed to predict customers' long-term value and develop strategies to enhance loyalty. This thematic area contributes to companies' ability to plan more effective strategies for minimizing customer churn and increasing customer loyalty.

Finally, market segmentation and target audience analysis have also been identified as critical thematic areas. ANN's capability to process large and complex data sets has helped companies more accurately and precisely define market segments. This segmentation has allowed for the organization of more specific and effective campaigns aimed at target audiences to enhance the effectiveness of marketing activities.

These thematic areas provide a broad perspective on how ANN can be utilized in marketing and consumer behavior, contributing to deepening research in this field. The studies reveal that ANN offers significant advantages in critical areas such as customizing marketing strategies, customer loyalty, pricing, and segmentation.

Trends

Artificial Neural Networks (ANN) and Consumer Behavior

Prediction of Consumer Behavior: A significant portion of the studies emphasizes the superiority of ANN in predicting consumer behavior. ANN has been used to forecast consumer purchasing habits, spending tendencies, and product preferences.

Comparison of ANN and Traditional Methods: Many studies reveal that ANN provides higher accuracy and sensitivity than traditional statistical methods. It is noted that conventional techniques like regression and logistic regression have limited capacity in modeling complex consumer behaviors compared to ANN.

Application Areas of ANN

Brand Equity: Some studies have demonstrated the use of ANNs in determining brand equity. ANNs have been used in conjunction with financial data to predict brand equity, and these methods have been found to have high accuracy rates.

Consumer Behavior: ANNs have been utilized to analyze consumer behavior and identify tendencies. These studies indicate that ANNs are an effective consumer segmentation and behavior modeling tool.

Methodological Approaches

Mixed Methods: In the literature reviewed, it was observed that mixed methods (for example, the use of statistical techniques such as ANN and SEM) are a common trend. These methods provide the capacity to model linear and nonlinear relationships, allowing for more in-depth analysis.

Data Variety: The data sets used in the studies usually show a wide variety. Different data sources such as e-commerce data, survey results, financial reports, and social media data have been used to model consumer behavior through ANNs.

Future Research Directions

Dynamic Consumer Segmentation: Future research emphasizes that dynamic consumer segmentation can be conducted more effectively using ANNs. In this context, attention is drawn to the potential of ANNs to capture changing trends in consumer behavior over time.

Sustainability and Ethical Usage: There is a growing recognition of the need to focus more on ethics and sustainability when using ANNs in marketing and consumer behavior analysis. In this regard, the transparency and fairness of ANN-based models are emerging as significant research topics for future studies.

Prediction Performance of ANNs

Accuracy: Studies highlight that ANNs provide high marketing and consumer behavior prediction accuracy rates. However, some studies also note that the performance of ANNs is highly dependent on the dataset used and the model parameters.

Reliability: ANNs can provide reliable predictions when used correctly. However, reliability is directly related to data quality, protection against overfitting, transparency, and generalization ability. Therefore, these factors must be carefully considered when implementing ANN models. Additionally, the reliability of ANN outputs can be enhanced by supporting them with other prediction methods and continuously validating the results.

Advantages and Challenges of ANNs

Advantages of ANNs

High Accuracy and Predictive Power: ANNs can make more accurate predictions than traditional statistical methods, especially because they can process large and complex datasets. Various studies highlight the superior performance of ANNs in predicting consumer behaviors, purchasing tendencies, and the outcomes of marketing strategies.

Ability to Model Complex Relationships: The multi-layered structure of ANNs allows them to model complex and nonlinear relationships between data. This capability enables a more precise understanding and analysis of dynamic and multidimensional processes, such as consumer behavior.

Comprehensive Data Analysis: ANNs can analyze large datasets quickly and efficiently, providing significant advantages, particularly in personalized marketing strategies and customer segmentation. Companies can use ANNs to analyze vast amounts of customer data and extract meaningful and strategic insights from it.

Flexibility and Adaptation: ANNs exhibit flexibility in various marketing and consumer behavior applications. These systems can be adapted to different types of data and problems, enabling them to adapt to constantly changing market conditions quickly.

Learning Capability: ANNs can continuously learn, allowing them to improve their performance over time as they are fed more data. This learning process is crucial for optimizing marketing strategies and detecting changes in customer behavior.

Challenges of ANNs

Model Complexity: The multi-layered and complex structure of ANNs can present significant challenges during model development and optimization. An overly complex model increases the risk of overfitting, negatively impacting the model's general performance on new data.

High Data Requirement: ANNs require large amounts of high-quality data to function effectively. When working with small datasets, the model's predictive power can diminish, making it more challenging to achieve accurate results.

Explainability and Transparency: ANNs are often called a "black box," which limits the explainability of the model's decision-making process. In marketing, understanding how and why results are obtained is essential, and this lack of transparency can hinder the adoption of ANNs.

High Computational Cost: ANNs require substantial computational power to process large datasets. This can be a barrier, especially for companies with limited resources. Providing the necessary resources for training and implementing ANNs can be challenging for small and medium-sized enterprises.

Sensitivity to Data Quality: ANNs are highly sensitive to data quality, significantly affecting the model's training and output quality. Missing, incorrect, or noisy data can negatively impact the accuracy and reliability of the model. Therefore, the preprocessing and cleaning of data present a significant challenge.

These challenges highlight the potential of ANNs in marketing and consumer behavior and the factors that must be considered for their successful implementation. While ANNs offer high accuracy and the ability to model complex relationships, contributing significantly to personalized marketing strategies and customer segmentation, challenges such as model complexity, data requirements, and explainability necessitate a careful approach when applying this technology.

Gaps Identified in the Literature

The 25 articles reviewed significantly contribute to understanding marketing and consumer behavior using ANNs. However, they also reveal existing gaps in the literature and unresolved issues. These gaps present significant opportunities for future research and indicate areas necessary for a deeper understanding of the impact of ANNs on marketing strategies.

Impact of ANNs on Consumer Behavior

While many studies highlight the high accuracy rates of ANNs in predicting consumer behavior, more research is needed on how these techniques can be adapted to all areas of consumer behavior. It has been noted that the performance of ANNs in different demographic and cultural contexts needs to be sufficiently explored.

Explainability and Transparency of ANNs

The "black box" nature of ANNs makes understanding how model outputs are generated difficult. This is a barrier, particularly in marketing, where knowing how and why results are obtained is crucial. The literature reveals a significant research gap in methods to enhance the explainability of ANNs. More studies are needed to focus on making the decision-making processes of ANNs more transparent.

Data Quality and Sufficiency for ANNs

ANNs require large amounts of high-quality data to function effectively. However, it has been noted that model performance can decline when working with small or incomplete datasets. There must be more techniques or strategies in the literature to overcome such challenges. Future research should focus on developing methods to improve the performance of ANNs when working with low-quality or limited datasets.

Applications of ANNs in Different Marketing Strategies

More studies are needed on the impact of ANNs on marketing strategies and how they can be integrated with different marketing techniques. Specifically, more research is required on the applications of ANNs in areas such as digital marketing, customer segmentation, and product recommendation systems. These gaps indicate the need for more studies to guide the integration of ANNs into marketing strategies.

Use of ANNs with Dynamic and Real-Time Data

Many studies focus on the use of ANNs with static data. However, dynamic marketing and consumer behavior may require real-time data analysis. The literature needs more research on how ANNs operate with dynamic and real-time data. Research in this area could enhance the use of ANNs as a more flexible and responsive tool in marketing strategies.

Ethical and Data Privacy Issues of ANNs

Using ANNs to predict consumer behavior raises concerns about data privacy and ethical issues. However, it has been observed that there needs to be more in-depth discussion on these topics in the literature. More research is needed on the ethical challenges and data privacy issues encountered when using ANNs in marketing. Addressing this gap would contribute to developing policies necessary for the safe and ethical application of ANNs.

In summary, the gaps in the literature include the transparency and comprehensibility of ANNs in predicting consumer behavior, the performance differences of ANN models across different demographic groups, the ethical use of ANNs and challenges in data privacy, and the methodological challenges encountered when integrating ANNs with traditional methods. Additionally, more research is needed on the long-term predictive performance of ANNs and their impact on evolving consumer behavior over time. These gaps stand out as important areas for future research.

Discussion

This systematic literature review aims to assess the current state of the literature on ANNs and consumer behavior by comprehensively examining research conducted in the Scopus database over the past five years (2020-2024). The study has obtained significant findings in this field by profoundly exploring the potential of ANNs in predicting marketing and consumer behaviors. It demonstrates that ANNs are a unique tool, particularly in modeling consumer behavior and optimizing marketing strategies. However, specific challenges and limitations must be considered to use this technology effectively.

While this study highlights the wide range of applications that ANNs offer in marketing and consumer behavior, it also thoroughly examines the trends, challenges, and future research areas identified in the current literature. The research conducted by Zhao and colleagues (2024) emphasizes the potential of ANNs to more accurately predict consumer behaviors, while Srivastava and Bag (2024) demonstrate that the integration of innovative marketing techniques, such as facial recognition and neuromarketing with ANNs can enhance the effectiveness of marketing strategies. Singh and Ebana-Cabanillas (2024) provide evidence of ANNs' accuracy in predicting user intentions in

online shopping. Mkedder and Özata (2024) successfully investigated the impact of ANNs on the intention to purchase virtual products.

The findings reveal the high accuracy of ANNs in making predictions in the marketing field while highlighting the challenges encountered in using these techniques. In particular, the study by Chen and Wu (2024) underscores the importance of ANNs working in harmony with variables such as cultural characteristics and audience interactions. Moreover, Jin and colleagues (2024) demonstrate how ANNs contribute to understanding market dynamics during food security events by providing high accuracy rates in predicting agricultural food prices.

However, the "black box" nature of ANNs complicates understanding the model's decision-making processes, which poses a significant barrier in situations where transparency is required in the marketing field. The literature emphasizes the need for more research on methods to enhance the explainability of ANNs (Zhao et al., 2024). Additionally, sensitivity to data quality and high data requirements are other key challenges encountered in ANN applications, necessitating the development of more innovative methods to overcome these challenges (Singh & Ebana-Cabanillas, 2024).

Future research should conduct more comprehensive studies in different demographic and cultural contexts to ensure the more effective integration of ANNs into marketing strategies. It should also focus on in-depth research on ethical and data privacy issues. Furthermore, increasing studies that examine how ANNs work dynamically and in real-time with data could allow this technology to be used as a more flexible and responsive tool in the marketing field (Srivastava & Bag, 2024). In this context, to fully realize the potential of ANNs in marketing, more transparent, understandable, and ethical solutions must be developed.

Theoretical Contributions

The high accuracy rates provided by ANNs in predicting consumer behavior compared to traditional methods have led to this technology gaining significant prominence in marketing literature. The findings from this study demonstrate that ANNs can make more accurate predictions in areas such as consumer segmentation, pricing strategies, customer loyalty, and product recommendation systems compared to traditional statistical methods. This supports the increasing preference for ANNs in the field of marketing.

Moreover, ANNs' ability to model complex and nonlinear relationships within data provides a significant advantage in personalizing marketing strategies and more accurately understanding dynamic consumer behaviors. This allows marketing professionals and researchers better to comprehend consumers' purchasing tendencies and decision-making processes. As a result, the theoretical contributions of ANNs in the marketing field facilitate the expansion of their application areas.

Practical Implications

Integrating ANNs into marketing strategies allows businesses to understand customer behavior better and direct their marketing efforts more effectively. This study found that ANNs perform highly in customer segmentation, dynamic pricing, and customer loyalty analysis applications. Particularly in analyses conducted on large datasets, the ability of ANNs to make fast and accurate predictions helps businesses optimize their marketing strategies more efficiently.

Furthermore, using ANNs in marketing strategies offers significant opportunities for companies to increase customer loyalty and minimize customer attrition. For example, customer loyalty models developed using ANNs can proactively predict customer behavior, enabling businesses to devise strategies that enhance customer satisfaction. These findings demonstrate the practical contributions of ANNs in marketing and support the broader acceptance of this technology.

Conclusion

This study systematically examines how ANNs are utilized in marketing and consumer behavior, providing an in-depth understanding of this area's current state of knowledge. The findings indicate that ANNs are a powerful tool for predicting consumer behavior and optimizing marketing strategies. Thanks to their ability to model complex and nonlinear relationships, ANNs enable the development of more accurate and effective marketing strategies.

However, challenges such as ANNs' "black box" nature, their sensitivity to data quality, and high data requirements limit the widespread adoption of this technology in the marketing field. Therefore, future research should focus on developing methods to enhance ANNs' explainability, improving the quality of datasets, and exploring their applicability in different demographic and cultural contexts.

Additionally, increasing research on the ethical use of ANNs and data privacy issues will contribute to this technology's more reliable and sustainable use in marketing. To fully realize the potential of ANNs, it is crucial to ensure transparency, reliability, and adherence to ethical principles. In this context, expanding the application range of ANNs in marketing and using them as a powerful tool to understand better consumer behavior will be possible through more profound research in this area and the development of practical applications.

Limitations and future research

While this study provides significant findings by systematically examining the applications of ANNs in marketing and consumer behavior, it also has some limitations. First, the study only examines articles from a specific time frame (2020-2024), and this limited period may only partially reflect the long-term effects of ANNs in the marketing field. Additionally, the articles included in the review were selected only from the Scopus database, which means that other essential studies in the literature may have been overlooked.

A second limitation of the study is that it focuses on synthesizing the existing literature rather than providing an in-depth theoretical framework for ANNs' applications in marketing. Therefore, more research is needed on the impact of ANNs on marketing theory and how this technology can be integrated into marketing literature. Furthermore, the study needs to sufficiently examine the technical and methodological challenges associated with using ANNs, which may highlight potential limitations in practical applications.

Several important directions are suggested for future research. First, studies spanning broader time frames should be conducted to understand the longer-term effects of ANNs in marketing. Such studies could reveal the lasting impacts of ANNs on marketing strategies and how they have evolved. Additionally, research should be conducted on how ANNs perform in different demographic and cultural contexts and how this technology can be used more effectively in global markets.

Moreover, research focusing on ANNs' explainability and transparency could contribute to the broader adoption of this technology in marketing. Specifically, new methods and tools should be developed to go beyond ANNs' "black box" nature and enable marketing professionals to better understand this technology. More research is needed on the ethical use of ANNs and data privacy issues. Research could contribute to developing policies and practices necessary for the responsible and sustainable use of ANNs in marketing.

Finally, studies should be conducted on how ANNs can be used in dynamic marketing strategies with real-time data. Closely monitoring and responding to constantly changing consumer behavior in the marketing field is critical to maximizing the potential of ANNs. In this context, integrating ANNs with real-time data analysis could be crucial in achieving higher accuracy and effectiveness in marketing strategies.

References

Abrardi, L., Cambini, C., & Rondi, L. (2022). Artificial intelligence, firms and consumer behavior: Asurvey. Journal of Economic Surveys, 36(4), 969-991.

Akdagli, E. (2021). Yapay Sinir Ağları (Artificial Neural Network (ANN)). https://eceakdagli.medium.com/yapay-sinir-a%C4%9Flar%C4%B1-artificial-neural-network annd7846dfcb022. Date of access: 20.08.2024

Alaminos, D., Esteban, I., & Salas, M. B. (2023). Neural networks for estimating Macro Asset Pricing model in football clubs. Intelligent Systems in Accounting, Finance and Management, 30(2),57-75.

Albahri, A. S., Alnoor, A., Zaidan, A. A., Albahri, O. S., Hameed, H., Zaidan, B. B., ... & Yass, A.A.(2022). Hybrid artificial neural network and structural equation modelling techniques: a survey. Complex & Intelligent Systems, 8(2), 1781-1801.

Al-Otaibi, Y. D. (2024). Enhancing e-Commerce Strategies: A Deep Learning Framework for Customer Behavior Prediction. Engineering, Technology & Applied Science Research, 14(4), 15656-15664.

Annunziata, A., Agovino, M., Ferraro, A., & Mariani, A. (2020). Household food waste: a case study in Southern Italy. Sustainability, 12(4), 1495.

Arranz, C. F., Kwong, C., & Sena, V. (2023). The effect of consumption and production policies on circular economy business models: A machine learning approach. Journal of Industrial Ecology, 27(4), 1089-1104.

Ashfaq, M., Tandon, A., Zhang, Q., Jabeen, F., & Dhir, A. (2023). Doing good for society! How purchasing green technology stimulates consumers toward green behavior: A structural equation modeling–artificial neural network approach. Business Strategy and the Environment, 32(4), 1274   1291.

Attaoui, M., & Gaber, H. (2024). Online Customer Engagement: A Systematic Literature Review using PRISMA protocol. Valley International Journal Digital Library, 6488-6515.

Azadravesh, H., Sheibani, R., & Forghani, Y. (2024). Predicted consumer buying behavior in neural marketing based on convolutional neural network and short-term long-term memory. Multimedia   Tools and Applications, 1-17.

Badea, L. M. (2014). Predicting consumer behavior with artificial neural networks. Procedia Economics and Finance, 15, 238-246.

Boozary, P. (2024). The impact of marketing automation on consumer buying behavior in the digital space via artificial intelligence. Power System Technology, 48(1), 1008-1021.

Borimnejad, V., & Eshraghi Samani, R. (2016). Modeling consumer's behavior for packed vegetable in "Mayadin management organization of Tehran" using artificial neural network. Cogent Business &Management, 3(1), 1208898.

Briesch, R., & Rajagopal, P. (2010). Neural network applications in consumer behavior. Journal of Consumer Psychology, 20(3), 381-389.

Çağil, G., & Erdem, M. B. (2012). An intelligent simulation model of online consumer behavior. Journal of Intelligent Manufacturing, 23, 1015-1022.

Chattoraj, A. (2024). Trends in Consumer Behavior. Contemporary Is Accounting

Chakraverty, S., Sahoo, D. M., Mahato, N. R., Chakraverty, S., Sahoo, D. M., & Mahato, N. R. (2019). McCulloch–Pitts neural network model. Concepts of soft computing: fuzzy and ANN with programming, 167-173.

Chaudhary, R., Chaudhary, S., Singh, A., Bhanu, A., Chandela, S., & Singh, B. (2024, March). Artificial Intelligence-Based Digital Marketing for Discovering Shopping Possibilities and Enhancing Customer Experience. In 2024 2nd International Conference on Disruptive Technologies (ICDT)   (pp. 413-417). IEEE.

Chen, J., & Wu, Y. (2024). Would you be willing to purchase virtual gifts during esports live streams? Streamer characteristics and cultural traits. Computers in Human Behavior, 152, 108075.

Chowdhury, P., & Samuel, M. S. (2014). Artificial neural networks: a tool for understanding green consumer behavior. Marketing Intelligence & Planning, 32(5), 552-566.

Dang, T. Q., Tan, G. W. H., Aw, E. C. X., Ooi, K. B., Metri, B., & Dwivedi, Y. K. (2023). How to generate loyalty in mobile payment services? An integrative dual SEM-ANN analysis. International Journal of Bank Marketing, 41(6), 1177-1206.

Dias, E. G., Oliveira, L. K. D., & Isler, C. A. (2021). Assessing the effects of delivery attributes one shopping consumer behaviour. Sustainability, 14(1), 13.

Duarte, V., Zuniga-Jara, S., & Contreras, S. (2022). Machine learning and marketing: A systematic literature review. IEEE Access, 10, 93273-93288.

Fraternali, P., Milani, F., Torres, R. N., & Zangrando, N. (2023). Black-box error diagnosis in Deep Neural Networks for computer vision: a survey of tools. Neural Computing and Applications, 35(4),3041-3062.

Ganeshkumar, C., Jena, S. K., Sivakumar, A., & Nambirajan, T. (2023). Artificial intelligence in agricultural value chain: review and future directions. Journal of Agribusiness in Developing and Emerging Economies, 13(3), 379-398.

Giovanis, A., Rizomyliotis, I., Konstantoulaki, K., & Magrizos, S. (2022). Mining the hidden seam of proximity m-payment adoption: A hybrid PLS-artificial neural network analytical approach. European Management Journal, 40(4), 618-631.

Greene, M. N., Morgan, P. H., & Foxall, G. R. (2017). NEURAL networks and consumer behavior: NEURAL models, logistic regression, and the behavioral perspective model. The Behavior Analyst, 40, 393-418.

Hajek, P., Barushka, A., & Munk, M. (2020). Fake consumer review detection using deep neural networks integrating word embeddings and emotion mining. Neural Computing and Applications, 32(23), 17259-17274.

Haryanto, J. O., Silva, M., & Moutinho, L. (2015). Neural network approach to understanding the children's market. European Journal of Marketing, 49(3/4), 372-397.

Herrera, M., García-Díaz, J. C., Izquierdo, J., & Pérez-García, R. (2011). Municipal water demand forecasting: tools for intervention time series. Stochastic Analysis and Applications, 29(6), 998-1007.

Jajić, I., Herceg, T., & Pejić Bach, M. (2022). Deployment of the Microeconomic Consumer Theory in the Artificial Neural Networks Modelling: Case of Organic Food Consumption. Mathematics, 10(17), 3215.

Jin, Y., Li, W., & Gil, J. M. (2024). Forecasting Fish Prices with an Artificial Neural Network Model during the Tuna Fraud. Journal of Agriculture and Food Research, 101340.

Kalinić, Z., Marinković, V., Kalinić, L., & Liébana-Cabanillas, F. (2021). Neural network modeling of consumer satisfaction in mobile commerce: An empirical analysis. Expert Systems with Applications, 175, 114803.

Karim, K. S., Islam, M. E., Ibrahim, A. M., Pan, S. H., & Rahman, M. M. (2023). Online marketing trends and purchasing intent: advances in customer satisfaction through PLS-SEM and ANN approach. Advances in Decision Sciences, 27(4), 1-31.

Kasem, M. S., Hamada, M., & Taj-Eddin, I. (2024). Customer profiling, segmentation, and sales prediction using AI in direct marketing. Neural Computing and Applications, 36(9), 4995-5005.

Kazemi, S. M. R., Hadavandi, E., Mehmanpazir, F., & Nakhostin, M. M. (2013). A hybrid intelligent approach for modeling brand choice and constructing a market response simulator. Knowledge Based Systems, 40, 101-110.

Kliestik, T., Zvarikova, K., & Lăzăroiu, G. (2022). Data-driven machine learning and neural network algorithms in the retailing environment: Consumer engagement, experience, and purchase behaviors. Economics, Management and Financial Markets, 17(1), 57-69.

Kurani, A., Doshi, P., Vakharia, A., & Shah, M. (2023). A comprehensive comparative study of artificial neural network (ANN) and support vector machines (SVM) on stock forecasting. Annals of Data Science, 10(1), 183-208.

Lee, C. T., Pan, L. Y., & Hsieh, S. H. (2022). Artificial intelligent chatbots as brand promoters: a two stage structural equation modeling-artificial neural network approach. Internet Research, 32(4), 1329-1356.

Leong, L. Y., Hew, T. S., Ooi, K. B., & Dwivedi, Y. K. (2020). Predicting trust in online advertising with an SEM-artificial neural network approach. Expert Systems with Applications, 162, 113849.

Lin, M., Afshari, A., & Azar, E. (2018). A data-driven analysis of building energy use with emphasis on operation and maintenance: A case study from the UAE. Journal of Cleaner Production, 192, 169 178.

Luckyn, B. J., Alabere, I., & Ogra, O. (2024). Predictive Modeling for Diaper Sales in Retail: An Artificial Neural Network Approach. Iconic Research and Engineering Journals, 7(8).

Ma, C., Wu, J., Sun, H., Zhou, X., & Sun, X. (2023). Enhancing user experience in digital payments: A hybrid approach using SEM and neural networks. Finance Research Letters, 58, 104376.

Matin, A., Khoshtaria, T., Todua, N., Bareja-Wawryszuk, O., Pajewski, T., & Todua, N. (2024). Determinants of Green Smartphone Application Adoption for Sustainable Food Consumption Among University Students. International Journal of Marketing, Communication and New Media, 11(21).

Mazurek, M., Hałas, M., Sikora, J., Wiśniewska-Vistula, A., Wróblewska, D., & Zupok, S. (2024). Analysis of consumer behavior using an intelligent multi-source system.

Mishra, A. K., Bansal, R., Maurya, P. K., Kar, S. K., & Bakshi, P. K. (2023). Predicting the antecedents of consumers' intention toward purchase of mutual funds: A hybrid PLS-SEM-neural network approach. International Journal of Consumer Studies, 47(2), 563-587.

Mkedder, N., & Bakır, M. (2023). A hybrid analysis of consumer preference for domestic products: Combining PLS-SEM and ANN approaches. Journal of Global Marketing, 36(5), 372-395.

Mkedder, N., & Özata, F. Z. (2024). I will buy virtual goods if I like them: a hybrid PLS-SEM-artificial neural network (ANN) analytical approach. Journal of Marketing Analytics, 12(1), 42-70.

Moussa, F. A., & El-Sherbini, N. N. (2024). Prediction of Consumer-Oriented Sales Promotion Technique Using Artificial Intelligence. Journal of Public Relations Research Middle East/Magallat Bhut Al-Laqat Al-Amh-Al-Srq Al-Aust, (50).

Nica, E., Sabie, O. M., Mascu, S., & Luţan, A. G. (2022). Artificial intelligence decision-making in shopping patterns: Consumer values, cognition, and attitudes. Economics, management and financial markets, 17(1), 31-43.

Oztekin, A. (2018). Creating a marketing strategy in healthcare industry: a holistic data analytic approach. Annals of Operations Research, 270(1), 361-382.

Peng, C. C., Wang, Y. Z., & Huang, C. W. (2020, May). Artificial-neural-network-based consumer behavior prediction: a survey. In 2020 IEEE 2nd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS) (pp. 134-136). IEEE.

Rigby, M., Anthonisen, M., Chua, X. Y., Kaplan, A., Fournier, A. E., & Grütter, P. (2019). Building an artificial neural network with neurons. AIP Advances, 9(7).

Romanenko, N., Sharma, K., & Verma, S. (2024). Prediction of financial customer buying behavior based on machine learning. Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006 4023, 5(1), 125-131.

Salah Alaloul, W., & Hannan Qureshi, A. (2020). Data Processing Using Artificial Neural Networks. IntechOpen.

Sharma, S., Sharma, S., & Athaiya, A. (2017). Activation functions in neural networks. Towards Data Sci, 6(12), 310-316.

Sharma, A., Dwivedi, Y. K., Arya, V., & Siddiqui, M. Q. (2021). Does SMS advertising still have relevance to increase consumer purchase intention? A hybrid PLS-SEM-neural network modelling approach. Computers in Human Behavior, 124, 106919.

Singh, A. K., & Liébana-Cabanillas, F. (2024). An SEM-neural network approach for predicting antecedents of online grocery shopping acceptance. International Journal of Human–Computer Interaction, 40(7), 1723-1745.

Sobhanifard, Y., & Eshtiaghi, K. (2021). Exploratory modelling and ranking of the trust factors of messages about organic foods in social networks. British Food Journal, 123(2), 594-609.

Špicas, R., Neifaltas, A., Kanapickienė, R., Keliuotytė-Staniulėnienė, G., & Vasiliauskaitė, D. (2023). Estimating the Acceptance Probabilities of Consumer Loan Offers in an Online Loan Comparison and Brokerage Platform. Risks, 11(7), 138.

Srivastava, G., & Bag, S. (2024). Modern-day marketing concepts based on face recognition and neuro marketing: a review and future research directions. Benchmarking: An International Journal, 31(2), 410-438.

Storm, H., Heckelei, T., Baylis, K., & Mittenzwei, K. (2023). Identifying farmers' response to changes in marginal and average subsidies using deep learning. American Journal of Agricultural Economics.

Şengüler, H., & İnel, M. N. (2021). An empirical study based on artificial intelligence for determining brand value based on financial data. Sosyoekonomi,(30), 53, 395-424.

Vinothkumar, K. R., Reka, D. M. P., & Janani, E. S. V. (2024). Predictions Of Consumer Behaviour And Their Impact On Visual Merchandising Using Combined Machine Learning Concept. Educational Administration: Theory and Practice, 30(4), 2865-2878.

Wang, L., Li, X., Zhu, H., & Zhao, Y. (2023). Influencing factors of livestream selling of fresh food based on a push-pull model: A two-stage approach combining structural equation modeling (SEM) and artificial neural network (ANN). Expert Systems with Applications, 212, 118799.

Ye, M., & Ching, T. C. (2023). Research and application flow-based live-streaming shopping towards compulsive buying. Annals of Operations Research, 1-29.

Zambrano-Asanza, S., Morales, R. E., Montalvan, J. A., & Franco, J. F. (2023). Integrating artificial neural networks and cellular automata model for spatial-temporal load forecasting. International Journal of Electrical Power & Energy Systems, 148, 108906.

Zhao, T., Shi, Q., Zhang, X., & Zhang, T. (2024). Decoding green food safety information dependency in the digital era: An intelligent validation using SEM-ANN framework. Journal of Retailing and Consumer Services, 79, 103886.

Zhou, Z., Li, T., Liu, C., Zhou, Y., Li, P., & Wen, S. (2023). Why do social media users follow tourism related posts? Roles of bloggers and posts in trip planning. Industrial Management & Data Systems, 123(12), 3080-3108.

Zou, J., Han, Y., & So, S. S. (2009). Overview of artificial neural networks. Artificial neural networks: methods and applications, 14-22.