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WHY DO SHOPPERS PREFER M-COMMERCE? DISCOVERING KEY DRIVERS BASED ON A SEM–ANN APPROACH

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Abstract:

In recent years, mobile commerce has experienced exponential growth, changing the current shopping circumstances for consumers. To address this new context, this paper proposes an adapted Technology Acceptance Model (TAM) that seeks to comprehend consumers' predisposition to use m-commerce in a comprehensive multi-analytic approach. A web-based survey was developed for assessing the proposed conceptual framework considering responses from 354 m-commerce users. For data analysis, this research established a hybrid approach based on structural equation model (SEM) and artificial neural networks (ANN). On one hand, SEM results showed that perceived usefulness and trust influenced attitude, whereas behavioral intentions were driven by consumers' subjective norms and m-commerce attitude. On the other hand, ANN findings asserted attitude as the most important factor in driving consumer intention for m-commerce adoption. Overall, this research offers contributions to understanding the adoption of a new technology, providing theoretical and practical implications for marketing strategies. Specifically, from a managerial perspective, m-commerce apps should focus on creating seamless customer experiences, highlighting the productivity feature of m-commerce.

Key words: *technology acceptance model, mobile commerce, artificial neural network, behavioral intention, SEM*

1. Introduction

In this contemporary society, digital technology is affecting customer purchasing processes and behaviors. Consequently, organizations choose to tackle digital environments (Vahdat et al., 2020; Lin et al., 2025) and connect with consumers through their mobile devices (Pop et al., 2022). The abundance of mobile device usage has

enabled marketers to create more effective marketing strategies and precisely targeted campaigns by giving them access to previously unmatched knowledge of customer behavior (Tong et al., 2019; Cao et al., 2024). Therefore, customer-company relationships are experiencing changes due to advances in mobile technologies.

Globally, in 2025, there were 6.04 billion internet users and 5.66 social media identities (Statista.com, 2025a). The popularity of smartphones and the surge of mobile applications ('apps') have impacted the different ways users connect with brands (Tang, 2019; Li et al., 2024; Lin et al., 2025). Therefore, there is tremendous business potential for mobile marketing, using apps as tools for reshaping the engagement and interaction between customers and companies. With this accelerated shift in app technology, mobile commerce (m-commerce or m-retailing) has become the preferred channel for customers, easily accessible to them from their devices (Ghazali et al., 2018; Pop et al., 2023). These accessibility and convenience patterns have resulted in significant changes in consumer behavior (Tan et al., 2014; Chi, 2018; Mason et al., 2022; Parker & Kuo, 2022).

Due to its huge effect on enterprises and consumers, the accelerated advancement of m-commerce has attracted the attention of both academics and professionals. Considering one of most popular theories of m-commerce acceptance, this research uses technology acceptance model (TAM) because it helps in comprehending the premises of anticipating consumer intent. TAM has proven its validity in previous empirical studies on mobile apps adoption (Yang, 2005; Ooi, & Tan, 2016; Munoz-Leiva et al., 2017; McLean et al., 2020; Huang & Chueh, 2022). Notwithstanding the extended body of TAM research, additional studies on different samples and contexts are necessary in exploring mobile technologies (Williams, 2021). Moreover, there is a research gap for a thorough examination of empirical data on the adoption of m-shopping apps from consumers of different cultural backgrounds (Molinillo et al., 2022; Ng et al., 2022; Kao et al., 2024).

Examining the core drivers that affect the adoption and recurring use of m-commerce is critical given the expansion of this industry and its relevance to business practices. Despite the existence of numerous studies on m-commerce acceptance models, there is a need to provide empirical evidence for consumers' predisposition to use m-commerce in various study contexts (Shankar et al., 2010; Al Amin, 2021). Thus, this study's initial goal is to explore the variables that influence consumer intent in m-commerce acceptance. More specifically, this paper's original contributions rely on incorporating perceived usefulness, subjective norms, and trust in a conceptual model that investigates consumers' attitude towards m-commerce apps and their future purchase intentions using m-shopping. By including trust and subjective norms, this research aims to enhance the TAM framework in m-commerce literature.

In examining m-commerce adoption, previous studies have focused primarily on structural equation modelling (SEM). SEM has proven its efficiency in evaluating causal linkages and testing hypotheses. Nonetheless, as a linear technique, SEM may hinder the comprehension of "complicated human decision-making process" (Kalinić et al., 2021). In contrast, artificial neural networks (ANNs) have the ability to model linear and non-linear relationships, despite their unsuitability to test theories (Kalinić et al., 2019, 2021). Hence, a hybrid SEM-ANN approach can provide a comprehensive outlook on a newly proposed model in m-commerce adoption. Thus, in this study, a SEM analysis contributes to

determining significant drivers of m-commerce and an ANN analysis focuses on establishing a ranking of relevant predictors. Based on these considerations, this empirical research aims to augment existing m-commerce literature by implementing a multi-analytic SEM-ANN approach. The results of this study, which are based on advanced methodologies like ANNs, reflect originality and relevancy for m-commerce research focused on comprehending consumer behavior in an emerging context. Additionally, the findings may prove to be of great importance to m-commerce providers and help in planning their operations and marketing efforts to drive consumer intent for m-shopping.

The next section introduces the theory of acceptance of m-commerce apps, along with the theoretical framework for the development of hypotheses. Furthermore, the manuscript continues with the presentation of the study methodology. Then, the results of the empirical analysis are presented and discussed, along with relevant theoretical contributions, managerial implications, study limitations, and opportunities to expand the study.

2. Literature review and hypotheses development

Technology Adoption Model (TAM) has emerged into one of the most reliable frameworks used to comprehend consumer attitude and intention to use m-commerce apps. Introduced as an extension of TRA, TAM was initially proposed to help estimate and predict the adoption of information systems, by enabling researchers and practitioners to understand the limitations of certain systems and their associated countermeasures (Davis, 1989; Davis et al., 1989; Tew et al., 2021; Huang & Chueh, 2022). Regarding mobile technologies, TAM has been extensively examined and adapted to explain consumer intent in different settings, such as m-banking (Muñoz-Leiva et al., 2017); m-commerce (Hubert et al., 2017; McLean et al., 2020; Al Amin et al., 2022); m-payments (Tan et al., 2014; Liébana-Cabanillas et al., 2014;); s-commerce (Williams, 2021); gaming platforms' acquisitions (Yu et al., 2022). Thus, TAM provides a flexible and adjustable theoretical background for this study, as it is considered a cornerstone for m-commerce conceptualization.

Increasingly, consumers choose the comfort and convenience provided by their mobile devices in their daily tasks, including m-commerce (Tam et al., 2020; Yu et al., 2022). Initially, mobile devices offered applications for 'productivity and information retrieval" (Tam et al., 2020); however, based on new tech innovations, consumers have various categories of apps at their disposal: social networks, lifestyle, gaming, fashion, entertainment, finance, and retailing/commerce. Businesses have adopted branded applications as a novel approach of reaching potential customers and fostering engagement and loyalty among current customers (Van Noort & van Reijmersdal, 2019).

With more than 5.78 billion unique mobile phone users, worldwide (DataReportal, 2025), m-commerce has experienced significant growth in recent years. As an extension of e-commerce, m-commerce can be defined "as consumer activities focused on purchasing products and services from retailers through mobile devices, such as smartphones and tablets" (Lissitsa and Kol, 2021).

Indeed, m-commerce enables transactions that are carried out anywhere. Based on this feature, customers have access to unmatched convenience, flexibility, and versatility (Chi, 2018; VanHeerde, 2019; Ng et al., 2022; Wen et al., 2022). With the help of omnichannel convergence and user-friendly interactive media features, m-commerce apps have empowered companies to design customized purchasing experiences and stimulate consumer-brand interactions (Vinerean et al., 2022; Siyal et al., 2025). To a large extent, consumers rely on m-commerce as it provides a more customized and unique experience by accessing the software characteristics of their mobile devices (McLean et al., 2020; Ngubelanga & Duffett, 2021). M-commerce apps can include camera features for artificial reality (AR) product displays, access the GPS feature for location-specific content, and keep users informed via push notifications (Rese et al., 2017; McLean & Wilson, 2019;). Customers benefit from special offers, incentives, discounts, and tailored services (Molinillo et al., 2022), while they are also able to compare products before purchasing, discuss, review, and share product details in a simple and understandable manner (Grewal et al., 2017). Therefore, the shopping experience in retail apps creates the basis for "customer hyper-context information" (Tong et al., 2019) and personalization (Barbu et al., 2021). Based on these technological advantages, this study focuses on examining TAM framework for m-commerce acceptance.

As a well-established component of TAM, Davis et al. (1989) defined perceived usefulness (PU) as "the subjective probability that using a specific application system will increase his/her job performance" (Davis et al., 1989). Another essential TAM construct is attitude. Attitude reflects a positive or negative assessment of an action or behavior depending on one's view of that action's outcomes (Fishbein and Ajzen,1975; Sarkar et al., 2020). The same concepts apply to m-commerce.

People are more willing to adopt and accept new technology if they believe that using it would result in greater performance (Chi, 2018; Ghazali et al., 2018). Users assume a positive attitude for an app if they are aware of its benefits, functionality, utility, and overall helpfulness (Vahdat et al., 2020). Consumers develop positive evaluations and attitudes towards m-commerce when they perceive a shopping experience that empowers them to increase their productivity and accomplish more things without restrictions of time or space (Ghazali et al., 2018). Previous empirical investigations provided support for the interaction between PU and m-shopping attitudes (Lee et al., 2017; Chi et al., 2018; Ghazali et al., 2018; Min et al., 2019; McLean et al., 2020; Al Amin et al., 2022). Hence:

H1: Consumers' perceived usefulness of m-commerce has a positive impact on their attitude.

Considering the scope of this study in explaining consumers' acceptance of m-commerce applications, trust is considered a key "influencer in human-machine interactions" (Pitardi and Marriott, 2021). Defined as the "individual willingness to depend based on the beliefs in ability, benevolence, and integrity" (Gefen et al., 2003), trust and trustworthiness are critical for m-commerce (Pavlou, 2003; Fan et al., 2018; Kaushik et al., 2019; Sim et al., 2021). Before using m-commerce apps, consumers must download the app, create an account, and provide personal details (including card information, in most cases). In this case, trust in m-commerce platforms is related to the belief that their data

will not be mishandled (Kaushik et al., 2019). Focusing on the trust-attitude relationship, various authors have indicated the need to examine this interaction based on m-commerce's specific characteristics (Chong, 2013; Zhao & Bacao, 2020; Khaw et al., 2022).

In mobile settings, existing research indicates that trust is critical in developing favorable attitudes (Arpaci, 2016; Munoz-Leiva et al., 2017; Hajiheydari & Ashkani, 2018). As studying customer trust in m-commerce reflects a compelling topic, this research aims to expand the theoretical background by proposing that:

H2: Consumers' trust of m-commerce has a positive impact on their attitude.

In accepting m-commerce, consumers can receive advice from family, friends, and acquaintances. Thus, the conceptualization of subjective norms reflects the extent to which individuals feel pressure from their peers to use or refrain from using a particular technology (Ajzen, 1991; AlAmin et al., 2022). In other words, consumers' thoughts and attitudes towards m-commerce are likely to be influenced by their subjective interactions with key individuals in their lives. Subjective norms positively affect consumers' attitudes, and this assessment extends to m-commerce (Ajzen, 1991; Arpaci, 2016; Ghazali et al., 2018). When people choose whether to approve or disapprove an m-commerce app, they also consider how their choice would affect their interpersonal ties (Vahdat et al., 2020). When using mobile technologies, this positive result was confirmed for mobile grocery shopping applications (Al Amin et al., 2022), AR-mediated m-commerce (Manchanda and Deb, 2020), and retail apps for m-shopping (McLean et al., 2020). Thus, considering previous theoretical underpinnings, we propose:

H3: Consumers' subjective norm has a positive impact on their attitude towards m-commerce.

According to TRA and TAM, behavioral intention reflects the "strength of the intention to perform a specified behavior" (Fishbein and Ajzen, 1975). In adopting a particular behavior, social pressure could be a determining factor. Subjective norms reflect the extent to which consumers alter their behavior due to external pressure (Vahdat et al., 2020). Thus, subjective norms indicate consumers' perceptions of the expectations of relevant people regarding the acceptance of m-shopping.

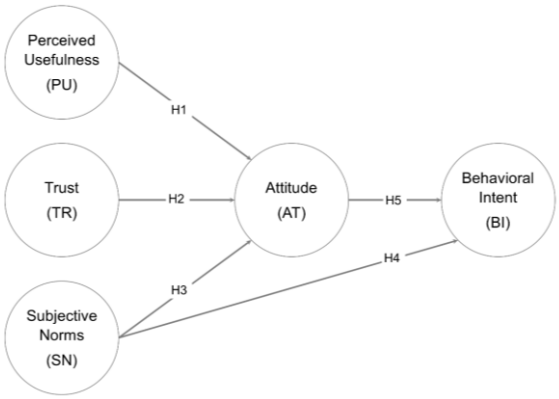
A similar concept to subjective norms is social influence, based on UTAUT2 model (Venkatesh et al., 2012). The positive effect of social influences on consumers' intent to accept and use new technologies has been broadly examined in m-commerce literature (Sim et al., 2021). Particularly in m-commerce investigations, subjective norms and social interactions reflect a key driver of consumers' behavioral intent (Yu and Huang, 2022), as people tend to adopt the majority's viewpoint (Venkatesh et al., 2012). Previous studies have demonstrated subjective norms' potential in influencing intention to use m-commerce (Arpaci, 2016; McLean et al.,2020; Vahdat et al., 2020; Meghisan-Toma et al., 2021; Kao and L'Huillier, 2022;). Therefore:

H4: Consumers' subjective norm has a positive impact on their intention to adopt m-commerce.

Typically recognized as inclinations to react favorably or unfavorably to a specific item, attitudes are thought of as precursors to behavioral intents (Davis, 1989; Fishbein and Ajzen, 1975). In general, the attitudes regarding m-apps determine their intention to engage in a certain activity in a specific environment (Ghazali et al., 2018; Pitardi and Marriott, 2021). Users are more likely to frequently visit an app and stay longer each time if they have an optimistic attitude towards it (Vahdat et al., 2020). The distinctive characteristics of m-commerce apps that support customer-company relationships can have a compelling impact on consumers' attitudes and purchasing intentions. Various authors have reached comparable assessments examining effectiveness of applications in increasing favorable attitudes and driving behavioral intent (Manchanda and Deb, 2020; Al Amin et al., 2022; Kao and L'Huillier, 2022). Consistent with TAM, numerous studies have shown a connection between attitudes and intention to adopt m-commerce (Ghazali et al., 2018; Chi et al., 2018; Min et al., 2019). Thus, we hypothesize:

H5: Consumers' attitude has a positive impact on their intention to adopt m-commerce.

Figure 1 shows the proposed research model.



3. Methodology

3.1. Research design and data collection

Based on relevant theoretical frameworks, this study aims to discover the impact of various drivers on the attitude towards m-commerce and the behavioral intention to use m-shopping (Figure 1). The primary audience for this research consisted of active m-retail customers. This research focused on Romanian m-shoppers for data collection. This m-commerce research context is relevant for Romania as Eurostat reported the highest increase in the proportion of individuals who use the internet for online purchases in this country. Specifically, from 2019 to 2024, this proportion of individuals increased by 33 pp (Eurostat, 2024). In fact, Romania ranks among the top in internet speed in Europe (247Mbps), (WorldPopulationReview.com, 2025). Also, Romanians frequently shop using mobile apps (Statista.com, 2021) with revenue in the online food delivery market set to reach US$599.76m in 2025 and US$933.71m by 2030 (Statista.com, 2025b).

For this study, data was collected using a voluntary and anonymous web-based survey, considering convenience and snowball sampling (Malhotra, 2020). By focusing on m-commerce users, screening questions were included in the questionnaire. The survey included a total of 453 respondents. The final acceptable data set of 354 respondents was established considering screening questions and data inspection procedures (Collier, 2020). Table 1 displays respondents' profile. The respondents are mostly members of the Gen Z cohort (70.1%), with an average age of 25.864 (SD=8.07).

Table 1. Respondents' profile

Variable		**Percentage (N)**
Gender	Female	72.30% (256)
	Male	27.70% (98)
Generation	Gen. Z	70.10% (248)
	Millennials	21.20% (75)
	Gen. X	8.80% (31)
M-shopping experience	Less than 1 year	5.60% (20)
	1-3 years	50.80% (180)
	3-6 years	29.40% (104)
	More than 6 years	14.10% (50)
M-commerce apps popularity	Food-and-delivery apps	24.00% (85)
	Fashion apps	44.60% (158)
	Grocery shopping apps	5.10% (18)
	Beauty products apps	15.30% (54)
	Other	11.00% (39)

3.2. Sample and measurement items

The survey instrument was developed by integrating the appropriate measures and scales from existing studies to gather the primary data needed to test the proposed hypotheses. This approach attests to the instrument's validity (Chi, 2018; Table 2). Five-point Likert scales were used to score each adapted survey item that reflected the study's scope.

Table 2. Operationalization of constructs

Constructs	**Items**	**Sources**
Attitude (AT)	AT1: "Overall, I feel favorable toward m-commerce." AT2: "Using m-commerce seems like a good idea to me." AT3: "I feel positive about shopping on m-commerce apps."	Ghazali et al. (2018); Vahdat et al. (2020)
Behavioral intent (BI)	BI1: "I intend to continue using m-commerce in the future."	Davis et al. (1989); Venkatesh et al.

	BI2: "I will always try to use m-commerce in my daily life." BI3: "I plan to continue to use m-commerce frequently."	(2012); Ghazali et al. (2018); Vahdat et al.(2020;)
Perceived usefulness (PU)	PU1: "I would find m-commerce useful in my daily life." PU2: "Using m-commerce would increase my productivity." PU3: "Using m-commerce would help me accomplish things more quickly."	Davis et al. (1989); Venkatesh et al. (2012)
Trust (TR)	TR1: "I believe m-commerce apps are trustworthy." TR2: "The information provided on m-commerce apps is reliable." TR3: "I felt secure in ordering and receiving orders through m-commerce apps."	Pavlou (2003); Ghazali et al. (2018); Zhao and Bacao (2020);
Subjective norms (SN)	SN1: "Important people in my life encourage me to adopt m-commerce." SN2: "People who are important to me support me in using m-commerce." SN3: "Important people in my life believe that using m-commerce is a good idea."	Venkatesh (2012), Ghazali et al. (2018); McLean et al. (2019)

3.3. Data Analysis

To conduct the analysis for this empirical study on m-commerce adoption, IBM SPSS and AMOS were utilized. Confirmatory factor analysis (CFA), structural equation modeling (SEM), and artificial neural networks (ANN) were the main methods used for data analysis. CFA assists in determining the degree to which measuring items accurately reflect the critical components examined in an empirical investigation (Hair et al., 2010). Further, the hypotheses of the suggested model are tested by SEM.

To improve the understanding of the empirical research, the study developed an artificial neural network analysis (ANN). ANNs reflect a prevalent approach to artificial intelligence that are highly effective in modeling intricate interactions between inputs and outputs (Kalinić et al., 2019a,b; 2021). Considering its learning process, ANN is a modeling technique that mimics human neural pathways and can advance new knowledge in understanding consumer behavior changes (Hew et al., 2018; Lee et al., 2020). Various studies support the application of ANN in addition to SEM (Leong et al., 2020), noting to the advantages of ANN in generating "higher prediction accuracy compared to conventional linear techniques" (Kalinić et al., 2021). Additionally, ANN models do not suffer from multicollinearity issues (Wilson & Bettis-Outland, 2020).

4. Results

4.1. Confirmatory factor analysis

In assessing m-commerce adoption, a CFA was developed to assess the validity and reliability of the measurements and latent variables (Tabel2). Fit indicators showed that the measurement model suited the data in an acceptable manner, considering Hu and Bentler's (1999) criteria: $\chi^2(78)$ = 214.647 (p<0.001), χ^2/df=2.752 (<5.0), CFI = 0.955(≥0.9), GFI = 0.924 (0.9), NFI = 0.931(≥0.9), TLI = 0.955(≥0.9), RMSEA = 0.070(<0.08), SRMR=0.0443(<0.05).

Further, the CFA was assessed on convergent validity. The tests revealed that the value of Cronbach's alpha coefficients for each construct were higher than the minimal cutoff value of 0.70 (Cronbach, 1970). The values calculated for the extracted average variance (AVE) and composite reliability (CR) met the minimum cut-off levels of 0.50 and 0.70, respectively (Hair et al., 2010). Furthermore, the standardized loading estimates were higher than the ideal value of 0.70 (Hair et al., 2010), or at least of 0.60 (Dash and Paul, 2021). Table 3 highlights the results for convergent validity.

The CFA was also examined for discriminant validity (Tables 4, 5). Based on the results, the pairwise correlations between constructs were lower than the threshold of 0.85 (Bagozzi & Yi, 1988). Additionally, the square roots of AVE values were higher than the pairwise correlations of the latent variables (Hair et al., 2010; Fornell & Larcker, 1981). Additionally, Table5 displays the heterotrait-monotrait correlations ratio (HTMT) values, which were less than 0.85 (Henseler et al., 2015). The calculated results show that CFA complies with discriminant validity criteria.

Table 3. Convergent validity and construct reliability

Construct	Items	Mean (SD)	Loadings	Average variance extracted (AVE)	Composite reliability (CR)	Cronbach's alpha
AT	AT1	4.014 (0.739)	0.790	0.662	0.855	0.844
	AT2	4.13 (0.726)	0.838			
	AT3	4.167 (0.72)	0.813			
PU	PU1	3.977 (0.855)	0.711	0.578	0.804	0.8
	PU2	4.308 (0.837)	0.777			
	PU3	4.09 (0.857)	0.791			
SN	SN1	3.359 (0.933)	0.602	0.585	0.806	0.794
	SN2	3.54 (0.828)	0.809			
	SN3	3.706 (0.813)	0.860			
BI	BI1	4.237	0.890	0.647	0.879	0.791

		(0.698)				
	BI2	3.427 (0.979)	0.618			
	BI3	4.099 (0.789)	0.875			
TR	TR1	3.718 (0.81)	0.798	0.709	0.843	0.834
	TR2	3.715 (0.818)	0.824			
	TR3	3.636 (0.875)	0.901			

Note: AT: Attitude; BI: Behavioral Intentions; TR: Trust; SN: Subjective Norms; PU: Perceived Usefulness. AVE> 0.5 (Hair et al., 2010); CR>0.7 (Hair et al., 2010); Loadings >0.6 (Dash and Paul, 2021).

Table 4. Discriminant Validity

Construct	**AT**	**PU**	**SN**	**TR**	**BI**
AT	**0.814**				
PU	0.753	**0.760**			
SN	0.524	0.657	**0.765**		
TR	0.721	0.628	0.510	**0.842**	
BI	0.749	0.684	0.637	0.621	**0.804**

Note: On the diagonal, the bold values are calculated as the square root of AVE. The off-diagonal values show pairwise correlations (Fornell & Larcker, 1981)

Table 5. Heterotrait-Monotrait Ratio (HTMT)

	SN	**PU**	**TR**	**AT**	**BI**
SN					
PU	0.661				
TR	0.52	0.658			
AT	0.515	0.759	0.774		
BI	0.688	0.717	0.704	0.752	

The empirical analysis also addressed the issue of common method bias (Podsakoff et al., 2003) in various ways. First, a priori measures to minimize potential bias were considered in the data collection process, i.e., structuring the questionnaire in sections, scattering items of related constructs throughout the questionnaire (McLean & Wilson, 2019), assuring respondents of the privacy and anonymity of their answers (Touni et al., 2020), and enabling respondents to select their preferred m-commerce apps to prevent unconscious bias. Second, we conducted a CFA test to determine the likelihood of common method bias (Podsakoff et al., 2003; MacKenzie and Podsakoff, 2012) and discovered a very poor fit, compared to the initial CFA (χ^2/df=9.366, GFI = 0.738, TLI =

0.708, RMSEA = 0.154). Due to the inadequate results, we can conclude that common method bias is not an issue. Furthermore, the variance inflation factor (VIF) analysis was used to assess the multicollinearity condition (McLean and Wilson, 2019). In this case, multicollinearity was not violated because the findings (ranging from 1.531 to 2.727) showed that the critical value of 5.0 was not surpassed (Hair et al., 2010).

4.2. Structural Modeling

The research model evaluated the effects of various latent variables on respondents' intention to use m-commerce. This SEM analysis was conducted in AMOS. The SEM findings provided empirical evidence for four hypotheses out of five, based on t-tests' statistically significant results (Table6). A significant and positive linkage was established between perceived usefulness and attitude for m-shopping (β=0.517, p<0.001), confirming H1. Furthermore, a positive relationship was determined between trust and attitude for m-commerce apps (β=0.422, p<0.001). Thus, H2 was supported. An inconsequential result was discovered for the relationship between subjective norms and attitude towards m-commerce (β= -0.035, p=0.592), leading to the rejection of H3. In exploring the effect of subjective norms on behavioral intention to continue to use m-shopping, the findings of the model supported H4 (β=0.336, p<0.001). Finally, the model reconfirmed a renowned TAM hypothesis that presented a positive and significant result with respect to the attitude and behavioral intent of consumers in adopting m-commerce (H5: β=0.584, p<0.001). In particular, the proposed model represented 68.2% of the variance in attitude and 66% of the variance in the intention to use m-shopping. Table 6 displays the SEM findings.

Table 6. Estimates' results for the research model

Hypothesis & Paths	**Standardized Regression Estimates (β)**	**t-value**	**Sig.**	**Result**	**R^2**
H1: PU → AT	0.517	6.287	***	Supported	0.682
H2: TR → AT	0.422	6.544	***	Supported	
H3: SN → AT	-0.035	-0.536	0.592	Rejected	
H4: SN → BI	0.336	6.097	***	Supported	0.660
H5: AT → BI	0.584	10.090	***	Supported	

Note: ***Significant at p<0.001 (two-tailed)

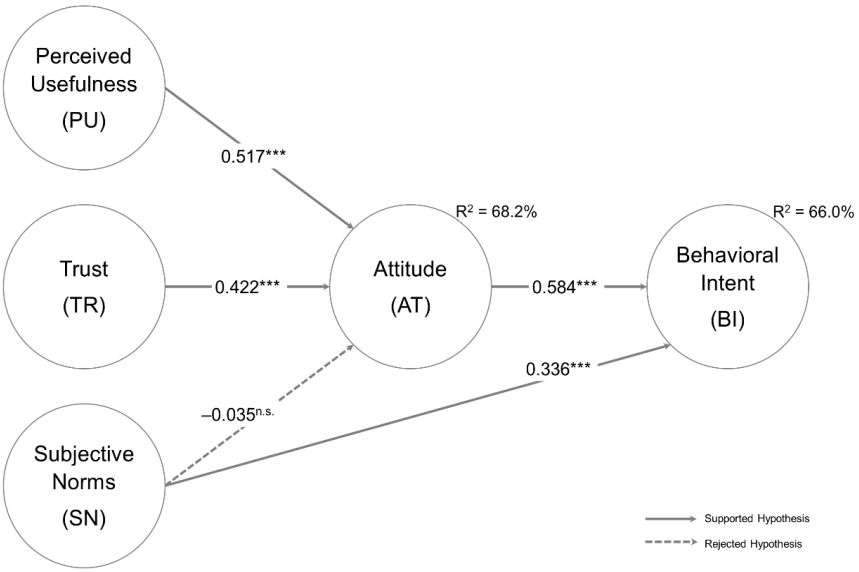


Figure 2. Estimates' results for the research model

4.3. Artificial neural network

For the proposed model (see figure 1), two ANN models were developed based on SEM's significant results (Kalinić et al., 2019a, 2021). Model A consisted of two inputs (PU and TR) as they reflected significant predictors of attitude (highlighted as an output). Model B included attitude and subjective norms as input variables and behavioral intention as output. Similar to previous studies (Liébana-Cabanillas et al., 2017; Lee et al., 2020; Kalinić et al., 2021), a multilayer perceptron with feedforward backpropagation algorithm was used in this investigation. Sigmoid was the activation function used for hidden and output layers, with one hidden layer (Figures 3,4).

A ten-fold cross-validation approach was utilized to avoid overfitting, with 90% of the data used for training and 10% for testing. Root Mean Square Error (RMSE) evaluated the accuracy of each network model (Hew et al., 2018; Liébana-Cabanillas et al., 2018).

Table 7 presents the predictive accuracy of the validations. Taking into account the training and testing samples for models A and B, the low values registered for RMSEs and the average RMSEs indicated good predictive precision and reliability (Chong, 2013; Ooi and Tan, 2016; Ooi et al., 2018; Kalinić et al., 2019a,b; Lee et al., 2020).

Figure 3. ANN – Model A

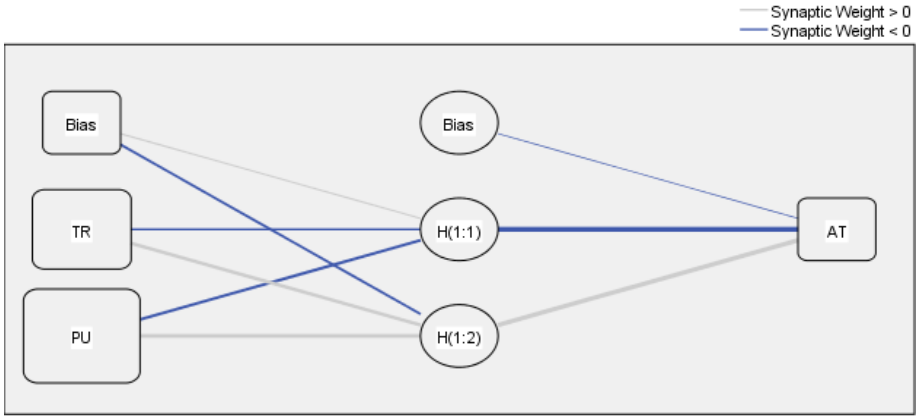


Figure 4. ANN – Model B

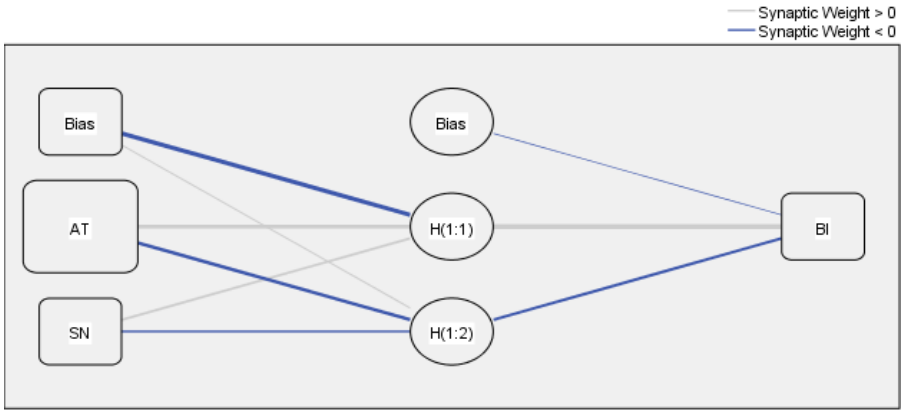


Table 7. RMSE during the training and testing processes

	Model A		**Model B**	
	R^2 = 0.7680		**R^2=0.7325**	
	Training	**Testing**	**Training**	**Testing**
ANN	**RMSE**	**RMSE**	**RMSE**	**RMSE**
1	0.0511	0.0438	0.0648	0.0567
2	0.0522	0.0428	0.0582	0.0618
3	0.0527	0.0440	0.0609	0.0501
4	0.0496	0.0430	0.0612	0.0625
5	0.0534	0.0476	0.0601	0.0467
6	0.0519	0.0464	0.0593	0.0442
7	0.0590	0.0642	0.0554	0.0752

8	0.0521	0.0409	0.0598	0.0446
9	0.0519	0.0471	0.0612	0.0504
10	0.0516	0.0442	0.0598	0.0448
Average	0.0525	0.0464	0.0601	0.0537
St. dev.	0.0025	0.0066	0.0024	0.0102

Note: Model A: Input neurons: Perceived Usefulness and Trust; Output neuron: Attitude
Model B: Input neurons: Attitude and Subjective Norms; Output neuron: Behavioral Intention

Furthermore, models A and B were examined based on the R^2 coefficient (Lee et al., 2020; Leong et al., 2020; Kalinić et al., 2021) to better assess the performance of the ANN models. For Model A, the R^2 value of 0.768 indicates that the ANN model explains 76.80% of the variance in consumers' attitudes towards m-commerce. Similarly, model B explains 73.25% of the variance of the intention to continue to use m-shopping apps. The R^2 values calculated in the ANN investigations (Table 7) are noticeably higher than their corresponding SEM values, signaling that endogenous variables are better explained in neural networks analyses (Lee et al., 2020). In addition, the relative importance of determinants' contributions was ranked using neural network modeling (Lee et al., 2020). Instead of using SEM estimates, ANN uses a measure of significance called normalized importance. Thus, a sensitivity analysis was conducted to determine the relative significance (Kalinić et al., 2021). Normalized importance was calculated as the "ratio of relative importance of each predictor over the highest relative importance" (Kalinić et al., 2019a). Based on the results of Table 8, the most important predictor of attitude (in ANN model A) was perceived usefulness, while the most important predictor of behavioral intention was attitude (in ANN model B), extending the perspectives of m-commerce adoption.

Table 8. Sensitivity analysis

	Model A		**Model B**	
ANN	**TR**	**PU**	**AT**	**SN**
1	0.504	0.496	0.513	0.487
2	0.371	0.629	0.633	0.367
3	0.388	0.612	0.637	0.363
4	0.455	0.545	0.585	0.415
5	0.435	0.565	0.661	0.339
6	0.425	0.575	0.646	0.354
7	0.575	0.425	0.659	0.341
8	0.405	0.595	0.597	0.403
9	0.424	0.576	0.583	0.417
10	0.392	0.608	0.670	0.330
Average	0.437	0.563	0.619	0.381
Normalized importance (%)	76.30	97.30	100.0	62.70

5. Discussions

This article responded to previous academic calls for papers (Williams, 2021) that have emphasized and recommended the development of empirical studies focused on the impact of mobile applications on consumer behavior, particularly in their connection to the influence of TAM constructs on consumers' buying intention (Yang, 2013). To this effect, this study was conducted to explain the variables that influence consumers' adoption of m-commerce in Romania, based on TAM framework, with new additions. For a broader conceptualization, we discuss this study's theoretical implications.

The results revealed that perceived usefulness and trust had a positive impact on consumers' attitudes towards m-commerce. Congruent with TAM (Davis et al., 1989), the findings support the significance of the usefulness of the mobile app in forming favorable consumer attitudes (H1), consistent with previously reported results (McLean & Wilson, 2019; McLean et al., 2020; Amin et al., 2022). Consumers might be more inclined to evaluate m-commerce in a positive manner if they believe it to be time-saving and simple to use. Furthermore, the usefulness of m-shopping apps extends to the incorporation of helpful wish-lists for consumers (to monitor product availability and prices), expeditious ordering and payment system (with saved card details and delivery preferences). Thus, when an app does not involve a laborious process, customers are more likely to utilize m-shopping (Ghazali et al., 2018; Pop et al., 2023).

With a key role in computer-human interactions (Pitardi and Marriott, 2021), trust was proposed in this research framework as a driver of consumers' attitudes towards m-commerce (H2). A positive and significant result was identified for this relationship, supporting previous findings (Arpaci, 2016; Kaushik et al., 2019). Before embracing and utilizing any technology-based transaction services, consumers must provide personal information to set up a profile on m-shopping apps (Kaushik et al., 2019). In this case, trust must be maintained to guarantee that the m-commerce app will not improperly exploit the data. Furthermore, according to the existing literature (Manchanda & Deb, 2020; McLean et al., 2020), this model proposed a positive relationship between subjective norms and attitude (H3). However, this relationship was rejected. Although this result is unexpected, a comparable result was found in research conducted by Pop et al. (2023). Therefore, this relationship requires reexaminations in future m-commerce studies.

In Hypothesis 4, this study posited and discovered that subjective norms impacted consumers' intention to use m-commerce, which was consistent with previous studies (McLean et al., 2020 Vahdat et al., 2020; Kao & L'Huillier, 2022; Yu & Huang, 2022). Therefore, the purchase decision is impacted by significant others. Including social hints within the app and offering the opportunity to share products with other people, could address the potential hesitancy of using m-commerce. According to TAM, attitudes were expected to have a favorable impact on consumers' behavioral intention for m-commerce (H5) and this confirmed result for H5 was analogous to previous investigations (Manchanda & Deb, 2020; Al Amin et al., 2022; Kao & L'Huillier, 2022; Pop et al., 2023). Positive perspectives on m-commerce apps would reflect higher levels of interaction with the apps and increased levels of buying intention.

In extending the SEM analysis with the ANN technique, the results showed that out of the significant drivers of consumers' attitudes, the most important determinant was perceived usefulness. Based on the results of ANN, the most important driver of intention to use m-commerce was consumers' attitude, furthering insights on m-retailing literature on relevant predictors for accepting this new technology and mode of shopping.

6. Conclusions

6.1. Theoretical Contributions

The emergence of digital technologies has had a profound impact on society and contemporary living. This research provides significant contributions to the existing body of literature in terms of accepting digital apps for m-commerce purposes and understanding consumer-technology interactions. Overall, these findings help improve comprehension of relational factors that drive m-shopping intention. Recent studies imply that there is an increasing need to understand customer m-commerce decision-making given the rapid advancement of this innovation.

In terms of conceptual relevance, this study's model offers new empirical insights into m-shopping research and intention to use apps for retail purposes. To this effect, this study aimed to examine key factors that impacted m-commerce adoption, shaping attitudes and subsequently affecting the intention to acquire different products through mobile devices. The findings show that the technology acceptance model should be used to forecast the attitudes and intentions of Romanian customers for m-commerce. This study covered this topic by contributing with knowledge on the adoption of m-retailing in different contexts.

Most importantly, the findings contribute to the expansion of TAM theoretical framework by offering additional proof for the drivers of m-commerce acceptance. In highlighting attitude, the results confirmed the importance of consumers' trust and their perceived usefulness of m-shopping. Trust is essential, particularly when using new services that have a payment component and collect personal details. Similarly, based on perceived usefulness, customers receive additional benefits from the ubiquitous settings of m-commerce apps, including quick access to various market offerings and the capacity to increase productivity while participating in m-shopping activities. The findings also indicate that behavioral intentions are significantly influenced by attitude and subjective norm, enhancing the literature on these relationships. To this effect, the usage of m-retailing apps is influenced by their view that significant people (peers, relatives) expect them to use this technology. This study adds the social aspect to TAM, building on previous research.

The study's contributions extend to the two-stage hybrid SEM-ANN approach in examining m-commerce. Regarding consumers' intention to use m-commerce, the study validated the SEM model and determined the relative contributions of each component using hybrid deep learning modeling. To develop this multi-analytic effort, the ANN procedure included only the significant determinants. This study also added to existing literature by identifying the most significant antecedents of intention and attitude for using m-shopping. The findings indicated that 76.8% and 73.25% of the variances in attitude and

intent of consumers, respectively, were explained by the input neuron nodes of models A and B.

6.2. Practical Implications

Mobile marketing's importance in retail is growing. Consequently, this study's findings are relevant for m-commerce marketers and business managers. For these entities, m-commerce provides the opportunity to create seamless experiences throughout the purchasing process. Nowadays, customers can browse, investigate, and try different products within their environments based on augmented reality characteristics of m-retailing apps. All m-commerce features help advance organizations' CRM opportunities based on customer interactions: to communicate directly with customers for attaining loyalty and retention, to tailor their experience according to their preferences, and to notify consumers of new promotions.

Trust was identified as a statistically relevant factor of consumer attitudes in the proposed theoretical model. Gaining trust in m-commerce is affected by the design of the app's interface and characteristics which should reassure consumers when registering on the app or reaching the payment phase. Therefore, m-retailers should emphasize the security features of applications and the transactions facilitated through m-shopping platforms. Given the significant impact of perceived usefulness on attitude, m-commerce businesses should stress the utility of these platforms in their marketing campaigns. In general, m-commerce enables businesses to reach shoppers regardless of their location. Particularly younger generations who are interested in daily productivity would be receptive to these usefulness advantages.

According to the results, key people (friends, family) can shape the intention of customers to accept m-commerce. On apps, users should be able to quickly share their experiences with others. Thus, m-commerce app features can have a positive effect on consumers' intent to buy, namely sharing products with friends or asking for feedback. Furthermore, based on consumers' positive attitudes, m-commerce businesses can develop unmatched online purchasing experience and provide promotional and engagement opportunities, as well as personalized marketing messaging.

6.3. Limitations and future research perspectives

Among the limitations of the research, we can pinpoint that the investigation was based on a cross-sectional study. Additional studies should be conducted throughout different timeframes to allow the observation of shifts in consumer behavior. Further, because the study was conducted only in Romania, its results may not be generalizable to other populations with different qualities and interests. Future studies could extend the hybrid SEM-ANN approach to various settings. Also, the model is limited to the set of latent variables, and future examinations might also incorporate supplementary variables in a hybrid SEM-ANN approach

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