



Research article

Determinants of consumer intention to adopt a self-service technology strategy for last-mile delivery in Guangzhou, China

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Abstract: Self-service technology (SST) is a logistic innovation in e-commerce that enhances last-mile delivery efficiency in supply chain management. By combining Innovation Diffusion Theory with Resource Matching Theory, we proposed a comprehensive framework to explain the relationships between beliefs, attitude, and intention in Guangzhou, China. The findings revealed that attitude played a crucial role in influencing consumer intention to adopt SST and that attitude has direct and indirect effects. Additionally, consumer perceptions of compatibility, relative advantage, reliability, and complexity indirectly affected their adoption intention through attitude. These factors had positive and negative effects. The results highlighted the importance of attitudes as immediate predictors of intention, as consumer attitudes (favorable and unfavorable) were shaped by their perceptions. We conclude by recommending strategies to promote positive attitudes toward SST and enhance safety, efficiency, and the overall user experience.

Keywords: last-mile logistics; self-service technology; automated parcel stations; consumer adoption behavior

1. Introduction

Contemporary advancements in information and communication technology have facilitated the widespread global acceptance of e-commerce activities [1]. For example, in the United Kingdom, the proportion of sales that are conducted online has increased to 33.8% in 2022 from 14.5% in 2015 [2]. In total, 45% of European consumers have participated in e-commerce activities [3], and e-commerce activities have grown rapidly in China, with annual parcel delivery volume increasing from 3.67 to 110.58 billion [4] between 2011 and 2022, representing a 32.88% annual rate of increase.

In particular, consumer freight volumes have rapidly increased [5], and transportation costs for traditional home delivery are high [6,7]. Thus, self-service technology (SST) and the use of automated parcel stations (APSs) are seen as promising solutions in last-mile logistics [8,9]. APSs are prevalent in the United Kingdom, France, Germany [3], and China. In 2022, China had 434,000 APSs [10]. However, consumers have not been as accepting of these new technologies as expected. For example, less than 65% of self-service express facilities in China are used by express delivery businesses [11]. Similarly, only 10% of online shoppers in France prefer SST over home deliveries [3]. APSs, which enable consumers to retrieve parcels at their convenience from centralized locations [12], constitute a paradigm shift in e-commerce logistics, but the acceptance of consumers toward this innovative system remains unknown.

Extensive research has been conducted on consumer adoption of new technology. Several theories addressing consumer intention to use APSs have been developed, including the technology acceptance model (TAM) [13], the theory of planned behavior (TPB) [14], innovation diffusion theory (IDT) [15], motivation theory [16], and the theory of reasoned action (TRA) [17]. Chen et al. used resource matching, consumer coproduction, and technology readiness theories to investigate customer intentions in China [11]. Yuen et al. used resource matching, perceived value, and transaction cost economics theories to explain technology acceptance by consumers in China [18]. Yuen et al. and Wang et al. applied attitude and innovation diffusion theories to explore customer intentions to use SST in Singapore [15,17].

Extensive empirical research has been conducted to investigate the factors influencing the propensity of customers to use APSs. Sociodemographic characteristics have been associated with the use of APSs. A study on online shopping behavior in the Netherlands discovered that individuals with a moderate to high educational level and with online shopping experience were more likely to adopt APSs [19]. Female consumers are more likely to use APSs than are male consumers. In France, home internet access, ownership of advanced electronic devices, frequency of shopping trips, and dwelling type are indicators that can be used to determine potential APS locations [3]. The success of an APS facility depends on its location [9]. According to Weltevreden (2008), APSs should be located close to densely populated areas (i.e., no more than 5 minutes away by car) [19]. Such locations tend to have a higher number of parcels collected and returned. Suburban residents prefer that parcels be delivered to their home rather than to an APS facility, whereas urban residents prefer the opposite [20]. Customers may be more likely to use APS facilities if they believe such facilities are environmentally friendly. Furthermore, price, location, and quality factors may be leveraged to incentivize customers to use APS facilities [12].

Attitude influences intention [15,17]. Belief also influences intention, but in a weaker, secondary, and indirect manner [21,22]. Positive perceptions, including perceived compatibility, trial, convenience, reliability, and relative advantage, directly and positively affect attitude [17,23–25].

Conversely, negative perceptions, including perceived complexity and risk, directly and negatively affect attitude [17,25]. Perceived complexity has a nonsignificant negative effect on attitude [15]. Attitude mediates the effect of belief on intention. Belief affects intention vis-à-vis attitude. Perceived behavioral control [24], perceived value, transaction costs [18], online shopping frequency, performance and effort expectations, social influence, and convenience conditions [25,26] affect intention. Several factors, including geographical location [11], network density, availability of parking spaces, and operation schedule, influence consumer intention to use ASPs [27].

Extensive research has been conducted on consumer intentions in last-mile logistics; however, more research is warranted. First, a unified perspective on consumer acceptance and willingness has not been established, necessitating the use of numerous cases to broaden the explanatory scope of consumption theory. Second, multiple theories must be used to lay out the factors influencing consumer acceptance and willingness because a single theory cannot do so. Finally, empirical findings derived from a single country cannot be generalized to other countries.

In the present study, we combined two consumer theories to examine the direct and indirect influence of attitude on APS adoption in Guangzhou, which is a leading e-commerce hub in China. According to the IDT, the value generation process drives customer intention to adopt an innovation [28]. Resource matching theory describes the effect of a customer's cognitive resources on their intention [11]. The study makes two contributions. First, it demonstrates that attitude significantly moderates the relationship between perceptions and behavioral intentions. Second, it integrates two theories to identify the factors that influence consumer behavioral intention. We provide critical insights that governments and corporations may use to design facilities in last-mile logistics.

The remainder of this article is structured as follows: Section 2 introduces the model and hypotheses on customer intention to use APSs. Section 3 details the research methodology. Section 4 presents the results of the study. Section 5 discusses the results. Finally, Section 6 concludes the paper.

2. Research framework and hypothesis

2.1. Theoretical background

Consumer adoption behavior is conceptualized as a psychological process involving the decision to accept or reject a particular course of action. Cognitive dissonance theory, formulated by Festinger in 1957, states that discrepancies between one's behavioral intentions and actual behavior generate psychological dissonance [29]. To alleviate this dissonance, individuals attempt to reconcile their behaviors with their intentions. In both the TRA and the TPB, behavioral intention is posited as the foremost predictor of consumer behavior. Specifically, the TRA asserts that an individual's attitude toward a concept is shaped by their salient beliefs, which, in turn, influence behavioral intention [30]. Rogers proposed a five-stage model of innovation adoption that encompasses pre-acceptance (knowledge, persuasion, and decision) and post-acceptance (implementation, confirmation) phases and that illustrates how perceived attributes affect the adoption of new technologies [31]. The pre-acceptance phase is crucial in forming an individual's perception of an innovation and thereby their attitude and subsequent decision to adopt or reject the innovation (Figure 1).

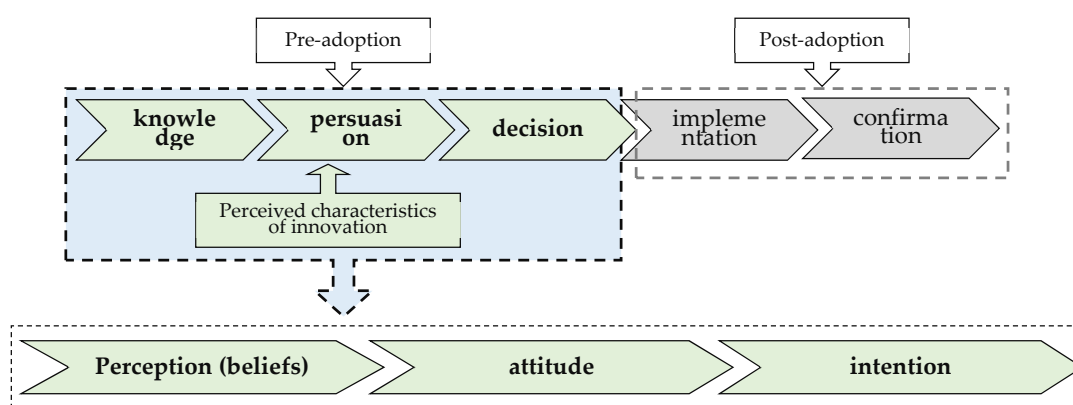


Figure 1. Theoretical premise [17].

We provide a cogent explanation of the relationship between consumer beliefs (perceptions of the innovation), attitudes (either favorable or unfavorable), and consequent behaviors (adoption or rejection of an innovation). Specifically, the perceived attributes of APSs (consumer beliefs) may affect intentions either directly or indirectly via attitudes. Prior research supports the premise that consumer beliefs influence adoption intention and that the effect can be direct or indirect depending on attitude [17,32–35]. However, several innovation diffusion studies have bypassed the attitude construct, suggesting a direct link between beliefs and intentions [36,37]. In our research, we postulate that attitude serves as either a direct predictor or a mediator in shaping consumer adoption intentions, leading to the formulation of the following hypotheses:

- H₁. Consumer beliefs directly influence APS adoption intention or indirectly through attitude.
- H₂. Favorable attitudes toward SST are positively correlated with APS adoption intention.

2.2. Hypothesis development

IDT and resource matching theory, when applied to measurement constructs, offer a framework of attitudinal beliefs in the context of adoption.

2.2.1. Innovation diffusion theory

An innovation can be described as an idea, practice, or object deemed new by an individual or a collective [31]. In this context, the integration of SST through APSs constitutes an innovation within the logistics domain, amalgamating novel practices (self-collection) with new objects (APSs) in the consumer landscape. Nevertheless, assessing the viability of innovative service offerings necessitates a careful balance with consumer perceptions and behaviors [38]. The TAM, introduced by Davis in 1989, provides a framework to understand the role of “perceived usefulness” and “perceived ease of use” in the adoption of innovative technologies [22]. The literature on innovation diffusion offers a theoretical foundation for beliefs regarding the perceived characteristics of innovations [39]; this approach refines the broad attitudinal beliefs contained in the original TRA [40]. Rogers delineated various characteristics that could affect the perception of an innovation, such as its relative advantage over existing solutions, compatibility with current systems, and the complexity and observability

involved in its adoption and its trialability [31]. Employing these characteristics, Yuen et al. and Wang examined relative advantage, compatibility, complexity, observability, and trialability, finding observability to be a nonsignificant factor, corroborating prior studies [15,17]. Such findings echoed the trends noted in trialability for this research. Therefore, the consumer perceptions used in the present study were categorized into distinct dimensions as supported by theoretical and empirical evidence.

Perceived compatibility (CPA) refers to the extent to which an innovation is consistent with the pre-existing values, needs, and experiences of potential adopters [31]. The congruence of self-pickup services for final delivery with the preferences, values, and lifestyles of potential users is likely to cultivate positive attitudes and intrinsic motivation toward the adoption of self-pickup services. Therefore, the subsequent hypothesis is posited:

H_{1a}. CPA positively influences consumer attitudes toward APS adoption intention.

Perceived complexity (CPL) refers to the degree to which an innovation is perceived as complex and challenging to use [31]. In the context of APSs, complexity becomes apparent when users interact with the system for parcel retrieval. To ensure secure and efficient package delivery, the APS employs a series of identity verification methods, including barcode scanning, password entry, and package serial number retrieval. Nonetheless, these procedures can impose an additional cognitive burden on consumers, potentially resulting in negative attitudes. Consequently, the following hypothesis is formulated:

H_{1b}. CPL negatively influences consumer attitudes toward APS adoption intention.

Perceived relative advantage (RAD) refers to the degree of superiority an innovation presents over existing practices. It significantly contributes to the prediction of consumer adoption of such innovations, fostering strong behavioral intentions among rational consumers [41]. Empirical studies have demonstrated that RAD directly influences consumer intentions [37]. Consequently, the following hypothesis has been proposed:

H_{1c}. RAD positively influences consumer attitudes toward APS adoption intention.

2.2.2. Resource matching theory

The TAM and the IDT were initially considered inadequate for a comprehensive understanding of consumer attitudes. Consequently, researchers integrated the Resource Matching Theory, which evaluates a consumer's available resources—including time, money, and effort—to determine their capacity to obtain specific services [18,24]. Studies have shown that the extent to which consumers leverage their resources when using an APS varies with individual abilities and motivation [11]. However, enhancing customer experiences through improved communication, effective management, and innovative service design may alleviate the perceived resource investment required for the efficient use of an APS. Prior studies have expanded our understanding of consumer beliefs by incorporating factors such as convenience, reliability, privacy security, location, and perceived risk to reinforce customers' perceived utility and thereby strengthen their usage intentions [11,18,25]. This study further enriches the model by including privacy security, reliability, and location as additional indices.

Privacy security (SEC) refers to the degree to which consumers consider the use of innovative technologies in finance, privacy, or other fields as safe [42]. Empirical studies have shown a significant inverse relationship between SEC and behavioral intention [43]. When evaluating delivery services that involve SST, consumers may feel a lack of certainty, resulting in a marked decrease in their readiness to use these services. Therefore, the following hypothesis was proposed:

H_{1d}. SEC positively influences consumer attitudes toward APS adoption intention.

Reliability (REA) refers to how consumers perceive the reliability of technological innovations. Compared with home delivery, self-pickup services are generally considered more reliable because they tend to reduce the potential for delivery complications (i.e., package theft, damage, and loss) [44]. REA affects the perceived value of technological innovations [18]. SST has an anticipated positive influence on consumers. Based on these observations, the following hypothesis is proposed:

H_{1e}. REA positively influences consumer attitudes toward APS adoption intention.

Location (LOC) plays a role in explaining how consumers perceive time constraints when using SST [45]. According to Resource Matching Theory, if APSs are deemed too remote or inaccessible, consumers may choose more convenient alternatives to complete the package self-pickup task [46]. As such, LOC directly influences both customer satisfaction and repurchase intention [47]. LOC has a direct and positive effect on the intention to use SST [11]. Given these findings, LOC has a clear and positive effect on consumer attitudes toward the adoption of SST. In this study, we propose the following related hypothesis:

H_{1f}. LOC positively influences consumer attitudes toward APS adoption intention.

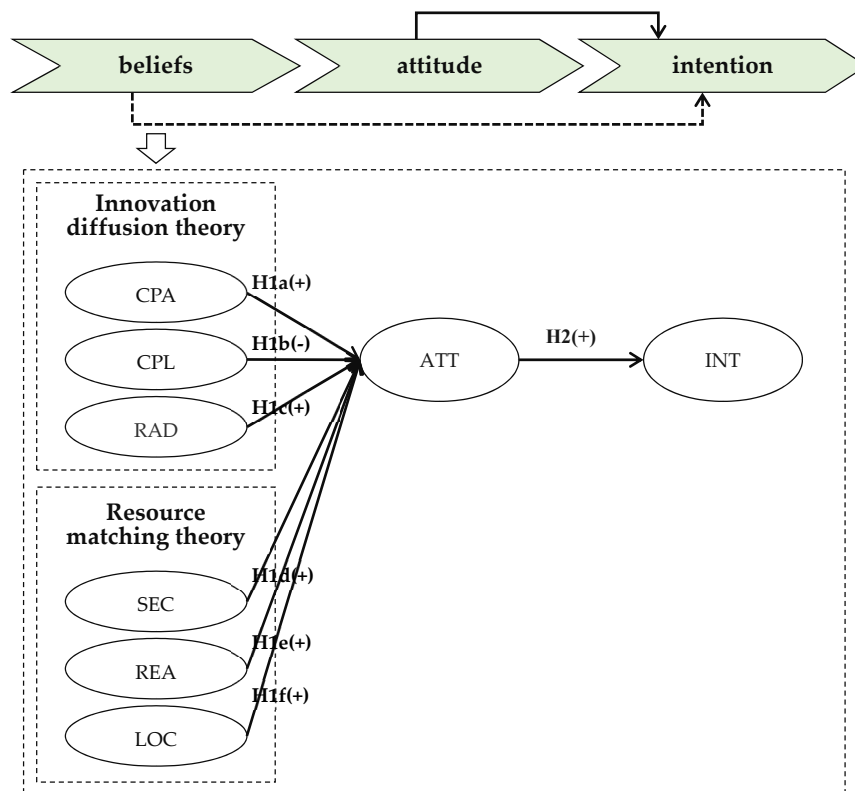


Figure 2. Conceptual framework.

3. Materials and methods

3.1. Survey design

A questionnaire with two sections was developed. The first section was on demographic

characteristics, namely, gender, age, education level, employment status, and monthly earnings. The second section was on attitudes and intention. The questionnaire comprised 25 items that were rated on a five-point Likert-type scale with endpoints ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Table 1. Constructs and measurement items.

Construct	Measurement items	Source
Perceived compatibility (CPA)	CPA1: Using APSs for delivery of goods purchased online is compatible with my lifestyle.	[15,17,24]
	CPA2: Using APSs for delivery of goods purchased online is compatible with my needs.	
	CPA3: APSs are compatible with the way I like to receive goods.	
	CPA4: Using APSs for delivery of goods purchased online is compatible with my current situation.	
Perceived complexity (CPL)	CPL1: Using APSs for delivery of goods purchased online is difficult.	[15,17,24]
	CPL2: Using APSs for delivery of goods purchased online requires a lot of effort.	
	CPL3: Learning how to use APSs for delivery of goods purchased online is difficult.	
Perceived relative advantage (RAD)	RAD1: APSs provide a superior overall parcel delivery experience compared with home delivery.	[15,17,24]
	RAD2: Receiving parcels is easier with APSs than with home delivery.	
	RAD3: Receiving parcels is faster with APSs than with home delivery.	
Privacy security (SEC)	SEC1: When using APSs, my personal information is kept private.	[18,24]
	SEC2: I can control my personal information when using APSs.	
	SEC3: I feel secure when using APSs.	
Reliability (REA)	REA1: APS systems are reliable.	[18,24]
	REA2: I don't expect mistakes to be made when having goods delivered to APSs.	
	REA3: APSs can be relied on to provide accurate services.	
Location (LOC)	LOC1: I live or work close to an APS (within 300 meters).	[11,17,18]
	LOC2: I live within walkable distance of an APS.	
	LOC3: APSs are accessible.	
Attitude (ATT)	ATT1: APSs are pleasant to use.	[32]
	ATT2: APSs are efficient and effective.	
	ATT3: APSs have positive effects on the environment and society.	
Intention (INT)	INT1: I intend to use APSs to receive goods for my next online purchase.	[11,17,18]
	INT2: I recommend using APSs to my friends.	
	INT3: I would say positive things about APSs to others.	

3.2. Sample collection

Quantitative data [11,25] were collected using an online survey platform (www.sojump.com). Data were collected between August 13 and 25, 2021. In total, 381 questionnaires were completed, and 322 questionnaires were deemed valid. To maintain proportional representation, the number of questionnaires collected from each of 11 districts in Guangzhou was adjusted on the basis of the population of each district. Subsequently, SPSS 22.0 was employed for descriptive statistical analysis, and AMOS 24.0 was used to conduct confirmatory factor analysis and path analysis to test the hypotheses.

The demographic characteristics of respondents are given in Table 2. The respondents had similar demographic characteristics to online shoppers, who have shown increased enthusiasm and familiarity with online shopping and offline self-pickup.

Table 2. Respondent demographic characteristics (N = 322).

Characteristic	Item	Percent
Gender	Male	44.7%
	Female	55.3%
Age	15–26	41.9%
	27–40	52.8%
	41–55	5.3%
Education	High school or below	7.1%
	Three-year college	22.7%
	Four-year college	65.5%
	Graduate school or above	4.7%
Occupation	Government	2.5%
	Government-sponsored institution	15.5%
	State-owned enterprise	9.0%
	Corporate	47.5%
	Self-employed	6.8%
	Unemployed	1.9%
	Student	14.0%
Monthly income (CNY)	Others	2.8%
	<5,000	27.3%
	5,000–9,999	44.7%
	10,000–19,999	22.7%
	>20,000	5.3%

3.3. Measurement model

Table 3 presents the reliability and validity assessments for the questionnaire used in the study. The Cronbach's α coefficients for the items ranged from 0.576 to 0.808. These values exceed the minimum threshold of 0.6, affirming the scales' reliability. Model-fit indices demonstrated an adequate fit to the data, as evidenced by the following values: Chi-square, 400.163; chi-square/degrees of freedom, 1.582; goodness of fit index, 0.910; adjusted goodness of fit index, 0.884; and root mean square error of approximation, 0.043. Furthermore, both composite reliability (CR) and average

variance extracted (AVE) measures confirmed convergent validity, with CR values exceeding 0.7 and AVE values exceeding 0.36 for all constructs except “attitude (ATT)”. Discriminant validity was established by comparing AVE values with squared correlation coefficients (Table 4). Consequently, the optimized structural equation model that met all criteria for validity is depicted in Figure 3.

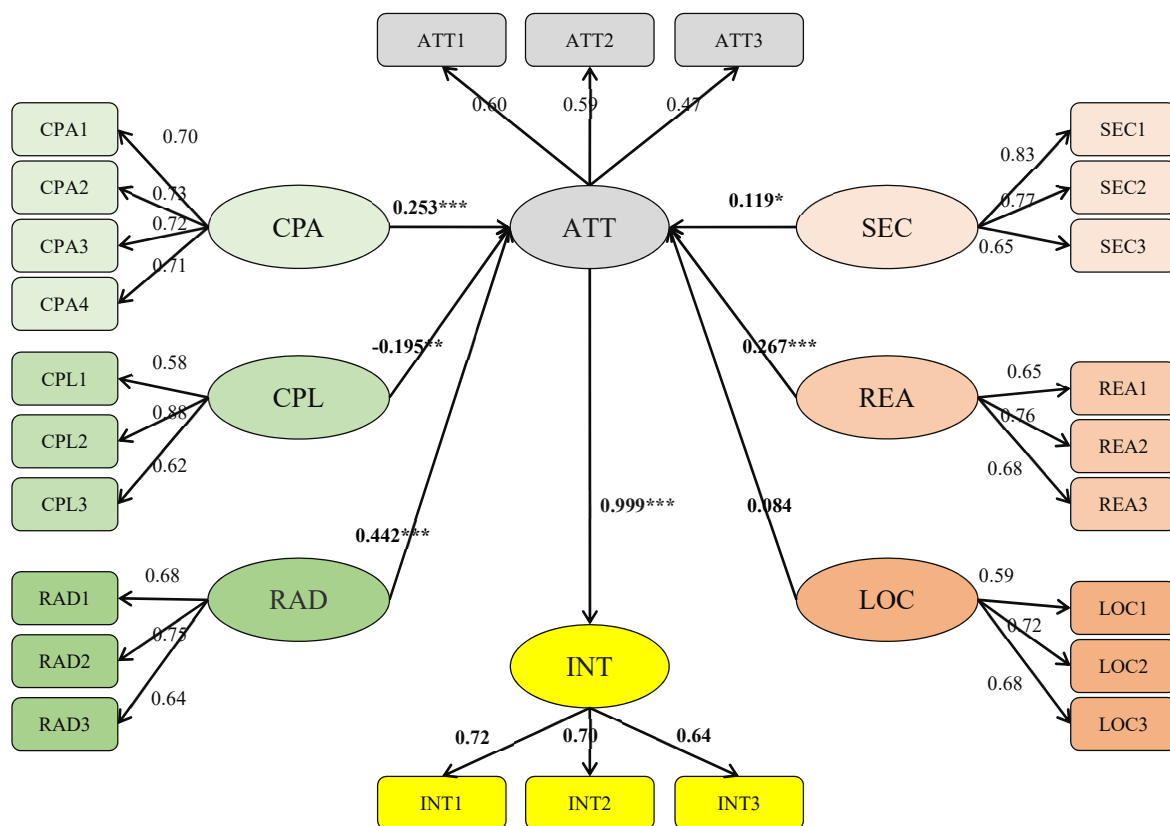
Table 3. Confirmatory factor analysis and scale reliability.

Item	Cronbach's α	CR	AVE	Standardized Factor Loadings	t value
Perceived compatibility (CPA)	0.808	0.810	0.517		
CPA1				0.721	10.550
CPA2				0.742	11.124
CPA3				0.720	***
CPA4				0.691	10.634
Perceived complexity (CPL)	0.742	0.745	0.496		
CPL1				0.639	8.700
CPL2				0.785	8.566
CPL3				0.680	***
Perceived relative advantage (RAD)	0.728	0.737	0.491		
RAD1				0.602	8.309
RAD2				0.855	7.609
RAD3				0.615	***
Privacy security (SEC)	0.788	0.793	0.563		
SEC1				0.810	9.955
SEC2				0.802	9.984
SEC3				0.625	***
Reliability (REA)	0.736	0.738	0.485		
REA1				0.643	8.494
REA2				0.766	8.366
REA3				0.675	***
Location (LOC)	0.687	0.706	0.450		
LOC1				0.580	7.506
LOC2				0.803	6.921
LOC3				0.608	***
Attitude (ATT)	0.576	0.588	0.326		
ATT1				0.617	4.811
ATT2				0.620	4.798
ATT3				0.461	***
Intention (INT)	0.730	0.731	0.476		
INT1				0.664	***
INT2				0.739	8.227
INT3				0.665	8.328

Notes: Model-fit indices: chi-square = 400.163; $df = 253$; chi-square/degrees of freedom = 1.582; goodness of fit index, 0.910; adjusted goodness of fit index = 0.884; root mean square error of approximation = 0.043. ***Donates a constrained relationship to 1 for identification.

Table 4. AVE, construct correlation and squared correlation.

	AVE	CPA	CPL	RAD	SEC	REA	LOC	ATT	INT
CPA	0.517	0.719							
CPL	0.496	-0.665	0.704						
RAD	0.491	0.615	-0.368	0.701					
SEC	0.563	-0.355	0.481	-0.241	0.750				
REA	0.485	0.560	-0.399	0.566	-0.526	0.696			
LOC	0.450	0.549	-0.468	0.437	-0.237	0.463	0.671		
ATT	0.326	0.808	-0.615	0.829	-0.332	0.714	0.603	0.571	
INT	0.476	0.808	-0.615	0.829	-0.332	0.713	0.603	0.999	0.690

**Figure 3.** Results of structural equation modeling.

4. Results

4.1. Hypothesis testing

The results of hypothesis testing, presented in Table 5, affirm that CPA ($\beta = 0.253$, $p = 0.006$), RAD ($\beta = 0.442$, $p < 0.001$), SEC ($\beta = 0.119$, $p = 0.066$), and REA ($\beta = 0.267$, $p = 0.001$) exert significant positive influences on consumer attitudes, hence supporting hypotheses H_{1a}, H_{1c}, H_{1d}, and H_{1e}. Conversely, CPL ($\beta = -0.195$, $p = 0.012$) was found to have a significant negative effect on consumer attitudes, substantiating H_{1b}. However, the influence of LOC ($\beta = 0.084$, $p = 0.192$) on

consumer attitudes was not significant, rendering H_{1f} unsupported. Additionally, ATT ($\beta = 0.999$, $p < 0.001$) showed a significant positive effect on consumer intentions to adopt SST for delivery of goods purchased online, corroborating H₂.

The empirical evidence corroborates Rogers' theory on the role of consumer beliefs in forming attitudes and subsequent behaviors, as delineated in the five-stage adoption process of the IDT. An examination of R² values, which indicate the proportion of variance in the dependent variables not explained by the model, reveals that 10.7% of the variance in ATT can be accounted for by the combined effects of CPA, CPL, RAD, SEC, REA, and LOC. Moreover, ATT accounts for 0.1% of the variance in intention to adopt SST.

Table 5. Hypothesis testing.

Hypothesis	Path	Parameter estimated		Standard error	t value	R2	Results
		Unstandard (B)	Standard (β)				
H _{1a}	CPA → ATT	0.233***	0.253	0.085	2.730	0.893	Supported
H _{1b}	CPL → ATT	-0.198**	-0.195	0.079	-2.507		Supported
H _{1c}	RAD → ATT	0.379***	0.442	0.077	4.955		Supported
H _{1d}	SEC → ATT	0.106*	0.119	0.058	1.842		Supported
H _{1e}	REA → ATT	0.274***	0.267	0.086	3.177		Supported
H _{1f}	LOC → ATT	0.096	0.084	0.074	1.304		Not supported
H ₂	ATT → INT	0.926***	0.999	0.102	9.107	0.999	Supported

Note: ***Denotes significance at the 0.01 level; **Denotes significance at the 0.05 level; *Denotes significance at the 0.10 level.

4.2. Mediating and moderating effects

ATT serves as a partial mediating variable and influences four pathways: CPA → INT, CPL → INT, RAD → INT, and REA → INT (Table 6). Two-tailed significance tests for the four aforementioned pathways yielded values of 0.047, 0.021, 0.012, and 0.023, respectively, suggesting that the indirect effects along these pathways are statistically significant. This finding is corroborated by bootstrap confidence intervals that do not encompass zero, further affirming the significance of the indirect effects. Conversely, for the pathways SEC → INT and LOC → INT, ATT does not act as a partial mediator, as indicated by two-tailed significance levels of 0.108 and 0.305, respectively, which are above the conventional threshold of 0.05. Notably, the proportion of the mediating effect of ATT on the pathways CPA → INT, CPL → INT, RAD → INT, and REA → INT was 100%, a ratio that is also observed in the pathways involving SEC → INT and LOC → INT. Moreover, all examined indicators of beliefs exhibited a negligible direct effect on intention.

Theoretical models propose that consumer beliefs engender attitudes, which in turn drive behavior. Such frameworks imply that individual attitudes are critical mediators affecting perceptions of compatibility, complexity, relative advantage, and reliability—factors aligned with perceived utility, a known key determinant of behavioral intention and subsequent adoption in applications of the TAM. By contrast, privacy security and location seem not to partake in this mediated relationship with attitudes, implying they may directly influence the dependent variable or interact with other unexamined variables.

Table 6. Direct, indirect, and mediating effects.

Mediator and path	Effects	Estimates	Bias–corrected 95% confidence interval		Comments
			lower	upper	
ATT, CPA—> INT	Direct effects	—	—	—	Partial mediation 100%
	Indirect effects	0.253**	0.004	0.481	
	Total effects	0.253	0.004	0.481	
ATT, CPL—> INT	Direct effects	—	—	—	Partial mediation 100%
	Indirect effects	-0.195**	-0.320	-0.025	
	Total effects	-0.195	-0.320	-0.025	
ATT, RAD—> INT	Direct effects	—	—	—	Partial mediation 100%
	Indirect effects	0.442**	0.210	0.650	
	Total effects	0.442	0.210	0.650	
ATT, SEC—> INT	Direct effects	—	—	—	Not supported
	Indirect effects	0.119	-0.027	0.256	
	Total effects	0.119	-0.027	0.256	
ATT, REA—> INT	Direct effects	—	—	—	Partial mediation 100%
	Indirect effects	0.267**	0.210	0.416	
	Total effects	0.267	0.210	0.416	
ATT, LOC—> INT	Direct effects	—	—	—	Not supported
	Indirect effects	0.084	-0.063	0.223	
	Total effects	0.084	-0.063	0.223	

Note: **Denotes significance at the 0.05 level.

5. Discussion

Extensive research has been conducted on the adoption of new technology. Davis's TAM was

proposed in 1989 and outlines how perceived characteristics of innovation influence consumer intentions either directly or indirectly via attitude. Substantial advancements in the field have occurred in the three decades since the TAM was established. The TAM has been broadly adapted and extended across multiple contexts, encompassing concepts such as the IDT introduced by Rogers in 1995. A further iteration of this theory came in the form of Parasuraman's Technology Readiness Index (TRI) in 2000, which highlights the role of mental enablers and inhibitors in consumer behavior [48]. Lin, Shih, and Sher integrated the TRI with the TAM in 2007, enhancing the model's complexity and relevance [49]. When considering innovations in logistics, several researchers have employed various theories to elucidate consumer intentions toward SST adoption. Wang et al., in their 2018 study, were the first to apply both the IDT and TAM to cognitive mechanisms to explain the "belief—>attitude—>intention" relationship [17]. Their framework, rooted in cognitive dissonance, sheds light on the psychological process consumers undertake when deciding to embrace or reject technology, positioning intention as a vital behavioral precursor. Wang's approach emphasized the significance of perceived attributes—compatibility, complexity, observability, trialability, and relative advantage—as key beliefs influencing SST acceptance within the TAM and IDT context. Notably, their analytical model scrutinized both the direct and indirect effects of attitude on intention. Adding to this spectrum of research, Chen et al. explored the concept of resource matching through technology readiness, highlighting the enhancement of user convenience, privacy security, and reliability for matching cognitive resources [11]. In the contemporary literature, including in studies by Yuen et al. and Zhou et al., explores the relationship between beliefs and intentions [15,25]. Unlike traditional studies that primarily examine the moderating effects of attitudes, these studies specifically investigated how beliefs directly influence attitudes and intentions.

The TAM and IDT describe the influence pathway and theoretical mechanisms well; however, these frameworks primarily focus on the static dimensions of perceived characteristics, which leaves a gap in fully comprehending the complex "beliefs—>attitude—>intention" relationship from alternative perspectives. For instance, Wang et al. and Tsai and Tiwasing used constructs such as compatibility, complexity, observability, trialability, and relative advantage to represent these characteristics [17,24]. Nonetheless, it remains unclear how cognitive attitudes (such as convenience, functionality, design, and security) and affective attitudes (such as enjoyment, assurance, and customization) or other cognitive dissonance factors contribute to consumer intent [17]. Resource Matching Theory has expanded the scope of perceived belief characteristics but fails to clearly outline the psychological process through which attitudes toward innovation are developed and how these attitudes subsequently determine adoption intentions or behaviors. For example, it suggests that attributes of SST that minimize user effort can fuel adoption intentions [50]. Accordingly, studies have incorporated variables related to cognitive and affective attitudes and other cognitive dissonance factors, such as location, security, perceived risk, and reliability [11,18,24,25]. We, by contrast, assess perceived characteristics such as compatibility, complexity, observability, trialability, and relative advantage, derived from the TAM and IDT, alongside other cognitive dissonance variables including location, privacy security, and reliability.

Building upon theoretical foundations, we hypothesized that attitudes directly or indirectly influence consumer intent to adopt SST. This proposition is supported by empirical evidence [17,23,24]. Wang and Tsai and Tiwasing applied distinct perceived characteristics to demonstrate that attitudes act as both predictors and mediators, influencing adoption intentions within the framework of "beliefs—>attitude—>intention" [17,24]. Both studies confirmed the significant positive role of

attitude in shaping adoption intentions. However, only Tsai and Tiwasing identified the moderating effects of attitude [24]. Several studies have confirmed that perceived belief characteristics directly affect attitudes or intentions related to adoption behaviors [15,17,24]. Our findings indicate that perceptions, whether favorable or unfavorable, correspondingly shape attitudes, aligning with the theoretical and empirical evidence but with several subtle differences. According to the TRA, an individual's attitudes, whether favorable or unfavorable, are shaped by readily accessible beliefs [30]. Moreover, knowledge acquisition, as an individual comprehends how an innovation functions, underpins the individual's perception of the innovation in question [31]. Within the framework of the IDT, favorable beliefs—such as perceived compatibility, observability, trialability, and relative advantage—are positively correlated with attitudes or intentions, and unfavorable beliefs, such as perceived complexity, are negatively correlated with attitudes or intentions. Empirical support has been provided for the positive effects of beliefs with regard to compatibility, relative advantage [15,17,24], trialability [15,17], convenience, reliability, and privacy security [18,24] on attitudes or intentions. Similarly, location [11,25] positively influences attitudes and intentions, whereas complexity [11,24], perceived risk [25], and technology anxiety [51] exert a negative influence. However, the effects of observability [15,17], complexity [15], and time pressure [11] have been found to be nonsignificant. Our research corroborates that compatibility, relative advantage, reliability, and privacy security positively affect attitudes or intentions, consistent with previous findings [15,17,18,24]. Conversely, our results indicated that location has a nonsignificant effect on attitude, inconsistent with finding by other study [11].

The present study demonstrated that positive attitudes directly lead to a stronger intention to adopt SST for delivery of goods purchased online, and that the effect of attitude on intention is significant. Furthermore, perceived characteristics and beliefs indirectly influence intentions through attitude. Specifically, elements such as CPA, CPL, RAD, SEC, and REA act as attractive attributes fostering a favorable attitude toward consumer adoption intention. However, these attributes alone are not compelling enough to directly elicit intention. Contrary to our initial hypothesis, LOC did not emerge as a significant predictor of attitude. We synthesized the IDT with the Resource Matching Theory to create a comprehensive explanatory framework that elucidates consumer adoption intentions in Guangzhou. This research extends the literature in several ways. First, it unifies the IDT and the Resource Matching Theory to enhance the analytical framework by accounting for the direct, indirect, and moderating effects of attitudes, clarifying the relationship between beliefs, attitudes, and intentions. Second, it refines the system of variables by identifying a set of perceived belief characteristics, namely CPA, CPL, RAD, SEC, REA, and LOC, which builds on and refines our understanding of variables and their relationships from prior research. Third, it demonstrates the relationships between beliefs, attitudes, and intentions, thereby validating existing research and offering novel theoretical insights. Consequently, we not only propose a revised theoretical model for investigating consumer adoption behavior in response to logistics innovations but also broaden the scope of innovation studies by integrating aspects of the Resource Matching Theory, contributing to the advancing body of literature in this area.

6. Conclusions and future work

According to the TRA, attitudes toward an object are formed from readily available beliefs, and these attitudes are a primary precursor to behavioral intentions. In this study, we demonstrate that

attitudes are indeed the most immediate predictor of intentions, with consumer attitudes (favorable and unfavorable) being directly shaped by their perceptions. Based on these results, we suggest the following: (1) Consumer attitudes toward SST in online shopping must be nurtured. Consumers can choose to use either home delivery services or SST. Online shoppers tend to consider SST as simply a means to an end in the delivery of purchased goods; shoppers lack an emotional connection to SST. Thus, consumers engage with this delivery method in a shallow manner. Promoting a more positive perception of APSs may significantly increase consumer willingness to use these services for the delivery of goods purchased online. (2) The safety, efficiency, and user-friendliness of SST require improvement, particularly in last-mile delivery. Consumers stated their dissatisfaction with regard to “agreement,” especially in terms of reliability, assurance, and dependability. Therefore, these critical features of SST must be enhanced to improve the competitive edge of SST over traditional home delivery methods.

This study has several limitations. First, structural equation modeling does not allow for the inclusion of individual characteristic variables; therefore, any variations in willingness caused by these variables cannot be uncovered. Future studies should use larger samples and improve the precision requirements of the model to better understand how different factors influence acceptance among different groups. Second, perceived behavioral control, perceived value, and transaction costs have been shown to affect intention to use SST. Further research is required to investigate how consumer intention is formed in this domain and what factors influence consumer intention. Future studies should incorporate multiple theories to establish a solid theoretical foundation for understanding intention generation. Additionally, constructing a multifactor mechanism that considers attitudes, positions, behavioral control, values, and cost, would provide a more comprehensive perspective on the psychological factors influencing online consumer decisions.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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