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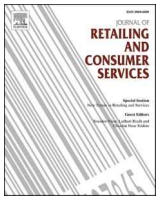

Examining the effects of weather on online shopping cart abandonment: Evidence from an online retailing platform

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ABSTRACT

As an important environmental factor, weather has been extensively studied for its effects on consumer behavior. However, the impact of weather on online shopping cart abandonment remains unclear, with limited managerial guidance provided. Through an empirical investigation using secondary data analysis and a scenario-based experiment, we find that sunny weather is associated with a decrease in online shopping cart abandonment, and such an effect is moderated by brand reputation. Furthermore, we identify a serial mediation mechanism through mood and perceived risk. This research contributes to a novel understanding of weather's impact on online retailing and extends the theoretical discussion of sunny weather's effects on mood and perceived risk from offline to online contexts. Practically, this paper provides managerial insights for online retailers aiming to optimize their strategies in response to varying weather conditions.

1. Introduction

With the rapid growth of online retailing, managing consumers' online shopping carts has become an increasingly important issue. While adding products to an online shopping cart is often an essential step toward making purchases, it does not guarantee that the item will ultimately be sold. Furthermore, consumers frequently abandon their online shopping carts, which is an enormous potential loss for online retailers. According to Statista (2023), the average online shopping cart abandonment rate is 69.82%, which shows that online retailers face difficulty in converting visitors into customers. Given this economic implication, it is a critical issue for both researchers and retailers to explore strategies for reducing online shopping cart abandonment and enhancing the conversion rate from browsing to purchase.

Prior studies have identified a series of factors that influence online shopping cart abandonment behaviors, including psychological factors (such as perceived risk, entertainment values, trust, and mindset, see Davari et al., 2016; Rodrigues et al., 2022; Kukar-Kinney and Close, 2010; Boas et al., 2020; Rubin et al., 2020), as well as behavioral factors (Rajamma et al., 2009; Xu and Huang, 2015; Wang et al., 2022a; Petcharat et al., 2023). In addition, scholars have begun to pay attention to environmental factors (El Haddad et al., 2018). For example, Floh and Madlberger (2013) demonstrate that the design of websites has an impact on shopping cart abandonment.

Despite the aforementioned studies on various factors influencing online shopping cart abandonment behavior, weather conditions, as an important natural environmental factor, have received limited attention in the e-commerce context. Nevertheless, weather plays a crucial role in influencing consumers' decision-making behavior, as evidenced by prior literature (Li et al., 2017; Badorf and Hoberg, 2020; Tian et al., 2021). For instance, Li et al. (2017) prove that weather conditions can impact consumers' purchase response to mobile promotions. As businesses adapt to the digital realm and grapple with numerous influencing factors, weather emerges as a tangible and influential force that extends beyond outdoor activities, shaping the indoor consumer experience as well. By examining how weather conditions affect online shopping cart abandonment, retailers can develop more effective marketing strategies to increase sales and enhance the overall shopping experience of their customers. Surprisingly, little research exists on how weather specifically affects shopping cart abandonment, highlighting a gap in the

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current knowledge.

There are two reasons for the lack of research on the relationship between weather and online shopping cart abandonment behavior. First, there is difficulty in matching sufficient shopping cart abandonment data and weather data. Weather conditions vary across different geographic locations and periods, making it difficult to establish a consistent and comprehensive dataset that aligns weather information with specific shopping cart abandonment data. Second, researchers encounter challenges in elucidating the psychological mechanisms underlying the relationship between weather and online shopping cart abandonment. Many studies rely solely on secondary data sources, which might lack the granularity and specificity needed to adequately capture and measure relevant psychological variables. The lack of accessible and well-integrated data sources limits researchers' ability to effectively study the relationship between weather and online shopping cart abandonment.

To address these issues, this study focuses on the impact of weather conditions on online shopping cart abandonment behaviors. To elucidate this understudied aspect, this study uses a dataset with shopping cart abandonment data from an online shopping platform that sells mobile phones, as well as weather data that match the time and location of the orders placed. Through this analysis, we aim to investigate the effect of weather on online shopping cart abandonment. Furthermore, this study conducts an experiment to examine the underlying mechanism. The main results show that sunny weather has a negative effect on online shopping cart abandonment behavior and that this relationship is serially mediated by mood and perceived risk. Additionally, we have identified brand reputation as a moderating factor. Specifically, when the product is associated with public praise, the negative effect of sunny weather on shopping cart abandonment is attenuated.

This research contributes to the literature by identifying weather as a crucial environmental factor influencing consumers' decision-making processes during online shopping, offering a nuanced perspective on how weather and reputation interact to shape consumer behaviors, and uncovering the underlying mechanism through which weather affects shopping cart abandonment. This study also offers valuable practical implications. In particular, online retailers may tailor their promotional strategies based on weather conditions and brand reputation, as well as take proactive measures to induce a positive mood and mitigate the negative effects of weather on consumer behavior.

The rest of this paper is organized as follows. Section 2 reviews the related literature and proposes the research hypotheses. Section 3 introduces the research design and methodology of this paper. Sections 4 and 5 present the empirical study and lab experiment conducted in this research. Finally, Section 6 discusses the theoretical and practical implications of this study.

2. Literature review and hypothesis

2.1. Affect-as-information theory

In this study, we draw from affect-as-information theory to understand how sunny weather impacts consumer shopping cart abandonment behavior in an online retailing environment. Affect-as-information suggests that individuals rely on their emotional states as a source of information when making judgments or decisions (Schwarz and Clore, 1983). The utilization of the affect-as-information framework involves two stages: first, the identification of affective reactions, and second, the determination of the relevance of these reactions for a given judgment (Albarracín and Kumkale, 2003). By relying on emotions as cues, individuals are able to evaluate their environment and guide their behaviors accordingly (Avnet et al., 2012).

Affect-as-information theory has been widely applied in the field of consumer behaviors, yielding valuable insights. For example, Cohen (1990) finds that people base their judgment on feelings when assessing their attitudes toward the brand. Similarly, Pham et al. (2013) use an affect-as-information model to confirm that feelings can significantly influence evaluations of advertisements. Moreover, consumers may rely on their current mood when evaluating products (Pham, 1998; Govind et al., 2020).

In light of affect-as-information theory, this study aims to uncover the impact of sunny weather on shopping cart abandonment behavior in the context of online retailing. Prior research has indicated that weather conditions have the potential to impact individuals' mood states (Persinger and Levesque, 1983; Keller et al., 2005). In accordance with affect-as-information theory, these mood states induced by weather can subsequently influence consumer behavior (Schwarz and Clore, 1983). For instance, Bujisic et al. (2019) demonstrate that the positive mood induced by pleasant weather can lead to consumers expressing more positive comments. By delving into the role of affect as a form of information, this study aims to elucidate the interplay between weather stimuli, mood states, perceived risk, and their collective impact on consumer shopping cart abandonment behavior in the e-commerce setting.

2.2. Online shopping cart abandonment

When shopping online, consumers go through four stages: the information search stage, consideration stage, evaluation stage, and purchase decision. In the second stage, consumers are inclined to place their chosen products into the shopping carts (Li and Chatterjee, 2005). Unlike traditional on-ground shopping carts, which mainly serve as a storing tool for immediate mass purchasing, virtual or online shopping carts can be used to obtain information, organize items, and entertain (Close and Kukar-Kinney, 2010). However, not every consumer will complete the purchase of all the items put in the shopping cart, which is defined as online shopping cart abandonment behavior (Kukar-Kinney and Close, 2010). In reality, consumers frequently abandon their shopping carts. According to Li and Chatterjee (2005), the average documented online shopping cart abandonment rate is 69.57%. The high rate of shopping cart abandonment suggests that many consumers choose to give up purchasing, which results in a significant loss of sales (Khan et al., 2022).

Given the importance of the shopping cart abandonment rate, it becomes crucial to identify the antecedents of online shopping cart abandonment behavior. Prior literature has mainly identified three streams of determinants: psychological factors, behavioral factors, and environmental factors (Cho et al., 2006; Boas et al., 2020; Wang et al., 2022a; Rajamma et al., 2009; Xu and Huang, 2015; Kukar-Kinney and Close, 2010; El Haddad et al., 2018; Egeln and Joseph, 2012; Kapoor and Vij, 2021; Petcharat et al., 2023).

The first stream focuses on how consumers' psychological factors impact online shopping cart abandonment (Erdil, 2018; Huang et al., 2018; Wang et al., 2022b; Wu et al., 2020; Petcharat et al., 2023). For example, Huang et al. (2018) find that the emotional ambivalence of consumers can lead to a higher shopping cart abandonment rate. Perceived risk is also an important psychological factor, as risk assessment is an essential step during online shopping processes (Wu et al., 2020). Studies have consistently shown a positive correlation between perceived risk and cart abandonment (Moore and Mathews, 2006; Xu and Huang, 2015). Consumers who perceive high-level risks during online shopping tend to find ways to lower their perceived risk. However, when such risks cannot be reduced to an acceptable level, they will abandon the purchase (Roselius, 1971; Davari et al., 2016; Rodrigues et al., 2022).

Researchers have also acknowledged the importance of exploring how behavioral factors influence online shopping cart abandonment (Shin and Lin, 2016). Consumers are more likely to abandon their shopping cart when they are not sure about the purpose of shopping, and they may add items simply for price comparison or even entertainment purposes (Greenleaf and Lehmann, 1995; Close and Kukar-Kinney, 2010). Moreover, the time pressure perceived by consumers during

online shopping can also lead to cart abandonment by affecting consumers' cognitive processes (Cho et al., 2006). When consumers do not have enough time to invest in shopping, they tend to delay their decision making (Amato and Bradshaw, 1985), which will lead to future online shopping cart abandonment (Rubin et al., 2020). For instance, Rajamma et al. (2009) have proven that increased perceived waiting time can increase the likelihood of online shopping cart abandonment.

In addition to consumers' psychological and behavioral factors, environmental factors may also cause online shopping cart abandonment. Past literature has emphasized environmental factors that are associated with online shopping platforms and consumers' social support systems (Kukar-Kinney and Close, 2010). Specifically, consumers may have higher tendencies to abandon their shopping carts because of several factors related to platforms, such as ease of website use, website security, and privacy protection (El Haddad et al., 2018; Garaus, 2018). In addition, consumers may abandon their shopping carts because of social evaluations in their social circle (Huang et al., 2018). Furthermore, perceived risk can be used to explain why these environmental factors influence online shopping cart abandonment. When the online shopping environment is poorly developed, consumers are more likely to perceive risks or uncertainties in terms of how to obtain information, how to identify alternatives, and how to assess consequences (Hogarth et al., 1980). They are more likely to abandon their shopping carts when such perceived risks cannot be reduced to an acceptable level (Dowling and Staelin, 1994; Rajamma et al., 2009).

Despite prior research as discussed above, weather conditions, as a form of exogenous environmental factor, have rarely been investigated as another form of the antecedent of online shopping cart abandonment (see Table 1). However, the literature establishes the importance of weather in affecting consumers' decision-making processes and results (Murray et al., 2010; Li et al., 2017; Badorf and Hoberg, 2020). To address this gap, this study aims to contribute to the online shopping cart abandonment literature by investigating the relationship between sunny weather and cart abandonment.

2.3. Impact of weather conditions on decision making

Recognizing the significant roles of weather in human life, existing literature has discussed its influence on decision making in three streams (Govind et al., 2020). The first category focuses on the impact of weather on consumption behaviors (Govind et al., 2014; Bruno et al., 2017). For example, in lab experiments, Murray et al. (2010) find that consumers tend to have higher purchase intentions for tea in sunny weather conditions. Similarly, Li et al. (2017), drawing on field experiment data, suggest that sunny weather also contributes to subscription to video streaming. Additionally, in the brick-and-mortar retailing context, Badorf and Hoberg (2020) also find a significant relationship between weather and daily sales, further supporting the impact of weather on consumption behaviors.

The second stream of literature pays attention to non-consumption behavior, such as recommendation behavior (Bakhshi et al., 2014), consumer satisfaction (Mittal et al., 2004), and productivity (Bellet et al., 2023). For example, Bujisic et al. (2019) explore the relationship between weather conditions and word of mouth and find that consumers are more likely to leave negative comments in unpleasant weather conditions.

The last stream of literature investigates the role of weather in financial behaviors (Hirshleifer and Shumway, 2003; Goetzmann and Zhu, 2005). Studies have shown that weather can influence the financial decisions of individuals. For instance, Bruyneel et al. (2005) suggest that consumers tend to buy more lottery tickets on sunny days. Moreover, weather exerts an impact on institutional investor trading behavior. For example, Goetzmann et al. (2015) use stock market data and find that cloudy days can increase perceived overpricing and further influence the Dow Jones Industrial Index.

2.4. Impact of sunny weather on online shopping cart abandonment

As an important environmental factor, the effect of weather on people's moods is well documented (Huibers et al., 2010; Flynn and Schaumberg, 2012; Shafi and Mohammadi, 2020). Specifically, the extant literature has found that sunny weather positively correlates with one's mood (Persinger and Levesque, 1983; Murray et al., 2010; Bellet et al., 2023). For example, Brandes and Dover (2022) prove that, compared to bad weather, sunny weather can induce more positive moods in consumers. Furthermore, in addition to studies reporting the impact of actual weather on positive affect, research has also shown that artificially simulated sunny weather can improve mood (Leppämäki et al., 2004). Therefore, the literature suggests that both real and simulated sunny weather can contribute to a positive mood.

Perceived risk refers to an individual's subjective assessment of the potential risks associated with purchasing a product (Dowling and Staelin, 1994). According to the affect-as-information model, individuals often rely on their mood as a source of information when making evaluations during online shopping (Schwarz and Clore, 1983; Govind et al., 2020; Shlefer and Kogut, 2021). Consequently, they may mistakenly attribute their positive mood to their perception of risk (Fedorikhin and Cole, 2004; van der Linden, 2014). Several studies have examined the influence of mood on perceived risk (Fedorikhin and Cole, 2004; Sar and Anghelcev, 2013). For instance, Campos-Vazquez and Cuilty (2014) demonstrate that people in a negative mood exhibit higher levels of perceived risk. In conclusion, previous research suggests that mood significantly influences consumers' perceived risk.

According to affect-as-information theory, the higher level of perceived risk induced by mood can further influence decision-making processes and judgments (Schwarz and Clore, 1983; Egeln and Joseph,

Table 1
Summary of online shopping cart abandonment studies.

Study	Independent Variables		Mediators	Research Methodology		
	Weather	Brand reputation		Field data	Experiment	Method of analysis
Kukar-Kinney and Close (2010)	X	X	Entertainment use of e-cart, organizational use of e-cart, waiting for a lower price	X	X	LVSEM
Rajamma et al. (2009)	X	X	X	X	X	Logistic regression
Moore and Mathews (2006)	X	✓	X	X	X	Qualitative approach
Xu and Huang (2015)	X	X	Organization and research of products within the cart	X	X	SEM
Egeln and Joseph (2012)	X	X	X	X	X	Correlation analysis
Floh and Madlberger (2013)	X	X	Impulsiveness, browsing, impulse-buying behavior	X	X	CBSEM
El Haddad et al. (2018)	X	X	Privacy concerns	X	X	SEM
Khan et al. (2022)	X	X	X	X	X	fs/QCA
This study	✓	✓	Positive mood, perceived risk	✓	✓	Logistic regression, ANOVA

2012). Regarding the relationship between perceived risk and shopping cart abandonment, the literature has shown that perceived risk positively correlates with cart abandonment (Moore and Mathews, 2006; Rajamma et al., 2009). For instance, Rodrigues et al. (2022) show that risks related to transactions and the object of consumption positively impact online shopping cart abandonment behaviors.

Therefore, drawing on affect-as-information theory, we hypothesize that the positive mood induced by sunny weather will result in a decrease in perceived risk, consequently reducing shopping cart abandonment behavior. In the context of online retailing, consumers are frequently confronted with an abundance of information and risk factors, and their emotional state plays an important role in shaping their perception and response to these risks. This dynamic differs significantly from offline scenarios, where consumers can mitigate risk through direct product experiences and observations. In the online realm, the mood induced by weather conditions becomes a critical determinant influencing how consumers perceive and react to these risks. As a result, we propose a serial mediation effect in which mood and perceived risk act as mediators in the relationship with shopping cart behavior. In other words, we suggest that the positive mood induced by sunny weather will lead to decreased perceived risk, reducing shopping cart abandonment behavior. Overall, we hypothesize the following.

H1. Compared to consumers experiencing other weather conditions, consumers experiencing sunny days will exhibit fewer cart abandonment behaviors.

H2. The negative effect of sunny weather on shopping cart abandonment behaviors is serially mediated by mood and perceived risk.

2.5. Moderating effect of brand reputation

In the realm of online shopping, consumers often rapidly form judgments based on product categories and extend their favorable perceptions of a brand to its products (Goldberg and Hartwick, 1990; Johnson et al., 2019). As an influential external information source, brand reputation shapes consumer responses and future purchasing behavior (Mu and Zhang, 2021). Prior research has shown that brand reputation serves as a high-scope cue that significantly guides consumer decision-making and evaluations (Purohit and Srivastava, 2001; Narwal and Nayak, 2020). For example, Akdeniz et al. (2013) found that brand reputation affects consumers' perceptions of quality more profoundly than other types of marketing messages.

Drawing upon the affect-as-information theory, we have hypothesized that the influence of weather conditions on online shopping cart abandonment is contingent upon mood and perceived risk in earlier subsections. Nonetheless, a strong brand reputation may override these factors, leading consumers to base their decisions primarily on the brand's reputation, irrespective of weather conditions. Prior research has found that when consumers encounter products from highly reputed brands, they are more inclined to perceive these products as high-quality with lower associated risks (Moore and Mathews, 2006). In line with this research, it is reasonable to expect that.

Similarly, in scenarios where consumers perceive a certain level of risk, the influence of sunny weather on the likelihood of abandoning shopping carts is diminished. Therefore, we propose the following hypothesis:

When consumers have a certain level of perceived risk, the impact of sunny weather on shopping cart abandonment is weakened. Thus, we posit.

H3. Brand reputation weakens the negative effect of sunny weather on shopping cart abandonment.

3. Research design

To provide a comprehensive understanding of the impact of weather on online shopping cart abandonment, this paper employed a mixed-methods design, combining an empirical study (Section 4) and a lab experiment (Section 5). The empirical study uses a secondary dataset collected from an online retailing platform, employing econometric analysis to provide real-world evidence of the impact of weather on shopping cart abandonment. The lab experiment, conducted on the platform of Credamo, serves to delve deeper into the underlying mechanisms of weather impact, offering causal evidence within a controlled experimental setting. By combining these different but complementary methodologies, our mixed-method design facilitates a comprehensive exploration of the research question, ensuring a robust and in-depth examination of the impact of weather on online shopping cart abandonment.

4. Empirical study: effect of sunny weather on shopping cart abandonment

4.1. Data collection

We collected shopping cart abandonment data from an online shopping platform belonging to one of the largest telecommunications companies in Asia. Mobile phones are the main products this platform sells, through which consumers can place orders and make payments. To reduce the possible confounding effects caused by the factors of geographical locations and individual differences, we selected all the orders placed by consumers from four cities in Hubei Province, China, because consumers there are geographically close to each other and tend to have similar living habits. To further reduce the impacts of other potential confounding factors, we also collected the users' demographic data, geographical location, order placement time, and the unit price of the purchased item. The duration of the data collected ranged from July to December.

Additionally, to obtain brand reputation data, we invited three experts from the mobile industry to rate the 32 mobile phone brands included in the dataset collected from the shopping platform using a 7-point scale (1 is the lowest rating and 7 is the highest) and then calculated the average rating of each brand. The average rating of all 32 brands was 5.2. Using this value as a threshold, we considered the brands with an average rating above 5.2 to be brands with good reputations. Accordingly, we established another dummy variable called *Brand reputation*$_i$.

We collected data from meteomanz.com, a website that provides meteorological data observed from worldwide locations to establish our weather dataset. Based on the geographical location and the time of order placement, we merged the filtered dataset provided by the online platform and the weather dataset across four cities at hourly intervals. We divided all weather conditions into two groups, i.e., sunny weather conditions and other weather conditions. Fig. 1a and b presents the frequency of each type of daily weather condition. As shown in Fig. 1a

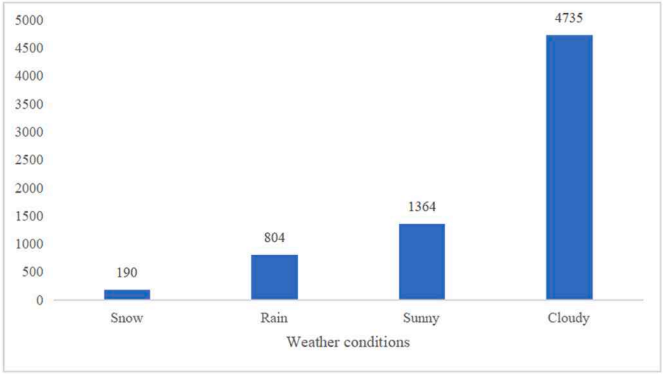

Fig. 1a. Distribution of weather conditions.

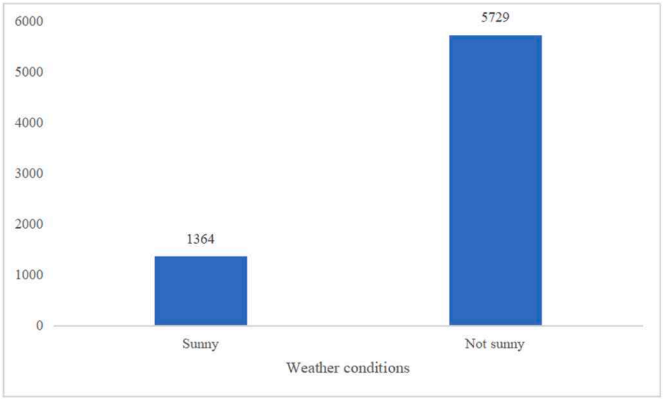

Fig. 1b. Distribution of sunny weather.

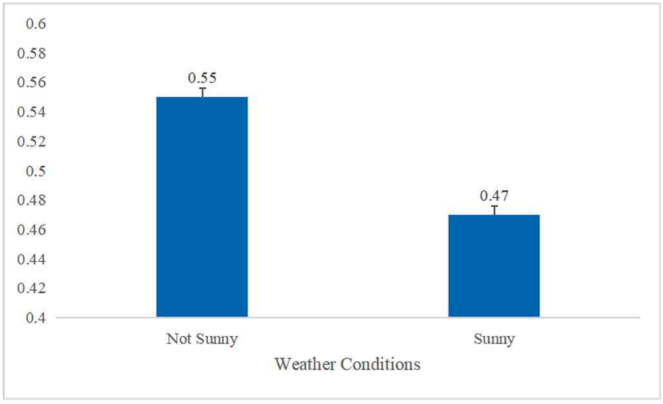

Fig. 2a. Cart abandonment rate in different weather conditions.

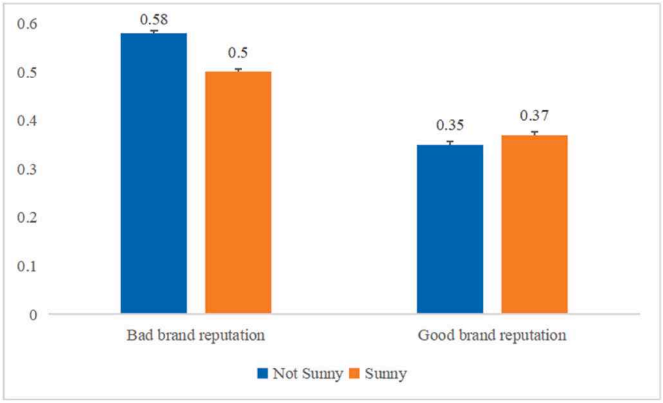

Fig. 2b. Interaction effect of sunny weather and brand reputation.

and b, sunny weather accounts for 19.23% of all weather conditions, which is consistent with the local climate.

4.2. Variables and measurement

4.2.1. Dependent variable

Cart abandonment is employed as the dependent variable. The *cart abandonment* variable equals 1 if the consumer abandoned the shopping cart and 0 if the consumer made the purchase.

4.2.2. Independent variable and moderator

Regarding the independent variables, the first variable of interest is the weather condition. We construct a dummy variable, $Sunny_i$, which equals 1 if the weather condition is sunny and 0 otherwise. *Brand Reputation*$_i$ is a dummy variable indicating the reputation of the brand selected by consumer *i*, which is equal to 1 if the brand has a good reputation and 0 otherwise.

4.2.3. Control variables

Following existing studies (Li et al., 2017; Badorf and Hoberg, 2020), we controlled for weather-related variables, including *temperature*$_i$, *temperature range*$_i$, and *relative humidity*$_i$. In addition, we controlled for product-related variables, including *price*$_i$, *ranking*$_i$, and *origin*$_i$. To minimize the impact of individual-level influences, we also controlled for demographic variables, including *gender*$_i$, *age*$_i$, and *experience*$_i$, which suggests whether the consumer had purchase experience on the platform. Table 2 reports the summary statistics of the main variables.

4.3. Empirical analysis

4.3.1. Model-free analysis

Fig. 2a and b depict model-free evidence for the effect of sunny weather on online shopping cart abandonment. As shown in Fig. 2a, the online shopping cart abandonment rate in sunny weather conditions is significantly lower than in other weather conditions ($p < 0.05$). In addition, Fig. 2b provides initial evidence of the interaction effect of sunny weather and the level of brand reputation. Specifically, in the condition of a bad brand reputation, the online shopping cart abandonment rate in sunny weather conditions is still lower than in other weather conditions. In contrast, in sunny weather conditions, there is a higher rate of online shopping cart abandonment than in other weather conditions when the selected product has a good brand reputation. These analyses provide preliminary results in our hypothesis testing.

Table 2
Summary statistics of variables.

	Obs.	Mean	Std	Min	Max
Cart abandonment	7093	0.532	0.499	0	1
Sunny	7093	0.192	0.394	0	1
Brand reputation	7093	0.147	0.355	0	1
Temperature	7093	14.828	11.90	−5.5	37.1
Temperature range	7093	1.543	1.934	−5.301	4.2
Relative humidity	7093	0.807	0.159	0.26	1
Price	7093	4055.7	2275	599	11,431
Ranking	7093	5.16	5.19	1	15
Origin	7093	2.177	0.922	1	3
Experience	7093	0.350	0.477	0	1
Gender	7093	−1.667	0.471	−2	−1
Age	7093	28.420	7.133	9	87

4.3.2. Main results

Our econometric model starts from a basic logit regression. The model estimates the consumer's likelihood of abandoning the cart. The regression model is as follows:

$$\boldsymbol{Cart\ Abandonment\ Likelihood}_i^{\boldsymbol{weather}} = \exp(\boldsymbol{Ui}^{\text{weather}})/1 + \exp(\boldsymbol{Ui}^{\text{weather}})$$

$$\boldsymbol{Ui}^{\text{weather}} = \alpha_0 + \alpha_1 \boldsymbol{Sunny}_i + \alpha_2 \boldsymbol{Brand\ reputation}_i + \Delta \boldsymbol{ControlVars} + \mu\Omega_i + \rho \boldsymbol{X}_i + \varepsilon_i \quad (1)$$

In the above equation, i represents the consumer. $Sunny_i$ denotes that consumer i is in sunny weather conditions. *Brand Reputation* indicates the reputation of the brand selected by consumer *i*. *ΔControlVars* represents the vector of all control variables. *Ωi* represents a vector of geographical control dummies, which helps us control location-based effects. Because consumers' behavior may vary during the observational period, we use X_i to represent the number of days to help control for day trends.

We then test the hypotheses with the logit model. As Table 3 shows, sunny weather consistently has a negative and significant effect on cart

Table 3
Sunny weather decreases the proportion of cart abandonment.

	(1)	(2)	(3)
Sunny	−0.3053***	−0.1550*	−0.1987**
	(0.060)	(0.067)	(0.070)
Temperature		−0.0408***	−0.0449***
		(0.011)	(0.011)
Relative humidity		−0.9171***	−0.9282***
		(0.212)	(0.220)
Temperature range		−0.0359*	−0.0366*
		(0.016)	(0.017)
Price		0.0001***	0.0001***
		(0.000)	(0.000)
Ranking		0.0145	0.0102
		(0.008)	(0.009)
Brand reputation		−0.5286***	−0.5414***
		(0.074)	(0.076)
Origin		0.0952	0.1002
		(0.050)	(0.053)
Experience			1.2930***
			(0.059)
Gender			0.1438**
			(0.055)
Age			−0.0191***
			(0.004)
Wind direction	No	Yes	Yes
Location-fixed effect	No	Yes	Yes
Days	No	Yes	Yes
N	7093	7093	7093
AIC	9780.599	9304.387	8749.243
BIC	9794.332	9400.523	8865.98

Standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

abandonment across all models. In other words, when the weather conditions are sunny, people are less likely to abandon their carts. Thus, H1 is supported.

We then use the logit model to test the interaction effect of sunny weather and brand reputation. As shown below, we add $\boldsymbol{Sunny_i}$*$\boldsymbol{Brand\ reputation_i}$ as an interaction term in model (1) and obtain model (2).

$$Ui^{weather=}\alpha_0 + \alpha_1 \boldsymbol{Sunny_i} + \alpha_2 \boldsymbol{Brand\ reputation_i} + \alpha_3 \boldsymbol{Sunny_i}*\boldsymbol{Brand\ reputation_i} + \Delta \boldsymbol{ControlVars} + \mu\Omega_i + \rho \boldsymbol{X_i} + \varepsilon_i \quad (2)$$

The estimation results are shown in Table 4. The positive coefficient of the interaction term between sunny weather and brand reputation suggests that good brand reputation weakens the negative effect of sunny weather on shopping cart abandonment, while the main effect of sunny weather on shopping cart abandonment is still significantly negative. In other words, sunny weather has less influence on shopping cart abandonment behavior when the brand reputation is good, thus H3 is supported.

4.4. Robustness tests

To further verify our results regarding the effects of sunny weather on online shopping cart abandonment, we conducted a series of robustness checks to rule out the influences of possible confounding factors.

4.4.1. Difference between day and night

To validate the influence of sunny weather on online shopping cart abandonment, we partitioned our dataset into two subsets based on the time consumers placed their orders: the daytime subsample (from 6 a.m. to 5 p.m.) and the nighttime subsample (remaining hours). The daytime group comprised 4968 samples, while the nighttime group included 2125 samples. We applied previously established logit models to independently assess the impact of sunny weather during both day and night.

As summarized in Table 5, our findings indicate a statistically significant negative effect of sunny weather on online shopping cart

Table 4
Interaction effect of sunny weather and brand reputation.

	(1)	(2)	(3)
Sunny	−0.3370***	−0.2082**	−0.2576***
	(0.067)	(0.072)	(0.076)
Brand reputation	−0.9156***	−0.6053***	−0.6239***
	(0.080)	(0.084)	(0.087)
Brand reputation*Sunny	0.3882*	0.3333*	0.3607*
	(0.165)	(0.170)	(0.176)
Temperature		−0.0411***	−0.0453***
		(0.011)	(0.011)
Relative humidity		−0.9053***	−0.9144***
		(0.212)	(0.220)
Temperature range		−0.0360*	−0.0368*
		(0.016)	(0.017)
Price		0.0001***	0.0001***
		(0.000)	(0.000)
Ranking		0.0148	0.0105
		(0.008)	(0.009)
Origin		0.0949	0.0996
		(0.050)	(0.053)
Experience			1.2936***
			(0.059)
Gender			0.1447**
			(0.055)
Age			−0.0191***
			(0.004)
Wind direction	No	Yes	Yes
Location-fixed effect	No	Yes	Yes
Days	No	Yes	Yes
N	7093	7093	7093
AIC	9632.121	9302.57	8747.076
BIC	9659.588	9405.572	8870.679

Standard errors in parentheses.
[a] $p < 0.1$,*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 5
Results of day data and night data.

	Day	Day	Night	Night
Sunny	−0.4902***	−0.3113***	0.0334	0.0265
	(0.079)	(0.091)	(0.126)	(0.149)
Brand reputation	−0.9968***	−0.6125***	−0.7337***	−0.5733***
	(0.096)	(0.106)	(0.142)	(0.153)
Brand reputation* Sunny	0.4674*	0.4255*	0.2227	0.1631
	(0.194)	(0.208)	(0.311)	(0.333)
Temperature		−0.0631***		0.0097
		(0.014)		(0.022)
Relative humidity		−1.0533***		−0.9287*
		(0.270)		(0.435)
Temperature range		−0.0282		−0.0358
		(0.022)		(0.029)
Experience		1.2019***		1.5403***
		(0.069)		(0.116)
Gender		0.1404*		0.1661
		(0.066)		(0.102)
Age		−0.0191***		−0.0190**
		(0.004)		(0.007)
Price		0.0001***		0.0001
		(0.000)		(0.000)
Ranking		0.0198		−0.0220
		(0.010)		(0.017)
Origin		0.1278*		0.0296
		(0.063)		(0.098)
Wind direction	No	Yes	No	YES
Location-fixed effect	No	Yes	No	Yes
Days	No	Yes	No	Yes
Constant	0.3982***	6.9487***	0.1358**	1.1577
	(0.035)	(1.124)	(0.052)	(1.706)
N	4968	4968	2125	2125
AIC	6696.085	6061.875	2921.677	2683.7
BIC	6722.128	6179.068	2944.324	2785.607

Standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

abandonment during the daytime. In contrast, this effect was statistically insignificant during the nighttime. Furthermore, we examined the interaction effect of sunny weather and brand reputation, revealing a positive interaction during the daytime but no significant interaction during the nighttime. These empirical results provide robust evidence supporting the hypothesis that sunny weather influences online shopping cart abandonment.

4.4.2. Effect of clouds

To further validate the impact of sunny weather on online shopping cart abandonment, we use the density of clouds, which is the opposite variable of sunlight, for a robustness check. As a higher density of clouds implies lower sunlight intensity, we expect the density of clouds to have a positive effect on online shopping cart abandonment. That is, the higher the clouds' density, the greater the possibility of online shopping cart abandonment. We replace the variable *Sunny* with *Clouds* in the established logit model and obtain the estimation results.

As shown in Table 6, *Clouds* has a significant positive effect on online shopping cart abandonment. This suggests that a lower level of cloud density (higher level of sunlight) leads to a lower probability of online shopping cart abandonment. Therefore, the robustness check with cloud density confirms that sunny weather has a significant influence on online shopping cart abandonment.

4.4.3. Incorporating weather-change variables

To verify that the reduced online shopping cart abandonment is due to sunny weather rather than the effects of weather change, we introduced two variables, *Better_than_yesterday* and *Worse_than_yesterday*, into our original model as part of a robustness analysis. We code *Better_than_yesterday* as 1 if the weather is better than yesterday and 0 otherwise. We coded *Worse_than_yesterday* in a similar way.

The results of this robustness analysis, as depicted in Table 7, illuminate a significantly negative effect of sunny weather with varying covariates. Specifically, the presence of sunny weather consistently exerts a negative impact on online shopping cart abandonment. This empirical consistency reinforces the findings of our main analysis and reaffirms the important role of sunny weather conditions in mitigating online shopping cart abandonment.

Table 6
Regression results when using Clouds to replace Sunny.

	(1)	(2)	(3)
Clouds	0.0230**	0.0240**	0.0274**
	(0.008)	(0.009)	(0.009)
Brand reputation	−0.8363***	−0.5263***	−0.5392***
	(0.070)	(0.073)	(0.076)
Temperature		−0.0419***	−0.0454***
		(0.011)	(0.011)
Relative humidity		−1.0067***	−1.0156***
		(0.218)	(0.227)
Temperature range		−0.0373*	−0.0383*
		(0.016)	(0.017)
Experience			1.2911***
			(0.059)
Gender			0.1439**
			(0.055)
Age			−0.0192***
			(0.004)
Price		0.0001***	0.0001***
		(0.000)	(0.000)
Ranking		0.0148	0.0105
		(0.008)	(0.009)
Origin		0.0953	0.1006
		(0.050)	(0.053)
Wind direction	No	Yes	Yes
Location-fixed effect	No	Yes	Yes
Days	No	Yes	Yes
Constant	0.1267*	5.2065***	5.4240***
	(0.050)	(0.878)	(0.923)
N	7093	7093	7093
AIC	9646.951	9301.992	8748.036
BIC	9667.551	9398.128	8864.773

Standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 7
Regression results considering the impact of weather change.

	(1)	(2)	(3)
Sunny	−0.3375***	−0.2000**	−0.2531**
	(0.071)	(0.077)	(0.080)
Brand reputation	−0.9124***	−0.6061***	−0.6243***
	(0.080)	(0.084)	(0.087)
Brand reputation* Sunny	0.3757*	0.3300[a]	0.3591*
	(0.165)	(0.170)	(0.176)
Better_than_yesterday	−0.0958	−0.0309	−0.0130
	(0.079)	(0.079)	(0.082)
Worse_than_yesterday	−0.1899*	−0.0309	−0.0130
	(0.076)	(0.079)	(0.082)
Temperature		−0.0409***	−0.0452***
		(0.011)	(0.011)
Relative humidity		−0.8959***	−0.9098***
		(0.212)	(0.221)
Temperature range		−0.0358*	−0.0367*
		(0.016)	(0.017)
Experience			1.2933***
			(0.059)
Gender			0.1452**
			(0.055)
Age			−0.0191***
			(0.004)
Price		0.0001***	0.0001***
		(0.000)	(0.000)
Ranking		0.0149	0.0106
		(0.008)	(0.009)
Origin		0.0946	0.0994
		(0.050)	(0.053)
Wind direction	No	Yes	Yes
Location-fixed effect	No	Yes	Yes
Days	No	Yes	Yes
Constant	0.3509***	5.1996***	5.4906***
	(0.032)	(0.884)	(0.929)
N	7093	7093	7093
AIC	9628.922	9306.146	8750.988
BIC	9670.123	9422.883	8888.325

Standard errors in parentheses.
[a]$p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

4.4.4. Alternative brand reputation measure

In the main analysis, *Brand reputation* was measured by employees from the mobile industry. To enhance the robustness of our findings, we explored a different measuring approach using product-related data. Under this alternative measurement, *Brand reputation* was coded as 1 if the product's brand ranked within the top 5 on the platform; otherwise, it was coded as 0.

Our analysis, as presented in Table 8, continues to confirm the negative effect of sunny weather on online shopping cart abandonment. Importantly, even when employing this new measurement approach, the interaction effect of sunny weather and brand reputation remains positive, reinforcing H3 that brand reputation weakens the negative effect of sunny weather on shopping cart abandonment.

5. Lab experiment: serial mediation of mood and perceived risk

While the empirical findings in Section 4 have shed light on the observable effects, the intricate mechanisms underlying the impact of weather conditions on online shopping cart abandonment remain undisclosed. A subsequent lab experiment is conducted to address this gap and enhance our understanding. Specifically, we test the hypothesis that consumers are less likely to abandon shopping carts in sunny weather conditions. In addition, we hypothesized that positive mood and perceived risk should explain this difference. Thus, we predicted a

Table 8
Regression results when using alternative measures of brand reputation.

	(1)	(2)	(3)
Sunny	−0.5605***	−0.3194**	−0.3598***
	(0.097)	(0.103)	(0.107)
New brand reputation*Sunny	0.4306***	0.2747*	0.2707*
	(0.125)	(0.129)	(0.135)
New brand reputation	0.2166***	−0.1986*	−0.1618
	(0.054)	(0.091)	(0.095)
Temperature		−0.0385***	−0.0429***
		(0.011)	(0.011)
Relative humidity		−0.9629***	−0.9812***
		(0.211)	(0.219)
Temperature range		−0.0296	−0.0300
		(0.016)	(0.017)
Price		0.0001***	0.0001***
		(0.000)	(0.000)
Origin		0.0885	0.1020*
		(0.046)	(0.048)
Experience			1.2859***
			(0.059)
Gender			0.1525**
			(0.055)
Age			−0.0196***
			(0.004)
Wind direction	No	Yes	Yes
Location-fixed effect	No	Yes	Yes
Days	No	Yes	Yes
Constant	0.0602	5.3149***	5.5448***
	(0.042)	(0.874)	(0.917)
N	7093	7093	7093
AIC	9646.951	9301.992	8748.036
BIC	9667.551	9398.128	8864.773

Standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

specific serial mediation model in which sunny weather should lead participants to induce a positive mood. In turn, a positive mood should lead to lower perceived risk and ultimately lower shopping cart abandonment intentions (i.e., sunny weather→positive mood→perceived risk→shopping cart abandonment).

5.1. Data collection

A power analysis was conducted using G*Power (Faul et al., 2007) to determine the required sample size for the study. Based on a medium effect size (Cohen's d = 0.50), a significance level (α) of 0.05 (two-tailed), and a desired statistical power of 80%, the analysis indicated that a total sample size of 102 participants was necessary.

We recruited 150 adults (63% female) on Credamo, which provides similar functions to Amazon's Mechanical Turk. All participants were paid for their participation and were randomly assigned to one of two conditions: sunny weather conditions and control conditions. In the sunny weather condition, participants viewed a picture of sunny weather and were asked to imagine themselves being present in that scene. Conversely, in the control condition, participants were shown a picture of the same location under cloudy weather and were instructed to imagine themselves being there.

After completing the imagery task, participants were asked to write down their moods. In addition, the PANAS scale (Watson et al., 1988) was used to assess their level of positive mood. To ensure their attention and engagement, a manipulation check item was included as part of this assessment. Subsequently, all participants were shown an online shopping page and were asked to imagine themselves browsing for athletic shoes. Then, they read short descriptions of a pair of white shoes and added this pair of shoes to their shopping cart.

Following an attention check, all participants answered questions that measured their perceptions of risk and shopping cart abandonment intention. Specifically, participants responded to a six-item scale adapted from Bhatnagar et al. (2000) and Huang et al. (2004) to assess their perceived risk (e.g., "To what extent do you agree that it is difficult to judge the quality when buying shoes online," 1 = not at all, 7 = strongly agree). Participants also evaluated their intention of shopping cart abandonment on a 7-point scale (1 = not at all likely, 7 = very likely). Finally, participants completed demographics. Table 9 shows the descriptive statistics of each group.

5.2. Results

Randomization check. A one-way MANOVA was performed, with weather condition (sunny weather condition vs. control condition) serving as the independent variable, and age, gender, and income as the dependent variables. The results indicated that the randomization was successful ($F(3, 146) = 0.668$, $p = 0.573$). Additionally, a univariable one-way ANOVA was conducted to examine the impact of the manipulation on each of the variables mentioned above. The results showed that the manipulation did not have a significant effect on any of the variables (F's $(1, 148) < 1.291$ and p's > 0.258).

Manipulation check. There was a significant difference between the sunny and control conditions in response to the manipulation question. Specifically, all participants in the sunny condition reported experiencing sunny weather, while all participants in the control condition reported experiencing cloudy weather.

Online shopping cart abandonment. We first examine the effect of sunny weather on online shopping cart abandonment. As depicted in Fig. 3, a planned contrast confirmed that participants expressed lower shopping cart abandonment intention in sunny weather conditions ($M_{sunny} = 3.31$, $SD = 1.37$ versus $M_{control} = 3.86$, $SD = 1.39$). A one-way ANOVA further revealed a significantly negative effect of sunny weather on online shopping cart abandonment intention ($F(1,148) = 5.81$, $p = 0.017$).

Mood. Furthermore, consistent with our theorizing, differences in weather also had an effect on mood. A one-way ANOVA revealed a significant effect of sunny weather on more positive mood ($F(1, 148) = 279.91$, $p < 0.001$). A planned contrast also confirmed that participants perceived higher levels of positive mood in the sunny condition than in the control condition ($M_{sunny} = 4.02$, $SD = 0.48$ versus $M_{control} = 2.06$, $SD = 0.89$).

Perceived risk. As predicted, regression results revealed a significant effect of positive mood on perceived risk ($F(1, 148) = 10.30$, $p = 0.002$) and a significant effect of perceived risk on shopping cart abandonment ($F(1, 148) = 15.48$, $p < 0.001$). However, the one-way ANOVA did not show a significant relationship between weather conditions and perceived risk ($M_{sunny} = 3.71$, $SD = 0.93$ versus $M_{control} = 3.92$, $SD = 0.89$).

Mediation. We then examined the specific pathway (sunny weather → positive mood → perceived risk → shopping cart abandonment) using a serial mediation model. A bootstrap analysis with 5000 samples (Preacher and Hayes, 2008) supported the hypothesized underlying process ($b = -0.328$, 95% CI = −0.61, −0.11). Sunny weather made consumers have a more positive mood ($b = 1.96$, $SE = 0.12$, $t = 16.73$, $p < 0.001$), which made them perceive lower levels of risk ($b = -0.36$, $SE = 0.10$, $t = -3.57$, $p < 0.001$), which increased online shopping cart

Table 9
Descriptive statistics of each group.

Group	Sunny Condition	Control condition
Sample size	74	76
Age	5	5
Income	4	4
Online shopping cart abandonment	3.31 (1.37)	3.86 (1.39)
Positive mood	4.02 (0.48)	2.06 (0.89)
Perceived risk	3.71 (0.93)	3.92 (0.89)

Standard errors in parentheses; for categorical variables, only the mode is provided.

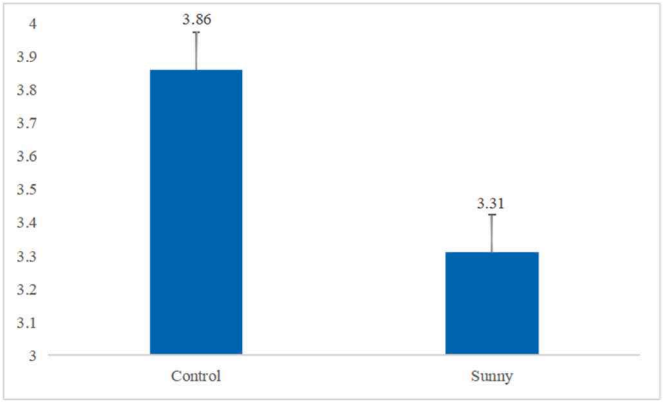

Fig. 3. Effects of sunny weather on online shopping cart abandonment.

abandonment (b = 0.47, SE = 0.12, t = 3.72, p < 0.001). Additionally, including these mediators led the direct effect to be reduced to non-significance (b = −0.63, 95% CI = −1.37, 0.11), indicating full mediation. The path model with estimated coefficients is displayed in Fig. 4. Furthermore, we carried out additional analyses that indicated that the "reverse" model (sunny weather→perceived risk→positive mood→-shopping cart abandonment) was nonsignificant (b = 0.003, 95% CI = −0.009, 0.0197), suggesting that the predicted serial mediation model best explained our data.

These results provided direct causal evidence that sunny weather decreases online shopping cart abandonment behaviors and underscored the hypothesized process behind the effect. First, consistent with the former study, consumers in sunny weather were less likely to abandon online shopping carts, which supported H1. Second, consistent with our theorizing, serial mediation demonstrated that these effects were driven by positive mood and perceived risk. Specifically, exposure to sunny weather led to an increase in positive mood, resulting in lower levels of perceived risk. Consequently, this decrease in perceived risk played a role in reducing online shopping cart abandonment behaviors. H2 was thus supported.

6. Discussion and implications

The significance of weather conditions in the retailing industry has been increasingly recognized, prompting retailers to leverage weather information for improved marketing operations. However, few empirical studies have investigated the influence of weather on consumer behaviors, particularly in the context of online shopping cart abandonment.

Based on a mixed-method study using secondary data analysis and a lab experiment, this article aims to examine the impacts of weather conditions on consumers' online shopping cart abandonment behavior and the underlying psychological mechanism that causes this relationship. Specifically, we find that sunny weather has a negative effect on consumers' online shopping cart abandonment behavior (H1), and a better brand reputation will weaken this negative effect (H3). Our conclusions still hold in follow-up robustness checks, which test the difference between day and night, the effects of clouds, the effects of weather change, and alternative measurements of brand reputation.

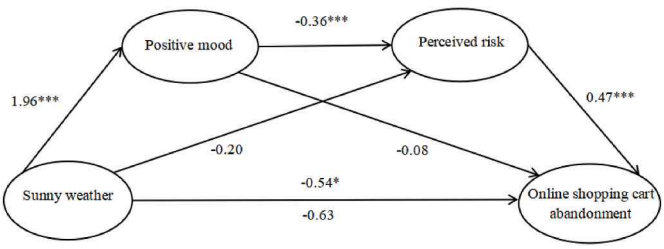

Fig. 4. Effects of sunny weather on online shopping cart abandonment: Mediating role of positive mood and perceived risk.

Moreover, according to the lab experiment results, this study demonstrates that mood and perceived risks work as the underlying mechanisms between weather conditions and online shopping cart abandonment (H2). When exposed to sunny weather, consumers tend to have a more positive mood, which can decrease their perception of risk, subsequently reducing online shopping cart abandonment behaviors.

6.1. Theoretical implications

This study makes three significant contributions to the existing literature. Firstly, it fills a gap in the literature on online shopping cart abandonment by identifying weather as a crucial environmental factor that influences consumers' decision-making processes during online shopping. While previous research has primarily focused on platforms and social support systems as environmental factors (El Haddad et al., 2018), the impact of weather, a critical antecedent, has been overlooked. By being the first to investigate the influence of weather on online shopping cart abandonment, this study reveals that sunny weather significantly reduces cart abandonment rates, providing a crucial dimension to our understanding of environmental influences in the online shopping context.

Secondly, our study offers a nuanced perspective on the role of weather on consumer behaviors by introducing brand reputation as a moderating factor. Although a few prior studies have acknowledged brand reputation as a determinant of online shopping cart abandonment behavior (Moore and Mathews, 2006), our knowledge of how brand reputation shapes consumers' decision-making behaviors in this context remains limited. Through empirical evidence demonstrating the mixed effects of brand reputation and weather on online shopping cart abandonment, this study not only identifies the moderating influence of brand reputation but also enriches the existing theoretical framework for understanding online shopping cart abandonment. This nuanced understanding adds complexity and depth to our knowledge of the interplay between brand reputation, weather conditions, and online shopping cart abandonment.

Thirdly, this study contributes to the affect-as-information framework by elucidating the psychological mechanisms through which weather impacts shopping cart abandonment behaviors in the digital realm. While previous literature has recognized these mechanisms in explaining the effects of weather in physical settings (Persinger and Levesque, 1983), their role in the digital shopping sphere has remained unclear. Our research bridges this gap by providing empirical validation for the serial mediation of positive mood and perceived risk. This advances discussions on weather-related impacts and extends theoretical insights by grounding the understanding of sunny weather's psychological effects in the digital realm within the framework of the affect-as-information theory. In doing so, our study strengthens the theoretical foundations of weather-related influences on online consumer behavior and contributes to the broader discourse on the application of affective states in the digital shopping context, thus expanding the theoretical landscape of the affect-as-information theory.

6.2. Practical implications

This study also provides valuable implications for online retailers. First, firms may adopt different promotional strategies targeting consumers based on weather conditions. For instance, as the study reveals a higher shopping cart abandonment rate during unpleasant weather compared to sunny weather, online retailers could offer more discount promotions on bad weather days to offset the negative impact of weather. Conversely, they could charge higher prices on sunny days due to the enhanced positive mood of consumers.

Second, this study suggests that online sellers may adopt different

marketing strategies for brands with different levels of reputation. It would be beneficial if online retailers prepare weather-specific marketing strategies for brands with lower reputations. In particular, emphasizing product launches and promotions on sunny days could enhance the visibility and reception of products associated with less reputable brands. However, such strategies may not be necessary for products associated with reputable brands. Retailers could be more flexible in their approach to reputable brands and focus on other environmental factors, such as website design and security.

Thirdly, this paper provides evidence that weather variables influence consumers' shopping cart abandonment behavior by impacting mood and perceived risk. Accordingly, retailers should take proactive measures to address the impact of weather on consumer mood and perceived risk. For example, during unfavorable weather conditions, firms can offer more discounts or change the website design to incorporate brighter colors, which can induce a positive mood. Consequently, the positive mood induced by promotions and website design can counteract the negative effects of bad weather on mood and perceived risk.

6.3. Limitations and future research

The current study has certain limitations that provide opportunities for future research. First, due to data availability issues, this study uses second-hand data from an online platform that only sells mobile phones, potentially limiting the generalizability of the findings to sellers in different product categories. Future research could extend this study using diverse datasets from various industries to validate the robustness of the results. Second, considering that individual characteristics may influence the impact of weather on shopping cart abandonment, researchers can explore moderating factors such as personality traits and shopping motivations.

CRediT authorship contribution statement

Chenxi Li: Writing – review & editing, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jing (Elaine) Chen:** Writing – review & editing, Project administration, Conceptualization. **Siyu Peng:** Writing – review & editing, Methodology, Formal analysis. **Jinsong Huang:** Data curation, Funding acquisition, Project administration. **Xiqing Sha:** Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Chenxi Li reports financial support was provided by National Natural Science Foundation of China. Jinsong Huang reports financial support was provided by National Natural Science Foundation of China. Chenxi Li reports financial support was provided by Ministry of Education in China. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Chenxi Li and Jing (Elaine) Chen contributed equally to this manuscript.

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