Sleep Deprivation and Shopping Regret: An Empirical Study Based on Large-Scale Individual-Level Data

Authors: Shiyang Gong, Zhang Yibo, Gao Yue Tao, Gao Yuetao

Date: 2022-09-10T00:00:00+00:00

Abstract

Sleep deprivation is emerging as a prevalent issue confronting individuals; however, extant research has seldom connected sleep deprivation with consumer behavior. This study utilizes large-scale individual-level consumer data (N=1625472) from real-world shopping contexts to investigate the relationship between sleep deprivation and shopping regret through econometric modeling. The findings demonstrate that sleep deprivation significantly augments consumers' propensity for shopping regret, behaviorally manifested through increased product return probability and accelerated product return speed. Moreover, product price positively moderates the effect of sleep deprivation on shopping regret, while promotional discount proportion negatively moderates the effect of sleep deprivation on shopping regret.

Full Text

Preamble

This research was supported by the National Natural Science Foundation of China (71972040), Fujian Provincial Innovation Strategy Research Project (2020R0009), Fujian Provincial Social Science Planning Project (FJ2021B153), and the Fundamental Research Funds for the Central Universities (2072021064).

Corresponding author: GAO Yuetao, E-mail: ytgao@xmu.edu.cn

1 Introduction

Sleep deprivation, also commonly referred to as insufficient sleep, has become a widespread social phenomenon. According to sleep duration recommendations

from the National Sleep Foundation, approximately 35% of adults worldwide experience sleep deprivation (Hirshkowitz et al., 2015). The 2020 China Sleep Index Report indicates that over 300 million people in China currently suffer from sleep disorders, with young people facing particularly acute sleep-related issues. Extensive research has explored the consequences of sleep deprivation. In terms of physical health, sleep deprivation affects the immune system (Spiegel et al., 2002), metabolic function (Knutson et al., 2007), cognitive abilities (Durmer & Dinges, 2005), and emotional states (Borbély & Wirz−Justice, 1982). In daily behavioral performance, sleep deprivation leads to more workplace accidents (Barnes & Wagner, 2009; Yam et al., 2020) and unethical behavior in the workplace (Akerstedt et al., 2007; Barnes et al., 2011; Wagner et al., 2012).

Nevertheless, few studies have directly examined the impact of sleep deprivation on consumer decision-making behavior. According to surveys, approximately 27% of consumers frequently shop during sleep-deprived periods. To cater to this trend, numerous online shopping platforms often schedule major promotional events to begin at midnight (e.g., JD.com' s "618" and Taobao' s "Double 11" sales). However, people often advise, "Don' t make any decisions late at night, or you' ll regret it." Similar proverbs exist in Western cultures, such as "Nothing good happens after midnight." This suggests that people frequently associate late-night hours with regret. The question then arises: Are consumers more likely to experience shopping regret after making purchases during sleep-deprived late-night hours?

To address this question, this study employs large-scale individual-level data (N=1,625,472) provided by a major domestic retail website to conduct empirical research. Leveraging the platform' s recorded reasons for consumer returns, we measure shopping regret using two dimensions of real shopping behavior data: return choice and return speed. First, we systematically analyze the impact of sleep deprivation on consumer shopping regret (return choice and return speed) by establishing Logit binary choice models and Cox proportional hazard models. We then further explore moderating effects that may influence this relationship. Since price information and promotional information are the two most common and salient environmental cues consumers face during shopping decisions, we examine the moderating role of these two factors: product price and the proportion of promotional discounts relative to total purchase amount. Through empirical analysis of large-scale data from real online shopping contexts, this study effectively extends research on sleep deprivation in the domain of consumer decision-making behavior.

1.1 The Impact of Sleep Deprivation on Cognition and Decision-Making

Human cognition and decision-making are closely linked to the systems that regulate sleep and wakefulness. Research indicates that human sleep-wake cycles are regulated by multiple biological mechanisms, including circadian rhythms (Saper et al., 2005) and sleep-wake homeostasis (Benington, 2000). These bi-

ological mechanisms collectively control when people feel sleepy and need rest (Borbély, 1982). Sleep deprivation refers to an individual' s lack of sufficient sleep duration or quality to maintain normal physiological performance. The main causes of sleep deprivation fall into two categories. The first involves internal physiological factors, such as sleep apnea (Zammit & Zanca, 1998), melatonin secretion disorders (Shilo et al., 2000), and primary and secondary insomnia (Morphy et al., 2007). The second category primarily involves external interference factors, such as poor sleep habits (Hershner & Chervin, 2014) and environmental noise (Wesselius et al., 2018). In recent years, internet and smart device usage has gradually become an important factor affecting sleep (Lanaj et al., 2014). According to Hershner and Chervin (2014), 67% of respondents use smartphones before bedtime, with additional usage rates of 60% for computers, 43% for music devices, and 18% for video games. Internet-related device usage significantly increases the risk of sleep deprivation (Alshobaili & AlYousefi, 2019).

The earliest research on sleep deprivation and cognition dates back to the late 19th century, when Patrick and Gilbert (1896) demonstrated through pioneering experimental studies that sleep loss creates a special connection with individual metabolism and neural activity. Subsequent research has deeply explored the relationship between sleep deprivation and numerous cognitive domains, including attention, memory, information processing capacity, and reasoning ability (see reviews in Durmer & Dinges, 2005; Lim & Dinges, 2010; Qian et al., 2020). Extensive research shows that the cognitive decline caused by sleep deprivation increases various decision-making risks. For example, May and Kline (1987) studied military personnel after two nights of sleep deprivation and found that, even without additional physical fatigue, participants' performance on creative thinking and flexible decision-making tasks significantly deteriorated. Harrison and Horne (1999) discovered that subjects who experienced one night of sleep deprivation were more likely to fail in a marketing strategy simulation game. Organizational research has found that sleep deprivation increases employees' unethical behavior in the workplace the following day (Akerstedt et al., 2007; Wagner et al., 2012). Yam et al. (2020) found that sleep deprivation caused by Asian audiences watching late-night football matches increased traffic accident rates the following day. Kolla et al. (2021) demonstrated that in the week following the start of daylight saving time in the United States (which reduces sleep by one hour), sleep deprivation increased medical errors by 4.2% to 8.8%.

Although existing sleep deprivation research has covered medical, military, and organizational domains, few studies have directly examined its impact on consumer decision-making behavior (Huang et al., 2019). With the rapid development of online shopping, consumers increasingly shop during sleep-deprived periods. Against this background, this study explores the relationship between sleep deprivation and consumer shopping regret. Building on this foundation, we further consider the moderating effects of two shopping environmental cues (see research framework in Figure 1 [Figure 1: see original paper]).

1.2 The Impact of Sleep Deprivation on Shopping Regret

Regret is a negative emotional manifestation in cognition (Gilovich & Medvec, 1995). Regret can target past events (retrospective regret) or future possible events (anticipatory regret). Consumer post-purchase regret falls into the category of retrospective regret. Shopping regret is detrimental to businesses because consumers who experience it typically generate negative word-of-mouth (Tsiros & Mittal, 2000), reduce repurchase intentions (Zeelenberg & Pieters, 2004), or switch to alternative products (Zeelenberg & Pieters, 1999).

Regret plays a very important role in consumer decision-making (Venkatesan & Kumar, 2004). Averse to regret, consumers adjust their actions to maximize short-term and long-term benefits, thereby mitigating the impact of this negative emotion (Cases, 2002). When regret occurs, consumers recall mistakes made and opportunities lost, and desire a second chance to correct errors and restore the situation (Hetts et al., 2000). Therefore, one key consumer demand after experiencing regret is the desire to reverse the decision that triggered the regrettable outcome. In most consumption contexts, product returns represent a primary means of reversing the initial purchase decision to reduce shopping regret. By returning products to retailers to eliminate losses from the purchase decision, returns can alleviate consumers' shopping regret from purchasing unsatisfactory products (Dunne et al., 2013; Li et al., 2013).

Does sleep deprivation affect shopping regret? Related research indicates that the main causes of shopping regret include insufficient consideration during shopping (Lee & Cotte, 2009), inadequate information collection (Janis & Mann, 1977), and failure to follow original shopping plans (Pieters & Zeelenberg, 2005). In summary, these decision-making processes are closely related to the use of cognitive resources. According to Baumeister et al.' s (2000) "ego depletion" theory, human cognitive resources are limited. For most people, cognitive resources are typically highest upon waking in the morning and inevitably deplete gradually throughout the day as various tasks are performed, ultimately leading to decreased self-control and regulation abilities (Muraven & Baumeister, 2000). When individuals are in a state of cognitive resource depletion, they struggle to avoid impulsive or counterproductive behaviors that are detrimental to themselves (Marcus & Schuler, 2004; Dou et al., 2014).

Sleep has a crucial impact on cognitive resource recovery (Hursh et al., 2004). Ghumman and Barnes (2013) noted that cognitive resources are restored during sleep, thereby helping people enhance their ability to suppress biases. Barnes et al. (2011) found that reduced sleep duration causes cognitive fatigue, which increases unethical behavior. In a more direct experimental study, researchers asked a group of smokers to consume cognitive resources by controlling their urge to smoke. Compared to participants not required to quit, those required to quit performed significantly worse on subsequent tasks. However, when these participants slept, their task performance improved substantially (Parrott et al., 1996). In addition to behavioral evidence, neurological research also corrob-

orates sleep' s role in restoring cognitive resources. Related studies show that the prefrontal cortex is crucial for individual self-regulation functions (Kaplan & Berman, 2010). During sleep deprivation, the metabolic rate of the prefrontal cortex drops sharply, reducing its executive function capacity (Schnyer et al., 2009). Therefore, individuals experiencing sleep deprivation are more likely to make impulsive decisions because they lack sufficient rest to restore cognitive resources (Baumeister, 2010). In the context of this study, we speculate that when consumers shop during sleep-deprived periods, they are more likely to make impulsive or unplanned purchase decisions due to insufficient cognitive resources, thereby increasing the likelihood of experiencing shopping regret later. Based on this inference, we propose Hypothesis 1:

Hypothesis 1: Compared to other times of day, consumers are more likely to experience shopping regret after shopping during sleep-deprived periods.

1.3 Moderating Effects of Shopping Environmental Cues: Price and Promotion

Next, we explore the boundary conditions of the relationship between sleep deprivation and shopping regret. Since price information and promotional information are the two most common and salient environmental cues consumers face during shopping decisions, we primarily discuss the moderating role of these two factors. First is the price factor. Compared to low-priced products, high-priced products create higher perceived risk for consumers, thereby increasing involvement in the selection process (Bloch & Richins, 1983). Existing research indicates that high-priced products stimulate consumers to engage in more complex decision-making processes. For example, when selecting high-priced products, consumers invest more time and effort searching for external information, considering larger candidate product sets, and comparing features across different products or shopping platforms (Beatty & Smith, 1987; Celsi & Olson, 1988; Divine, 1995; Ratchford, 1982). These processes undoubtedly consume more cognitive resources during shopping. Therefore, when consumers happen to be in a sleep-deprived state with limited cognitive resources, they are more likely to make erroneous decisions leading to shopping regret. We thus speculate that product price may positively moderate the relationship between sleep deprivation and shopping regret. In summary, we propose Hypothesis 2:

Hypothesis 2: Product price positively moderates the relationship between sleep deprivation and shopping regret; that is, when consumers purchase higher-priced products, their tendency to experience shopping regret after shopping during sleep-deprived periods increases.

Second, we consider the influence of promotional cues. According to classic consumer decision-making theory, after making decisions, people have strong motivation to prove to themselves or others that their decisions were correct (Simonson, 1989). In daily life, consumers frequently consider providing "reasonable" justifications or explanations for their previous purchase decisions, which further

influences their subsequent attitudes and behaviors (Simonson & Nowlis, 2000). Since consumers shopping during sleep-deprived periods are more likely to regret their previous impulsive decisions, they have stronger motivation to provide a "reasonable" justification for their shopping decisions, thereby increasing their tendency to retain those decisions (Shafir et al., 1993). We speculate that if consumers obtain substantial promotional discounts during purchase, especially when the discount proportion relative to total payment is high, their regret tendency and return probability may decrease. One justification is economic: when promotional discounts are substantial, consumers perceive lower costs and thus consider the same product more cost-effective (Choi et al., 2014). Another justification is emotional: Schindler (1998) demonstrated that beyond economic factors, obtaining promotional discounts also increases consumers' sense of responsibility, thereby promoting positive emotional and behavioral consequences toward products.

In summary, we propose Hypothesis 3:

Hypothesis 3: Promotional discount proportion negatively moderates the relationship between sleep deprivation and shopping regret; that is, when consumers obtain higher promotional discount proportions during shopping, their tendency to experience shopping regret after shopping during sleep-deprived periods decreases.

2.1 Data Source and Description

Our research data comes from a major domestic e-commerce retail website. The dataset contains individual consumer-level behavioral data from June 1 to July 31, 2021, with a sample size of 1,625,472 records. The dataset primarily includes information related to consumer purchases, returns, promotional participation, and demographics.

Purchase data includes buyer information, purchase time (precise to the minute), and product ID for each order. Using minute-level purchase time information, we can distinguish orders generated during sleep-deprived versus non-sleep-deprived periods. Following Kanuri et al.' s (2018) classification standard, we categorize orders placed between 12:00 A.M. and 5:59 A.M. as sleep-deprived period shopping, while orders placed between 6:00 A.M. and 11:59 P.M. are classified as non-sleep-deprived period shopping. Figure 2 [Figure 2: see original paper] details consumer shopping frequency across different time periods. Panel (a) shows that consumer shopping volume during the sleep-deprived early morning period (12:00 A.M. to 5:59 A.M.) is significantly lower than during other periods. Panel (b) further reveals that shopping volume drops rapidly after 12:00 A.M. and only begins to rise after 6:00 A.M., gradually returning to a relatively stable state. This pattern suggests that most consumers sleep between 12:00 A.M. and 5:59 A.M., and those shopping during this period are more likely to experience sleep deprivation.

Thanks to the platform' s survey function during consumer returns, we can

measure shopping regret using real behavioral performance. When consumers click the return option on the website, a survey question automatically pops up: "Please select the reason for return (required)." Consumers must select a reason before submitting their formal return request. One option is "no longer want it," and when consumers select this option, the behavior generates a return data record representing shopping regret in our dataset. The dataset tracks whether consumers generate returns due to shopping regret within ten days after purchase. Using this information, we can depict consumers' regret patterns over time after shopping. As shown in Figure 3 [Figure 3: see original paper], return rates gradually decline over time. On the first day after purchase, the return rate is far higher than on subsequent days, reaching 3.47%. Subsequently, the return rate drops rapidly to 0.98% on the second day, then gradually decreases to 0.15% by the tenth day. This return pattern aligns with retrospective shopping regret behavior following impulse purchases (Li et al., 2013; Zeelenberg & Pieters, 2007).

Figure 4 [Figure 4: see original paper] further displays regret patterns for purchases made during sleep-deprived versus non-sleep-deprived periods. We can intuitively observe that if consumers shopped online during sleep-deprived periods, their return rate on the first day after purchase is significantly higher than for those who shopped during non-sleep-deprived periods (5.29% vs. 3.40%). As the time interval increases, the return rates triggered by the two groups gradually converge. This phenomenon preliminarily indicates that consumers who shop during sleep-deprived periods are more likely to quickly recognize their impulsive consumption behavior and subsequently experience shopping regret.

Additionally, we obtained data on consumers' participation in lottery-style promotional activities initiated by banks during the payment process. When consumers enter the payment page during shopping and choose to pay by bank card, they simultaneously participate in a "random discount up to 188 yuan" promotion. This promotion provides a random discount on consumers' original payment amount, ranging from 0.01 to 188 yuan. The specific discount amount is displayed to consumers after payment completion. Upon completion, the dataset generates a corresponding record containing the consumer' s payment time, payment amount, and discount amount.

2.2 Variable Description

Based on the raw data, we constructed variables for subsequent empirical analysis. Table 1 summarizes and describes the main variables.

(1) **Dependent variables**. This study uses consumer return behavior to measure shopping regret. We constructed two dependent variables related to return behavior. The first dependent variable is consumer return choice: whether the consumer chooses to return within ten days after purchase (binary variable; 1 = return, 0 = no return). The second dependent variable is consumer return speed: the number of days between return time and

purchase time for consumers who choose to return (continuous variable; 1, ···, 10 days).

(2) **Independent variable**. We use shopping time period to measure whether customers experienced sleep deprivation during shopping. Following Kanuri et al.' s (2018) research, if a consumer' s purchase time falls between 12:00 A.M. and 5:59 A.M., we consider them to have experienced sleep deprivation and assign the independent variable a value of 1; if purchase time falls between 6:00 A.M. and 11:59 P.M., we consider them not to have experienced sleep deprivation and assign the variable a value of 0. Thus, our independent variable is binary (1 = sleep deprivation; 0 = non-sleep deprivation).

(3) **Moderating variables**. To examine the moderating effects of shopping environmental cues, we constructed two related moderating variables. The first is product price. The second is promotional discount ratio: the ratio of discount amount obtained during bank card promotional activities to total payment amount.

(4) **Control variables**. We also constructed a series of control variables to account for other factors that might potentially affect results. First, discount amount directly affects the monetary cost consumers pay when shopping, which may influence regret levels. Second, when shopping websites are in major promotional periods (e.g., the "618" promotion season), consumers are more likely to engage in impulse buying, potentially increasing shopping regret tendencies. Therefore, we constructed a website promotion period control variable, assigned a value of 1 during major promotional periods and 0 otherwise. Finally, we constructed two consumer individual characteristic variables: customer gender (binary variable; 1 = male, 0 = female) and customer type (categorical variable; 1 = new user, 2 = regular user, 3 = old user).

Table 2 presents descriptive statistics for the main variables. Among all 1,625,472 shopping orders, 114,237 orders were returned due to shopping regret. Over half of return behaviors occurred on the first day after purchase (accounting for 51.06%), with an average return speed of 2.78 days after purchase. Sleep-deprived period shopping (12:00 A.M. to 5:59 A.M.) accounts for 9.1% of all orders, with remaining orders generated during other periods (6:00 A.M. to 11:59 P.M.). For moderating variables, the average product price is 275.346 yuan, and the average promotional discount ratio obtained from bank card promotions is approximately 2.2%. For control variables, the average discount amount from bank card promotions is 0.587 yuan; 28.4% of orders occurred during major website promotional periods; 62.5% of consumers are male; and regular users, new users, and old users account for 57.2%, 1.00%, and 41.9% respectively.

3.1 The Impact of Sleep Deprivation on Shopping Regret

The first part of the empirical analysis examines the relationship between sleep deprivation and shopping regret. We use two dependent variables to measure shopping regret: return choice and return speed. First, we analyze the impact of sleep deprivation on return choice. Since return choice is a binary dependent variable (1 = return, 0 = no return), we employ a Logit regression model to estimate customers' return probability as follows:

$$P(y_i = 1) = \frac{\exp(U_i)}{1 + \exp(U_i)}$$

$$U_i = \alpha_0 + \alpha_1 x_i + Z_i \varphi + \varepsilon_i, \quad (1)$$

In Model (1), the dependent variable y_i represents customer return choice, taking a value of 1 when the customer chooses to return and 0 when they do not. The independent variable x_i represents sleep deprivation, taking a value of 1 when purchase time falls in the sleep-deprived period (12:00 A.M. to 5:59 A.M.) and 0 when purchase falls in the non-sleep-deprived period (6:00 A.M. to 11:59 P.M.). Z_i is a vector containing a series of control variables: product price (in thousand yuan), promotional discount ratio, discount amount (in yuan), website promotion period, customer gender, customer type, and time effects (Monday through Sunday).

Table 3 presents the Logit regression results. Panel A shows results for the full sample, while Panel B shows results after removing samples from the platform' s June 18 promotional event. Since the shopping platform may have initiated many promotional activities at midnight during the June 18 promotion period, potentially creating within-sample bias for the sleep deprivation effect, we employ two methods to control for this influence. In Panel A, we use the full sample and include a control variable representing website promotion period; in Panel B, we remove June 18 samples from the full sample. We also attempted removing samples from three and five days before and after June 18. All regression results indicate that the sleep deprivation coefficient is positive and significant.

Table 3 reports marginal effects at sample means. We find that the independent variable sleep deprivation has a positive and significant coefficient estimate (b = 0.0136, p < 0.001, 95% CI = [0.0122, 0.0150]), indicating that when customers shop during sleep-deprived periods (12:00 A.M. to 5:59 A.M.), they have a higher probability of choosing to return. According to the regression results, sleep deprivation' s marginal contribution to return rate at sample means is approximately 1.36%. To more intuitively illustrate the effect size, we can compare the coefficients of sleep deprivation and discount amount (yuan) (0.0136 vs. -0.0006), which means offsetting the impact of sleep deprivation on returns is equivalent to increasing promotional discount by approximately 23 yuan (0.0136 / -0.00061 -23 yuan). Based on descriptive statistics (Table 2), the average

promotional discount amount businesses actually provide is only 0.587 yuan, making a 23-yuan increase nearly impossible for businesses to bear as a promotional cost. This demonstrates that the impact of sleep deprivation on customer return choice is non-negligible.

Other control variable results also align with expectations: higher product prices lead to higher return rates (b = 0.0087, p < 0.001); larger discount amounts lead to lower return rates (b = -0.0006, p = 0.006); return rates increase during website promotional periods (b = 0.0109, p < 0.001); customer gender has no significant effect on return rates (b = -0.0003, p = 0.525); and old users have higher return rates than new and regular users (b = 0.0098, p < 0.001).

A further empirical challenge arises from heterogeneity among consumers shopping at different times and potential sample self-selection bias—our findings may not stem from sleep deprivation but rather from the possibility that consumers who habitually stay up late are more prone to regret after shopping. Although we cannot strictly rule out this possibility, we can employ propensity score matching (PSM) to select and match samples, constructing "treatment" and "control" groups that are as similar as possible, thereby minimizing sample selection bias and verifying the robustness of empirical results (Rosenbaum & Rubin, 1983).

Using PSM, we adopt multi-dimensional matching to find non-sleep-deprived period samples similar to sleep-deprived period samples. When calculating propensity scores using a Logit model, we include all control variables contained in Z_i in Model (1) as covariates in the matching model. We then use nearest neighbor matching (1:1 with and without replacement), nearest neighbor matching (1:4), and spline matching to calculate the average treatment effect of sleep deprivation. Using multiple matching methods to calculate average treatment effects can test result robustness. Appendix Table 2 shows sample balance after matching, with standardized bias for all variables between treatment and control groups substantially reduced, averaging only 1.14%.

Table 4 reports average treatment effects of sleep deprivation from different matching methods. Results show that effects from all four matching methods are significant at p < 0.001. The average treatment effects from nearest neighbor matching (1:1, with replacement), nearest neighbor matching (1:1, without replacement), nearest neighbor matching (1:4), and spline matching are 0.0118, 0.0149, 0.0112, and 0.0141 respectively, with a mean of 0.0130. These results are all very close to the sleep deprivation estimate of 0.0136 in Table 3, thus proving the robustness of the original regression results.

Table 5 reports regression results using different sleep deprivation coding methods. Panel A divides time into four categories: early morning (12:00 A.M.-5:59 A.M.), morning (6:00 A.M.-11:59 A.M.), afternoon (12:00 P.M.-5:59 P.M.), and evening (6:00 P.M.-11:59 P.M.). Since evening is the main shopping period, we use evening (6:00 P.M.-11:59 P.M.) as the baseline for regression analysis. Results show that afternoon shopping return rates show no significant difference

(b = 0.0008, p = 0.094), while morning shopping return rates are only slightly higher (b = 0.0029, p < 0.001). However, return rates increase significantly during the early morning period (b = 0.0149, p < 0.001).

Panel B further uses hourly coding, dividing time into 24 hours. Again using evening (8:00 P.M.-8:59 P.M.) as the main shopping period baseline, results show that return rates are highest for shopping during the midnight hour (12:00 A.M.-0:59 A.M.), increasing by 2.24% compared to evening (8:00 P.M.-8:59 P.M.). The next highest periods are subsequent early morning hours (1:00 A.M.-4:59 A.M.), when return probabilities increase by over 1% compared to evening (8:00 P.M.-8:59 P.M.). Additionally, all morning period return probabilities are slightly higher than evening (8:00 P.M.-8:59 P.M.), until after 3:00 P.M. when return rates gradually decline to levels not significantly different from evening (8:00 P.M.-8:59 P.M.). These results further corroborate the impact of sleep deprivation on shopping regret.

To further substantiate the causal relationship between sleep deprivation and shopping regret, we conducted two subsample regression analyses, with results shown in Table 6 . First, we obtained two additional product categories from the data provider: hedonic products prone to impulse consumption (beauty products) and utilitarian products less prone to impulse consumption (refrigerators). Since sleep deprivation reduces consumers' cognitive resources and self-control, it should more likely increase return rates for hedonic products through impulse consumption, while the impact on utilitarian products may be relatively smaller. Empirical results align with our expectations: the impact of sleep deprivation on hedonic products (b = 0.0306, p < 0.001) is significantly higher than on utilitarian products (b = 0.0122, p = 0.313).

Second, we divided the original data into weekday and weekend subsamples for separate regression. We can expect that for most working consumers, late-night shopping during weekdays more easily produces sleep deprivation, while sleep deprivation may be relatively less severe during weekend rest periods. Empirical results in Table 6 align with our expectations: the impact of sleep deprivation on return choice is higher during weekdays (b = 0.0176, p < 0.001) than during weekends (b = 0.0123, p < 0.001). These subsample regression results further theoretically substantiate the mechanism through which sleep deprivation affects shopping regret.

Next, we analyze the relationship between sleep deprivation and return speed. Since the dependent variable represents duration, we use a proportional hazard model for analysis (Gilovich & Medvec, 1995). This model can jointly analyze both the terminal event and the time experienced until the terminal event occurs. The specific model is as follows:

$$\lambda(t) = \lambda_0(t) \exp(U_i)$$

$$U_i = \beta_0 + \beta_1 x_i + Z_i \delta + \epsilon_i, \quad (2)$$

In Model (2), the dependent variable $\lambda(t)$ represents the hazard rate of product return at time t for a shopping order. The independent variable x_i represents sleep deprivation, taking a value of 1 when purchase time falls in the sleep-deprived period (12:00 A.M. to 5:59 A.M.) and 0 when purchase falls in the non-sleep-deprived period (6:00 A.M. to 11:59 P.M.). Z_i is a vector containing a series of control variables: product price, promotional discount ratio, discount amount, website promotion period, customer gender, customer type, and time effects (Monday through Sunday).

Table 7 presents Cox proportional hazard model regression results. We report both coefficient estimates and corresponding hazard ratios. The independent variable sleep deprivation has a positive and significant coefficient estimate (b = 0.1943, $p < 0.001$), with a corresponding hazard ratio greater than 1 (hazard ratio = 1.2144, 95% CI = [1.1924, 1.2369]). This result indicates that sleep deprivation leads to higher return risk, meaning the terminal event (return) occurs after a shorter "survival" time. Under other constant conditions, sleep deprivation increases return risk by 21.44% above the baseline.

Figure 5 [Figure 5: see original paper] visually demonstrates this result through Kaplan-Meier survival curves. The figure shows that the survival curve for sleep deprivation declines faster than for non-sleep deprivation, indicating that risk events (returns) occur earlier after shopping during sleep-deprived periods.

In summary, the series of analytical results support Hypothesis 1: compared to non-sleep-deprived periods, customers are more likely to experience shopping regret after shopping during sleep-deprived periods.

3.2 Moderating Effects of Shopping Environmental Cues

This section analyzes the moderating effects of shopping environmental cues on the relationship between sleep deprivation and shopping regret. Based on our research hypotheses, we specifically examine the moderating role of two variables: product price and promotional discount ratio.

Building on Model (1), we separately add interaction terms between sleep deprivation and these two moderating variables for regression analysis. Table 8 shows results after adding moderating effects. First, the interaction term between sleep deprivation and product price is positive and significant (b = 0.0030, $p < 0.001$). This result indicates that product price positively moderates the relationship between sleep deprivation and shopping regret; that is, when consumers purchase higher-priced products, their tendency to experience shopping regret after shopping during sleep-deprived periods increases. Hypothesis 2 is supported.

Second, the interaction term between sleep deprivation and promotional discount ratio is negative and significant (b = -0.0227, p = 0.032). This result indicates that promotional discount ratio negatively moderates the relationship between sleep deprivation and shopping regret; that is, when consumers obtain higher promotional discount ratios during shopping, their tendency to experience shopping regret after shopping during sleep-deprived periods decreases. Hypothesis 3 is supported.

4.1 Research Conclusions

In recent years, sleep problems have become a widespread social phenomenon. Meanwhile, consumers shopping during sleep-deprived periods has also increased substantially. Does sleep deprivation affect consumer shopping regret? Based on large-sample data (N = 1,625,472) from a major domestic shopping website, this study empirically explores the relationship between sleep deprivation and shopping regret, as well as the moderating role of promotional cues experienced during shopping. The main findings are as follows.

First, we find that sleep deprivation has a significant positive impact on shopping regret. Logit model regression results show that compared to non-sleep-deprived periods (6:00 A.M. to 11:59 P.M.), customers who shop during sleep-deprived periods (12:00 A.M. to 5:59 A.M.) are more likely to subsequently choose to return products. Calculations show that sleep deprivation' s marginal contribution to return probability is approximately 1.36%. Moreover, sleep deprivation results remain robust after multiple empirical method tests including propensity score matching, different sleep deprivation coding methods, and subsample regressions. Additionally, Cox proportional hazard model analysis also indicates that sleep deprivation leads to higher return risk. Under other constant conditions, sleep deprivation increases return risk by 21.44% above the baseline.

Second, we find that environmental cues experienced during shopping can moderate the impact of sleep deprivation on shopping regret. We analyzed two shopping environmental cues: product price and promotional discount ratio. Results show that product price positively moderates the relationship between sleep deprivation and shopping regret, while promotional discount ratio negatively moderates this relationship.

4.2 Theoretical Contributions

This paper's theoretical contributions are mainly reflected in three aspects. First, our findings help understand how sleep deprivation affects consumer shopping regret behavior. Given the prevalence of sleep deprivation, existing research has widely revealed its negative health impacts, such as depression (Chellappa et al., 2009), cardiovascular disease (Mullington et al., 2009), and dementia (Foley et al., 2003). Other research has focused on sleep deprivation' s impact on individual cognition, such as decreased creativity (Harrison & Horne, 1999), memory impairment (Chee & Choo, 2004), and risk decision biases (Venkatraman et

al., 2007). Although these studies provide insights for consumer behavior, they mainly focus on general decision-making tendencies, with few directly analyzing sleep deprivation' s impact on consumer behavior (Huang et al., 2019). Our study supplements consumer behavior research by analyzing the relationship between sleep deprivation and return behavior.

Second, this study expands research on circadian rhythms in the marketing domain. In recent years, marketing scholars have gradually begun to focus on heterogeneous impacts of different times of day on consumer behavior. For example, Kanuri et al. (2018) found that social media content posted in the morning receives approximately 8.8% and 11.1% more clicks than content posted in the afternoon and evening. Gullo et al. (2019) found that consumers show lower variety-seeking tendencies for product types in the morning compared to other times of day. This paper supplements circadian rhythm theory in marketing from the perspective of consumer shopping regret and returns.

Third, this study' s conclusions expand measurement methods for consumer shopping regret. Shopping regret is a negative emotional state for consumers. Since return behavior can help consumers regulate this emotional state by reversing their initial purchase decision, returns represent a primary behavioral manifestation of shopping regret. By leveraging the shopping website' s survey function during consumer returns and using large-scale objective behavioral data to measure shopping regret, this approach has two main advantages: first, both the independent variable (sleep deprivation) and dependent variable (shopping regret) are generated in real contexts, providing higher external validity than traditional survey and experimental data; second, regression estimation with large-sample data can yield more stable effect sizes regarding the relationship between sleep deprivation and shopping regret.

4.3 Managerial Implications

This study' s conclusions provide the following implications for consumers and businesses. For consumers, they should minimize shopping during the 12:00 A.M. to 5:59 A.M. period. The cognitive impairment caused by sleep deprivation makes consumers more prone to impulse shopping during this period, thereby bearing greater shopping risks and experiencing more anticipatory regret and return behavior. If shopping during this period is unavoidable, consumers should pay more attention to central information about products and promotions, and adopt more rational and deliberative thinking patterns when making purchase decisions.

For businesses, increased consumer shopping regret and return rates not only raise management costs but also harm customer relationship building and maintenance. Therefore, businesses should control the negative impacts of sleep deprivation. First, shopping websites could consider adjusting promotional event times from sleep-deprived periods to other periods. For example, websites could shift "618" and "Double 11" events from traditional midnight start times to

prime evening hours between 8:00 P.M. and 12:00 A.M. This adjustment could prevent consumers from staying up late to shop, increase rational consumption, and reduce shopping regret and return tendencies. Second, for consumers accustomed to shopping during sleep-deprived periods, businesses should provide more attention and targeted strategies. For instance, during consumers' shopping processes, provide more product and promotional cues that stimulate rational decision-making. Additionally, for consumers and dates predicted to have high return risk rates, businesses could send targeted messages conveying product intrinsic value to reduce regret and return tendencies.

4.4 Research Limitations and Future Directions

Future research could consider several directions. First, future studies could use other measurement methods (e.g., survey and experimental methods), other variables (e.g., repurchase intention, brand switching, negative reviews), and other return reasons (e.g., "wrong/extra product selected," "did not use/underuse/misuse discounts") to measure shopping regret, further verifying the relationship and underlying mechanisms between sleep deprivation and shopping regret. Second, beyond shopping regret, sleep deprivation may affect other forms of consumer behavior. For example, due to weakened cognitive abilities, consumers may be less sensitive to marketing cues requiring deliberative thinking (e.g., numbers, text) while heuristic marketing cues (e.g., colors, endorsers) may be more effective. Third, our study uses real individual-level consumer data, which has the advantage of high external validity and practical business implications. However, the disadvantage of using secondary data is the difficulty in revealing the mediating mechanisms between sleep deprivation and shopping regret from a consumer psychological perspective. Future research could consider using experimental manipulation methods to further analyze mediating mechanisms underlying this relationship. Finally, due to businesses' confidentiality requirements for consumer data, our empirical data has limited dimensions at the individual consumer level. For example, existing research has found that sleep deprivation affects different age groups differently (Webb & Levy, 1982). Future research could further analyze heterogeneous effects of sleep deprivation on different consumer populations.

References

Akerstedt, T., Kecklund, G., Alfredsson, L., & Selen, J. (2007). Predicting long-term sickness absence from sleep and fatigue. *Journal of Sleep Research*, 16(4), 341–345.

Alshobaili, F. A., & AlYousefi, N. A. (2019). The effect of smartphone usage at bedtime on sleep quality among Saudi non-medical staff at King Saud University Medical City. *Journal of Family Medicine and Primary Care*, 8(6), 1953–1957.

Barnes, C. M., Schaubroeck, J., Huth, M., & Ghumman, S. (2011). Lack of sleep and unethical conduct. *Organizational Behavior and Human Decision*

Processes, 115(2), 169–180.

Barnes, C. M., & Wagner, D. T. (2009). Changing to daylight saving time cuts into sleep and increases workplace injuries. *Journal of Applied Psychology*, 94(5), 1305–1317.

Baumeister, R. F. (2010). *The self*. Oxford University Press.

Baumeister, R. F., Muraven, M., & Tice, D. M. (2000). Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Social Cognition*, 18(2), 130–150.

Beatty, S. E., & Smith, S. M. (1987). External search effort: An investigation across several product categories. *Journal of Consumer Research*, 14(1), 83–95.

Benington, J. H. (2000). Sleep homeostasis and the function of sleep. *Sleep*, 23(7), 959–966.

Bloch, P. H., & Richins, M. L. (1983). A theoretical model for the study of product importance perceptions. *Journal of Marketing*, 47(3), 69–81.

Borbély, A. A. (1982). Sleep regulation: Circadian rhythm and homeostasis. In *Sleep* (pp. 83–103). Springer.

Borbély, A. A., & Wirz-Justice, A. (1982). Sleep, sleep deprivation and depression. *Hum Neurobiol*, 1(205), 205–210.

Cases, A.-S. (2002). Perceived risk and risk-reduction strategies in Internet shopping. *The International Review of Retail, Distribution and Consumer Research*, 12(4), 375–394.

Celsi, R. L., & Olson, J. C. (1988). The role of involvement in attention and comprehension processes. *Journal of Consumer Research*, 15(2), 210–224.

Chee, M. W., & Choo, W. C. (2004). Functional imaging of working memory after 24 hr of total sleep deprivation. *Journal of Neuroscience*, 24(19), 4560–4567.

Chellappa, S. L., Schröder, C., & Cajochen, C. (2009). Chronobiology, excessive daytime sleepiness and depression: Is there a link? *Sleep Medicine*, 10(5), 505–514.

Choi, J., Li, Y. J., Rangan, P., Chatterjee, P., & Singh, S. N. (2014). The odd-ending price justification effect: The influence of price-endings on hedonic and utilitarian consumption. *Journal of the Academy of Marketing Science*, 42(5), 545–557.

Cox, D. R. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society: Series B (Methodological)*, 34(2), 187–202.

Cox, D. R., & Oakes, D. (2018). *Analysis of survival data*. Chapman and Hall/CRC.

Darke, P. R., & Freedman, J. L. (1997). The belief in good luck scale. *Journal of Research in Personality*, 31(4), 486–502.

Divine, R. L. (1995). The influence of price on the relationship between involvement and consideration set size. *Marketing Letters*, 6(4), 309–319.

Dunne, P. M., Lusch, R. F., & Carver, J. R. (2013). *Retailing*. Cengage Learning.

Durmer, J. S., & Dinges, D. F. (2005). Neurocognitive consequences of sleep deprivation. *Seminars in Neurology*, 25(01), 117–129.

Dou, K., Nie, Y. G., Wang, Y. J., Li, J. B., & Shen, W. B. (2014). Ego depletion promotes impulsive decision: Evidences from behavioral and ERPs studies. *Acta Psychologica Sinica*, 46(10), 1564–1579.

Foley, D. J., Masaki, K., White, L., Larkin, E. K., Monjan, A., & Redline, S. (2003). Sleep-disordered breathing and cognitive impairment in elderly Japanese-American men. *Sleep*, 26(5), 596–599.

Ghumman, S., & Barnes, C. M. (2013). Sleep and prejudice: A resource recovery approach. *Journal of Applied Social Psychology*, 43, E166–E178.

Gilovich, T., & Medvec, V. H. (1995). The experience of regret: What, when, and why. *Psychological Review*, 102(2), 379–395.

Griffiths, M. D., & Bingham, D. (2005). A study of superstitious beliefs among bingo players. *Journal of Gambling Issues*, 13, 1–13.

Gullo, K., Berger, J., Etkin, J., & Bollinger, B. (2019). Does time of day affect variety-seeking? *Journal of Consumer Research*, 46(1), 20–35.

Harrison, Y., & Horne, J. A. (1999). One night of sleep loss impairs innovative thinking and flexible decision making. *Organizational Behavior and Human Decision Processes*, 78(2), 128–145.

Hershner, S. D., & Chervin, R. D. (2014). Causes and consequences of sleepiness among college students. *Nature and Science of Sleep*, 6, 73–84.

Hetts, J. J., Boninger, D. S., Armor, D. A., Gleicher, F., & Nathanson, A. (2000). The influence of anticipated counterfactual regret on behavior. *Psychology & Marketing*, 17(4), 345–368.

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O' Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., & Adams Hillard, P. J. (2015). National Sleep Foundation' s sleep time duration recommendations: Methodology and results summary. *Sleep Health*, 1(1), 40–43.

Huang, Z. (Tak), Liang, Y., Weinberg, C., & Gorn, G. (2019). The sleepy consumer and variety seeking. *Journal of Marketing Research*, 56(2), 179–196.

Hursh, S. R., Balkin, T. J., Miller, J. C., & Eddy, D. R. (2004). The fatigue avoidance scheduling tool: Modeling to minimize the effects of fatigue on cognitive performance. *SAE Transactions*, 111–119.

Janis, I. L., & Mann, L. (1977). *Decision making: A psychological analysis of conflict, choice, and commitment*. Free Press.

Jiang, Y., Cho, A., & Adaval, R. (2009). The unique consequences of feeling lucky: Implications for consumer behavior. *Journal of Consumer Psychology*, 19(2), 171–184.

Kanuri, V. K., Chen, Y., & Sridhar, S. (Hari). (2018). Scheduling content on social media: Theory, evidence, and application. *Journal of Marketing*, 82(6), 89–108.

Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science*, 5(1), 43–57.

Knutson, K. L., Spiegel, K., Penev, P., & Van Cauter, E. (2007). The metabolic consequences of sleep deprivation. *Sleep Medicine Reviews*, 11(3), 163–178.

Kolla, B. P., Coombes, B. J., Morgenthaler, T. I., & Mansukhani, M. P. (2021). Increased patient safety-related incidents following the transition into daylight savings time. *Journal of General Internal Medicine*, 36(1), 51–55.

Kramer, T., & Block, L. (2008). Conscious and nonconscious components of superstitious beliefs in judgment and decision making. *Journal of Consumer Research*, 34(6), 783–793.

Lanaj, K., Johnson, R. E., & Barnes, C. M. (2014). Beginning the workday yet already depleted? Consequences of late-night smartphone use and sleep. *Organizational Behavior and Human Decision Processes*, 124(1), 11–23.

Lee, S. H., & Cotte, J. (2009). Post-purchase consumer regret: Conceptualization and development of the PPCR scale. *ACR North American Advances*, 36, 456–462.

Lim, J., & Dinges, D. F. (2010). A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin*, 136(3), 375–389.

Li, D. J., Wu, B., & Li. Y. (2013). The influence of product return on purchase regret in remote purchase environment. *Nankai Business Review*, 16(5), 77–89.

Marcus, B., & Schuler, H. (2004). Antecedents of counterproductive behavior at work: A general perspective. *Journal of Applied Psychology*, 89(4), 647–660.

May, J., & Kline, P. (1987). Measuring the effects upon cognitive abilities of sleep loss during continuous operations. *British Journal of Psychology*, 78(4), 443–455.

McDaniel, S. R. (2002). Investigating the roles of gambling interest and impulsive sensation seeking on consumer enjoyment of promotional games. *Social Behavior and Personality: An International Journal*, 30(1), 53–64.

Morphy, H., Dunn, K. M., Lewis, M., Boardman, H. F., & Croft, P. R. (2007). Epidemiology of insomnia: A longitudinal study in a UK population. *Sleep*, 30(3), 274–280.

Mullington, J. M., Haack, M., Toth, M., Serrador, J., & Meier-Ewert, H. (2009). Cardiovascular, inflammatory and metabolic consequences of sleep deprivation. *Progress in Cardiovascular Diseases*, 51(4), 294–302.

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin*, 126(2), 247–259.

Parrott, A. C., Garnham, N. J., Wesnes, K., & Pincock, C. (1996). Cigarette smoking and abstinence: Comparative effects upon cognitive task performance and mood state over 24 hours. *Human Psychopharmacology: Clinical and Experimental*, 11(5), 391–400.

Patrick, G. T. W., & Gilbert, J. A. (1896). Studies from the psychological laboratory of the University of Iowa: On the effects of loss of sleep. *Psychological Review*, 3(5), 469–483.

Pieters, R., & Zeelenberg, M. (2005). On bad decisions and deciding badly: When intention–behavior inconsistency is regrettable. *Organizational Behavior and Human Decision Processes*, 97(1), 18–30.

Qian, L., Ru, T. T., Luo, X., Niu, J. X., Ma, Y. J., & Zhou, G. F. (2020). Effect of sleep restriction on cognitive function and its underlying mechanism. *Advances in Psychological Science*, 28(9), 1493–1507.

Ratchford, B. T. (1982). Cost-benefit models for explaining consumer choice and information seeking behavior. *Management Science*, 28(2), 197–212.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41–55.

Saper, C. B., Scammell, T. E., & Lu, J. (2005). Hypothalamic regulation of sleep and circadian rhythms. *Nature*, 437(7063), 1257–1263.

Schindler, R. M. (1998). Consequences of perceiving oneself as responsible for obtaining a discount: Evidence for smart-shopper feelings. *Journal of Consumer Psychology*, 7(4), 371–392.

Schnyer, D. M., Zeithamova, D., & Williams, V. (2009). Decision-making under conditions of sleep deprivation: Cognitive and neural consequences. *Military Psychology*, 21(sup1), S36–S45.

Shafir, E., Simonson, I., & Tversky, A. (1993). Reason-based choice. *Cognition*, 49(1–2), 11–36.

Shilo, L., Dagan, Y., Smorjik, Y., Weinberg, U., Dolev, S., Komptel, B., & Shenkman, L. (2000). Effect of melatonin on sleep quality of COPD intensive care patients: A pilot study. *Chronobiology International*, 17(1), 71–76.

Simmons, L. C., & Schindler, R. M. (2003). Cultural superstitions and the price endings used in Chinese advertising. *Journal of International Marketing*, 11(2), 101–111.

Simonson, I. (1989). Choice based on reasons: The case of attraction and compromise effects. *Journal of Consumer Research*, 16(2), 158–174.

Simonson, I., & Nowlis, S. M. (2000). The role of explanations and need for uniqueness in consumer decision making: Unconventional choices based on reasons. *Journal of Consumer Research*, 27(1), 49–68.

Spiegel, K., Sheridan, J. F., & Van Cauter, E. (2002). Effect of sleep deprivation on response to immunization. *JAMA*, 288(12), 1471–1472.

Tsiros, M., & Mittal, V. (2000). Regret: A model of its antecedents and consequences in consumer decision making. *Journal of Consumer Research*, 26(4), 401–417.

Venkatesan, R., & Kumar, V. (2004). A customer lifetime value framework for customer selection and resource allocation strategy. *Journal of Marketing*, 68(4), 106–125.

Venkatraman, V., Chuah, Y. L., Huettel, S. A., & Chee, M. W. (2007). Sleep deprivation elevates expectation of gains and attenuates response to losses following risky decisions. *Sleep*, 30(5), 603–609.

Wagner, D. T., Barnes, C. M., Lim, V. K. G., & Ferris, D. L. (2012). Lost sleep and cyberloafing: Evidence from the laboratory and a daylight saving time quasi-experiment. *Journal of Applied Psychology*, 97(5), 1068–1076.

Webb, W. B., & Levy, C. M. (1982). Age, sleep deprivation, and performance. *Psychophysiology*, 19(3), 272–276.

Wesselius, H. M., Van Den Ende, E. S., Alsma, J., Ter Maaten, J. C., Schuit, S. C., Stassen, P. M., de Vries, O. J., Kaasjager, K. H., Haak, H. R., & Van Doormaal, F. F. (2018). Quality and quantity of sleep and factors associated with sleep disturbance in hospitalized patients. *JAMA Internal Medicine*, 178(9), 1201–1208.

Yam, K. C., Jackson, J. C., Lau, J., Qin, X., Barnes, C. M., & Chong, J.-K. (2020). Association of high profile football matches in Europe with traffic accidents in Asia: Archival study. *BMJ*, 371, m4465.

Zammit, G. K., & Zanca, J. A. (1998). *Good nights: How to stop sleep deprivation, overcome insomnia, and get the sleep you need*. Andrews McMeel Pub.

Zeelenberg, M., & Pieters, R. (1999). Comparing service delivery to what might have been: Behavioral responses to regret and disappointment. *Journal of Service Research*, 2(1), 86-97.

Zeelenberg, M., & Pieters, R. (2004). Beyond valence in customer dissatisfaction: A review and new findings on behavioral responses to regret and disappointment in failed services. *Journal of Business Research*, 57(4), 445-455.

Zeelenberg, M., & Pieters, R. (2007). A theory of regret regulation 1.0. *Journal of Consumer Psychology*, 17(1), 3-18.

Zhu, H. W., & Huang, M. X. (2013). Does hyperopia lead to self-control or indulgence: Self-control and impulsive buying. *Journal of Marketing Science*, 8(3), 45-62.

Sleep Deprivation and Post-Purchase Regret: An Empirical Study Based on Large-Scale Individual-Level Data

GONG Shiyang[1], ZHANG Yibo[2], GAO Yuetao[2]
([1] Business School, Beijing Normal University, Beijing 100875, China)
([2] School of Management, Xiamen University, Xiamen 361005, China)

Abstract: Sleep problems have become a very common phenomenon in modern society, but few studies have directly explored the impact of sleep deprivation on consumer choice and decision-making behavior. This study combines the common late-night shopping scene in the current market with ego-depletion theory. We speculate that when consumers shop during sleep-deprived periods, they are more likely to make impulsive or unplanned purchases due to insufficient cognitive resources, leading to regret and return behaviors subsequently. Additionally, we explore the moderating effects of two promotional cues (discount ratio and lucky numbers).

The data comes from a large domestic e-commerce retail website, containing individual consumer-level shopping behavior data from June 1 to July 31, 2021, with a sample size of 1,625,472. Using minute-level purchase time information, we distinguish orders generated during sleep-deprived versus non-sleep-deprived periods. This paper uses Logit regression models to estimate return probability and Cox hazard models to analyze the relationship between sleep deprivation and return speed. Finally, moderating variables are added to the Logit regression model for verification.

This paper derives several findings. First, it shows that sleep deprivation significantly increases consumers' shopping regret behavior, manifested as increased product return probability and accelerated return speed. Second, we find that product prices positively moderate the effect of sleep deprivation on shopping regret, while promotional discount ratios negatively moderate this effect.

The findings help understand how sleep deprivation affects consumer behavior —consumers are more likely to experience shopping regrets (e.g., returns) after

shopping during sleep-deprived periods compared to other times of day, while promotional depth negatively moderates the effect of sleep deprivation on shopping regret. The results suggest that consumers should minimize shopping during the 12:00 A.M. to 5:59 A.M. period. If shopping during this period, they need to pay more attention to central information about products and promotions. Meanwhile, this study suggests that companies could consider adjusting promotional activity times from sleep-deprived periods to other periods to reduce increased operating costs due to consumer shopping regrets and return rates.

Keywords: sleep deprivation; post-purchasing regret; product return; large-scale individual-level data; empirical study

---

Appendix Table 1: Sleep Deprivation and Return Choice: Regression Results After Removing Website Promotion Period Samples

Appendix Table 2: Data Balance Results from Propensity Score Matching (based on nearest neighbor matching 1:1 with replacement)

Note: Figure translations are in progress. See original paper for figures.