Research on Consumer Energy-Saving Awareness Based on Online Reviews of Energy-Efficient Home Appliances

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Abstract. Green consumption is a key development strategy outlined in China's "14th Five-Year Plan" and the 2035 Vision Outline. Research reports indicate that 80% of consumers are in favor of sustainable consumption practices. Despite this, several studies suggest that there exists a noticeable gap between intention and behavior in consumers' eco-friendly consumption patterns. Utilizing web crawler technology, this study collected data on 8,020 home appliances that were energy-efficient and screened 1.481 million customer opinions associated with these products on Jingdong platform. The study measured consumer energy-saving attention through word frequency statistics. The research concluded that consumers' attention towards energy-saving behaviors when utilizing energy-efficient home appliances was low, accounting for merely 4.279% of their energy consumption. This outcome highlights the observed gap between consumers' environmental intentions and their actual energy-saving behaviors. Besides, based on descriptive analysis and Kruskal-Wallis test results, the study discovered significant differences in consumers' levels of energy-saving attention towards various categories and energy efficiency levels of eco-friendly home appliances. As a solution, the study recommends that businesses can guide customers to improve their energy-saving attention through effective customer service guidance, offers such as gift coupons, augmented yet meaningful experience cards, or even through setting up a dedicated energy-saving comment section. The proposal aims to amplify other consumers' comprehension of energy-saving information and usage experience of ecological products.

Keywords: Energy-Saving Attention · Green Consumption · Energy-Saving Home Appliances · Online Comments

1 Introduction

In China, as the economy rapidly grows, the concepts of green environmental protection and low-carbon development have been widely disseminated among the citizens, leading to greater recognition of green consumption. The "Survey Report on the Present Status of Public Green Consumption in China" revealed that 83.34% of respondents

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supported green consumption behavior, with 46.75% expressing a strong inclination towards it. Studies carried out by Alibaba's New Service Research Center indicated that over 60% of participants were conscious of green consumption, with post-90s and post-2000s generations exhibiting considerably greater awareness than their older counterparts, amounting to 70% and 79%, correspondingly. "Developing green consumption" was included as one of the critical strategies for China's future development in the 14th Five-Year Plan and the 2035 Vision Goal Outline, indicating the significance of green consumption in the country's prospects.

Ajzen proposed the TPB model in 1985, based on the TRA theory, which suggests that behavioral attitudes influence behavioral intentions that further reflect in the behavior, a viewpoint substantiated by a substantial corpus of empirical studies. Despite the model's popularity, there exists abundant research indicating that the impact of attitudes or intentions on behavior is nonlinear and can differ, leading to the "gap between intention and behavior" or "inconsistency between words and deeds." Consequently, even though 80% of customers endorse green consumption, research suggests that their attitudes towards this practice may be affected by variables such as purchasing power and information transparency, creating a discrepancy between their attitudes and actual green consumption behavior.

One of the crucial green consumption behaviors is consumers buying and being mindful of energy-saving home appliances that they can recognize in their daily consumption; furthermore, online comments provide consumers' subjective assessment of their experience after buying the product. Therefore, the research on energy-saving home appliances analyzes the frequency of keywords associated with energy-saving consumption in online comments about energy-efficient home appliances to understand how customers perceive them, and proposes measures to promote such behavior from the perspective of online comments.

2 Correlational Research

Presently, research on green consumption focuses on exploring driving forces, fostering green consumption values, and examining relevant institutional mechanisms. Various approaches, including the TPB model, regression analysis, and SEM, have been employed by scholars to investigate the factors that influence eco-friendly behavior. Studies contend that numerous variables, such as age, education, income level, occupation [1, 2], green awareness and environmental consciousness [3, 4], media promotion [5, 6], gamification and intelligence [7, 8], and packaging design, have an impact on eco-friendly behavior, according to individual consumer characteristics.

Nonetheless, a linear relationship between driving factors and eco-friendly behavior does not exist. Scholars have found that a hole exists between factors that drive ecological behavior, consumer attitudes towards eco-friendly behavior, and their willingness to act on such attitudes. As an illustration, William et al. discovered that 30% of UK consumers expressed significant concerns about environmental matters, yet they struggled to translate it into their purchasing behavior. Similarly, according to Essiz Oguzhan [9] et al., although consumers have positive perspectives towards green consumption, they usually find it challenging to transform these values into green purchasing behavior, known as the "Green Gap." Several scholars have explored the causes that underlie

this gap. According to Chen Kai et al. [10], the gap arises from various factors such as perceived efficacy and expectations of others' consumption behavior, group, and individual past consumption behavior, balancing green and non-green product attributes, green product prices, availability factors, and situational factors of green consumption behavior. Li Chuang et al. [11] also found that trust and information reduce this gap, while behavioral costs such as extra expenses, time, and energy increase it. In a similar vein, Li Pengxiang [12] research identified several causes behind this gap, including self-control, purchasing behavior inertia, social reference group norms, balancing green and non-green product attributes, high prices and low availability of green products, and a lack of information, transparency, and trust.

In summary, extensive research has shown that there is a fundamental discordance between consumers' attitudes and intentions towards green consumption practices and their actual behavior. This discrepancy highlights the need for more in-depth research into how to bridge this gap. Unfortunately, several studies rely too heavily on the TPB model, and their investigation methods are restricted by SEM tools. As a result, we must expand our research beyond the traditionally limited methods. Therefore, this article ("this study" can be more specific) advocates for analyzing consumer usage comments on products, seeing as they could accurately reflect their actual consumption patterns, including their perception of energy-saving protocols. By examining customers' online reviews of energy-saving products, we have a more natural avenue to better comprehend their energy-saving proclivities and investigate whether this gap exists.

3 Data Collection and Pre-processing

3.1 Data Collection

The data utilized for this study originates from JD.com, the largest home appliance e-commerce platform in China. This study selected four of the most commonly purchased household appliances from this platform - refrigerators, air conditioners, washing machines, and televisions. A web crawler program was employed to gather a total of 8,916 products and 1.842 million corresponding comments in regards to the designated four household appliances. The data retrieved includes essential product attributes such as the product ID, product title, and product parameters. Moreover, this data includes factors such as the total number of comments, hot review tags, comment content, and score for each product. Furthermore, the product parameters include energy efficiency levels that conform to the "Management Measures for Energy Efficiency Labeling" in China.

3.2 Data Pre-processing

Initially, this study utilized regular expressions to extract the energy efficiency levels of the 8,916 products from their respective product parameters. The results identified that 896 items did not indicate their energy consumption level, although 8,020 products possessed a relevant energy consumption rating. Following this, the comments related to those 8,020 products were subject to a screening process. Comments with a text length

of fewer than five words or default replies like "This user did not fill in the evaluation content" were eliminated. Consequently, this process yielded 8,020 products and their 1.481 million associated, valid online reviews.

4 Data Empirical Analysis

4.1 Measurement of Consumer Energy Efficiency Concerns

Consumer online reviews provide subjective evaluations of the consumer's experience of a product after actual use. From these reviews, it can be inferred that if consumers are mindful of saving energy, they will express this in their comments. As such, a method to quantify consumers' energy conservation concerns can be achieved by analyzing the frequency of energy conservation keywords in their reviews. The frequency with which these keywords appear can be used to determine the level of consumers' attention towards energy conservation information.

Additionally, this study has identified nine relevant energy conservation keywords. These keywords include energy consumption, energy efficiency, energy conservation, power-saving, low carbon, green consumption, green lifestyle, environmental protection, eco-friendliness, as well as trade-in.

4.2 Overall Energy Conservation Concern Analysis

The general level of energy conservation concern is calculated as the ratio of comments that contain energy conservation keywords to the total number of "relevant" comments. That is, comments that contain one or more energy conservation keywords. According to our statistics, amongst the 1.481 million reviews analyzed, 63,377 showcased energy conservation keywords, and thus the overall level of energy conservation concern was established at 4.279%. Among the reviews that contain energy conservation keywords, they are distributed as shown in table 1:

Table 1. The distribution of all energy-saving keywords with a frequency greater than 0

count	mean	std	min	25%	50%	75%	max
63377	1.574	0.893	1.0	1.0	1.0	2.0	11.0

It is apparent that consumers display limited awareness of energy-saving efforts, with only 4.279% showcasing concern. Even within the consumers focusing on promoting energy-saving efforts, the average value is just 1.574. This study aims to delve deeper into consumers' energy-saving awareness in different product categories and energy efficiency levels, and thus utilized differential analysis via ANOVA, t-tests, non-parametric testing, and descriptive analysis. Typically, ANOVA necessitates normality data to yield accurate outcomes. To this end, this study performed normality tests on both frequency data of all energy-saving words and frequency data of energy-saving words greater

than zero separately, employing tools such as histograms, Q-Q plots, and Kolmogorov-Smirnov tests. However, the results showed non-normal distribution data. Therefore, this study utilized descriptive analysis and the non-parametric Kruskal-Wallis test to conduct differential analysis on energy-saving awareness in different product categories and energy efficiency levels.

4.3 Analysis of Differences in Energy-Saving Attention Among Different Product Categories

Table 2 provides differential analysis of energy-saving attention for different product categories based on descriptive analysis methods.

Table 2. The distribution of energy-saving attention and energy-saving keywords (with a frequency greater than 0) for different product categories

	energy-saving attention	count	mean	std	min	25%	50%	75%	max
Refrigerator	4.028%	18169	1.335	0.619	1	1	1	2	8
Air condition	8.111%	26715	2.039	1.055	1	1	2	3	11
Washing machine	1.406%	6254	1.236	0.528	1	1	1	1	6
Television	4.787%	12239	1.088	0.371	1	1	1	1	7

Additionally, this paper employed the Kruskal-Wallis test to examine the frequency data of energy-saving keywords for different product categories, with and without restrictions of frequency greater than zero. Results demonstrated that the Kruskal-Wallis statistics and p-values were 21,642.563, 0, and 9,086.129, 0, respectively. Since the p-values were both less than 0, the null hypothesis was rejected, indicating significant differences among different product categories. As per descriptive analysis, consumers exhibit the highest energy-saving awareness for air conditioners and the lowest for washing machines.

4.4 Analysis of Differences in Energy Efficiency Level and Energy Efficiency Concern

Table 3 showcases the differences in energy efficiency concerns for different energy efficiency levels, based on descriptive analysis methods.

The Kruskal-Wallis test was also conducted on the frequency data of all energy-saving keywords and frequency data of energy-saving keywords with frequency greater than zero for different energy efficiency levels. The Kruskal-Wallis statistics and p-values were 2,984.956, 0 and 1,720.614, 0, respectively. As all p-values were less than 0, the null hypothesis was rejected, signifying significant differences between different energy efficiency levels. As per descriptive analysis, consumers showcase increased

Table 3. Distribution of Energy Efficiency Concern and Keyword Frequency (greater than 0) for Different Energy Efficiency Levels

	Energy Efficiency Concern	count	mean	std	min	25%	50%	75%	max
Level One Energy Efficiency	5.037%	35055	1.711	0.975	1	1	1	2	11
Level Two Energy Efficiency	2.753%	6181	1.337	0.659	1	1	1	2	6
Level Three Energy Efficiency	3.646%	14316	1.433	0.794	1	1	1	2	9
Level Four Energy Efficiency	4.203%	4765	1.115	0.429	1	1	1	1	6
Level Five Energy Efficiency	5.609%	3060	1.867	0.834	1	1	2	2	9

energy efficiency concerns when energy-saving appliances are rated level one or five. Moreover, amongst the five energy efficiency levels, ratings one and three are more preferred by consumers.

5 Conclusion

This study focuses on analyzing online reviews of energy-efficient appliances to examine the energy-saving awareness of consumers. To this end, we obtained a dataset of 8,020 energy-efficient appliance products and 1.481 million corresponding online reviews using web crawling technology. By conducting statistical analysis on the occurrence frequency of nine energy-saving keywords in the online reviews, we measured the level of energy-saving awareness among consumers. The data was further subjected to descriptive analysis and Kruskal-Wallis test to examine the differences in energy-saving awareness across different product categories and different levels of energy efficiency. The findings of our study indicate that:

(1) Despite the fact that various surveys suggest that 80% of consumers support environmentally-friendly consumption, the actual energy-saving awareness exhibited by consumers when utilizing energy-efficient appliances is meager, at 4.279%. This outcome is indicative of the "intention-behavior" gap that exists among consumers when purchasing energy-efficient appliances.

(2) Results from the statistical tests demonstrate noteworthy disparities in consumers' energy-saving awareness levels that vary according to the energy efficiency level and

appliance category. Consumer awareness is at its highest when using air conditioners, whereas washing machines have the lowest awareness levels. Additionally, when energy-efficient appliances are classified into either level 1 or level 5 efficiency categories, consumers exhibit a greater level of energy-saving awareness.

A multitude of research studies suggest that online reviews have a substantial impact on consumers' behavior regarding consumption. Hence, directing consumers towards eco-friendly consumption through online reviews is currently a challenging issue that scholars are investigating. In the context of online reviews of energy-efficient appliances, boosting users' knowledge of energy conservation, and motivating them to actively offer feedback and comments on energy-saving information while utilizing the products, can foster the promotion of energy-efficient appliances among other consumers and encourage green consumption. As such, companies can use various methods such as customer service guidance, offering coupons or attaching experience description cards to the product to encourage users to share their energy-saving perceptions during actual usage. Furthermore, establishing a specific area for energy-saving experience reviews can invite consumers to provide feedback on energy-saving perceptions, increase their awareness of energy conservation, and make the product's energy-saving information and user experience easier for others to comprehend.

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