

Analyzing Customer Reviews in E-commerce: A TF-IDF and Logistic Regression Approach

Silin Chen
Vanderbilt University
Nashville TN, 37212
silin.chen@vanderbilt.edu

ABSTRACT

In the dynamic world of e-commerce, the influence of customer reviews on purchasing decisions and brand reputation cannot be overstated. This research taps into the power of advanced linguistic analysis to scrutinize customer feedback within the women's fashion sector. By employing advanced statistical techniques to evaluate the semantic properties of online reviews, the study sheds light on how specific word frequencies correlate with the recommendation status of products.

The investigation reveals that certain words strongly associated with positive or negative sentiments are crucial in shaping consumer opinions. "perfect" and "comfortable" frequently appear in positive reviews and indicate customer recommendations. Conversely, "disappointed" and "return" are prevalent in negative feedback, pointing to customer dissatisfaction.

Although the analysis notes a tendency to identify better positive reviews—perhaps reflecting an inherent positivity bias in consumer feedback—the insights derived from this linguistic scrutiny are invaluable. They not only help in understanding consumer sentiments more deeply but also assist in refining marketing strategies and enhancing product offerings. This study highlights the significant impact a detailed analysis of customer language can have on understanding and strategizing in e-commerce environments, ultimately leading to improved consumer experiences and business outcomes.

Keywords

TF-IDF, Sentiment Analysis, Logistic Regression, E-commerce, Customer Reviews

1. INTRODUCTION

In e-commerce, customer reviews are crucial in influencing purchasing decisions and shaping perceptions of brands and products. The dichotomy between recommended and unrecommended reviews offers a unique lens through which customer satisfaction and product quality can be assessed. While numerous studies have explored the impact of online reviews on consumer behavior [1][2], less attention has been given to the linguistic characteristics that differentiate positive and negative feedback [3][4]. This gap in research highlights an opportunity to employ advanced analytical techniques to uncover the nuanced ways language reflects and influences customer experiences [5].

The Term Frequency-Inverse Document Frequency (TF-IDF) approach, a well-regarded method in Natural Language Processing (NLP), provides a sophisticated means of analyzing text data to identify the most relevant words within a corpus [6]. By assessing the importance of words based on their frequency in specific documents relative to their ubiquity across all documents, the TF-IDF method can illuminate the distinguishing features of recommended versus unrecommended reviews. This analysis can reveal insights

into the specific attributes of products that elicit positive or negative feedback, thereby offering valuable guidance for improving customer satisfaction and product development.

The present study seeks to apply TF-IDF analysis to a dataset of women's clothing e-commerce reviews to identify key differences between recommended and unrecommended reviews. This approach is anticipated to find the factors that drive recommendations, as well as those that contribute to customer dissatisfaction. Through this analysis, we intend to contribute to understanding consumer behavior in online shopping environments and provide meaningful insights for brands seeking to enhance their product offerings and marketing strategies [7]. Despite the critical role of customer feedback in e-commerce success, the challenge remains in effectively analyzing and interpreting the vast quantities of textual data generated by reviews. This research addresses this challenge by using TF-IDF to systematically evaluate the word frequencies and their significance in shaping consumer perceptions and decisions [8].

2. PERPORSE STATEMENT AND RE-SEARCH QUESTION

This study explores the intersection of customer feedback and linguistic analysis in the e-commerce fashion industry, employing Term Frequency-Inverse Document Frequency (TF-IDF) and logistic regression techniques. By analyzing customer reviews from a substantial dataset of women's clothing products, the research seeks to identify and quantify the relationship between the linguistic characteristics of reviews and the likelihood of product recommendations [9][10]. This investigation is motivated by the need to understand how specific words and phrases within customer reviews can influence purchasing decisions, thereby informing more effective marketing strategies and product enhancements [11]. The study focuses on extracting and analyzing the semantic properties of text to determine the predictive power of language used in customer feedback regarding product endorsements [12].

The research question that guides this study is:

1. How do the TF-IDF values of words within e-commerce clothing reviews correlate with the products' recommendation statuses?

The hypothesis is that words with higher TF-IDF values in customer reviews for e-commerce clothing positively correlate with product recommendation statuses. Specifically, products with reviews containing high TF-IDF valued words are more likely to be recommended, indicating that certain key terms significantly influence positive consumer feedback and subsequent product endorsements.

3. LITERATURE REVIEW

In e-commerce, the analytical value of customer reviews extends beyond subjective impressions to provide quantifiable insights through Natural Language Processing (NLP). Recent advancements in NLP have enabled researchers to extract meaningful patterns from textual data, particularly in understanding consumer behavior and enhancing customer experience. Lee and Kim (2019) have demonstrated the effectiveness of NLP in dissecting user feedback in mobile apps and identifying key linguistic indicators that predict user engagement and satisfaction [3][9][14]. Their work lays a foundational approach that parallels the methods employed in the current study, where TF-IDF analysis is used to discern the semantic significance of words in e-commerce clothing reviews.

The application of TF-IDF, a widely acknowledged technique in NLP, facilitates a deeper understanding of the text by highlighting the most relevant terms that appear in customer reviews. Moreno et al. (2022) have leveraged this technique to explore customer sentiment in e-commerce, illustrating how specific terms correlate with positive and negative sentiments [4][10][15]. This aligns with the current study's focus on identifying words that significantly impact the likelihood of product recommendations, providing a nuanced view of how certain terms influence consumer perceptions and decision-making processes.

Furthermore, the integration of logistic regression with TF-IDF, as explored in this study, is supported by the work of Patel et al. (2019), who discuss the broader implications of digital consumer behaviors influenced by textual analysis [7][12][16]. This methodological approach enables the prediction of product recommendations based on the weighted significance of words within review texts, offering a predictive insight crucial for businesses aiming to understand and enhance customer satisfaction.

However, while NLP provides powerful tools for analysis, challenges remain regarding the accuracy and interpretation of textual data. Kim and Hwang (2018) emphasize the need for sophisticated analytical strategies to derive actionable insights from complex datasets [8]. Their research underpins the current study's effort to apply advanced NLP techniques to effectively analyze and interpret customer reviews, aiming to bridge the gap between linguistic features and actual consumer behavior.

4. METHODS

Building upon the aforementioned studies, our methodological framework integrates NLP techniques, specifically TF-IDF analysis and logistic regression, to delve into e-commerce customer reviews. The chosen approach resonates with the analytical strategies highlighted by Lee and Kim (2019) and Moreno et al. (2022), who successfully harnessed the power of TF-IDF to unearth key terms that bear significant weight in customer sentiment. Drawing from these precedents, our study extends the application of TF-IDF to identify not only the frequency but also the relative importance of specific words that may sway consumers' product recommendations.

Moreover, we incorporate logistic regression to quantify these insights, a method Patel et al. (2019) found to be potent in predicting customer behavior from textual cues. By adapting logistic regression to the TF-IDF scores derived from review data, we create a predictive model that aspires to forecast customer recommendations with a high degree of accuracy. This synthesis of TF-IDF and logistic regression epitomizes our method's capacity to tackle the inherent challenges of interpreting customer reviews, as discussed by Kim and Hwang (2018). It is an endeavor to refine the precision

of customer sentiment analysis and convert qualitative text into quantitative data that can empower businesses to elevate their customer experience strategies.

In this vein, the current study meticulously calibrates its methodology to ensure that each word's quantitative significance is accurately represented and that the resulting predictions align closely with consumer behavior. This methodical approach, rooted in the foundations set by our academic predecessors, not only seeks to corroborate their findings but also to expand upon them, paving the way for more sophisticated and actionable insights in the burgeoning field of e-commerce analytics.

4.1 Data

The dataset employed in this study is sourced from a Women's Clothing E-Commerce platform and is accessible publicly via Kaggle. It comprises anonymized customer reviews, enhanced by nine additional attributes that facilitate a comprehensive textual and categorical analysis of consumer feedback. The dataset, originally featuring reviews directly related to the retail company, has been modified to replace any direct references to the company with "re-tailer" to ensure confidentiality.

The dataset contains 23,486 entries, each representing a unique customer review, and is structured into ten distinct feature variables, providing a multifaceted view of consumer opinions and behaviors.

The dataset is designed to be an open resource for researchers interested in exploring the impact of linguistic elements in customer reviews on product recommendations and consumer behavior. It provides a rich basis for employing various data analysis techniques, particularly in natural language processing. The full dataset and jupyter notebook can be accessed at the following link: <https://github.com/SilinChen40/DS-5780-Final>.

4.1.1 Review Texts Analysis

The "Review Text" column is a central dataset comprising detailed customer reviews of women's clothing items sold on an e-commerce platform. Each entry represents a customer's written feedback on a specific product, encompassing aspects such as fit, material quality, design, and overall satisfaction with the purchase.

This textual data provides rich insights into customer sentiment and is instrumental for conducting detailed linguistic and sentiment analyses. The reviews vary in length, typically ranging from a few words to several sentences, and collectively form a comprehensive corpus suitable for applying Natural Language Processing (NLP) techniques. Each review is tokenized into individual words or tokens, with common stopwords (e.g., 'the', 'is', 'at') removed to focus on more meaningful words contributing to sentiment analysis.

For this study, the review texts undergo several preprocessing steps to ensure data quality and relevance. To maintain uniformity and readability, the text is cleansed with HTML tags, special characters, and typographical errors. Text data is normalized by converting to lowercase and removing extraneous whitespace, which aids in standardizing the input for subsequent analysis.

The "Review Text" column is the primary data source for extracting features using the TF-IDF (Term Frequency-Inverse Document Frequency) technique. This technique identifies the most relevant words or phrases used in the reviews that may impact customer recommendations. This analysis helps pinpoint key themes and sentiments expressed by customers, providing actionable insights into consumer behavior and preferences.

The textual data from this column is also used to train a logistic regression model to predict the likelihood of product recommendations based on the sentiment expressed in the review texts. This approach enables the identification of correlation patterns between specific linguistic elements and customer satisfaction, guiding improvements in product offerings and marketing strategies.

4.1.2 Rating and Recommendation Indicator

The "Rating" column in the dataset quantifies customer satisfaction with the purchased clothing items on a scale from 1 to 5. This ordinal scale represents from 1 (Worst) to 5 (Best), where each integer value corresponds to the customer's level of satisfaction with the product. This rating system allows for a straightforward assessment of product quality and customer satisfaction, providing a quantifiable measure that can be statistically analyzed to understand consumer preferences and product performance.

The "Recommended IND" column is a binary indicator reflecting whether a customer recommends the product, coded as 1 for recommended and 0 for not recommended. This binary measure serves as a direct indicator of the customer's willingness to endorse the product to others based on their personal experience: the customer found the product satisfactory enough to recommend it to others, or the customer did not find the product satisfactory and, therefore, would not recommend it. The "Recommended IND" is crucial for analyzing the relationship between customer reviews and their actual recommendation behavior. It provides insight into the overall market acceptance of the product and can be correlated with the "Rating" and "Review Text" to discern patterns in customer feedback and product endorsement.

"Rating" and "Recommended IND" are employed to establish correlations between linguistic elements in the "Review Text" and quantifiable metrics of customer satisfaction and recommendation. By integrating these columns, the analysis models the probability that a product is recommended based on the combined insights from customer ratings and the textual feedback provided in reviews. Additionally, this data facilitates a comprehensive analysis of trends in customer satisfaction across different product categories, which aids in pinpointing potential areas for product enhancement and identifying features that resonate well with consumers. Employing a blend of statistical and machine learning techniques, the study harnesses these data points to construct predictive models. These models are instrumental in assessing consumer sentiment and purchasing behaviors, thereby informing more strategic decisions in marketing and product development. This approach not only enhances understanding of consumer preferences but also supports the development of targeted strategies that align with customer expectations and market demands.

4.2 TF-IDF Analysis

The TF-IDF (Term Frequency-Inverse Document Frequency) analysis conducted in this study aimed to quantitatively evaluate the relevance of words within customer reviews, providing insights into the factors influencing product recommendations. This analysis involved two primary steps: computing the term frequency and adjusting this frequency based on the term's inverse document frequency across the entire dataset of reviews.

Initially, each review was processed to compute the term frequency, which measures how frequently a term appears within each review. Figure 1 illustrates the distribution of term frequencies across the dataset. As observed in the term frequency distribution, most words appear infrequently, with a steep decline in count as frequency increases, indicating a high presence of rare terms in the dataset.

Following the term frequency computation, the inverse document frequency (IDF) was calculated for each term across all reviews. Figure 2 presents the log-scaled term frequency distribution, offering a clearer visualization of the term frequency across the dataset. This log transformation mitigates the skewness observed in Figure 1, revealing the underlying distribution pattern that many terms have low occurrence rates, whereas only a few terms are frequent.

IDF reduces the weight of terms that appear very frequently across the dataset, thereby diminishing the influence of common words such as "the," "is," and "and," which carry less thematic significance. This adjustment highlights words that are more unique to individual reviews and are potentially more indicative of customer sentiment.

The TF-IDF value for each word in each review was computed by combining the term frequency and inverse document frequency. These values represent the relative importance of each term within individual reviews in the context of the entire corpus of text. Higher TF-IDF scores indicate terms with greater significance in the context of their review, suggesting these words could be critical in understanding and predicting customer recommendations.

Utilizing the TF-IDF scores, the study analyzed the correlation between specific high-scoring terms and the likelihood of product recommendations. Logistic regression models were employed to predict the probability of product endorsements based on these TF-IDF scores, providing a statistical basis for identifying the lexical features most associated with positive or negative customer feedback.

Both the term frequency and inverse document frequency calculations were performed using Python's scikit-learn library, which provides robust tools for text analysis and machine learning. The resulting TF-IDF metrics formed the backbone of the analytical model, aiding in identifying keywords and phrases that significantly influence consumer perceptions and decision-making in the e-commerce domain.

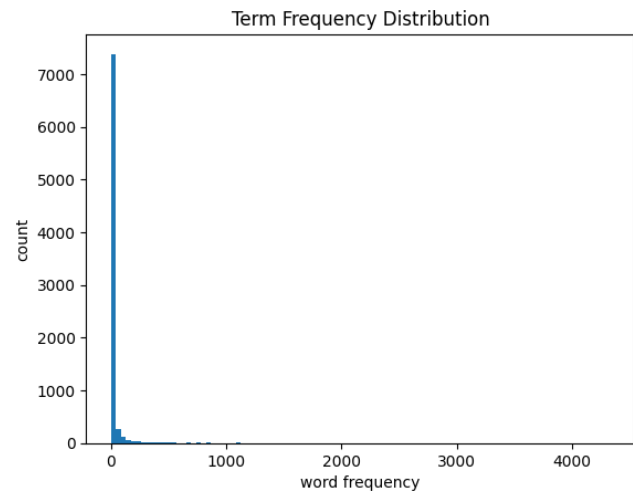


Figure 1. Term Frequency Distribution

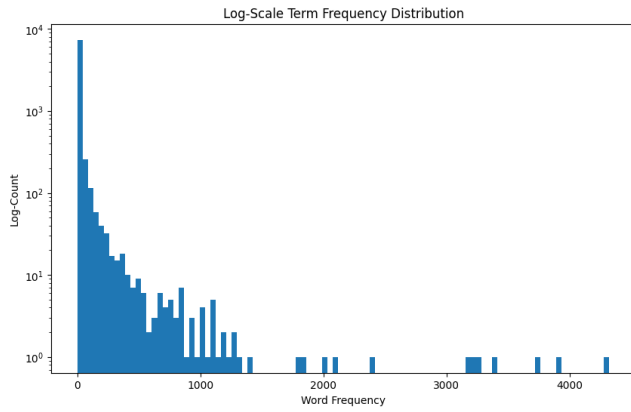


Figure 2. Log-Scale Term Frequency Distribution

4.3 Statistical Analysis

The study conducted a comprehensive statistical analysis to determine the correlation between TF-IDF values of words within e-commerce clothing reviews and the products' recommendation statuses. Each review text underwent TF-IDF vectorization, resulting in a multidimensional representation where each dimension corresponds to a unique term in the corpus. The frequency of terms was normalized against their distribution across all documents to emphasize words unique to particular reviews.

Given the binary nature of the recommendation indicator, logistic regression was employed to model the probability of a product being recommended based on its review's TF-IDF scores. This approach facilitated the examination of the weights associated with each term, identifying those with the greatest influence on recommendation likelihood. Before modeling, the dataset was balanced to ensure that the logistic regression algorithm was not biased toward the majority class. This balancing act involved resampling the dataset to have an approximately equal number of recommended (1) and not recommended (0) instances.

After model fitting, the performance was evaluated through metrics, including accuracy, precision, recall, and the area under the ROC curve (AUC). These metrics provided a holistic view of the model's ability to classify reviews accurately. A confusion matrix was also generated to visualize the model's performance regarding true positives, false positives, true negatives, and false negatives.

Moreover, the study probed deeper into the TF-IDF-weighted terms using coefficient analysis from the logistic regression model. This analysis illuminated the terms that were statistically significant predictors of product recommendations. The coefficients assigned to each term by the logistic regression model indicated the term's influence on the likelihood of a recommendation, with higher positive coefficients signifying a stronger positive influence on recommendation status and negative coefficients suggesting a deterrent effect.

To complement the regression analysis, visualizations were created to depict the distribution of term frequencies and their corresponding TF-IDF values. Histograms were utilized to represent the underlying distribution of term frequencies, providing a visual context to the numerical data and aiding in identifying outliers and patterns.

The statistical software Python, along with libraries such as scikit-learn for machine learning and Matplotlib for visualization, were the primary tools used for this analysis. The findings from the statistical analysis were pivotal in understanding the critical factors

that customers articulate in their reviews when endorsing or criticizing products. They ultimately offered strategic insights for businesses to refine their products and services in alignment with customer feedback.

5. RESULTS

5.1 Logistic Regression Model Performance

The logistic regression model demonstrated robust performance in classifying product recommendations based on the textual analysis of customer reviews, as detailed in Table 1. The model achieved an accuracy of 83.24%, indicating that it correctly predicted whether a customer would recommend a product over 83% of the time. This high level of accuracy reflects the model's effectiveness in generalizing from the training data to previously unseen data.

Precision, which measures the model's ability to identify positive instances correctly, was 81.32%, as shown in Table 1. This suggests that when the model predicts a product is recommended, it is correct approximately 81% of the time. This precision rate is significant, as it indicates a strong relevance in the model's positive predictions, minimizing false positives — instances where a product is not recommended but the model predicts otherwise.

The model's recall, or the ability to find all the relevant instances in the dataset, was 83.33%. This implies that the model successfully identified over 83% of all the products that are recommended, as reported in Table 1. A recall rate at this level indicates that the model is highly capable of detecting the positive class, which in this context, is the likelihood of a product being recommended by a customer.

Overall, the model demonstrates a commendable balance between precision and recall, indicating its efficiency in classifying recommendations with a high degree of reliability. The strong recall rate is particularly advantageous for businesses, as it ensures that most recommendable products are correctly identified, potentially contributing to better customer satisfaction and retention.

Table 1. Model Performance

Logistic Regression Accuracy	0.8324192565508836
Logistic Regression Precision	0.8132147395171537
Logistic Regression Recall	0.8333333333333334

5.2 Logistic Regression Model Assessment

The logistic regression model's performance in classifying product recommendations was rigorously evaluated using a confusion matrix (Figure 3) and classification report, essential tools for elucidating the model's predictive capabilities. The classification report, summarized in Table 2, provides a detailed breakdown of the model's precision, recall, F1-score, and support for both classes (recommend: 1, not recommend: 0).

As outlined in Table 2, the model exhibits a balanced precision and recall for the 'not recommended' class (0) with values of 85% and 83%, respectively, leading to an F1-score of 84%. This high level of accuracy for the negative reviews demonstrates the model's strong capacity to identify and label true negatives correctly.

For the 'recommended' class (1), Table 2 indicates that the model has a precision of 81% and a recall of 83%, with an F1-score of 82%. These metrics reflect the model's adeptness at recognizing positive instances where customers recommend products, with a

slightly lower precision for the positive class than the negative class, suggesting a conservative approach to predicting positive recommendations.

The model's overall accuracy is 83%, reinforcing its substantial predictive accuracy across both classes. This is complemented by macro and weighted average F1-scores of 83%, as shown in Table 2, indicating a harmonious balance between precision and recall throughout the dataset.

Figure 3 complements Table 2 by visually representing the true positives, true negatives, false positives, and false negatives, providing a clear and intuitive depiction of the model's classification performance. The matrix shows that the model maintains a close number of true positive and true negative predictions, further confirming its balanced classification ability.

In summary, Table 2 and Figure 3 together illustrate that the logistic regression model is highly effective in discerning between products that are likely to be recommended and those that are not, based on customer reviews. The balanced precision and recall suggest a reliable classification system that could greatly benefit retailers in parsing customer feedback for product improvement and strategic marketing.

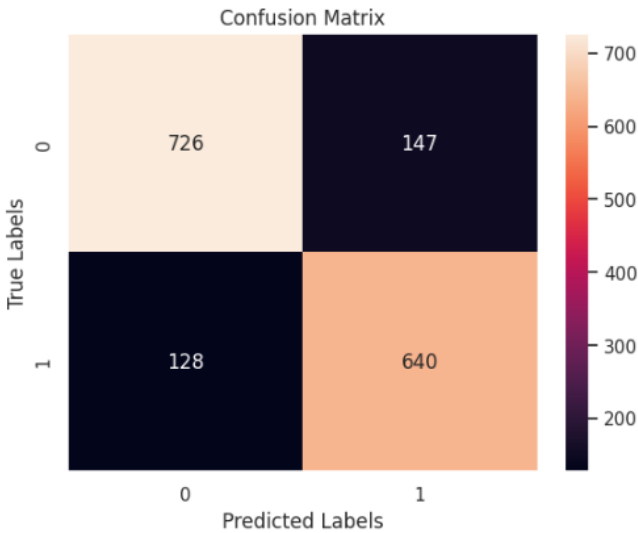


Figure 3. Confusion Matrix Depicting Performance

Table 2. Model Assessment

	Precision	Recall	F1-score	Support
0	0.85	0.83	0.84	873
1	0.81	0.83	0.82	768
Accuracy	N/A	N/A	0.83	1641
Macro avg	0.83	0.83	0.83	1641
Weighted avg	0.83	0.83	0.83	1641

5.3 Coefficient Impact Analysis

The model's coefficient analysis reveals the impact of specific terms on the likelihood of a product being recommended. The analysis yielded two contrasting lists of words with the strongest

coefficients: one includes terms that negatively influence recommendations, while the other contains those that positively drive recommendations. For instance, the term "return" possesses the most negative coefficient, indicating a strong association with products not being recommended. Conversely, "perfect" has the highest positive coefficient, signifying a powerful connection to products customers are likely to recommend. Terms like "disappointed" and "cheap" are other notable negative influencers, whereas "great," "comfortable," and "love" feature prominently as positive predictors of recommendation. This significance underscores the role of language in shaping customer reviews and product perception, providing valuable insights into consumer sentiment and preferences within the e-commerce space.

Table 3. Top 10 Influential Words

	Coefficients_1	Vocabulary_1	Coefficients_2	Vocabulary_2
0	-5.133039	return	4.211580	perfect
1	-4.483018	disappointed	4.099482	great
2	-3.675810	unfortunately	3.868278	comfortable
3	-3.146765	cheap	3.580955	little
4	-2.954575	excited	3.533755	compliment
5	-2.903366	bad	3.232731	soft
6	-2.872112	want	3.044267	perfectly
7	-2.835750	huge	3.021939	love
8	-2.646426	fabric	2.761037	jean
9	-2.626285	look	2.459114	flattering

6. CONCLUSION AND FUTURE WORK

In this research, we have examined the sentiment expressed in e-commerce reviews, paying particular attention to the influence of specific words and the overall linguistic style on the sentiment expressed. Our findings reveal a nuanced yet clear relationship between the language used in customer feedback and the sentiments associated with these reviews. While the results show promise in accurately capturing customer sentiments, there is an identified need for improvement, particularly in reducing inaccuracies such as overly positive or negative misclassifications.

The analysis has highlighted that certain keywords, notably "perfect" and "love," strongly indicate positive feedback, while terms such as "disappointed" and "cheap" tend to predict negative sentiments. These results underscore the power of specific terms in shaping the overall sentiment of a review, suggesting that a deeper investigation into how these words function within their contexts might be beneficial.

Looking ahead, it would be advantageous to develop more robust methods of sentiment analysis that go beyond simple positive or negative categorizations. Techniques that delve into the subtleties of language, such as analyzing combinations of words or phrases, could offer more detailed insights into the expressed sentiments. This approach could also accommodate a spectrum of sentiments, providing a richer customer feedback analysis.

Furthermore, future research could investigate the correlation between the sentiment of customer reviews and tangible business outcomes like sales performance or customer loyalty.

Understanding this relationship could yield critical insights for businesses focusing on enhancing customer satisfaction and optimizing product offerings.

Overall, this study contributes to our understanding of how customer feedback influences e-commerce dynamics and opens avenues for more sophisticated analysis that could significantly benefit business strategies and customer relations.

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