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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

CLASSIFICATION OF TOGG CUSTOMER COMPLAINTS USING BERTOPIC ISSUE MODELLING TECHNIQUE

BERTOPİC KONU MODELLEME TEKNİĞİ KULLANILARAK TOGG MÜŞTERİ ŞİKAYETLERİNİN SINIFLANDIRILMASI

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ABSTRACT

In the study, TOGG's 500,000 user messages are analyzed using the BERTopic topic modeling technique; the resulting data reveals that customer dissatisfaction is concentrated in financial (banking operations), technical (vehicle ınformation, software error, android compatibility), operational (online shopping), and service (delivery process, logistics problem) domains. The temporal variation of the complaints reflects the influence of periodic fluctuations and external factors, while the dendrogram analysis, by identifying the thematic proximities of topics, unveil the multidimensional nature of the customer experience. The findings emphasize the necessity for TOGG to address customer complaints through an integrated strategic planning process to create a competitive advantage. In the future, it is recommended to further enhance the application of BERTopic in Turkish by incorporating additional feedback from various data sources.

Keywords: Artificial Intelligence, Customer Complaints, BERTopic Topic Modelling, Electric Vehicle User Experience.

JEL Classification Codes: C45, L62, M31.

ÖZ

Bu çalışmada, TOGG'un 500,000 kullanıcı mesajı, BERTopic konu modelleme tekniği kullanılarak analiz edilmiş; elde edilen veriler, müşteri memnuniyetsizliğinin finansal (banka işlemleri), teknik (araç bilgileri, yazılım hatası, android uyumu), operasyonel (online alışveriş) ve hizmet (teslimat süreci, lojistik problemi) alanlarında yoğunlaştığını ortaya koymuştur. Şikayetlerin zamansal değişimi, dönemsel dalgalanmaların ve dışsal faktörlerin etkisini yansıtırken, dendrogram analizi, konuların tematik yakınlıklarını belirleyerek çok boyutlu müşteri deneyimini gözler önüne sermiştir. Bulgular, TOGG'un rekabet avantajı yaratabilmesi için müşteri şikayetlerini bütüncül bir stratejik planlama süreciyle ele almasının gerekliliğini vurgulamaktadır. Gelecekte, farklı veri kaynaklarından elde edilecek ek geri bildirimlerle BERTopic'in Türkçe uygulamalarının daha da geliştirilmesi önerilmektedir.

Anahtar Kelimeler: Yapay Zekâ, Müşteri Şikâyetleri, BERTopic Konu Modellemesi, Elektrikli Araç Kullanıcı Deneyimi.

JEL Sınıflandırma Kodları: C45, L62, M31.

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EXTENDED SUMMARY

Purpose and Scope:

The main objective of the study is to analyze customer complaints about Türkiye's domestic automobile brand, TOGG, shared on digital platforms, and to reveal the themes around which these complaints are concentrated. The advanced topic modeling method, BERTopic, which is based on natural language processing, is used to make sense of large-volume text data where traditional methods fall short. The study comprehensively addresses the financial, technical, and operational elements prominent in the user experience from a holistic perspective. Furthermore, evaluating BERTopic's performance on Turkish data and demonstrating the contribution of this method to customer complaint analysis are also among the research objectives. In this context, the results obtained are aimed at contributing to the academic literature and shedding light on the strategic decision-making processes of new brands like TOGG. For this purpose, 500,000 user messages obtained from the Telegram platform using the web scraping method are analyzed.

Design/methodology/approach:

In the study, user messages regarding the TOGG brand are thematically classified using the BERTopic topic modeling technique. The dataset consists of 500,000 messages collected from the Telegram platform using web scraping, and texts containing date information are used for time-based analysis. The texts are underwent standard preprocessing steps (cleaning of punctuation and stop words), but stemming and lemmatization are consciously avoid to preserve semantic integrity. For vectorization of the texts, the 'paraphrase-multilingual-mpnet-base-v2' model, whose effectiveness on the Turkish language is also referenced by Koruyan (2022), is used. To enhance the strength of topic representations, 1-2-grams are created via the Scikit-learn library to capture common Turkish noun phrases. For topic discovery, a large number of granular topics are initially generated with a low min_topic_size value of 15, and then these topics are merged using an automated reduction procedure, targeting a final theme count of 20. This approach ensures the derivation of strategically meaningful and interpretable final topics. Outlier topics marked as '-1' by the model are reassigned to their most probable topics with a probability threshold of 0.01. Furthermore, a dynamic topic modeling method is also applied to analyze the temporal trends of the complaints, with each topic being examined on a monthly basis. This allows for the tracking of trends.

Findings:

The examination of 500,000 user messages about TOGG, analyzed using the BERTopic method, results in the identification of 13 main topic clusters and one outlier group. 32.04% of the complaints are concentrated in the "Banking Transactions" cluster, with issues such as credit score, insurance cancellation, and interest-bearing loans being prominent. This indicates that users experience significant dissatisfaction not only with product performance but also with the financial processes associated with the vehicle. Complaints grouped under the "Vehicle Information" heading specifically focus on technical details such as range, battery capacity, and charging time; this reveals that a lack of information regarding electric vehicles negatively affects the customer experience. Although at lower rates, issues like the online shopping experience, delivery process, software updates, navigation errors, and Android incompatibilities are also among the dissatisfaction topics frequently raised by users. Especially complaints concerning software and mobile applications point to situations where the technological infrastructure falls short of meeting user expectations. The outlier cluster, which constitutes 60.77% of the data and carries no significant theme, consists of short, contextually disconnected phrases frequently encountered in social media- based analyses and requires careful management during the modeling process. Furthermore, the dynamic analysis results show a significant increase in complaints during certain periods of the year, especially when campaign and delivery processes intensified. All these findings reveal that customer complaints concentrate not only on the product itself but also in multi-dimensional areas such as finance, technical support, logistics operations, and digital communication, and that TOGG needs to develop a holistic satisfaction strategy in this regard.

Conclusion and Discussion:

The study analyzes customer complaints about the TOGG brand through the topic modeling technique, BERTopic, revealing the multi-dimensional structure of customer dissatisfaction. The findings indicate that complaints are not limited solely to technical issues but concentrate in various areas such as financial transactions, software errors, delivery processes, digital compatibility, and campaign management. The frequent discussion of financial issues, particularly credit allocation, insurance cancellation, and interest rates, suggests that electric vehicle users value not only product performance but also the surrounding financial services. Time series analyses observe an increase in specific complaint topics during certain periods, suggesting this could be related to external factors such as economic conditions, campaign periods, and the supply chain. The dendrogram analysis clusters thematically similar complaints, demonstrating that financial transactions and technical issues are often considered interconnected. All these results indicate that TOGG should address customer complaints not merely as a feedback mechanism but as a fundamental element of a holistic improvement strategy. Especially as a newly established brand, TOGG's adoption of a multi-faceted management approach - from financial processes to technical support, digital communication to logistics operations - would play a critical role in increasing customer satisfaction and loyalty. Furthermore, the findings of the study demonstrate that advanced text mining techniques like BERTopic can be effectively used with Turkish datasets, shedding light on new research in the area.

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GENİŞLETİLMİŞ ÖZET

Amaç ve Kapsam:

Bu çalışmanın temel amacı, Türkiye'nin yerli otomobil markası TOGG hakkında dijital ortamlarda paylaşılan müşteri şikâyetlerini analiz ederek, bu şikâyetlerin hangi temalar etrafında yoğunlaştığını ortaya koymaktır. Geleneksel yöntemlerin yetersiz kaldığı büyük hacimli metin verilerinin anlamlandırılması amacıyla, doğal dil işleme tabanlı gelişmiş bir konu modelleme yöntemi olan BERTopic kullanılmıştır. Çalışmada, kullanıcı deneyiminde öne çıkan finansal, teknik ve operasyonel unsurlar bütüncül bir bakış açısıyla ele alınmıştır. Ayrıca, BERTopic'in Türkçe veriler üzerindeki performansının değerlendirilmesi ve bu yöntemin müşteri şikâyet analizlerinde nasıl bir katkı sunduğunun ortaya konulması da araştırmanın amaçları arasında yer almaktadır. Bu bağlamda, elde edilen sonuçların hem akademik literatüre katkı sağlaması hem de TOGG gibi yeni markaların stratejik karar alma süreçlerine ışık tutması hedeflenmiştir. Bu amaçla da telegram platformundan web scraping yöntemi ile elde edilen 500,000 kullanıcı mesajı analiz edilmiştir.

Yöntem:

Bu çalışmada, TOGG markasına yönelik kullanıcı mesajları, BERTopic konu modelleme tekniği ile tematik olarak sınıflandırılmıştır. Veri seti, Telegram platformundan web scraping yöntemiyle toplanan 500.000 mesajdan oluşmaktadır ve analizde zaman bazlı inceleme için tarih bilgisi içeren metinler kullanılmıştır. Metinler, standart ön işleme adımlarından (noktalama ve durak kelimelerin temizlenmesi) geçirilmiş, ancak anlam bütünlüğünü korumak amacıyla kök alma ve gövdeleme işlemlerinden bilinçli olarak kaçınılmıştır. Metinlerin vektörleştirilmesi için, Türkçe dili üzerindeki etkinliği Koruyan (2022) tarafından da referans gösterilen paraphrase-multilingual-mpnet-base-v2 modeli kullanılmıştır. Konu temsillerinin gücünü artırmak amacıyla, Scikit-learn kütüphanesi aracılığıyla Türkçedeki yaygın isim tamlamalarını yakalamak için 1-2'li n-gramlar oluşturulmuştur. Konu keşfi için, min_topic_size 15 gibi düşük bir değerle başlangıçta çok sayıda granüler konu üretilmiş, ardından bu konular otomatik bir indirgeme prosedürü ile nihai tema sayısı 20 olarak hedeflenerek birleştirilmiştir. Bu yaklaşım, stratejik olarak anlamlı ve yorumlanabilir nihai konuların elde edilmesini sağlamıştır. Model tarafından "-1" olarak işaretlenen aykırı konular ise, 0.01'lik bir olasılık eşiğiyle en olası konularına yeniden atanmıştır. Ayrıca, şikayetlerin zamansal eğilimlerini analiz etmek amacıyla dinamik konu modelleme yöntemi de uygulanarak, her konu aylık bazda incelenmiştir. Böylece eğilimlerin takip edilmesine olanak sağlanmıştır.

Bulgular:

BERTopic yöntemiyle analiz edilen, TOGG hakkındaki 500,000 kullanıcı mesajının incelenmesi sonucunda, 13 ana konu kümesi ve bir aykırı grup belirlenmiştir. Şikâyetlerin %32.04'ü "Banka İşlemleri" kümesinde toplanmış, kredi skoru, sigorta iptali ve faizli kredi gibi konular öne çıkmıştır. Bu durum, kullanıcıların sadece ürün performansı değil, aynı zamanda araçla ilişkili finansal süreçlerden de ciddi düzeyde memnuniyetsizlik yaşadığını göstermektedir. "Araç Bilgisi" başlığı altında toplanan şikâyetler ise özellikle menzil, batarya kapasitesi ve şarj süresi gibi teknik detaylara yönelmiştir; bu durum, elektrikli araçlarla ilgili bilgi eksikliğinin müşteri deneyimini olumsuz etkilediğini ortaya koymaktadır. Daha düşük oranlarda da olsa, çevrimiçi alışveriş deneyimi, teslimat süreci, yazılım güncellemeleri, navigasyon hataları, Android uyumsuzlukları gibi konular da kullanıcıların sıkça gündeme getirdiği memnuniyetsizlik başlıkları arasında yer almıştır. Özellikle yazılım ve mobil uygulamalara yönelik şikâyetler, teknolojik altyapının kullanıcı beklentilerini karşılamada yetersiz kaldığı durumlara işaret etmektedir. Verilerin %60.77'sini oluşturan ve anlamlı bir tema taşımayan aykırı küme ise sosyal medya temelli analizlerde sıkça karşılaşılan, bağlamdan kopuk kısa ifadelerden oluşmakta ve modelleme sürecinde dikkatle yönetilmesi gereken bir yapıya sahiptir. Ayrıca dinamik analiz sonuçları, yılın belli dönemlerinde, özellikle kampanya ve teslimat süreçlerinin yoğunlaştığı zamanlarda şikâyetlerin ciddi şekilde arttığını göstermiştir. Tüm bu bulgular, müşteri şikâyetlerinin sadece ürün bazlı değil, aynı zamanda finans, teknik destek, lojistik operasyonlar ve dijital iletişim gibi çok boyutlu alanlarda yoğunlaştığını ve TOGG'un bu kapsamda bütüncül bir memnuniyet stratejisi geliştirmesi gerektiğini ortaya koymaktadır.

Sonuç ve Tartışma:

Bu çalışma, TOGG markasına yönelik müşteri şikâyetlerini konu modelleme tekniği olan BERTopic aracılığıyla analiz ederek, müşteri memnuniyetsizliğinin çok boyutlu yapısını ortaya koymuştur. Elde edilen bulgular, şikâyetlerin yalnızca teknik sorunlarla sınırlı kalmadığını; finansal işlemler, yazılım hataları, teslimat süreçleri, dijital uyumluluk ve kampanya yönetimi gibi çeşitli alanlarda yoğunlaştığını göstermektedir. Özellikle kredi tahsisi, sigorta iptali ve faiz oranları gibi finansal konuların sıkça dile getirilmesi, elektrikli araç kullanıcılarının sadece ürün performansına değil, aynı zamanda süreci çevreleyen finansal hizmetlere de önem verdiğini göstermektedir. Zaman serisi analizlerinde bazı dönemlerde belirli şikâyet konularında artış gözlemlenmiş, bu durumun ekonomik koşullar, kampanya dönemleri ve tedarik zinciri gibi dışsal faktörlerle ilişkili olabileceği değerlendirilmiştir. Dendrogram analizi ise tematik açıdan yakın olan şikâyetlerin kümelenmesini sağlayarak, finansal işlemler ile teknik konuların çoğu zaman birbiriyle bağlantılı değerlendirildiğini ortaya koymuştur. Tüm bu sonuçlar, TOGG'un müşteri şikâyetlerini yalnızca bir geri bildirim aracı olarak değil, aynı zamanda bütüncül bir iyileştirme stratejisinin temel unsuru olarak ele alması gerektiğini göstermektedir. Özellikle yeni konumlanan bir marka olarak TOGG'un finansal süreçlerden teknik desteğe, dijital iletişimden lojistik operasyonlara kadar çok yönlü bir yönetim yaklaşımını benimsemesi, müşteri memnuniyetini ve sadakatini artırmada kritik rol oynayacaktır. Ayrıca, bu çalışmada elde edilen bulgular, BERTopic gibi gelişmiş metin madenciliği tekniklerinin Türkçe veri setlerinde etkin şekilde kullanılabileceğini göstermekte ve bu alanda yapılacak yeni araştırmalara ışık tutmaktadır.

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1. INTRODUCTION

Customer complaints are defined as any expression of dissatisfaction made by consumers when an item is not up to their expectations, with regard to either the products or the services offered. These complaints are very serious signals of the customer's dissatisfaction and provide feedback for the management of goods and services (Morgeson et al., 2023). Organizations should not view complaints merely as problems; they should be thought of as opportunities for improvement and innovation. With the right management of customer complaints, firms can enhance their operational processes to raise customer satisfaction and retention levels (Pio et al., 2023). In this regard, a proactive (preventive) complaint management style can yield long-term benefits to customers and businesses alike by turning negative experiences into positive ones (Davidow, 2020).

The complaints that customers make regard, specifically, exchanges on products, returns, employees' behaviors, and delays in service. The type of complaints can impact the relationship between a customer and the business directly; when issues are not resolved there might be customer attrition and negative word-of-mouth communications, whereas effective complaint management might enhance customer loyalty and give the business a competitive edge in the market (Frasquet et al., 2021). Inherent in the notions surrounding complaints of management are the assumptions that identifying customers' complaints has not only removed dissatisfaction but promoted the reputation of the brand and its positioning in the market (Carlson et al., 2023).

In today's highly competitive market, customer satisfaction-based strategies are crucial. However, programs executed without proper consideration can lead to unintended negative consequences that affect multiple areas of the business. Customer satisfaction is recognized as one among several essential tools that underpin customer loyalty (Uyar, 2019); but after-sales services have emerged not just as a facilitator of customer support but also among the very few determinants of gaining competitive advantage (Güllülü & Bilgili, 2011). These businesses building up customer loyalty over the long run through the use of customer-oriented strategies are really an extension of service quality. Research suggests that customer-oriented approaches exhibit strong associations with perceived service quality (Soysal, 2015). Therefore, effective management of customer complaints is not just a mere problem-solving procedure, but a strategic factor by which firms can gain competitive advantage (Uyar, 2019).

Effective implementation of customer complaint management is critically necessary for newly established firms or those that are trying to consolidate their market position (Bengül, 2019). Negative impression sourced from customers' first engagements with a company can weaken its brand in the market; on the other hand, quick and effective solutions to customer complaints can become an advantage over competitors. Customers are more committed when their problems have been resolved, which is highly favorable for sales. Customers that complain and get responses to their complaints will become more loyal to the brand compared with those who have never complained (Yapraklı & Mutlu, 2022). In this sense, companies that analyze customer complaints and devise dynamic solutions to them can establish a strong position in the market.

Because of the advent of the Internet and social networks, customers today can voice their grievances in some very powerful ways. Websites, blogs, forums, and social media are digital manifestations of the age-old word-of-mouth communication through which customers air complaints (Arora & Chakraborty, 2020). Online complaints provide instant feedback and allow businesses to study patterns of customer dissatisfaction, while also assisting in developing a method of complaint management that is more effective in the simplest of terms (Sugathan et al., 2018). Complaint redressal, in this context, is outlined by virtue of the online channels that could act as a form of immediacy and accessibility for businesses in addressing the grouse of customers (Golmohammadi et al., 2021).

The rising number of customer complaints does not merely call for effective ways of data analysis- it also requires their classification so as to be channeled appropriately to specific departments for resolution within an acceptable time frame, thus hopefully enhancing customer satisfaction (Carlson et al. 2023). In other words, the complaint classification and redirection should facilitate quick resolution and improve customer satisfaction. However, the traditional approach fails to analyze enormous quantities of unstructured customer complaint data. Therefore, innovative data analysis methods are being introduced into a business environment with superior insights into customer attitude and behavior.

Machine learning and natural language processing (NLP) techniques provide significant opportunities to analyze customer complaints more efficiently through extracting meaningful patterns from larger data. Particularly, advanced topic modeling techniques like BERTopic have optimized classifying and analyzing customer complaints, thus enabling better decision-making in business. BERTopic identifies the most salient words in texts

through a class-based Term Frequency-Inverse Document Frequency. Due to its ability to allow companies to track changing customer expectations over time and acquire a better understanding of trends in complaints, it has been said that BERTopic assists in customer complaint analysis. The study illustrated that BERTopic helps in the dynamic analysis of complaints, the tracking of changes over time, and the identification of other key drivers for customer dissatisfaction.

The study's primary goal involves analyzing and categorizing customer complaints regarding TOGG's (Türkiye's Automobile Initiative Group) newly-established brand, mainly utilizing the advanced BERTopic technique. Since effective management of customer feedback is one of the critical issues that shape the perception of an emerging brand, such analysis aims to give insight into the performance improvement processes of TOGG's aided by product and service customer satisfaction and loyalty behaviors. In this scope, this will find through advanced topic modeling when, where, and in what timeframe issues appear concerning products or services based on customers' feedback in order that businesses helpfully respond to resolve any arising issues. Additionally, given that it is one of the first applications to Turkish, the utilization of the BERTopic Method would provide this particular study with a significant contribution to the literature.

2. LITERATURE

A plethora of studies aiming at customer complaint classification among various sectors has been well documented in the literature, employing ML algorithms in Turkish and other languages. However, BERTopic, other than attaching customer complaints directly into several categories, attempts to provide and explain the subjects dealt with in the customer complaints. Being completely different from the traditional ways of classification, BERTopic is a relatively new way of dealing with TM in the scientific literature. This section will briefly present examples of recent studies on classifying customer complaints via machine learning techniques and explain in detail the BERTopic technique.

2.1. Classification of Customer Complaints

Supervised machine learning or ML techniques have proven widely popular in the classification of customer complaints, with numerous studies showing their success rate. For instance, Bayesian Networks, Logistic Regression, Random Forest (RF), Convolutional Neural Networks (CNN), and Long Short-Term Memory (LSTM) networks provided effective classifying techniques for complaints. HaCohen-Kerner and others (2019) Lu were integrated with the feature selection methods to produce a higher accuracy rate when using a combination of supervised learning algorithms to classify the customer complaints in the telecommunications area. At the same time, Gupta et al. (2021) extended this theory by applying CNNs for the purpose of sentiment analysis of customer feedback, showing how the model was able to capture intricate patterns in textual data. On the other hand, Sänn et al. (2021) looked into using the LSTM networks in the classification of complaints from the e-commerce area, highlighting how the model had worked towards sequential data classification and allowed the possibility of contextual understanding within complaints. Together, these studies highlight the versatility and effectiveness of supervised machine learning techniques for classifying customer complaints across many industries.

In contrast to supervised methods, unsupervised machine learning techniques, and very specifically Latent Dirichlet Allocation (LDA), have also proven useful in tackling the classification of customer complaints. LDA is a generative statistical model that helps identify latent topics from within a corpus of documents. Karami and Pendergraft in (2018) demonstrated the applicability of LDA in the insurance complaints of customers by identifying central themes within customer complaints that were useful in improving corresponding services. Their findings suggest that LDA effectively summarizes huge portions of text, simultaneously providing insights into improving customer service. These case studies convey a look into the world of practical benefits that other unsupervised methods such as LDA have to offer in the extraction of valuable information from unstructured complaint data, thus creating a better understanding and settlement of customer issues.

Research on Turkish customer complaint classification has recently turned to different algorithms such as LSTM, TF-IDF, Word2Vec, and LDA. In this regard, Bayrak et al. (2021) developed a model based on LSTM techniques for the classification of Turkish customer complaints and used it to obtain promising results regarding the flexibility of the model for the Turkish language. Further advances to the domain were done by Bozyiğit et al. (2022), exploiting TF-IDF and Word2Vec methods for customer feedback sentiment analysis and showcasing the impact of feature extraction methods on enhancing classification accuracy. In addition, İlhan Omurca et al. (2021) investigated LDA for classifying complaints in Türkiye and provided insights into the thematic structure of

customer feedback. More recently, logistic regression analysis on e-commerce platforms by Akbıyık and Arı (2022) illustrates other growing interests in this developing area while highlighting the need for effective classification methods proposed for the Turkish context. Collectively, these studies illustrate the variegated methodologies in this domain of the classification of Turkish customer complaints and show that this domain of research is gradually advancing.

2.2. Topic Modelling: BERTopic

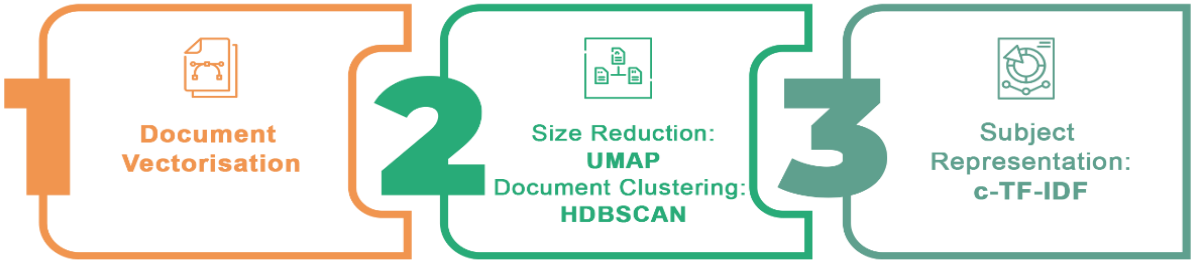
Topic modeling techniques are, indeed, great tools that summarize and organize large volumes of textual data. Traditional methods of TM have included LSA, PLSA, NMF, and, of course, LDA, which seek to identify hidden topics in documents and measure the relations between them. Among these, LDA is the most prominently utilized approach. This is attributed to its ability to relate a mixture distribution of topics across the various documents, providing insight and perspective on the theme-oriented structure to text documents (Shou et al., 2022). By relying on such techniques, researchers are thereby able to discover latent themes and patterns that could inform the decision-making processes in many areas, such as customer service or feedback analysis.

The emergence of pre-trained language models (PLMs) has revolutionized the field of natural language processing (NLP) and significantly enhanced the capabilities of topic modeling techniques. One such innovation is BERTopic**,** originally introduced by Grootendorst (2022)**,** which performs topic modeling by integrating the strengths of PLMs with the class-based TF-IDF (c-TF-IDF) method. By leveraging PLMs, BERTopic captures contextual information and semantic relationships within text, leading to more coherent and meaningful topic representations (Yang et al., 2021). The development of BERTopic runs in parallel with another topic modeling technique, Top2Vec, which also emphasizes the importance of word embeddings in the extraction of latent topics (Alrumiah & Al-Shargabi, 2022). The integration of PLMs into topic modeling frameworks marks a significant advancement, enabling researchers to analyze textual data with greater precision and depth.

BERTopic has been favored particularly for its ability to generate more coherent and meaningful topics in short, contextual, and unstructured texts compared to traditional methods. Classical models such as LDA and LSA, which operate without considering context, often fall short in capturing the deep semantic relationships embedded in the text. In contrast, BERTopic leverages pre-trained language models (PLMs) to construct contextual vector representations, leading to more consistent and semantically rich topic clusters (Grootendorst, 2022). Egger and Yu (2022) showed that BERTopic outperformed traditional methods such as LDA and NMF in short and noisy text sources like social media. Similarly, Abuzayed and Al-Khalifa (2021) reported that BERTopic achieved higher semantic coherence and topic integrity in Arabic texts. Moreover, Mendonça and Figueira (2024) demonstrated that BERTopic generated more stable and meaningful topics than LDA in political discourse analysis. These findings provide a methodological justification for choosing BERTopic, particularly in datasets where contextual depth is crucial.

BERTopic runs in three fundamental stages: document vectorization (embedding), document clustering, and topic representation. First of all, it uses Sentence-BERT, a contextualized embedding model of sentences capable of capturing their semantic meaning, to embed the documents. Next, UMAP is performed to reduce the dimensionality of the embedded documents, after which HDBSCAN is applied to cluster the similar documents effectively. This clustering process yields different, unique topics that are present in the dataset. Then, the c-TF-IDF is applied in order to represent the found topics, clearly and interpretable in terms of thematic content. This systematic procedure means that BERTopic returns solid topic modeling results, making it worthwhile for researchers and practitioners alike.

Figure 1. BERTopic Topic Modelling Process



Key to BERTopic is the c-TF-IDF, a method to improve traditional TF-IDF that incorporates contextual information. While classical TF-IDF treats terms as independent, c-TF-IDF recognizes the co-occurrences of terms in the same document, giving better representations of topics (Jalal & Ali, 2021). This contextual awareness creates a better understanding of the interactions between terms and topics and improves the quality of the topics produced. The merits of c-TF-IDF for representing topics are most apparent when dealing with short text applications, where traditional methods would likely provide little insight. With c-TF-IDF's novel perspective, BERTopic stands to improve the interpretativeness and relevance of topic modeling results tremendously.

BERTopic has several advantages that make it a desirable method for topic modeling. A principal strength of BERTopic is that it does not require users to specify the number of topics in advance, achieving the development of the thematic structure of the data more expeditiously. Additionally, it has also proven effective with dealing with short texts-which are a problem in traditional topic modeling techniques (Jiang et al., 2021). In addition, its ability to work over different languages further allows users to apply the model across different linguistic contexts. However, there are also still some disadvantages of BERTopic. One potential issue may arise from a tendency to produce a large number of topics-it would not be easy to provide interpretations for them. In addition, there are no objective evaluation metrics to suggest the quality of the produced topics, thereby making it a very responsible decision for the beginners. These advantages and shortcomings show the importance of careful consideration in actual applications for the enhanced understanding of what BERTopic can do well and where there are limitations.

Table 1. Relevant Studies

Authors and Year	Topic
Qi et al. (2024)	The current study employs BERTopic to understand perspectives relating to artificial intelligence in the light of the post-ChatGPT era, identifying 232 topics based on 33,912 Reddit comments. The analysis into the technical and societal dimensions indicates how different communities exhibit enthusiasm and concern about AI.
Gupta et al. (2024)	This study explores generative AI research using BERTopic, analyzing 1,319 academic records collected from the Scopus database (1985–2023). The study identifies seven topic clusters, including image processing, content generation, data privacy, cognitive inference, and engineering.
Farzadnia et al. (2024)	This study examines customer reviews of flight classes by analyzing 49,320 airline passenger reviews using Latent Dirichlet Allocation (LDA), Latent Semantic Indexing (LSI), and Hierarchical Dirichlet Process (HDP). The findings highlight differences in service expectations and satisfaction levels among economy, business, and first-class passengers.
Chagnon et al. (2024)	This study evaluates topic modeling performance in scientific articles by developing a tool called BERTeley and assessing the effectiveness of the BERTopic method in processing scientific texts. Experiments conducted using three datasets compare different language models to determine the most suitable approaches for scientific literature.
Ahammad (2024)	This study investigates hidden patterns in COVID-19 misinformation, combining sentiment analysis (SA) and topic modeling (TM) techniques to analyze 10,254 news headlines. Using LDA, the study identifies 20 negative and 18 positive topics, showing that misinformation is primarily centered around vaccines, crime, quarantine, medicine, and politics.
Jiang et al. (2024)	This study examines news storytelling preferences, identifying topics in 6,632 YouTube videos on CGTN using BERTopic from May 2021 to August 2023. The findings indicate that international audiences are more interested in geopolitics and technology, while showing less interest in Chinese culture and social news.
Khodeir & Elghannam (2024)	This study identifies urgent student posts in MOOC forums using BERTopic and traditional topic modeling techniques, analyzing 6,415 emergency posts. Comparisons reveal that NMF and BERTopic provide higher consistency than other models and better identify the reasons behind urgent postings.
Ocal (2024)	This study explores social media perceptions of AI's future, analyzing 16,611 Reddit comments and 998 threads using BERTopic and BERT sentiment analysis models. The findings reveal how public expectations and concerns about AI evolve over time.
Mahdikhani (2023)	This study analyzes Amazon fashion reviews using LDA and TF-IDF vectorization to identify frequently used terms and predict review helpfulness. The findings indicate that fabric quality, sizing information, and price significantly influence review helpfulness.
Arslan & Cruz (2023)	This study classifies business news using natural language processing (NLP) techniques to develop a text relevance hierarchy framework. The five-level framework aims to assist companies in evaluating business news relevance by using named entity recognition, topic modeling, and similarity analysis to prioritize and manage business news more effectively.

Authors and Year	Topic
Saidi et al. (2022)	This study classifies cyber-terrorist communities, analyzing Twitter posts using BERTopic. Through machine learning and social network analysis, the study identifies extremist groups and key influencers, revealing how cyber-terrorist communities are structured and their key actors.
Okazaki & Takahashi (2024)	This study predicts future corporate activities based on news headlines using BERTopic. 24 years (1996–2019) of news headlines from Japanese chemical companies were analyzed. The results highlight BERTopic's ability to detect corporate trends and predict future business strategies.
Abuzayed & Al-Khalifa (2021)	This study compares topic modeling methods for Arabic texts, conducting experiments using BERTopic, LDA, and NMF on Arabic news and academic articles. Evaluations based on Normalized Pointwise Mutual Information (NPMI) indicate that BERTopic achieves higher accuracy than other models.
Mendonça & Figueira (2024)	This study investigates Twitter data from the 117th U.S. Congress to determine the most prevalent topics in political discussion. The findings suggest that BERTopic seems to produce more stable and meaningful topics than LDA. Such topics include abortion, student debt, and Supreme Court Justice Ketanji Brown Jackson.
Wang et al. (2024)	This study analyzes interdisciplinary research domains with the help of BERTopic through analyzing the interactions in Library and Information Science (LIS) based on data grabbed from Web of Science (WoS). The results revealed that LIS growth has been driven primarily by multidimensional collaboration.
Egger & Yu (2022)	The performance of four different topic modelling techniques was compared; the methods include BERTopic, LDA, NMF, and Top2Vec. In the context of this study, BERTopic demonstrated a better ability of generating more plausible or coherent topics from short and unstructured texts, such as Twitter data.
Yang et al. (2024)	This study applies topic modeling techniques to global peatland research, analyzing 10,158 research articles (1953–2022). The study identifies key themes such as fire, carbon emissions, and management policies, mapping topic relationships and temporal evolution using BERTopic.
Bu et al. (2023)	This study integrates BERTopic and BERT-BiLSTM models for software classification. An automatic topic modeling and labeling system for app stores was developed and tested using SourceForge and the China App Store, demonstrating that BERTopic enhances precise software categorization.
Lee et al. (2023)	This study analyzes Environmental, Social, and Governance (ESG) news and academic publications using BERTopic. LexisNexis news articles and Web of Science papers were compared to examine the differences in ESG topics between media and academia.
Mishra (2024)	This study examines BERTopic's use in customer experience research, analyzing topics related to retail, luxury consumption, and AI integration to identify key trends in the field of customer experience.
Alhaj et al. (2022)	This study investigates cognitive distortions in Arabic social media content using BERTopic. Analyses of Twitter data reveal that BERTopic outperforms other models in identifying cognitive distortions.
Franco et al. (2023)	This study analyzes sports management research using BERTopic, examining 3,704 Scopus articles to identify key topics and trends in sports management development.
Yi et al. (2025)	This study explores factors influencing customer satisfaction in mobile commerce applications using BERTopic. User reviews were analyzed to determine key factors affecting service quality.
Tang et al. (2024)	This study examines public grievances in Chinese online government petition platforms using BERTopic. A system was developed to help the government identify priority issues requiring urgent intervention.

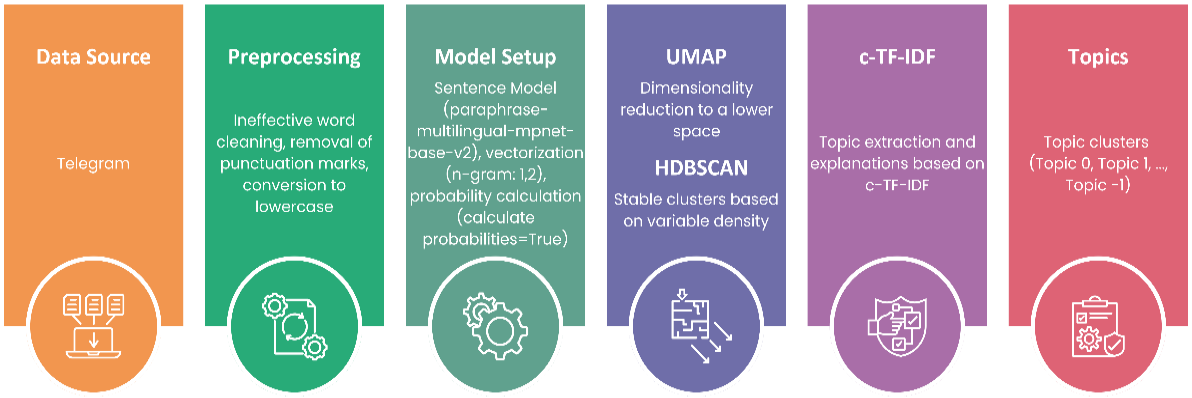
Various studies on topic modeling performed with the use of BERTopic are showcased in Table 1. A wide-ranging overview of BERTopic's implementation in several different disciplines is rendered herewith. Studies on artificial intelligence and perceptions of social media (Qi et al., 2024; Ocal, 2024; Saidi et al., 2022) analyze social concerns, misinformation, and the various perceptions surrounding digital platforms. Studies of scientific articles and news content (Chagnon et al., 2024; Wang et al., 2024; Yang et al., 2024; Lee et al., 2023) emphasize the insight into academic texts and news headlines from using BERTopic. Studies of consumer behavior and market analysis (Yi et al., 2025; Mishra, 2024) look into the utility of BERTopic in measuring customer satisfaction, service quality, and motivations for purchasing. Thus, studies of public policies and political analysis (Tang et al., 2024; Mendonça & Figueira, 2024) add knowledge regarding public priorities for governments and policymakers. Considering such a diversity of studies, it is well-established that BERTopic is quite generalizable and offers valuable analytical benefits toward its modeling process for finding topics.

Despite the extensive literature on BERTopic, the majority of studies have been conducted in English and conventional languages. A modest of research into BERTopic applications the Turkish etymology reveals significant opportunities for research. Consequently, the gap may provide valuable avenues for future research, especially regarding how BERTopic can be developed and applied in other languages outside of English. In this regard, the investigation conduct on the efficacy of BERTopic with Turkish texts may contribute positively to the applicability and viability of BERTopic in topic modeling.

3. METHODOLOGY

Customer complaints about TOGG, a national automobile brand in Türkiye, were examined using the topic modeling method called BERTopic v0.11.0. The methodology was designed based on established practices in similar studies to ensure the accuracy and efficiency of the results. The model parameters would have been assigned to empower the maximum performance of the model, by the distinct characteristics of the dataset. Figure 2 presents the flowchart detailing the methodology of the study and illustrates the systematic approach adopted throughout the analysis.

Figure 2. Flow Chart



To collect data, the researchers used web scraping to extract customer feedback from various Telegram groups and channels dedicated to TOGG. The full dataset consists of 500,000 user messages, including several parameters such as Complaint Topic, Date, Time, and Complaint Content. For the purpose of analysis, only complaint texts that included a date were taken into consideration (Teichert et al., 2020). Web scraping is a well-documented and efficient method for collecting large volumes of unstructured data from online platforms (Winarko, 2023).

The preprocessing steps formed an important part of the NLP workflow in helping to ready the data for analysis. Cleaned data generally involves removal of punctuation and stopwords and through standardization, conversion into lower case. As an important consideration, stemming and lemmatization were purposely omitted to maintain the integrity of the original complaint texts, as that would ensure contextual meaning in the data output from the algorithms. In keeping with best practices with NLP, in their original forms, the words could carry meaningful semantics (Acheampong et al., 2020).

BERTopic model used in the study is sophisticated NLP technique to cluster topics from text based on transformer architectures. Due to its high effectiveness in more than fifty languages, including Turkish, the paraphrase-multilingual-mpnet-base-v2 variant of BERTopic has been chosen. In selecting the model, a similar study by Koruyan (2022), which utilized the BERTopic technique on Turkish texts, was referenced. Therefore, choosing this model was justified as the best possible choice for the analysis.

The topic modeling process was systematically configured to identify a manageable number of relevant themes. First, the vocabulary for topic representation was refined with a CountVectorizer using ngram_range=(1,2) to capture common noun phrases in Turkish, and min_df=0.00005 with max_df=0.05 to filter out both extremely rare and overly common terms. For the topic discovery itself, a two-step approach was adopted rather than relying on a single, high min_topic_size. Initially, min_topic_size was set to a low value of 15, which allowed the model to capture a large number of granular topics. Subsequently, an automated topic reduction procedure within the

BERTopic framework was applied to consolidate these initial topics, with the final number of themes specified as 20 (nr_topics=20). This method of managing topic granularity by first generating and then merging topics is a core component of the framework (Grootendorst, 2022). The final 13 topics presented in this study are the result of this process. Finally, to ensure a comprehensive classification, the outlier cluster (Topic -1) was managed by utilizing the calculate_probabilities=True parameter and reassigning outlier documents to their most probable topics with a probability threshold of 0.01.

The study also looked into the temporal dynamics of customer complaints by way of the BERTopic's dynamic topic modeling technique in understanding how such topics have progressed in time. This method allows for the investigation of topic furnish at clearly demarcated time intervals, reading into trends and shifts in customer opinions (Park & Park, 2020). Monthly segmentation on each topic was carried out in this analysis, giving room for a deep understanding of how customer complaints in general developed month by month through a year. This time analysis aids in disclosing trends in customer issues, thereby assisting decision-making processes actively engaged by businesses.

4. FINDINGS

In this study, TOGG consumer complaints data has been analyzed using BERTopic topic modelling method, which provides a valid base for a comprehensive thematic analysis of consumer feedback. The analysis reveals that customer dissatisfaction is a complex issue, influenced by various parameters such as service quality, financial transactions, technical infrastructure, and logistics. These insights highlight the multifaceted nature of customer concerns and illustrate the necessity for businesses to operate from a bigger-picture point of view to improve their functions and customer experience.

Table 2. BERTopic Topic Modelling Results: Complaint Subjects and Number of Complaints

ID	Keywords	Frequency	Percentage (%)	Complaint Description
0	credit score, insurance cancellation, interest-bearing loan, banking transactions, credit allocation	160,224	32.04	Banking Transactions
1	vehicle numbers, range information, charging duration, battery capacity, speed limit	16,516	3.30	Vehicle Information
2	campaign codes, price comparison, product warranty, second-hand sales, tax fee	10,658	2.13	Online Shopping
3	delivery process, order management, update process, brand reliability, form approval	5,701	1.14	Delivery Process
4	software update, quality deficiency, payment completion, vehicle status, factory release	1,450	0.29	Software Error
5	navigation issue, map data, update deficiency, routing error, road information	472	0.09	Navigation Issue
6	android version, update problem, compatibility issue, Android application, software error	466	0.09	Android Compatibility
7	bursa delivery, branch issue, appointment process, delivery delay, logistics problem	352	0.07	Logistics Problem
8	email notification, Gmail issue, update deficiency, spam filtering, communication problem	152	0.03	Email Issue
9	free service, campaign complaint, misinformation, promotion error, complimentary service	147	0.03	Promotion Error
10	application installation, phone access, connection issue, system compatibility, access error	98	0.02	Application Access
11	fraud allegation, payment issue, transaction error, order problem, customer complaint	96	0.02	Fraud Suspicion

ID	Keywords	Frequency	Percentage (%)	Complaint Description
12	banking transactions, customer service, credit card issue, money transfer, atm problem	78	0.02	Banking Services
13	vehicle accessories, tire recommendations, floor mat quality, protective coating, auto care products	47	0.01	Vehicle Accessories
-1	I will check, if I find, immediately, code, you can get it	303,543	60.77	Outlier Topics
Total		500,000	100	

An examination of Table 2 reveals that among the 500,000 user messages analyzed, thirteen main topic clusters were identified, along with an outlier cluster labeled as "-1" which accounts for approximately 60.77% of the total data. It is crucial to interpret this high outlier ratio not as a model deficiency, but as a key finding reflecting the nature of the raw data. The analyzed user messages contained significant "noise" such as greetings, confirmations, or off-topic remarks like "bakacağım" (I will check) and "hemen" (immediately) alongside actual complaints. The model effectively isolated this non-thematic content into the outlier cluster, thereby ensuring that the 13 resulting topics represent coherent complaint themes. These 13 topics are the final output of the topic reduction procedure that targeted 20 themes, with smaller, consolidated clusters being reclassified into this outlier group during the process.

Other than outlier clusters, the general topic labeled ID 0 "Banking Transactions" consists of 160,224 complaints, approximately 32.04% of the entire dataset. The key words most pronounced in this cluster were "credit score," "insurance cancellation," "interest-bearing loan," and "credit allocation," indicating that a large part of complaints regarding TOGG are not related strictly to automobiles but are also closely tied to the banking and financial processes. It seems that great customer dissatisfaction or uncertainty regarding credit applications, insurance procedures, and interest rates caused this great concentration of complaints in that category. These findings reveal a critical area in after-sales assistance and financing processes for a newly positioned brand into the automobile market. For TOGG to improve customer satisfaction, this further recommends the need for streamlined financial services and more effective customer support in this area.

The group of complaints with the label ID 1 is represented in 16,516 complaints, which amounts to roughly 3.30% of the complete dataset. By investigating the entire termset, we could examine key featured themes by electric vehicle users: "range information," "charging time," "battery capacity," and "speed limit," referring to the most frequently raised complaints. Such findings may indicate information uncertainty or dissatisfaction from consumers as a result of the fact that due to the novelty of electric vehicle adoption in society, a general lack of awareness regarding EV technology prevails. This seems to suggest that a general request for TOGG users is for information on technical matters related to their vehicles. Also, enhancing technical support and the dissemination of information-dissemination processes could significantly enhance the user experience and satisfaction.

The other less prominent topic clusters include "Online Shopping" (ID 2; 2.13%), "Delivery Process" (ID 3; 1.14%), "Software Error" (ID 4; 0.29%), "Navigation Issue" (ID 5; 0.09%), and "Android Compatibility" (ID 6; 0.09%). These topics point out that the consumers have raised concerns not only about the vehicle itself but also about the entire services surrounding it: logistics, software integration, navigation, and mobile applications. The prominence of "Delivery Process" and "Online Shopping" suggests that TOGG is facing challenges at the intersection of online sales and fast delivery expectations, both of which are critical to strengthening its market position. The similar complaints of "Software Errors," "Navigation Issues," and "Android Compatibility" demonstrate the marketing role played by technological components in modern vehicles. This shows that users are highly sensitive to malfunctions in technology; thus, there will need to be unfaltering development, perfect integration with smart devices, and proactive troubleshooting to improve customer satisfaction.

Conversely, smaller topic clusters identified such as "Logistics Problem" (ID 7), "Email Issue" (ID 8), "Promotion Error" (ID 9), and "Application Access" (ID 10) make evident the need for TOGG to adopt remedial approaches directed specifically at aftersales service , customer communication and marketing activities. The nomination of the “Fraud Suspicion” (ID 11) category is worthy of special mention since it signals likely user concern about scams or deceptive standard promotional campaigns targeting the brand in the online space. This implies a need

to strengthen cyber protection systems, restore trust in the brand in the eyes of indirect customers, and take active measures against fraud in order to assure the customers' confidence.

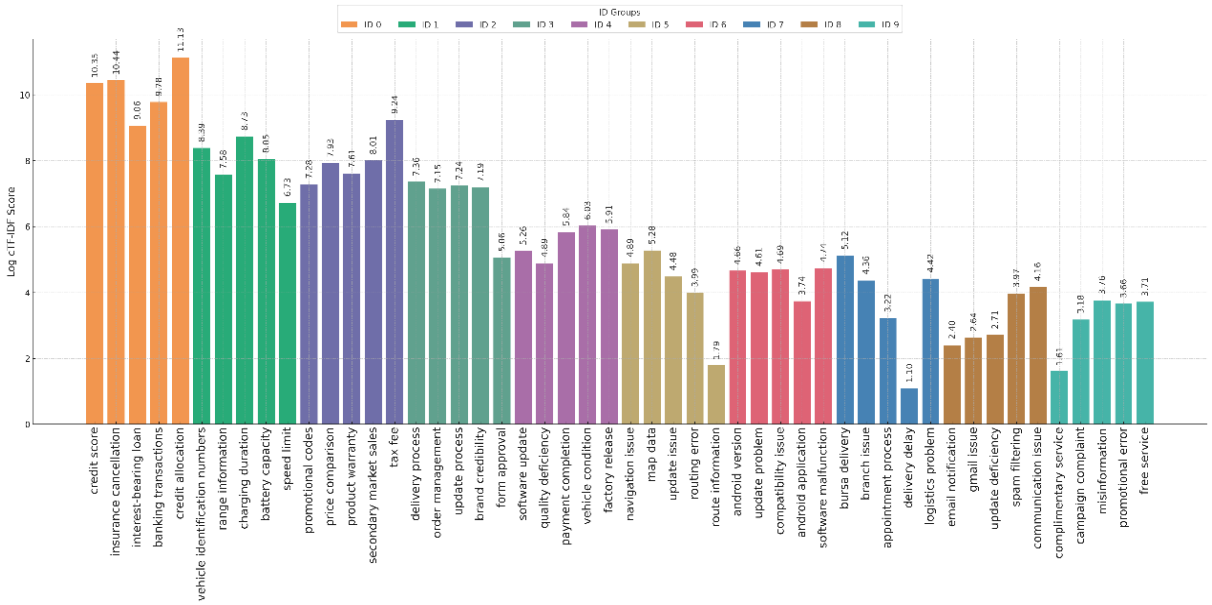
Finally, lower-frequency but highly specific complaint topics, such as "Banking Services" and "Vehicle Accessories," reflect the multidimensional nature of customer experiences. The subcategory of "Banking Services," which includes terms like "credit card issue," "money transfer," and "ATM problem," has thematic similarities with ID 0 ("Banking Transactions"), but it was modelled as a separate cluster. Such difference could arise from the distinctive wording in the contextual usage of customer statements. Similarly, complaints regarding vehicle accessories, such as "tire recommendations" and "floor mat quality," suggests that dissatisfaction extends beyond a vehicle's core functionality to a distinctiveness in auxiliary services and customization options. It is explicitly indicative that a portion of customers places a great deal of importance on personalization accessory quality, thereby creating overall experiences. The study analyzes TOGG customer complaints by means of the BERTopic technique and consequently draws valuable thematic insights into the essence of customer feedback. The findings from Table 2 show that customer complaints are concentrated around a few topics. The most frequent topic, Banking Transactions, covered 32.04% of complaints (160,224 mentions), indicating significant dissatisfaction oriented toward concerns regarding financial transactions. Most second frequent complaints surfaced around Vehicle Information, wherein some 16,516 went to indicate that customers have gaps in information regarding range, charging time, and battery capacity; hence the need for clear communication regarding skills that electric vehicle users may need to function with their cars was underscored. The third most complained category-Online Shopping-had complaints basically regarding campaign codes and price comparison to the tune of 10,658, indicating such issues tend to negatively impact the customer experience.

These insights accentuate the urgent need for TOGG to address dissatisfaction emanating from financial services, enhance education on electric vehicle features, and better their online sales strategies for better customer satisfaction with brand perception.

In summary, Table 2 data indicates that the underlining issues for which TOGG customers complain include; financial transactions, vehicle range, and technical issues. Whereas, lesser but still mentioned concerns included logistics, software, campaign management, and fraud prevention, all of which could negatively influence the overall customer experience. These numerous problem areas offered great supporting insight for TOGG as a new brand-in-a-value-chain for optimizing product development and after-sales services and developing various customer communication strategies. In addition, the high proportion of outlier clustering shows that further attention needs to be given to noise and context gaps in the data collection process, as they could influence the topic modeling analysis accuracy. Based on these results, in order for TOGG to strengthen its position in the market, it should adopt what can be referred to as a holistic approach inclusive of technical enhancement and the entire financial, logistical, and communications processes involved in guaranteeing comprehensive customer orientation.

The c-TF-IDF Log scores of Figure 3 provide important information regarding the topical structure of TOGG customer complaints. The Log c-TF-IDF is a method of scoring the significance of certain words or terms found in documents according to their contextual relevance. In particular, terms with the highest scores indicate main areas of concern in the customers' complaints, as well as their associated impact on customers' experiences. This analysis, by identifying the foremost terms, establishes an understanding of issues frequently reported by the customers, as well as how such concerns compare one another in relative importance in the corpus.

Figure 3. c-TF-IDF Scores for the Top Ten Topics



While terms such as "credit allocation" (11.13), "insurance cancellation" (10.44), "banking transactions" (9.78), and "charging time" (9.84) possess highest log c-TF-IDF scores, were prominent, Figure 3 of this study does reveal two axes: financial transactions (e.g., credits, insurance) and electric vehicle technology (e.g., charging time). Customer complaints will, hence, revolve more or less around these aspects. Credit allocation and insurance cancellation being high log c-TF-IDF scores indicate, from this finding, that complainants will frequently enunciate grievances within the domain of financial services-a still more precise articulation. This reflects that aspirant EV owners would actually like their focus not just on automobile technicalities but also the nebulous aspects of financial services like credit approval procedures, insurance cover, and interest rates. As well, terms such as charging time (9.84) and range information (9.60) point that usual concerns of the EV market, such as infrastructure for charging, battery performance, and range on a single charge, also stand to be the focal point of customer dissatisfaction within the ecosystem of TOGG. These insights also point definitely at a need to integrate a thorough financial service model to articulate elucidations of the technical specifications adequately therein enhancing customer satisfaction as well as confidence in TOGG's offerings.

Further, terms like the second-hand sales (9.46) or tax fee (9.39) with moderate-to-high log c-TF-IDF indicate uncertainty and concerns at different stages of vehicle ownership, such as resale and taxation processes. The findings indicate that customers are not only concerned with the initial purchase and usage experience but also the long-term financial and regulatory effects over the life of a TOGG vehicle. Other terms, with meaning and log c-TF-IDF scores, are brand reliability (9.20) and product warranty (9.07). Customers' expectations do not only enclose vehicle performance but corporate image and after-sales services. The importance of these terms with highly-specific values indicates that, apart from technical reliability, trust and corporate communication also form a fundamental basis for the customer experience. Lower frequencies but meaningful log c-TF-IDF scores still appear for terms such as update issue (7.84), software error (7.67), and compatibility issue (7.19), suggesting a fair share of customers have raised concerns on the vehicle's digital infrastructure. This further emphasizes the growing importance of software and hardware integration in customer satisfaction within the automotive sector, highlighting ongoing issues with software upgrades, system stability, and compatibility with outside applications.

The log c-TF-IDF distribution found in Figure 3 indicated that complaints from TOGG customers showed multivariate behavior: among others, the complaints could build on their complexity around monetary, technological, corporate positive image, and after-sales servicing propositions. Being a brand new automotive brand, this would mean that TOGG must concentrate not only on the technology of their vehicles, which includes making investments toward any financial services, corporate communication, and even after-sales support. Conferring strengths to these processes, which are in fact complementary, will certainly be essential to TOGG,

which is now probably eyeing a competitive niche in the market of automotive drivers as well as an overall satisfying pleasure for its customers.

Table 3. Top 10 Examples of Complaint Subjects

ID	Complaint Description	Complaint Text
0	Banking Transactions	Hello, people; I am trying to get an auto loan for TOGG, but the bank is appealling such a high-interest rate. I also have the issue of cancellation of insurance. Is there somebody else who has been through that?
1	Vehicle Information	Friends, there is a lack of information regarding the vehicle's range and battery capacity. The details on the official website do not match reality. The charging duration is also longer than expected. Has anyone come across accurate information on this?
2	Online Shopping	Hi everyone, while comparing TOGG accessories and spare part campaigns, I noticed significant price differences. When additional taxes are applied in online shopping, the budget exceeds my expectations. Has anyone made a purchase under these conditions before?
3	Delivery Process	Hello everyone, I am unable to get information about the TOGG delivery process. I submitted a form to update my order, but there has been no response. I trust the brand, but the process is taking too long. Is anyone else experiencing the same issue?
4	Software Error	I heard that a new software update was released, but I am experiencing quality issues with the vehicle's system. Even though I completed the payment, some features are still disabled. Could this be a factory-related issue?
5	Navigation Issue	Friends, the navigation system keeps directing me to incorrect routes. The map data seems incomplete. Since there is no update available, I am hesitant to drive outside the city. Has anyone faced a similar issue?
6	Android Compatibility	Due to my Android version, I am unable to update the TOGG application. It seems like there is a compatibility issue between my phone and the vehicle. Is this a software bug, or is it just my device?
7	Logistics Problem	I scheduled an appointment to pick up my vehicle from the Bursa branch, but they informed me about logistical disruptions. The delivery is delayed, and customer service cannot provide a clear date. Can anyone share insights on this issue?
8	Email Issue	Hello, I was expecting an official email for a test drive, but it never arrived. I also checked my spam folder, but I could not find it. Are emails delayed, or is there a system malfunction?
9	Promotion Error	I tried to use my TOGG promotion code, but the system did not accept it. Even though I entered the code correctly, the discount was not applied. Has anyone encountered this issue or found a solution?

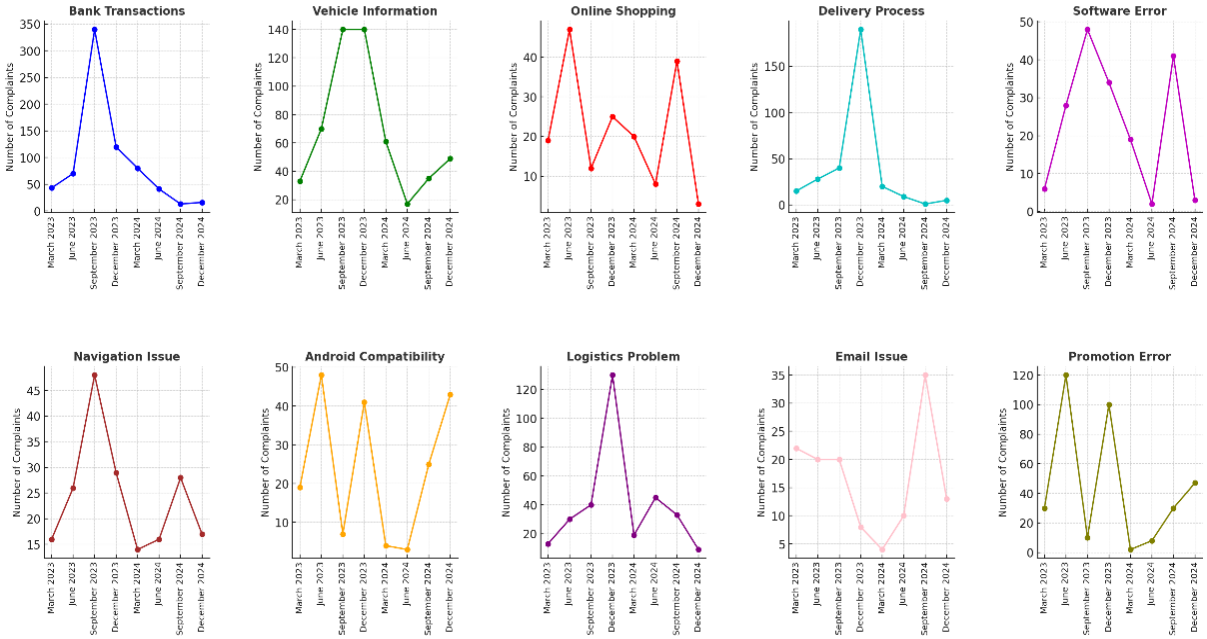
The ten most critical complaint topics listed in Table 3 shed light on the contentions and thematic distribution of TOGG customer complaints, and offer a qualitative perspective on their substance. In the Banking Transactions (ID 0) category, customers' complaints typically concern high interest rates on loans during the application process and insurance cancellations. In this respect, they show what uncertainty and dissatisfaction concerning financial transactions would influence the whole purchase experience of vehicles. These findings highlight that financial services are prime factors defining consumer perceptions and decisions, indicating that if loan and insurance processes could be more transparent and accessible, then customers would be more satisfied and trusting of TOGG.

The complaint texts are linked to various codes in Table 3 and provide qualitative insights into the particular concerns of TOGG consumers that reinforce the important themes formed from topic modeling. ID 1 – "Vehicle Information": Out of the various complaints, the major concerns brought forward were improper or incomplete information of important technical specifications like range, battery capacity, and charging time. To an extent, raised customer expectations toward electric vehicle technology support the importance given to complete and thorough technical disclosures. ID 2 – "Online Shopping": Customers are complaining about price differences among TOGG accessories, spare parts campaigns, and the additional tax fees adding to the financial burden. ID 3 – "Delivery Process": Complaints highlight frustration over not being updated on the order status, despite repeated inquiries, indicating the customers' trust in the process of delivery is damaged by uncertainty. ID 4 – "Software Error": Customers report issues with system-related quality, even after having completed payment, strengthening the concern of software reliability. ID 5 – "Navigation Issue": Users mention wrong route guidance, missing map data, negatively impacting the driving experience. ID 6 – "Android Compatibility": Complaints signify trouble

with the mobile application and vehicle integration, emphasizing the uninspiring digital connectivity experience of customers. ID 7 – "Logistics Problem": Customers pinpoint the lagging delivery times and unclear boundaries in their wait, thus lowering overall satisfaction. ID 8 – "Email Issue": The complaints are concentrated in the area of ineffective digital communication, for instance, customers claim that they face non-receiving official emails for test drive appointment confirmations. ID 9 – "Promotion Error": Customers are frustrated by the promotional codes that the system doesn't accept, which seems to indicate technical repercussions for campaign implementation. What this suggests is an overall multidimensional scope of the complaints emerging since together they signal that TOGG has to focus not only on vehicle performance but also improving its financial processes and digital infrastructure, the channels of communication with its customers, and logistics management to boost overall customer satisfaction.

This shows that TOGG complaints are found throughout many types of multidimensional problems, including trouble with financial transactions, technical features, logistics processes, digital communication, and promotional strategies. The complaint texts provided in Table 3, clearly illustrate consumers' concerns and give direct and explicit expressions of dissatisfaction. The identified thematic areas will be a very important tool for TOGG in strategic improvements because they indicate the pain points which searchlight on customer satisfaction and brand perception. For TOGG to strengthen its market position and cultivate long-term customer trust and loyalty, addressing these issues through better financial transparency, improved technical support, bettered logistics, optimized digital communication, and more refined promotional strategies will be essential.

Figure 4. Monthly Change in Top Ten Complaint Subjects



The data shown in Figure 4 presents the monthly fluctuations of the ten most common complaint themes throughout the interval from March 2023 to December 2024 representing crucial insights on how TOGG customer complaints varied in a trendlike manner over the point in time. Their variations may be attributed to several other factors, including seasonal campaigns, economic realities, software updates, or supply chain challenges.

In June 2023, the "Banking Transactions" category massively increased from 70 to 340 in September 2023, raise bright the alarm of increasing anxiety in finances. Rapid changes indicate that customers became more sensitive to financial processes possibly due to fluctuations in economic affairs or changing rates of interest. The complaints have gradually decreased in the coming months (120 in December 2023; 80 in March 2024), showing some responsiveness by the TOGG or the banks to the customer demands, or at best, there was some damage control for the relevant macroeconomic factors that outweighed such matters over time.

Similarly, the increase in complaints under the "Vehicle Information" category from 70 in June 2023 to 140 in September 2023, and its steady level at 140 in December 2023, indicates that concerns related to range, charging time, and technical specifications among electric vehicle users intensified during certain periods of the year. The sharp decline observed in later months (e.g., 17 in June 2024) may suggest that TOGG's efforts in technical communication and user education yielded some positive results or that consumer awareness naturally increased over time.

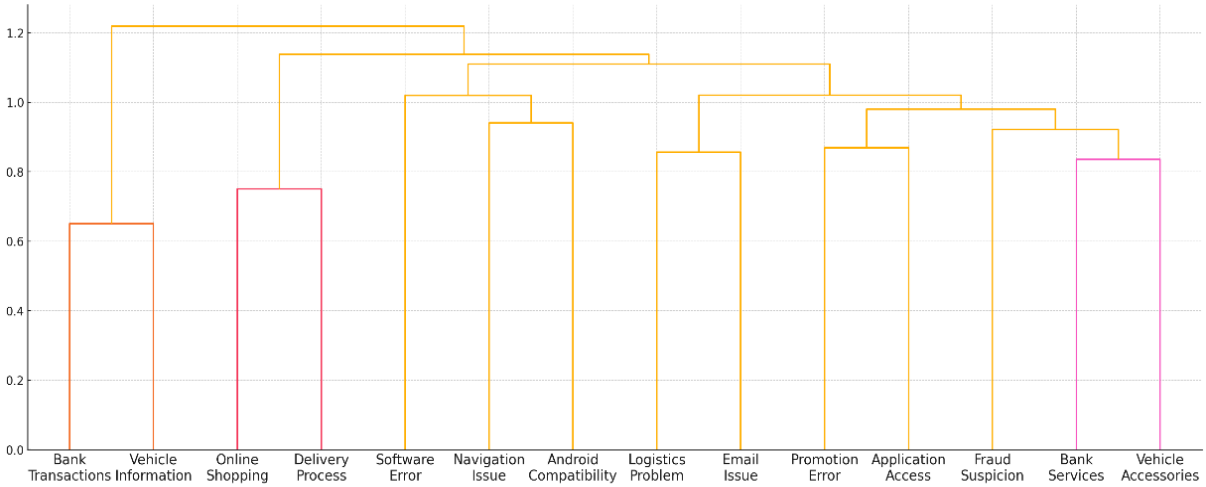
The "Delivery Process" category reaching a high value of 190 in December 2023 may be associated with increased delivery demands toward the end of the year or supply chain congestion triggering complaints. At the same time, the "Logistics Problem" category also rose to 130, suggesting that these two issues were frequently mentioned together and were likely influenced by similar underlying factors. The notable decrease in complaints related to both topics in March 2024 and June 2024 indicates that logistics processes stabilized after the year-end surge, restoring operational efficiency.

The fluctuations in complaints about digital and software components have been equally striking. For example, the category "Android Compatibility" increased from 48 complaints in June 2023 to 7 complaints in September 2023 and then went up again to 41 complaints in December 2023. Such sporadic shifts are likely a product of monthly software updates or transient compatibility-adjacent handshake problems with mobile apps. The Software Error category went up to 48 complaints from September 2023 to December 2023 and down to 34 complaints. Another small spike in complaints on the Software Error topic appeared in September 2024 before another decline to 41. Fluctuations like this do suggest some regular software updates or version changes that impact user experience led to these variations.

The extreme high values that have been seen in June 2023 (120) and December 2023 (100) under "Promotion Error" indicate that high customer complaints arose at those times when the seasonal campaigns or discount code applications failed to meet the anticipated results. After these peaks, the sudden decline to 2 in March 2024 implies that the brand has seen some positive short-term effects in that area. However, the system was somewhat back up to 30 in September 2024, then 47 in December 2024, showing that promotion management is a field still requiring continual examination and fine-tuning.

The monthly variation data in Figure 4 demonstrate that TOGG customer complaints are influenced by both seasonal and conjunctural factors. Complaints across various areas, such as financial transactions, delivery-logistics processes, and technical and software-related issues, exhibit notable fluctuations over time. These findings once again emphasize that, in order to strengthen its market position, the brand must not focus on a single area but instead implement holistic improvements across multiple dimensions, including financial services, logistics, technical operations, and digital communication.

Figure 5. Hierarchical Visualisation of Complaint Subjects



The dendrogram in Figure 5 hierarchically clusters TOGG customer complaints based on their thematic similarity, allowing for a visual representation of which topics are more closely related or distinct. Examining the graph,

"Banking Transactions" and "Vehicle Information" cluster at a relatively short distance, suggesting that dissatisfaction with financial processes (e.g., credit, insurance) is sometimes intertwined with concerns about fundamental vehicle information (e.g., range, battery capacity). Following these two topics, "Online Shopping" and "Delivery Process" merge, indicating that issues related to digital purchasing channels and delivery planning are often raised by a similar customer segment. At later stages, "Software Error," "Navigation Issue," and "Android Compatibility" are incorporated sequentially, suggesting that in-vehicle software and mobile application-related issues exist on a somewhat different level compared to delivery and shopping-related complaints. However, these topics still share a common problem space within the overall customer experience. This grouping is followed by the addition of "Logistics Problem" and "Email Issue," indicating that delays in digital communication (e.g., emails being delayed or not received at all) and logistics disruptions contribute to a broader customer dissatisfaction with process management, alongside software and navigation concerns. At higher levels in the dendrogram, "Promotion Error" and "Application Access" merge before combining with "Fraud Suspicion," revealing that campaign management and application access issues are closely linked to security and fraud concerns in users' perceptions. Finally, the inclusion of "Banking Services" and "Vehicle Accessories" suggests that while these topics share fewer similarities with other clusters, they still exhibit thematic proximity within the broader, multidimensional customer experience, spanning from financial transactions to auxiliary products.

This integrated table highlights the importance of analyzing TOGG customer complaints not merely as individual categories but as broader thematic groups formed by related topics. For instance, financial transactions (e.g., banking, credit, insurance) share common ground with basic vehicle information (e.g., range, battery capacity), while logistics (e.g., delivery, shipping) and software issues (e.g., navigation, mobile integration) exhibit interconnections at varying levels. Therefore, when designing improvement strategies, the brand should focus on implementing holistic solutions for topics within similar clusters, which could lead to more effective outcomes in enhancing customer satisfaction.

5. CONCLUSION AND DISCUSSION

In this study, customer complaints received by TOGG were evaluated using the BERTopic topic modeling technique to strengthen its market establishment as a new brand. The findings from this study provided a comprehensive view of the main characteristics of customer dissatisfaction, based on the analysis of 500,000 user messages. Among the findings were vast concerns: financial expectations, like "Banking Transactions," technical and operational processes like "Vehicle Information" or "Online Shopping." Furthermore, complaints related to service included "Delivery Process" and "Logistics Problems," while points concerning digital infrastructure were primarily focused on "Software Errors" and "Android Compatibility." This multiple structure indicates that customer satisfaction does not stretch in a single domain; instead, it needs a holistic approach where circles of financial, technical, logistic, and digital communication issues are engulfed. This confirms the valuation made by The study's results are consistent with Morgeson et al. (2023), who frame customer complaints as a crucial feedback mechanism for improving product and service quality. This perspective reframes complaints not merely as problems but as opportunities for improvement and innovation, a viewpoint also shared by Pio et al. (2023). The prominence of the "Banking Transactions" topic, with high c-TF-IDF scores for terms like "credit allocation" and "insurance cancellation," highlights the strategic importance of handling financial-related concerns. This aligns with Bengül (2019), who argues that effective complaint management is vital for emerging organizations, and with Uyar (2019), who identifies it as a key factor for gaining a competitive advantage.

Similarly, findings related to "Vehicle Information" and software glitches suggest that applying a proactive management method, as proposed by Davidow (2020), can effectively turn negative experiences into positive outcomes. Addressing these technical and informational gaps through greater transparency and proactive communication is essential for positioning TOGG in the marketplace, a point supported by Carlson et al. (2023). Ultimately, as affirmed by Frasquet et al. (2021), such effective complaint handling fosters customer loyalty and enhances the overall user experience, particularly when coupled with continuous technological upgrades and a focus on customer-oriented betterment.

The temporal variation data indicates that financial and technical complaints tend to peak during certain months of the year. In this case, the surge of June-September 2023 in complaints relating to Banking Transactions and Vehicle Information can be attributed to external factors, such as the economic climate, seasonal campaigns, or temporal performance issues at the company in question. Similarly, the rise in frequency of other discussed topics,

such as Promotion Error and Logistics Problem, supports the notion by Arora and Chakraborty (2020) and by Sugathan et al. (2018) that customer-feedback spreads fast on online platforms. This correlates well with Golmohammadi et al. (2021), putting stress on the great importance to address customer concerns in the digital world as soon as they arise. For example, complaints regarding Promotion Error spiked suddenly and sharply in June 2023 and December 2023; therefore, indicating to the brand that it needs to pay serious attention to upgrading its campaign management in a way that meets customer expectations.

The dendrogram illustrates, in Figure 5, the relationship between customer complaint topics and is consistent with the findings of Egger and Yu (2022) on the ability of BERTopic to obtain coherent topics from short and unstructured texts, examples of which could be comments posted on social media. The clustering of the financial and technical issues into distinct groups exemplifies the multiplicity of the user experience. Yapraklı and Mutlu (2022) emphasized that customers who get responses to complaints which they raise exhibit more brand loyalty. Similarly, this very study suggested that TOGG can increase customer satisfaction and loyalty through the resolution of complaints in multifarious dimensions. In addition to this, the results are in conformity with Güllülü and Bilgili (2011) and Soysal (2015), who highlighted the after-sale service quality's contribution to the development of customer commitment. The findings identifying software and logistics as issues further justify this viewpoint, indicating that addressing them might reinforce customer trust and retention. Moreover, such more specific subcategories such as, "Banking Services," and "Vehicle Accessories," further support Bengül's(2019) argument that novel brands should utilize a multidimensional approach to satisfy customers' demand. That reason highlights the necessity for a complete strategy that would combine improvements in finances, technology, and service into a powerful and competitive stand in the market.

The findings indicate that TOGG cannot rest on its laurels relying on the identification of customer complaints alone; it must bring that information into the realm of multidimensional strategic planning. The results further corroborate what has already been made evident by Uyar (2019) and Carlson et al. (2023): effective complaint management can engender a competitive advantage. Thus, through a strong solution-building and communication strategy for financial and technical processes, customer satisfaction can be sustainably enhanced. Moreover, given that complaints are subject to seasonal and conjunctural influences, crisis management and flexible organizational structures take pivotal form as critical capabilities providing for survival and mobility with changing customer concerns. Furthermore, the study demonstrates a robust methodological approach for handling noisy, unstructured social media data. By employing a two-step topic reduction process and leveraging the model's ability to filter out non-thematic user interactions into an outlier cluster, it was possible to distill strategically valuable insights from a very large and heterogeneous dataset. This highlights the practical utility of BERTopic in real-world business intelligence applications where data is rarely clean.

In brief, this study showed that, in addition to being broad-themed and having periodic fluctuations, customer complaints in the specific case of TOGG in the electric vehicle sector. This suggests that companies should incorporate a holistic management approach not only for product and service delivery but extended to financial operations, logistics, and digital interactions with customers. Future work can improve the findings by sourcing customer feedback broadly across various digital forms, such as social media, blogs, words, etc., and would further extend the application of advanced topic modeling approaches such as BERTopic in the Turkish language, thus allowing a broader appraisement of how proactive complaints management influences brand perception and loyalty.

The findings of this study offer several critical and actionable insights for management, moving beyond simple complaint identification to inform strategic direction. The overwhelming dominance of financial complaints underscores that the customer journey extends far beyond the vehicle itself, making the financing and insurance processes a critical touchpoint; a key implication is the need to develop a seamless purchasing ecosystem, potentially through partnerships with financial institutions. Beyond the purchasing process, complaints regarding core vehicle information like range and battery highlight a crucial need for proactive and transparent customer education to manage expectations. This focus on the user experience extends deeply into the vehicle's digital dimension, as the prevalence of software issues confirms that TOGG must operate with the mindset of a technology company, prioritizing reliable Over-the-Air (OTA) updates and seamless software integration. Finally, the study demonstrates that the dynamic analysis of complaints is a powerful strategic tool in itself. By identifying seasonal trends in specific issues, such as delivery problems, management can shift from a reactive to a proactive operational

stance, using this data as an early warning system to inform resource allocation and enhance both customer satisfaction and operational efficiency.

DECLARATION OF THE AUTHORS

Declaration of Contribution Rate: The authors have equal contributions.

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Declaration of Conflict: There is no potential conflict of interest in the study.

Declaration of Ethics: The study does not necessitate an approval of ethical committee.

YAZARLARIN BEYANI

Katkı Oranı Beyanı: Yazarlar çalışmaya eşit oranda katkı sağlamıştır.

Destek ve Teşekkür Beyanı: Çalışmada herhangi bir kurum ya da kuruluştan destek alınmamıştır.

Çatışma Beyanı: Çalışmada herhangi bir potansiyel çıkar çatışması söz konusu değildir.

Etik Beyanı: Etik kurul belgesi gerektiren bir çalışma değildir.

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