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# How should Bank Syariah Indonesia respond to cyber-attacks? Churn, sentiments, and emotions analysis with machine learning

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## ABSTRACT

### Introduction
This study aims to identify the most popular topics and words in Twitter conversations regarding cyber-attacks on Bank Syariah Indonesia that occurred in May 2023. It also seeks to analyze the sentiments, emotions, and potential customer churn of netizens following cyber-attacks.

### Objectives
The objective of this study is to investigate the public's response to cyber-attacks on Bank Syariah Indonesia, focusing on identifying key topics, analyzing sentiments and emotions, and estimating potential customer churn.

### Method
This study uses a qualitative method with a sentiment analysis approach utilizing Orange Data Mining software. The data comprises tweets collected from May 10, 2023, to May 24, 2023, using keywords such as "BSI" and "Bank Syariah Indonesia," resulting in 30,014 tweets. Sentiment and emotion analyses were conducted to categorize tweets and identify the prevalent sentiments and emotions.

### Results
The analysis reveals that the words "BSI," "Data," and "Lockbit" are most frequently mentioned, indicating the relevance of the cyber-attackers who targeted Bank Syariah Indonesia. The sentiment analysis showed that 56% of the tweets were neutral and dominated by emotions of joy. The study also identifies a short-term potential churn rate of 1.60% for Bank Syariah Indonesia's total customer base, indicating the risk of customers switching to other banks.

### Implications
The results highlight the importance of robust cybersecurity measures and quick response strategies for maintaining customer trust and satisfaction. Financial institutions, particularly banks, must prioritize information and technology security to prevent customer churn and ensure the continuity of their services.

**JEL Classification:**
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**ABSTRACT**

**Originality/Novelty**
This study provides insights into public reactions to cyber-attacks on Islamic banks, emphasizing the role of sentiment and emotion analysis in understanding customer behavior. This offers practical implications for improving risk management and customer retention strategies in the banking sector.

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## INTRODUCTION

Islamic banking in Indonesia makes a significant contribution to the economy. The use of Islamic financial products and instruments in macroeconomic management will improve the links between the Islamic financial sector and the real sector (El Ayyubi et al., 2018; Putri et al., 2023). The increasing use of Sharia products and instruments also encourages economic activities and reduces speculative transactions. As a financial intermediary, Islamic banking plays a role in distributing funds from parties who have excess funds to those who need funds through efficient financing sources and is used to drive economic sectors and spur economic growth (Araminta et al., 2022; Nabila & Thamrin, 2022).

In the Indonesian Banking Development Roadmap for 2020-2025 issued by the Otoritas Jasa Keuangan (Otoritas Jasa Keuangan, 2021), Islamic banking plays an important role as a catalyst for developing the Islamic economy. In addition, Islamic banking in Indonesia is considered to play an important role in consistently improving economic performance in Indonesia from year to year (Lutfi et al., 2023; Minaryanti & Mihajat, 2024). The rapid development of Islamic banking is driven by the use of technology to create more efficient performance (Rozzani et al., 2016). In addition, the use of technology also allows Islamic banking to develop innovative products that are connected with other entities in other Islamic economic industries, such as halal e-marketplaces (Nurillah et al., 2022), ZISWAF fund distribution media (Rakhmawati & Rizky, 2023; Ratnasari et al., 2023), and financing in the halal sector (Pusparini et al., 2020; Timur, 2022; Timur et al., 2022; Timur & Herianingrum, 2022).

The banking sector plays a very important role in formulating strategies related to business continuity and ensuring that risk-mitigation efforts can run well (Kurniawan et al., 2022; Widarjono & Misanam, 2023). Therefore, risk management is a fundamental aspect of Islamic banking. Increased shadow banking activities, new types of fraud, and the possibility of cyber-attacks are risks associated with the digitalization of the Indonesian banking sector (Bank Indonesia, 2019). The estimated annual loss experienced by the financial services sector globally caused by cyber-attacks is USD 100 billion or more than IDR 1,433 trillion (Adelmann et al., 2020).

Cyber-attacks that threaten the security of customer privacy data are the most important issue in the banking sector (Hosen et al., 2021). As service providers, the main capital that a banking company must own is customer trust (Ahmed et al., 2022). Security and privacy issues in banking companies can reduce consumer trust and satisfaction (Al-Dulaimi et al., 2022; Arenas-Gaitan et al., 2015; Mbama & Ezepue, 2018; Zahoor et al., 2016). In addition, banking failures in maintaining customer data can reduce customer loyalty to banking services in the long term (Alimolaei, 2015). Ultimately, the leakage of cus-tomer privacy data can potentially lead to massive customer churn (Keramati et al., 2016; Muneer et al., 2022).

Bank Syariah Indonesia was one of the banks in Indonesia that recently experienced a cyber-attack. A group of hackers hacked Bank Syariah Indonesia's customer data for sale via the Dark Web (Safitri, 2023). Bank Syariah Indonesia is the largest Islamic bank in Indonesia with an asset value of IDR 305.72 trillion in the first half of 2023 (Abigail, 2023). As a result of the cyber-attack that hit Bank Syariah Indonesia, Bank Syariah Indonesia's services and products could not be accessed by customers for at least ten days. This incident had a negative impact on Bank Syariah Indonesia with a decline in its share price of Bank Syariah Indonesia, which reached its lowest point at IDR 1,530/share (Santika, 2023).

Several previous studies are relevant to this research topic. In their study, Hasan & Al-Ramadan (2021) explained that Iraqi private banks emphasize the countermeasures of the systems that their companies use by promoting the bank's intersystems and motivating them to increase their precautions to save the bank's databases and servers to respond to the cyber security breaches experienced. Bajwa et al. (2023) explained that explained that banks in Pakistan are focusing more on proactive communication, transparency and robust incident response so that organisations can build customer trust by prioritising customer information and transaction protection in response to a cyber-attack. Based on these two studies, the question arises as to what the main focus of Islamic banking is in responding to a cyber-attack? This is very important, considering the possibility that customers will churn to other financial services.

Based on this background, this study aims to comprehensively analyze people's sentiments and emotions regarding Bank Syariah Indonesia in the short term after experiencing a cyber-attack by the Lockbit Ransomware group in May 2023. According to Nasar et al. (2019), the theory of planned behavior (TPB) makes short-term intention a crucial predictor of long-term intention. Short-term intentions are the most accurate predictors of future behavior and can enhance precision (Esmeli et al., 2019). Understanding how sentiment, image, and service quality are felt by cus-tomers in banking is important because it can lead to customer loyalty (Arfan & Arfan, 2021; Hosen et al., 2021; Riyadi, 2021). Customers' confidence and trust in the bank result in efficient performance and provide a competitive advantage for banks (Ajike et al., 2024; Langat & Atheru, 2023; Zeitun & Benjelloun, 2012). This study also pinpoints the subjects and dialogues that Twitter users most frequently discuss with their emotional expressions. Finally, the research will also identify potential customer churn based on

word tagging in the Tweets data, which are words that are considered to have the purpose of no longer using products and services from Bank Syariah Indonesia.

This study presents the findings of societal feelings and views as viewed from a different angle that originates from social media. The results of this study provide information in the form of an overview of conditions for banking industry players when experiencing similar conditions when experiencing cyber-attacks from the aspect of potential customer churn and sentiment towards banking in the short term. Banking industry players can use the results of this study as a risk management measure if a similar condition occurs in the banking institutions they lead. The results also add to the body of knowledge, especially for theories related to risk management, crisis management, and customer behavior in the banking sector.

## LITERATURE REVIEW

### Sharia Banking in Indonesia

Indonesia has a dual-banking system (Usman et al., 2022) with the development of Islamic Banks is a form of fulfilling many requests for a banking system that adheres to the Sharia principles (Amin et al., 2013; Arfan & Arfan, 2021). Indonesia has three types of Islamic banks under Islamic banking law No. 21 of 2008. These three types of banks are Sharia commercial banks, Islamic banking windows, and Sharia rural banks (BPRS) (Kartika et al., 2019). The Government of Indonesia fully supports the development of Islamic banking by establishing a new bureau under the Directorate of Bank Supervision, which managed finances at national banks in 2000 (Mohd. Shariff et al., 2022). This leads to the development of the Islamic banking industry, which can be seen in Table 1, where the number of banks and bank operational offices has a positive trend from year to year.

**Table 1**

*Number of Banks and Sharia Bank Branch Offices in Indonesia*

| Bank Period | Sharia Commercial Bank | | Sharia Business Unit | | Sharia Rural Banks (BPRS) | |
|---|---|---|---|---|---|---|
| | Number of Banks | Number of Office | Number of Banks | Number of Office | Number of Banks | Number of Office |
| **2015** | 12 | 1990 | 22 | 2015 | 12 | 1990 |
| **2016** | 13 | 1869 | 21 | 2016 | 13 | 1869 |
| **2017** | 13 | 1825 | 21 | 2017 | 13 | 1825 |
| **2018** | 14 | 1875 | 20 | 2018 | 14 | 1875 |
| **2019** | 14 | 1919 | 20 | 2019 | 14 | 1919 |
| **2020** | 14 | 2034 | 20 | 2020 | 14 | 2034 |
| **2021** | 12 | 2035 | 21 | 2021 | 12 | 2035 |
| **2022** | 13 | 2007 | 20 | 2022 | 13 | 2007 |

Source: Otoritas Jasa Keuangan (2023).

Islamic banks are financial institutions which operational activities are based on the basic principles of Islamic economics and applicable laws and regulations

(Minaryanti & Mihajat, 2024). Sharia banking is also interpreted as all banking activities that use parameters of Islamic jurisprudence (Masvood, 2019). Islamic banking does not charge interest on loans and instead uses a profit-and-loss-sharing mechanism (Ahmed et al., 2022). Islamic banks must always pay attention to Maqashid Syariah in every operational activity, namely Tahdhib al-Fard, Iqamah Al-adl, and Jaib al-Maslahah (Antonio et al., 2012). The embodiment of Maqasid Syariah in the banking industry can reduce the inequality and usury practices that still occur in society (Sutrisno & Widarjono, 2018).

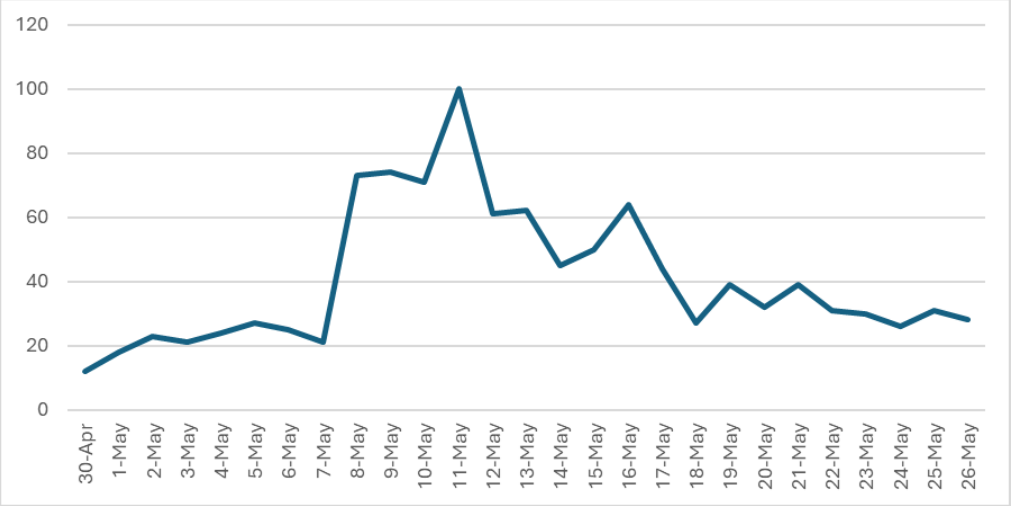
## Cyber-attack on Bank Syariah Indonesia in May 2023

In the current digital era, banking transactions use digital systems with specific technical and non-technical risks (Yusuf et al., 2022). Cyber-attacks are one of the operational risks that often occur in banking institutions. There are at least three threats to watch out for when a cyber-attack occurs in the banking system: hardware, software, and data/information (Efijemue et al., 2023; Gupta et al., 2023; Shankar et al., 2024). Bank Syariah Indonesia has experienced cyber-attacks since the beginning of May 2023, which have caused various service disruptions and limited customer access to all transactions involving Bank Syariah Indonesia. The reason for this is the hacking action carried out by hackers who collect customer privacy data.

Cyber-attacks often have the potential to shock customers (International Monetary Fund, 2020). Likewise, during a cyber-attack that hit Bank Syariah Indonesia in early May 2023. Google Trend data in Figure 1, taken from April 30, 2023, to May 30, 2023, shows an increase in searches on the google.com site with the keywords "BSI" and "Bank Syariah Indonesia. Google Trends data showed a significant increase in searches with the keyword Bank Syariah Indonesia on May 11. At this time, various reports began to appear in both print and online media about cyber-attacks aimed at Bank Syariah Indonesia.

**Figure 1**

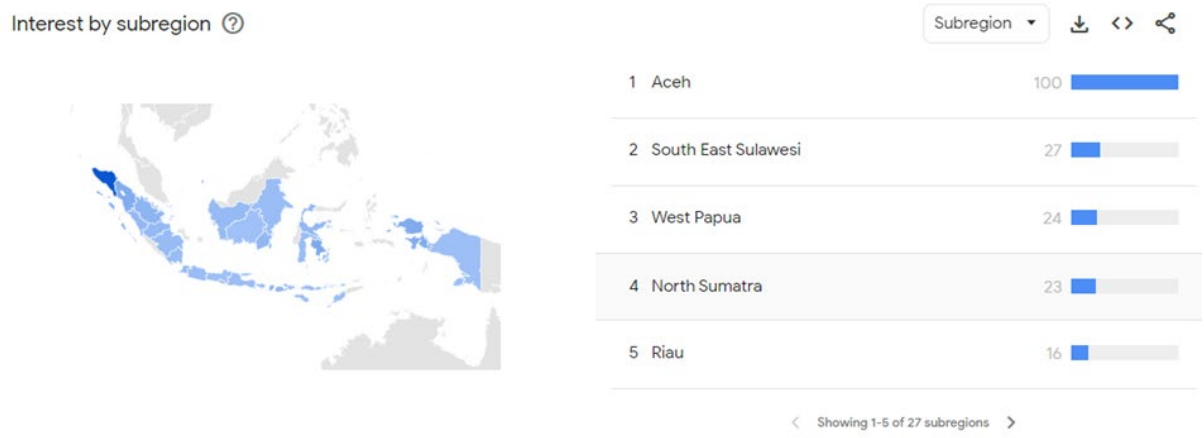
*Google Trend Search Index with the Topic of Bank Syariah Indonesia*




Source: Google Trend (2023).

Figure 2

*Interest by Region for Bank Syariah Indonesia Topic*




Source: Google Trend (2023)

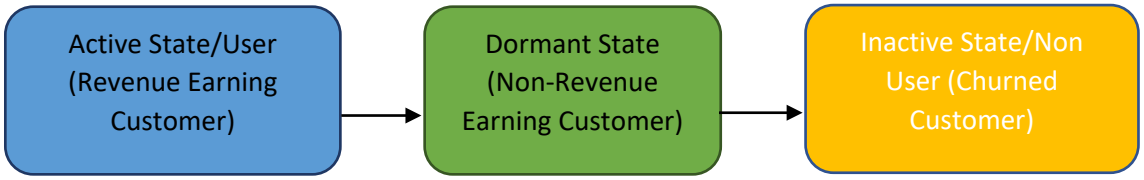
An interesting thing can be found in the Google Trends data in Figure 2, where the region that searches the most on Google.com with the keyword "Bank Syariah Indonesia" is the Special Region of Aceh. Aceh Qanun Number 11 of 2018 has rules about Islamic Financial Institutions that apply to the Province of the Special Region of Aceh. These rules have been in force since they were officially established on January 4, 2019 (Simanjuntak et al., 2023). This regulation requires financial institutions operating in Aceh to be based on Sharia principles (Damanhur et al., 2018).

## Customer Churn in Banking Industry

Customer churn has been defined differently by various researchers. For example, Geetha & Kumari (2012) defined customer churn as the number of regular customers who cut ties with service providers or manufacturers. Khodabandehlou & Rahman (2017) define customer churn as a marketing term for customers who are no longer interested in an organization or product. Bhattacharyya & Dash (2020) define customer churn as the migration of clients from one service provider to another within the same industry. On the other hand, Customer Churn prediction is defined as identifying customers based on churner or non-churner class based on profile information from consumer behavior (Coussement, 2014). Customer churn can occur due to service improvements and other company offers to customers who are considered to provide more customer benefits (Bhattacharyya & Dash, 2020). Therefore, studying customer churn behavior is very important for company management. First and one of the most impartant is knowing the position of the consumer in the customer churn phase, as shown in Figure 3.

**Figure 3**

*The Customer Churn Phase*




Source: Geetha & Kumari (2012)

When a negative situation occurs that allows customer churn, the company must avoid this situation and find the right solution as soon as possible to overcome the customer churn problem before the customer enters the inactive state phase (Sandhya N. et al., 2019). Lifting customer churn can reduce the satisfaction of other customers (Bhattacharyya & Dash, 2020) and cause a company to lose revenue (De Lima Lemos et al., 2022).

## Sentiment Analysis from Twitter Data

Twitter, rebranded as X in July 2023 after its acquisition by Elon Musk on October 27, 2022, is a popular social media tool that is widely used by the public. Twitter is the second most popular social media platform, behind Facebook, with 31.2 million monthly visitors (Kemp, 2021). When Twitter was used frequently, 58.3% of Indonesians (16–64 years old) were active users. Twitter users' tweets can provide free original data and information (Mittal et al., 2021). As quick communications with a word limit of 280 characters, tweets are a trademark on Twitter (Antonakaki et al., 2021). Numerous categories of metadata, including tweets, retweets, comments, comment answers, number of likes, tweet date, author name, language, and author location, were returned by the Twitter data crawl process. Because Twitter's text data is better organized, analysts may more easily utilize it to make strategic judgments (Chan et al., 2017; Sarmast et al., 2023; Timur, Ratnasari, Pitchay, et al., 2023b).

Data tweets have been significant for sentiment analysis and opinion mining, which analyze people's opinions, sentiments, evaluations, attitudes, and emotions in written language. Text-mining definitions and algorithms involved in its implementation have been discussed in detail (Hudaefi et al., 2021; Hudaefi & Badeges, 2022). Text mining can be understood as a specialized procedure for extracting information and discovering knowledge from vast volumes of unstructured textual data (Jadhav et al., 2023; Jeong et al., 2023; Shaffiei et al., 2023). The idea of opinion mining has primarily been addressed in the context of sentiment analysis.

Sentiment analysis is a text-categorization-based analytical technique that examines the author's thoughts, sentiments, and emotions on a given issue using language, linguistics, and text-mining data (Azhagiri et al., 2023; Kallam et al., 2023). Sentiment analysis requires data in the form of words that are subsequently filtered

and identified as outputs. Sentiment analysis techniques are generally supported by most automated text classification tools, which are regularly used by marketers as a computer-supported, fast, scalable, and effective way of measuring consumer sentiment (Dhaoui et al., 2017). Automated sentiment analysis is receiving increasing attention from both academia and industry and has become one of the main techniques for handling big social media data (Nemes & Kiss, 2021). Typically, automated sentiment analysis techniques are used to classify any text-based document into predefined categories that reflect the polarity of the sentiments referenced in the text (Chakraborty et al., 2020; Drus & Khalid, 2019). The analyzed word or sentence produces an expression or sensation of joy, surprise, sadness, fear, disguise, or anger (Wang & Li, 2015; Yue et al., 2019).

### Orange Data Mining

Orange was developed by the Bioinformatics Lab at the University of Ljubljana, Slovenia. Orange helps build data analysis workflows; perform statistical distributions, box plots, and scatter plots; or conduct analysis with decision trees, hierarchical clustering, heatmaps, multidimensional scaling (MDS), and linear projections (Demšar et al., 2013). Other machine learning tools require language programming skills to perform the analysis (for example, R), and Orange does not require researchers who possess fewer programming skills to perform data mining. Orange provides "widgets" and "canvas" for the analysis (Demšar et al., 2013). Widgets are computational units of Orange for analyzing data, whereas canvas is Orange's visual programming environment (Demšar et al., 2013).

### Research Question

The most significant and influential platform for examining public opinion on a subject is Twitter (Li et al., 2018). To create policy initiatives intended to mold and guide public behavior toward desired outcomes, it is crucial to understand public opinion (Khanday et al., 2021). Based on this, the first question is as follows:

RQ1: What topics are most liked and retweeted by netizens on Twitter related to cyber-attacks in Bank Syariah Indonesia?

RQ2: What are the most discussed topics in the word cloud visualization by netizens on Twitter related to cyber-attacks at Bank Syariah, Indonesia?

RQ3: What are the sentiments of netizens on Twitter regarding Bank Syariah Indonesia after experiencing a cyber-attack?

RQ4: What are the majority of emotion types on Twitter related to Bank Syariah Indonesia after experiencing a cyber-attack?

RQ5: What is the potential level of customer churn that can occur in Bank Syariah Indonesia in the short term after a cyber-attack?

## METHOD

### Data

Using the Twitter Application Programming Interface (API), crawl https://developer.twitter.com/ on May 26, 2023, to retrieve metadata sources from tweets on Twitter from May 10, 2023, to May 24, 2023. A 14-day period was used to determine how likely customers were to leave Bank Syariah Indonesia in the short term, from the time that news of the attack first came out on May 11, 2023, to 14 days later. This study focuses on Internet users in Indonesia, where Indonesian is the predominant language. Therefore, the three keywords used in this study are a combination of research objects that employ Indonesian and English as their absorption languages. "BSI" and "Bank Syariah Indonesia" are the two keys that are used. The total number of tweets obtained and processed for this investigation was 30,013 in both Indonesian and English.

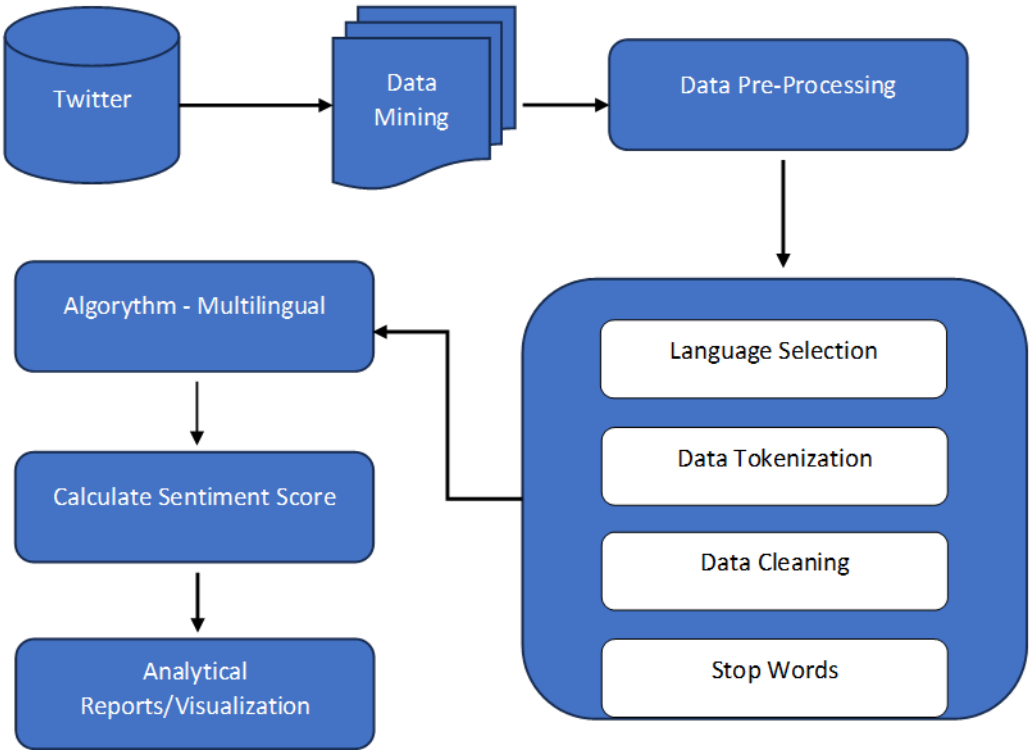
### Data Analysis

This study combines a sentiment analysis technique using a qualitative methodology with the Orange Data Mining application as a tool, as well as Microsoft Excel. This study uses a machine learning-based sentiment analysis approach with word vectors to classify text or data that contain positive, negative, or neutral sentiments. The machine-learning-based sentiment analysis approach was chosen despite its higher complexity in the interpretation process; it promises higher accuracy and fewer misclassifications (Hartmann et al., 2023). This information comes from tweets on Twitter's social media sites. The study was divided into three parts. The first was data crawling on Twitter. Pre-processing, sentiment analysis, and visualization were performed in the second step using the Orange Data Mining tool and the Multilingual Sentiment approach. The third category is the results of the identification and visualization (Timur, Ratnasari, Hadi, et al., 2023).

During the preprocessing stage, four procedures were used to remove tweet content that was unrelated to the research, resulting in clearer crawler data outputs. The researchers used the "Lowercase" tool to lowercase every letter in the tweet phrase, "Remove Accents" to eliminate unnecessary accents, and "Purse HTML" to delete tweets with HTML or URLs. In the second stage, tokenization separates tweet words, and machine learning can assess them faster. The three steps are to use stopwords to eliminate irrelevant and unrelated comments to the required keywords. During the sentiment analysis phase, researchers have utilized the Multilingual Sentiment method. As the only Lexicon language technique that can identify Indonesian tweets and phrases, Multilingual Sentiment was chosen (Timur, Ratnasari, Pitchay, et al., 2023a).

**Figure 4**

*Diagram of the Orange Data Mining Process*




Source: Primary data. Authors' modification.

To identify recognized data, three types of dictionary files are used: words that indicate a good attitude, generic terms, and phrases that describe a negative mood. The outcome of sentiment weighting using Multilingual Sentiment is positive, neutral, and negative. The final step is to measure customer churn on Bank Syariah Indonesia customers, which is expected to occur in the short term, based on the 30,013 Twitter metadata used in this study. All the data were filtered in two stages. First, in measuring potential customer churn, researchers only use negative sentiment data. Second, from the data that have negative sentiment, the researcher uses the help of Microsoft Excel to carry out the filter process a second time with the keywords "pindah (move: in English)", "ganti (change: In English)", "selamat tinggal (goodbye: in English)", "keluar (out: in English)", "tidak lagi (no more: in English)", dan "uninstall," to identify the desire consumers to stop using Bank Syariah Indonesia services.

## RESULTS

### Twitter Text Mining Dialogue Data with Most Liked and Most Retweeted Tweets

Table 2 displays the top five tweets from the mining process metadata that received the most likes and retweets. The tweet's original Indonesian text and its English translations are presented below.

**Table 2**

*Tweets with Most Likes and Retweets*

| Tweet Content (Original) | Tweet Content (In English) | Number of Likes | Number of Retweets |
|---|---|---|---|
| Guys yang pada pake BSI, mungkin udah pada tau ya kemaren eror karena ada serangan Ransomware. Nah kayaknya negosiasinya… | Guys who are using BSI, maybe you already know that there was an error yesterday because there was a Ransomware attack. Well, it's a negotiation… | 0 | 5436 |
| Tadi pagi ramai berita bahwa kelompok Ransomware LockBit akhirnya sebar 1,5 TB data karyawan dan nasabah BSI ke internet…. | This morning there was a lot of news that the LockBit Ransomware group finally spread 1.5 TB of BSI employee and customer data to the internet…. | 0 | 3347 |
| The LockBit ransomware gang has also made public the chat logs related to the negotiation with BSI. They demanded a ran… | The LockBit ransomware gang has also made public the chat logs related to the negotiation with BSI. They demanded a ran… | 0 | 1478 |
| Jika info ini benar nasabah BSI bisa menggugat rame2 @bankbsi_id karena selain gagal melindungi data pribadi kalian juga… | If this information is true, BSI customers can sue @bankbsi_id because apart from failing to protect your personal data, you also… | 0 | 1181 |
| Not sure if BSI understands what it means when they have their data stolen or they do and just trying to play dumb. | Not sure if BSI understands what it means when they have their data stolen or they do and just trying to play dumb. | 0 | 473 |
| Grup ransomware LockBit mengakui menyerang Bank Syariah Indonesia (Bank BSI), menyetop semua layanan perbankan serta mencuri… | The LockBit ransomware group admits to attacking Bank Syariah Indonesia (Bank BSI), stopping all banking services and stealing… | 0 | 293 |

Source: Processed by Orange Data Mining

Identification was carried out on all metadata of 30,014 tweets using Microsoft Excel to select the five tweets with the highest number of likes and retweets. The results show that tweets with news sentences informing cyber-attacks carried out by hacker groups at Bank Syariah Indonesia are found in this study. In addition, these news tweets contain many retweets or are retweeted multiple times by different Twitter users. Interestingly, the researchers did not find Likes on the tweets. In the context of this research, with the many retweets made by netizens, it means that many netizens are interested in discussing cyber-attacks on Indonesian Sharia Banks and want to share them with other netizens.

On the other hand, the absence of likes on several tweets with many retweets means that netizens respond negatively to the news in the tweet, so netizens only want to share information with the public. In several other tweets, researchers also

found negative sentences because they were disappointed with the performance of Bank Syariah Indonesia, particularly in terms of security. Bank Syariah Indonesia is considered to have failed to maintain customer privacy.

## Word Cloud Visualization

In this sub-chapter of the most discussed tweets, the research results are divided into two parts: the first is the most discussed words by netizens visualized in the Word Cloud widget area (See Figure 5 and Table 3) as a representation of a collection of high-intensity phrases that are commonly used as themes in tweets about cyber-attacks in Bank Syariah Indonesia. Word clouds have emerged as an easy-to-use method for displaying interesting visualizations on a set of texts (Heimerl et al., 2014). Word clouds are used in a variety of contexts as a means of providing an overview by filtering texts to determine whether they are related to the assessment (DePaolo & Wilkinson, 2014; Nguyen et al., 2011). Word clouds are also capable of displaying words derived from social media in small to large sizes, according to their frequency (Hudaefi et al., 2021; Tessem et al., 2015). Word cloud visualization generated for a set of texts can serve as a starting point for more in-depth analysis Word cloud visualization has two types of meanings: frequency and categorization (Jin, 2017; Nguyen et al., 2011).

**Figure 5**

*Word Cloud Display*


Source: Processed by Orange Data Mining

In word clouds with frequency types, the font size represents the number of keywords that appear in the collection. In word clouds with categorization types, the font size indicates the number of subcategories of a word collection. In previous study employing internet data, word cloud was utilised to display the textual data from Youtube, Zoom and other online sources (M. R. Hasan et al., 2021; Hudaefi et al., 2021; Lwin et al., 2020; Timur, Ratnasari, Hadi, et al., 2023). Word Cloud works under the following logic:

$$\frac{\frac{\text{sel}_\text{w}}{\text{sel}_\text{tot}}}{\left(\frac{net_w}{net_{tot}}\right)k}$$

where $sel_w$ denotes the number of selected nodes, $sel_{tot}$ represents total number of nodes, $net_w$ is the number of nodes in the entire network, $net_{tot}$ is the total number of nodes in the network, and $k$ is the network normalisation coefficient. Words appear more frequently in tweets, as seen from the larger word size in the term cloud. The second is the topic most discussed by netizens, which is visualized on the Topic Modelling Display in Figure 6.

**Table 3**

*The Most Common Words in Tweets*

| Word (Original) | Word (In English) | Most Common Words in the Word Cloud |
|---|---|---|
| BSI | BSI (Abbreviation of Bank Syariah Indonesia) | 16.910 |
| Data | Data | 5.915 |
| Lockbit | Lockbit | 5.584 |
| Ransomware | Ransomware | 5.138 |
| Bank | Bank | 4.496 |
| Nasabah | Customers | 4.491 |
| Berita | News | 2.312 |
| QRIS | QRIS | 1.014 |
| Order | Order | 780 |
| Gagal | Failure | 777 |
| Melindungi | Protect | 629 |
| Menggugat | Sued | 614 |
| Dana | Fund | 602 |
| Layanan | Service | 530 |
| E-Wallet | E-Wallet | 426 |
| Aman | Safe | 365 |
| Gopay | Gopay | 311 |
| Keamanan | Security | 273 |
| Percaya | Trust | 223 |
| Bertahap | Gradually | 210 |

Source: Processed by Orange Data Mining

In the word cloud visualization in Figure 5, we can find some of the words that most often appear in the conversations of netizens on Twitter related to the topic of cyber-attacks on Bank Syariah Indonesia. For example, there are the words “BSI”, “Data”, “Lockbit”, “Ransomware”, “Bank”, and “Nasabah (customers: in English)” which

indicate the name of the group of organizations as perpetrators of cyber-attacks against Bank Syariah Indonesia. The word "Data" denotes the object taken by the perpetrators of cyber-attacks in the form of personal data of Bank Syariah Indonesia customers. In addition to the word "data," the results of the study also found words such as "QRIS," "E-Wallet," "Gopay," "Layanan (service: in English)", "and "Gagal (failure: in English)" to appear in netizen conversations on Twitter. These five words reflect several services provided by Bank Syariah Indonesia in collaboration with third parties that cannot be used during cyber-attacks. For example, in the following tweet:

> "Saya mau komplain terkait transaksi, saya transfer gopay ke rekening kenapa gak masuk ya padahal rekeningnya sudah benar dan saldo gopay saya sudah terpotong." (Original Content)
>
> "I want to complain about the transaction, I transferred Gopay to the account, why didn't it go in, even though the account was correct and my GoPay balance had been deducted." (In English)

Some words with negative sentiments were also found by researchers, such as "Menggugat (sued: in English) and" dan "Gagal (failure: in English)." The word "Gagal (failure: in English)" appears frequently in discussions where the public considers Bank Syariah Indonesia to have failed to protect customer privacy data. In contrast, the word "Menggugat (sued: in English)" reflects plans and threats made by customers due to the leakage of private data from these customers. The thing that interests the researcher is the words "Keamanan (security: in English)", "Bertahap (gradually: in English)", dan "Percaya (trust: in English)". These three words relate to the response from Bank Syariah Indonesia in improving data security and returning services gradually

The topic-modeling visualization is shown in Figure 6. It shows the types of topics most frequently discussed by netizens on Twitter. Of the 30,014 tweets processed in this study, researchers found several topic words such as "BSI", "Data", "Lockbit", "Ransomware", "Nasabah (customers: in English)", "Karyawan (employee: in English)", "Kelompok (group: in English)", "Sebar (share: in English)", "Berita (news: in English)", and "Internet. This study used LDA to model topics from the sampled words. The logical framework of the LDA analysis is $Ii = (A_i, A_2, .. ., A_n)$. The documents to i(Ii) have a distribution of the number of terms An, where the bag-of-words vector operates the LDA process of the input corpus that generates a subject model, which is the distribution of words across k-topics (Hudaefi et al., 2021). Overall, some words in the topic modeling visualization were similar to those in the word cloud visualization.

**Figure 6**

*Topic Modelling Display*

| Topic | Topic keywords |
|---|---|
| 1 | bsi, data, lockbit, ransomware, nasabah, karyawan, kelompok, sebar, berita, internet |
| 2 | bsi, bank, sebar, ramai, internet, kelompok, berita, karyawan, data, nasabah |
| 3 | data, ransomware, nasabah, pribadi, gagal, melindungi, menggugat, lockbit, serangan, berita |
| 4 | bank, lockbit, qris, bsi, order, syariah, netflix, bca, trusted, ewallet |
| 5 | ransomware, qris, serangan, netflix, bank, order, bca, trusted, ewallet, fast |
| 6 | lockbit, data, nasabah, ransomware, berita, bsi, internet, ramai, karyawan, qris |
| 7 | serangan, ransomware, lockbit, bank, syariah, bsi, data, bca, netflix, qris |
| 8 | data, gagal, nasabah, menggugat, melindungi, lockbit, pribadi, ransomware, bsi, bank |
| 9 | dana, gopay, ovo, payment, ewallet, link, spotify, fast, trusted, bca |
| 10 | syariah, layanan, nasabah, sandi, password, bank, hacker, nomor, lockbit, call |

Source: Processed by Orange Data Mining

Several interesting topics were found in topic number 8 where there are several topics such as "Gagal (failure: in English)", "Nasabah (customers: in English)", "Menggugat (sued: in English)", Melindungi (protect: in English)", and "Pribadi (private: in English)" as an example in the following tweet:

> "Jika info ini benar nasabah BSI bisa menggugat rame2 @bankbsi_id karena selain gagal melindungi data pribadi kalian juga."
>
> "If this information is true, BSI customers can sue @bankbsi_id for not only failing to protect your personal data." (In English)

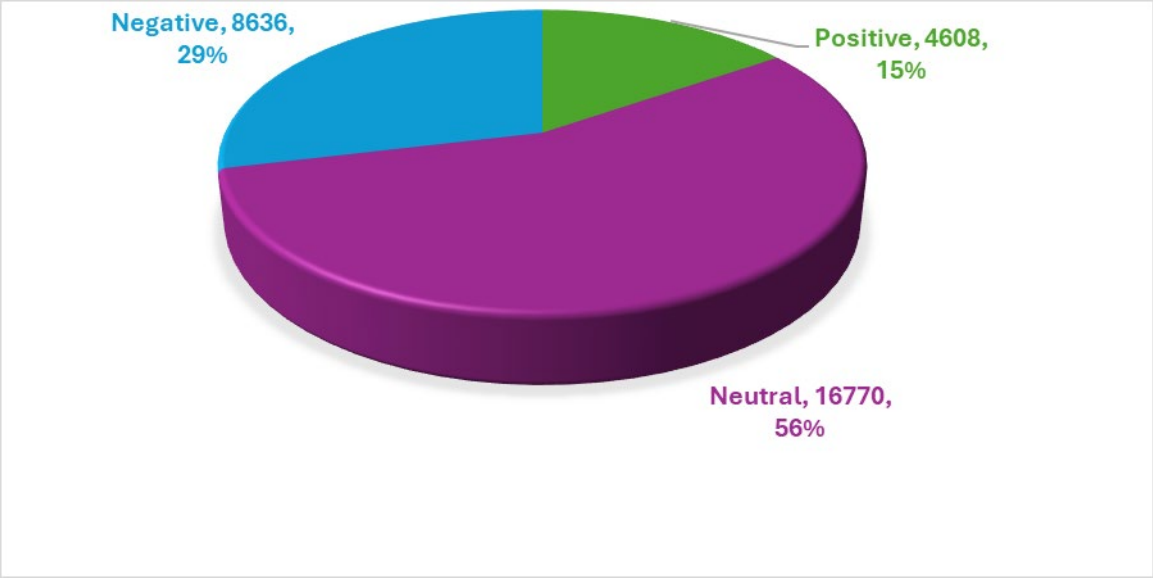
These five topics indicate that most netizens think that Bank Syariah Indonesia failed to protect customer privacy data, so some customers have plans to file a lawsuit against Bank Syariah Indonesia.

## Sentiment Analysis

The sentiment analysis visualization shows the entire sentiment value (compound), which is then classified into three categories: positive, neutral, and negative. If the sentiment number is greater than zero, then the sentiment from the tweet data is positive. By contrast, if the sentiment is 0.00, the tweet data are negative. Meanwhile, if the emotion value was 0, the tweet was regarded as neutral. In addition, the outcomes of calming sentiment are shown in Figure 7. As shown in Figure 7, the 30,014 tweets included in this study's sentiment analysis were dominated by tweets with neutral sentiment or a value of 0. There were 16,770 tweets in this study, with a total score of zero or neutral. The researcher found that most of the sentences with Neutral sentiment were in the form of news that informed the incident of cyber-attacks carried out by the Lockbit Ransomware hacker group on Bank Syariah Indonesia

**Figure 7**

*Sentiments Analysis on Tweets Data*




Source:Processed by Orange Data Mining

The researchers found several types of sentences that appeared most often in tweets with positive sentiments. For example, a sentence conveys a positive experience from a customer when using the services of a responsible Indonesian Sharia Bank. Other positive sentiment sentences are in the form of news sentences, which are counter sentences or responses to negative news about threats from cyber-attacks. For example, one of the sentences in Table 3 states that Bank Syariah Indonesia responds to cyber-attacks by increasing the quality of BSI Mobile regarding system specifications and features so that it is hoped to be used again shortly. It is interesting to note that the number of sentences with negative sentiments (8636 tweets or 29%) is greater than that with positive sentiments (4608 tweets or 15%). Sentences that have negative sentiments have several negative words such "lemah (weak: in English)", "krisis (crisis: in English)", dan bersedih (sad: in English)" which show the feelings of customers who are worried about the data that hacker groups have controlled

**Table 4**

*Tweets With Most Likes and Retweets*

| Tweet Content (Original) | Tweet Content (In English) | Sentiment Type | Sentiment Score |
|---|---|---|---|
| Hal ini memacu perseroan untuk menjaga kepercayaan nasabah melalui peningkatan kualitas BSI Mobile baik secara sistem maupun fitur, yang mencakup transaksi finansial, transaksi sosial dan transaksi | This has spurred the company to maintain customer trust by improving the quality of BSI Mobile in terms of systems and features, including financial transactions, social | Positive | 50 |

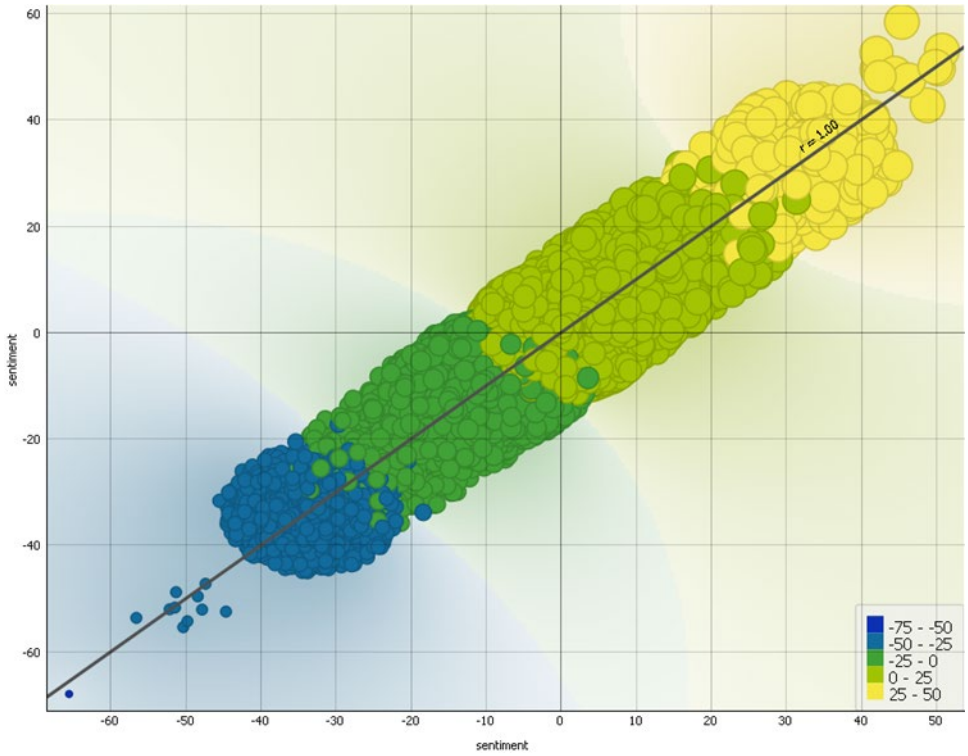
| Tweet Content (Original) | Tweet Content (In English) | Sentiment Type | Sentiment Score |
|---|---|---|---|
| spiritual. | transactions, and spiritual transactions. | | |
| Ini hanyalah pengalaman pribadi. Semoga ada manfaatnya. Dan saya berterimakasih pada BSI yg menerima kami dengan penjelasan yg memuaskan dan juga bertanggungjawab terhadap raibnya uang kami. Trims | This is just personal experience. I hope it's of use. And I thank BSI for receiving us with a satisfactory explanation and also for taking responsibility for our money's disappearance | Positive | 25 |
| Kelompok hacker LockBit diduga meminta tebusan sebesar US$20 juta atau setara Rp295,6 milar kepada pihak Bank Syariah Indonesia | The LockBit hacker group is suspected of asking for a ransom of US $ 20 million, or the equivalent of Rp 295.6 billion, from Bank Syariah Indonesia. | Neutral | 0 |
| Berhubung lagi rame tentang Ransomware dari Lockbit yg nyerang BSI, temen-temen bisa baca beberapa hal yg bisa kita lakukan untuk mencegah Ransomware | Since there is more talk about Ransomware from Lockbit that attacks BSI, friends, you can read some things we can do to prevent Ransomware. | Neutral | 0 |
| Serangan siber menunjukkan lemahnya sistem pertahanan digital Bank Syariah Indonensia (BSI). Tidak ada protokol krisis sehingga membuat nasabah panik. | The cyber-attack shows the weakness of the Bank Syariah Indonesia (BSI) digital defense system. There is no crisis protocol so that it makes customers panic. | Negative | -25 |
| -50Kita patut bersedih atas apa yang menimpa @bankbsi_id. LockBit Ransomware sudah mempublish data-data BSI yang mereka kuasai.... | We should be sad for what happened to @bankbsi_id. LockBit Ransomware has published the BSI data that they control.... | Negative | -50 |

Source: Processed by Orange Data Mining

Twitter's metadata help results are shown as a widget scatter plot of randomly dispersed dots in a pattern. Scatter plot data, depending on the x- and y-axis features with varied colors and graphics, assist clients in understanding the data processing outcomes. This study used sentiment features on both axes to build a scatter plot distribution using the acquired sentiments (See Figure 8). The scatter plot widget shows that most tweet data are vivid green, with a sentiment value of 0 to 25. This shows that the scatter plot results confirm the preceding visualization that Indonesian public opinion is neutral toward Bank Syariah Indonesia's cyber-attack.

**Figure 8**

*Scatter Plot Display*



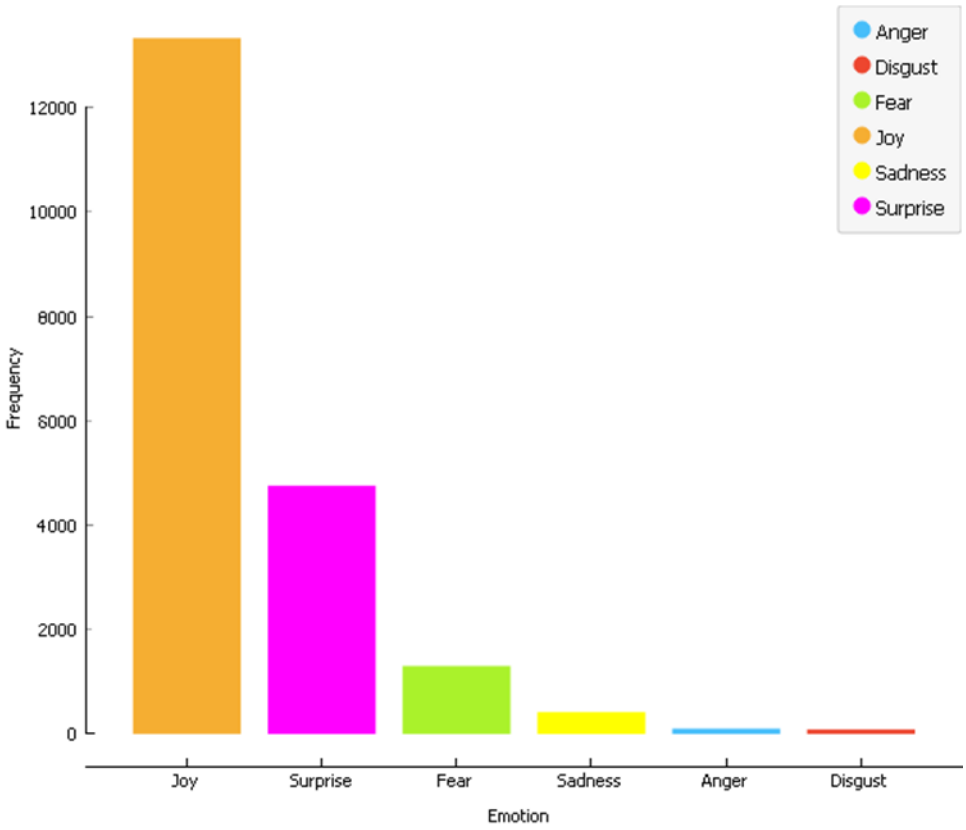

Source: Processed by Orange Data Mining

## Emotion Analysis

Twitter profilers can quantify sentiment analysis by using crawled documents. Ekman's, Plutchik's, and POMS will be categorized by the Twitter profiler widget to assess each article's emotional likelihood (See Figure 9). The Twitter Data Profiler widget sentiment analysis shows that 937 data tweets are joyful. This joyful emotion dominated the tweet data at 93.51%. Subsequently, 52 tweets (5.19%) show surprise. However, only a few tweets were found to be negative. Five or 0.5% of the tweet data showed fear and sadness, according to the Twitter profiler widget sentiment analysis. The lower figure was also acquired through sentiment analysis data, which indicated that rage and deception were the most prevalent emotions, with 5 and 2, respectively.

**Figure 9**

*Data Sentiment Display Based on Twitter Profiller*




Source:Processed by Orange Data Mining

According to the sentiment analysis results obtained, 937 data tweets exhibited a joy reaction using the Twitter Data Profiler widget. With a percentage value of 93.51% of the analyzed tweet data, this joyous emotion predominates. Subsequently, 52 data tweets (5.19 %) were found to be tweets expressing astonishment. However, there aren't many tweets that express unfavorable opinions. For instance, sentiment analysis of tweet data using the Twitter profiler widget revealed that 5 or 0.5% of the tweet data indicated sentiments of dread and despair. The lower figure was also acquired through sentiment analysis data, which indicated that rage and deception were the most prevalent emotions, with 5 and 2, respectively.

## Customer Churn Analysis

The procedure of customer churn analysis involves the utilization of a filtering mechanism with the assistance of Microsoft Excel to categorize tweets that indicate customers discontinuing their use of specific products or services.

**Table 5**

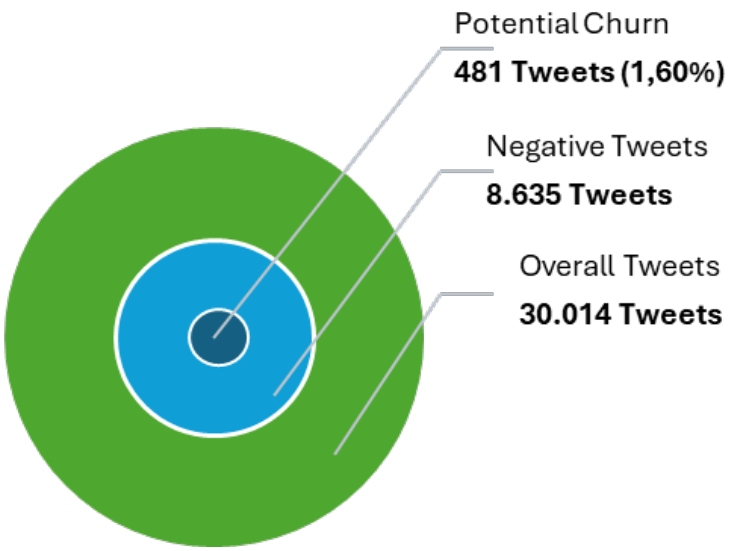
*Volume of Negative Tweets and Potential Churn*

| Total Tweets | Negative Tweets | Potential Churn |
|---|---|---|
| **30.104** | 8.635 | 481 |

Source: Processed by Orange Data Mining

**Figure 10**

*Volume of Negative Tweets and Potential Churn Display*




Source:Processed by Orange Data Mining

The results of the customer churn analysis show that of the total tweet metadata used, 8,635 tweets have a negative sentiment (See Table 5). After that, out of 8,635 tweets that had negative sentiments, the researcher found 481 tweets (1.60% of the total Tweets) that contained the words "pindah (move: in English)", "ganti (change: in English)", "selamat tinggal (goodbye: in English)", "keluar (out: in English)", "tidak lagi (no more: in English)", dan "uninstall." These five words indicate a customer's intention to stop using products and services from Bank Syariah Indonesia.

Figure 10 visually presents sentiment data derived from Twitter Profiller, processed by Orange Data Mining. It offers an overview of sentiment distribution, showcasing the prominence of negative sentiment tweets identified as indicators of potential churn. The graphical representation underscores how negative sentiments can be a precursor to customer churn, particularly when language explicitly indicates dissatisfaction or an intent to switch services. Together, Table 5 and Figure 10 provide a clear indication of how cyber-related incidents impact customer loyalty and satisfaction, emphasizing the importance of addressing negative customer sentiments to mitigate potential losses in customer retention.

## DISCUSSION

The results of the study show that many tweets with the highest number of retweets discussing the topic of Bank Syariah Indonesia have the form of informative sentences that aim to spread the news of cyber-attacks that have occurred on Bank Syariah Indonesia to the broader community. Kakar et al. (2021) stated that retweeting action comes from someone who has significant influence and can disseminate information quickly and accurately. Retweet behavior also indicates that a person is interested in the topic discussed (Huang et al., 2014; Timur, Ratnasari, Hadi, et al., 2023). The many

retweeting behaviors carried out by netizens towards tweets reporting cyber-attacks indicate that netizens want to share information with the public so that they are also aware of the news and can take anticipatory steps to prevent the adverse effects of cyber-attacks.

In the results of the word cloud visualization, we can also see several words that often appear with negative sentiments, such as "gagal (failure: in English)", "melindungi (protect: in English)", dan "layanan (service: in English)". Because of the Lockbit attack, many Bank Syariah Indonesia services such as ATMs, mobile banking, and Internet banking cannot be used by customers (Safitri, 2023). As providers of banking services, trust and satisfaction are the leading indicators for customers to use banking product services sustainably. Customer satisfaction, reputation, and trust affect loyalty to Islamic banks. Customers who do not trust Islamic banks will not be loyal (Faza et al., 2022; Riyadi, 2021). In the context of the banking industry, data privacy and security are important keys, so consumers choose banking products (Barth et al., 2019).

According to the study, the 30,014 processed tweets were mostly neutral with joy. This neutral sentiment is expected when the tweets discussed are dominated by news or information sentences (Timur, Ratnasari, Hadi, et al., 2023). The findings of this neutral sentiment support the findings of word cloud and topic modeling, which show that the words and topics that appear in the discussion of cyber-attacks against Bank Syariah Indonesia are concerned with information about the disruption of services provided by Bank Syariah Indonesia to customers. The emotion of joy shows that most netizens on Twitter still have faith in the performance of Bank Syariah Indonesia in dealing with cyber-attack. This can be seen in several tweets that show positive sentiments, as shown in Table 3. As with the stages of customer churn conveyed by Geetha and Kumari (2012), when experiencing a problem or crisis when using certain services, consumers do not immediately switch products from other companies. Therefore, a positive response, identifying, protecting, and recovering the company in solving these problems quickly and appropriately, determines the potential results of customer churn (Adelmann et al., 2020).

The results of customer churn analysis show that in the short term, there are 481 tweets, or 1.60% of the total tweets, which indicate whether to stop or not using Bank Syariah Indonesia services in the future. Even though the figure of 1.60% looks small, with a total of 18.4 million customers (Abigail, 2023) and a very large potential for Muslims, the potential for losing customers will be quite large. In addition, customer churn incurs greater costs than attracting new customers (Svendsen & Prebensen, 2013). In addition, customer churn caused by dissatisfaction with the service received can potentially increase customer churn due to recommendations from fellow dissatisfied customers. According to Nasar et al. (Nasar et al., 2019), intentions that develop over a relatively short period of time have a strong capacity to mediate the effect that exists between the dimensions of planned action and long-term intent. Therefore, if consumers of Bank Syariah Indonesia intend to switch their banking

services to those of another bank in the near future, it is conceivable that they will act in accordance with this goal.

## CONCLUSION

The results of the study show that the response of netizens on Twitter to cyber-attacks on Bank Syariah Indonesia is still positive, dominated by emotions of joy, where these emotions are shown through tweets that show that customers still believe in Bank Syariah Indonesia's products and services, especially in maintaining customer privacy data. On the other hand, this study found potential customer churn whose value, although insignificant, if it is responded to quickly, will positively impact the growth of Bank Syariah Indonesia customers.

Based on the research results, financial institutions are predicted to use technology massively in all aspects of their operational lines in the future. Therefore, customer trust and satisfaction will rest on the fast and accurate banking services provided through technology. Therefore, the results of this study provide practical implications, especially for management in the banking industry in general, and Bank Syariah Indonesia in particular, to provide a quick response if a cyber-attack occurs so that customer churn does not occur in customers.

### Limitations of the Study

The primary limitation of this study is its reliance on a single social media platform, Twitter, as the sole data source for analyzing public sentiment and potential customer churn following the cyber-attack on Bank Syariah Indonesia. Twitter users may not fully represent the broader demographic or customer base of Bank Syariah Indonesia because social media platforms have unique user demographics and engagement patterns. This narrow data source could limit the generalizability of the findings to other platforms and potentially overlook sentiment trends that might be present on more widely used platforms among diverse age groups, such as Facebook or Instagram.

Another limitation of the study lies in its limited timeframe for data collection, which was restricted to two weeks after the cyber-attack incident. While this window provides a snapshot of immediate reactions, it may not capture the evolving sentiments or behavioral changes that can occur over the longer term, as customers process their responses to security issues. Long-term sentiment shifts and loyalty impacts could reveal different insights into customer reactions and retention challenges, which are critical in understanding the sustained impact of cybersecurity incidents on customer trust.

Lastly, the study focuses on analyzing sentiment and emotions but does not delve deeply into the socioeconomic backgrounds or specific behavioral traits of the customer base. Demographic information such as age, income, and frequency of Islamic banking service use could provide an additional context for understanding customer churn and sentiment patterns, potentially yielding a more nuanced view of which customer segments are most affected by cyber-attacks. Without these insights,

the study offers a broad sentiment analysis but may miss critical factors influencing specific groups' loyalty and trust in Islamic banking services.

### Recommendations for Further Research

Future research should incorporate data from multiple social media platforms such as Facebook, Instagram, and LinkedIn to capture a broader range of public sentiment and provide a more comprehensive analysis. Because different platforms cater to various demographics, adding these sources would help researchers gauge reactions across a wider audience, allowing for a richer understanding of public sentiment regarding cyber-attacks on Islamic banks and offering insights into how different segments perceive cybersecurity issues.

Expanding the data collection timeframe would also be beneficial, allowing researchers to monitor customer sentiment and churn over an extended period, such as six months to a year, following a cyber-attack. This approach reveals whether the initial positive sentiments persist or evolve as customers experience the bank's response to the incident. Longitudinal studies would provide a more in-depth understanding of long-term trust recovery, effectiveness of cybersecurity strategies, and sustainability of customer loyalty in Islamic banking.

Further research could also benefit from segmenting the analysis based on customer demographics and behavioral characteristics such as age, income, and usage frequency of Islamic banking services. By examining these variables, researchers can better identify which customer groups are more vulnerable to cyber-related churn and assess how targeted communication strategies might mitigate these risks. Such insights would allow Islamic banks to implement tailored risk management and customer retention strategies, address specific concerns across customer segments, and ultimately strengthen customer loyalty.

### Author Contributions

| | | | |
|---|---|---|---|
| Conceptualization | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Resources | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |
| Data curation | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Software | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |
| Formal analysis | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Supervision | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |
| Funding acquisition | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Validation | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |
| Investigation | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Visualization | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |
| Methodology | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Writing – original draft | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |
| Project administration | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. | Writing – review & editing | Y.P.T., A.A.R., K.F., F.D.S., C.C., & F.N. |

All authors have read and agreed to the published version of the manuscript.

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## Institutional Review Board Statement

The study was approved by Program Studi Ekonomi Islam (S1), Universitas Negeri Surabaya, Surabaya, Indonesia.

## Informed Consent Statement

Informed consent was not required for this study.

## Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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## Conflicts of Interest

The authors declare no conflicts of interest.

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