

# **AUTOMOBILE SALES FORECASTING USING TWITTER**

Hisaki Goto<sup>1</sup> and Yukiko Goto<sup>2</sup>

<sup>1</sup>*Nagoya Gakuin University, Aichi, Japan*

<sup>2</sup>*Enconnect Inc., Fukuoka, Japan*

## **ABSTRACT**

Social listening on Twitter is actively performed as alternative data for marketing and product development in various business fields. In an attempt to create a formula to forecast future automobile sales from content posted on Twitter, we collected and analyzed tweets related to automobiles in Japan from June 2018 to May 2020. The results showed that automobile sales could be forecast when the number of tweets was high. This indicated that social media is useful as alternative data for product sales forecasting. During the study, we noticed that forecasts became possible after a product entered the so-called "cash cow" phase in the "product portfolio matrix", developed by the Boston Consulting Group, which uses market growth rates and relative markets to develop business strategies. Based on this, we propose a hypothesis that in order for the sale of a product to be forecast, the product needs to enter the "cash cow" phase in addition to a large number of tweets.

## **KEYWORDS**

Twitter, Social Listening, Automobile Sales Forecasts

## **1. INTRODUCTION**

In our previous study we had analyzed national elections in Japan through social listening by gathering and utilizing text data posted on Twitter (Goto, 2018, Goto, 2019). 2,009,520 tweets were gathered for the election analyses (Goto, 2019), making the study uniquely valuable because other previous studies had only used several hundred thousand tweets. Figure 1 shows a correlation between the number of tweets and the number of votes obtained at the 23<sup>rd</sup> Upper House election under the proportional representation system, and Figure 2 is our prediction and actual results. We found that it is difficult to forecast election results through Twitter of political parties such as JCP (Japanese Communist Party) and Komeito (party backed by religious group) that are supported by organized votes.

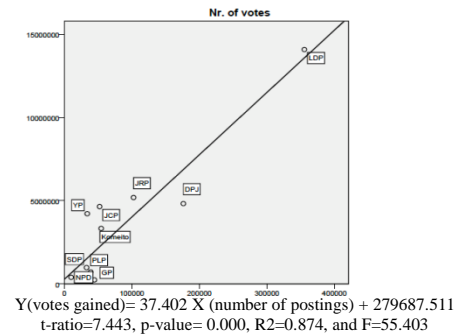


Figure 1. Analysis of 23rd Upper House General Election: Proportional Representation  
(Source: Goto, 2019)

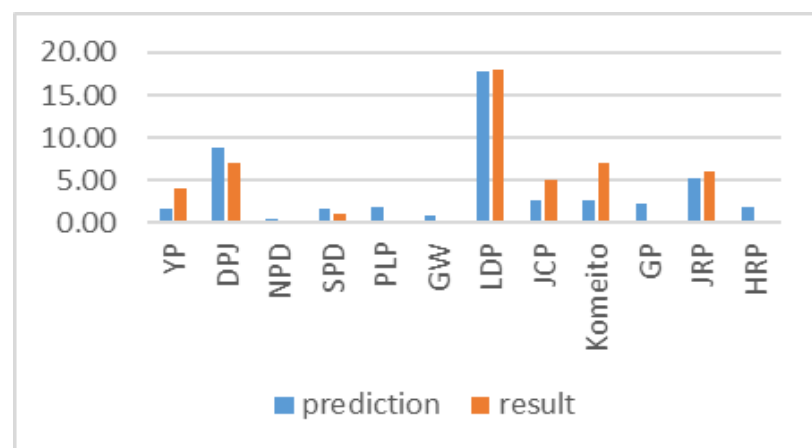


Figure 2. 23rd Upper House General Election: Prediction and Actual Results under Proportional Representation  
(Source: Goto, 2019)

We found that social media is a useful tool to make predictions about elections under the proportional representation system and that it can replace conventional prediction methods such as the RDD (Random Digit Dialing) method at low cost with frequency.

As Figure 3 shows, Japan's Twitter population is ranked as the second following the U.S. Considering the U.S. population is 2.6 times larger than that of Japan (329,500,000 in the U.S. and 125,800,000 in Japan in 2020), it is easy to understand how large the proportion of Twitter population is in Japan. TPS (Tweets Per Second) numbers also show the Japanese love of Twitter: Akimoto (2011) mentions that New Year's tweets in Japanese in 2011 made the world record of 6,939 TPS, and 143,199 TPS during the broadcast of the animation movie 'Castle in the Sky' on August 2, 2013 renewed the world record. Also, the majority of top 10

TPS come from Japan. In this study, we attempted to forecast automobile sales in Japan by taking advantage of the Japanese love of Twitter.

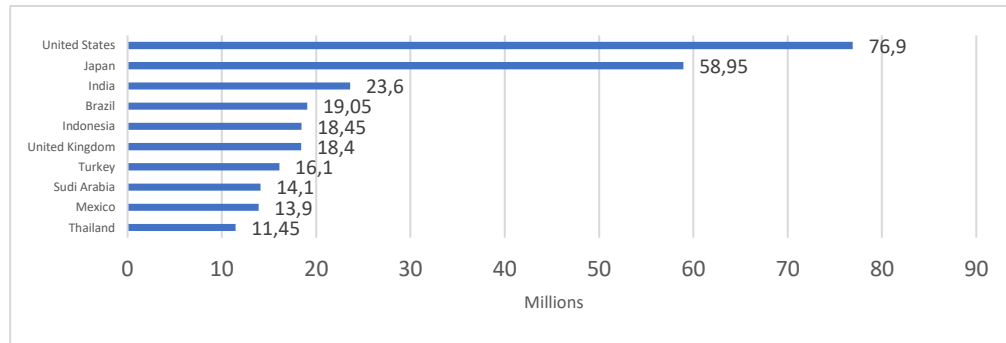


Figure 3. Leading countries based on number of Twitter users as of January 2022

Source: Statista (2022), <<https://www.statista.com/statistics/242606/number-of-active-twitter-users-in-selected-countries/>> Retrieved on April 29, 2021

## 2. TWITTER IN JAPAN

Twitter is a simple submission site on which users can send short messages to exchange opinions and thoughts. Those messages are published on the site unless they are private, and users can follow other users' tweets. Topics are often hash-tugged, and by clicking hash-tugs, users can read other messages. Also, there is a list of "trending" tweets on the site, so people can know what the Twitter community is talking about the most.

The reasons for the popularity of Twitter in Japan seem well connected to the cultural and regional characteristics of the country. One of the big factors for its popularity is the number of words (140 Japanese letters). Japanese is not a fully phonetic language, and people are good at shortening words that can be easily understood. In 140 letters users can deliver much more information than users in English. Also, Twitter is a good SNS tool for long commuters in the country. It is not unusual for people to take more than an hour to commute to their office, and in subways or trains speaking is against the societal norm; thus, mobile phones are a perfect tool for those commuters to quietly spend time while reading and responding to a posting in less than 140 letters. In addition, Twitter offers privacy to Japanese users. Unlike Facebook, which requires users to reveal their true identity, Twitter allows users anonymity, so users can enjoy casual conversations without worrying, which is an important factor in the Japanese market.

With the ability to spread information quickly and far and wide, Twitter is considered an important information delivery tool and is widely utilized by government agencies in Japan. When it started service in the Japanese language in 2008, Twitter appeared merely a tool to share and exchange particular interests among friends and communities, and was not considered a news and information delivery tool. That perspective changed with the Great East Japan Earthquake on March 11, 2011. Figures 4 and 5 are the number of tweets by local governments and the number of followers on local governments' tweets around the earthquake, respectively. According to Yoshitsugu (2011), Twitter obtained 572,000 new users on the day

after the earthquake, compared to 460,000 new users per day in the previous month, and Twitter access in the week of the earthquake increased by 33% from the previous week. The data on March 11 shows that within an hour from the earthquake, more than 1,200 tweets were posted from Tokyo, and before the date changed in the U.S. Twitter office, 246,075 tweets containing the word “earthquake” were posted. In order to avoid tweeted information being scattered around, the Twitter office proposed the earthquake-related hash-tugs and called on users to use those hash-tugs when they tweet about the earthquake. Twitter was used as a source to acquire information about, for example, the need for supplies for evacuees or the state of the stricken areas. Since then Twitter has grown as an important information source on occasions of emergency such as earthquakes and typhoons.

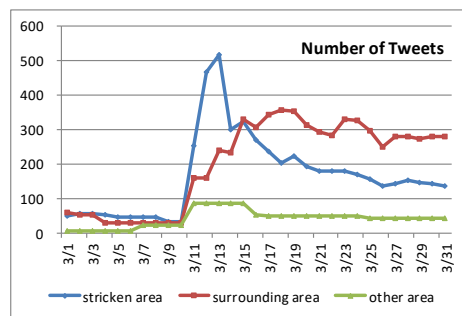


Figure 4. Number of tweets by local governments

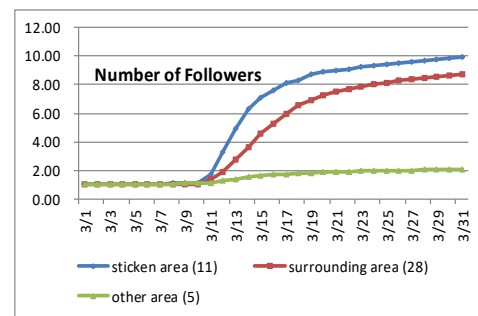


Figure 5. Number of followers on local governments' tweets

※Comparison with the number of followers on March 1 as 1

Created from excel data by Ministry of Internal Affairs and Communications  
(Source: <https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/h23/html/nc143c00.html>)

### 3. SOCIAL MEDIA

Conventionally, in the field of marketing communications, the induced consumer behavior process has been analyzed using the AIDA model<sup>(1)</sup>, which was published by Strong (1925). The model consists of four stages: consumers become aware of the existence of a particular product or service through advertisements (Attention); take interest in the product (Interest); have a desire to purchase the product (Desire); and take actions to purchase the product (Action). The AIDA model has several types such as the AIDMA model by Hall (1924), which adds Memory because it takes time to move from Desire to Action, and the AIDCA model by Kitson (1920), which adds Conviction consumers come to before the purchase. Japan traditionally uses Hall's AIDMA model in marketing practices.



Figure 6. AIDMA model

However, due to the widespread use of the internet, consumer behavior processes have been changing, and Akiyama et al. (2004) propose the AISAS model. In the AISAS model, consumers pay attention to a particular product through an advertisement (Attention); take interest in the product (Interest); quickly search the product through internet search engines (Search); purchase the product after comparing it to similar products or confirming its popularity (Action); and, after the purchase, share the information of the product through social media (Share). Needless to say, a loop is formed from Share to Search.



Figure 7. AISAS model

#### 4. SOCIAL LISTENING

In the business world, the method of so-called “social listening”, which utilizes social media as data, is used to solve problems. Rappaport (2011) asserts that there are two kinds of research methods for social listening. One is social monitoring, which is used for PR brand protection, business activities, customer service, social activities and architect engagements by routinely tracking comments on products online. The other is social research, which understands the background of customer activities and products they use in their daily lives by analyzing the contents of their online conversations. Rappaport (Ibid.) differentiates between social monitoring and social listening as tactical and strategic, respectively.

It is possible, for example, to find reasons from Point-of-Sale data or customer data as to why customers purchased certain products, but it is difficult to find reasons why customers did not choose said products. Also, although acquiring negative information is possible from complaints or suggestions collected at customer service departments or call centers for product improvement, it is difficult to include positive information from satisfied customers for overall analysis. However, social listening makes it possible to collect both positive and negative information together. Through social listening it is possible to collect massive data that was not available before, and with that prospect social listening plays an important role in the business world. In short, under the conventional method, marketing research is conducted by gathering information at the scene or by survey using a certain number of samples for product development, marketing and management as shown in Figure 8. In contrast, social listening makes it possible for companies to listen to numerous opinions from consumers and society through SNS as shown in Figure 9; as a result, consumers and society can be put in the center for product development, marketing and management. The merit of social listening is that straightforward opinions from consumers or citizens, who evaluate the quality of products, services or policies, can be heard.

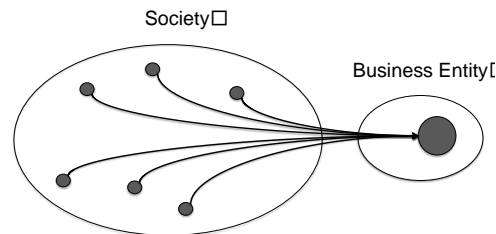


Figure 8. Information gathering structure by business entity

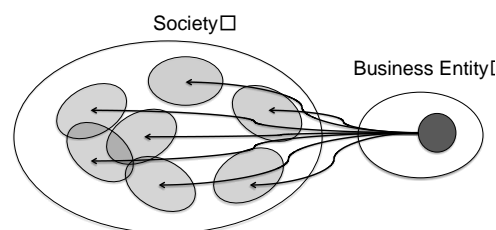


Figure 9. Information gathering structure by social media

## 5. LITERATURE REVIEW

Previous studies that forecast product sales using social media include Dijkman, Ipeirotis & Aertsen (2015), Wijnhoven & Plant (2017) and Pai & Liu (2018). The study by Dijkman, Ipeirotis & Aertsen (2015) showed that commodities that receive less attention on social media did not show similar results as shown in books or movie tickets. This case study classified tweets into three types of tweet: the type of tweet, the type of user who posted the tweet, and the sentiment of the tweet in four countries. Their analysis suggested that positive tweets by persons may be useable to predict sales and that there was a relation between a peak in the number of positive tweets and an increase in sales in the following weeks. However, they pointed out that the relation between tweets and sales was not necessarily a causal relation but may be affected by a third factor for the sales. Wijnhoven & Plant (2017) explored the usefulness of sentiment analysis and Google Trends for automobile sales forecasts. They analyzed half a million postings related to the eleven automobile models on social media using linear regression models. Also, the study compared its results to Google Trends for predictability. The study concluded that sentiment analysis on social media showed little predictability on automobile sales, while Google Trends data and social mention volume showed meaningful results. Pai & Liu (2018) employed social media data, stock market values and time-series models to predict monthly sales of automobiles in the U.S. Sentiment analysis of tweets, stock market values and hybrid data were used for the analysis to forecast the total monthly sale of automobiles in the U.S. The study concluded that the values from social media and the stock market were essential for the monthly sales forecast and that the exclusion of seasonal variability improved the forecast of precise monthly sales. As such, most sales forecasts using Twitter have not seen success yet.

Our study gathered tweets related to 12 vehicle models sold in Japan for two years, from June 2018 to May 2020. The total number of tweets gathered was 3,247,796, quite large compared to other previous studies

## **6. METHODS FOR THE STUDY**

The study analyzed Twitter data of 12 automobile models and actual sales data published by Japan Automobile Dealers Association (JADA). In this chapter we discuss the methods for social listening and how the social listening data was analyzed.

### **6.1 Methods for Social Listening**

We can think of three methods for social listening using Twitter, which are: the use of Twitter API (Application Programming Interface), the use of Twitter Firehose, and the use of a real-time search engine. In order to perform social listening from Twitter, Twitter API is the most popular tool. By using the research API in Twitter, search on tweets by keywords (for example those related to car model names) can be performed. Twitter API allows free access by a master's student, doctoral candidate, post-doc, faculty, or research-focused employee at an academic institution or university as long as applicants can clearly define their academic research purpose, not for commercial use, in the application form. Twitter terminated the offering of free access to Twitter API Ver.2 and Ver.1.1 on February 9, 2023, and according to an email sent to us by Twitter on March 30, they were still looking at new ways to serve the research community. For non-academic use, retrieving up to 10,000 tweets per month was available with 100 U.S. dollars. The second method is to use Twitter Firehose. Twitter Firehose makes it possible to acquire all published tweets on a real-time basis through Twitter's Streaming API. That tweets data can be purchased from companies which are licensed with Twitter. In Japan NTT Data Corporation has a Firehose contract with Twitter and provides the service for a fee. The service also provides their contracted customers with various Twitter data analyses such as popularity of their products or services, or results of promotional campaigns. However, those customers are not only business enterprises but also government related agencies, which conduct censorship of information or information control to suppress activities by anti-government organizations. The third method is the use of a real-time search engine, which we used for the study. Real-time search is an internet search that reflects and adds postings on a real-time web service like Twitter on a second-by-second basis. Google initiated the service in October 2009 but halted the service in July 2011 due to the expiration of the access provision contract with Twitter. Yahoo! Japan started the real-time research services on June 14, 2011. Tweets that can be extracted through a Yahoo! Japan real-time search are tweets that are written in Japanese and are not set in private. Some tweets that are considered inappropriate for the company's own criteria are automatically deleted. Yahoo! in the U.S. does not provide the real-time search services.

### **6.2 Vehicle Models Subject for the Study**

JADA publishes previous month's sales by models, and we selected the 25 top sold vehicle models published in May 2018. Those model names were searched by keywords on real-time

search by Yahoo! Japan, and models that cannot be identified due to homonyms were excluded (for example, when searching for Toyota 'AQUA' ('Prius C' is the international name), non-related words such as 'aquarium' were excluded). Among 25 models, we selected twelve models after having removed model names with many homonyms (Table 1).

Figure 10 is the sales record of the 12 models from June 2018 to May 2020 published by JADA. Toyota's models are always high on the list of the chart. Especially, Toyota Prius had been the most sold model since January 2019, but a Higashi-Ikebukuro runaway car accident <sup>(2)</sup> on April 19, 2019 damaged the sales, and after August 2019 the sales dropped to 1/3 of its peak. On the other hand, Toyota Yaris has become the top seller since May 2020. Honda came second on the number of sales. Nissan had held the second ranking on the sales for a long time, but after the arrest of the former Nissan CEO Carlos Ghosn on charges of fraud related to the executive compensation, its sales dramatically plummeted, and although the Nissan X-TRAIL was subject to the research, the sales dropped by half during the data gathering.

Table 1. Models subjected for study

Prius	VOXY	SIENTA	COROLLA
C-HR	Vitz	IMPENZA	VEZEL
ALPHARD	STEP WGN	X-TRAIL	DEMIO

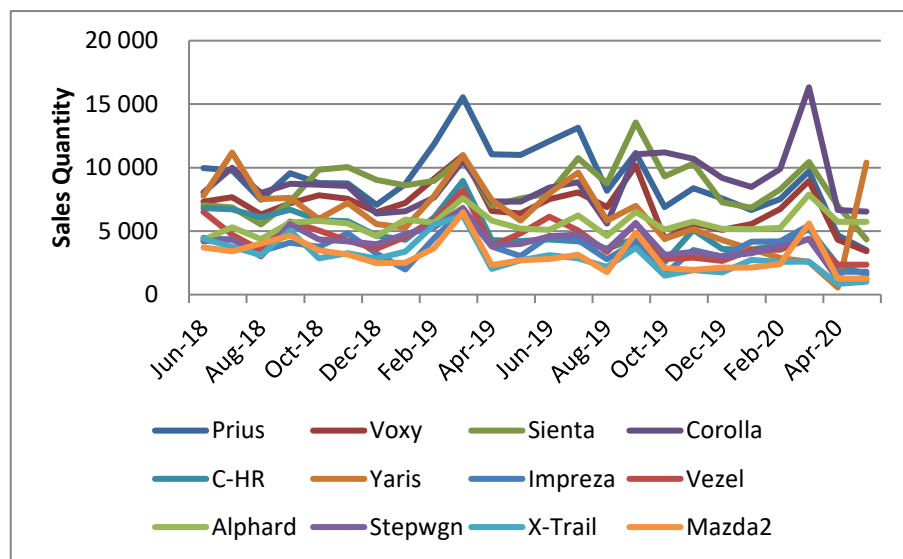


Figure 10. Sales by models

Source: JADA (2018-2020), <<http://www.jada.or.jp/data/month/m-r-hanbai/m-r-type>>  
Retrieved on April 29, 2021 (Vits and Demio were renamed Yaris and Mazda 2, respectively)



### 6.3 Social Listening for the Study

We obtained data on vehicle models by social listening through the real-time search provided by Yahoo! Japan. Through the real-time search, Japanese tweets that are written in Japanese and are not set in private can be searched. Therefore, tweets written overseas (for example, tweets from Honolulu, Hawaii, which has a 19hour time-difference to Japan) are also included in the data. We believed that gathering Twitter information by keywords makes the information volume bigger and more precise than gathering hash-tagged information.

Figure 11 is the number of tweets on each model. This shows only positive tweets identified through sentiment analysis, where criteria of ‘negative’ and ‘positive’ are set by Yahoo. Also, since Japanese anime characters occasionally take after Japanese car model names, words related to anime characters had to be excluded when researching Yahoo! Japan. For example, when searching a model name ‘Sienta’, keywords for search looks like this: ‘Sienta -Sientaris - Senisienta - Sienta Super Beast - Enamel Made Sienta’ (‘-’ means ‘to exclude’). The figure shows that tweets about Toyota Prius increase around every January. The reason for the increase is because Toyota announces minor changes to the model during that period. Also, as Figure 12 shows, the previously mentioned Higashi-Ikebukuro run away car accident brought the fire to Twitter; thus, we decided to use only positive tweets for the analysis. The tweets on Toyota Prius gradually took a downhill slide since April 2019 (shown in Figure 11), while tweets on Toyota Yaris showed rapid increase.

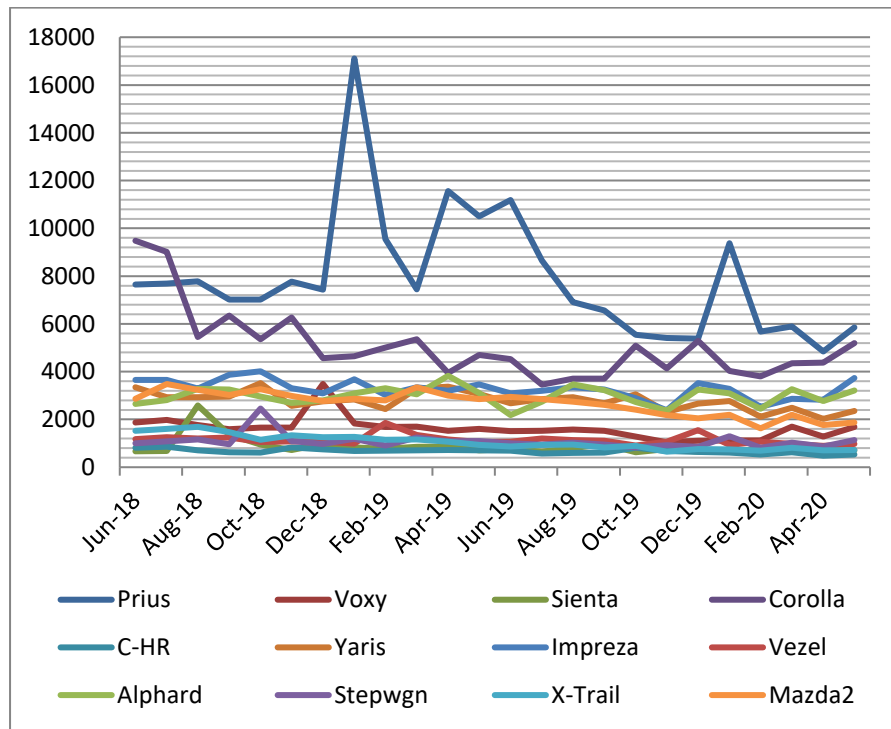


Figure 11. Positive tweets by month

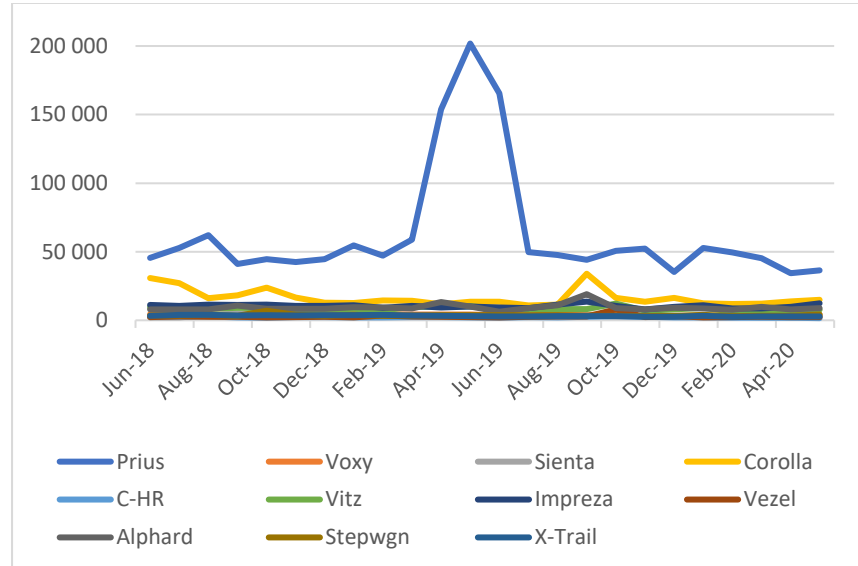


Figure 12. Tweets by month

## 6.4 Methods for Analysis

Because the data used for the study is time-series data, we first performed a cross correlation calculation for the models to measure time-lag between tweets and actual sales. Analysis was performed after the time-lag was adjusted.

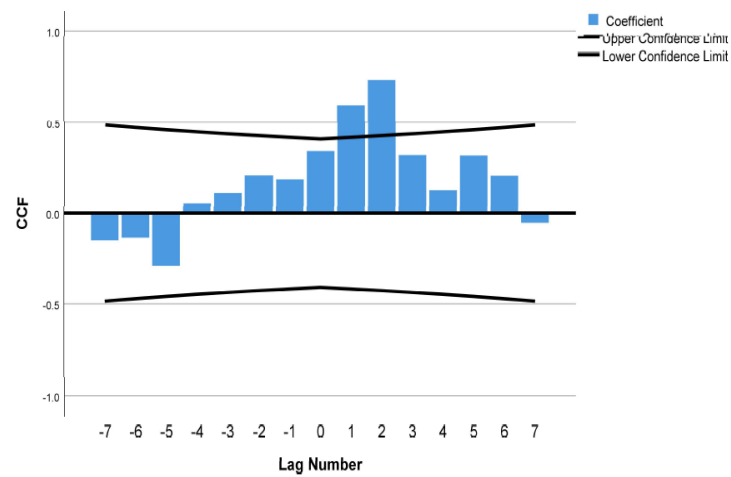


Figure 13. Prius Twitter with Prius sales volume

Figure 13 is a cross correlation graph between the number of tweets on Prius and its actual sales. The cross-correlation coefficient is the highest at the lag value of 2. This means the leading index is two months ahead of actual sales, which means two months of time-lag exists between the tweets and actual sales. This time-lag can be justified, because in Japan brand-new cars are assembled after a sales contract, and actual delivery takes 2 to 3 months after the contract.

## 7. ANALYSIS

In this chapter we analyze the sales forecast for Prius, which was the most tweeted from June 2018 to May 2020 (1,516,016 tweets), with the methods discussed in the previous chapter. We set up a regression formula by creating a scatter chart using the total number of tweets of a month and actual sales two months after those tweets were posted. Sales forecast was made for August and September 2020, using the regression formula. Figure 14 is a scatter chart and a regression formula from June 2018 to May 2020. Figure 15 is a correlation coefficient between tweets on Prius and the number of sales during that period, which is the mark of 1% and is significant.

From the regression formula:

The number of sales =  $0.87 \times \text{number of tweets two months before} + 1,830$

Sales forecast of Prius in August 2020 is:

Number of tweets in June 2020: 5,309

Sales forecasts of Prius in August 2020:  $0.87 \times 5,309 + 1,830 = 6,448.8$

Number of sales of Prius in August 2020: 6,429

Relative error:  $(6,429 - 6,449) \div 6,449 = -0.3\%$

Sales forecast of Prius in September 2020 is:

Number of tweets in July 2020: 4,943

Sales forecasts of Prius in September 2020:  $0.87 \times 4,943 + 1,830 = 6,130.4$

Number of sales of Prius in September 2020: 5,818

Relative error:  $(5,818 - 6,130) \div 6,130 = -5.1\%$

Next, we discuss Corolla, which had the second largest number of tweets during the 24 months of data gathering. According to Toyota, Corolla went on the market in 1966 in Japan. The model was sold 0.4 million units at its peak in the 70s, but recently sells less than 0.1 million (Toyota, 2022). However, outside Japan its annual sales is over one million since 2000, and repeating minor changes contribute to the accumulated total sales of over 50 million so far. The total number of tweets about Corolla was 393,523, which was 26% of Prius', and the sales forecast of the model was not possible.

The model with the third highest number of tweets was Vits (currently Yaris). Its sales volume has been rapidly increasing after renaming to Yaris in February 2020. The number of tweets about Vits has been increasing since the spring of 2020. The forecast was not successful with the current data, but we expect that the forecast will be possible with more Twitter data. Forecasts for other models were not successful either.

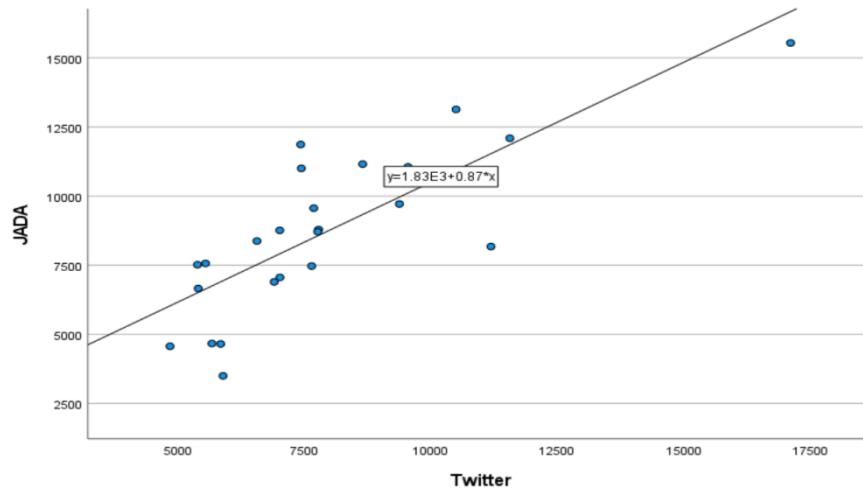


Figure 14. Scatter chart and regression formula for tweets on Prius

Correlations			
		JADA	Twitter
JADA	Pearson Correlation	1	.796**
	Sig. (2-tailed)		<.001
	N	24	24
Twitter	Pearson Correlation	.796**	1
	Sig. (2-tailed)	<.001	
	N	24	24

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Figure 15. Correlation coefficient of number of tweets and sales for Prius

Table 2. Number of tweets on each model

Prius	Voxy	Sienta	Corolla	C-HR	Vitz
1,516,016	96,697	68,470	393,523	54,468	204,176
Impreza	Vezel	Alphard	Stepwgn	X-Trail	Mazda2
250,772	65,692	231,582	89,675	78,066	198,658

Now we discuss each model. According to the sales data published by JADA (Figure 10), Prius was in the transition period from a maturity stage to a decline stage, Corolla was in a decline stage in Japan, and Yaris was in a growth stage. When those stages were applied to the PPM (Product Portfolio Management) Model<sup>(3)</sup> by BCG (Boston Consulting Group) (Henderson 1979), Prius was in a transitional period from ‘star’ to ‘cash cow’ and then to ‘dog’, and Yaris was in a transitional period from ‘star’ to ‘cash cow’. To confirm that, we created matrix diagrams for the models applying PPM. Figure 16 is a matrix by models in the first half of 2019. The vertical axis shows a growth rate (an increase or decrease of the total automobile sales) from the latter half of 2018 to the first half of 2019, and the horizontal axis is a share of each model in the first half of 2019. The size of the circle indicates the sales of each model. Figures 17, 18 and 19 are created in the same manner.

As these figures show, Prius was in the position of star in the first half of 2019 but shifted to cash cow in the latter half of the year. The model was in the transitional period to dog in the first half of 2020 and positioned in dog in the latter half of the year. Other models transition in random order.

From the above, we assumed that although a number of tweets are necessary to make sales forecast through social listening, it is important for products to undergo the four stages of the life cycle, which consist of introduction, growth, maturity and decline, to be forecast. In other words, forecast through social listening is not possible on products which shift to decline stage straight after introduction stage.

It is likely that sales forecast is possible during the process of products shifting from cash cows to dogs after positioning as stars and that the products in stars and dogs phases are difficult to forecast sales. This is because people are less likely to write about products in question mark and dog phases. There is a possibility that both a large number of tweets and the product being shifted from cash cow to dog after positioning as star contributed to the correct sales forecast of Prius.

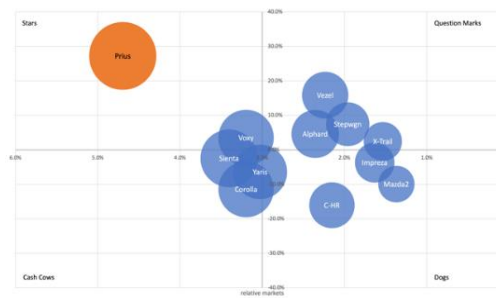


Figure 16. PPM in the 1st half of 2019 by models

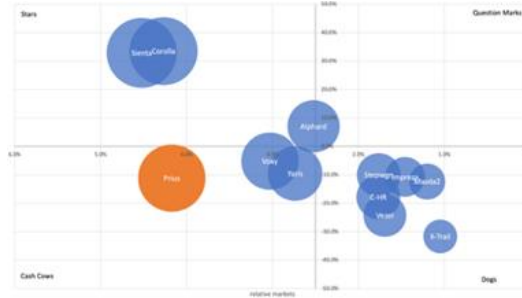


Figure 17. PPM in the 2nd half of 2019 by models

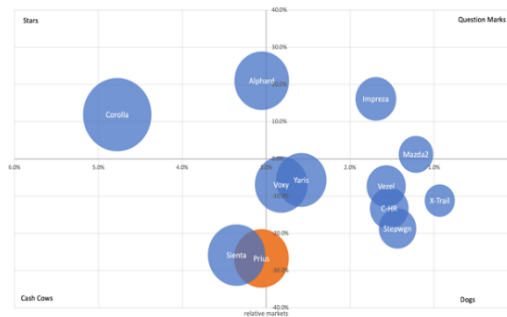


Figure 18. PPM in the 1st half of 2020 by models

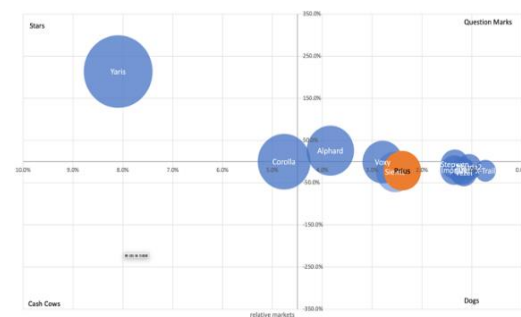


Figure 19. PPM in the 2nd half of 2020 by models

## 8. CONCLUSION

In this study we gathered tweets related to automobile models in Japan and used them as alternative data for social listening to forecast the sales of each model. A cross correlation between the number of tweets and the actual number of sales published by JADA showed two months of time-lag. In Japan brand-new cars are assembled after a sales contract, and actual delivery takes two to three months after the contract; thus, this time-lag is deemed accurate. However, models with a lower number of tweets were unforecastable, and a versatile sale forecast model which can be applied to all models has not been built yet. For this study we gathered 3,247,796 tweets from June 2018 to May 2020, and Prius accounted for 1,516,016 tweets. This large number of tweets contributed to the correct sales forecast of Prius. In addition, after a PPM analysis, we came to think that the fact that Prius shifted from cash cow to dog after positioning in star may be also a factor for the forecast. Hence, we propose a hypothesis that sales forecast is possible for products whose life cycle undergoes the growth, maturity, and decline; in other words, sales can be forecast during the process of products shifting from cash cows to dogs after positioning in stars. Our future task is to find the number of tweets necessary for forecast and to establish a versatile model which takes into account life cycle's stage changes in the PPM analysis model caused by various factors such as sales decline due to negative tweets and change of sales price.

## ACKNOWLEDGEMENT

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## NOTE

- (1). The AIDA model was developed by St. Elmo Lewis around 1900 (Lewis publicized the AID model in 1898). Barry (1987) details the AIDA model.

- (2). The Higasi Ikebukuro runaway car accident is a fatal car accident, which occurred in Tokyo on April 19, 2019 when a driver mistakenly stepped on the accelerator instead of the brake, resulting in two deaths and nine injuries. The driver, who was a retired elite public bureaucrat and was 87 years old at that time, was driving Prius and insisted that its brake pedal did not work. There were several factors why the number of tweets increased. There was criticism about Prius itself, but also his status as a retired elite public bureaucrat helped the number of tweets on Prius increase. Toyota announced that its driving record showed no brake pedal was hit right before the accident, and he was sentenced to five years in jail. This accident caused many elders to surrender their driver's license.
- (3). PPM is also called the growth-share matrix, BCG-matrix or Boston matrix.

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