

University of Tartu
Faculty of Science and Technology
Institute of Computer Science

Odeyinka Olubunmi T

Measuring Corporate Reputation through Online Social Media: A case study of the Volkswagen Emission Scandal

Master's Thesis (30 ECTS)
Software Engineering Curriculum

Supervisors:

Rajesh Sharma PhD
Darya Lapitskaya, MA

Tartu 2020

Measuring Corporate Reputation through Online Social Media: A case study of the Volkswagen Emission Scandal

Abstract: Reputation, a priceless but yet essential factor in a company's success, influences a company's customers, employees, and even the public relations with the company. Therefore, most companies consider reputation building as a priority in their daily interaction with their staff and the public.

Such companies that successfully build a good reputation, which attracted investors, staff, and goodwill of the public sometimes run into issues or events (i.e. self-inflicted or not) that can result in a significant change in their reputation.

The series of events that happen after a reputation tarnishing event includes more related news article releases, comments in message boards, and an increase in the number of people talking about the event on social media.

In this thesis, we analyzed the company's online media reputation (i.e. online media sentiment) and compared it with their financial reputation (i.e. stock price and volume) using the Volkswagen (VW) emission scandal as a case study. We did this by computing the monthly correlation, weekly correlation, rolling correlation, partial correlation, trend analysis, and brought out the context of a discussion with a word clouds and we tested our hypothesis of a relationship between online media sentiment and stock values using the Granger causality test.

This analysis was done not just on VW online media sentiment and stocks but also on Ford, Toyota, and Audi as control cases for the period under analysis (i.e. VW scandal period). The result shows that during the heat of the scandal the company that is involved (i.e. VW) is the one that presents their sentiment result to be a measure of their reputation only in the media sources that had their context based on the scandal(i.e. news and Twitter) and with a stronger relationship in the weeks of major scandalous news or events. This relationship is not so for other substitute companies' media dataset like Ford and Toyota whose media context and sentiment were not influenced by the VW scandal events.

While Audi, a subsidiary of VW, and our third control case presented sentiment to be a relative measure of the corporate reputation in the news dataset because that is the only dataset of it that had the VW emissions scandal as one of its main focal points of discussion during the scandal timeline.

CERCS: P170 - Computer science, numerical analysis, systems, control

Keywords: Sentiment Analysis, Granger Causality Test, Trend Analysis, Online media, tweet, Corporate Reputation, crisis, Volkswagen scandal, Message Board Comment, News, Stock market prediction, Rolling Correlation, Partial Correlation, Word Cloud, Reputation Loss

Ettevõtte maine mõõtmine veebipõhise sotsiaalmeedia kaudu: Volkswageni heitgaasiskandaali juhtumianalüüs

Abstraktne: Maine, mis on hindamatu, kuid samas ettevõtte teguritele oluline tegur, mõjutab ettevõtte kliente, töötajaid ja isegi ettevõttega suhtlemist. Seetõttu peab enamik ettevõtteid igapäevases suhtluses töötajate ja avalikkusega esmatähtsaks mainekujundust.

Sellised ettevõtted, kes loovad edukalt hea maine, mis meelitas ligi investoreid, töötajaid ja üldsuse heatahtlikkust, satuvad mõnikord probleemide või sündmuste hulka (s.t. ise või mitte), mis võivad põhjustada nende maine olulise muutuse.

Sündmuste rida, mis juhtub pärast mainet kahjustavat sündmust, hõlmab rohkem seotud uudiste väljaandeid, kommentaare teadetetahvritel ja sotsiaalmeedias sündmusest rääkivate inimeste arvu kasvu.

Selles lõputöös analüüsisime ettevõtte veebimeedia mainet (s.o veebimeedia meeleolu) ja võrdlesime seda nende finantsmaine (s.o aktsia hind ja maht) abil, kasutades juhtumianalüüsina Volkswageni (VW) heitgaasiskandaali. Tegime seda arvutades igakuise korrelatsiooni, igapäevase korrelatsiooni, jooksva korrelatsiooni, osalise korrelatsiooni, trendianalüüsi ja tõime välja sõnapilvedega peetud arutelu konteksti ning testisime oma hüpoteesi veebimeedia meeleolu ja aktsia väärtuste vahel, kasutades Grangeri põhjuslikkuse test.

Seda analüüsi ei tehtud mitte ainult VW veebimeedia meeleolu ja aktsiate, vaid ka Fordi, Toyota ja Audi kui analüüsitava perioodi (s.o VW skandaaliperioodi) kontrolljuhtumite kohta. Tulemus näitab, et skandaali kuumuse ajal on kaasatud ettevõtte (st VW) see, kes esitab oma meeleolutulemuse oma maine mõõdupuuna ainult meediaallikates, mille skandaalil põhinev kontekst (st uudised) ja Twitter) ning tugevamate suhetega suurte skandaalsete uudiste või sündmuste nädalatel. See suhe ei kehti teiste asendusettevõtete meediaandmete kohta, nagu Ford ja Toyota, mille meediakonteksti ja meeleolu VW skandaali sündmused ei mõjutanud.

Kuigi VW tütarettevõtte Audi ja meie kolmas kontrolljuhtum esitasid meeleolu uudisteandmekogumis ettevõtte maine suhteliseks mõõdupuuks, kuna see oli ainus selle andmestik, mille VW heitkoguste skandaal oli üks peamisi arutelu skandaali ajajoonel.

CERCS: P170 - arvutiteadus, arvuline analüüs, süsteemid, juhtimine

Märksõnad: Sentimentide analüüs, Grangeri põhjuslikkuse test, trendianalüüs, veebimeedia, säuts, ettevõtte maine, kriis, Volkswageni skandaal, teadetetahvli kommentaar, uudised, aktsiaturu prognoos, jooksev korrelatsioon, osaline korrelatsioon, sõnapilv, maine kaotus

Contents

1	Introduction	6
1.1	Research Contribution	7
1.2	Thesis Organization	7
2	Background	9
2.1	Volkswagen Company	9
2.2	The Emission Scandal	9
3	Related Works	11
3.1	Related Research Works	11
3.2	Corporate Reputation Definition	12
3.3	Measuring Corporate Reputation	13
3.4	Corporate Reputation and Financial Performance	14
3.5	Corporate Reputation and the Online Media	16
4	Dataset Review	19
4.1	Media Dataset	19
4.2	Stock Dataset	20
5	Approach	22
5.1	Sentiment with Package ‘SentimentAnalysis’	23
5.2	Correlation	25
5.3	Rolling Correlation	27
5.4	Partial Correlation	28
5.5	Granger Causality Test	28
5.6	Word Cloud	30
6	Volkswagen Result Analysis	31
6.1	VW Stocks and Sentiments Correlation	31
6.2	VW Stocks and Sentiment Weekly Correlation	34
6.3	VW Stocks and Sentiment Rolling Correlation	35
6.4	VW Stocks and Sentiment Partial Correlation	38
6.5	VW Stocks and Sentiments Trends	41
6.6	VW Stocks and Sentiments Granger Causality Test Analysis	46
6.7	VW Online Media Word Cloud	48
6.8	VW Stocks and Sentiment Result Conclusion	50

7	Ford Result Analysis	52
7.1	Ford Stocks and Sentiments Correlation	52
7.2	Ford Stocks and Sentiment Weekly Correlation	55
7.3	Ford Stocks and Sentiment Rolling Correlation	55
7.4	Ford Stocks and Sentiment Partial Correlation	57
7.5	Ford Stocks and Sentiments Trends	61
7.6	Ford Stocks and Sentiments Granger Causality Test Analysis	64
7.7	Ford Online Media Feed Word Cloud	65
7.8	Ford Stocks and Sentiment Result Analysis Conclusion	67
8	Toyota Result Analysis	68
8.1	Toyota Stocks and Sentiments Correlation	68
8.2	Toyota Stocks and Sentiment Weekly Correlation	70
8.3	Toyota Stocks and Sentiment Rolling Correlation	71
8.4	Toyota Stocks and Sentiment Partial Correlation	73
8.5	Toyota Stocks and Sentiments Trends	76
8.6	Toyota Stocks and Sentiments Granger Causality Test Analysis	80
8.7	Toyota Online Media Word Cloud	81
8.8	Toyota Stocks and Sentiment Result Analysis Conclusion	83
9	Audi Result Analysis	84
9.1	Audi Stocks and Sentiments Correlation	84
9.2	Audi Stocks and Sentiment Weekly Correlation	86
9.3	Audi Stocks and Sentiment Rolling Correlation	87
9.4	Audi Stocks and Sentiment Partial Correlation	89
9.5	Audi Stocks and Sentiments Trends	92
9.6	Audi Stocks and Sentiments Granger Causality Test Analysis	95
9.7	Audi Online Media Word Cloud	96
9.8	Audi Stocks and Sentiment Result Analysis Conclusion	98
10	Conclusion	100
	References	102
	Licence	131

1 Introduction

The reputation of a company is made up of the company's image and identity and can either be a measure of the company's financial achievement, the overall impression that people have about the company, or the views of internal and external company's stakeholders about the company [1]. In this thesis, while using the Volkswagen Emission scandal as a case study, we looked at the corporate reputation as the view of the customer and the public about the company in general while juxtaposing it with the financial standing of the company (i.e. in this case company stocks). In this way, we saw how customers are influenced by the activities of the company during a crisis.

The automobile giant Volkswagen is one of the major automobile companies from Germany and is a major stakeholder in the revenue and market success of the German automobile industry in the world [2]. As of 2014 before the Volkswagen scandal that got public attention in 2015, the German car (i.e. Volkswagen and other German manufacturers) purchased, as estimated by the United Nations, was more than 22 percent of the cars bought worldwide, making Germany the first country in car exportation in the world [2].

However, the German automobile industry and the Volkswagen company reputation suffered a reasonable setback when the issue of the Volkswagen emissions scandal became public [2]. This was evident in the fall and the subsequent sustained lower value of the Volkswagen stocks that followed the publicity of the scandal [2]. Other major companies that had fallen victim to reputation loss because of their company scandal or errors getting public attention including Toyota [3].

Consequently, the focus of this thesis is to take a closer look at the Volkswagen emission timeline and how events in this timeline triggered changes in the social value (i.e. their sentimental score) of Volkswagen and correlate that with economic value (i.e., stock prices and traded volume) of the company [4]. In other words, we sought out patterns in sentiments (i.e. their reputation in terms of how people consider the company) changes in correlation with stock changes (i.e. reputation in terms of financial achievements) during the company's crisis timeline. This was done by considering data from Twitter, online news sites, and message board comments on the Volkswagen Emission scandal from August 2015 which was a month before the event to June 2016 (i.e. about ten months after the event), while paying close attention to days and weeks when the announcement concerning the scandal was released.

We also considered Toyota, Ford, and Audi automobile brands (i.e. as controlled cases) which were substitute brands, and studied the influences of the events during the VW scandal period on those companies' reputation.

Part of the research questions we intend on answering are:

- **RQ1:** Is there a change in the sentiment of different media sources during a scandal timeline?

- **RQ2:** Is there a correlation between events during the company's crisis timeline and the media sentiments?
- **RQ3:** Is there a correlation between media sentiments during the company's crisis and stock market values?
- **RQ4:** Is there a correlation between the substitute brand's media sentiments and stock market values during the VW scandal timeline?

We will be using a data science approach for this paper. We plan to use online media data sources (i.e. Twitter feed, online news articles, and message board comments) and stock data (i.e. Yahoo finance). After the collection of the data, we clean it, ran several analyses, and created a report to derive our conclusions ¹.

1.1 Research Contribution

This thesis, as stated earlier will contribute to the understanding of the relationship between the online media sentiment(i.e company social reputation) and the stock values(i.e. financial reputation) during the company scandal timeline, with special emphasis on small detail changes during the life cycle of the scandal. This will help the:

1. Investors understand the reputation and its dynamics better during company scandal timeline
2. Corporations understand the impact of the scandal on their corporate reputation and for how long this reputation influence is expected to last.
3. Related companies to understand how their corporate reputation can be influenced by others in crises.
4. Corporate leaders to detect early an imminent corporate reputation loss during scandal timeline and so be able to act on such information.

1.2 Thesis Organization

We organized the rest of the thesis as follows:

- **Chapter 2:** Discussion of the Volkswagen company and the emission scandal timeline.
- **Chapter 3:** Literature review of past works and related theorems.
- **Chapter 4:** Overview description of the features, origin, and nature of the dataset used.
- **Chapter 3:** Literature review of past works and related theorems.

¹<https://medium.com/ml-research-lab/data-science-methodology-101-2fa9b7cf2ffe>

- **Chapter 5:** Discussion of the techniques used in data analysis, their relevance, and how each technique is carried out.
- **Chapters 6, 7, 8 and 9:** These chapters present the results, result analysis and analysis preliminary conclusions for Volkswagen, Ford, Toyota, and Audi brand respectively.
- **Chapter 10:** Overall observation across all brands analyzed and how their media sentiment was related to their corporate reputation during the VW scandal timeline and made some conclusive statements based on the pattern observed

2 Background

2.1 Volkswagen Company

Although, the Volkswagen group company has its headquarters in Wolfsburg, Germany, the Volkswagen group brand spans seven European countries and is made up of 12 brands. These brands include Volkswagen Passenger Cars, Audi, SEAT, ŠKODA, Bentley, Bugatti, Lamborghini, Porsche, Ducati, Volkswagen Commercial Vehicles, Scania, and MAN. This group also provides financial services, which include customer financing, leasing, banking, and insurance activities ².

The Volkswagen company as of 2019 has 664,496 employees that supported their 122 production plants worldwide with 20 European countries hosting the majority of them and the rest spread over Asia, America, and Africa to meet the demand of their population of customers that use their vehicles in 153 countries worldwide ³.

2.2 The Emission Scandal

In 1999, the US announced a more stringent rule on NOx emission making them the country with the lowest tolerated NOx emission in the world. The new rule decreased the emission limits allowed from 1.0 g/mi to .07 g/mi.

In 2009 the Volkswagen TDI category 5 was introduced into the US market and passed the clean test (i.e. NOx emission test). The celebration and accolade of the Volkswagen clean diesel engine cars continued from 2009 to 2014 until they were tested with the new Portable Emissions Measurement Systems (PEMS). The new PEMS allows the authority to test the emission outside the laboratory environment and see how the vehicle performs in the real world. The significant variation between the expected and the real test results pushed the US EPA (i.e. the United States Environmental Protection Agency) to verify the Volkswagen claim of being compliant. The results of the EPA investigation showed a significant variation from the expectation and they had to ask Volkswagen for an explanation.

In December 2014, as a result of the pressure from CARB (i.e. California Air Resources Board) and EPA, Volkswagen ordered a voluntary TDI cars recall ⁴.

Pressure from EPA and CARB as a result of more failures of on-road emission tests conducted by CARB and further threatening of Volkswagen that their 2016 vehicles will not be certified by these environmental regulatory bodies resulted in Volkswagen acceptance of responsibility for their illicit acts on 3 September 2015. They agreed that the car software was designed to detect when the car is being tested in the laboratory and enable all the emission control systems that are disabled when the car is running on the road. This means that the car

²<https://www.volkswagenag.com/en/group.html>

³<https://www.volkswagenag.com/en/group/portrait-and-production-plants.html>

⁴https://en.wikipedia.org/wiki/Volkswagen_emissions_scandal

normally runs with some of its emission filter turned off on the road.

On 18 September 2015, the EPA announced the recall of 2009-2015 TDI cars and two days after Volkswagen publicly accepted deceiving their customers and apologized to them [2] ⁵. This admittance triggered a series of events. See Appendix A for the subsequent events in the VW scandal timeline.

⁵https://en.wikipedia.org/wiki/Volkswagen_emissions_scandal

3 Related Works

In this chapter, we will explain some related concepts and theorem to our thesis topic. We started by reviewing some related research works (Section 3.1), followed by definition of corporate reputation (Section 3.2). We then looked at techniques of measuring corporate reputation (Section 3.3). Thereafter, we examined the effect of corporate reputation on the corporation finances (Section 3.4) and finally the influences of media on public perception or sentiment (Section 3.5).

3.1 Related Research Works

In 2016, a study was conducted with a topic measuring corporate reputation through online social media [5], this study focused on the VW brand and twitter dataset only to make an attempt to prove how the corporate reputation is related to the social media (i.e. Twitter) during the scandal timeline. This particular research concluded that the general sentiment of VW was stable during the scandal period but the user Twitter sentiment change rapidly from negative to positive.

Another study was originally done in 2017 and later revised in 2019 [2] used the Volkswagen emission scandal to show that reputation lost during a scandal can have an effect not just on one product that is involved but also on other related products that share a reputation with the company in crises. This study further proves the effect of collective responsibilities with results showing people migrating away from German cars and even diesel engine cars as a result of the scandal.

The study in 2018, a study [6] on the measurement of organizational legitimacy in social media, used sentiment analysis of Twitter to study the response of citizen to actions of the organization. They discovered that conventional measurement of a company's legitimacy only indicates the institutional evaluator's point of view but doesn't give a good account of ordinary citizen opinion which is considered important in the measurement of the company's legitimacy.

In 2017, research was conducted [7] using Heineken's brand as a case study of the impact of community sponsorship in major events like Olympic on the online reputation of the sponsoring company. This they did by measuring the companies online reputation(i.e. Facebook, Twitter, and Instagram) before the sponsorship and after it. They concluded that only their online Twitter reputation increased positively after sponsoring such community events.

While in 2015 [8], a study of how data breach(i.e. a scandal) can affect the reputation of the company was done. Through this research, it was empirically proven that there is a reputation loss after such a scandal. Also, an empirical study of the Japanese companies to determine the effect that corporate reputation has on financial performance was conducted in 2015 [4]. The study adopted a survey research design using questionnaires and interviews for the collection of the data. One thousand one hundred and thirty-five companies were selected as the sample

for this study. Based on the analysis of this study, the result shows that there is a relationship between social value, economic value, organizational value, and customer value and that social value has an influence on customer value, customer value has an influence on organizational value, and organizational value has an influence on economic value.

Another corporate reputation study in 2014 [9], focused on possibilities of celebrity tweets repairing damaged corporate reputation. The study found out that it is possible to influence the public perception of the company positively (i.e. repair the corporate reputation) if the right and intelligent celebrity is used to lead the reputation recovery campaign.

The study of 2013 on building a unique online corporate identity in Malaysia and Singapore [10], compared the dissimilarities of three hundred (300) Malaysian and two hundred and fourteen Singaporean consumer organizations established on Aaker's big five brand personality structure and also did their online content analysis. The result shows that Malaysian and Singaporean organizations are weak in product personality dimensions that reflect the projection of the corporate identity of companies. Also observed are significant differences in the brand personality dimensions between Malaysian and Singaporean consumer organizations and the absence of clear mission and vision statements leads to failure to position corporations in the marketplace.

While other related study shows that increase in online media interactivity between user and corporation, leads to better corporate reputation [11]. The same study also concluded that negative user evaluation has a more damaging effect on the company than the same proportion of positive evaluation.

Some other researchers attempted to measure corporate reputation using Italian banks as a case study [12]. This research work help to identify and suggest key features and dimension in the reputation framework measurement and explore important reputation models.

In this thesis, we will be focusing on the immediate impact of the scandal on corporate reputation. We intend to study the patterns of the different periods in the scandal timeline and see which period is marked by a strong relationship between the corporate reputation(i.e. stock values) and the different online media sentiments. We will try to understand this relationship further by carrying out different tests and analyses on our dataset.

3.2 Corporate Reputation Definition

An attempt to find the dictionary meaning of the phrase "Corporate Reputation" failed after searching several dictionaries. Separating the phrase into the containing words of Corporate and Reputation enable us to get separate meaning for these words in the dictionary. Corporate according to Cambridge dictionary is "of or shared by a whole group and not just of a single member" ⁶ and the reputation according to Macmillan dictionary is "the opinion that people have about how good or how bad someone or something is" ⁷.

⁶<https://dictionary.cambridge.org/dictionary/english/corporate>

⁷<https://www.macmillandictionary.com/dictionary/british/reputation>

Generally, after surveying several papers that tried to define corporate reputation, it was concluded that the stakeholder's overall opinion of the corporation is the corporate reputation [13]. This opinion is built over time by the interaction of the stakeholder with the corporation. The stakeholders who internally are the employee, owner, etc, and externally comprising shareholders, customers, government, the general public, etc., relative standing with the company is another generic definition of corporate reputation [13, 14, 15].

Therefore, since corporate reputation is the image of a corporation to the stakeholders, image building activities like goods marketing, quality good, and services, customer services, good online media engagement, etc., tend to influence corporate reputation positively [14].

In this thesis. online media sentiment(i.e. public opinion) during the VW scandal will be compared with the stock values (i.e. shareholders opinion) at different periods during the VW scandal timeline.

3.3 Measuring Corporate Reputation

Measuring corporate reputation is not straight forward because of its different perspective based on different fields such as marketers, sociologists, economists, organization theorists, and strategists [16].

Since Corporate reputation, which is an essential imitable (i.e by corporate competitors) ingredient in corporate success must be measured because anything that cannot be measure, cannot be improved [17] ⁸.

Several models and approaches have been developed from several studies for measuring corporate reputation. These include using RepTrak, Reputation Quotient (RQ), ROA Factor analysis and covariance structure analysis, public sentiments analysis, and financial achievement like stocks [1, 2, 4, 12]. In this thesis, we assumed the company's stock value as the default indicator of corporate reputation.

3.3.1 RepTrak System

The Reprtrak seven dimensions and 23 attribute system has become a popular choice when it comes to corporate reputation measurement [18, 19].

The Reprtrak system started as a study at the Reputation Institute in 2000 and evolved into a systematic tool used for measurement and analysis of stakeholders' perception of the company. This tool has been proved to be a rigorous instrument in measuring reputations by practitioners and researchers [18].

Appendix B shows the graphical model of the Reprtrak dimensions and their attributes. Where e1 to e23 are the attributes and e24 to e30 are the dimensions.

⁸<https://guavabox.com/if-you-cant-measure-it-you-cant-improve-it>

3.3.2 Sentiment Analysis

Sentimental analysis is the analysis of the opinion and perception of an individual or group about a product, service, policy, thought, or person [20].

Increasing the Company's engagement and publication online has shown to increase the company's reputation [7, 10, 11].

With the help of social media, passive customers are turned into active customers through their feedback and eWOM(i.e. electronic Word of mouth), helping with the building of the company's reputation [9, 11, 21, 22].

The customer opinion on digital media is a better indicator of consumer choice when compared to other opinion sources. This has been proven by several studies.

3.3.3 Sentiment Analysis Measurement Levels

1. **Document-level:** Analysis is done on the whole document as a single entity because it is assumed to contain a single opinion [20, 22, 23]. This analysis can be done using a supervised learning approach e.g. PMI (Pointwise Mutual Information) VM, KNN, Naïve Bayes, Logistic Regression, etc. or an unsupervised learning approach [24, 25, 26].
2. **Sentence level:** In this approach, sentences are assumed to be unit of opinion, and analysis is done at sentence level [20, 22, 23]. Sentences are handled based on their types which can be conditional, sarcastic, or question sentence types [24, 26].
3. **Aspect level:** Each attribute, term, or aspect of an entity or discussion is first classified as either positive, negative, or neutral. Then this classification is used to compute the overall sentiment of the document [20, 24, 26, 27].

3.3.4 Sentiment Analysis Calculation

The total positive and negative sentiment is the sum of each individual sentiment in a data set [20, 26]. See equation (1) and (2) for the +ve and -ve sentiment. Where the W1 means the first word, W2 means the second word, etc.

$$(+ve)Sentiment = (W1 + W2 + W3 + \dots + Wn) \quad (1)$$

$$(-ve)Sentiment = (W1 + W2 + W3 + \dots + Wn) \quad (2)$$

3.4 Corporate Reputation and Financial Performance

The intangible corporate reputation has been empirically proven to make a firm persistently profitable and ensure its product is preferred to other similar products in the market place [28].

Corporate reputation, which can be seen as the customer and shareholder perspective on a company, has an effect on its economic value [1, 2, 4]. An easy way to see the effect of reputation on financial standing (i.e. economic value) is to observe the rapid changes in the stock value of a company during a major event or announcement that had an effect on customer perspectives.

Figure 3.1 and 3.2 shows the rapid transformation in the stock activities of Volkswagen shareholders after that EPA announced the recall of the TDI vehicles on 18 September 2015 and the subsequent coming out of Volkswagen authorities to publicly render an apology on 20 September 2015. Looking at Figure 3.1, we saw that on 16 and 17 September 2015 there was relatively low volume (i.e. around 1 million units) of VW stocks traded but it moved up to around 3 million units on the day of the announcement. The day of the announcement was a Friday and on Monday and Tuesday of the week after the volume of VW shares traded jumped to around 14 million and over 14 million units of shares respectively. This was a clear indication of the shareholders taking a new stand because the reputation of the company was eroded by the scandal.

Similarly, in Figure 3.2, we observed the share value of VW stock fallen on the day of the EPA announcement on 18 September and continued to crash till 22 September 2015, losing more than one-third of its value (i.e. from around 160 dollars per unit to around 100 dollars per unit). All these losses are related to the fact that the company's perception of the stakeholder was changed.

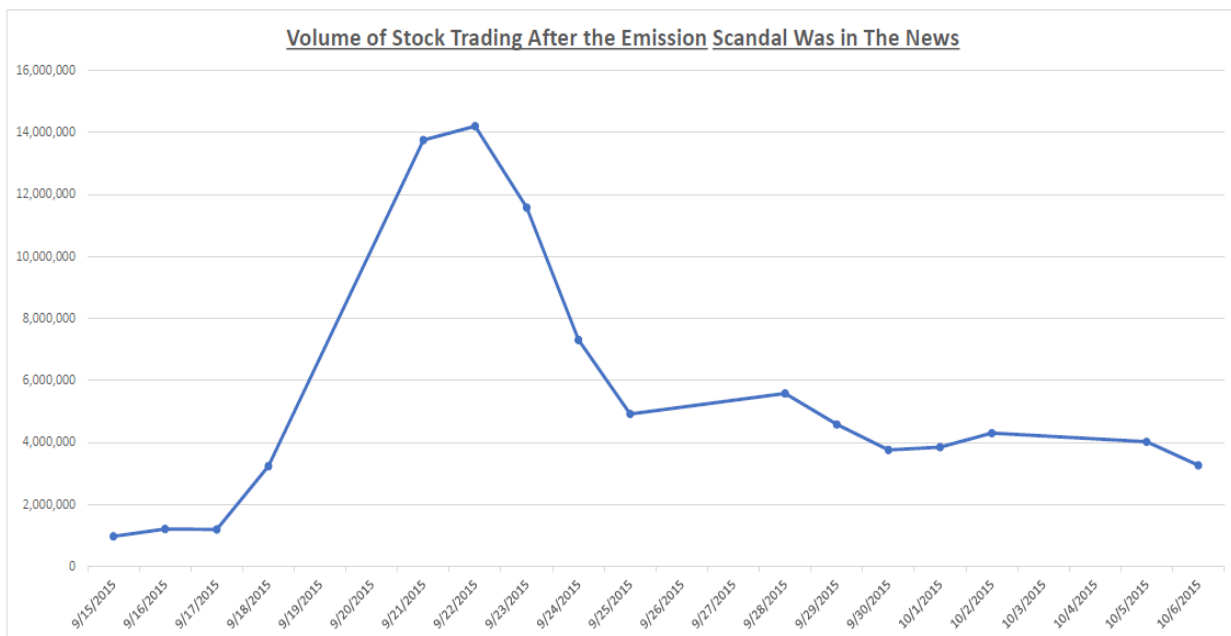


Figure 3.1: Volume of Stock Trading About the Time of Emission Publication

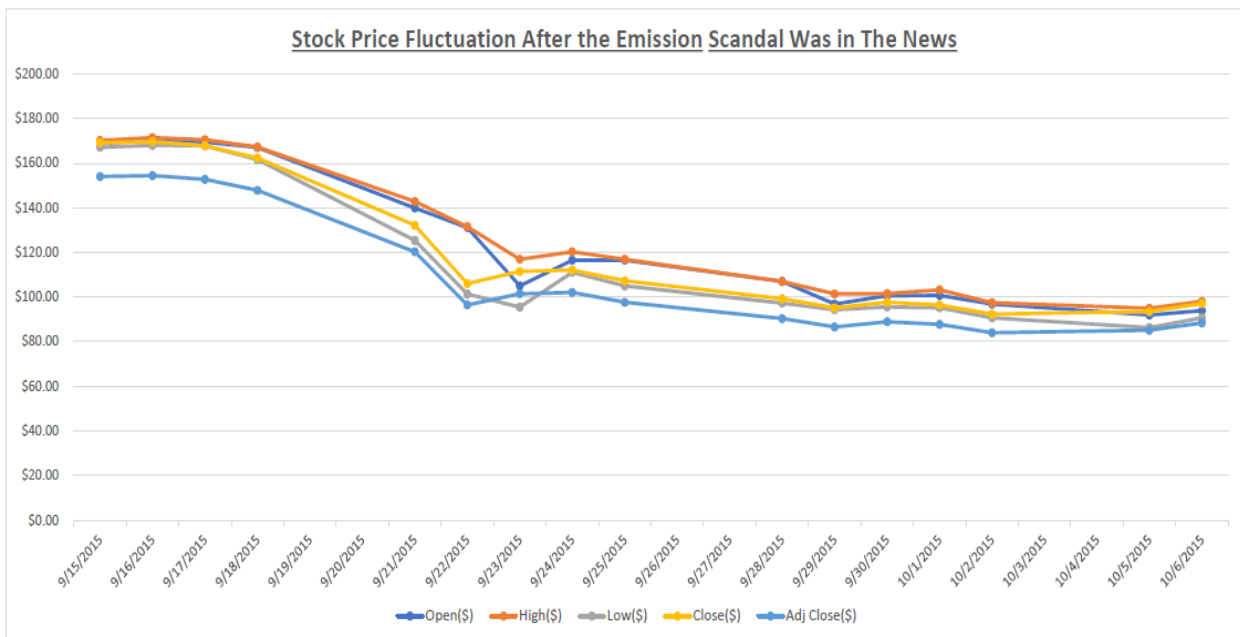


Figure 3.2: Stock Price Fluctuation About the Time of Emission Publication

3.5 Corporate Reputation and the Online Media

Reputation is an intangible and essential part of an organization. Customers and non-customers (i.e. prospecting customers) are actively influencing it through different social media. This means that social media sentiment can reduce the chances of prospecting customers from becoming real customers [8, 29].

Agenda Setting Theory has been an approach to studying the public reaction to the media. This theory in summary states that the media has the power to influence public opinion through information broadcasted resulting in changes in this public perception about issues and events. This theory raises the possibility of using media to influence public sentiment [11].

Further research on the agenda-setting theory led to the Ideodynamic Model. This model changes the agenda-setting theory into a predictive tool. The Ideodynamic model has been used in predicting successful events like elections in different countries, people's opinions about things like sex, drugs, diseases, etc. The model proved to be able to predict opinion trends once the media have enough persuasive information [11, 30].

Therefore, the media has shown to be a strong influencer of the public sentiment in general and from this, we can start to assume that if the media is flooded with news on certain events about a company that can have a similar effect or the company's perception and resultant reputation.

3.5.1 Media News Framing

News should be objective and not influenced in any way but in most cases, this is not so. The media at most times usually have an angle to every story they are presenting. This focusing of

news from a perceptive is news framing⁹ [18, 31, 32].

News can be framed as a talk, a fight, a crisis, or even an impasse. The framing and frequency of the coverage of an issue on media determine the public opinion and awareness on the issue on the news [31].

The frame of the emission scandal news would have influenced the extent to which the sentiment and volume of response in social media.

While framing influences mainly the opinion of the news receiver, agenda-setting influences the importance of the news reported¹⁰ [31, 33].

3.5.2 Agenda Setting Theorem

Agenda setting is the extent to which media influence the public perception of the importance of an issue through the news [26, 31, 32]. The more the media give attention to an issue the more the issue is given attention by the receiver according to agenda setting [34].

Over 4 decades of studies of this theorem show that variation in the correlation of agenda-setting strength on individuals is a result of individual characteristic nature like education, age, background, culture, attention span, etc. of the news receiver. The less involved and motivated individuals that depend heavily on the news as their source have shown higher correlations to agenda-setting effects than others [11, 32, 35].

Individual agenda is therefore as shown in equation (3)

$$MassMediaAgenda + VarA + VarB + \dots + VarN = IndividualAgenda \quad (3)$$

Mathematically expressed as seen in formula (4) [32]

$$M = (a * ka) + (b * kb) + (c * kc) + R \quad (4)$$

The k's represents the unique coefficients of each variable and R is white noise. a, b and c are variables and M is the accumulation of the influence of multiple moderating variables.

The wide coverage of the VW emission scandal in the news and repetition of related news during the week of announcement and subsequent weeks must have influenced the rapid change in the reputation of the VW company that is obvious in the rapid change in volume and value of the stock trading of the VW company.

The agenda-setting effect of different media types (i.e. online news, Twitter, message board comment, etc.) can now be used to predict public opinion through the ideodynamic model [11].

3.5.3 Ideodynamic Theorem

The ideodynamic model recognizes that the resultant effect of media is not unidirectional or uniform. It believes that the environment the media broadcast influences the way the news is

⁹<https://criticalmediareview.wordpress.com/2015/10/19/what-is-media-framing/>

¹⁰<https://criticalmediareview.wordpress.com/2015/10/19/what-is-media-framing/>

gathered, presented, and accepted [8].

Research showed that changes in public opinion about a lot of social issues like nuclear energy, presidential approval, defense spending, contra aid, etc., can be predicted with a high level of accuracy over an extended period of time by the idiomatic theory with the help of the messages in the news about the issue predicted reaching the public [8].

The ideodynamic theorem, which is the mathematical model of persuasion, specifies that messages' pressure only has a significant effect on opposing sentiments. In other words, the part of the populace who is already in favor of an issue will not be changed by further pressure of favorable messages about the same issue from the media. The favorable messages pressure will mainly have an impact on the fraction that is not in favour of the issue in context.

See the mathematical representation of Ideodynamic theorem in equation (5)

$$F_t = F_{t-1} + k'(GF_t * U_{t-1} - GU_t * F_{t-1}) \quad (5)$$

where: F is favorable sentiment, k' is a constant, GF is message pressure on favorable sentiment, U is unfavorable sentiment, GU is message pressure on unfavorable sentiment, and t is time [8].

Opinion prediction original mathematical equations are far more complex than the mathematical representation because the GF and GU parameters consider the residual half-life of messages while the constant in the equation is to control prediction volatility [8].

The Ideodynamic model in Figure 3.3, shows the movement of the percentage of the populace by the persuasive force of the media. Those with a positive opinion can be moved to a neutral position by the negative persuasion of the media and also further to being part of those with a negative opinion of the issue by further negative persuasion of the media. The opposite effect will be observed by the positive persuasion as shown in the model [11].

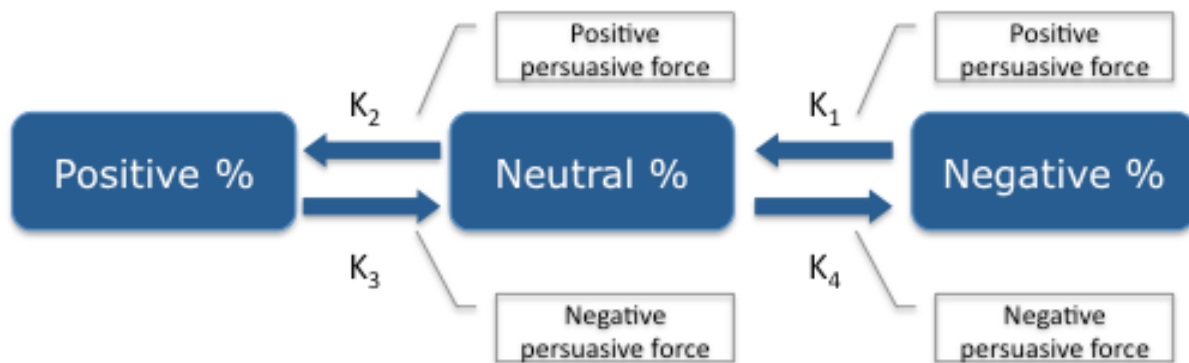


Figure 3.3: Ideodynamic model. Reprinted from Stakeholder Tracking and Analysis: The RepTrak® System for Measuring Corporate by C. Fombrun L. J Ponzi W. Newburry [18]

4 Dataset Review

We used two categories of the dataset, the media dataset (Section 4.1) and the stock dataset (Section 4.2). The categories were combined based on brands and media sources into twelve datasets in all (i.e 3 data sources and 4 brands dataset for each source)

4.1 Media Dataset

The media dataset used in this thesis was sourced from three different websites (Section 4.1.1) and a good description of their features can be found in Section 4.1.2.

4.1.1 Media Dataset Description

Please see Table 1 for the listing of the dataset sources, row counts, brands, period which the dataset is for, etc.

Table 1: Online Media Dataset

Dataset	Source	Language	Brands	Format	Rows Count	Data Period
Twitter	twitter.com	English	Audi	CSV	285,000	28-Aug-2015 to 06-Jun-2016
			Toyota		154,047	
			Ford		220,245	
			Volkswagen		644,836	
News	eventregistry.org	English	Audi	Jsonl	305,242	28.08.2015 and 06.06.2016
			Toyota			
			Ford			
			Volkswagen			
Message Board	pistonheads.com	English	Audi	RDATA	598,250	28.08.2015 and 06.06.2016
			Toyota			
			Ford			
			Volkswagen			

4.1.2 Dataset Features Analysis

Each dataset had many features but we focus on those features relevant to this thesis. The features are description in Table 2 .

Table 2: Dataset Features

Data Sources	Fields	Description
Twitter	PostedTime	This is the date tweet was posted
	Text	This feature contains the tweeted text
	Tweet_id	This feature contains a unique identifier of the tweet
News	Date	This is the date the news was published
	Title	This is the news headline
	Body	This is the news full article
Message Board	Date2	This is the date tweet was posted
	Text	This feature contains the tweeted text
	Brand	This feature holds the brand this message board comment belongs to. This has only 4 possible values i.e. Audi, Toyota, Ford, and Volkswagen
	Date	This feature holds the string form of feature Date2

4.2 Stock Dataset

This dataset is made up of the stock’s prices and volume for the three distinct brands analyzed in this thesis. The brands were Toyota, Ford, and Volkswagen.

4.2.1 Stock Data Source and Properties

This dataset was extracted from the yahoo finance website ¹¹.

Table 3: Stock Dataset Description

Property	Values
Stock Period	Stock Period
Format	CVS
Rows Count	195
Brands	Toyota, Ford and Volkswagen

4.2.2 Stock Data Feature Analysis

All the features in the dataset were used in the analysis. They are

- **Date:** Effective date of the stock value.
- **Open:** Price of stock first traded when the market opens for a trading day.

¹¹<https://finance.yahoo.com/>

- **High:** The highest price a stock traded for a trading day.
- **Low:** The lowest price a stock traded for a trading day.
- **Close:** Price of stock last traded when the market closes for a trading day.
- **Adj.Close:** Is considered the true price of the stock because is the price after considering any other factors (e.g. corporate action) that might influence the price after market closure.
- **Volume:** Amount of stock traded for a trading day.

5 Approach

As stated in the introduction section of this thesis, we will be analyzing social media sentiment of different online media sources to see how these relate to the company’s reputation (i.e. stock values) of different automobile companies during the VW emission scandal period.

We used mainly the Sentiment Analysis R package for our sentiment analysis. We then merged the result from our sentiment analysis with the stock values for easy analysis.

We ended up with twelve major datasets for analysis that looks like Table 4.

Table 4: Sentiment and Stock Combination analyzed

	Sentiment Source	Stock Source
Volkswagen	Volkswagen Tweets	Volkswagen Stocks
	Volkswagen News Articles	Volkswagen Stocks
	Message Board Comment	Volkswagen Stocks
Ford	Ford Tweets	Ford Stocks
	Ford News Articles	Ford Stocks
	Message Board Comment	Ford Stocks
Toyota	Toyota Tweets	Toyota Stocks
	Toyota News Articles	Toyota Stocks
	Message Board Comment	Toyota Stocks
Audi	Audi Tweets	Volkswagen Stocks
	Audi News Articles	Volkswagen Stocks
	Message Board Comment	Volkswagen Stocks

We computed and analyzed the correlation for each dataset, analyze the trends, rolling correlation, granger test etc. Please see the flow diagram in Figure 5.1 for the cycle each brand goes through that gave rise to the results presented in Chapters 6, 7, 8 and 9.

First, all computation and analysis are done for the whole period of our dataset (i.e. 28.08.2015 to 06.06.16) except in correlation and trend graphs. This computation and analysis are repeated as seen in the Granger causality test, partial correlation, and word cloud for the first 3 months dataset. This repetition computation is done to reveal the early impact of the clusters of announcements and events during the early stage of the VW scandal timeline. It is our belief that we can learn more about the influences of the scandal on reputation and see if it a better measure of it at the early stage of such a scandal timeline. The correlation was done in monthly and weekly intervals to reveal the relationship between the stock and media sentiment in shorter periods. Finally, the trend lines are drawn to reveal the immediate effect of news and events on the sentiment on daily basis and only cover the first two months of the scandal timeline.

Therefore, based on the flow diagram, in this chapter we will be looking at the Sentiment Analysis(Section 5.1), Correlation(Section 5.2), Rolling Correlation (Section 5.3), Partial Correlation (Section 5.4), GrangerCausality Test (Section 5.5) and Word Cloud (Section 5.6). This is to help us understand them and their relevance to the research in this thesis.

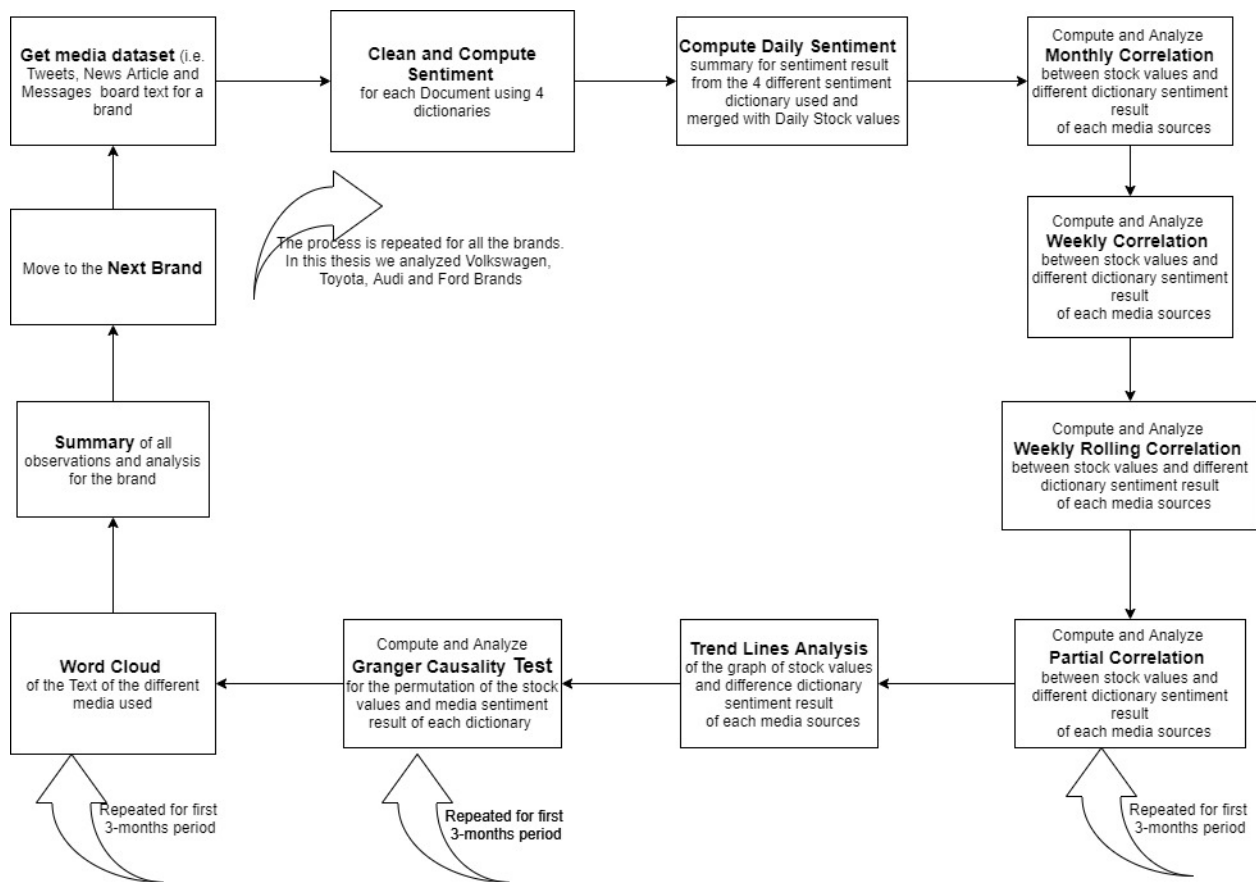


Figure 5.1: Thesis Data Analysis Flow Diagram

5.1 Sentiment with Package ‘SentimentAnalysis’

For sentiment analysis, we used “SentimentAnalysis” an R package to perform sentiment analysis on text. This package uses four sentiment dictionaries and can be configured to use other dictionaries.

We used the function “analyzeSentiment” in the Package ‘SentimentAnalysis’ for computing the sentiment. This function gives four different sentiment result sets. One result set for each sentiment dictionary’s configured by default into the ‘SentimentAnalysis’ library.

5.1.1 ‘SentimentAnalysis’ Package Dictionaries

The four result sets from the four dictionaries from “SentimentAnalysis” generate similar columns. The dictionaries and their results are [36]

- **DictionaryGI:** This generates the NegativityGI, PositivityGI, and SentimentGI features in the returned dataset of the “SentimentAnalysis” package “analyzeSentiment” function call. This dictionary has a compilation of words categorized into positive and negative words based on a psychological Harvard-IV dictionary as used in the General Inquirer software.

- **DictionaryHE:** This generates the NegativityHE, PositivityHE, and SentimentHE features in the returned dataset of the “SentimentAnalysis” package “analyzeSentiment” function call. This dictionary has a list of words categorized into positive and negative words based on Henry’s finance-specific dictionary. DictionaryHE was quickly adopted in finance discipline when first presented.
- **DictionaryLM:** This generates the NegativityLM, PositivityLM, SentimentLM, and RatioUncertaintyLM features of the returned dataset in the “SentimentAnalysis” package “analyzeSentiment” function call. This dictionary has a list of words categorized into positive, negative, and uncertainty words based on the LoughranMcDonald finance-specific dictionary.
- **DictionaryQDAP:** This generates the NegativityQDAP, PositivityQDAP, and SentimentQDAP features of the returned dataset in the “SentimentAnalysis” package “analyzeSentiment” function call. This dictionary loads the polarity words from data objects from the R package qdap.

5.1.2 ‘SentimentAnalysis’ ResultSet

The four dictionaries result set from “SentimentAnalysis” generate similar column name patterns. Each result set from each dictionary has feature names that consistently starts with Negativity, Positivity, and Sentiment prefixed names. This feature resultant set is explained below:

- **Negativity:** This feature holds values computed by dividing the proportion of words categorized as negative by the dictionary by the total word of the document. This results in features like NegativityLM, NegativityQDAP, etc based on the dictionary used.
- **Positivity:** This feature holds values computed by dividing the proportion of words categorized as positive by the dictionary by the total word of the document. This results in features like PositivityHE, PositivityGI, etc based on the dictionary used.
- **Sentiment:** This feature holds the difference between the Positivity sentiment and the Negativity sentiment. This results in features like SentimentLM, SentimentHE, etc of the generated result.

5.1.3 Daily Sentiment Summary

In this thesis, we used a daily Twitter summary for most of our analysis as discussed already. This summary is computed by the summation of the sentiment result for each days’ text documents divided by the number of documents for that day. This is expressed mathematically in

	Date2	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Doc_Count	Open	High	Low	Close	Adj.Close	Volume	WordCount
1	8/28/2015	0.032903082	0.007554636	-0.034365212	0.034624638	327	121.02	121.61	120.33	120.77	104.5698	285800	117018
2	8/31/2015	0.019757415	0.005439499	-0.041385298	0.015865362	160	119.13	119.26	118.19	118.38	102.5004	243000	45260
3	9/1/2015	0.034800217	0.006572415	-0.024686521	0.036418109	159	115.58	115.93	114.08	114.34	99.0023	426000	52402
4	9/2/2015	0.03878321	0.00697432	-0.026506726	0.032698479	157	117.25	117.69	116.21	117.62	101.8423	266100	49919
5	9/3/2015	0.042908742	0.007366808	-0.03032101	0.04130962	123	120.19	120.44	119.34	119.61	103.5654	352100	32846
6	9/4/2015	0.045410089	0.007156976	-0.032886228	0.04651532	244	116.68	116.9	115.84	116.5	100.8726	262200	85093

Figure 5.2: A Daily Sentiment Summary

Equation (6)

$$\text{Resultant Daily Sentiment} = (\text{Doc 1 Sentiment} + \text{Doc 2 Sentiment} + \dots + \text{Doc n Sentiment}) / n \quad (6)$$

The daily sentiment is then merged with the daily stocks to arrive at a table as shown in Figure 5.2.

The features in the resultant dataset presented in Figure 5.2 are explained in Table 5. Other fields in the daily summary dataset like Open, high, low, Adj.Close, Volume, and close are all the stock values for the row item date.

Table 5: Daily Sentiment Summary Features

Features	Description
Date2	The date of the data for the row item
SentimentGI	The resultant sentiment for that date using psychological Harvard-IV dictionary for analysis
SentimentHE	The resultant sentiment for that date using Henry's finance-specific dictionary for analysis
SentimentLM	The resultant sentiment for that date using LoughranMcDonald finance-specific dictionary for analysis
SentimentQDAP	The resultant sentiment for that date using the polarity words from the R package qdap for analysis
Doc_Count	Total number of documents used in the calculation of the daily sentiment
WordCount	Total word when all the document of that day are merged

5.2 Correlation

Correlation is the statistical measure of the strength of the relationship between two or more variables. Variables are said to be correlated (i.e. related/associated), when the movement of one leads to the corresponding movements of the other variables ¹².

In other words, correlation is a measure of the degree with which the movement of variables is related. It should be noted that when variable A correlates to variable B, that does not necessarily mean that variable A causes B or B causes A ¹³.

Correlation value (i.e. correlation coefficient) ranges between -1 to +1. If the correlation coefficient is 1 that means we have a perfect positive correlation. This implies that both variables move either up or down in the same direction. While a correlation coefficient of -1 is a perfect

¹²<https://www.investopedia.com/terms/c/correlation.asp>

¹³<https://www.investopedia.com/terms/c/correlation.asp>

negative correlation and it implies the two variable moves in opposite directions. The closer a correlation is to 0 the weaker the relationship of the variable being measured. Therefore, a correlation coefficient of zero otherwise known as Zero correlation means no relationship between the variables at all ¹⁴¹⁵.

In this thesis, we use Pearson Correlation(r) which is a measure of the strength of a linear association between two variables. We choose Pearson Correlation because our dataset features meet most of the following criteria expected of those using Pearson Correlation ¹⁶. Some of those criteria are

- Normal distribution of values in the feature.
- There are few outliers in the features of the dataset.
- The values in our dataset are mainly continuous values
- Variables show some linear relationship to each other.

Here are different values of correlation coefficient (r) and their interpretation

- When the value is 1 there is a positive perfect relationship
- When the value is between 0.75 to 1 there is a strong positive relationship
- When the value is between 0.5 to 0.75 there is a moderate positive relationship
- When the value is between 0.25 to 0.5 there is a weak positive relationship
- When the value is less than 0.25 there is no relationship
- When the value is -1 there is a negative perfect relationship
- When the value is between -0.75 to -1 there is a strong negative relationship
- When the value is between -0.5 to -0.75 there is a moderate negative relationship
- When the value is between -0.25 to -0.5 there is a weak negative relationship
- When the value is less than -0.25 there is no relationship

Please see below the Pearson correlation equation (7) ¹⁷

$$r_{xy} = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n \sum x_i^2 - (\sum x_i)^2} \sqrt{n \sum y_i^2 - (\sum y_i)^2}} \quad (7)$$

¹⁴<https://www.simplypsychology.org/correlation.html>

¹⁵<https://www.statisticssolutions.com/correlation-pearson-kendall-spearman>

¹⁶<https://towardsdatascience.com/pearson-coefficient-of-correlation-explained-369991d93404>

¹⁷<https://www.statisticssolutions.com/correlation-pearson-kendall-spearman/>

r_{xy} = Pearson r correlation coefficient between x and y

n = number of observations

x_i = value of x (for i th observation)

y_i = value of y (for i th observation)

In this thesis, we computed the correlation for each dataset(i.e. online media sentiment vs stock values daily summary) in these patterns.

- For Monthly Correlation Analysis
 - First, we compute the correlation for the whole period of study.
 - Second, we compute the correlation for the period before the scandal was in the news.
 - Then for the period after the scandal was in the news, we segmented the dataset into a monthly interval, and we calculated correlation for each month period.
- For Weekly Correlation Analysis
 - Computed weekly correlation for the first 3 months of each dataset.

The result gotten from the correlation analysis will help us to understand the relationship between the stock value and the online sentiment for the different periods analyzed.

5.3 Rolling Correlation

Correlation shows if a variable is related to another. The issue with correlation in time series is that it gives a single value for a correlation that is changing over time.

The changing nature of correlation makes it quite inaccurate when we compute one value for a long period dataset. This is why in time series we use a rolling correlation to visualize correlation changes over time ¹⁸.

Rolling correlation computes correlation as a rolling window of a static shorter period. In other words, correlation is computed in a smaller time period incrementally until the whole period correlation has been computed. For example, we have a dataset with variable X and Y that has values for day one to day ten. Instead of finding the correlation between variable X and Y in one calculation, we can choose to calculate the correlation in a window of 3 days (i.e. rolling correlation). This means we will compute the correlation between variable X and Y for the dataset of days 1 to 3, then repeat the correlation for days 2 to 4, then days 3 to 5, etc. This then gives us a series of correlations for the whole period that will show different correlation values at different periods in the dataset and this can easily be drawn into a graph to show the overall movement of the correlation at different periods in the dataset.

¹⁸<https://www.business-science.io/timeseries-analysis/2017/07/30/tidy-timeseries-analysis-pt-3.html>

In this thesis we used a rolling window of two weeks for the computation of our rolling correlation(i.e. we computed correlation for week 1 and 2, then week 2 and 3 etc). We then draw a graph of the first 12 correlation results for each sentiment dictionary’s result against stock values of each dataset. Look under Sections 6.3, 7.3, 8.3 and 9.3 for the resulting graphs.

The analysis of the generated rolling correlation graph will allow us to know the direction of change of the correlation each week.

5.4 Partial Correlation

Partial correlation is used to reveal the possibility of some other variables in the dataset influencing the correlation result of two variables in the same dataset. This revelation is done by controlling the effect of the other variables while measuring the relationship strength of two variables.

Just like in Pearson correlation, partial correlation results range between -1 and +1, and this result is usually computed using multiple regression analysis ¹⁹.

Let’s look at an example of a dataset that has variable A, B, and C. If both variables A and B are influenced by C. Computing correlation between A and B will give a result that will present A and B as related because of C. Therefore, we use partial correlation to eliminate this fallacy by controlling the influence of C while computing the correlation of A and B.

See the partial correlation equation (8) ²⁰

$$\rho^{AB.C} = \frac{\rho^{AB} - \rho^{AC}\rho^{BC}}{\sqrt{1 - \rho^{2AC}}\sqrt{1 - \rho^{2CB}}} \quad (8)$$

The partial correlation result is interpreted by comparing the real correlation with the partial correlation result. If the partial correlation is greater than zero and lesser than real correlation(e.g. real correlation can be Pearson correlation) then some other variable could have caused the higher value in the real correlation. It is important that the P-Value is less than 0.05 for the result to be statistically significant (i.e. acceptable statistically).

In this thesis we used the “pcor” function of the “ppcor” R library to generate all the partial correlation results. Please see Sections 6.4, 7.4, 8.4 and 9.4 for the partial correlation results and analysis.

The analysis of the partial correlation will help us to verify if the correlation we saw is direct or partial(i.e. not as a result of some other variables) correlation.

5.5 Granger Causality Test

Granger Causality Test is a statistically hypothetical test for showing whether one-time series is useful in predicting the other. In the Granger causality test, we measure the capacity of the

¹⁹<https://www.statisticshowto.com/partial-correlation/>

²⁰https://en.wikipedia.org/wiki/Partial_correlation

future value of one series to be estimated with the previous value of another ²¹.

Causality is closely related to cause and effect idea, though it is not the same. It should be noted that the word “cause” in Granger causality of the field of econometrics means “precedence” in a more appropriate term ²².

The researchers in the time series econometric used the Granger causality method to examine the causal interactions which exist among economic indicators in different nations of the world. Its investigation is sensitive to the type of set up of the model, and it is then significant to select and measured data based on the lags number decision to apply to the two series in the regressions to follow. Granger causality between two variables cannot be understood as a real causal association but simply show that a variable can aid to forecast the other variable better [37].

Granger causality believes in two fundamental principles:

- The cause always precedes its effect in time.
- The causal series contains information about the effect series that is only from it and not provided in preceding values of effect [38]

Assuming we have two stationary time series i.e. series a and b.

Now to carry out Granger causality for the null hypothesis test of ‘a’ does not Granger cause ‘b’, we first find proper lagged values of b to be included in a univariate autoregression of b see equation (9) ²³.

$$b_t = x_0 + x_1b_{t-1} + x_2b_{t-2} + \dots + x_mb_{t-m} + error_t \quad (9)$$

then we augment this autoregression equation with the lagged value of a series. See equation (10) ²⁴

$$b_t = x_0 + x_1b_{t-1} + x_2b_{t-2} + \dots + x_mb_{t-m} + error_t \quad (10)$$

All lagged values of a that are significant according to their t-statistics, as long as they improve the explanatory power of the regression according to an F-test are retained. Therefore, the null hypothesis of series ‘a’ Granger causes ‘b’ is only accepted when no lagged value of ‘a’ improves the explanatory of the regression and is not retained ²⁵.

In simpler terms, Granger’s causality tests the null hypothesis that the coefficients of previous value in regression gives us zero. In other words, the past value of the first time series does

²¹https://en.wikipedia.org/wiki/Granger_causalitycite_note-Eichler-7

²²https://en.wikipedia.org/wiki/Granger_causalitycite_note-Eichler-7

²³https://en.wikipedia.org/wiki/Granger_causalitycite_note-Eichler-7

²⁴https://en.wikipedia.org/wiki/Granger_causalitycite_note-Eichler-7

²⁵https://en.wikipedia.org/wiki/Granger_causalitycite_note-Eichler-7

not cause the second time series to be tested. While if the p-value of this Granger test is lesser than the threshold significant value of 0.05 then, the null hypothesis is rejected ²⁶.

In this thesis, so as not to lose focus on the complexity of calculation of Granger causality test, we used an R library for our Granger causality test computation known as “lmtest” that comes with “grangertest” function as part of its array of functions.

We combined the stocks feature with the sentiment values from different dictionaries and ran the lmtest’s grangertest function on each combination with different order values. If the p-value is less than 0.05 we reject the null hypothesis. More details on how the features of daily sentiment summary is combined for causality test is available in Section 6.6 and in Table 6.

The analysis of the Granger causality test will allow us to see a closer relationship between the stock values and the media sentiment on pairwise bases and at different lag/order values. In other words, shining more light on the relationship between the stock values and media sentiment relationship.

For our granger result and analysis look at Sections 6.6, 7.6, 8.6 and 9.6.

5.6 Word Cloud

Word clouds are a visually appealing way of providing an overview of the words that appear with the highest frequency in text documents. The words’ font size is used to depict the frequency of usage of the word while the varying word orientation, color, position, etc are mainly for aesthetic purposes [39, 40].

In this thesis, we used “wordcloud” function of the “wordcloud” R library to generate the word cloud. After cleaning and preparing our text for analysis, we generate the word cloud with the R library as a concentric circle of words, with the most frequently used words presented in the center. The lesser a word is used the further out toward the circumference of the word cloud it appears.

Only the top 100 words are displayed in the word clouds generated in this thesis. For our word cloud result and analysis look at section Sections 6.7, 7.7, 8.7 and 9.7.

²⁶<https://towardsdatascience.com/granger-causality-and-vector-auto-regressive-model-for-time-series-forecasting-3226a64889a6>

6 Volkswagen Result Analysis

We will start by analyzing the case study company's result (i.e. Volkswagen Result).

6.1 VW Stocks and Sentiments Correlation

In this section, we look at the correlation between Volkswagen stocks value and different social media datasets (i.e. Twitter, News, and Message Board) during the period of the Volkswagen emission scandal.

6.1.1 VW Twitter Correlation

Figure 6.1 shows the overall correlation for the period under consideration. It presents a weak correlation of SentimentGI, SentimentHE, and SentimentQDAP (i.e. correlation values mainly between 0.25 to 0.5 or -0.25 to -0.5).

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.337335102	0.181440976	0.398408978	0.379863704
High	0.324438507	0.173991254	0.383071123	0.363824642
Low	0.373349646	0.218700111	0.444483258	0.429030362
Close	0.357876594	0.204658744	0.421092163	0.402809265
Adj.Close	0.36109478	0.208678693	0.432458935	0.413827912
Volume	-0.331094706	-0.248670022	-0.48588189	-0.493291709

Figure 6.1: Correlation VW Twitter Sentiments against VW Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.329034213	0.182468418	-0.238761199	-0.023543874
High	-0.13002305	0.165956344	-0.145299206	0.167048036
Low	-0.057154136	0.096707782	-0.144379763	0.198157141
Close	-0.083864736	0.192128846	-0.135421359	0.144722
Adj.Close	-0.083865655	0.192130274	-0.13542228	0.14472059
Volume	0.104555265	-0.537813466	0.348754265	0.12507157

Figure 6.2: Correlation VW Twitter Sentiments against VW Stock For the period before (i.e. 01.09.2015 to 15.09.20)

While the period when VW admits fault to the authority, but the scandal is not yet in the news as seen in Figure 6.2 shows no correlation (i.e. the correlation values are between -0.25 and 0.25).

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.749101364	0.209370748	0.647206224	0.574030347
High	0.751685748	0.200170244	0.644029876	0.563369973
Low	0.826662086	0.265760603	0.706230762	0.699389242
Close	0.821192628	0.246167965	0.690425874	0.667438128
Adj.Close	0.821192683	0.246168019	0.690425964	0.667438217
Volume	-0.37316465	-0.379276864	-0.332772301	-0.675735696

Figure 6.3: Correlation VW Twitter Sentiments against VW Stock For period 16.09.2015 to 15.10.2015

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.666230304	0.049201884	-0.445352183	-0.438038893
High	-0.763429689	-0.088064162	-0.543170914	-0.59619855
Low	-0.62957489	0.109796925	-0.358290884	-0.399884242
Close	-0.739348207	-0.063882288	-0.477966008	-0.569005882
Adj.Close	-0.739348021	-0.063882226	-0.477965882	-0.569005723
Volume	-0.358953144	-0.618850735	-0.672100248	-0.476871634

Figure 6.4: Correlation VW Twitter Sentiments against VW Stock For period 16.10.2015 to 15.11.2015

Of all the correlation results generated for different periods of VW Twitter sentiment against its stock's value. Figure 6.3, presents the strongest correlation (i.e. with most values are above 0.65). The period of Figure 6.3 (i.e. 16.09.2015 to 15.10.2015) was when the scandal was in the news, the CEO resigned, and several other events took place that dented the image of Volkswagen. From the result, we observe a positive correlation meaning the sentiment and stocks were increasing in the same direction.

The result of the period that follows i.e. Figure 6.4, shows a strong rebound in the opposite direction as the sentiment vs stock correlation presents weak to moderate negative correlation

(i.e. with most values between 0.3 and 0.8). This means that the stock value increased in the opposite direction of the sentiment for the period in this Figure.

Further analysis of the subsequent period after 15.11.2015 shows a continuous reduction in the correlation every month until there was no correlation(i.e. with values mostly between -0.25 and 0.25) at the end of the period under consideration as seen in Figures 6.5 and 6.6.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.118385079	-0.576328686	-0.042853841	-0.013761661
High	0.199286581	-0.536287014	-0.035828089	0.01489593
Low	0.191896285	-0.523345507	-0.019665119	0.01236169
Close	0.277040924	-0.433162305	0.018484875	0.05280377
Adj.Close	0.277041015	-0.433162311	0.018485126	0.052803929
Volume	0.228608419	-0.144505396	0.106348153	0.144458811

Figure 6.5: Correlation VW Twitter Sentiments against VW Stock For period 16.03.2016 to 15.04.2016

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.179116101	-0.015623027	-0.042345615	0.062184631
High	-0.059799892	-0.12781651	-0.1565841	-0.062860807
Low	-0.098424393	0.023866086	0.080010644	0.138082875
Close	0.020862385	-0.117126787	-0.129088847	-0.041881786
Adj.Close	-0.044161061	-0.066403351	-0.086712758	0.016053692
Volume	0.354082489	-0.47737309	-0.599780978	-0.599589361

Figure 6.6: Correlation VW Twitter Sentiments against VW Stock For period 16.04.2016 to 15.05.2016

6.1.2 VW News Correlation

Figure 6.7, shows the correlation for the whole period of study of the VW News dataset. The weak correlation here(i.e. with values mostly in the range of 0.25 and 0.5) presented between the stock value and SentimentQDAP, SentimentLM, and SentimentGI is exactly what we saw in the VW Twitter dataset too.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.347458196	0.053814491	0.422925032	0.409389002
High	0.336614094	0.039103359	0.404982084	0.396017043
Low	0.366767408	0.108738787	0.469633096	0.446034434
Close	0.358598838	0.087107988	0.445278668	0.426564342
Adj.Close	0.362627191	0.094017062	0.453282591	0.424246421
Volume	-0.239089264	-0.453718794	-0.503446069	-0.398217403

Figure 6.7: Correlation VW News Sentiments against VW Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.175896211	0.129481449	0.079000359	0.122514043
High	-0.154456663	0.308602806	0.101242113	0.212022593
Low	-0.15147622	0.261770676	0.051603158	0.097884521
Close	-0.157120196	0.363677541	0.019399255	0.082277361
Adj.Close	-0.157116929	0.363677626	0.019399941	0.082278411
Volume	-0.296110884	-0.228704352	0.286130578	0.049736817

Figure 6.8: Correlation VW News Sentiments against VW Stock For period before (i.e. 01.09.2015 to 15.09.2015)

The period before scandal was in the news presents no correlation (i.e. with values between -0.25 and 0.25)as seen in Figure 6.8). While the period immediately after the announcement of the scandal presents an increase in correlation in a similar pattern as seen in the VW Twitter data in Figure 6.9. Very important to note is the consistent SentimentHE in both Twitter and News sentiment showing no correlation in the first month of scandal in the news with the stock price.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.54674655	0.067594526	0.435475525	0.632775397
High	0.530938974	0.042031034	0.41627927	0.614886702
Low	0.619220264	0.218559738	0.557667881	0.752750743
Close	0.612335799	0.181630622	0.527481467	0.720210756
Adj.Close	0.612335855	0.181630726	0.527481579	0.720210824
Volume	-0.411684418	-0.759246073	-0.627953001	-0.638959439

Figure 6.9: Correlation VW News Sentiments against VW Stock For period 16.09.2015 to 15.10.15

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.286874256	0.424002584	-0.032361917	-0.079771354
High	-0.430317559	0.367981363	-0.174771771	-0.255506359
Low	-0.236762376	0.435731441	-0.002996456	-0.061592424
Close	-0.372356167	0.399659383	-0.130346064	-0.208253743
Adj.Close	-0.372355921	0.399659344	-0.130346191	-0.208253676
Volume	-0.567273207	-0.174811719	-0.586252513	-0.623991692

Figure 6.10: Correlation VW News Sentiments against VW Stock For period 16.10.2015 to 15.11.2015

The month that followed (i.e. Figure 6.10) shows a weak negative correlation (i.e. with values mainly between 0.25 and 0.5 or -0.25 and -0.5) and far lesser than expected when compared to the stronger negative correlation shown in Twitter.

Unexpectedly, we keep observing a periodic weak correlation (i.e. with values mainly between 0.25 and 0.5) followed by no correlation (i.e. with values mainly between -0.25 and 0.25) throughout the months that followed. Examples are shown in Figures 6.11 and 6.12.

The retention of correlation by the volume even when the stock prices are no longer showing correlation is seen in both Twitter and news datasets as observed in Figures 6.6 and 6.12.

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	-0.38885952	-0.384997944	-0.410890749	-0.549546387
High	-0.423665467	-0.405930498	-0.472428898	-0.554464935
Low	-0.462909108	-0.390618051	-0.443110464	-0.546047782
Close	-0.407818214	-0.421040741	-0.444788541	-0.506121782
Adj.Close	-0.407818209	-0.421040901	-0.444788543	-0.506121827
Volume	-0.043835697	-0.493036287	-0.200784969	-0.190318483

Figure 6.11: Correlation VW News Sentiments against VW Stock For period 16.03.2016 to 15.04.2016

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	0.207426963	0.281074076	0.226567224	-0.052354603
High	0.243848891	0.129242115	0.053892367	-0.220216657
Low	0.225647203	0.287104664	0.273288781	-0.009234229
Close	0.239564486	0.073139024	0.017431833	-0.24653989
Adj.Close	0.216634583	0.155385671	0.110906673	-0.170301393
Volume	0.194465155	-0.539806511	-0.693592498	-0.616524432

Figure 6.12: Correlation VW News Sentiments against VW Stock For period 16.04.2016 to 15.05.2016

6.1.3 VW Message Board Comment Correlation

There was no overall correlation between the message board comment and the stock's value when we used the data for the whole period under analysis as shown in Figure 6.13

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	0.034885392	-0.020690315	0.034070528	0.08827555
High	0.027751811	-0.020856744	0.027293369	0.091895772
Low	0.04316862	-0.015438681	0.06404951	0.120190424
Close	0.033756172	-0.015929301	0.056409414	0.118497243
Adj.Close	0.030559855	-0.017933725	0.058639551	0.118740461
Volume	-0.11070356	-0.033608215	-0.252665997	-0.208622005

Figure 6.13: Correlation VW Message Board comment Sentiments against Stock for dataset whole period (i.e. 28.08.2015 to 06.06.16)

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	-0.26770634	-0.318639148	-0.313695403	-0.216831568
High	-0.296607816	-0.272871905	-0.336236783	-0.233676035
Low	-0.330710338	-0.254489331	-0.318415653	-0.241004791
Close	-0.279740904	-0.202177953	-0.265181079	-0.190976085
Adj.Close	-0.279740869	-0.202178292	-0.265181545	-0.190976227
Volume	0.301207029	-0.013494752	0.005857643	0.186457948

Figure 6.14: Correlation VW Message Board comment Sentiments against Stock for period before (i.e. 01.09.2015 to 15.09.2015)

While in Figure 6.14, the message board comment sentiment shows a weak to strong correlation (i.e. with values mainly between 0.25 and 0.65) with stocks during the period before the scandal was in the news. We then started to speculate that the message boards are better informed even more than other media since they are the only ones that show correlation out of the three sentiment sources we used before the VW scandal was in the news.

By the time the public became aware of the scandal, unexpectedly, most of the correlation of message board comment sentiment and that of stock prices were lost except in *SentimentGI* but there is still a significant correlation with stock volume as seen in Figure 6.15.

The period that followed shows no real correlation between the message board comment and stock values as shown in Figure 6.16.

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	0.409218064	-0.055305663	0.156860379	0.179808235
High	0.379825422	-0.050903156	0.104331147	0.147419461
Low	0.475311083	0.030928779	0.248520348	0.31639966
Close	0.448910548	0.020523092	0.198677366	0.284858793
Adj.Close	0.448910465	0.020522963	0.198677347	0.284858737
Volume	-0.386406264	-0.348430517	-0.60576617	-0.655767033

Figure 6.15: Correlation VW Message Board comment Sentiments against Stock for dataset whole period (i.e. 28.08.2015 to 06.06.16)

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	0.073975548	-0.026777855	-0.120934578	0.096972583
High	0.085295377	0.059196686	-0.091409868	0.091308827
Low	0.152980409	-0.04045924	-0.089224809	0.120506444
Close	0.138648443	0.060820103	-0.037958026	0.076816375
Adj.Close	0.143395535	0.055969948	-0.029525298	0.085941861
Volume	-0.259435642	0.060238412	-0.109817797	-0.109171717

Figure 6.16: Correlation VW Message Board comment Sentiments against Stock for period before (i.e. 01.09.2015 to 15.09.2015)

6.1.4 VW Stocks and Sentiment Correlation Result Summary

In summary, we saw a clear correlation between stock values and the sentiment analysis results for most of our sentiment dictionaries in the case of news and Twitter datasets especially during the heat of the scandal (i.e the first 2 to 3 months after the scandal was announced).

While the message board comment sentiment shows no correlation with the stock price but presents some good correlation with the volume.

6.2 VW Stocks and Sentiment Weekly Correlation

We took a closer look at the correlation at the weekly interval to see the immediate impact of the news and events of the emission scandal. We started by calculating our correlation from two weeks before the scandal publicity and for two and a half months after. We referred to each correlation box as week 1, week 2 to week 12 i.e. from right to left then from top to the bottom. In all data analyzed week 1 and week 2 are the weeks before the scandal events and week 3 to week 12 were the week during and after the major events(i.e. recall of 500k faulty cars, the admittance of fault in the new, etc) of the VW scandal timeline.

6.2.1 VW Twitter Weekly Correlation

In Appendix C, the first two correlation boxes(i.e. weeks 1 and 2) show the weeks before the scandal was in the news, and here, there was no consistent correlation (i.e. most values fall between -0.25 and 0.25). The third correlation box which in the period when US authority instructed VW to recall 500k cars and a day before the scandal was in New York Times, shows the highest correlation values (i.e. with values mainly between 0.8 and 1.0). The weeks that followed(i.e. week 4 and week 5 in second and 3rd row) started to show diminishing in correlation but still maintain good correlation in most of the dictionaries. The 9th week/box (i.e. the week VW announce a loss of 3.5bn euro), 10th week/box (i.e. the week VW and Audi were hit with a lawsuit in Australia), and 12th week/box (i.e. the week Germany regulator signed off on software update for the VW cars) also show strong correlation(i.e. with correlation values greater than 0.5) across the different dictionaries.

6.2.2 VW News Weekly Correlation

In Appendix D, just as we saw in VW Twitter, had the highest correlation figures in the 3rd week (i.e. when US authority instructed VW to recall 500k cars and a day before the scandal was in New York Times). The rest of the weeks still follow similar patterns as observed in VW Twitter results but to a lesser extent of correlation strength.

6.2.3 VW Message Board Weekly Correlation

In Appendix E, like the other VW media sources, presents a high correlation in the 3rd week (i.e. when US authority instructed VW to recall 500k cars and a day before the scandal was in New York Times) but the highest correlation is in the 12th week/box (i.e. the week Germany regulator signed off on software update for the VW cars).

6.2.4 VW Stocks and Sentiment Weekly Correlation Result Summary

In summary, we saw the highest impact of the scandal was felt about the time the VW recall 500k cars in the US and scandal news gets out to the media for the first time (i.e. 3rd week of analysis).

The subsequent increase in correlation coincides with the week of major events during the scandal timeline, like the lawsuit, announcement of company loss, approval of software upgrade, etc.

The news and Twitter media show a consistently strong correlation that coincides with events of the scandal timeline but the message board correlation is not in sync with the events of the scandal timeline.

6.3 VW Stocks and Sentiment Rolling Correlation

Since correlation figures were not so pleasant to the eyes, we then used the rolling correlation graph to show the direction of correlation changes. The x-axis is the weeks of analysis. Like in weekly correlations weeks 1 and 2 were two weeks before the major event of the timeline. Week 3 was the week of recall of the 500k cars followed by weeks of other major events in the scandal timeline. The y-axis is the rolling correlation values. The green line is the volume vs sentiment rolling correlation and the other colors are the stock prices vs sentiment rolling correlation.

6.3.1 VW Twitter Rolling Correlation

In Figure 6.17, SentimentLM, and SentimentQDAP Rolling Correlation graph, we observed at the 3rd week, has the highest rolling correlation value in the stock price correlation and lowest in the stock volume correlation. This is in conformity with the weekly correlation result that

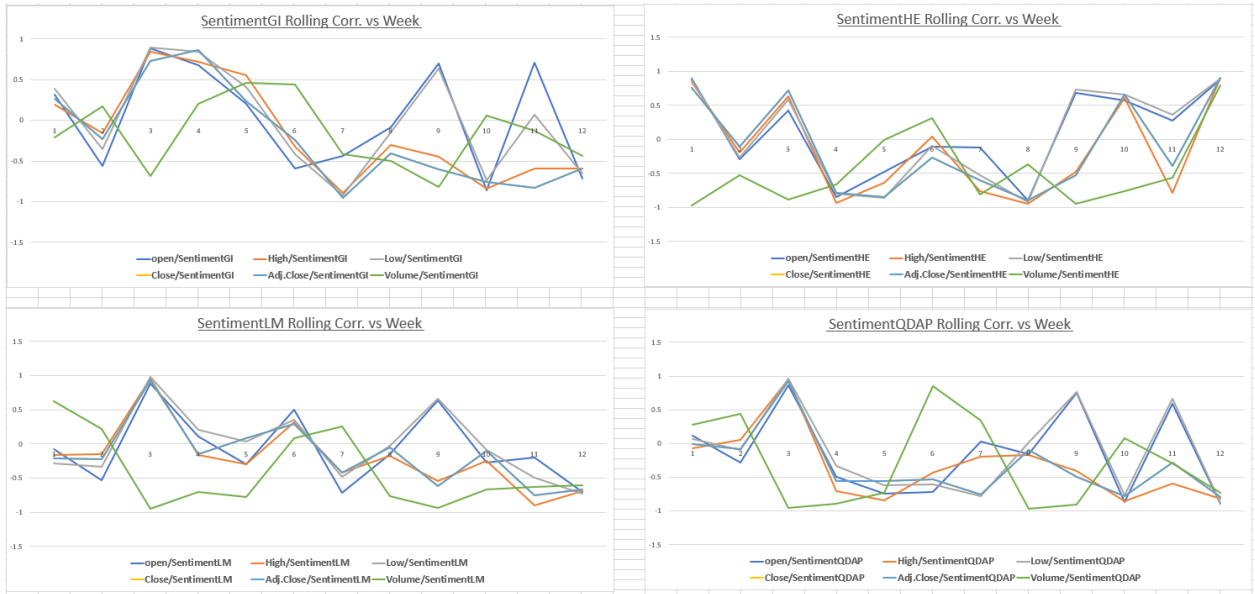


Figure 6.17: Rolling Correlation of VW Stock VS Twitter Sentiment Weekly Correlation

presents the highest correlation strength at 3rd week. We should remember that rolling correlation shows changes in correlation and such peaking of rolling correlation value meant there was a big difference between 2nd and 3rd week correlation, which points to the fact that the 3rd week was the beginning of the events of the scandal timeline.

6.3.2 VW News Rolling Correlation

In Figure 6.18, as we saw in VW Twitter rolling correlation result, we had the highest rolling correlation in stock price and the lowest rolling correlation in stock volume rolling correlation values in SentimentHE, SentimentLM, and SentimentQDAP at the 3rd week. This further confirms the observation of the VW scandal causing changes in the correlation value during the inception of the scandal events.

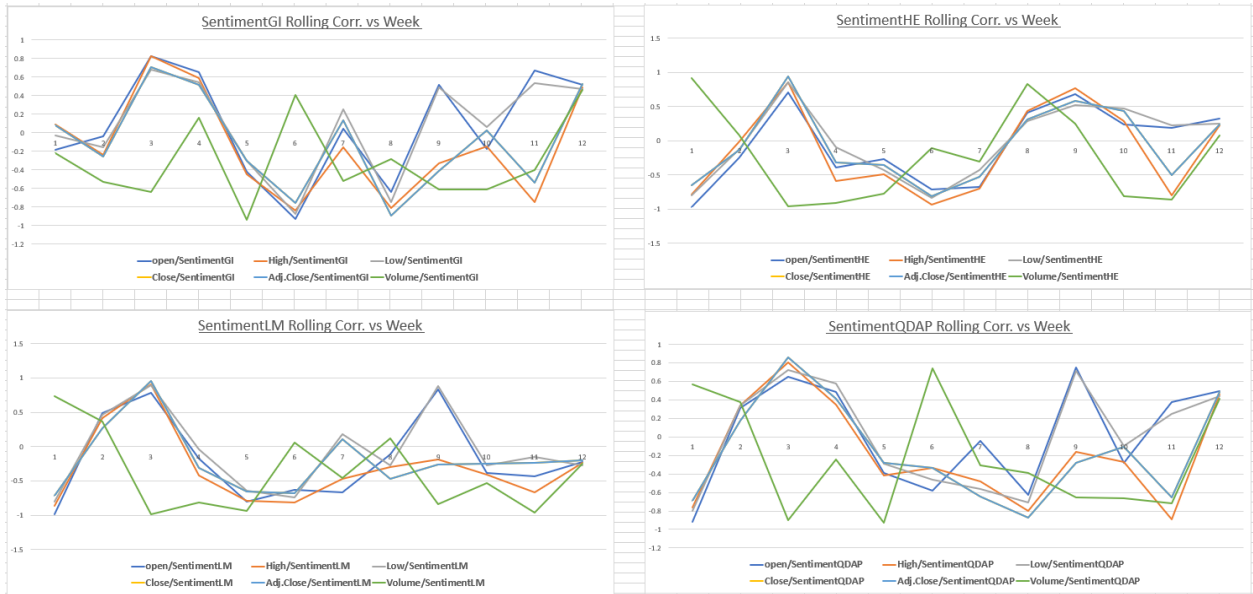


Figure 6.18: Rolling Correlation of VW Stock VS News Sentiment Weekly Correlation

6.3.3 VW Message Board Rolling Correlation

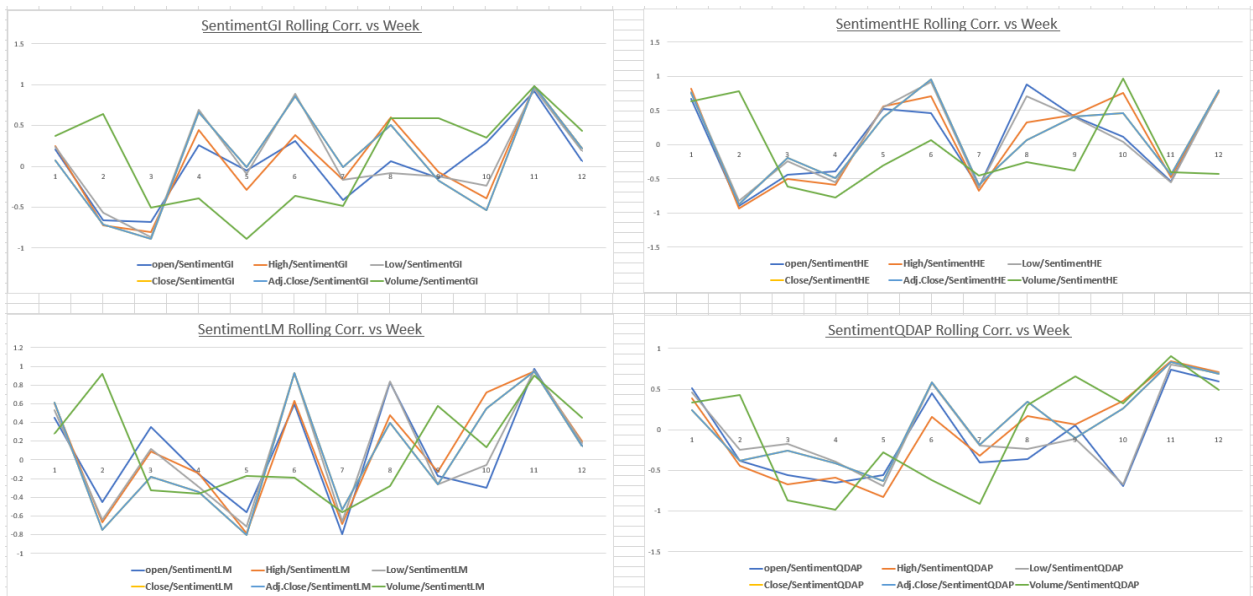


Figure 6.19: Rolling Correlation of VW Stock VS Message Board Sentiment Weekly Correlation

From Fig 6.19, there is no clear trend pattern in Message Board obvious to the eyes, and this fall in line with the weekly correlation result that didn't show a clear correlation that was influenced by the events of the VW scandal as otherwise seen in Twitter and News.

6.3.4 VW Stocks and Sentiment Rolling Correlation Result Summary

In summary, we saw the highest rolling correlation variation just about the time the VW recalled 500k cars in the US and the scandal got out to the media for the first time (i.e. 3rd week of analysis) and this is evident in Twitter and news media sources rolling correlation results.

6.4 VW Stocks and Sentiment Partial Correlation

Partial correlation measures the correlation of two variables while controlling the effect of other variables on the measured correlation dataset. We investigated the partial correlation we saw earlier if it was a direct correlation or as a result of the influence of some other variables. This computation was done for 9 months period (i.e. 28.08.15 to 06.06.16 that represent our dataset full period range) and 3 months period which comprises two weeks before the scandal was in the news and 10 weeks that followed, to capture the possible missed partial correlation at the inception of the scandal activities.

We should remember that If the partial correlation is greater than zero and lesser than the real correlation then some other variable is possibly responsible for the higher value of the real correlation. We should also note, the interpretation of the partial correlation will really be relevant if the result is statistically significant (i.e. with P-Values less than 0.05).

6.4.1 VW Twitter Partial Correlation

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.019100807	0.173709424	0.397200247	0.075709516	-0.080752943	-0.088748562	0.176314557	-0.146464226
SentimentHE	0.019100807	1	0.115622989	0.047656629	-0.021306406	-0.048031382	0.069549861	0.006555794	0.001504006
SentimentLM	0.173709424	0.115622989	1	0.619933528	0.02257506	-0.051697926	0.032496045	-0.081824768	0.118711287
SentimentQDAP	0.397200247	0.047656629	0.619933528	1	-0.053402572	4.40963E-06	0.149090901	-0.142293925	0.120325343
Open	0.075709516	-0.021306406	0.02257506	-0.053402572	1	0.874009973	0.696757886	-0.396176957	-0.004211759
High	-0.080752943	-0.048031382	-0.051697926	4.40963E-06	0.874009973	1	-0.537103229	0.458214814	0.010820349
Low	-0.088748562	0.069549861	0.032496045	0.149090901	0.696757886	-0.537103229	1	0.546347872	-0.045666656
Close	0.176314557	0.006555794	-0.081824768	-0.142293925	-0.396176957	0.458214814	0.546347872	1	0.796326631
Adj.Close	-0.146464226	0.001504006	0.118711287	0.120325343	-0.004211759	0.010820349	-0.045666656	0.796326631	1

Figure 6.20: VW Twitter Sentiment against VW Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.794189328	0.016826843	1.5233E-08	0.300474784	0.269328786	0.224597013	0.015228973	0.044320112
SentimentHE	0.794189328	0	0.113119444	0.514921209	0.771047869	0.511617793	0.341623903	0.928660449	0.983612998
SentimentLM	0.016826843	0.113119444	0	1.8808E-21	0.757826537	0.479885557	0.65711465	0.263003635	0.103749457
SentimentQDAP	1.5233E-08	0.514921209	1.8808E-21	0	0.465503551	0.999951951	0.040606909	0.050796988	0.099101842
Open	0.300474784	0.771047869	0.757826537	0.465503551	0	1.61741E-60	8.64435E-29	1.67094E-08	0.954132372
High	0.269328786	0.511617793	0.479885557	0.999951951	1.61741E-60	0	1.61952E-15	3.35938E-11	0.882522163
Low	0.224597013	0.341623903	0.65711465	0.040606909	8.64435E-29	1.61952E-15	0	4.23199E-16	0.532645003
Close	0.015228973	0.928660449	0.263003635	0.050796988	1.67094E-08	3.35938E-11	4.23199E-16	0	1.07997E-42
Adj.Close	0.044320112	0.983612998	0.103749457	0.099101842	0.954132372	0.882522163	0.532645003	1.07997E-42	0

Figure 6.21: VW Twitter Sentiment against VW Stock Partial Correlation P-Value (9 Months)

Figure 6.20 presents the 9 months partial correlation result with some of the results lesser than zero when looking at the sentiment vs stock values part of the partial correlation (i.e. the relevant part) result. Now comparing with the P-Value result for the 9 month partial correlation in Figure 6.22. There are only two pairs (i.e. "Low/SentimentQDAP" and "Close/SentimentGI") that produces a statistically significant result and have partial correlation values greater than zero and less than real correlation value of approximately 0.429 and 0.361 respectively.

Therefore, the direct correlation between "Low/SentimentQDAP" and "Close/SentimentGI" are partially correlated and therefore likely caused by some other features in the dataset.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.255739719	0.338971325	0.555444218	0.047553049	-0.008101139	-0.037636619	-0.022113084	-0.028411334
SentimentHE	0.255739719	1	-0.994082649	0.378557076	0.035608454	-0.109817828	0.103396626	0.029091549	0.030026211
SentimentLM	0.338971325	-0.994082649	1	0.357821572	0.026174618	-0.093021867	0.084064572	0.034028041	0.035421389
SentimentQDAP	0.555444218	0.378557077	0.357821572	1	-0.011530205	-0.061398057	0.162735093	-0.037116349	-0.032399931
Open	0.047553049	0.035608454	0.026174618	-0.011530205	1	0.907711565	0.656141036	-0.64732904	-0.647038069
High	-0.008101139	-0.109817828	-0.093021867	-0.061398057	0.907711565	1	-0.545632933	0.748931266	0.749017012
Low	-0.037636619	0.103396626	0.084064572	0.162735093	0.656141036	-0.545632933	1	0.86536499	0.864731614
Close	-0.02211321	0.029091588	0.034028088	-0.037116262	-0.647329036	0.748931272	0.865364975	1	-0.99997904
Adj.Close	-0.028411182	0.030026165	0.035421333	-0.032400036	-0.647038073	0.749017004	0.864731633	-0.999979037	1

Figure 6.22: VW Twitter Sentiment against VW Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.021203226	0.001964683	7.36463E-08	0.673343219	0.942778436	0.738694264	0.844650557	0.801212289
SentimentHE	0.021203226	0	6.21085E-78	0.000492687	0.752309867	0.329087091	0.358319944	0.796554306	0.790165534
SentimentLM	0.001964683	6.21085E-78	0	0.00103937	0.816576979	0.40881689	0.455580484	0.762972491	0.753569567
SentimentQDAP	7.36463E-08	0.000492687	0.00103937	0	0.91862784	0.58609197	0.146627599	0.742179502	0.774003217
Open	0.673343219	0.752309867	0.816576979	0.91862784	0	1.57122E-31	2.9464E-11	6.56761E-11	6.74076E-11
High	0.942778436	0.329087091	0.40881689	0.58609197	1.57122E-31	0	1.38123E-07	9.00616E-16	8.9017E-16
Low	0.738694264	0.358319944	0.455580484	0.146627599	2.9464E-11	1.38123E-07	0	2.04026E-25	2.42482E-25
Close	0.844649684	0.796554042	0.762972174	0.742180088	6.56761E-11	9.00615E-16	2.04026E-25	0	1.0898E-174
Adj.Close	0.80121333	0.790165853	0.753569948	0.774002502	6.74076E-11	8.90171E-16	2.42481E-25	1.0963E-174	0

Figure 6.23: VW Twitter Sentiment against VW Stock Partial Correlation P-Value(3 Months)

The fact that Figure 6.23, which is the P-Value of the partial correlation for the 3 months period presents no statistically significant result (i.e. all values greater than 0.05) means that we can generally ignore any partial correlation result seen in Figure 6.22. Therefore, there is no acceptable partial correlation in 3 months period and any correlation saw earlier could have been caused by direct correlation.

6.4.2 VW News Partial Correlation

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.085284059	-0.174619557	0.722348908	0.137799658	-0.121554793	-0.152073786	-0.11568495	0.252038501
SentimentHE	-0.085284059	1	0.322889764	0.211886833	-0.005151467	-0.103346704	0.048014663	-0.039892514	0.088093102
SentimentLM	-0.174619557	0.322889764	1	0.51262853	0.077634213	-0.1298613	0.055672823	-0.194700876	0.272912524
SentimentQDAP	0.722348908	0.211886833	0.51262853	1	-0.108934675	0.108558518	0.123257629	0.207169642	-0.345715034
Open	0.137799658	-0.005151467	0.077634213	-0.108934675	1	0.873737515	0.698054841	-0.359770434	-0.057898799
High	-0.121554793	-0.103346704	-0.1298613	0.108558518	0.873737515	1	-0.5384389	0.431269368	0.053927427
Low	-0.152073786	0.048014663	0.055672823	0.123257629	0.698054841	-0.5384389	1	0.488873706	0.033925018
Close	-0.11568495	-0.039892514	-0.194700876	0.207169642	-0.359770434	0.431269368	0.488873706	1	0.790684471
Adj.Close	0.252038501	0.088093102	0.272912524	-0.345715034	-0.057898799	0.053927427	0.033925018	0.790684471	1

Figure 6.24: VW News Sentiment against VW Stock Partial Correlation (9 Months)

Comparing Figures 6.24 and 6.25 with the rule of acceptance of the partial correlation in mind resulted in no acceptable partial correlation result for the 9 month result. The fact that partial correlation should be greater than zero and lesser than real correlation and must be statistically significant (i.e. P-Value lesser than 0.05) disqualifies all the partial correlation seen in 6.24

The same partial correlation test result was conducted for a 3-month period of our news sentiment and stock values produced the Figure 6.26 partial correlation result and Figure 6.27

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.243286704	0.016252753	8.89465E-32	0.058638344	0.095673526	0.03671088	0.112925161	0.000467668
SentimentHE	0.243286704	0	5.85594E-06	0.003423088	0.943913808	0.157024813	0.51176493	0.585746545	0.228052557
SentimentLM	0.016252753	5.85594E-06	0	4.66981E-14	0.288318766	0.074911897	0.446724162	0.00725995	0.000145037
SentimentQDAP	8.89465E-32	0.003423088	4.66981E-14	0	0.135669488	0.137033284	0.091081504	0.004232202	1.10281E-06
Open	0.058638344	0.943913808	0.288318766	0.135669488	0	1.95329E-60	6.2076E-29	3.68596E-07	0.42873363
High	0.095673526	0.157024813	0.074911897	0.137033284	1.95329E-60	0	1.33745E-15	5.8193E-10	0.461123702
Low	0.03671088	0.51176493	0.446724162	0.091081504	6.2076E-29	1.33745E-15	0	9.52371E-13	0.643055252
Close	0.112925161	0.585746545	0.00725995	0.004232202	3.68596E-07	5.8193E-10	9.52371E-13	0	1.04301E-41
Adj.Close	0.000467668	0.228052557	0.000145037	1.10281E-06	0.42873363	0.461123702	0.643055252	1.04301E-41	0

Figure 6.25: VW News Sentiment against VW Stock Partial Correlation **P-Value (9 Months)**

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.670440347	0.772483209	-0.208212616	0.095690978	-0.008394978	-0.133046098	0.033590642	0.007335357
SentimentHE	0.670440348	1	-0.989076802	-0.586108122	0.074773033	-0.2453401	0.215778674	0.071777285	0.087841836
SentimentLM	0.772483209	-0.989076802	1	-0.460276747	0.044989942	-0.208318961	0.21111046	0.054763518	0.073728893
SentimentQDAP	-0.208212616	-0.586108121	-0.460276747	1	0.203085716	-0.332606413	0.139141767	0.131321306	0.123827126
Open	0.095690978	0.074773033	0.044989942	0.203085716	1	0.908394091	0.669027112	-0.662117594	-0.659732577
High	-0.008394978	-0.2453401	-0.208318961	-0.332606413	0.908394091	1	-0.561020397	0.771942646	0.771612705
Low	-0.133046098	0.215778674	0.21111046	0.139141767	0.669027112	-0.561020397	1	0.855109916	0.852678884
Close	0.033590511	0.071777416	0.054763656	0.131321336	-0.662117593	0.771942665	0.855109888	1	-0.999652866
Adj.Close	0.007335516	0.087841677	0.073728726	0.12382709	-0.659732579	0.771612683	0.852678917	-0.999652856	1

Figure 6.26: VW News Sentiment against VW Stock Partial Correlation **(3 Months)**

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	7.57301E-12	3.02926E-17	0.062141211	0.395444387	0.940706619	0.236382903	0.765931413	0.9481796
SentimentHE	7.57301E-12	0	1.85335E-67	8.99988E-09	0.507056934	0.027272219	0.053029443	0.524270055	0.435509898
SentimentLM	3.02926E-17	1.85335E-67	0	1.5367E-05	0.690027245	0.062004859	0.058511697	0.627268032	0.513023158
SentimentQDAP	0.062141211	8.99988E-09	1.5367E-05	0	0.069008808	0.002414884	0.21540162	0.242568595	0.270736679
Open	0.395444386	0.507056934	0.690027245	0.069008808	0	1.18772E-31	8.6901E-12	1.6849E-11	2.10906E-11
High	0.940706618	0.027272219	0.062004859	0.002414884	1.18772E-31	0	5.1047E-08	3.28931E-17	3.45851E-17
Low	0.236382903	0.053029443	0.058511697	0.21540162	8.6901E-12	5.1047E-08	0	3.01584E-24	5.54051E-24
Close	0.765932299	0.524269296	0.627267163	0.242568488	1.6849E-11	3.2893E-17	3.01587E-24	0	1.5461E-126
Adj.Close	0.948178484	0.435510728	0.513024114	0.270736818	2.10906E-11	3.45852E-17	5.54046E-24	1.5479E-126	0

Figure 6.27: VW News Sentiment against VW Stock Partial Correlation **P-Value (3 Months)**

which is the P-Value result. Similar to VW news partial correlation analysis for 9 months period, the 3 months period result produces no acceptable partial correlation too because the values are not statistically significant(i.e. with P-values greater than 0.05) or they are lesser than zero.

6.4.3 VW Message Board Partial Correlation

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.100422611	0.046880936	0.557872002	0.057115296	-0.007042095	0.015346602	0.018589672	-0.073791357
SentimentHE	0.100422611	1	0.129493458	0.095748307	-0.000750761	0.011746146	-0.015865016	0.027185555	-0.035926592
SentimentLM	0.046880936	0.129493458	1	0.387269485	0.066095018	-0.122062903	0.008313989	0.004952971	0.043386681
SentimentQDAP	0.557872002	0.095748307	0.387269485	1	-0.099664369	0.03005095	0.036059179	0.000135165	0.029060053
Open	0.057115296	-0.000750761	0.066095018	-0.099664369	1	0.882043491	0.714823725	-0.405883273	0.000642196
High	-0.007042095	0.011746146	-0.122062903	0.03005095	0.882043491	1	-0.594417895	0.506162891	-0.026614467
Low	0.015346602	-0.015865016	0.008313989	0.036059179	0.714823725	-0.594417895	1	0.519768284	0.018335273
Close	0.018589672	0.027185555	0.004952971	0.000135165	-0.405883273	0.506162891	0.519768284	1	0.78401166
Adj.Close	-0.073791357	-0.035926592	0.043386681	0.029060053	0.000642196	-0.026614467	0.018335273	0.78401166	1

Figure 6.28: VW Message Board Sentiment against VW Stock Partial Correlation **(9 Months)**

Looking at the P-Values of both 3 month and 9 month partial correlation result for the VW Message Board sentiment and stock values presented in Figures 6.29 and 6.31, there is no

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.171465467	0.524034285	1.09299E-16	0.437490988	0.923794833	0.834864545	0.800633548	0.315530622
SentimentHE	0.171465467	0	0.077334181	0.192384966	0.991863583	0.873231937	0.829369939	0.71187993	0.625442013
SentimentLM	0.524034285	0.077334181	0	4.36278E-08	0.368781217	0.096068101	0.910084689	0.946361091	0.555456515
SentimentQDAP	1.09299E-16	0.192384966	4.36278E-08	0	0.17473902	0.683070041	0.624165789	0.998535122	0.692983786
Open	0.437490988	0.991863583	0.368781217	0.17473902	0	2.28632E-62	1.49508E-30	8.25541E-09	0.993040125
High	0.923794833	0.873231937	0.096068101	0.683070041	2.28632E-62	0	3.00269E-19	1.46766E-13	0.717672555
Low	0.834864545	0.829369939	0.910084689	0.624165789	1.49508E-30	3.00269E-19	0	2.48029E-14	0.803305985
Close	0.800633548	0.71187993	0.946361091	0.998535122	8.25541E-09	1.46766E-13	2.48029E-14	0	3.63991E-40
Adj.Close	0.315530622	0.625442013	0.555456515	0.692983786	0.993040125	0.717672555	0.803305985	3.63991E-40	0

Figure 6.29: VW Message Board Sentiment against VW Stock Partial Correlation P-Value (9 Months)

statistically significant value here and it will be safe to ignore any partial correlation observed in Figures 6.28 and 6.30

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.999999997	-1	-1	0.064156412	-0.149514956	0.012442764	0.103718293	0.10046207
SentimentHE	-0.999999997	1	-0.999999995	-0.999999998	0.064230181	-0.149588524	0.012377318	0.10378415	0.100527949
SentimentLM	-1	-0.999999994	1	-0.999999999	0.064127178	-0.149484575	0.012462933	0.103695837	0.100439607
SentimentQDAP	-1	-0.999999997	-0.999999999	1	0.064162976	-0.14952079	0.01243715	0.103723189	0.100466967
Open	0.064156412	0.064230181	0.064127178	0.064162976	1	0.916382268	0.721730336	-0.662141873	-0.662153423
High	-0.149514956	-0.149588524	-0.149484575	-0.14952079	0.916382268	1	-0.66625567	0.786896101	0.786668649
Low	0.012442764	0.012377318	0.012462933	0.01243715	0.721730336	-0.66625567	1	0.895820778	0.896162676
Close	0.103718309	0.103784165	0.103695853	0.103723204	-0.662141874	0.786896103	0.895820778	1	-0.999994644
Adj.Close	0.100462052	0.10052793	0.100439588	0.100466949	-0.662153422	0.786668646	0.896162677	-0.999994641	1

Figure 6.30: VW Message Board Sentiment against VW Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	4.31586637859	0	0	0.574303557	0.188462114	0.913333273	0.363017153	0.378358225
SentimentHE	8.63626748930	0	0	0	0.573862596	0.188242287	0.913787368	0.362710877	0.378044026
SentimentLM	0	3.4383E-306	0	0	0.57447835	0.188552951	0.913193331	0.363121625	0.378465399
SentimentQDAP	0	1.29339469162	0	0	0.574264316	0.188444676	0.913372225	0.362994382	0.378334865
Open	0.574303557	0.573862597	0.57447835	0.574264316	0	2.389E-32	6.17422E-14	3.03071E-11	3.02749E-11
High	0.188462114	0.188242288	0.188552951	0.188444676	2.389E-32	0	2.06772E-11	8.21561E-18	8.52057E-18
Low	0.913333273	0.913787368	0.913193331	0.913372225	6.17422E-14	2.06772E-11	0	7.64696E-29	6.78234E-29
Close	0.363017082	0.362710806	0.363121553	0.36299431	3.03071E-11	8.21561E-18	7.64696E-29	0	4.038E-193
Adj.Close	0.378358314	0.378044115	0.378465487	0.378334954	3.02749E-11	8.52058E-18	6.78234E-29	4.1401E-193	0

Figure 6.31: VW Message Board Sentiment against VW Stock Partial Correlation P-Value (3 Months)

6.4.4 VW Stocks and Sentiment Partial Correlation Result Summary

In summary, the result shows that the real correlations in different media sources that we analyzed are not partially correlated.

Therefore, we can say that most of the correlation results we saw were because of direct correlation, not partial correlation.

6.5 VW Stocks and Sentiments Trends

We analyzed different graphs of the sentiments from our different sentiment dictionary and stock values. Drawing graphs with those values produced a poor looking and not analyzable graph because of variation in value scale. Therefore, we decided to draw the stock volume,

stock price, and sentiment separately which were in hundreds of thousands, hundreds, and in fractional numbers respectively against the date. We then laid the three graphs on each other for analysis.

In all cases, the sentiment is the red line, and the volume is the deep blue line. The other colors are the stock prices (i.e. the high, low, close, open, and adjusted close prices), and in most cases, those prices are close in value and moved in a similar direction with little variations. The vertical line markers are days of special events and news in relation to the VW scandal timeline and that helps us to identify places we expect changes in sentiment and stock trend line direction.

6.5.1 VW Twitter Trend

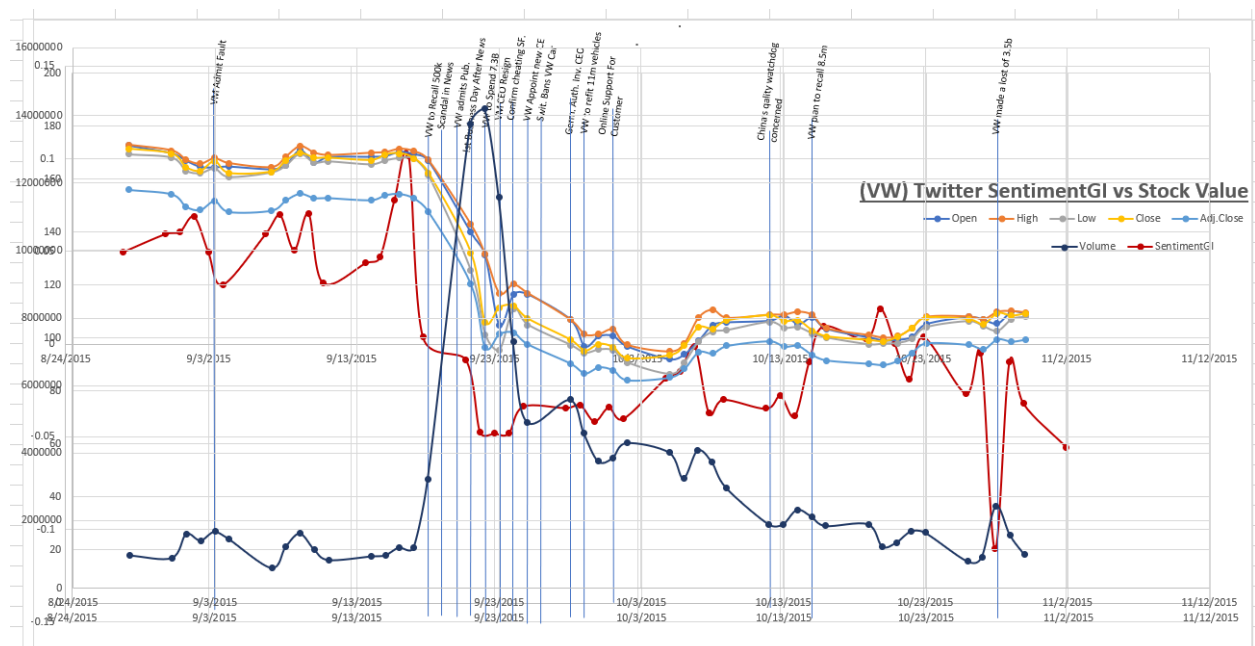


Figure 6.32: VW Twitter SentimentGI vs Stock Values

The four graphs (i.e. Figures 6.32, 6.33, 6.34, and 6.35) presents similar behavior but in different magnitude. On 3rd September we saw some loss in the reputation i.e. sentiment of the company and a change in the price and volume in all the graphs when VW admitted their fault, but this effect became extremely amplified just before the announcement of the recall of the 500k cars(i.e. second vertical marker on 18th September). Several other announcements/events that followed fell in the period of this strong change in the sentiment and stock values.

The steep descent in sentiment on 17th September followed by the fall of the price and the short period of the spike in trading volume on the 18th September as presented in the four graphs is a clear indication of how sentiment (i.e. social media) had influenced the reputation(i.e. stocks value). While the trading volume crashes as it rose a few days later and continued decreasing gradually. The price value keeps on descending but at a lower rate as more related news and events took place.

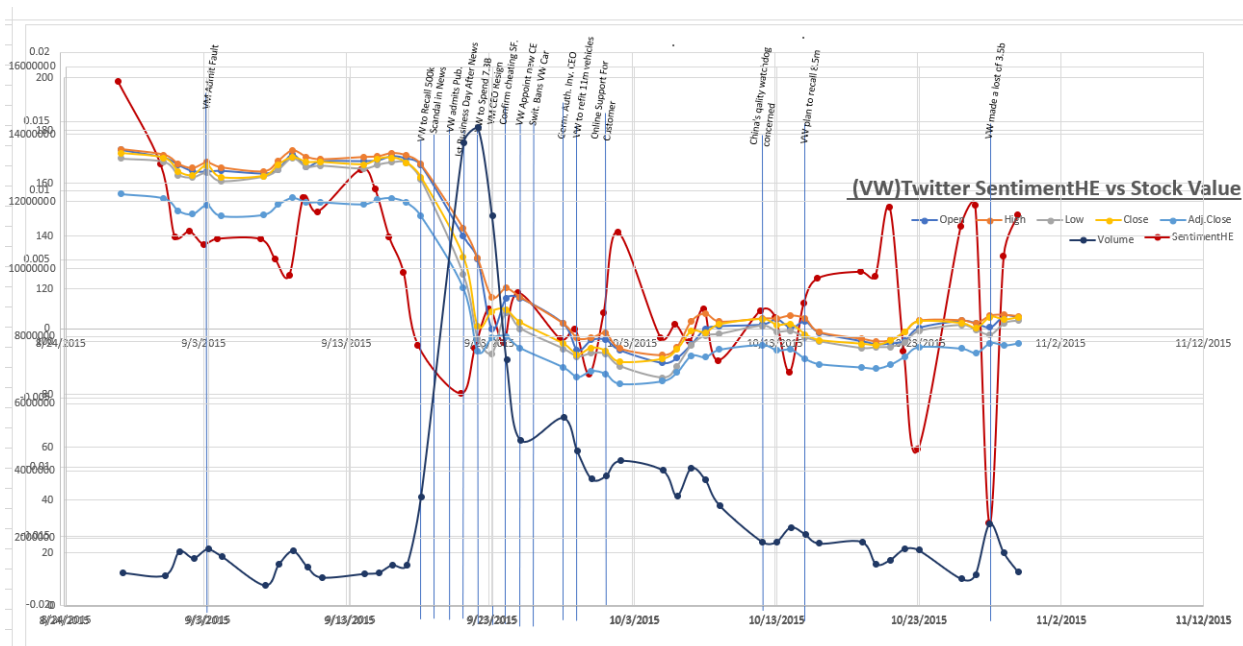


Figure 6.33: VW Twitter SentimentHE vs Stock Values

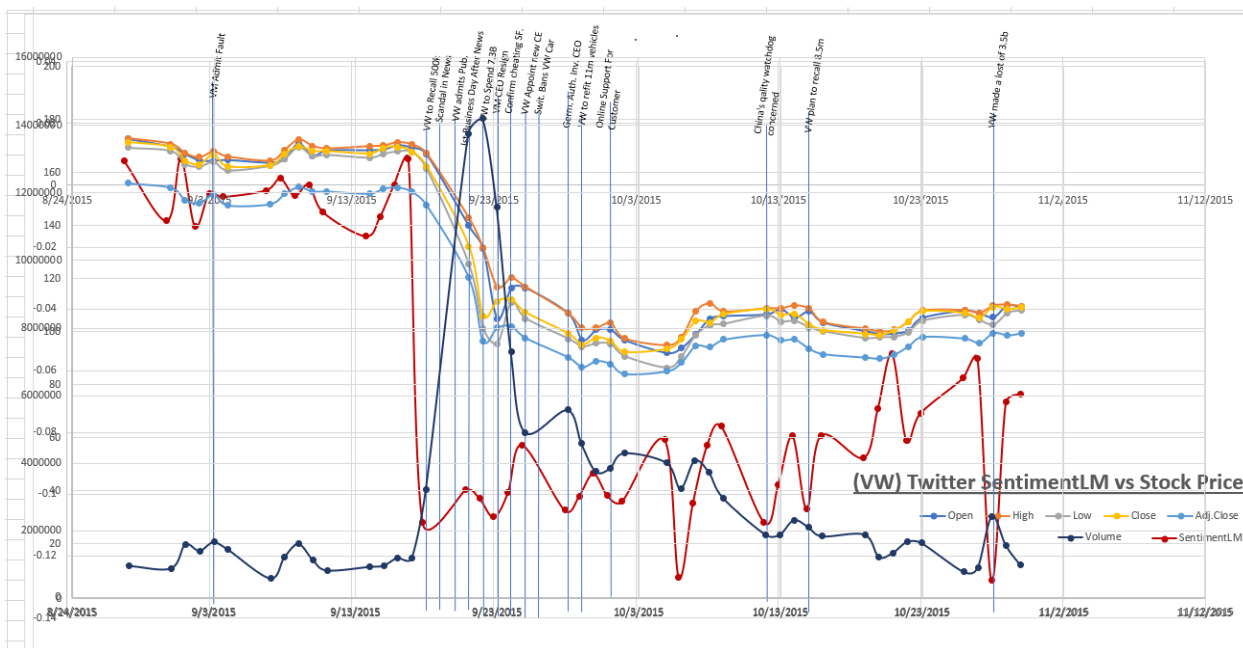


Figure 6.34: VW Twitter SentimentLM vs Stock Values

This was not an isolated case as more of this trend is observed in closer proximity not just in the first month but also on the 12th, 15th, and 17th October (i.e. the last three vertical marks in the graphs). Those markers are three news events i.e. *China's quality watchdog concerned*, *VW said it will recall 8.5m Cars Across Europe* and *VW made a loss of 3.5bn Euro*, shows a clear change in sentiment followed closely by a change in stock volume traded and a smaller but clear change also in price.

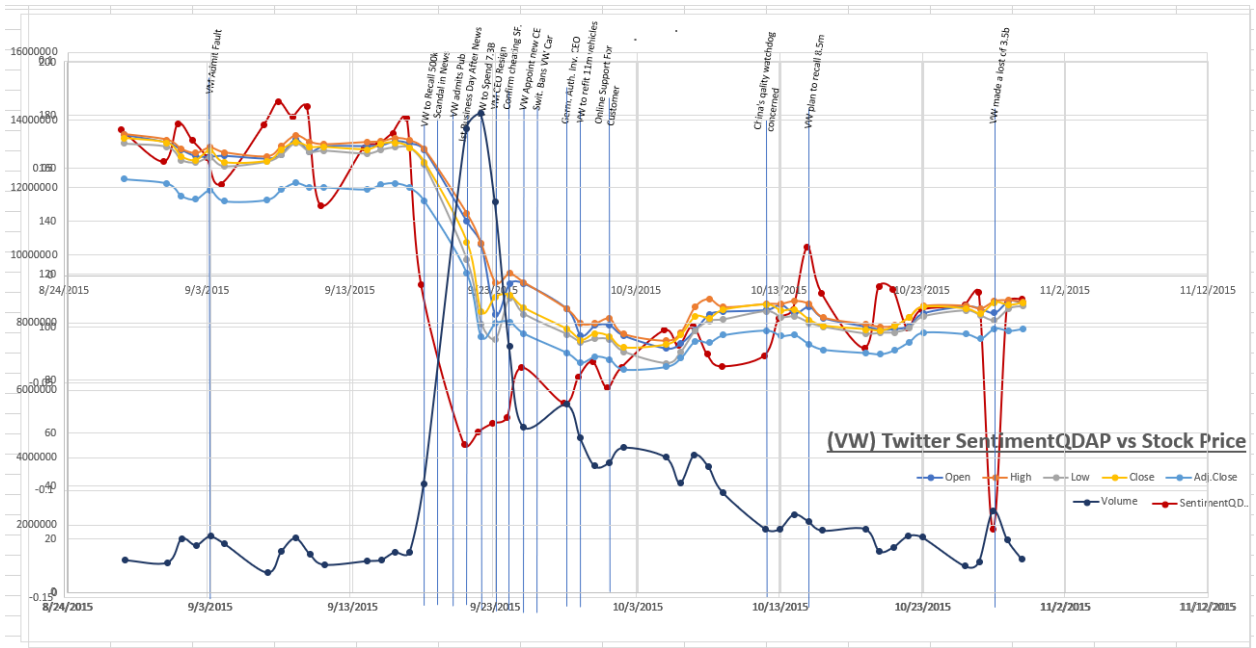


Figure 6.35: VW Twitter SentimentQDAP vs Stock Values

6.5.2 VW News Trend

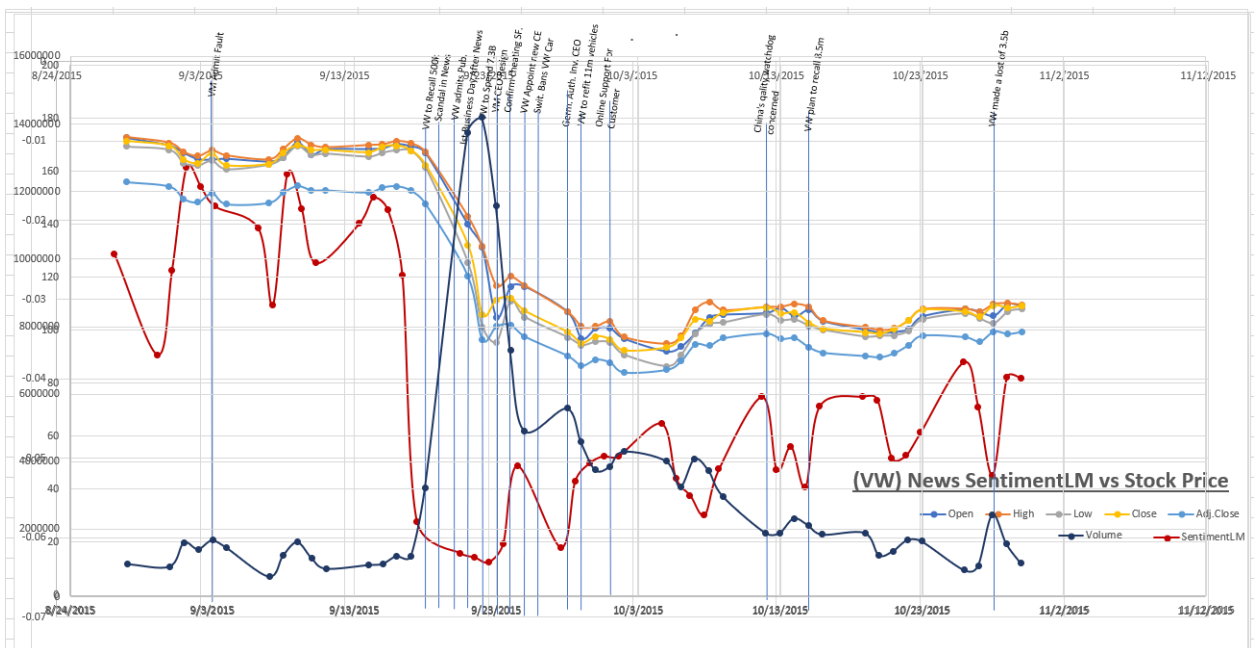


Figure 6.36: VW News SentimentLM vs Stock Values

Just as we saw in correlation, we observed that the trend in Twitter and news had similar patterns and told a similar story from Figures 6.36 and 6.37. The trend pattern shows the sentiment influencing the stock values by dropping in value first (i.e. on 15th September) and two days later in the case of this news graph, the stock prices crashed while trading volume increased astronomically for a short period before crashing and continued on a downward trend in response to the events of the VW emission scandal.

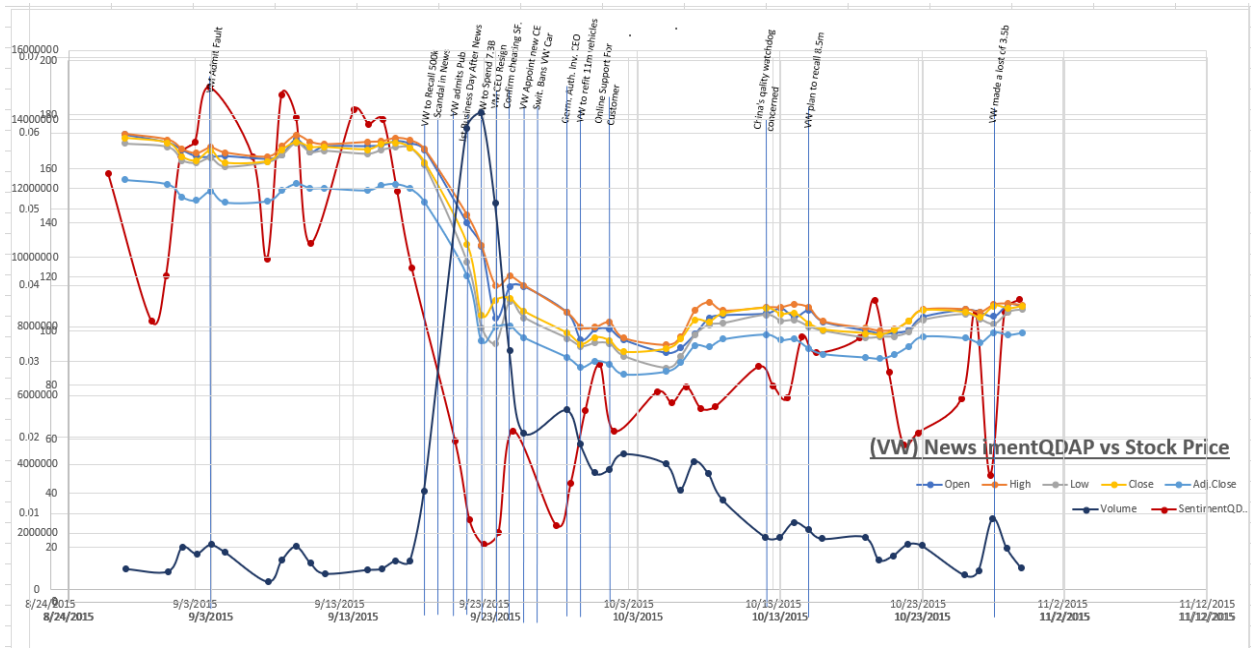


Figure 6.37: VW News SentimentQDAP vs Stock Values

6.5.3 VW Message Board Comment Trend

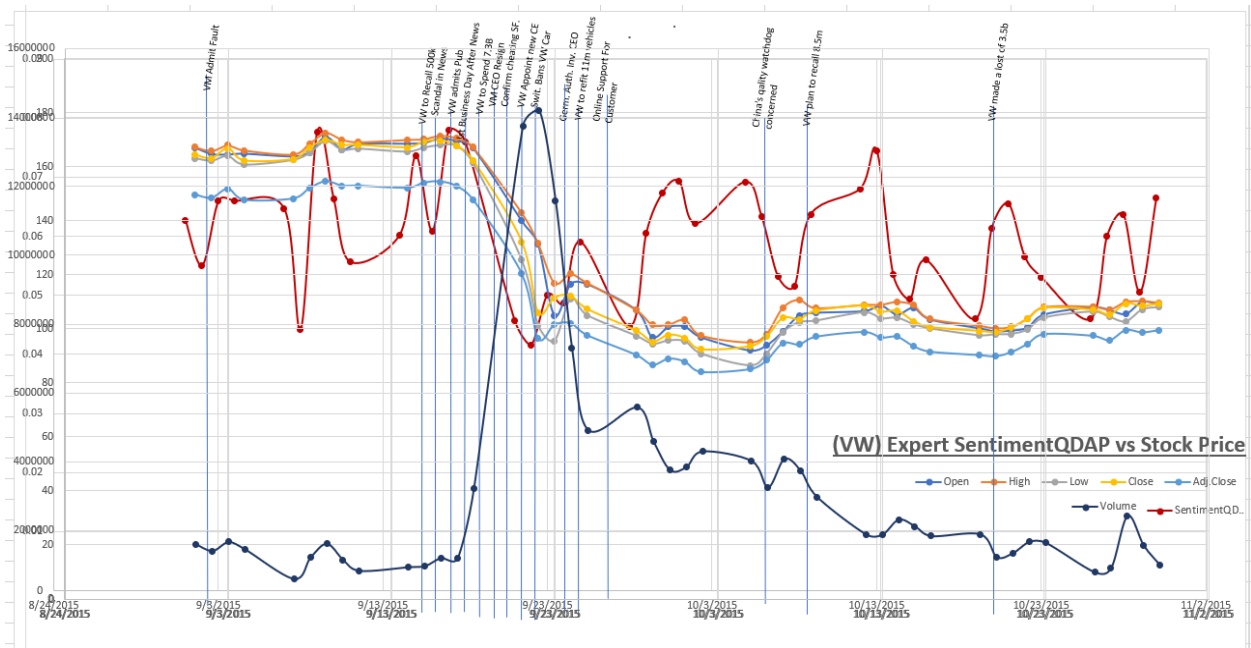


Figure 6.38: VW Message Board SentimentQDAP vs Stock Values

Figures 6.38 and 6.39 shows the trend lines of the message board comment and stock value. There was no strong relationship between stock values, trend lines, and sentiment. This is in conformity with what we observed in the correlation analysis of the message board comment.

After giving it a close look, we were able to see some patterns between message board sentiment and volume which were not very clear and consistent as seen in Twitter and news trend lines against the stock.

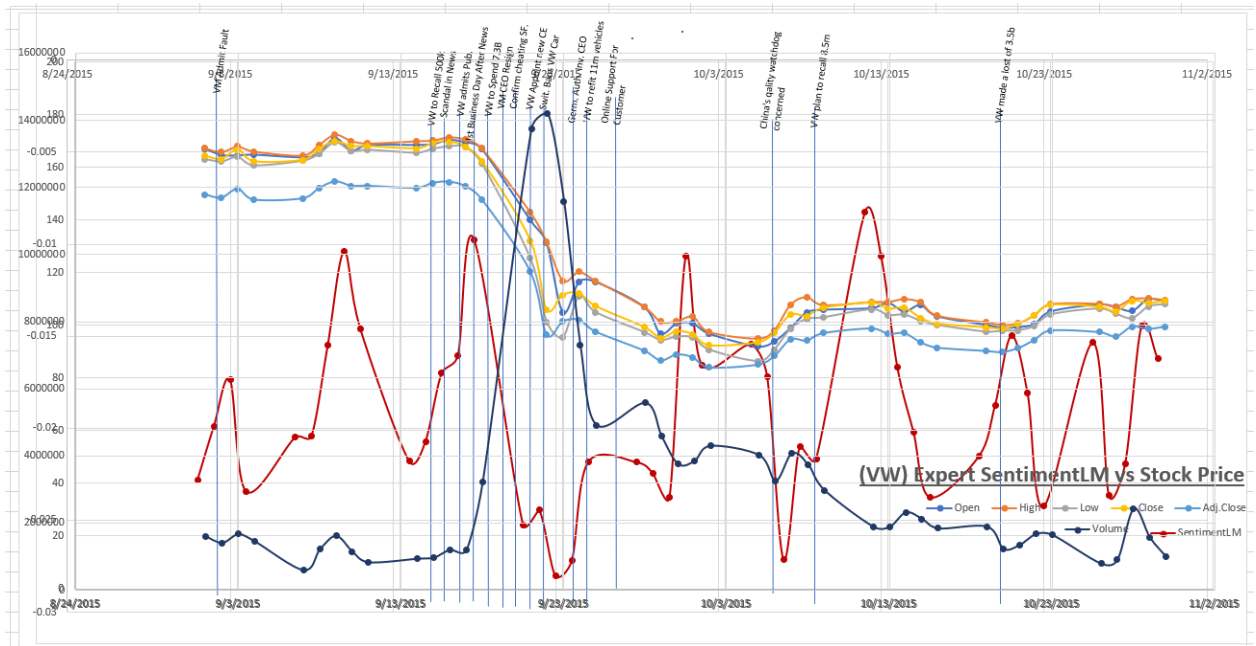


Figure 6.39: VW Message Board SentimentLM vs Stock Values

6.5.4 VW Stocks and Sentiment Correlation Result Summary

Similar to what we saw in correlation results, we saw a closer trend pattern between stock values and sentiment in the graph of Twitter and news dataset. They both show the sentiment leading in the responses to the scandal event and the stock values following it up closely.

While the message board comment presents the weakest relationship between the sentiment and stock values trend lines of the three media sources.

6.6 VW Stocks and Sentiments Granger Causality Test Analysis

In this section, we test some of our observations as hypotheses. We assume all are correlated to all. Meaning we will do 24 x 2 x 6 Granger Causality tests for each dataset (i.e. Twitter, News, and Message Board Comment).

Table 6: Combination of Granger analyzed

		Sentiment			
		SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Stock	Open	Open / SentimentGI	Open / SentimentHE	Open / SentimentLM	Open / SentimentQDAP
	High	High / SentimentGI	High / SentimentHE	High / SentimentLM	High / SentimentQDAP
	Low	Low / SentimentGI	Low / SentimentHE	Low / SentimentLM	Low / SentimentQDAP
	Close	Close / SentimentGI	Close / SentimentHE	Close / SentimentLM	Close / SentimentQDAP
	Adj.Close	Adj. Close / SentimentGI	Adj. Close / SentimentHE	Adj. Close / SentimentLM	Adj. Close / SentimentQDAP
	Volume	Volume / SentimentGI	Volume / SentimentHE	Volume / SentimentLM	Volume / SentimentQDAP

The 24 part of the test is made up of the stock value and sentiment combination as shown in Table 6.

The 2 parts of the test account for the fact that we ran two separate tests for each combination in Table 6. For example, for the combination “*Open / SentimentGI*” we will have tests “*Open / SentimentGI*” and “*SentimentGI / Open*” .

While the final 6 part of the test means we ran each test for 6 different order numbers i.e. Order 1, 2, 3, 4, 5, and 6 separately.

In each test, we color green those that had a null hypothesis rejected because they are the ones that show causality. For example if Granger cause of “*Open / SentimentGI*” gives a P-Value of below 0.05 then the null hypothesis of “*SentimentGI does not Granger test Open*” is rejected and the alternative hypothesis of “*SentimentGI does Granger cause Open*” is accepted.

6.6.1 VW Twitter Granger Causality Test

Appendix F (i.e. the 9 month’s result) shows those lines with the null hypothesis rejected in at least one of the order values tested.

These results show SentimentLM and SentimentQDAP Granger causing all the stock prices and SentimentLM also causing the stock volume. While SentimentGI causes Low, Close, Adj.Close and Volume. Generally, sentiment causes the stock values from this result.

We did the same test on the first 3 months period of the same dataset with the hope of seeing the early rush of events of the VW scandal on the Granger causality test result. Appendix F (i.e. the 3 month’s result) presents an increase in stock value items that is causing the sentiment and that we have lesser causality intensity when compared to the 9-month period result.

6.6.2 VW News Granger Causality Test

From the news dataset Granger causality test result of the 9 months dataset (i.e. whole dataset), both the sentiment and stock value shows causality for each other. The causality result is shown in detail in Appendix G (i.e. the 9 month’s result).

Repeating the same test for the first 3 months (i.e. to catch early causality missed in the 9 months period dataset causality test) of the VW news sentiment and stock produced the result in Appendix G (i.e. the 3 month’s result). This result shows stock as mainly the causality of sentiment.

6.6.3 VW Message Board Comment Granger Causality Test

Appendix H shows the 9 months and 3 months period dataset Granger causality result. Like we saw in the news and Twitter dataset. The longer period dataset (i.e. 9 months) shows the sentiment causing the stock values and the shorter period dataset (i.e. 3 months) shows the stock values causing the sentiment.



Figure 6.44: VW Message Board Word Cloud (9 Months i.e. 28.08.15 to 06.06.16)



Figure 6.45: VW Message Board Word Cloud (3 Months i.e. 28.09.15 to 31.12.15)

6.7.4 VW Stocks and Sentiment Correlation Result Summary

The words in the word cloud of the message board are not related to the VW scandal timeline but those of the news and Twitter are related to it. This can justify the similarities we saw in the result of news and Twitter and the clear pattern of their conformity with that of the VW scandal timeline.

6.8 VW Stocks and Sentiment Result Conclusion

We can then conclude from the VW dataset analyzed for the period we study (i.e. the VW emission scandal announced period and months that follow).

- There was a clear pattern match in the events in the scandal timeline and that of the result analyzed (i.e. good correlation, trend lines, and causality in news and Twitter dataset analyzed).
- The best correlation is seen at the inception of the timeline. This means the sentiment at that time is almost a perfect measure of corporate reputation. This we noticed in the 3rd-week correlation of the weekly correlation and the 3rd-week rolling correlation both of which had the highest value.
- There was a periodic increase in the correlation as very important events took place. That also implies that during the announcement of critical events the significance of media sentiment being a measure of corporate reputation increases. This was observed in an increase in weekly correlation at those weeks of special events.
- The Twitter and news media sentiment are valid measures of corporate reputation at the critical time in a company's scandal timeline, but this cannot be said of the message board

in this study.

- Periodic increase in correlation is seen at weeks of special events in the timeline in the correlation (i.e. news and Twitter) media dataset.
- Any media related to the company in crises that had its discussion not centered around the companies' crises will not have the sentiment as a measure of the company reputation even during the crises. This is the case of the message board dataset result during the VW scandal period.

Therefore, we say the measurement of the sentiment of online media like news articles and Twitter is also a measure of the corporate reputation during the company's crisis timeline.

7 Ford Result Analysis

In this chapter, we analyzed another car company (i.e. our first control case). This way we are able to compare the effect of the VW emission scandal on other substitute brand's reputations.

7.1 Ford Stocks and Sentiments Correlation

In this first section, we look at the correlation between Ford stocks and different Ford social media datasets (i.e. Twitter, News, and Message Board) for the emission scandal period and the months that followed.

7.1.1 Ford Twitter Correlation

Figure 7.1 shows the overall correlation for the period under consideration. This presents no correlation (i.e. the values were between 0.25 and -0.25) for the whole period.

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	-0.022138099	-0.137426386	-0.05569165	0.02992363
High	-0.013904825	-0.122260957	-0.039259611	0.034461972
Low	-0.034019925	-0.135902411	-0.080483699	0.015426706
Close	0.022609421	-0.120931977	-0.058497042	0.04916632
Adj.Close	0.022609421	-0.120931977	-0.058497042	0.04916632
Volume	0.060637335	0.050172247	0.157331637	0.087170729

Figure 7.1: Correlation Ford Twitter Sentiments against Ford Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	0.001533869	0.342402701	0.4790074	-0.184942367
High	0.446219096	0.212120737	0.457559524	0.114477477
Low	0.243178601	-0.028281034	0.471580416	-0.119901223
Close	0.621909559	0.146040274	0.391134069	0.417663581
Adj.Close	0.621909559	0.146040274	0.391134069	0.417663581
Volume	0.435990661	0.345177771	0.348204558	0.319167872

Figure 7.2: Correlation Ford Twitter Sentiments against Ford Stock For the period before (i.e. 01.09.2015 to 15.09.20)

While Figure 7.2, which is the period before the scandal was in the news, presents a weak correlation (i.e. with values between 0.25 and 0.5) already between the stock values and sentiment.

For the 2 months period immediately after the scandal announcement (i.e. Figures 7.3 and 7.4), there is no clear consistent correlation across the period except a weak correlation in only *SentimentLM* in the second month.

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	0.092324201	-0.268019212	-0.03504229	0.163331343
High	0.128422211	-0.197808563	0.054756554	0.249406314
Low	-0.044688025	-0.312511488	-0.028012666	0.106911773
Close	0.033577206	-0.243494446	0.05395673	0.199646283
Adj.Close	0.033577206	-0.243494446	0.05395673	0.199646283
Volume	0.298868041	0.102611447	0.194590009	0.405767625

Figure 7.3: Correlation Ford Twitter Sentiments against Ford Stock For period 16.09.2015 to 15.10.2015

	<i>SentimentGI</i>	<i>SentimentHE</i>	<i>SentimentLM</i>	<i>SentimentQDAP</i>
Open	-0.045282678	-0.303536426	-0.448651911	-0.111353715
High	0.091960905	-0.332914711	-0.587881641	-0.022607531
Low	-0.016561593	-0.298341317	-0.455575809	-0.194372364
Close	0.145448049	-0.357111684	-0.56264563	-0.06563721
Adj.Close	0.145448049	-0.357111684	-0.56264563	-0.06563721
Volume	0.094147324	-0.252845666	-0.601934997	0.031347333

Figure 7.4: Correlation Ford Twitter Sentiments against Ford Stock For period 16.10.2015 to 15.11.2015

The no consistent correlation pattern continued across the rest of the period as seen in Figures 7.5 and 7.6. This means that the scandal seems not to be influencing the stocks and sentiment values. We then begin to speculate a related product company might not suffer reputation losses with the company with scandal during the period of the scandal.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.083474188	-0.212852213	-0.557380268	-0.060492137
High	-0.083391033	-0.335760685	-0.398621979	-0.159670882
Low	-0.007409759	-0.17093088	0.028086417	0.061084538
Close	0.260768426	-0.343669049	0.087353175	0.218904718
Adj.Close	0.260768426	-0.343669049	0.087353175	0.218904718
Volume	0.07921324	-0.026660767	-0.324235662	0.088256588

Figure 7.5: Correlation Ford Twitter Sentiments against Ford Stock For period 16.03.2016 to 15.04.2016

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.005536685	-0.264002038	-0.121957155	-0.047332308
High	0.054664326	-0.344044295	-0.155118523	-0.038189715
Low	0.004261254	-0.322533246	-0.203958295	-0.081655802
Close	0.104759392	-0.290131134	-0.125858234	0.038375742
Adj.Close	0.104759392	-0.290131134	-0.125858234	0.038375742
Volume	-0.119847231	-0.02665505	-0.050995909	-0.027784714

Figure 7.6: Correlation Ford Twitter Sentiments against Ford Stock For period 16.04.2016 to 15.05.2016

For the sake of completion, we move to the result of other media datasets that are associated with this first control case brand (i.e. Ford).

7.1.2 Ford News Correlation

Figure 7.7 presents no correlation (i.e. the values are between 0.25 and -0.25) in the dataset for the whole period of study. While the period just before the scandal was in the news presents no correlation as shown in Figure 7.8.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.072265059	-0.07908335	0.032822359	0.026291051
High	-0.077507271	-0.117644443	0.037121065	0.014991998
Low	-0.063559272	-0.062028276	0.064813043	0.0653008
Close	-0.071082002	-0.101262911	0.046356788	0.033197979
Adj.Close	-0.071082002	-0.101262911	0.046356788	0.033197979
Volume	-0.017588441	-0.10881411	-0.010313875	-0.049245725

Figure 7.7: Correlation Ford News Sentiments against Ford Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.308210964	0.469018366	-0.215847756	-0.246791379
High	-0.414202277	0.230039341	-0.39422114	-0.33385443
Low	-0.091410521	0.274746139	-0.148220102	-0.058445226
Close	-0.266539452	-0.048966521	-0.413069681	-0.296789255
Adj.Close	-0.266539452	-0.048966521	-0.413069681	-0.296789255
Volume	-0.44063874	0.046475986	-0.460340082	-0.422208202

Figure 7.8: Correlation Ford News Sentiments against Ford Stock For period before (i.e. 01.09.2015 to 15.09.2015)

The Ford news sentiment and stock values did not show any real correlation (i.e. the values were mostly between -0.25 and 0.25) across the result during the first month of scandal announcement as seen in Figure 7.9. While the correlation became stronger (i.e. the values were mostly between 0.4 and 0.7) in the second month of news and events of the VW scandal (see Figure 7.10)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.255741379	-0.356316364	0.086266667	0.226686623
High	0.286998453	-0.339409994	0.172081154	0.323317205
Low	0.205472017	-0.422033952	0.050780939	0.23139662
Close	0.126292477	-0.436649553	0.06752493	0.228420999
Adj.Close	0.126292477	-0.436649553	0.06752493	0.228420999
Volume	0.259218609	-0.114625088	0.402602717	0.359143384

Figure 7.9: Correlation Ford News Sentiments against Ford Stock For period 16.03.2016 to 15.04.2016

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.171669625	-0.200479172	0.139170712	0.446488801
High	0.420753904	-0.082038408	0.353499455	0.630058184
Low	0.284549278	-0.104726725	0.206749841	0.552363074
Close	0.530910929	-0.068377979	0.394593879	0.676964533
Adj.Close	0.530910929	-0.068377979	0.394593879	0.676964533
Volume	0.57335703	-0.033399036	0.485453873	0.606340981

Figure 7.10: Correlation Ford News Sentiments against Ford Stock For period 16.04.2016 to 15.05.2016

By the third month, all correlation reduces to insignificant values and continues to reduce to no correlation by the 6th and 7th months as shown in Figure 7.11 and 7.12, respectively.

Seeing that there were no serious changes in correlation at the month the scandal event started, we then wondered if the correlation in the month that follows were really a result of the scandal events i.e. late response to the scandal.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.076721522	-0.082552877	-0.200999972	-0.177720944
High	-0.315183556	-0.34236364	-0.07296418	-0.278581416
Low	0.005090546	0.199932655	0.080637601	0.034793345
Close	0.126931476	0.137957621	0.172832256	0.154172261
Adj.Close	0.126931476	0.137957621	0.172832256	0.154172261
Volume	0.027906194	-0.115176297	-0.202253437	0.069614917

Figure 7.11: Correlation Ford News Sentiments against Ford Stock For period 16.03.2016 to 15.04.2016

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.257950611	0.192649841	0.012260156	0.199032632
High	-0.045579117	-0.128248237	-0.316272875	-0.119922578
Low	0.206127112	0.055213471	-0.157670426	0.124452077
Close	0.084203078	-0.082610982	-0.236094715	-0.011049919
Adj.Close	0.084203078	-0.082610982	-0.236094715	-0.011049919
Volume	-0.508630767	-0.469046903	-0.495110008	-0.541844645

Figure 7.12: Correlation Ford News Sentiments against Ford Stock For period 16.04.2016 to 15.05.2016

7.1.3 Ford Message Board Comment Correlation

In this case also just as we saw in the news and Twitter, there was no overall correlation(i.e. the values were between -0.25 and 0.25) between the Ford message board comment and the stock's value for the period under analysis as shown in Figure 7.13.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.009919757	0.021599052	-0.198718704	-0.066412308
High	-0.02316327	0.027437306	-0.228494469	-0.108861396
Low	0.02000558	0.056411549	-0.183233187	-0.024888914
Close	0.023556155	0.097511973	-0.184940372	-0.048831925
Adj.Close	0.023556155	0.097511973	-0.184940372	-0.048831925
Volume	-0.05765477	0.023337369	-0.134716673	-0.102841347

Figure 7.13: Correlation Ford Message Board Sentiments against Ford Stock for dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.708134752	-0.535049898	-0.119191871	-0.575631263
High	-0.480846021	0.17572008	-0.049977564	-0.200605992
Low	-0.671251082	-0.385734711	0.055924146	-0.390436487
Close	-0.255897469	0.498301434	0.143443325	-0.07239973
Adj.Close	-0.255897469	0.498301434	0.143443325	-0.07239973
Volume	-0.154283042	0.355832493	-0.058028902	-0.104839708

Figure 7.14: Correlation Ford Message Board Sentiments against Ford Stock for period before (i.e. 01.09.2015 to 15.09.2015)

In Figure 7.14 (i.e. before the scandal is in the news), the message board comment sentiments show some weak to strong correlation(i.e. the absolute values are between -0.35 and 0.7) between sentiment and stock High, Open, and Low across most result and SentimentLM presents no correlation with the whole stock values.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.411535222	-0.155757061	-0.058354292	0.113566186
High	0.397632885	-0.096435575	-0.05545384	0.063745248
Low	0.344270189	-0.143574578	-0.184780587	0.051453177
Close	0.302737535	-0.053806936	-0.136893325	0.048352155
Adj.Close	0.302737535	-0.053806936	-0.136893325	0.048352155
Volume	0.199270846	-0.022811647	0.095747843	-0.066530879

Figure 7.15: Correlation Ford Message Board Sentiments against Ford Stock For period 16.09.2015 to 15.10.2015

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.102463248	0.206085342	0.044127146	0.039328384
High	0.009714829	0.270251416	0.251836939	0.34512183
Low	0.156002655	-0.17811117	0.135299884	0.288725796
Close	0.290764669	0.150821277	0.318345609	0.472870252
Adj.Close	0.290764669	0.150821277	0.318345609	0.472870252
Volume	-0.223489183	0.229444222	-0.029696456	-0.256451616

Figure 7.16: Correlation Ford Message Board Sentiments against Ford Stock For period 16.03.2016 to 15.04.2016

The period that followed the scandal announcement (i.e. Figures 7.15 and 7.16) shows mostly no correlation(i.e. the values are mostly between -0.25 and 0.25) and these clearly show that this media sentiment was not being influenced by the events of the VW scandal.

7.1.4 Ford Stocks and Sentiment Correlation Result Summary

There was not any significant influence on Ford's online media sentiment and stock value by the events of the VW scandal. Instead, we saw some periodic random correlation that cannot be explained with VW scandal events because those increases in correlation were not in sync with the events of the VW scandal.

7.2 Ford Stocks and Sentiment Weekly Correlation

Next, we looked at the correlation at a shorter time interval for the immediate effect of the VW scandal on the Ford sentiment and stock values that we probably missed.

7.2.1 Ford Twitter Weekly Correlation

From Appendix I, the highest correlation figures (i.e. mostly between 0.5 and 0.95) were found in the 2nd week (i.e. the week before the major events in the scandal timeline) and thereafter, no strong consistent correlation was exhibited across the dictionaries sentiment in the weeks following.

This result in general is not in sync with the VW scandal and correlation because the correlation did not increase in the week of special events as seen in the same dataset analysis in Volkswagen.

7.2.2 Ford News Weekly Correlation

Appendix J, which contains the result of Ford News Weekly correlation, presents different strong correlations at weeks i.e. 8th, 9th, and 10th week but it should be noted that the 3rd week where the VW event kicked off shows no consistent significant correlation (i.e. mostly results are between -0.25 and 0.25). Therefore, the observed correlation is difficult to ascertain to be affiliated to the VW scandal events.

7.2.3 Ford Message Board Weekly Correlation

In Appendix K, that holds the Ford message board weekly correlation, the first week shows the highest correlation (i.e. mostly between -0.5 and 0.95). While the 3rd and 4th week (i.e. the weeks of major events in the VW timeline) did not show any remarkable change in correlation but presented similar scattered inconsistent correlation as seen across other weeks after.

7.2.4 Ford Stocks and Sentiment Weekly Correlation Result Summary

In summary, the correlation increases and decreases in patterns not in sync with the VW scandal timeline. Therefore, we cannot say for certain if the scattered correlation we saw is influenced by the VW scandal timeline activities.

7.3 Ford Stocks and Sentiment Rolling Correlation

Like we did in Volkswagen datasets, we investigate the direction of the movement of media against sentiment correlation in the Ford company during the heat of the VW emission scandal with the help of Rolling correlation. The green line is volume/sentiment rolling correlation and the rest of the lines are the stock prices/sentiment rolling correlation.

7.3.1 Ford Twitter Rolling Correlation

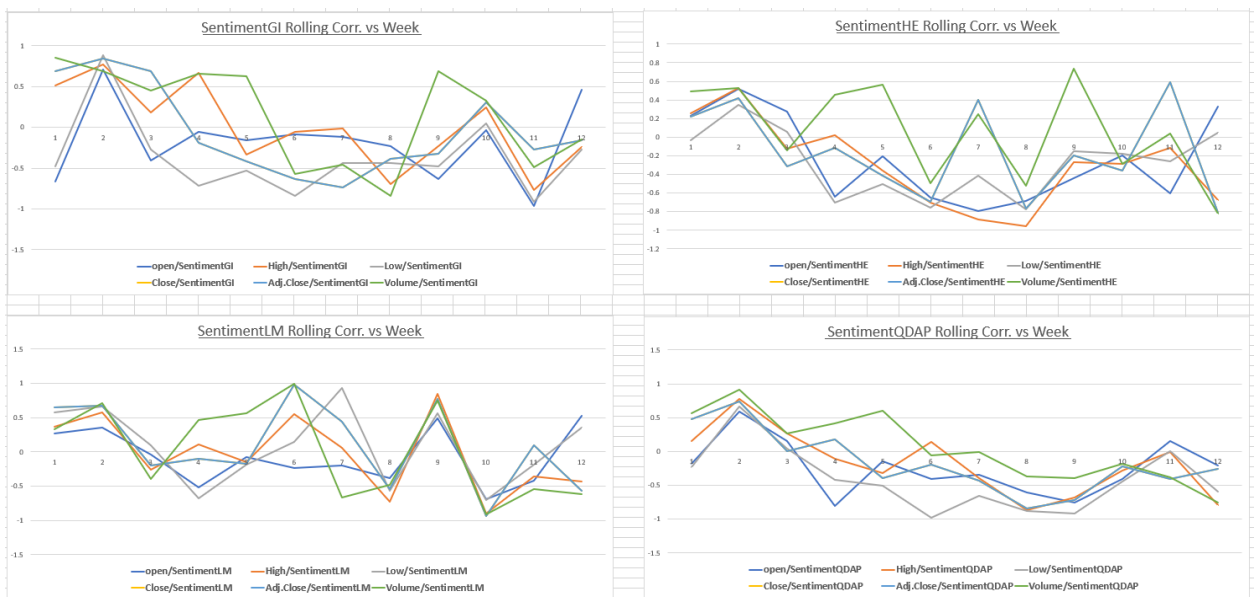


Figure 7.17: Rolling Correlation of Ford Stock VS Ford Twitter Sentiment Weekly Correlation

The Ford Twitter rolling correlation result, in Figure 7.17 presents no clear pattern and seems not to be influenced by anything thing during the scandal timeline. This is evident in the four graphs presentation all being different.

7.3.2 Ford News Rolling Correlation

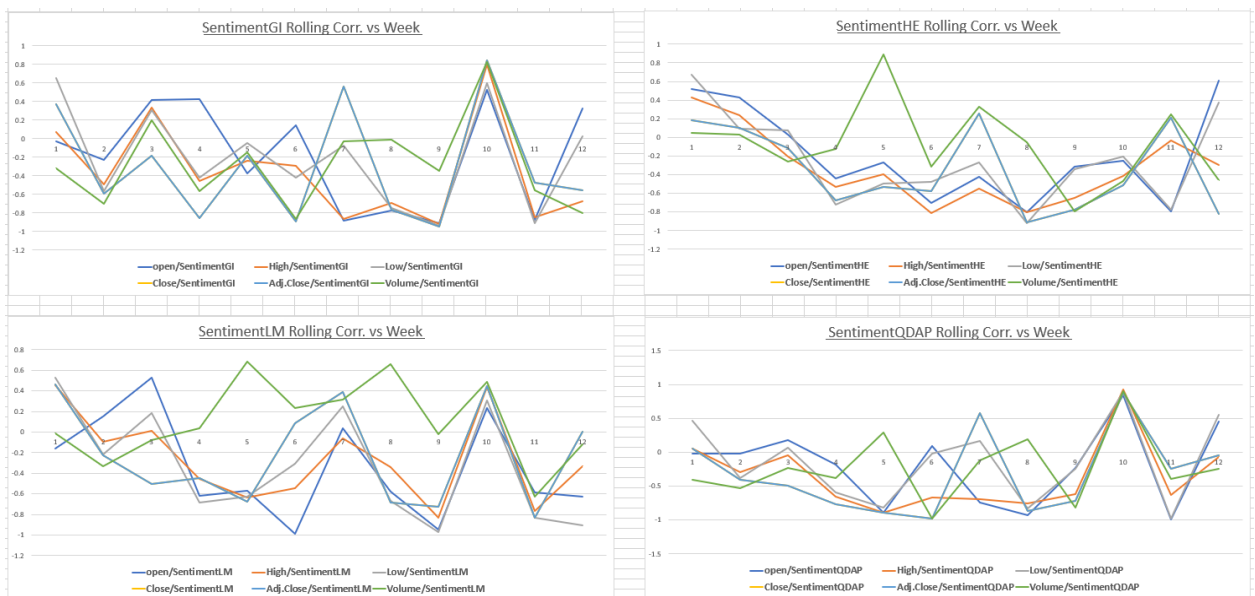


Figure 7.18: Rolling Correlation of Ford Stock VS Ford News Sentiment Weekly Correlation

Similarly, just like Ford Twitter, the Ford news rolling correlation result, in Figure 7.18 presents no clear pattern and seems not to be influenced by anything thing during the scandal timeline.

7.3.3 Ford Message Board Rolling Correlation

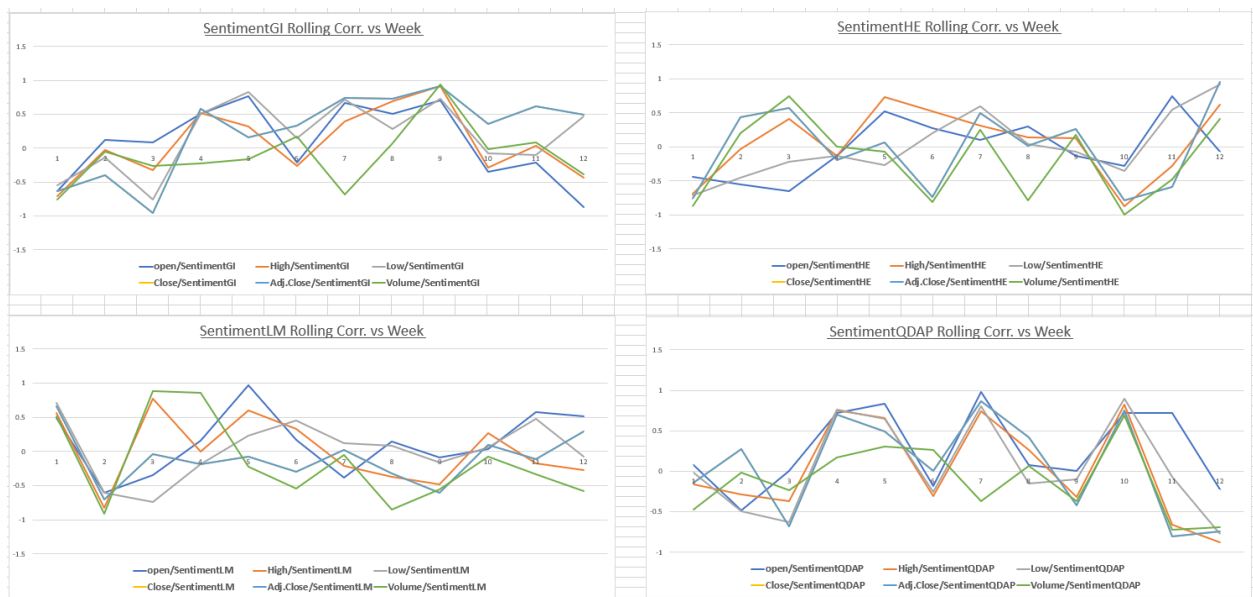


Figure 7.19: Rolling Correlation of Ford Stock VS Ford Message Board Sentiment Weekly Correlation

Figure 7.19 presents the Ford message board rolling correlation result. This result didn't show any clear pattern to the eye between the graph of the sentiment and the stock.

7.3.4 Ford Stocks and Sentiment Rolling Correlation Result Summary

All Ford rolling correlations present no clear pattern as seen in the 3 rolling correlation results that were presented. There was no clear dictator of direction for the Ford stock and sentiment correlation because they were not being influenced by anything during the scandal timeline.

7.4 Ford Stocks and Sentiment Partial Correlation

We computed the partial correlation which helps to investigate if the correlation between a specific sentiment and a specific stock value was caused by some other variable under consideration. We got the results in the following sections.

7.4.1 Ford Twitter Partial Correlation

For the whole dataset period (i.e. 9 months), Figure 7.20 and 7.21, which are the partial correlation and partial correlation P-Value respectively between Ford Twitter sentiment and stock values presents no partial correlation after considering the values that are above zero, less than the real correlation (i.e. in Figure 7.1) and are statistically significant (i.e. with P-Values less than 0.05).

We repeated the computation of the partial correlation for the 3 months period (i.e. period with highest activities in the scandal timeline) and because non of the partial correlation is

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.051166148	-0.093695311	0.705113645	0.060338958	-0.103245627	-0.13129379	0.15172681	0.15172681
SentimentHE	-0.051166148	1	0.371450658	0.085869565	-0.034944726	-0.012062899	0.00116274	0.006327386	0.006327386
SentimentLM	-0.093695311	0.371450658	1	0.249170606	0.026788307	0.023619845	-0.051613703	0.002445547	0.002445547
SentimentQDAP	0.705113645	0.085869565	0.249170606	1	0.00660297	0.024331193	0.029905722	-0.03095837	-0.03095837
Open	0.060338958	-0.034944726	0.026788307	0.00660297	1	0.654058288	0.744048154	-0.470289971	-0.470289971
High	-0.103245627	-0.012062899	0.023619845	0.024331193	0.654058288	1	-0.451061053	0.720560965	0.720560965
Low	-0.13129379	0.00116274	-0.051613703	0.029905722	0.744048154	-0.451061053	1	0.752469489	0.752469489
Close	0.15172681	0.006327386	0.002445547	-0.03095837	-0.470289971	0.720560965	0.752469489	1	-1
Adj.Close	0.15172681	0.006327386	0.002445547	-0.03095837	-0.470289971	0.720560965	0.752469489	-1	1

Figure 7.20: Ford Twitter Sentiment against Ford Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.48795597	0.203366174	2.80471E-29	0.413293286	0.160813504	0.074054248	0.038704729	0.038704729
SentimentHE	0.48795597	0	1.79185E-07	0.243871772	0.63584623	0.870193349	0.987433225	0.931694443	0.931694443
SentimentLM	0.203366174	1.79185E-07	0	0.000604517	0.716645178	0.74896469	0.484153244	0.973572498	0.973572498
SentimentQDAP	2.80471E-29	0.243871772	0.000604517	0	0.928727145	0.741668173	0.6853299	0.674872554	0.674872554
Open	0.413293286	0.63584623	0.716645178	0.928727145	0	4.41773E-24	4.67108E-34	1.26269E-11	1.26269E-11
High	0.160813504	0.870193349	0.74896469	0.741668173	4.41773E-24	0	1.04062E-10	4.45852E-31	4.45852E-31
Low	0.074054248	0.987433225	0.484153244	0.6853299	4.67108E-34	1.04062E-10	0	3.31412E-35	3.31412E-35
Close	0.038704729	0.931694443	0.973572498	0.674872554	1.26269E-11	4.45852E-31	3.31412E-35	0	0
Adj.Close	0.038704729	0.931694443	0.973572498	0.674872554	1.26269E-11	4.45852E-31	3.31412E-35	0	0

Figure 7.21: Ford Twitter Sentiment against Ford Stock Partial Correlation P-Value (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.070693607	-0.13820321	0.757801028	0.03595991	-0.004912778	-0.100481132	0.082732201	0.082732201
SentimentHE	0.070693607	1	0.487271936	0.12326164	-0.017897526	-0.018793338	0.006356947	-0.014020436	-0.014020436
SentimentLM	-0.13820321	0.487271936	1	0.030300275	0.012188721	0.067160705	-0.10085795	0.014471158	0.014471158
SentimentQDAP	0.757801028	0.12326164	0.030300275	1	0.115152269	-0.089550653	-0.100746847	0.110881589	0.110881589
Open	0.03595991	-0.017897526	0.012188721	0.115152269	1	0.755229981	0.817420082	-0.655777808	-0.655777808
High	-0.004912778	-0.018793338	0.067160705	-0.089550653	0.755229981	1	-0.549371374	0.788946742	0.788946742
Low	-0.100481132	0.006356947	-0.10085795	-0.100746847	0.817420082	-0.549371374	1	0.800901938	0.800901938
Close	0.082732201	-0.014020436	0.014471158	0.110881589	-0.655777808	0.788946742	0.800901938	1	-1
Adj.Close	0.082732201	-0.014020436	0.014471158	0.110881589	-0.655777808	0.788946742	0.800901938	-1	1

Figure 7.22: Ford Twitter Sentiment against Ford Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.535851399	0.224504864	6.24756E-16	0.753045655	0.965725466	0.378267295	0.468535992	0.468535992
SentimentHE	0.535851399	0	5.26039E-06	0.279144047	0.87559664	0.869423455	0.955659081	0.902395285	0.902395285
SentimentLM	0.224504864	5.26039E-06	0	0.790945581	0.915096104	0.556473708	0.376472494	0.899273678	0.899273678
SentimentQDAP	6.24756E-16	0.279144047	0.790945581	0	0.312232598	0.432549987	0.377001149	0.330636603	0.330636603
Open	0.753045655	0.87559664	0.915096104	0.312232598	0	8.89627E-16	3.95476E-20	5.41244E-11	5.41244E-11
High	0.965725466	0.869423455	0.556473708	0.432549987	8.89627E-16	0	1.57947E-07	5.90279E-18	5.90279E-18
Low	0.378267295	0.955659081	0.376472494	0.377001149	3.95476E-20	1.57947E-07	0	7.96401E-19	7.96401E-19
Close	0.468535992	0.902395285	0.899273678	0.330636603	5.41244E-11	5.90279E-18	7.96401E-19	0	0
Adj.Close	0.468535992	0.902395285	0.899273678	0.330636603	5.41244E-11	5.90279E-18	7.96401E-19	0	0

Figure 7.23: Ford Twitter Sentiment against Ford Stock Partial Correlation P-Value (3 Months)

statistically significant as seen in the P-Value result Figure 7.23 (i.e. all value greater than 0.05) then we can generally ignore the partial correlation result in Figure 7.22

7.4.2 Ford News Partial Correlation

Similarly, Figures 7.24 and 7.26 presents no partial correlation when compared with their P-Values (i.e Figures 7.25 and 7.27) after considering the partial correlation acceptance rule on the Ford news sentiment and stock values for the 9 months and 3 months period respectively an-

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.026306373	-0.044318154	0.753387327	0.080799302	-0.04338798	-0.144387527	0.065923916	0.065923916
SentimentHE	-0.026306373	1	0.45609377	0.013290494	0.038183111	-0.079974541	0.015887166	-0.024371801	-0.024371801
SentimentLM	-0.044318154	0.45609377	1	0.439136789	-0.042340794	0.066199221	0.000896739	0.003814496	0.003814496
SentimentQDAP	0.753387327	0.013290494	0.439136789	1	-0.082186561	0.023000238	0.15761701	-0.073459723	-0.073459723
Open	0.080799302	0.038183111	-0.042340794	-0.082186561	1	0.653031097	0.744650373	-0.467534162	-0.467534162
High	-0.04338798	-0.079974541	0.066199221	0.023000238	0.653031097	1	-0.439379679	0.711369852	0.711369852
Low	-0.144387527	0.015887166	0.000896739	0.15761701	0.744650373	-0.439379679	1	0.746550239	0.746550239
Close	0.065923916	-0.024371801	0.003814496	-0.073459723	-0.467534162	0.711369852	0.746550239	1	-1
Adj.Close	0.065923916	-0.024371801	0.003814496	-0.073459723	-0.467534162	0.711369852	0.746550239	-1	1

Figure 7.24: Ford News Sentiment against Ford Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.720804328	0.546991718	1.61854E-35	0.271635634	0.555444667	0.048658237	0.370024773	0.370024773
SentimentHE	0.720804328	0	5.38598E-11	0.856733267	0.603876231	0.276574709	0.829135356	0.740573577	0.740573577
SentimentLM	0.546991718	5.38598E-11	0	3.23328E-10	0.565036036	0.368025138	0.990281602	0.958677791	0.958677791
SentimentQDAP	1.61854E-35	0.856733267	3.23328E-10	0	0.263463901	0.754694036	0.031207801	0.317716389	0.317716389
Open	0.271635634	0.603876231	0.565036036	0.263463901	0	4.14605E-24	2.58229E-34	1.51848E-11	1.51848E-11
High	0.555444667	0.276574709	0.368025138	0.754694036	4.14605E-24	0	3.15351E-10	3.7962E-30	3.7962E-30
Low	0.048658237	0.829135356	0.990281602	0.031207801	2.58229E-34	3.15351E-10	0	1.42768E-34	1.42768E-34
Close	0.370024773	0.740573577	0.958677791	0.317716389	1.51848E-11	3.7962E-30	1.42768E-34	0	NA
Adj.Close	0.370024773	0.740573577	0.958677791	0.317716389	1.51848E-11	3.7962E-30	1.42768E-34	0	0

Figure 7.25: Ford News Sentiment against Ford Stock Partial Correlation P-Value (9 Months)

alyzed. The fact that none of the stock values vs news sentiment partial correlation results meet the combination of requirements of being greater than zero, lesser than original correlation(i.e. in Figure 7.7) and being statistically significant(i.e. with lesser than 0.05 P-Values) resulted in the no partial correlation conclusion.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.059575727	-0.256827387	0.812128828	0.118655689	-0.110119431	-0.246155222	0.152499095	0.152499095
SentimentHE	-0.059575727	1	0.226313286	0.182518606	0.001773238	-0.038482752	-0.014658876	-0.046581298	-0.046581298
SentimentLM	-0.256827387	0.226313286	1	0.558817498	0.06073115	0.007684267	-0.15620353	0.083965688	0.083965688
SentimentQDAP	0.812128828	0.182518606	0.558817498	1	-0.208023696	0.18196568	0.322673516	-0.202535057	-0.202535057
Open	0.118655689	0.001773238	0.06073115	-0.208023696	1	0.768416886	0.818859729	-0.654692042	-0.654692042
High	-0.110119431	-0.038482752	0.007684267	0.18196568	0.768416886	1	-0.572178824	0.79608062	0.79608062
Low	-0.246155222	-0.014658876	-0.15620353	0.322673516	0.818859729	-0.572178824	1	0.796532466	0.796532466
Close	0.152499095	-0.046581298	0.083965688	-0.202535057	-0.654692042	0.79608062	0.796532466	1	-1
Adj.Close	0.152499095	-0.046581298	0.083965688	-0.202535057	-0.654692042	0.79608062	0.796532466	-1	1

Figure 7.26: Ford News Sentiment against Ford Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.599623725	0.021465215	6.19492E-20	0.294502992	0.330852597	0.027735016	0.176874999	0.176874999
SentimentHE	0.599623725	0	0.04352657	0.105136462	0.987544956	0.734678609	0.897313054	0.68158486	0.68158486
SentimentLM	0.021465215	0.04352657	0	7.16333E-08	0.592552235	0.946064695	0.166466305	0.458995923	0.458995923
SentimentQDAP	6.19492E-20	0.105136462	7.16333E-08	0	0.064076204	0.106212548	0.00350964	0.071586234	0.071586234
Open	0.294502992	0.987544956	0.592552235	0.064076204	0	8.80207E-17	1.71166E-20	4.48256E-11	4.48256E-11
High	0.330852597	0.734678609	0.946064695	0.106212548	8.80207E-17	0	2.94608E-08	1.09156E-18	1.09156E-18
Low	0.027735016	0.897313054	0.166466305	0.00350964	1.71166E-20	2.94608E-08	0	1.01042E-18	1.01042E-18
Close	0.176874999	0.68158486	0.458995923	0.071586234	4.48256E-11	1.09156E-18	1.01042E-18	0	NA
Adj.Close	0.176874999	0.68158486	0.458995923	0.071586234	4.48256E-11	1.09156E-18	1.01042E-18	0	0

Figure 7.27: Ford News Sentiment against Ford Stock Partial Correlation P-Value (3 Months)

7.4.3 Ford Message Board Partial Rolling Correlation

Finally, Figures 7.28 and 7.30 just like in Twitter and news, presented no partial correlation when compared with their P-Values (i.e Figures 7.29 and 7.31) after considering the statistically significance(i.e only result with corresponding P-Values of less than 0.05 is accepted), lesser partial correlation values than real correlation(i.e. in Figure 7.13) and partial correlation value that are greater than zero.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.087207482	-0.160437503	0.590570115	0.008944867	-0.010353722	-0.044001678	0.050843841	0.050843841
SentimentHE	0.087207482	1	0.299250254	-0.093320632	-0.018072853	-0.112518636	-0.027652423	0.17329446	0.17329446
SentimentLM	-0.160437503	0.299250254	1	0.612227597	0.041382618	-0.024323638	-0.078328971	0.001098025	0.001098025
SentimentQDAP	0.590570115	-0.093320632	0.612227597	1	-0.055739036	-0.051906182	0.11898527	-0.013389781	-0.013389781
Open	0.008944867	-0.018072853	0.041382618	-0.055739036	1	0.454230445	0.763279197	-0.331940096	-0.331940096
High	-0.010353722	-0.112518636	-0.024323638	-0.051906182	0.454230445	1	-0.308862574	0.736698064	0.736698064
Low	-0.044001678	-0.027652423	-0.078328971	0.11898527	0.763279197	-0.308862574	1	0.627124998	0.627124998
Close	0.050843841	0.17329446	0.001098025	-0.013389781	-0.331940096	0.736698064	0.627124998	1	-1
Adj.Close	0.050843841	0.17329446	0.001098025	-0.013389781	-0.331940096	0.736698064	0.627124998	-1	1

Figure 7.28: Ford Message Board Sentiment against Ford Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.237856806	0.029142977	8.93473E-19	0.903816862	0.888758683	0.552031174	0.491888351	0.491888351
SentimentHE	0.237856806	0	3.5053E-05	0.206426163	0.807098229	0.127285905	0.708675263	0.018326235	0.018326235
SentimentLM	0.029142977	3.5053E-05	0	2.05908E-20	0.575964429	0.742425156	0.289236802	0.988164985	0.988164985
SentimentQDAP	8.93473E-19	0.206426163	2.05908E-20	0	0.451101196	0.482873487	0.106713796	0.856450437	0.856450437
Open	0.903816862	0.807098229	0.575964429	0.451101196	0	8.34698E-11	1.46819E-36	3.91535E-06	3.91535E-06
High	0.888758683	0.127285905	0.742425156	0.482873487	8.34698E-11	0	1.88946E-05	6.415E-33	6.415E-33
Low	0.552031174	0.708675263	0.289236802	0.106713796	1.46819E-36	1.88946E-05	0	1.295E-21	1.295E-21
Close	0.491888351	0.018326235	0.988164985	0.856450437	3.91535E-06	6.415E-33	1.295E-21	0	0
Adj.Close	0.491888351	0.018326235	0.988164985	0.856450437	3.91535E-06	6.415E-33	1.295E-21	0	0

Figure 7.29: Ford Message Board Sentiment against Ford Stock Partial Correlation P-Value (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.0565629	-0.03055803	0.616163303	-0.044152174	0.003035018	-0.011031731	0.080952557	0.080952557
SentimentHE	0.0565629	1	0.437023029	-0.025134323	-0.14566558	-0.089597147	0.066647003	0.175803878	0.175803878
SentimentLM	-0.03055803	0.437023029	1	0.363796038	0.111015905	0.008412133	-0.10839836	-0.069146361	-0.069146361
SentimentQDAP	0.616163303	-0.025134323	0.363796038	1	0.074011821	-0.048203513	-0.001568964	-0.018560413	-0.018560413
Open	-0.044152174	-0.14566558	0.111015905	0.074011821	1	0.522273363	0.832644137	-0.450128295	-0.450128295
High	0.003035018	-0.089597147	0.008412133	-0.048203513	0.522273363	1	-0.369166578	0.79839843	0.79839843
Low	-0.011031731	0.066647003	-0.10839836	-0.001568964	0.832644137	-0.369166578	1	0.619641887	0.619641887
Close	0.080952557	0.175803878	-0.069146361	-0.018560413	-0.450128295	0.79839843	0.619641887	1	-1
Adj.Close	0.080952557	0.175803878	-0.069146361	-0.018560413	-0.450128295	0.79839843	0.619641887	-1	1

Figure 7.30: Ford Message Board Sentiment against Ford Stock Partial Correlation (3 Months)

Absence of result value matching these criteria in partial correlation result between Ford stock values any Message Board sentiment for the 3 months period dataset resulted in the no partial correlation for this dataset.

7.4.4 Ford Stocks and Sentiment Partial Correlation Result Summary

In summary, all the correlation we saw in our previous Ford analysis must have been a direct correlation since we could not get the partial correlation that would prove that the real correlation values were caused by some other variables in the dataset.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.622805014	0.790558092	1.91311E-09	0.701102177	0.978960752	0.923632165	0.481078965	0.481078965
SentimentHE	0.622805014	0	6.32117E-05	0.827093378	0.203190995	0.435334528	0.562081603	0.123655926	0.123655926
SentimentLM	0.790558092	6.32117E-05	0	0.001060203	0.33322847	0.941729933	0.344822607	0.547476894	0.547476894
SentimentQDAP	1.91311E-09	0.827093378	0.001060203	0	0.51958484	0.675148644	0.989122777	0.871866203	0.871866203
Open	0.701102177	0.203190995	0.33322847	0.51958484	0	9.375E-07	3.40832E-21	3.55167E-05	3.55167E-05
High	0.978960752	0.435334528	0.941729933	0.675148644	9.375E-07	0	0.000880802	2.04741E-18	2.04741E-18
Low	0.923632165	0.562081603	0.344822607	0.989122777	3.40832E-21	0.000880802	0	1.46111E-09	1.46111E-09
Close	0.481078965	0.123655926	0.547476894	0.871866203	3.55167E-05	2.04741E-18	1.46111E-09	0	0
Adj.Close	0.481078965	0.123655926	0.547476894	0.871866203	3.55167E-05	2.04741E-18	1.46111E-09	NA	0

Figure 7.31: Ford Message Board Sentiment against Ford Stock Partial Correlation P-Value (3 Months)

7.5 Ford Stocks and Sentiments Trends

We superimposed the different scaled graphs of stock volume, stock price, and media sentiment against the date for better analysis.

In all cases, as we had in VW trend analysis, the sentiment is the red line, and the volume is the deep blue line. The other colors are the stock prices (i.e. the high, low, close, open, and Adjusted close), and as we must have noticed those prices were very close in value and move in a similar direction with little variations. While the vertical lines were special days of announcement and event in the VW scandal timeline.

7.5.1 Ford Twitter Trend

Figures 7.32 and 7.33 presents the trend line of the Ford stock volume, stock prices, and the Ford Twitter sentiment. Although the sentiment line kind of flowed like the price of the stock but there seems not to be a clear trend between them. Also, the vertical markers are not point of triggering flow change as seen in VW stocks and sentiment trend lines.

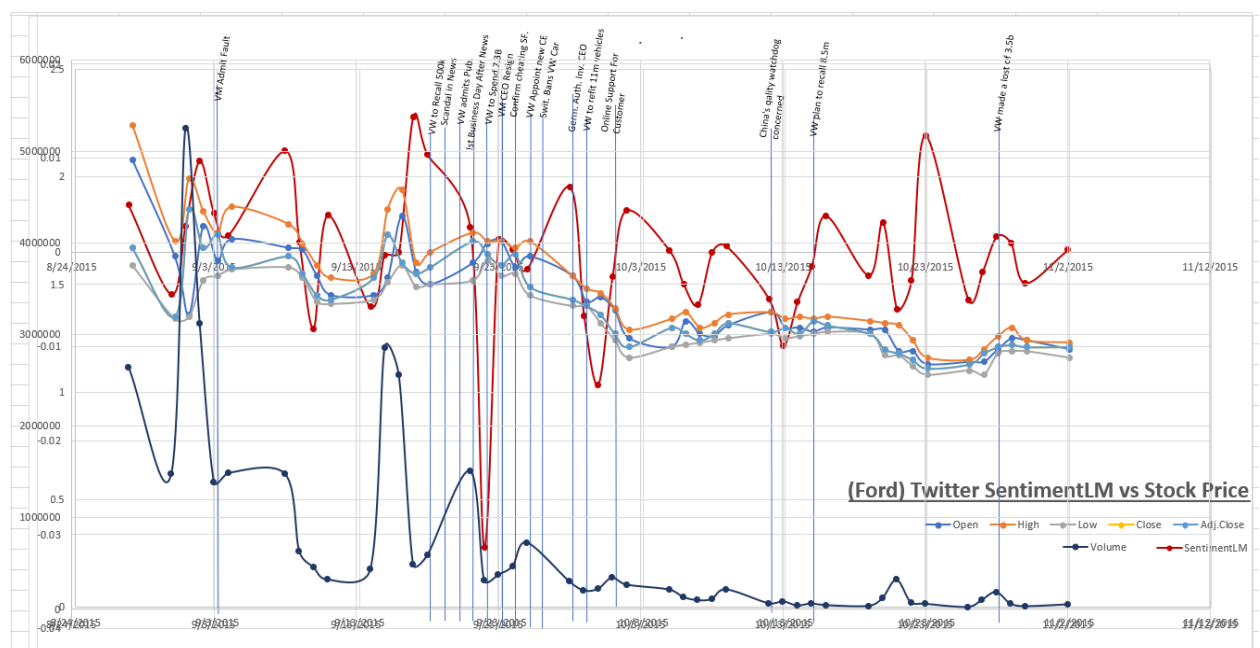


Figure 7.32: Ford Twitter SentimentLM vs Ford Stock Values

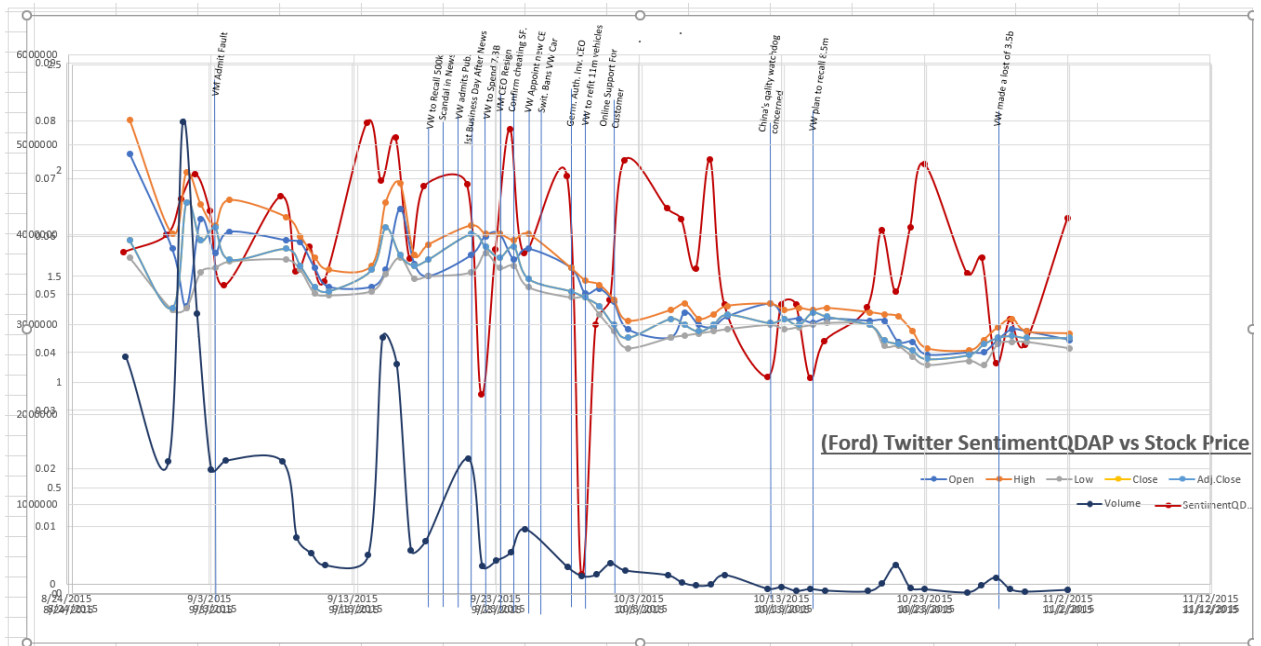


Figure 7.33: Ford Twitter SentimentQDAP vs Ford Stock Values

7.5.2 Ford News Trend

Figures 7.34 and 7.35 just as we saw in Ford Twitter trend analysis, presents not a clear relationship between the Ford news sentiment line and stock values lines. Also, like the Ford Twitter trend, the vertical markers were not the point of triggering consistent flow change as seen in VW stocks and sentiment trend lines.

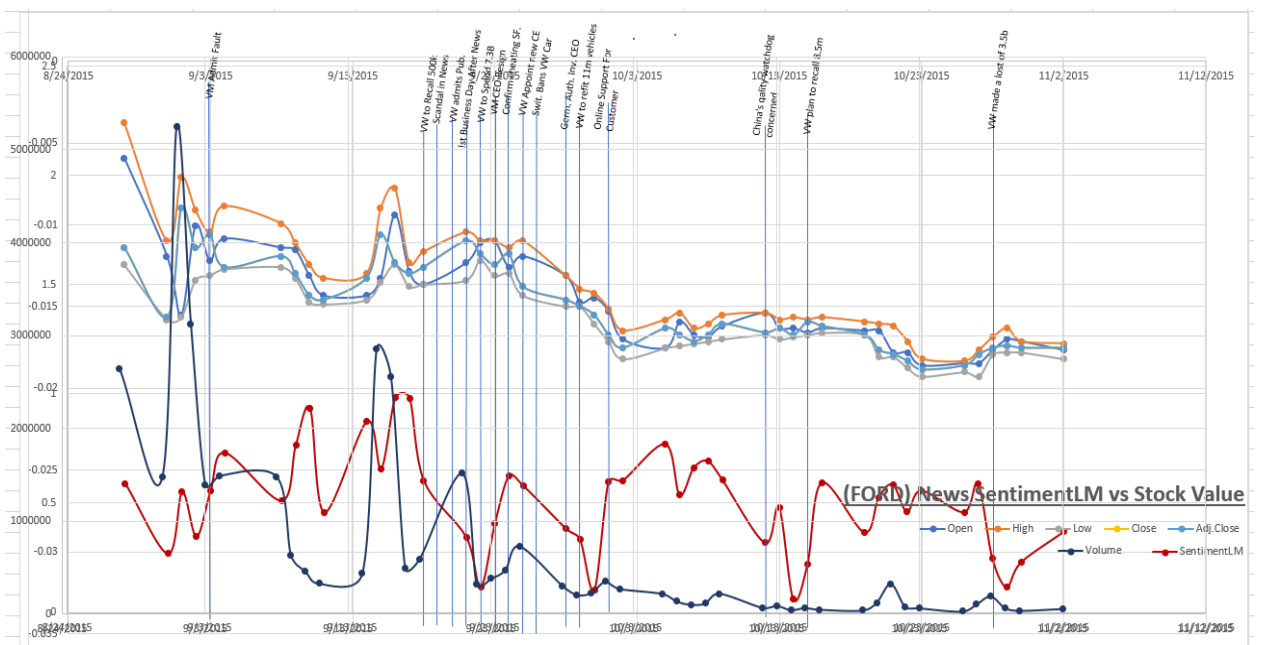


Figure 7.34: Ford News SentimentLM vs Ford Stock Values

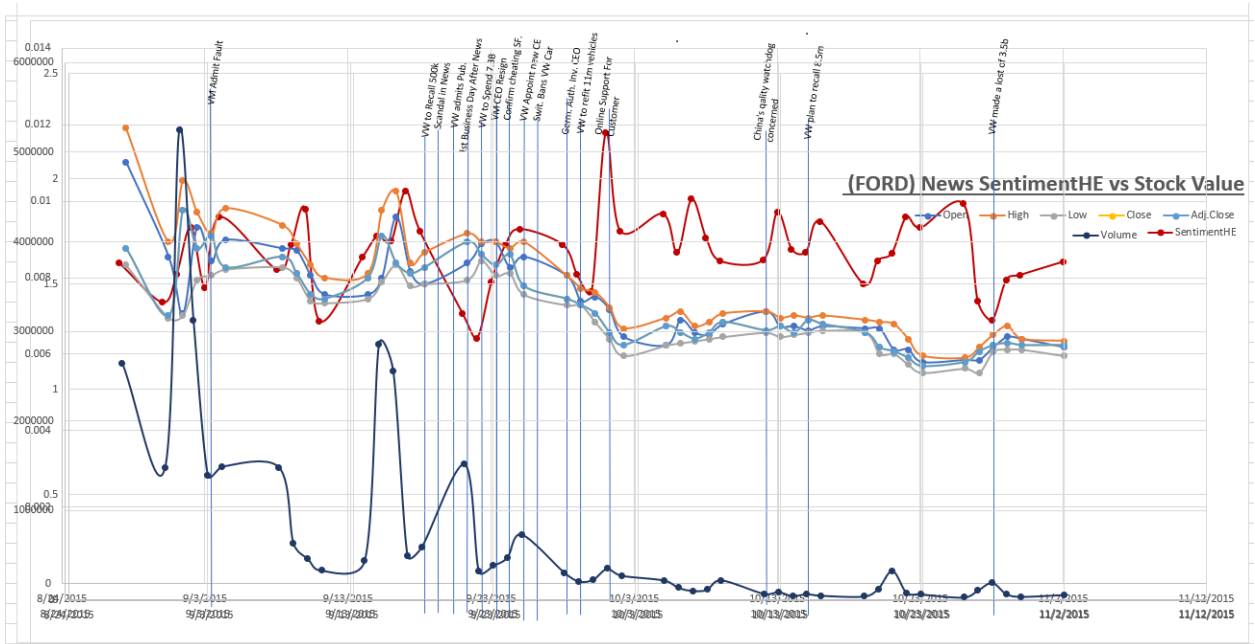


Figure 7.35: Ford News SentimentHE vs Ford Stock Values

7.5.3 Ford Message Board Comment Trend

Unlike the Twitter and News trend graph, there was no consistent clear pattern between the stock price, stock volume, and sentiment trend line during the period under investigation for the Ford message board comment sentiment against date as seen in Figures 7.36 and 7.37.

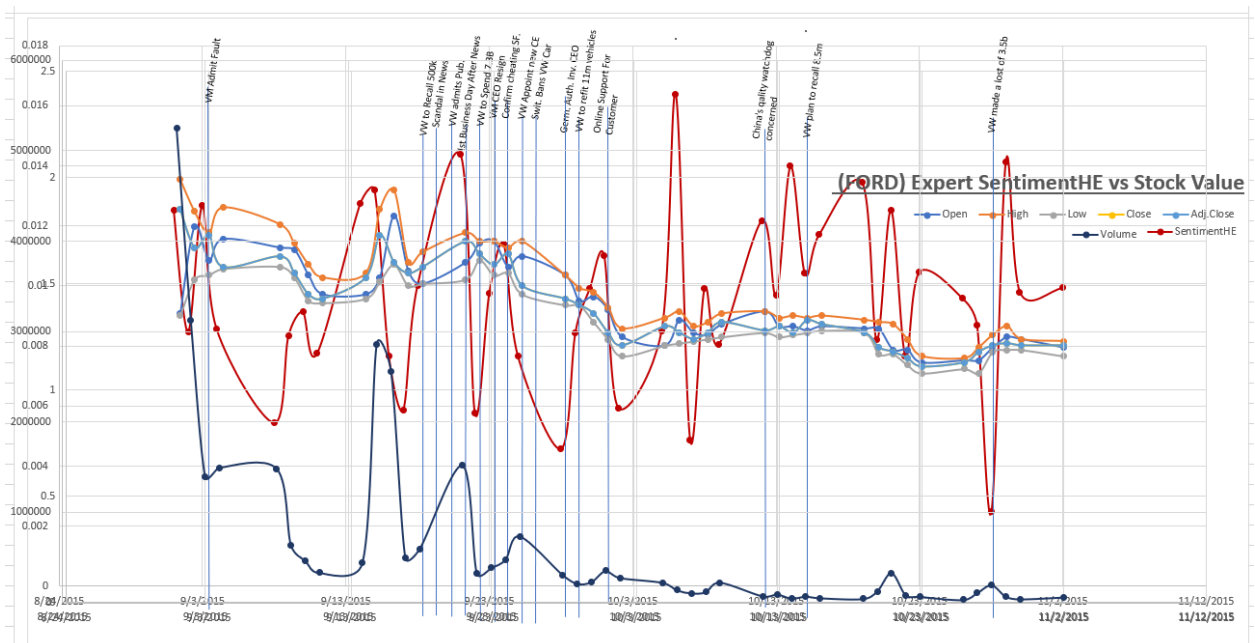


Figure 7.36: Ford Message Board SentimentHE vs Ford Stock Values

Also, the vertical markers were also not points of changing the trend direction, unlike the VW trend lines.

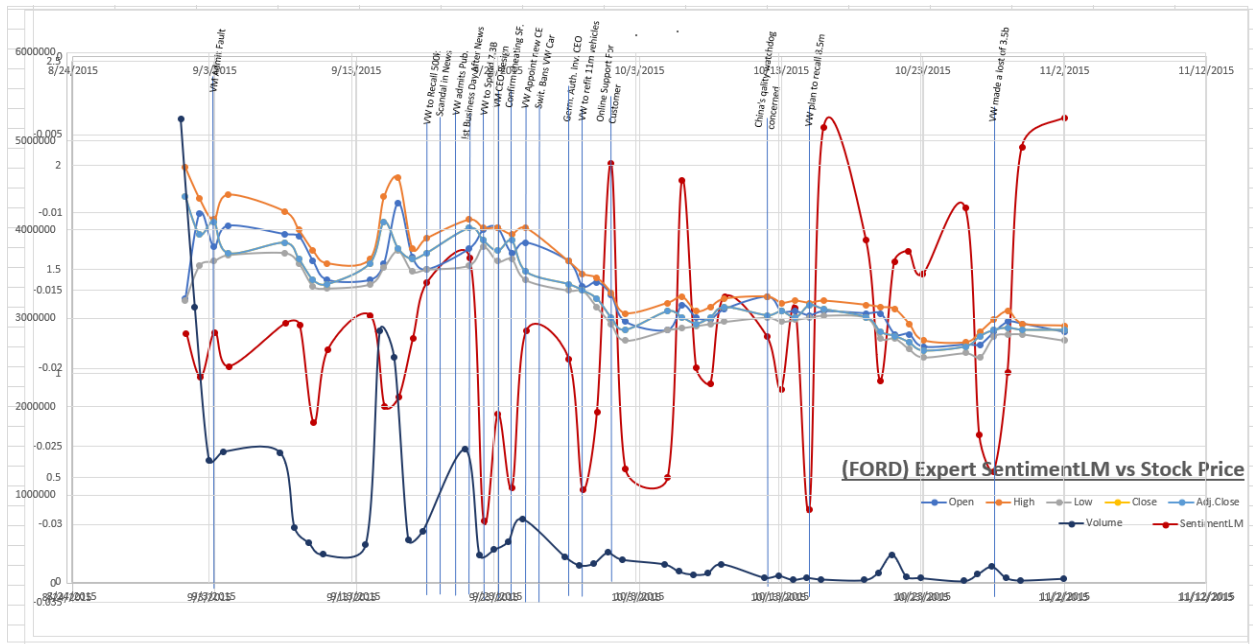


Figure 7.37: Ford Message Board SentimentLM vs Ford Stock Values

7.5.4 Ford Stocks and Sentiment Trend Result Summary

The Ford stocks and sentiment trend line did not show flow/pattern matching and seem not to be influenced by the events of the VW scandal.

We started speculating from the result so far that, if the company is not in crises the public sentiment is not a measure of their reputation as seen from correlation and trend analysis

We moved to further analysis of our Ford dataset to see if our speculation holds water.

7.6 Ford Stocks and Sentiments Granger Causality Test Analysis

We believe our eyes must have missed some things in the correlation and trend analysis. Therefore, we carried out 288 Granger causality tests on each of our Ford media datasets. This allowed us to investigate causation between stock and sentiment during the scandal period.

7.6.1 Ford Twitter Granger Causality Test

The whole table of our Granger tests (i.e. 48 lines) mostly shows acceptance of the null hypothesis except the few scattered rejection listed which indicated causality as seen in Appendix L 9 months result. This Ford Twitter result presents far lesser causality when compared with the 9-month Twitter result of the VW brand.

This supported our observation of no significant correlation and trend pattern from the previous analysis.

While the 3-month dataset produced a mixed result showing the stock causing the sentiment and vice versa as seen in Appendix L 3-months result.

7.6.2 Ford News Granger Causality Test

Just like we saw in the Ford Twitter Granger test above, the whole table of our Granger test (i.e. 48 lines) shows acceptance of the null hypothesis except the single line as seen in Appendix M 9-months result. Remember rejection of the null hypothesis means causality.

This supported our earlier observation of no significant correlation and trend pattern from the previous analysis.

We repeated the test with the 3 months period dataset and got the result in Appendix M 3-months result. This result shows a bit more causality (i.e. more rejection).

7.6.3 Ford Message Board Comment Granger Causality Test

Like in news and Twitter, we saw a table of results filled with acceptance of the null hypothesis except for the 4 rows in Appendix N 9-months result. This result for the whole dataset (i.e. 9 months period) presented the stock values showing the causality of SentimentHE.

The 3 months period (i.e. Appendix N 3-months result) result showed some more lines of causality. Is as good as the VW message board 3 months dataset result.

7.6.4 Ford Stocks and Sentiment Granger Test Result Summary

The result shows Ford dataset presents poor causality (i.e. fewer lines than expected) between the media sentiment and stock value for the 9-month period result when compared to VW dataset results.

We decided to move on to the word cloud result for further dataset analysis.

7.7 Ford Online Media Feed Word Cloud

We then took a glimpse at the words used in the Ford media sources analyzed in this chapter with the help of the word cloud.

We generated the word cloud for the text postings from different media sources used in the Ford dataset we have been analyzing. This we did for the 3 months and 9 months dataset for each media source.

7.7.1 Ford Twitter Word Cloud

Figures 7.38 and 7.39 shows the word cloud of the VW tweets for the 9 months and 3 months period, respectively. We saw that apart from the word *ford* that was at the center of the discussion, no other words came close to it at that time.

This further supports the result that we have been seeing, of out of sync correlation, no clear pattern in rolling correlation, and trendlines insensitive to the scandal events. The discussions in Ford related tweets at that time were not related or being influenced by the VW scandal timeline news/events.

8 Toyota Result Analysis

We analyzed a different brand (i.e. another control case) that manufactured cars like VW and Ford. This will help to understand more the effect of the scandal on related companies.

8.1 Toyota Stocks and Sentiments Correlation

Using Toyota's reputation (i.e. stock value and Online media sentiment), we analyzed their correlation and saw how they were influenced by the VW scandal period.

8.1.1 Toyota Twitter Correlation

Just like we saw in Ford, in Figure 8.1 Toyota presents no correlation (i.e. all values between -0.25 and 0.25) over the whole period under consideration.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	2.67588E-05	0.015595943	0.101206545	0.113045097
High	0.000547886	0.015842369	0.103734947	0.114154567
Low	0.005025296	0.025983367	0.096761646	0.122024593
Close	0.003425947	0.018890079	0.095313539	0.117246328
Adj.Close	0.006220844	0.029576081	0.093133355	0.119674186
Volume	-0.042122419	-0.15378612	-0.065142904	-0.11671465

Figure 8.1: Correlation Toyota Twitter Sentiments against Stock
For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.389602418	0.427277053	0.448902497	0.145426208
High	0.410786511	0.458494107	0.454917113	0.101812308
Low	0.404164931	0.424410981	0.382413411	0.106324752
Close	0.406927237	0.486769466	0.389071025	0.039519905
Adj.Close	0.406926962	0.486769996	0.389071071	0.039519837
Volume	0.158357084	0.196200972	0.383381601	0.067382883

Figure 8.2: Correlation Toyota Twitter Sentiments against Stock
For the period before (i.e. 01.09.2015 to 15.09.20)

While in Figure 8.2, there was a consistent weak correlation (i.e. all values between 0.25 and 0.5 or -0.25 and -0.5) across SentimentGI, SentimentHE, and SentimentLM for the period before the scandal was in the news from Toyota Twitter feeds and stock values. This correlation continued in the first month after the announcement and reduced in the second month as seen in Figures 8.3 and 8.4.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.458608893	0.292689351	-0.103837291	-0.429203712
High	-0.426406745	0.296721059	-0.102797367	-0.406434406
Low	-0.417087905	0.318762183	-0.092846878	-0.395195376
Close	-0.42196573	0.245426368	-0.17880717	-0.42783149
Adj.Close	-0.410334591	0.15227405	-0.243352053	-0.456336707
Volume	0.071547257	0.151622445	-0.1787374	-0.005919812

Figure 8.3: Correlation Toyota Twitter Sentiments against Stock
For period 16.09.2015 to 15.10.2015

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.239675867	0.178826231	0.027889286	-0.224582524
High	-0.264515606	0.068786551	-0.034311076	-0.333594467
Low	-0.255482	0.138767045	0.006146516	-0.302443093
Close	-0.311625903	0.067248685	-0.046188314	-0.322702546
Adj.Close	-0.311625947	0.067248836	-0.046190234	-0.322703772
Volume	0.003646704	0.39638414	0.135646863	-0.140845649

Figure 8.4: Correlation Toyota Twitter Sentiments against Stock
For period 16.10.2015 to 15.11.2015

The months after the scandal period were months of high and low in correlation which were not in sync with the activities of the VW emission scandal as seen in Figures 8.5 and 8.6.

Therefore, we can assume that the correlation observed seems to be caused by some other activities during that period.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.240321698	0.101211888	0.144757578	-0.134954061
High	-0.254877812	0.137860467	0.15356547	-0.10884476
Low	-0.285058726	0.126756799	0.134150267	-0.151577302
Close	-0.274640168	0.131810711	0.125270261	-0.126514898
Adj.Close	-0.370760899	0.1361883	0.027892685	-0.27095332
Volume	-0.015548842	0.010455391	-0.188234497	-0.006762349

Figure 8.5: Correlation Toyota Twitter Sentiments against Stock For period 16.09.2015 to 15.10.2015

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.080330653	-0.228838016	-0.135983838	-0.249730364
High	-0.060760482	-0.257565408	-0.15133502	-0.211156833
Low	-0.064046766	-0.142731089	-0.169197226	-0.230195171
Close	-0.034804583	-0.139775649	-0.147112108	-0.225475203
Adj.Close	-0.034803937	-0.139775631	-0.147111301	-0.225474712
Volume	-0.043291498	-0.346841177	0.076774227	0.110329686

Figure 8.6: Correlation Toyota Twitter Sentiments against Stock For period 16.10.2015 to 15.11.2015

8.1.2 Toyota News Correlation

Figures 8.7 shows news sentiment presenting no overall correlation(i.e. all values were between -0.25 and 0.25) for the whole period of study and we saw it presenting an overall no correlation(i.e. most values between -0.25 and 0.25) between the stock values and the sentiment before the scandal was in the news (i.e. Figure 8.8).

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.057036877	-0.053569689	-0.140693113	-0.09014054
High	-0.06004268	-0.0626315	-0.147747004	-0.099791043
Low	-0.068179973	-0.051972571	-0.146133147	-0.099936506
Close	-0.060160879	-0.057664124	-0.147606916	-0.097983415
Adj.Close	-0.058667032	-0.041346994	-0.141776833	-0.114766897
Volume	0.201249602	0.012629861	0.217658213	0.227153107

Figure 8.7: Correlation Toyota News Sentiments against Toyota Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.170935038	-0.153157494	0.139056503	0.524840666
High	0.149314704	-0.134211509	0.072837881	0.44296475
Low	0.141625037	-0.061713755	-0.072245918	0.359587923
Close	0.107279514	-0.065588668	-0.174198569	0.223386749
Adj.Close	0.107280202	-0.065589141	-0.174198078	0.2233881
Volume	0.114022642	-0.198426692	0.409579185	0.586135533

Figure 8.8: Correlation Toyota News Sentiments against Toyota Stock For period before (i.e. 01.09.2015 to 15.09.2015)

The highest correlation occurred at this period is shown in Figure 8.9 (i.e. year-end) and the values were between 0.5 and 0.8 or -0.5 and -0.8 making that a strong correlation. The new year shows no correlation for the rest of the period seen in Figure 8.10. The Toyota correlation seems to be influenced by more things than the VW scandal because the correlation changes were not in sync with the events of the scandal just as we saw in the Toyota Twitter correlation.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.616870463	-0.270320107	-0.730360739	-0.710335295
High	-0.628989396	-0.299850306	-0.734793535	-0.717314246
Low	-0.625953156	-0.286714713	-0.721602781	-0.708962739
Close	-0.594002441	-0.273715192	-0.700335362	-0.682283563
Adj.Close	-0.594002155	-0.27371496	-0.700335105	-0.682283256
Volume	0.527471388	0.090199333	0.528585145	0.576755358

Figure 8.9: Correlation Toyota News Sentiments against Stock For period 16.12.2015 to 15.01.16

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.182423587	0.328423782	-0.204291219	-0.10480245
High	0.140602862	0.34666498	-0.222263376	-0.143774787
Low	0.092466786	0.307181254	-0.277682917	-0.189683833
Close	0.132546556	0.30915692	-0.264673865	-0.13949489
Adj.Close	0.132546186	0.3091563	-0.264674201	-0.13949525
Volume	0.332924363	-0.047989718	0.312094832	0.449596175

Figure 8.10: Correlation Toyota News Sentiments against Stock For period 16.01.2016 to 15.02.2016

8.1.3 Toyota Message Board Comment Correlation

There was no overall correlation(i.e. most values were between -0.25 and 0.25) between the message board comment and the stock's values when we consider the data for the whole period under analysis as shown in Figure 8.11.

In Figure 8.12, the message board comment sentiments present mostly a weak correlation (i.e. most values between 0.25 and 0.5) with stocks during the period before the scandal publication.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.055772299	0.090035865	-0.215848635	-0.166630931
High	-0.055676392	0.093405767	-0.215672314	-0.163713996
Low	-0.062024704	0.082035833	-0.215969584	-0.166395627
Close	-0.061070702	0.086172877	-0.215210652	-0.165131003
Adj.Close	-0.087227537	0.055607697	-0.199589661	-0.179386765
Volume	-0.023454745	0.054742683	0.022817713	0.039173326

Figure 8.11: Correlation Toyota Message Sentiments against Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.029296938	-0.317409148	-0.641128938	0.279087994
High	0.073358482	-0.341124058	-0.60566069	0.365040451
Low	0.085178084	-0.386557183	-0.569317838	0.454133144
Close	0.050588354	-0.295721788	-0.439780582	0.461016374
Adj.Close	0.050587275	-0.295719991	-0.439780955	0.461017009
Volume	-0.421336188	0.434848218	-0.253401788	-0.053014237

Figure 8.12: Correlation Toyota Message Sentiments against Stock For period before (i.e. 01.09.2015 to 15.09.2015)

While Figure 8.13 shows the period after scandal publication which presents a reduction in correlation strength and further reduction to the 2015-year end. The 2016 beginning did not show correlation either until the second quarter of the year as seen in Figure 8.14.

The correlation pattern is out of sync with the activities of the VW scandal from our results.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.112096104	-0.349324024	-0.048491499	0.333845817
High	0.151814162	-0.330781861	-0.06791451	0.375605509
Low	0.22983478	-0.338057881	-0.004914444	0.444358835
Close	0.238650107	-0.352513314	-0.052482118	0.444910876
Adj.Close	0.17024707	-0.324575934	-0.104030058	0.407939123
Volume	-0.054337642	-0.157912504	-0.287196394	-0.182448956

Figure 8.13: Correlation Toyota Message Sentiments against Stock For period 16.09.2015 to 15.10.15

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.198899554	0.31961499	0.178237759	0.275977279
High	0.156668804	0.325617987	0.133558833	0.231461028
Low	0.198912078	0.324337979	0.174351472	0.269519287
Close	0.149323341	0.331890511	0.13577604	0.21718263
Adj.Close	0.079732681	0.165082388	0.203233694	0.134951806
Volume	-0.140449402	-0.100440878	-0.147253321	-0.205790423

Figure 8.14: Correlation Toyota Message Sentiments against Stock For period 16.03.2016 to 15.04.2016

8.1.4 Toyota Stocks and Sentiment Correlation Result Summary

The result shows that the Toyota brand from a correlation result point of view is not being influenced by the event and news of the VW scandal period. Instead, we saw a period of correlation that was random and cannot be explained with the VW scandal.

8.2 Toyota Stocks and Sentiment Weekly Correlation

Like we did in other brands we then reviewed correlation in shorter time intervals (i.e. one-week interval).

8.2.1 Toyota Twitter Weekly Correlation

From Appendix O, as we saw in VW, presents correlation in the 3rd and 4th week which were the period the events of the VW scandal started. This correlation was sustained even till the 5th week and followed by weeks of scattered strong correlation.

It will be difficult to associate this correlation in Toyota results here to the VW scandal since it started the first week of analyses which was weeks before the events of the VW scandal were in the news.

8.2.2 Toyota News Weekly Correlation

Appendix P, as seen in Toyota Twitter result, the Toyota News result started to show strong consistent correlation(i.e. values were mostly between 0.5 and 0.75 or -0.5 and -0.75) in the 3rd week and weak correlation(i.e. values were mostly between 0.25 and 0.5 or -0.25 and -0.5) in 4th week of analysis just as it was in VW Twitter dataset. This correlation is sustained in the 5th week and we continue to see scattered strong correlation all along the weeks that followed.

8.2.3 Toyota Message Board Weekly Correlation

From Appendix Q, the highest correlation figures were found in the 2nd week (i.e. the week before the major events in the scandal timeline), and thereafter no strong consistent correlation was exhibited across the sentiment dictionaries for the weeks that followed.

8.2.4 Toyota Stocks and Sentiment Weekly Correlation Result Summary

In summary, the correlation increases, and decreases seem not to be in sync with the VW scandal timeline therefore we cannot say for certain if the correlation we saw is actually influenced by it.

8.3 Toyota Stocks and Sentiment Rolling Correlation

Just like we did in VW and Ford, we plotted the direction of the movement of correlation with the rolling correlation graph.

8.3.1 Toyota Twitter Rolling Correlation

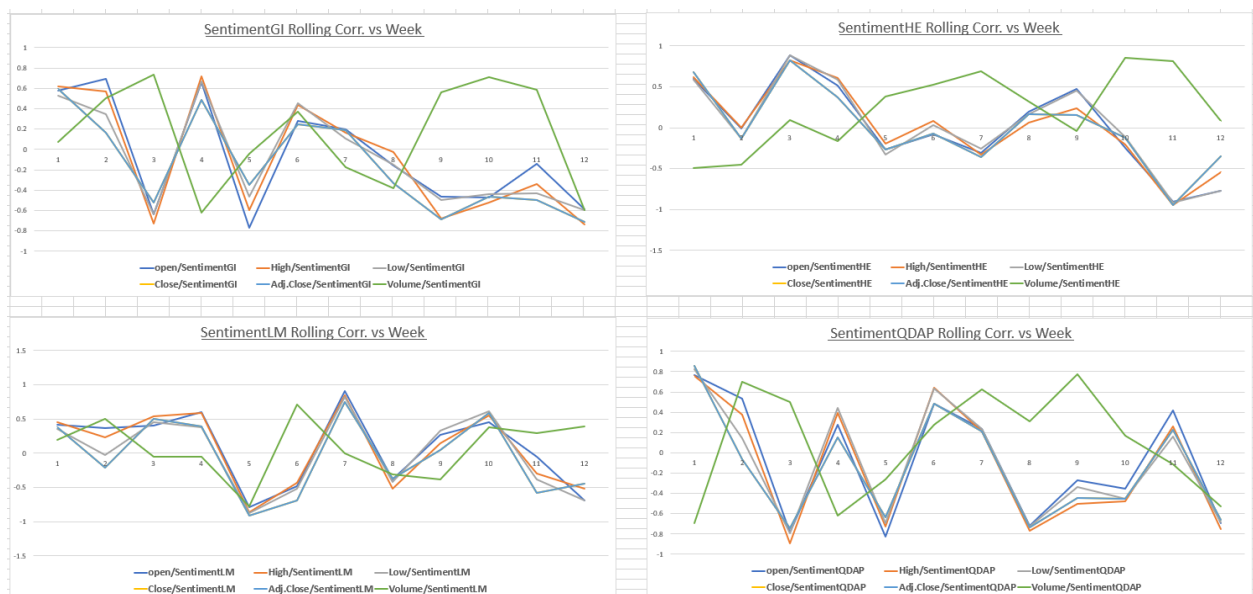


Figure 8.15: Toyota Twitter Sentiment against Toyota Stock Rolling Correlation

The Toyota Twitter rolling correlation result, in Figure 8.15 presents no clear pattern especially when compared with the scandal timeline. This indication is not being controlled by it.

8.3.2 Toyota News Rolling Correlation

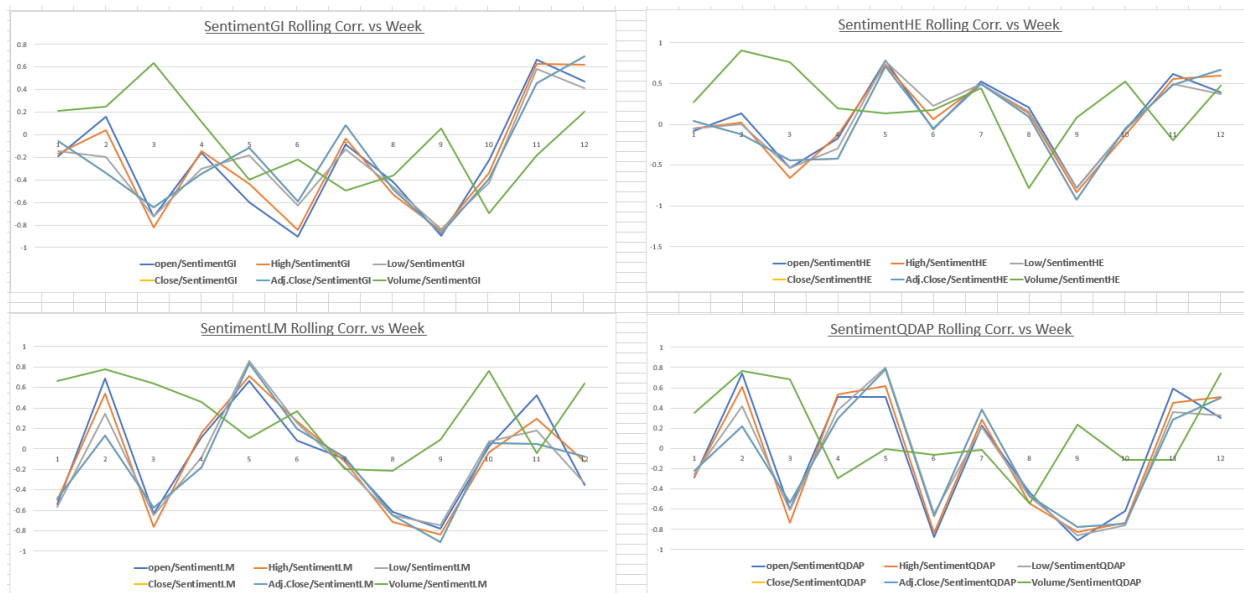


Figure 8.16: Toyota News Sentiment against Toyota Stock Rolling Correlation

Similarly, just like Toyota Twitter, the Toyota news rolling correlation result, in Figure 8.16 presents no clear pattern and seems not to be influenced by the VW scandal timeline activities.

8.3.3 Toyota Message Board Rolling Correlation

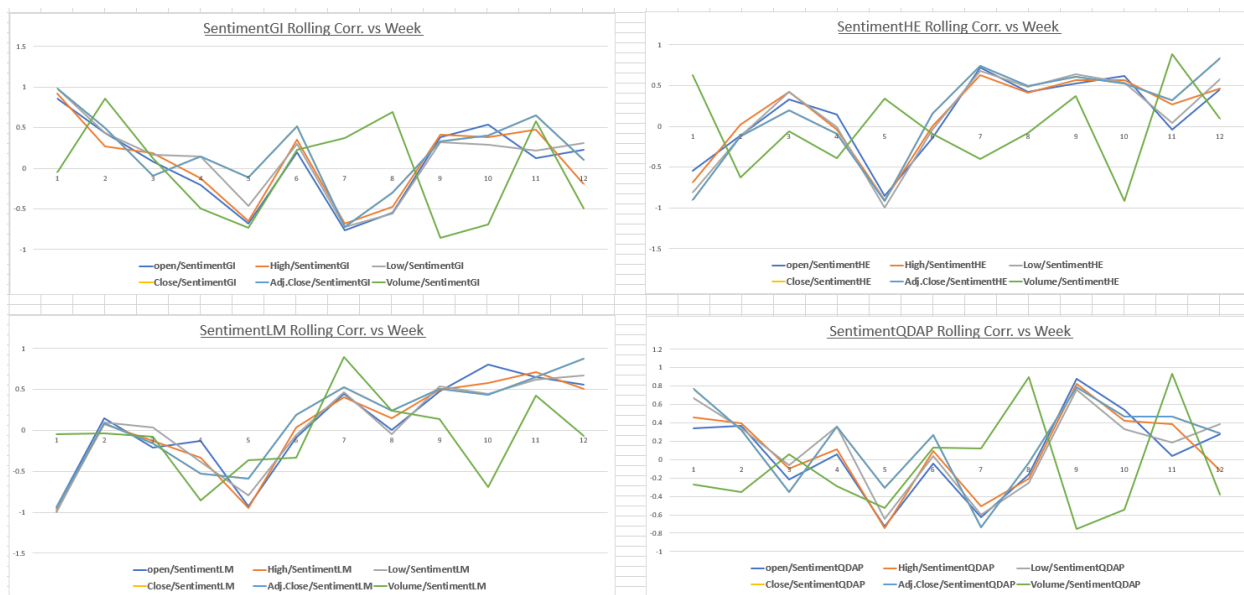


Figure 8.17: Toyota Message Board Sentiment against Toyota Stock Rolling Correlation

Figure 8.17 presents the Toyota message board rolling correlation result. This result didn't show any clear pattern to the eye between the graph of the sentiment and the stock.

8.3.4 Toyota Stocks and Sentiment Rolling Correlation Result Summary

Like we saw in the Ford Rolling correlation, there was no clear pattern that was presented by the 3 rolling correlation results that we saw in this section. Therefore, we move on to other analyses.

8.4 Toyota Stocks and Sentiment Partial Correlation

We then analyzed partial correlation results from the three media sources used for Toyota's reputation.

8.4.1 Toyota Twitter Partial Correlation

When the 9 months and 3 months dataset partial correlation values, which are Figures 8.18 and 8.20, are compared with their respective P-Value which are 8.19 and 8.21 with consideration for the statistically significance(i.e only result with corresponding P-Values of less than 0.05 is accepted), lesser partial correlation values than real correlation(i.e. in Figure 8.11) and partial correlation that are greater than zero, then presents no acceptable partial correlation for this dataset(i.e. Toyota Twitter sentiment vs stock partial correlation).

This implies any correlation seen in earlier Sections must have been direct correlation and not partially influenced.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.029197624	-0.011135679	0.636198601	0.032107753	-0.024853156	-0.052648053	0.042700417	0.007398814
SentimentHE	0.029197625	1	0.164450776	0.097473294	-0.061616697	-0.007543092	0.138837817	-0.069854694	0.015964276
SentimentLM	-0.011135679	0.164450776	1	0.328696035	-0.029428254	0.138140003	-0.067137325	-0.076921425	0.027504258
SentimentQDAP	0.636198601	0.097473294	0.328696035	1	-0.049980946	-0.020551863	0.118199152	-0.028299111	-0.02614799
Open	0.032107753	-0.061616697	-0.029428254	-0.049980946	1	0.799896689	0.525311177	-0.489363822	-0.040217802
High	-0.024853156	-0.007543092	0.138140003	-0.020551863	0.799896689	1	-0.215897824	0.664174271	-0.122525963
Low	-0.052648053	0.138837817	-0.067137325	0.118199152	0.525311177	-0.215897824	1	0.648542184	0.238955307
Close	0.042700417	-0.069854694	-0.076921425	-0.028299111	-0.489363822	0.664174271	0.648542184	1	0.216542117
Adj.Close	0.007398814	0.015964276	0.027504258	-0.02614799	-0.040217802	-0.122525963	0.238955307	0.216542117	1

Figure 8.18: Toyota Twitter Sentiment against Toyota Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.691604241	0.879769234	1.3201E-22	0.662665932	0.735638158	0.474225759	0.561733293	0.919947203
SentimentHE	0.691604237	0	0.024506993	0.184458308	0.402175445	0.918391524	0.058087566	0.342109922	0.828318838
SentimentLM	0.879769234	0.024506993	0	4.3696E-06	0.689293802	0.059373262	0.361261596	0.295384318	0.708654408
SentimentQDAP	1.3201E-22	0.184458308	4.3696E-06	0	0.496934443	0.78010089	0.107143923	0.700632531	0.722416104
Open	0.662665932	0.402175445	0.689293802	0.496934443	0	6.91603E-43	1.17475E-14	1.18561E-12	0.584719725
High	0.735638158	0.918391524	0.059373262	0.78010089	6.91603E-43	0	0.003000934	3.70699E-25	0.094804032
Low	0.474225759	0.058087566	0.361261596	0.107143923	1.17475E-14	0.003000934	0	1.06589E-23	0.000989132
Close	0.561733292	0.342109922	0.295384318	0.700632531	1.18561E-12	3.70699E-25	1.06589E-23	0	0.002913554
Adj.Close	0.919947203	0.828318838	0.708654408	0.722416104	0.584719725	0.094804032	0.000989132	0.002913554	0

Figure 8.19: Toyota Twitter Sentiment against Toyota Stock Partial Correlation P-Value (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.011056665	-0.007782877	0.66676444	-0.21202061	0.236388085	0.002316693	-0.109860074	0.048063374
SentimentHE	0.011056665	1	0.325620051	0.301094614	-0.093939752	0.002404205	0.206528064	0.005588681	-0.134832228
SentimentLM	-0.007782877	0.325620051	1	-0.023500888	-0.062972228	0.189545145	-0.05436627	-0.061213562	-0.048935597
SentimentQDAP	0.66676444	0.301094614	-0.023500888	1	0.283631205	-0.28784898	-0.043050545	0.089690714	0.007090578
Open	-0.21202061	-0.093939752	-0.062972228	0.283631205	1	0.788299775	0.507186167	-0.500183397	0.130699321
High	0.236388085	0.002404205	0.189545145	-0.28784898	0.788299775	1	-0.085926674	0.498145724	-0.119681548
Low	0.002316693	0.206528064	-0.05436627	-0.043050545	0.507186167	-0.085926674	1	0.567915211	-0.005959355
Close	-0.109860074	0.005588681	-0.061213562	0.089690714	-0.500183397	0.498145724	0.567915211	1	0.640390204
Adj.Close	0.048063374	-0.134832228	-0.048935597	0.007090578	0.130699321	-0.119681548	-0.005959355	0.640390204	1

Figure 8.20: Toyota Twitter Sentiment against Toyota Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.922456129	0.945373612	1.4601E-11	0.059019255	0.034767031	0.983728247	0.331999756	0.672024708
SentimentHE	0.922456129	0	0.00320487	0.006648108	0.407198428	0.983113672	0.066056429	0.960759645	0.233084843
SentimentLM	0.945373612	0.00320487	0	0.836073372	0.578944334	0.092188662	0.631961348	0.589610892	0.666422523
SentimentQDAP	1.4601E-11	0.006648108	0.836073372	0	0.01078661	0.009621983	0.704560555	0.428833807	0.950226228
Open	0.059019255	0.407198428	0.578944334	0.01078661	0	4.00742E-18	1.57755E-06	2.31003E-06	0.247854385
High	0.034767031	0.983113672	0.092188662	0.009621983	4.00742E-18	0	0.448535457	2.57708E-06	0.29031854
Low	0.983728247	0.066056429	0.631961348	0.704560555	1.57755E-06	0.448535457	0	3.92857E-08	0.958159261
Close	0.331999756	0.960759645	0.589610892	0.428833807	2.31003E-06	2.57708E-06	3.92857E-08	0	1.58829E-10
Adj.Close	0.672024708	0.233084843	0.666422523	0.950226228	0.247854385	0.29031854	0.958159261	1.58829E-10	0

Figure 8.21: Toyota Twitter Sentiment against Toyota Stock Partial Correlation P-Value (3 Months)

8.4.2 Toyota News Partial Correlation

In Toyota News sentiment vs stock partial correlation, a similar result was observed when compared to Toyota Twitter sentiment vs stock partial correlation.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.341887358	-0.167829589	0.687529572	-0.053123599	0.138929295	-0.183572713	-0.003415883	0.230415743
SentimentHE	0.341887358	1	-0.83268644	0.153640692	0.018978953	-0.036411203	0.088661553	-0.073317705	0.034220443
SentimentLM	-0.167829589	-0.83268644	1	0.670337181	-0.072718707	0.095301882	0.030435406	-0.129154964	0.189897676
SentimentQDAP	0.687529572	0.153640692	0.670337181	1	0.177298624	-0.233226552	0.038132477	0.15195605	-0.289670146
Open	-0.053123599	0.018978953	-0.072718707	0.177298624	1	0.814310526	0.513170877	-0.50448062	0.005962212
High	0.138929295	-0.036411203	0.095301882	-0.233226552	0.814310526	1	-0.216530402	0.670242797	-0.174621738
Low	-0.183572713	0.088661553	0.030435406	0.038132477	0.513170877	-0.216530402	1	0.647779951	0.247503701
Close	-0.003415883	-0.073317705	-0.129154964	0.15195605	-0.50448062	0.670242797	0.647779951	1	0.238784877
Adj.Close	0.230415743	0.034220443	0.189897676	-0.289670146	0.005962212	-0.174621738	0.247503701	0.238784877	1

Figure 8.22: Toyota News Sentiment against Toyota Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	1.6762E-06	0.021678388	1.65387E-27	0.470237054	0.057920736	0.011906747	0.962992688	0.001511012
SentimentHE	1.6762E-06	0	2.28323E-49	0.035781775	0.796548686	0.620782794	0.227556603	0.318655419	0.641962955
SentimentLM	0.021678388	2.28323E-49	0	9.32241E-26	0.322635837	0.194476253	0.679238069	0.078118086	0.009237692
SentimentQDAP	1.65387E-27	0.035781775	9.32241E-26	0	0.015202062	0.001316502	0.604356498	0.037884107	5.79088E-05
Open	0.470237054	0.796548686	0.322635837	0.015202062	0	1.41076E-45	5.932E-14	1.81859E-13	0.935453038
High	0.057920736	0.620782794	0.194476253	0.001316502	1.41076E-45	0	0.002915122	9.52397E-26	0.016834627
Low	0.011906747	0.227556603	0.679238069	0.604356498	5.932E-14	0.002915122	0	1.24929E-23	0.000637445
Close	0.962992688	0.318655419	0.078118086	0.037884107	1.81859E-13	9.52397E-26	1.24929E-23	0	0.00099768
Adj.Close	0.001511012	0.641962955	0.009237692	5.79088E-05	0.935453038	0.016834627	0.000637445	0.00099768	0

Figure 8.23: Toyota News Sentiment against Stock Toyota Partial Correlation P-Value (9 Months)

There was no partial correlation because when we compared the partial correlation values of Figures 8.22 and 8.24 of the two periods(i.e. 9 months and 3 months) with their respective P-Values non of them pass all the criteria of being statistically significant (i.e. with P-Value of

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.028054874	-0.182502194	0.742916675	-0.139817899	0.023998325	0.124681322	-0.032775025	0.008897172
SentimentHE	-0.028054874	1	0.359235176	0.196641904	0.086077407	-0.142120818	-0.023039356	0.028606782	0.151594679
SentimentLM	-0.182502194	0.359235176	1	0.520873873	0.030369546	-0.044523899	0.05213864	-0.088546162	0.098010569
SentimentQDAP	0.742916675	0.196641904	0.520873873	1	0.149674594	-0.023870024	-0.138255828	0.065356124	-0.084050401
Open	-0.139817899	0.086077407	0.030369546	0.149674594	1	0.78469349	0.533326127	-0.469847795	0.089782854
High	0.023998325	-0.142120818	-0.044523899	-0.023870024	0.78469349	1	-0.114514018	0.470983584	-0.073154789
Low	0.124681322	-0.023039356	0.05213864	-0.138255828	0.533326127	-0.114514018	1	0.584378112	-0.028959242
Close	-0.032775025	0.028606782	-0.088546162	0.065356124	-0.469847795	0.470983584	0.584378112	1	0.641888766
Adj.Close	0.008897172	0.151594679	0.098010569	-0.084050401	0.089782854	-0.073154789	-0.028959242	0.641888766	1

Figure 8.24: Toyota News Sentiment against Toyota Stock Partial Correlation (3 Months)

less than 0.05), partial correlation lesser than real correlation and partial correlation greater than zero.

Similarly, this implies any correlation seen in earlier Sections must have been direct correlation and not partially influenced.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.804885195	0.10516828	3.03339E-15	0.216096862	0.832653402	0.270488299	0.772877891	0.937567296
SentimentHE	0.804885195	0	0.001066018	0.080420684	0.447736936	0.208552578	0.839249209	0.801125003	0.17948692
SentimentLM	0.10516828	0.001066018	0	7.30131E-07	0.78914577	0.694939389	0.646007792	0.434771764	0.387082007
SentimentQDAP	3.03339E-15	0.080420684	7.30131E-07	0	0.185125053	0.833535201	0.221322588	0.564629289	0.458541287
Open	0.216096862	0.447736936	0.78914577	0.185125053	0	7.18929E-18	3.51591E-07	1.09735E-05	0.428357802
High	0.832653402	0.208552578	0.694939389	0.833535201	7.18929E-18	0	0.311798022	1.0379E-05	0.519002841
Low	0.270488299	0.839249209	0.646007792	0.221322588	3.51591E-07	0.311798022	0	1.26364E-08	0.79872602
Close	0.772877891	0.801125003	0.434771764	0.564629289	1.09735E-05	1.0379E-05	1.26364E-08	0	1.39544E-10
Adj.Close	0.937567296	0.17948692	0.387082007	0.458541287	0.428357802	0.519002841	0.79872602	1.39544E-10	0

Figure 8.25: Toyota News Sentiment against Toyota Stock Partial Correlation P-Value (3 Months)

8.4.3 Toyota Message Board Partial Correlation

Finally, analysis of the last partial correlation result(i.e. Toyota Message Board Partial Correlation) in Toyota media sources didn't produce a different result from all the media other media result analyzes so far.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.075030599	-0.10841289	0.647366072	0.064033305	-0.015261311	-0.034466828	0.012805771	-0.076546463
SentimentHE	0.075030599	1	0.160684931	0.030427514	-0.031560621	0.084036103	-0.040622524	0.011444964	-0.13167378
SentimentLM	-0.10841289	0.160684931	1	0.477348127	0.052855287	-0.039391562	-0.051815172	-0.00765056	0.167049903
SentimentQDAP	0.647366072	0.030427514	0.477348127	1	-0.094770762	0.044485514	0.064904932	-0.010003883	-0.064316799
Open	0.064033305	-0.031560621	0.052855287	-0.094770762	1	0.804944058	0.520026701	-0.481105552	-0.05170258
High	-0.015261311	0.084036103	-0.039391562	0.044485514	0.804944058	1	-0.222677122	0.658144661	-0.097232534
Low	-0.034466828	-0.040622524	-0.051815172	0.064904932	0.520026701	-0.222677122	1	0.650157804	0.246572667
Close	0.012805771	0.011444964	-0.00765056	-0.010003883	-0.481105552	0.658144661	0.650157804	1	0.206706388
Adj.Close	-0.076546463	-0.13167378	0.167049903	-0.064316799	-0.05170258	-0.097232534	0.246572667	0.206706388	1

Figure 8.26: Toyota Message Board Sentiment against Toyota Stock Partial Correlation (9 Months)

The result generally produce no correlation after comparing the partial correlations (i.e. Figures 8.22 and 8.24) and their corresponding P-Values (i.e. Figures 8.23 and 8.25) because non pass the criteria of being statistically significant (i.e. with P-Value of less than 0.05), partial correlation lesser than real correlation and partial correlation greater than zero.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.310086262	0.141856314	2.35627E-23	0.386526882	0.836649247	0.641386934	0.862648392	0.300385056
SentimentHE	0.310086263	0	0.028892085	0.680963224	0.669767163	0.255421116	0.583000091	0.877122243	0.074001309
SentimentLM	0.141856315	0.028892085	0	6.42373E-12	0.474895416	0.594477792	0.483642283	0.917681166	0.023043186
SentimentQDAP	2.35627E-23	0.680963224	6.42373E-12	0	0.199430769	0.547663427	0.38008214	0.892494339	0.384423522
Open	0.386526881	0.669767163	0.474895416	0.199430769	0	2.3938E-43	3.3016E-14	4.15676E-12	0.484594296
High	0.836649247	0.255421116	0.594477792	0.547663427	2.3938E-43	0	0.002314821	2.45928E-24	0.187951377
Low	0.641386934	0.583000091	0.483642283	0.38008214	3.3016E-14	0.002314821	0	1.32385E-23	0.00071591
Close	0.862648392	0.877122243	0.917681166	0.892494339	4.15676E-12	2.45928E-24	1.32385E-23	0	0.004757533
Adj.Close	0.300385056	0.074001309	0.023043186	0.384423522	0.484594296	0.187951377	0.00071591	0.004757533	0

Figure 8.27: Toyota Message Board Sentiment against Toyota Stock Partial Correlation P-Value (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.079714897	0.073441178	0.684947536	-0.042027926	0.036026768	0.044260357	-0.06230801	0.027777485
SentimentHE	-0.079714897	1	0.408248045	0.193680932	0.090227569	-0.021814228	-0.103505215	-0.073571645	0.144011449
SentimentLM	0.073441178	0.408248045	1	0.28650219	0.076981373	-0.066891842	-0.013824561	0.049824076	-0.046585855
SentimentQDAP	0.684947536	0.193680932	0.28650219	1	-0.083036621	0.034315589	0.027879663	0.087802944	-0.103304978
Open	-0.042027926	0.090227569	0.076981373	-0.083036621	1	0.774887332	0.528691352	-0.470874477	0.115356018
High	0.036026768	-0.021814228	-0.066891842	0.034315589	0.774887332	1	-0.098169547	0.482155388	-0.126994446
Low	0.044260357	-0.103505215	-0.013824561	0.027879663	0.528691352	-0.098169547	1	0.556199105	0.012297682
Close	-0.06230801	-0.073571645	0.049824076	0.087802944	-0.470874477	0.482155388	0.556199105	1	0.655974899
Adj.Close	0.027777485	0.144011449	-0.046585855	-0.103304978	0.115356018	-0.126994446	0.012297682	0.655974899	1

Figure 8.28: Toyota Message Board Sentiment against Toyota Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.487831736	0.522818543	4.64716E-12	0.714850652	0.754170936	0.700404514	0.587865365	0.80923745
SentimentHE	0.487831736	0	0.000206946	0.089308656	0.43209772	0.849646027	0.367163185	0.522078323	0.208424681
SentimentLM	0.522818543	0.000206946	0	0.010989985	0.502921894	0.560642798	0.904380415	0.664870095	0.685468335
SentimentQDAP	4.64716E-12	0.089308656	0.010989985	0	0.469821813	0.765503299	0.808549076	0.444621258	0.368095839
Open	0.714850652	0.43209772	0.502921894	0.469821813	0	8.45128E-17	6.50597E-07	1.35688E-05	0.314554875
High	0.754170936	0.849646027	0.560642798	0.765503299	8.45128E-17	0	0.392506844	7.82832E-06	0.267874967
Low	0.700404514	0.367163185	0.904380415	0.808549076	6.50597E-07	0.392506844	0	1.24404E-07	0.914899505
Close	0.587865365	0.522078323	0.664870095	0.444621258	1.35688E-05	7.82832E-06	1.24404E-07	0	7.08917E-11
Adj.Close	0.80923745	0.208424681	0.685468335	0.368095839	0.314554875	0.267874967	0.914899505	7.08917E-11	0

Figure 8.29: Toyota Message Board Sentiment against Toyota Stock Partial Correlation P-Value (3 Months)

8.4.4 Toyota Stocks and Sentiment Rolling Correlation Result Summary

In summary, just like in Ford, all the correlation we saw in our previous Toyota analysis must have been a direct correlation since we could not get the partial correlation that would prove that the real correlation values were caused by some other variables in the dataset

8.5 Toyota Stocks and Sentiments Trends

Like we did in VW and Ford, we then looked at the trendline of the stock volume, stock price, and media sentiment over the period of study.

The vertical lines indicate days of special events and announcements. The red line is the sentiment, the deep blue line the volume, and the other lines the stock prices.

8.5.1 Toyota Twitter Trend

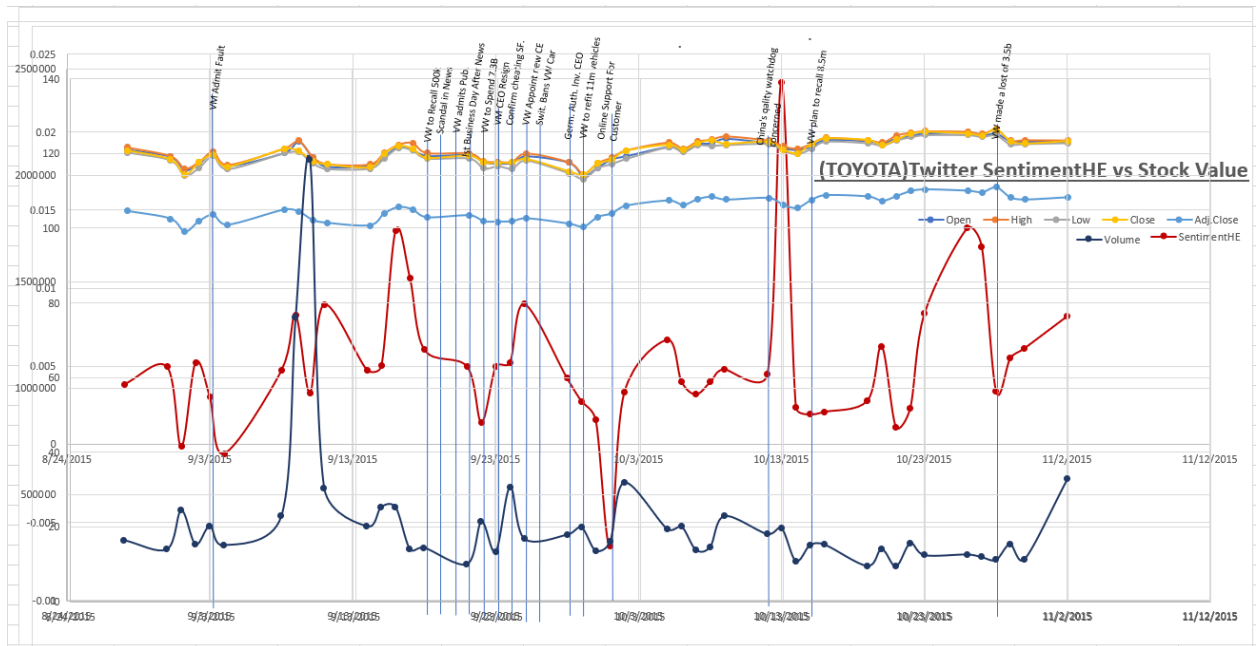


Figure 8.30: Toyota Twitter SentimentHE vs Toyota Stock Values

From Figures 8.30 and 8.31, apart from the spike in the volume of trading on the 8th of September, there was no overall change in stock price and stock volume in any obvious way. The sentiment shows so many activities, but the price was not being influenced by this activity.

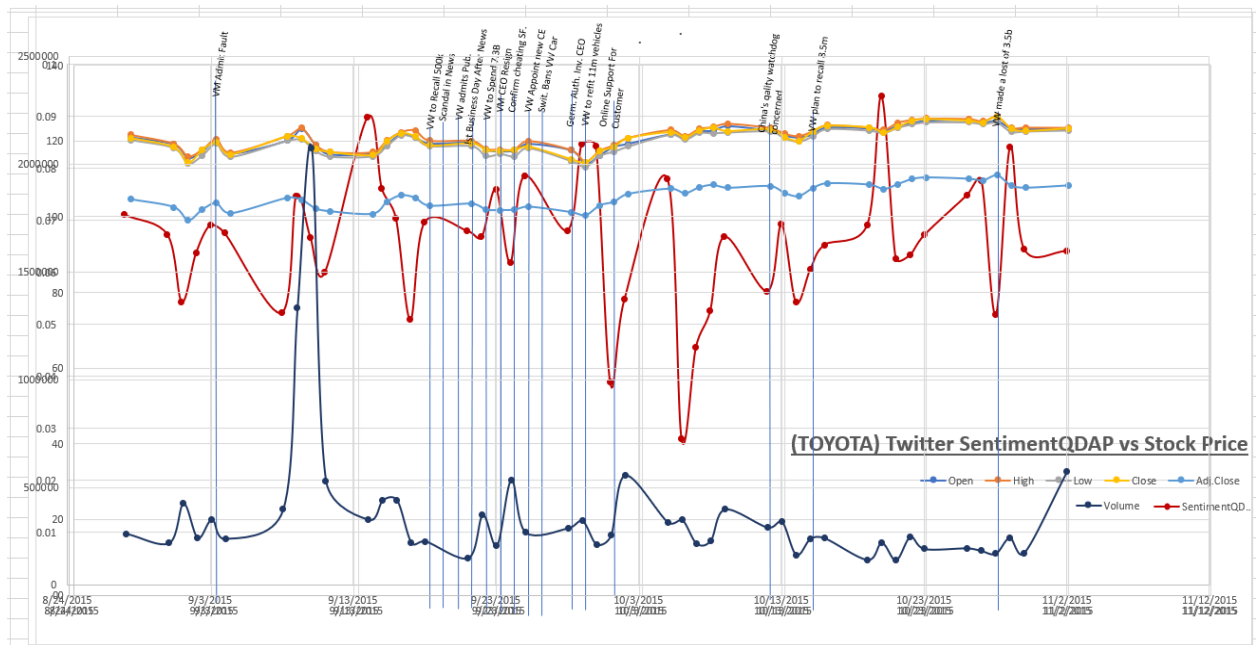


Figure 8.31: Toyota Twitter SentimentQDAP vs Toyota Stock Values

8.5.2 Toyota News Trend

From Figures 8.34 and 8.35, just like we saw in the Toyota Twitter trend analysis, apart from the spike in volume of trading on the 8th of September, there seems not to be an overall change in stock price and stock volume in any obvious way. The sentiment presents so many activities, but the prices were not being influenced in any obvious way.

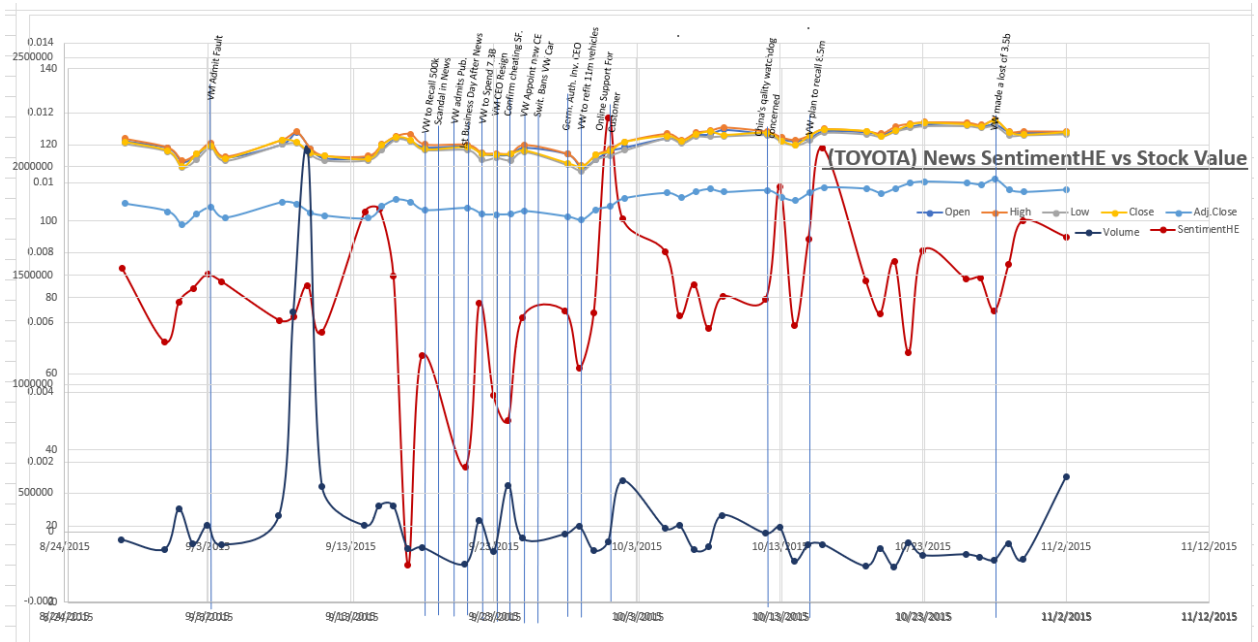


Figure 8.32: Toyota News SentimentHE vs Toyota Stock Values

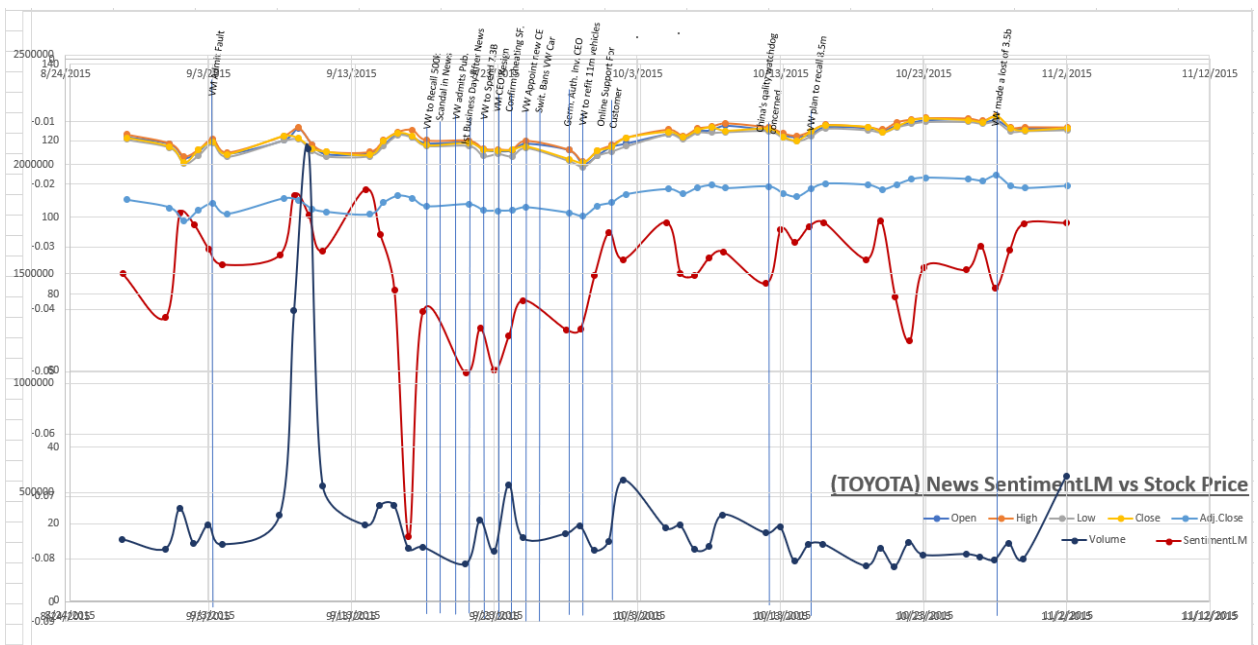


Figure 8.33: Toyota News SentimentLM vs Toyota Stock Values

8.5.3 Toyota Message Board Comment Trend

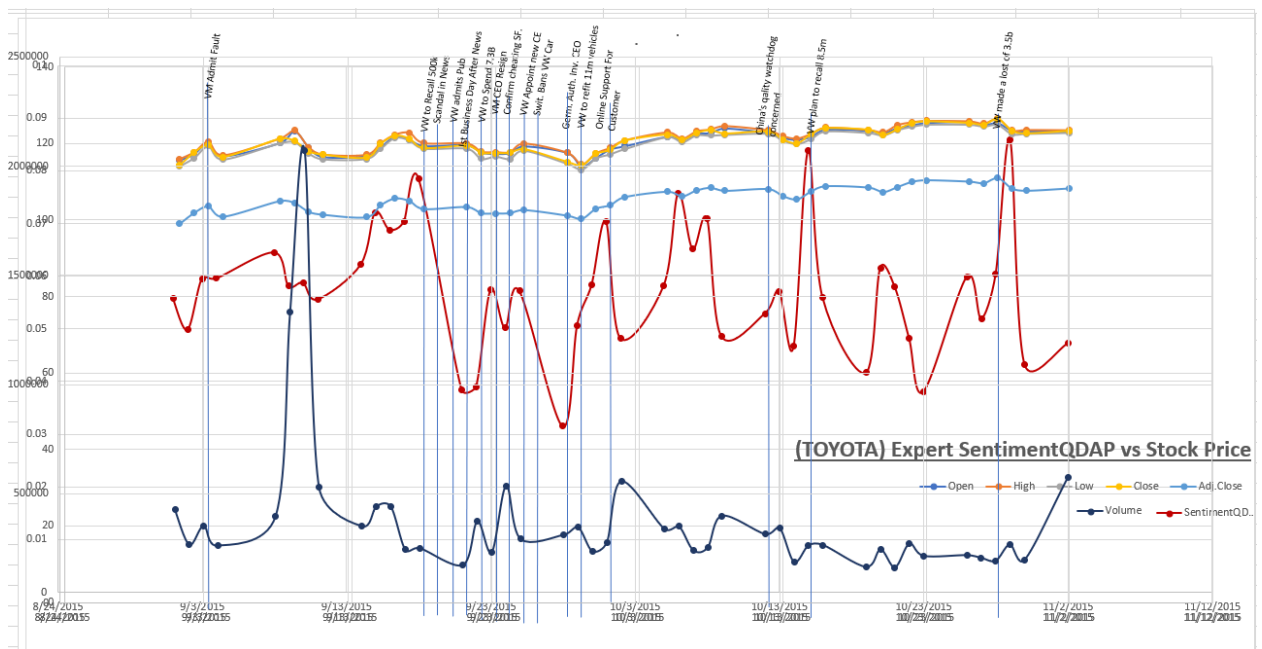


Figure 8.34: Toyota Message Board SentimentQDAP vs Toyota Stock Values

Figures 8.34 and 8.35 shows the trend result of the message board comment and stock value. Just as seen in correlation there was no special clear pattern between the message board comment and the stock values on the overall look.

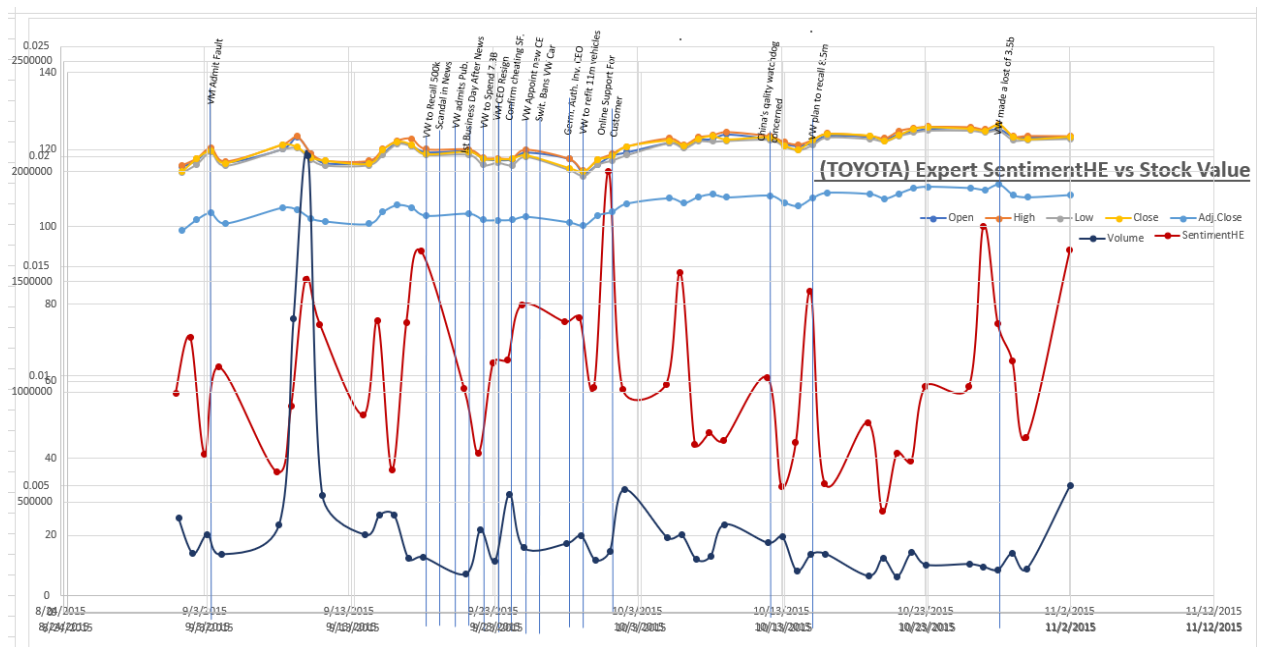


Figure 8.35: Toyota Message Board SentimentHE vs Toyota Stock Values

8.5.4 Toyota Stocks and Sentiment Trend Result Summary

From trend analysis, there are no clear changes in the stock values but there are some reasonable sentiment changes from the trend line seen. What we expect to see is synchrony in stock and sentiment movement. We will need to investigate more with our Granger test to come up with logical patterns here.

8.6 Toyota Stocks and Sentiments Granger Causality Test Analysis

We did 288 Granger causality tests in a similar pattern as we did with the VW and Ford on the Toyota dataset.

8.6.1 Toyota Twitter Granger Causality Test

In Appendix R 9 months result, shows different stock values, Granger causing mainly sentiment and some sentiment values Granger causing the stock. SentimentLM and SentimentGI present to be influenced the most by the stock values.

While, the 3 months result of the same appendix, which is the period closer to the inception of the scandal announcement (i.e. first 3 months), presents strong causality of the stock prices by the Twitter sentiment and SentimentGI being mainly leading in causation results seen.

8.6.2 Toyota News Granger Causality Test

Appendix S, mostly presents causality of the stock values causing the sentiment. SentimentQDAP and SentimentHE present to be influenced the most by the stock values base on the 9 months causality result. While SentimentHE shows to be influenced the most by the stock values in 3 months dataset result.

8.6.3 Toyota Message Board Comment Granger Causality Test

Appendix T shows no causality in the 9 months period dataset and just one line out of 48 with little causality in 3 months period dataset. Meaning no relationship at this period between the stock values and sentiment.

8.6.4 Toyota Stocks and Sentiment Granger Test Result Summary

The overall causality for the news and Twitter Granger causality result presents lots of influences of stock by sentiment and vice versa. The message board Granger result on the other hand is empty(i.e no causality result).

Next, we analyzed the word spoken by the Toyota related media during the scandal timeline.

that those were not related to the VW scandal event and announcements.

8.8 Toyota Stocks and Sentiment Result Analysis Conclusion

Toyota trend and correlation occurred out of sync when we looked at the emission scandal news and event timeline. This was also supported in the word cloud results that present the terms in the media not pointing to the event of the VW scandal in the Toyota dataset.

The substitute brand, in this case, Toyota, might have a correlation influenced by some other events but the fact that is out of sync with the events of the scandal and the discussion in its media is not related to the scandal was a clear pointer that is not being influenced by it.

Consequently, the increase in the relation/correlation of the sentiment of the Toyota brand and its stock values which was not backed by the VW scandal activity is possible and could have been easily caused by some other activities or scandal in the Toyota world.

9 Audi Result Analysis

In this section, we looked at the result of the Audi brand. Audi, a brand under Volkswagen, was our last brand analyzed. This analysis was done to see how this help us better understand the influence of online media on the reputation of other companies during the scandal timeline.

9.1 Audi Stocks and Sentiments Correlation

As usual, we did correlation first. It was between the stock price (i.e. of VW stocks values) and the different sentiment results from the different sentiment dictionary for different online media sources.

9.1.1 Audi Twitter Correlation

Figure 9.1 presents the Audi Twitter sentiment showing no correlation (i.e. all values between -0.25 and 0.25) with the stocks for the period of study.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.030790832	0.036025354	0.073666592	0.006302519
High	-0.020818636	0.028079935	0.075786778	0.006830949
Low	-0.029878233	0.036160867	0.085631234	0.013888097
Close	-0.020784763	0.028174048	0.085398074	0.012602873
Adj.Close	-0.016997072	0.025588779	0.086483958	0.013629592
Volume	0.063530404	-0.029797483	-0.147242194	-0.062475399

Figure 9.1: Correlation Audi Twitter Sentiments against VW Stock
For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.405940978	-0.711987896	-0.021163645	-0.40207171
High	-0.259669183	-0.447223651	0.116310639	-0.283183738
Low	-0.18907874	-0.458663755	0.094015312	-0.259447054
Close	-0.266657292	-0.398050169	0.008293138	-0.225800294
Adj.Close	-0.266656744	-0.398048537	0.008294837	-0.225800211
Volume	0.126408252	0.110650598	-0.2619349	0.322871642

Figure 9.2: Correlation Audi Twitter Sentiments against VW Stock
For the period before (i.e. 01.09.2015 to 15.09.20)

Figure 9.2 presents the period before the scandal was in the news and here, we saw a weak correlation (i.e. most values between 0.25 and 0.5 or -0.25 and -0.5) already in SentimentGI, SentimentHE, and SentimentQDAP.

This weak correlation continued across the different dictionary results in the first month and second month of the scandal announcement as seen in Figures 9.3 and 9.4.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.460547868	-0.284765187	-0.350461272	-0.339825048
High	-0.434564779	-0.290114271	-0.341618669	-0.314535012
Low	-0.452728603	-0.298903964	-0.339778556	-0.27181371
Close	-0.416194757	-0.330903304	-0.324560901	-0.260218467
Adj.Close	-0.416194696	-0.330903251	-0.324560778	-0.260218365
Volume	-0.021221586	-0.068410272	-0.044612751	-0.205802812

Figure 9.3: Correlation Audi Twitter Sentiments against VW Stock
For period 16.09.2015 to 15.10.2015

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.339293826	0.212333669	-0.073003458	-0.330754599
High	-0.404362796	0.161009301	-0.143417648	-0.42223039
Low	-0.389328276	0.153350139	-0.126831177	-0.419782043
Close	-0.397978297	0.126185994	-0.118464334	-0.411400604
Adj.Close	-0.397978294	0.126186212	-0.118464201	-0.41140052
Volume	0.10771249	-0.067270424	-0.190928339	-0.034138241

Figure 9.4: Correlation Audi Twitter Sentiments against VW Stock
For period 16.10.2015 to 15.11.2015

From the third month after the scandal announcement and beyond the correlation continued to diminish until it was lost but later the following year there was an increase in correlation as seen in Figures 9.5 and 9.6.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.333975901	0.009671203	-0.371054805	-0.365114189
High	-0.283099142	-0.039770358	-0.356445602	-0.358888505
Low	-0.27281426	-0.022014754	-0.337919886	-0.329327266
Close	-0.245735742	-0.069252577	-0.358864819	-0.336468181
Adj.Close	-0.245735868	-0.069252278	-0.35886484	-0.336468253
Volume	0.087249894	0.27215636	0.183099602	0.055228326

Figure 9.5: Correlation Audi Twitter Sentiments against VW Stock For period 16.03.2016 to 15.04.2016

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.170361389	0.471190841	0.207857194	-0.352401075
High	-0.023150758	0.441896498	0.283212421	-0.177701826
Low	-0.155135626	0.474573308	0.224934736	-0.317976954
Close	0.003670943	0.373400149	0.222206089	-0.230908152
Adj.Close	-0.055342439	0.387829807	0.204844573	-0.269988844
Volume	0.42963811	-0.109008164	0.145278273	0.333831481

Figure 9.6: Correlation Audi Twitter Sentiments against VW Stock For period 16.04.2016 to 15.05.2016

9.1.2 Audi News Correlation

Figure 9.7 presents no correlation (i.e. most values are between 0.25 and -0.25) for the whole period of study except in stock volume. Then, strangely before the scandal was published, there was a weak correlation between the stocks and all sentiment as seen in Figure 9.8.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.114562279	-0.004599913	0.184906979	0.171398395
High	0.111679439	-0.010654543	0.171944879	0.164344824
Low	0.122529712	0.055528542	0.25355782	0.211101759
Close	0.124422751	0.039997417	0.2303489	0.199543884
Adj.Close	0.130057453	0.045370698	0.237756653	0.204249086
Volume	-0.168321606	-0.489662973	-0.683701933	-0.434219432

Figure 9.7: Correlation Audi News Sentiments against VW Stock For dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.393610675	0.216718435	0.486299855	0.34500173
High	0.594427976	0.503533937	0.628771377	0.543603025
Low	0.456653222	0.404842113	0.437782414	0.347197117
Close	0.409160733	0.491977279	0.458840802	0.341059905
Adj.Close	0.409161426	0.491976356	0.458839302	0.341058998
Volume	0.423891953	0.318074181	0.497986896	0.404843264

Figure 9.8: Correlation Audi News Sentiments against VW Stock For the period before (i.e. 01.09.2015 to 15.09.20)

Figure 9.9 only presents a strong correlation with the volume in the first month of the scandal but was followed by a period of a general increase in correlation from no correlation to a weak correlation. This weak correlation was sustained for the whole period of study. See Figure 9.10.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.089156078	-0.34143632	0.021515776	0.234297299
High	-0.095791184	-0.358665754	0.014913373	0.208244665
Low	-0.106286064	-0.198552861	0.195394436	0.359880446
Close	-0.090457346	-0.234204561	0.161445283	0.319605606
Adj.Close	-0.090457383	-0.23420452	0.161445383	0.319605632
Volume	0.019796511	-0.729168002	-0.791954448	-0.688275043

Figure 9.9: Correlation Audi News Sentiments against VW Stock For period 16.09.2015 to 15.10.15

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.26770634	-0.318639148	-0.313695403	-0.216831568
High	-0.296607816	-0.272871905	-0.336236783	-0.233676035
Low	-0.330710338	-0.254489331	-0.318415653	-0.241004791
Close	-0.279740904	-0.202177953	-0.265181079	-0.190976085
Adj.Close	-0.279740869	-0.202178292	-0.265181545	-0.190976227
Volume	0.301207029	-0.013494752	0.005857643	0.186457948

Figure 9.10: Correlation Audi News Sentiments against VW Stock For period 16.03.2016 to 15.04.2016

9.1.3 Audi Message Board Comment Correlation

There was no overall correlation (i.e. most values are between 0.25 and -0.25) between the message board comment and the stock's value for the whole period of study as shown in Figure 9.11.

Figure 9.13 shows that there was no increase in correlation (i.e. there was no correlation) in the first month of the scandal announcement. While in Figure 9.13, is a sample of the result from several months that followed that did not show any significant change in correlation.

It was noted that there were some months in which we saw some increase in the correlation of the sentiment result and the stock value.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.008732388	-0.066236487	-0.122122642	-0.017662753
High	0.008674553	-0.065044608	-0.128317126	-0.014333814
Low	-0.005265139	-0.056131473	-0.103966901	-0.019939881
Close	0.001101268	-0.050489718	-0.117003686	-0.011742303
Adj.Close	-0.000922497	-0.049660465	-0.11463745	-0.008354469
Volume	0.057185785	-0.033942812	-0.143520622	0.016351472

Figure 9.11: Correlation Audi Message Board Sentiments against VW Stock for dataset whole period (i.e. 28.08.2015 to 06.06.16)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.355392808	0.191501303	-0.211342152	0.450226271
High	0.275241724	0.072996188	-0.467307924	0.409718183
Low	0.153728069	-0.071223091	-0.4290022	0.330801835
Close	0.211321471	-0.041997149	-0.518146023	0.355782354
Adj.Close	0.211319357	-0.04199768	-0.518143729	0.355780044
Volume	0.183774929	-0.029502437	-0.507537931	0.240655221

Figure 9.12: Correlation Audi Message Board Sentiments against VW Stock for the period before (i.e. 01.09.2015 to 15.09.20)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.059758331	-0.208979044	-0.012210021	-0.221433748
High	-0.002817773	-0.160940125	-0.061509997	-0.155077161
Low	-0.06541628	-0.089818513	0.048825392	-0.192416023
Close	-0.006140864	-0.047733586	-0.014842559	-0.129332569
Adj.Close	-0.006140899	-0.047733606	-0.014842591	-0.129332592
Volume	0.124501678	-0.312291396	-0.36182451	0.030971124

Figure 9.13: Correlation Audi Message Board Sentiments against VW Stock for period 16.09.2015 to 15.10.15

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.306892392	0.061296226	0.24324931	0.345039641
High	0.244530423	0.012984671	0.282144024	0.292746789
Low	0.299397309	0.084520073	0.301614293	0.349287255
Close	0.227950671	0.020174735	0.271033902	0.283123305
Adj.Close	0.227950662	0.020174601	0.271033746	0.283123179
Volume	-0.211564684	-0.294341345	0.004797319	-0.227235703

Figure 9.14: Correlation Audi Message Board Sentiments against VW Stock for period 16.03.2016 to 15.04.2016

9.1.4 Audi Stocks and Sentiment Correlation Result Summary

There were some good correlations shown in the news and Twitter data but nothing much was presented in the message board comment dataset correlation with stock values.

Generally, the correlation is far weaker than what we saw in the VW dataset and seems not to be in good sync with it.

9.2 Audi Stocks and Sentiment Weekly Correlation

In a similar pattern, we repeated the correlation in weekly time intervals.

9.2.1 Audi Twitter Weekly Correlation

Figure U, shows the increased correlation in the 3rd (i.e. when US authority instructed VW to recall 500k cars and a day before the scandal was in New York Times) and 4th week as seen in the VW result but this was followed by much stronger correlations in the week that followed.

9.2.2 Audi News Weekly Correlation

Figure V, which is Audi newsweekly correlation presents a strong correlation in the 2nd and 3rd week. This was followed by scanty and inconsistent but strong correlations across the weeks that followed in different sentiment results.

9.2.3 Audi Message Board Weekly Correlation

The result available in Appendix W presents a strong correlation in the 1st week to 4th week. This correlation became weaker and less consistent but was sustained across the weeks that followed.

9.2.4 Audi Stocks and Sentiment Weekly Correlation Result Summary

In summary, the correlation increases, and decreases seem not to be in sync with the VW scandal timeline. Therefore we cannot say for certain if the correlation we saw was actually influenced by it.

We then moved on to other analysis for a better understanding of the Audi dataset.

9.3 Audi Stocks and Sentiment Rolling Correlation

For the sake of completeness, we looked at the rolling correlation results that are used to show the direction of the correlation change.

9.3.1 Audi Twitter Rolling Correlation

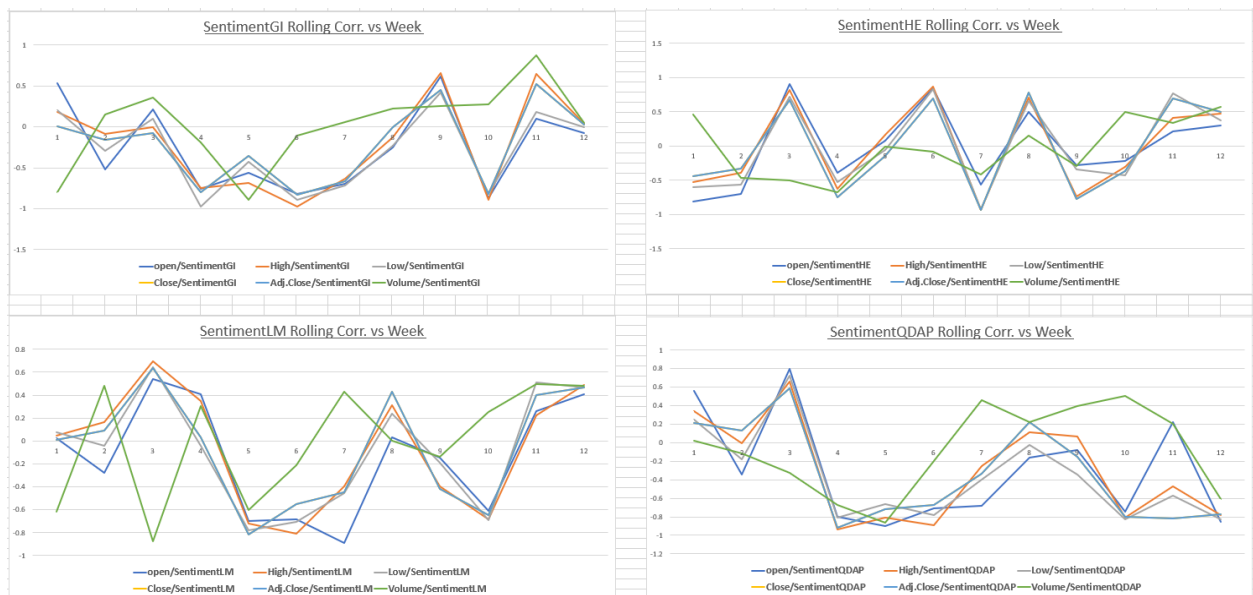


Figure 9.15: Rolling Correlation of VW Stock VS Audi Twitter Sentiment Weekly Correlation

In Figure 9.15, SentimentLM presents the highest price/sentiment and lowest volume/sentiment rolling correlation at the 3rd week (i.e. the week of the first events of the scandal).

9.3.2 Audi News Rolling Correlation

In Figure 9.16, SentimentLM and SentimentQDAP both presented the highest price/sentiment rolling correlation at the 3rd week (i.e. the week VW recalled 500k cars). Also, in the 3rd week, we saw the lowest volume/sentiment rolling correlation is observed for SentimentHE, SentimentLM, and SentimentQDAP.

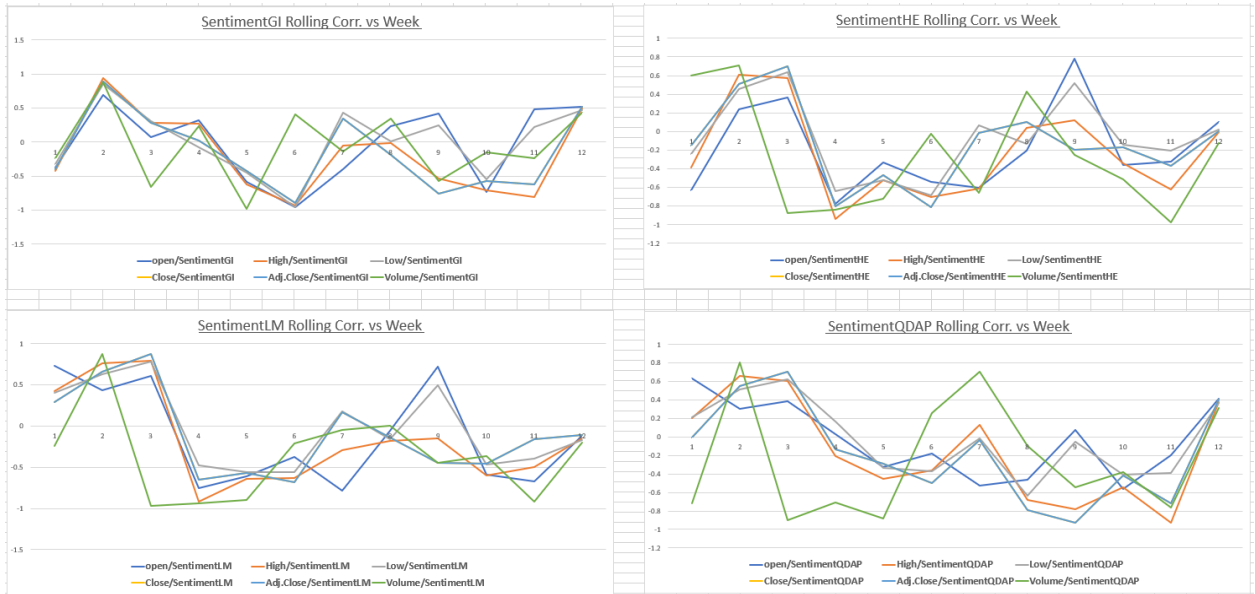


Figure 9.16: Rolling Correlation of VW Stock VS Audi News Sentiment Weekly Correlation

9.3.3 Audi Message Board Rolling Correlation

Here there is no clear pattern in the direction of change of correlation from the result of rolling correlation as presented in Figure 9.17.

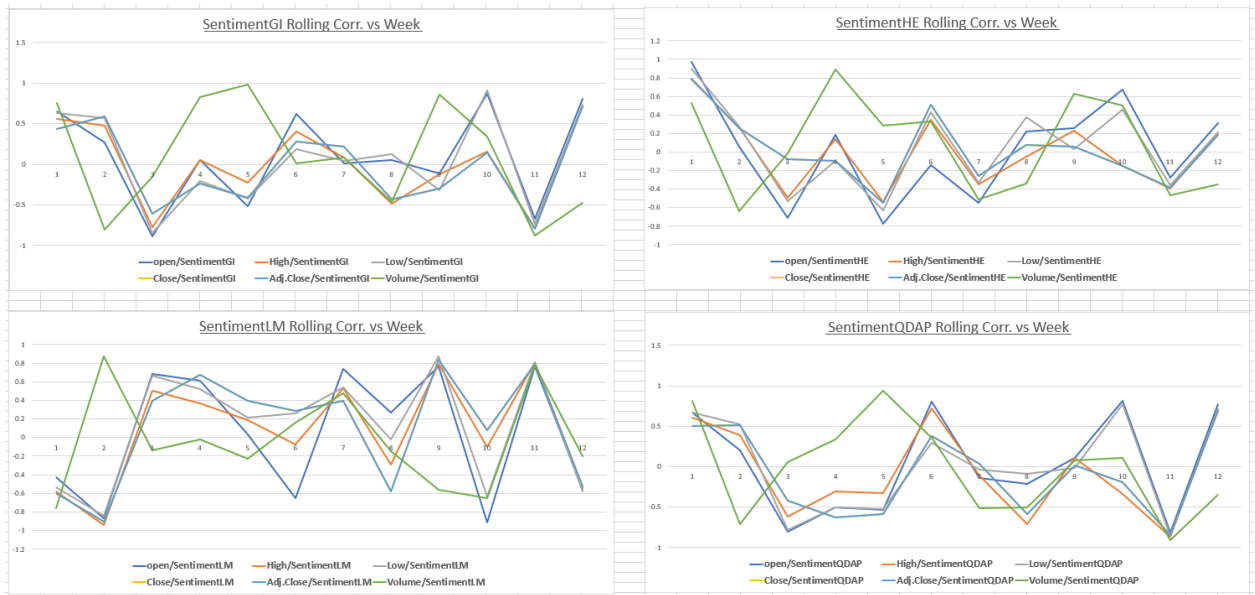


Figure 9.17: Rolling Correlation of VW Stock VS Audi Message Board Sentiment Weekly Correlation

9.3.4 Audi Stocks and Sentiment Rolling Correlation Result Summary

Just like we did in the VW dataset, in the Audi brand dataset, we saw the highest rolling correlation variation just about the time the VW recall 500k cars in the US and the scandal gets out to the media for the first time (i.e. 3rd week of analysis) and this is evident in just one out of four Twitter and two out of four News media rolling correlation results.

9.4 Audi Stocks and Sentiment Partial Correlation

Like what we did in other brands we computed and analyzed partial correlation results from the three media sources used for Audi's reputation. This we did for 9 months (i.e. the whole dataset) and 3 months (i.e. the first 3 months of the VW scandal) period.

As stated already, with the partial correlation we were able to know if the correlation we saw is a direct correlation or because of the influence of another variable in the dataset.

9.4.1 Audi Twitter Partial Correlation

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.092507738	0.023362686	0.460707011	-0.054691427	0.06870194	-0.047439424	-0.051882672	0.080021922
SentimentHE	0.092507738	1	0.400406289	-0.018644645	0.059261938	-0.042601951	0.020572137	0.038542136	-0.072152754
SentimentLM	0.023362686	0.400406289	1	0.463500426	-0.038341039	0.008152759	0.009802627	-0.010913055	0.033611823
SentimentQDAP	0.460707011	-0.018644645	0.463500426	1	0.02178044	-0.030560479	0.02949681	0.01325809	-0.02933651
Open	-0.054691427	0.059261938	-0.038341039	0.02178044	1	0.886100366	0.710741351	-0.40290549	-0.004154791
High	0.06870194	-0.042601951	0.008152759	-0.030560479	0.886100366	1	-0.595695024	0.504350312	-0.026895612
Low	-0.047439424	0.020572137	0.009802627	0.02949681	0.710741351	-0.595695024	1	0.51715112	0.028650931
Close	-0.051882672	0.038542136	-0.010913055	0.01325809	-0.40290549	0.504350312	0.51715112	1	0.782833958
Adj.Close	0.080021922	-0.072152754	0.033611823	-0.02933651	-0.004154791	-0.026895612	0.028650931	0.782833958	1

Figure 9.18: Audi Twitter Sentiment against VW Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.205494881	0.74965321	2.5476E-11	0.454789257	0.34755611	0.516840871	0.478315342	0.273701684
SentimentHE	0.205494881	0	1.13769E-08	0.798998691	0.417926166	0.560526968	0.778730613	0.598507962	0.323817912
SentimentLM	0.74965321	1.13769E-08	0	1.86349E-11	0.600419035	0.911346572	0.893502973	0.881522985	0.64612611
SentimentQDAP	2.5476E-11	0.798998691	1.86349E-11	0	0.766099752	0.676351132	0.687013248	0.856314671	0.688625511
Open	0.454789257	0.417926166	0.600419035	0.766099752	0	2.33064E-64	2.21063E-30	9.04217E-09	0.954752111
High	0.34755611	0.560526968	0.911346572	0.676351132	2.33064E-64	0	1.54684E-19	1.37148E-13	0.713345234
Low	0.516840871	0.778730613	0.893502973	0.687013248	2.21063E-30	1.54684E-19	0	2.56026E-14	0.695536687
Close	0.478315342	0.598507962	0.881522985	0.856314671	9.04217E-09	1.37148E-13	2.56026E-14	0	2.18395E-40
Adj.Close	0.273701684	0.323817912	0.64612611	0.688625511	0.954752111	0.713345234	0.695536687	2.18395E-40	0

Figure 9.19: Audi Twitter Sentiment against VW Stock Partial Correlation P-Value (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.002478574	0.219547143	0.411054399	-0.131067625	0.117812147	0.079982737	-0.08247798	-0.083655611
SentimentHE	0.002478574	1	-0.960203453	0.598203982	0.100042582	-0.125130243	-0.090751493	0.132309937	0.112098095
SentimentLM	0.219547143	-0.960203453	1	0.364147246	0.118158365	-0.145992569	-0.100409571	0.148505872	0.129370745
SentimentQDAP	0.411054399	0.598203982	0.364147246	1	-0.030499593	0.025038408	0.037161229	-0.031024054	-0.018404182
Open	-0.131067625	0.100042582	0.118158365	-0.030499593	1	0.9189534	0.725681739	-0.661159026	-0.660843222
High	0.117812147	-0.125130243	-0.145992569	0.025038408	0.9189534	1	-0.677916196	0.786217044	0.785675027
Low	0.079982737	-0.090751493	-0.100409571	0.037161229	0.725681739	-0.677916196	1	0.901438584	0.901843266
Close	-0.082477913	0.132309937	0.148505855	-0.031024095	-0.661159018	0.786217036	0.901438579	1	-0.999792113
Adj.Close	-0.083655691	0.112098095	0.129370766	-0.018404132	-0.660843232	0.785675037	0.901843272	-0.999792126	1

Figure 9.20: Audi Twitter Sentiment against VW Stock Partial Correlation (3 Months)

The results from Figures 9.18 and 9.20, which were the 9 months and 3 months period partial correlation computation results and its P-Values (Figures 9.19 and 9.21) respectively, show no partial correlation between the stock values and the sentiments based on the fact that it didn't meet the criteria of being statistically significant (i.e. only result with corresponding P-Values

of less than 0.05 is accepted), lesser partial correlation values than real correlation(i.e. in Figure 9.1) and partial correlation value that are greater than zero.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.982479484	0.048917383	0.000137884	0.243487715	0.294877216	0.477831546	0.464160709	0.457783716
SentimentHE	0.982479484	0	1.61705E-45	3.69357E-09	0.374206875	0.265687107	0.42039672	0.239009509	0.319081757
SentimentLM	0.048917383	1.61705E-45	0	0.000832032	0.293450499	0.193432684	0.372448051	0.185792459	0.249697445
SentimentQDAP	0.000137884	3.69357E-09	0.000832032	0	0.786935032	0.824408912	0.74187865	0.783360144	0.870457851
Open	0.243487715	0.374206875	0.293450499	0.786935032	0	1.15757E-33	1.8085E-14	1.84447E-11	1.90015E-11
High	0.294877216	0.265687107	0.193432684	0.824408912	1.15757E-33	0	3.6114E-12	3.45379E-18	3.77412E-18
Low	0.477831546	0.42039672	0.372448051	0.74187865	1.8085E-14	3.6114E-12	0	1.86536E-30	1.59825E-30
Close	0.46416107	0.239009508	0.185792512	0.783359865	1.84448E-11	3.45379E-18	1.86536E-30	0	2.4827E-135
Adj.Close	0.457783283	0.319081758	0.249697367	0.870458197	1.90015E-11	3.77411E-18	1.59825E-30	2.4766E-135	0

Figure 9.21: Audi Twitter Sentiment against VW Stock Partial Correlation P-Value (3 Months)

9.4.2 Audi News Partial Correlation

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.03302017	-0.269903894	0.788912064	0.114935424	-0.023975433	-0.192953878	-0.02180547	0.104198029
SentimentHE	0.03302017	1	0.336643066	0.152211772	-0.067813699	-0.019539773	0.071387561	0.004828266	-0.002297323
SentimentLM	-0.269903894	0.336643066	1	0.548546713	0.019429645	-0.159897745	0.131647348	-0.069250198	0.125192361
SentimentQDAP	0.788912064	0.152211772	0.548546713	1	-0.061357293	0.050208806	0.079112832	0.036481163	-0.098862307
Open	0.114935424	-0.067813699	0.019429645	-0.061357293	1	0.852404519	0.707286489	-0.394825061	-0.020811748
High	-0.023975433	-0.019539773	-0.159897745	0.050208806	0.852404519	1	-0.508876002	0.472900165	0.01257268
Low	-0.192953878	0.071387561	0.131647348	0.079112832	0.707286489	-0.508876002	1	0.506537168	0.011345832
Close	-0.02180547	0.004828266	-0.069250198	0.036481163	-0.394825061	0.472900165	0.506537168	1	0.780301959
Adj.Close	0.104198029	-0.002297323	0.125192361	-0.098862307	-0.020811748	0.01257268	0.011345832	0.780301959	1

Figure 9.22: Audi News Sentiment against VW Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.651943559	0.000172723	2.09617E-41	0.11529293	0.743313801	0.007811169	0.765838742	0.153617368
SentimentHE	0.651943559	0	2.17598E-06	0.036538574	0.353839671	0.789568572	0.328989111	0.947427413	0.974971686
SentimentLM	0.000172723	2.17598E-06	0	3.05676E-16	0.790727148	0.027962787	0.070963272	0.343713011	0.086079319
SentimentQDAP	2.09617E-41	0.036538574	3.05676E-16	0	0.401627575	0.492643292	0.279206587	0.618221968	0.175917166
Open	0.11529293	0.353839671	0.790727148	0.401627575	0	1.49818E-54	5.57988E-30	1.88726E-08	0.776221138
High	0.743313801	0.789568572	0.027962787	0.492643292	1.49818E-54	0	7.63766E-14	6.37109E-12	0.863668745
Low	0.007811169	0.328989111	0.070963272	0.279206587	5.57988E-30	7.63766E-14	0	1.03469E-13	0.87686103
Close	0.765838742	0.947427413	0.343713011	0.618221968	1.88726E-08	6.37109E-12	1.03469E-13	0	5.67046E-40
Adj.Close	0.153617368	0.974971686	0.086079319	0.175917166	0.776221138	0.863668745	0.87686103	5.67046E-40	0

Figure 9.23: Audi News Sentiment against VW Stock Partial Correlation P-Value (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-1	-1	-1	0.073194168	-0.190947212	0.038357262	0.133273898	0.127264319
SentimentHE	-1	1	-1	-1	0.073187054	-0.190934126	0.038348707	0.133273793	0.127264213
SentimentLM	-1	-1	1	-1	0.07318461	-0.190931479	0.038348456	0.133273461	0.127263881
SentimentQDAP	-1	-1	-1	1	0.073194838	-0.190946665	0.038352453	0.133276807	0.12726723
Open	0.073194168	0.073187054	0.07318461	0.073194838	1	0.912364467	0.715787055	-0.657482857	-0.657558992
High	-0.190947212	-0.190934126	-0.190931479	-0.190946665	0.912364467	1	-0.65206419	0.785357007	0.784814937
Low	0.038357262	0.038348707	0.038348456	0.038352453	0.715787055	-0.65206419	1	0.887496513	0.888438085
Close	0.133273898	0.133273793	0.133273461	0.133276807	-0.657482857	0.785357005	0.887496513	1	-0.99998163
Adj.Close	0.127264327	0.127264221	0.127263889	0.127267238	-0.657558993	0.784814939	0.888438085	-0.999981632	1

Figure 9.24: Audi News Sentiment against VW Stock Partial Correlation (3 Months)

Similarly, Figures 9.22 and 9.24 when compared with its P-Values 9.23 and 9.25 for the 9 month and 3 month data period present no partial correlation based on our partial correlation acceptance criteria.

Meaning the correlation seen earlier (i.e. 9.7) are direct and are not partial.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0	0	0	0.516092407	0.087717259	0.733875441	0.235574186	0.257555746
SentimentHE	0	0	NA	0	0.5161333	0.0877394	0.733932585	0.235574562	0.257556146
SentimentLM	0	0	0	0	0.516147352	0.087743879	0.733934264	0.235575736	0.257557395
SentimentQDAP	0	0	0	0	0.516088554	0.087718184	0.733907564	0.235563872	0.257544771
Open	0.516092407	0.5161333	0.516147352	0.516088554	0	2.2306E-32	5.91888E-14	2.6018E-11	2.58345E-11
High	0.087717259	0.0877394	0.087743879	0.087718184	2.2306E-32	0	4.28317E-11	3.97525E-18	4.34222E-18
Low	0.733875441	0.733932585	0.733934264	0.733907564	5.91888E-14	4.28317E-11	0	2.63458E-28	1.92595E-28
Close	0.235574211	0.235574586	0.23557576	0.235563896	2.6018E-11	3.97525E-18	2.63458E-28	0	5.9537E-177
Adj.Close	0.257555715	0.257556115	0.257557364	0.25754474	2.58345E-11	4.34222E-18	1.92595E-28	5.9284E-177	0

Figure 9.25: Audi News Sentiment against VW Stock Partial Correlation P-Value (3 Months)

9.4.3 Audi Message Partial Rolling Correlation

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	0.187146584	-0.096807698	0.762382087	0.056200419	0.017664794	-0.03226786	0.10242285	-0.162163668
SentimentHE	0.187146584	1	-0.086170532	0.292945888	0.008098906	-0.085021811	0.007314918	0.053964432	-0.014609084
SentimentLM	-0.096807698	-0.086170532	1	0.045351334	-0.026336806	-0.022505497	0.094726808	-0.043545342	0.021152214
SentimentQDAP	0.762382087	0.292945888	0.045351334	1	-0.039787545	0.008286233	-0.00136999	-0.118779843	0.174644559
Open	0.056200419	0.008098906	-0.026336806	-0.039787545	1	0.88125497	0.718096682	-0.405847534	0.013754476
High	0.017664794	-0.085021811	-0.022505497	0.008286233	0.88125497	1	-0.598046335	0.50197788	-0.039222261
Low	-0.03226786	0.007314918	0.094726808	-0.00136999	0.718096682	-0.598046335	1	0.523150923	-0.00389955
Close	0.10242285	0.053964432	-0.043545342	-0.118779843	-0.405847534	0.50197788	0.523150923	1	0.79882206
Adj.Close	-0.162163668	-0.014609084	0.021152214	0.174644559	0.013754476	-0.039222261	-0.00389955	0.79882206	1

Figure 9.26: Audi Message Board Sentiment against VW Stock Partial Correlation (9 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	0.010747804	0.189897093	1.98324E-36	0.447357356	0.811371329	0.662815553	0.165347152	0.027430769
SentimentHE	0.010747804	0	0.24350422	5.19613E-05	0.912875561	0.249868686	0.921280709	0.465663741	0.843538976
SentimentLM	0.189897093	0.24350422	0	0.539889924	0.721950598	0.761073331	0.199640249	0.55616616	0.775044179
SentimentQDAP	1.98324E-36	5.19613E-05	0.539889924	0	0.590774409	0.910868618	0.985233925	0.107324436	0.017424554
Open	0.447357356	0.912875561	0.721950598	0.590774409	0	1.83494E-61	1.26702E-30	9.96723E-09	0.852584441
High	0.811371329	0.249868686	0.761073331	0.910868618	1.83494E-61	0	2.51071E-19	3.35497E-13	0.596064366
Low	0.662815553	0.921280709	0.199640249	0.985233925	1.26702E-30	2.51071E-19	0	2.17925E-14	0.957986623
Close	0.165347152	0.465663741	0.55616616	0.107324436	9.96723E-09	3.35497E-13	2.17925E-14	0	2.98795E-42
Adj.Close	0.027430769	0.843538976	0.775044179	0.017424554	0.852584441	0.596064366	0.957986623	2.98795E-42	0

Figure 9.27: Audi Message Board Sentiment against VW Stock Partial Correlation P-Value (9 Months)

No partial correlation was concluded after comparing the partial correlation result in Figures 9.26 and 9.28 and their corresponding P-Values in Figures 9.27 and 9.29 respectively. This was done with consideration to our partial correlation acceptance criteria of it being statistically significance (i.e. only result with corresponding P-Values of less than 0.05 is accepted), lesser partial correlation values than real correlation (i.e. in Figure 9.11) and partial correlation value that are greater than zero.

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	1	-0.977071799	-0.877247721	-0.190429966	-0.010862165	0.029473636	-0.073196633	0.020229118	0.055829373
SentimentHE	-0.977071799	1	-0.959338924	0.022950236	0.014546667	0.001412089	-0.062727623	0.015615497	0.05407065
SentimentLM	-0.877247721	-0.959338924	1	0.30419938	0.047248629	-0.035944211	-0.044434357	0.008437129	0.047944473
SentimentQDAP	-0.190429966	0.022950235	0.30419938	1	-0.118158544	0.131974827	-0.054409134	0.022912658	0.012764914
Open	-0.010862165	0.014546667	0.047248629	-0.118158544	1	0.920040276	0.710741459	-0.652956237	-0.653842525
High	0.029473636	0.001412089	-0.035944211	0.131974827	0.920040276	1	-0.660014927	0.774118828	0.774380528
Low	-0.073196633	-0.062727623	-0.044434357	-0.054409134	0.710741459	-0.660014927	1	0.900784717	0.901629116
Close	0.020229362	0.015615757	0.008437391	0.022912605	-0.652956247	0.774118834	0.90078473	1	-0.999216994
Adj.Close	0.055829078	0.054070337	0.047944156	0.012764977	-0.653842514	0.774380521	0.901629099	-0.999216977	1

Figure 9.28: Audi Message Board Sentiment against VW Stock Partial Correlation (3 Months)

	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Open	High	Low	Close	Adj.Close
SentimentGI	0	1.73064E-53	2.95631E-26	0.092758866	0.924307706	0.796524328	0.521472739	0.859545675	0.625058096
SentimentHE	1.73063E-53	0	4.72544E-44	0.840885309	0.898750865	0.990145679	0.582875117	0.891355185	0.636015794
SentimentLM	2.95631E-26	4.72545E-44	0	0.006418408	0.679245954	0.753150025	0.697395769	0.941172041	0.6747858
SentimentQDAP	0.092758866	0.84088531	0.006418408	0	0.299682299	0.246292988	0.633900697	0.841142434	0.911098432
Open	0.924307706	0.898750865	0.679245954	0.299682299	0	4.57592E-33	2.17499E-13	6.96856E-11	6.43864E-11
High	0.796524328	0.990145679	0.753150025	0.246292988	4.57592E-33	0	3.68458E-11	5.95784E-17	5.72837E-17
Low	0.521472739	0.582875117	0.697395769	0.633900697	2.17499E-13	3.68458E-11	0	1.28407E-29	9.39091E-30
Close	0.859543997	0.891353387	0.941170213	0.841142794	6.96856E-11	5.95784E-17	1.28406E-29	0	8.9266E-110
Adj.Close	0.625059923	0.636017755	0.674787827	0.911097992	6.43864E-11	5.72838E-17	9.39097E-30	8.934E-110	0

Figure 9.29: Audi Message Board Sentiment against VW Stock Partial Correlation P-Value (3 Months)

9.4.4 Audi Stocks and Sentiment Rolling Correlation Result Summary

No partial correlation was observed between the sentiment and stock prices across all the media sources analyzed.

Therefore, all the correlation seen in earlier sections must have not been caused by another variable in the dataset since there was no partial correlation in all the results analyzed.

9.5 Audi Stocks and Sentiments Trends

To make more sense of the correlation result we looked at the trend line of the stock values and the sentiments.

9.5.1 Audi Twitter Trend

Figures 9.30 and 9.31, showed as expected the stock(i.e VW stock) responding to events and moving as we saw in the VW section. The sentiment which is the red line on the other hand is not showing any clear pattern and appears not to be influenced by the events of the VW scandal.

The drop and rise in sentiment values are out of sync and mostly zig-zag, unlike the VW sentiment which presents flows that appear to be influenced by the vertical marker(i.e. special events of the VW timeline).

9.5.2 Audi News Trend

In Figures 9.32 and 9.33, just as observed in the VW Twitter trend analysis, the Audi VW news trend presented the same pattern of dropping in the sentiment and stock price just before the

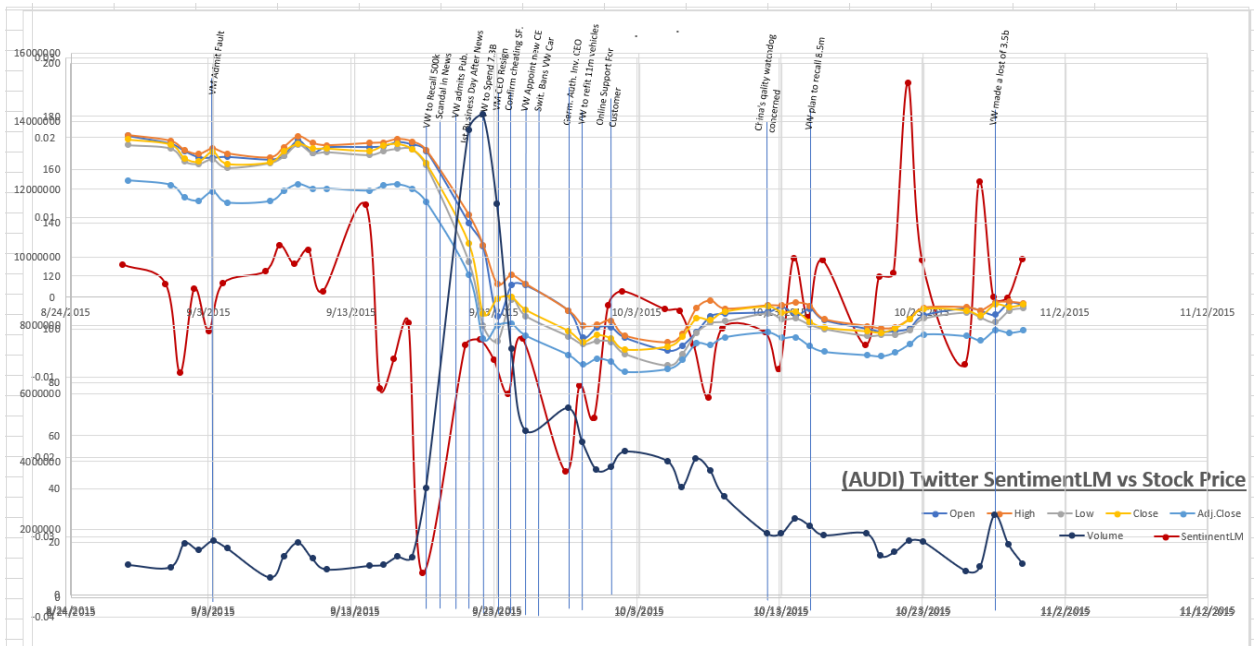


Figure 9.30: Audi Twitter SentimentLM vs Stock Values

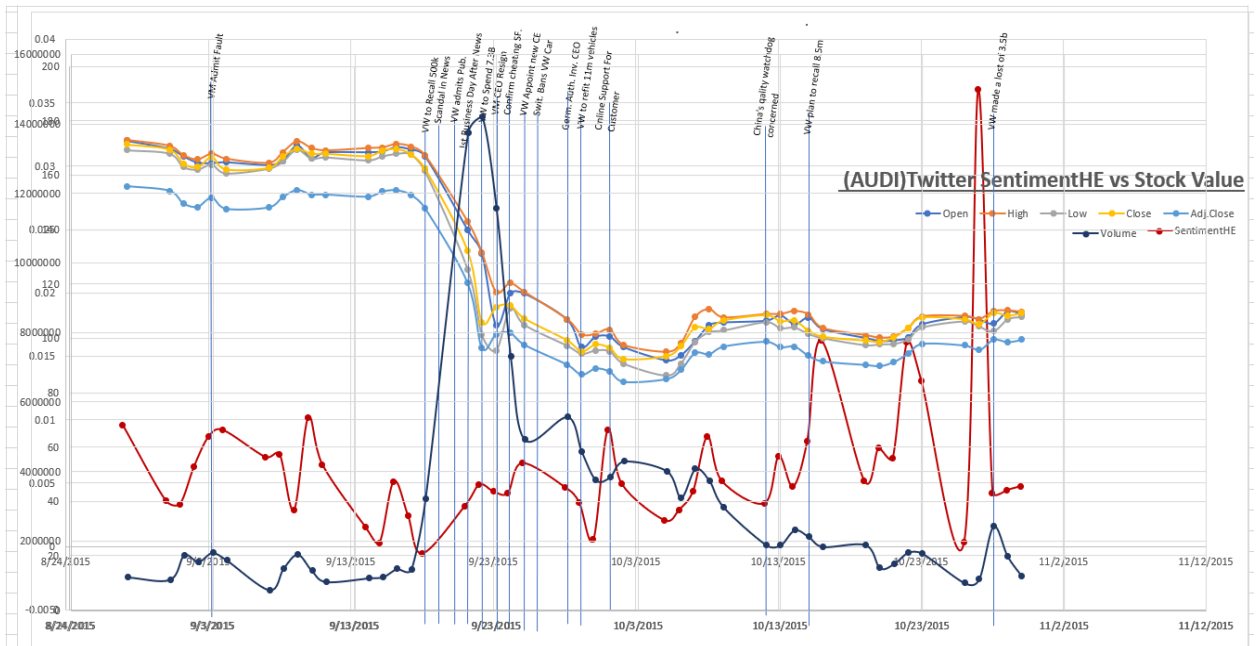


Figure 9.31: Audi Twitter SentimentHE vs Stock Values

scandal was in the news and continued response of the Audi news sentiment to events of the scandal timeline. Although, the sentiment was not closely following the news and event of the scandal as found in VW's news and Twitter trend but was the closest of all the control case brands analyzed.

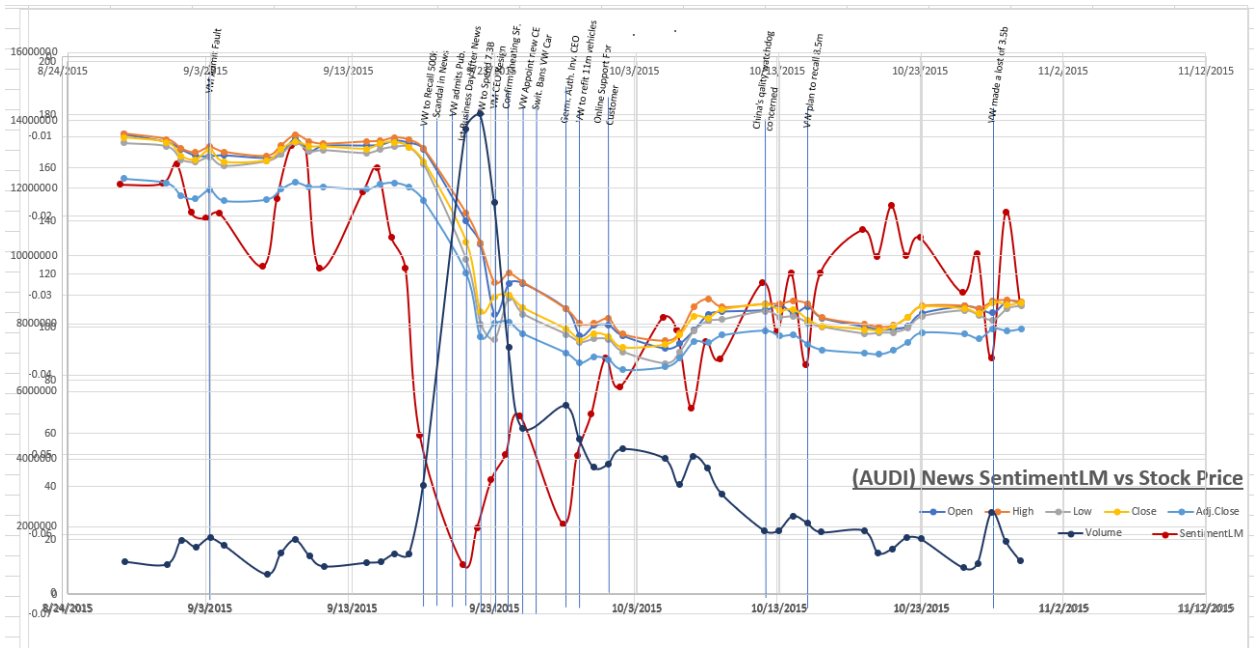


Figure 9.32: Audi News SentimentLM vs Stock Values

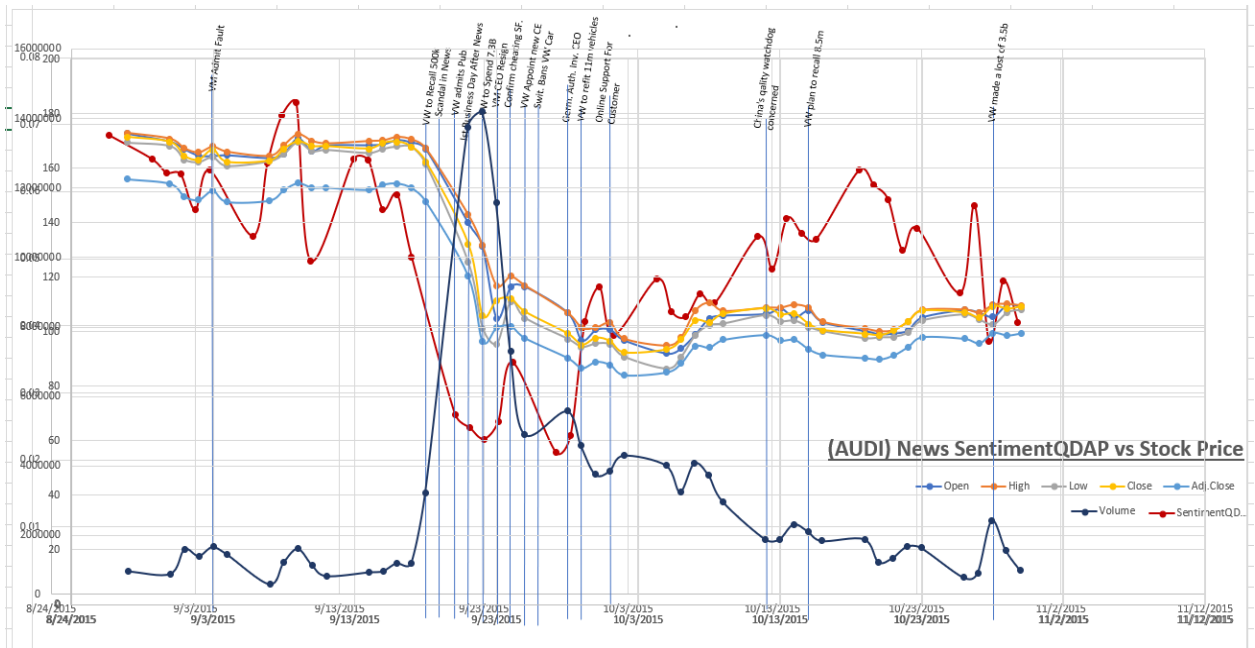


Figure 9.33: Audi News SentimentQDAP vs Stock Values

9.5.3 Audi Message Board Comment Trend

Figures 9.34 and 9.35 shows some significant changes in sentiment but the flow of the sentiment trend is not consistent with the stock trend. The news shows clearer trending with the stock value when compared to the message board trend graph. Most of the sentiment trendline here too are mostly zig-zag.

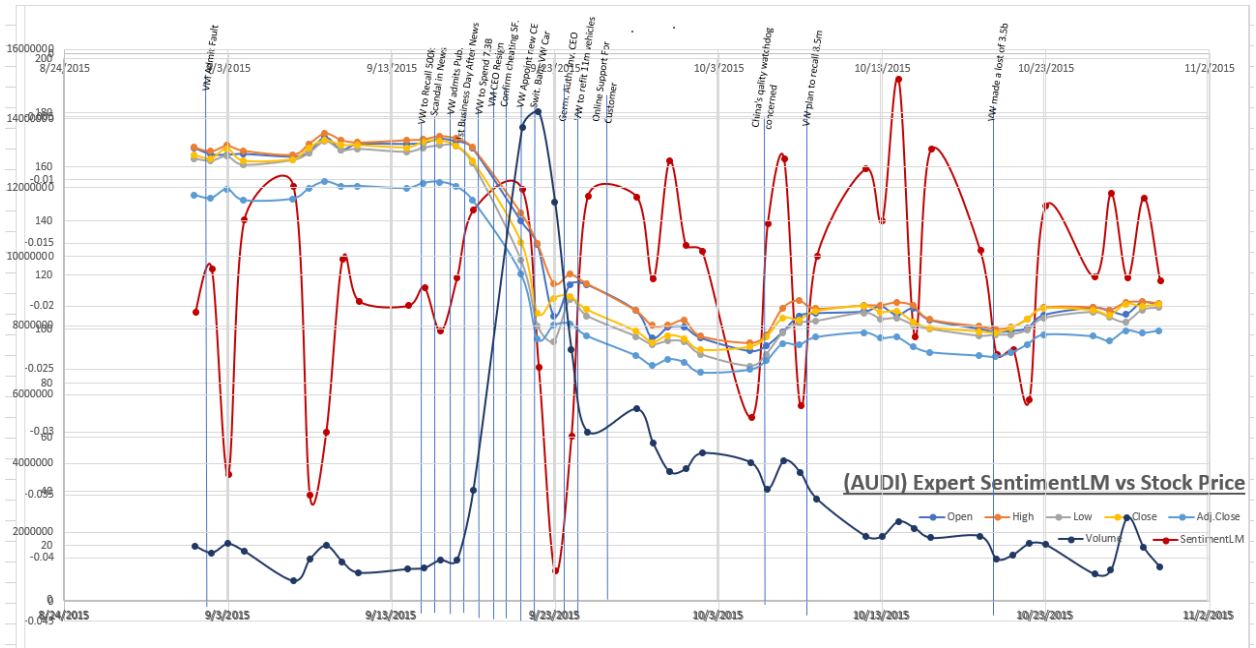


Figure 9.34: Audi Message Board SentimentLM vs Stock Values

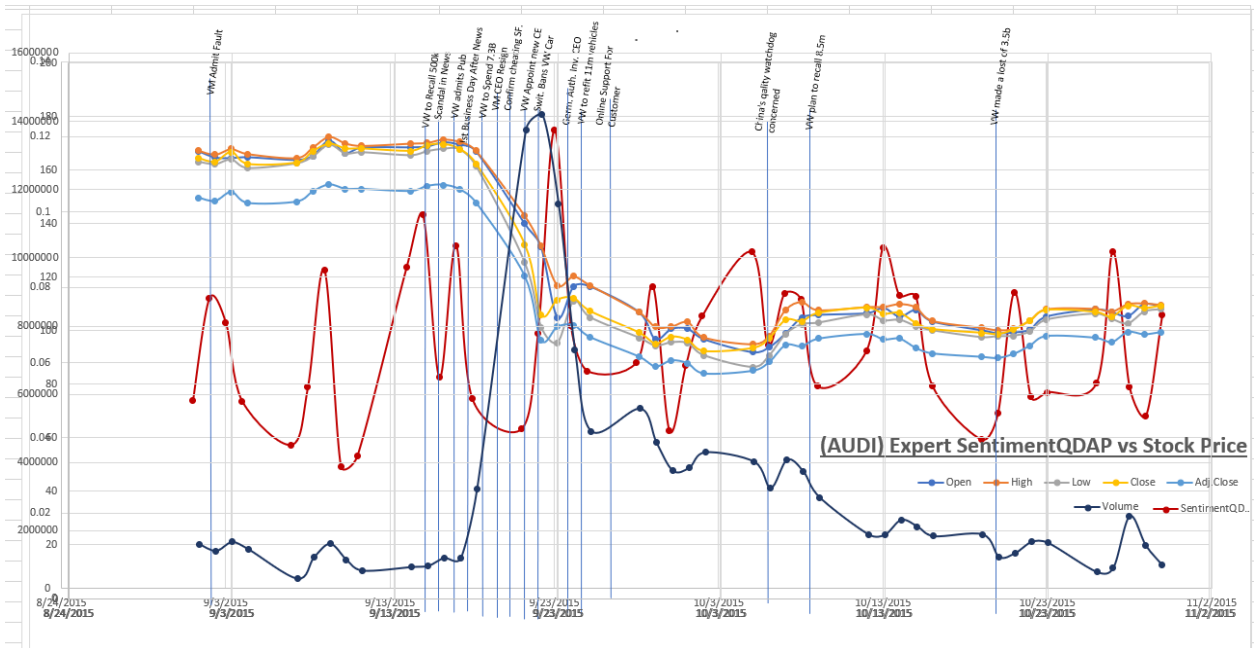


Figure 9.35: Audi Message Board SentimentQDAP vs Stock Values

9.5.4 Audi Stocks and Sentiment Trend Result Summary

The Audi news sentiment and stock values trend graph shows a pattern close to that seen in VW’s Twitter and news, but that of the Twitter and message board comment trend was not showing such a clear trend with stock values.

9.6 Audi Stocks and Sentiments Granger Causality Test Analysis

Again, we did a Granger test to help us analyze further what we saw in the trend line.

9.6.1 Audi Twitter Granger Test

As observed in Appendix X 9 months result, all causality results show the sentiment influencing the stock. SentimentLM and SentimentGI lead in accounting for the casualties result seen of stock values.

This Audi 9 months causality result was far less intense when compared to the VW Twitter 9 months result.

Similarly, in the 3 months result of the same appendix (i.e. Appendix X), the causality intensity was not as intense as the VW Twitter 3 months causal result.

9.6.2 Audi News Granger Test

The Audi news Granger results in Appendix Y has the 9 months result presenting a similar causality and even at a higher intensity than the causality found VW news 9 months period. This is a sign of a strong relationship between stock values and Audi news sentiment during the VW scandal timeline.

Similarly, 3 months result also showed higher intensity than the same dataset and period of VW.

9.6.3 Audi Message Board Comment Granger Test

Appendix Z holds the 9 months and 3 months period dataset Granger causality result. This time the causality seen in the 9 months period is lesser than that of 3 months.

This result was strange because in most cases we have seen the 9 months period presents more causality result than the 9 months.

9.6.4 Audi Stocks and Sentiment Granger Test Result Summary

While there were many lines for the Audi news, we cannot make anything of the causality in Twitter and message board 9-months results because the number of lines is quite a few.

The 3-months period presented more lines than even expected when compared to the VW 3-months causality result.

The result here is not really a replica of the VW dataset causality result. We moved to the next result analysis.

9.7 Audi Online Media Word Cloud

Next, we generated word clouds from the text posting from different Audi media sources used thus far. This we did for the whole period of the dataset (i.e. 9 months) and the period of most events of the scandal concentration (i.e. 3 months).

9.7.1 Audi Twitter Word Cloud

Figures 9.36 and 9.37 shows the word cloud result for the 9 months and 3 months period, respectively. This result showed that the scandal related work was scarce in most of the tweeted text and it seems the discussion then was not centered around the scandal activities.

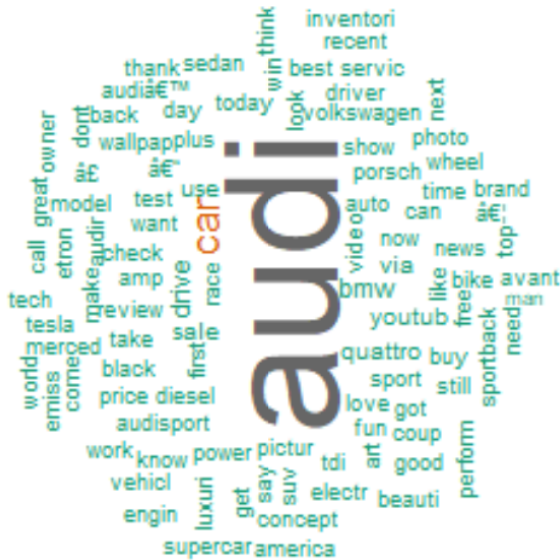


Figure 9.36: Audi Twitter Word Cloud (9 Months i.e. 28.08.15 to 06.06.16)



Figure 9.37: Audi Twitter Word Cloud (3 Months i.e. 28.09.15 to 31.12.15)

This scarcity of emission scandal related language in the Ford Twitter result was considered the reason for poor causality, out of sync trend and low correlation in the Audi data results so far.

9.7.2 Audi News Word Cloud



Figure 9.38: Audi News Word Cloud (9 Months i.e. 28.08.15 to 06.06.16)

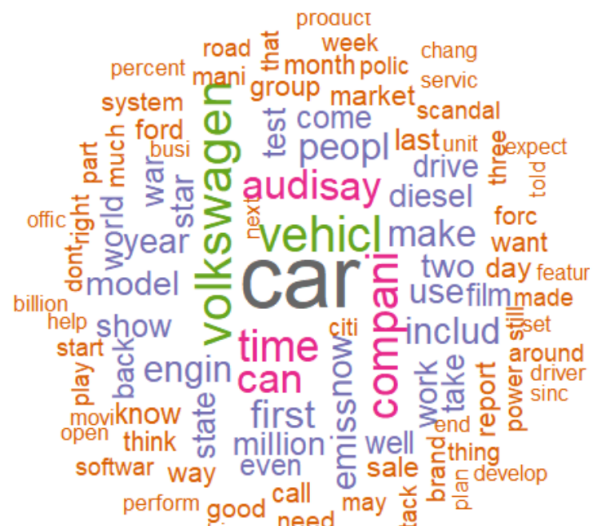


Figure 9.39: Audi News Word Cloud (3 Months i.e. 28.09.15 to 31.12.15)

Figures 9.38 and 9.39 presents the main word in the news media about the Audi brand during the emission scandal period. Words like *emiss*, *scandal* etc appear in bigger size(it should be

noted that in word clouds the bigger the size of the word the more frequent is used in the dataset) especially in the 3 months more than the 9 months dataset.

This helped explain the reason we had a good weekly correlation, better causality, and trend line results presented by the Audi news dataset.

9.7.3 Audi Message Board Word Cloud

Like all other message boards, results analyzed Figures 9.40 and 9.41 presented word cloud results that have no content related to the VW emission scandal. This explained all the results we got that did not show that the Audi message board was in sync with the scandal.



Figure 9.40: Audi Message Word Cloud (9 Months i.e. 28.08.15 to 06.06.16)

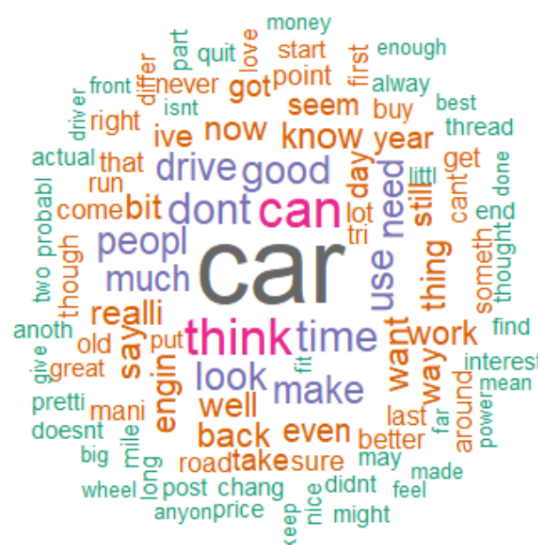


Figure 9.41: Audi Message Word Cloud (3 Months i.e. 28.09.15 to 31.12.15)

9.7.4 Audi Stocks and Sentiment Correlation Result Summary

The result shows that only the news media presents significant use of words related to the VW scandal and therefore, showed better sync of trend lines, better causality (more lines of causality between the sentiment and stock), rolling correlation, and weekly correlation result that showed results that can easily be explained by the scandal timeline.

While the Twitter and message board Audi media sources generated word clouds that show no use of words related to the scandal and this helped explain the other result that we saw of those media sources. Results like out of sync monthly correlation, weekly correlation, and no clear trend sync with the VW scandal activities can now be justified.

9.8 Audi Stocks and Sentiment Result Analysis Conclusion

The Audi brand, which is a brand under the Volkswagen presented a result that was different from the Volkswagen brand.

The Audi news dataset, which had its result closest to the VW news and Twitter dataset result did so because the discussion in it was centered around the emission scandal during the scandal timeline as we saw in the Audi news word cloud. This allow us to understand that the nature of discussion(i.e. what topic most of the texts were based on) during the scandal timeline goes a long way in determining if that sentiment will be a measure of the corporate reputation (i.e stocks values) under the influence of the scandal.

The scandal starting week and weeks of special events are the weeks of highest correlation(i.e best relationship) between the stock values and the media sentiment. This was evident in the Audi newsweekly correlation result and rolling correlation result which presents the highest during special events week.

10 Conclusion

In this thesis, we try to show how the changes in Online social media sentiment can be a measure of corporate reputation during a companies crisis timeline.

We used different datasets of different car manufacturing brands but using the period of the Volkswagen emission scandal of 2015/2016 as our focal period of analysis.

We did this by

- Analyzing the correlation between each brand sentiment for the whole period of study and stock price. Then repeat the analysis for a smaller time frame before and after the scandal is in the news.
- We recompute the correlation for the weekly time interval for the first 3 months of the dataset. This allowed us to see the immediate effect of the scandal timeline on weekly basis.
- Then, we computed the rolling correlation of the stock and sentiment combination. This we drew into a graph to see the changes in the correlation each week.
- We also computed partial correlation to see if the correlation we saw is direct or are partial i.e. as a result of influences of some other variables in the dataset.
- We analyzed the trend lines of the stock value and the sentiment from different sentiment dictionaries and took note of the days of special events and news during the heat of the emission scandal period. We kept track of sentiment changes over the trend analyzed.
- We tested causality with the Granger causality test for the combination of sentiment result from different dictionaries and all our stock values
- Finally, we generated word clouds for each dataset and that gave us a glimpse into what is actually being discussed in each media dataset.

From the analysis of the results, we came up with the following observations

- The measurement of the online media sentiment of a company in the center of scandal events/news is a measure of its reputation (i.e. stock values) when the specific media has text content centered around the scandal. This is the case of the relationship between the news and Twitter datasets of the VW brand and stock values during the scandal timeline.
- Related brands, in this case Audi, can have their sentiment as a measure of their reputation if the scandal is influencing the discussion in that related brand. This is the case of the relationship between the Audi news dataset and stock values during the scandal timeline.

- The relationship between the online media sentiment and stock values can last up two months but not beyond three months even if more same scandal related events and news are being published. This was observed in Twitter and News media of VW and News media of Audi.
- Related companies (i.e. producing similar products), that are not in crisis do not show this online media sentiment and corporate reputation relationship. This is the case of the Ford motor result analysis.
- A company can have non-scandal events that cause an increase in online media sentiment and stock correlation/relation. This is evident in the Toyota result, which is not under the influence of scandal but yet presents some reasonable out of sync with scandal correlations.
- The inception of the scandal events and weeks of special announcement always produces the highest correlation(i.e. greater measure of relationship) between the stock values and media sentiment for the brands and their media that is influenced by the scandal.

The online media being a measure of the corporate reputation at the scandal timeline is backed by the fact that the media narrative changes and its context is focused on people expressing their opinion about the company during company crises. Making the scandal a perfect time to measure and compare the relationship between online media sentiment and corporate reputation. Normally media users will choose not to express their feeling (i.e. give reputation assessment) that way or far lesser people will choose to join the discussion except they are influenced by such event as a scandal.

It is clearer now based on our observations that a brand online media context, its online media sentiment and stock trend line at the early stage of the scandal timeline are an early indicator of how much a corporation will be influenced by the scandal, and such understanding should be capitalized and used by investors, employee, corporate leaders, etc to position themselves for other consequences of the scandal down the line.

Also, the later impact should be expected as more events and news related to the scandal is unraveled as seen in our observation. Studying the early impact with correlation analysis, trend analysis, and analyzing the intensity of the scandal discussion(i.e. scandal word cloud result) can also help corporate decision-makers and other stakeholders (i.e. employee, customers, etc) to estimate the possible impact and prepare for it.

This thesis, unlike the related study [5] that wasn't conclusive, manages to show that there exists a good relationship between a company in crises and the online sentiment if the media focus its discussion around the scandal. And that this relationship grows stronger during weeks of special events and this frizzle out over time. Similarly, the same relationship exists between the sentiment and stock values(i.e reputation) in related brands whose media discussion is focused on another companies scandal during the scandal timeline.

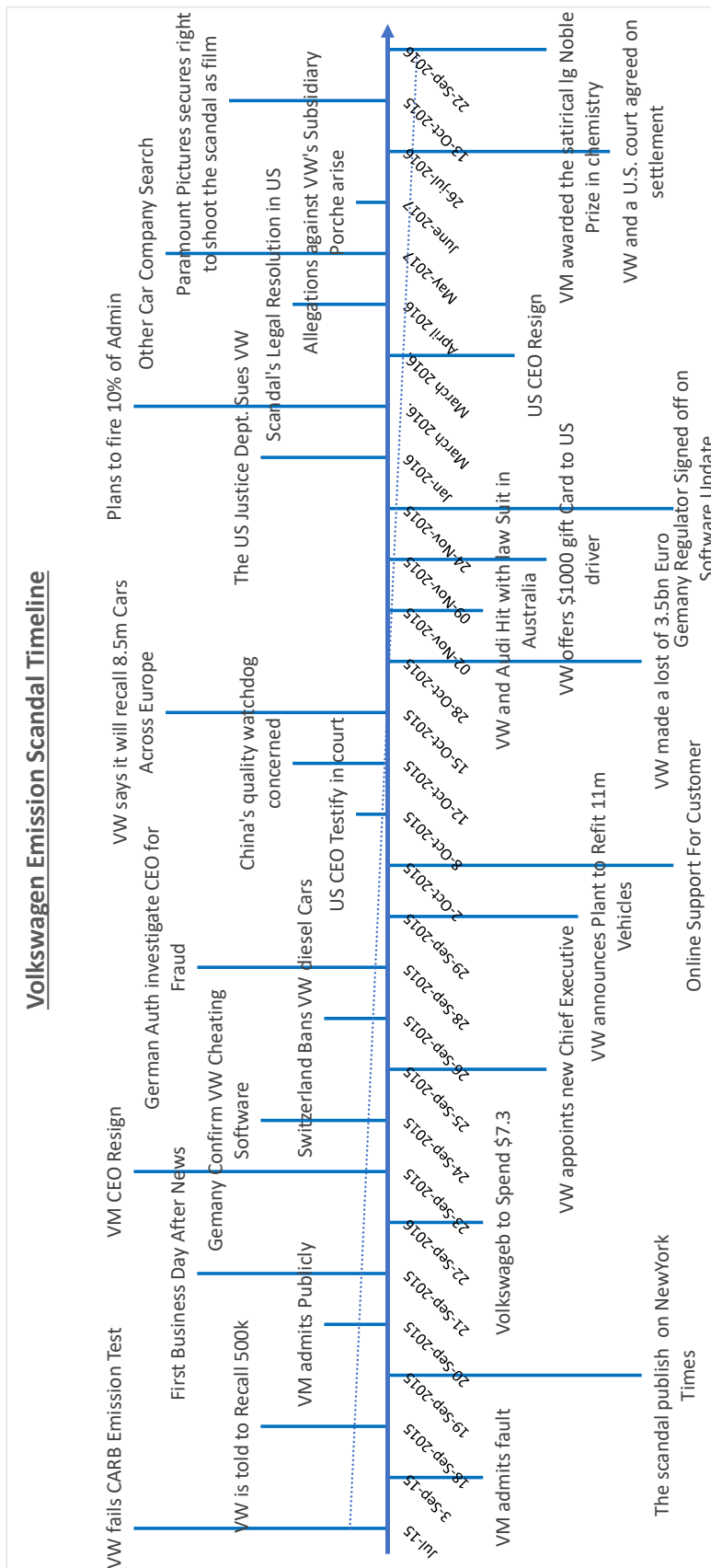
References

- [1] R. Chun, "Corporate reputation: Meaning and measurement," *International journal of management reviews*, vol. 7, no. 2, pp. 91–109, 2005.
- [2] R. Bachmann, G. Ehrlich, Y. Fan, and D. Ruzic, "Firms and collective reputation: a study of the volkswagen emissions scandal," National Bureau of Economic Research, Tech. Rep., 2019.
- [3] D. Fan, D. Geddes, and F. Flory, "The toyota recall crisis: Media impact on toyota's corporate brand reputation," *Corporate Reputation Review*, vol. 16, no. 2, pp. 99–117, 2013.
- [4] K. Ito, H. Sekiya, and M. Sakurai, "The relationship between corporate reputation and financial performance."
- [5] M.-M. Barbato and D. Montesi, "Measuring corporate reputation through online social media," 2016.
- [6] M. Etter, E. Colleoni, L. Illia, K. Meggiorin, and A. D'Eugenio, "Measuring organizational legitimacy in social media: Assessing citizens' judgments with sentiment analysis," *Business & Society*, vol. 57, no. 1, pp. 60–97, 2018.
- [7] S. Vermeer, P. Remmelswaal, and S. Jacobs, "Heineken in the house: improving online media reputation through featuring a sponsored brand community," *Communication Management Review*, vol. 2, no. 01, pp. 76–103, 2017.
- [8] G. Sinanaj, J. Muntermann, and T. Cziesla, "How data breaches ruin firm reputation on social media!-insights from a sentiment-based event study." *Wirtschaftsinformatik*, no. 2015, pp. 902–916, 2015.
- [9] N. D. Van Norel, P. A. Kommers, J. J. Van Hoof, and J. W. Verhoeven, "Damaged corporate reputation: Can celebrity tweets repair it?" *Computers in human behavior*, vol. 36, pp. 308–315, 2014.
- [10] Z. Abdullah, S. M. Nordin, and Y. A. Aziz, "Building a unique online corporate identity," *Marketing Intelligence & Planning*, vol. 31, no. 5, pp. 451–471, 2013.
- [11] D. Eberle, G. Berens, and T. Li, "The impact of interactive corporate social responsibility communication on corporate reputation," *Journal of business ethics*, vol. 118, no. 4, pp. 731–746, 2013.
- [12] A. Trotta and G. Cavallaro, "Measuring corporate reputation: A framework for italian banks," *International Journal of Economics and Finance Studies*, vol. 4, no. 1, pp. 21–30, 2012.

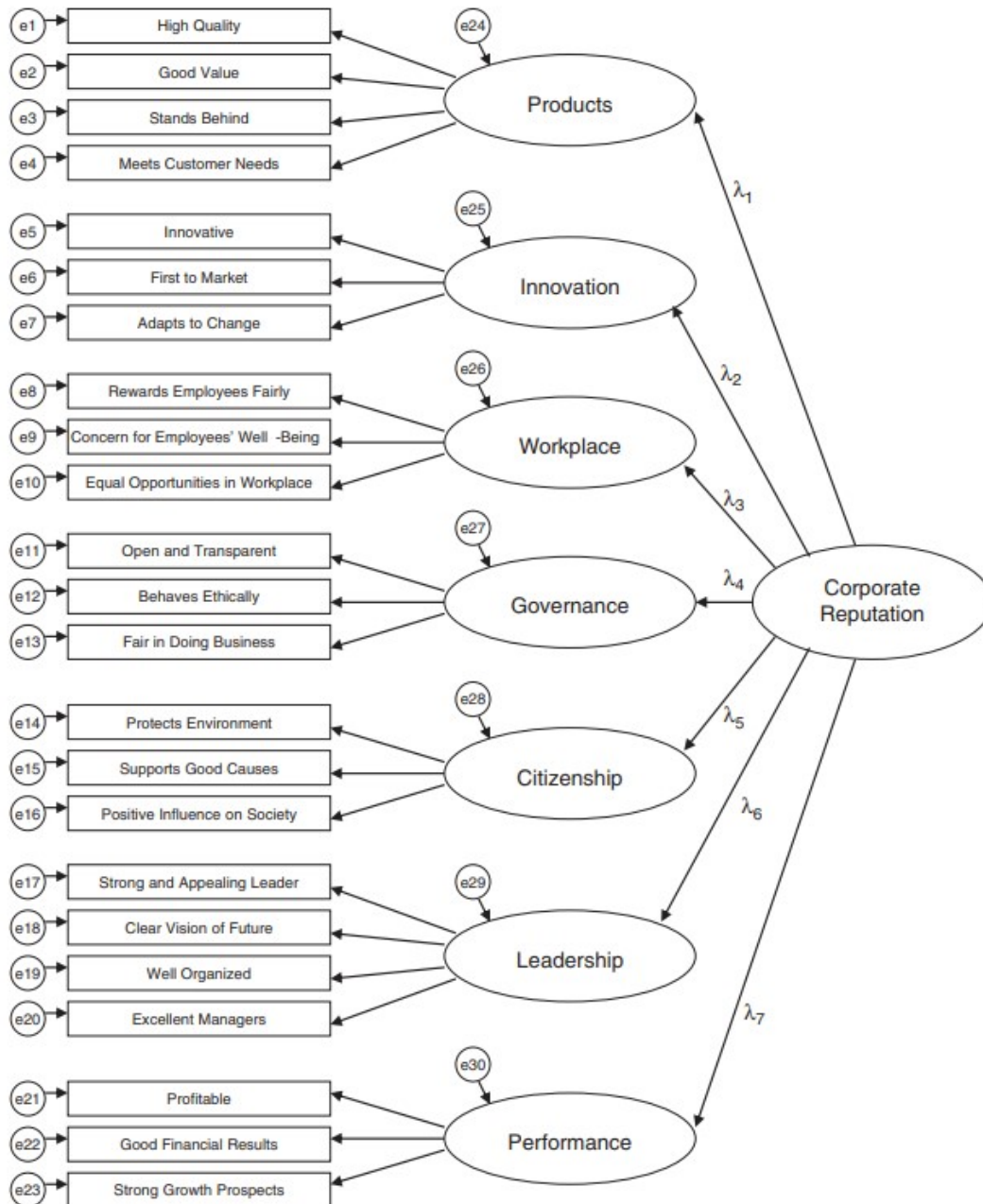
- [13] M. Gotsi and A. M. Wilson, "Corporate reputation: seeking a definition," *Corporate communications: An international journal*, 2001.
- [14] M. L. Barnett, J. M. Jermier, and B. A. Lafferty, "Corporate reputation: The definitional landscape," *Corporate reputation review*, vol. 9, no. 1, pp. 26–38, 2006.
- [15] S. L. Wartick, "Measuring corporate reputation: Definition and data," *Business & Society*, vol. 41, no. 4, pp. 371–392, 2002.
- [16] G. Geller, "A review and critique on the relation between corporate reputation, value creation and firm performance." *Amazônia, Organizações e Sustentabilidade*, vol. 3, no. 1, 2014.
- [17] M. Sarstedt, "Reputation management in times of crisis," 2009.
- [18] C. J. Fombrun, L. J. Ponzi, and W. Newburry, "Stakeholder tracking and analysis: The reptrak® system for measuring corporate reputation," *Corporate reputation review*, vol. 18, no. 1, pp. 3–24, 2015.
- [19] L. J. Ponzi, C. J. Fombrun, and N. A. Gardberg, "Reptrak™ pulse: Conceptualizing and validating a short-form measure of corporate reputation," *Corporate Reputation Review*, vol. 14, no. 1, pp. 15–35, 2011.
- [20] R. Sindhu, R. R. S. Jandail, and R. R. Kumar, "A novel approach for sentiment analysis and opinion mining," *International Journal of Emerging Technology and Advanced Engineering*, vol. 4, no. 4, 2014.
- [21] E. Horster and C. Gottschalk, "Computer-assisted webnography: A new approach to online reputation management in tourism," *Journal of Vacation Marketing*, vol. 18, no. 3, pp. 229–238, 2012.
- [22] A. Westerski, "Sentiment analysis: Introduction and the state of the art overview," *Universidad Politecnica de Madrid, Spain*, pp. 211–218, 2007.
- [23] A. Agarwal, B. Xie, I. Vovsha, O. Rambow, and R. J. Passonneau, "Sentiment analysis of twitter data," in *Proceedings of the workshop on language in social media (LSM 2011)*, 2011, pp. 30–38.
- [24] R. Feldman, "Techniques and applications for sentiment analysis," *Communications of the ACM*, vol. 56, no. 4, pp. 82–89, 2013.
- [25] J. Read, "Using emoticons to reduce dependency in machine learning techniques for sentiment classification," in *Proceedings of the ACL student research workshop*, 2005, pp. 43–48.

- [26] R. R. S. Jandail, "A proposed novel approach for sentiment analysis and opinion mining," *International Journal of UbiComp*, vol. 5, no. 1/2, p. 1, 2014.
- [27] P. Zhu and T. Qian, "Enhanced aspect level sentiment classification with auxiliary memory," in *Proceedings of the 27th International Conference on Computational Linguistics*, 2018, pp. 1077–1087.
- [28] P. W. Roberts and G. R. Dowling, "Corporate reputation and sustained superior financial performance," *Strategic management journal*, vol. 23, no. 12, pp. 1077–1093, 2002.
- [29] C. Dijkmans, P. Kerkhof, and C. J. Beukeboom, "A stage to engage: Social media use and corporate reputation," *Tourism management*, vol. 47, pp. 58–67, 2015.
- [30] E. L. Rossi, "The ideodynamic action hypothesis of therapeutic suggestion: Creative replay in the psychosocial genomics of therapeutic hypnosis." *European Journal of Clinical Hypnosis*, vol. 6, no. 2, 2005.
- [31] C. Guizlo, "'dealing with jell-o': How framing and agenda setting affected public opinion in the 2011 debt ceiling debate," *Retrieved on January*, vol. 12, p. 2013, 2012.
- [32] C. A. Massart, "Agenda-setting and mathematically predictable mass behavior." 2010.
- [33] A. R. Tims, D. P. Fan, and J. R. Freeman, "The cultivation of consumer confidence: A longitudinal analysis of news media influence on consumer sentiment," *ACR North American Advances*, 1989.
- [34] C. E. Carroll, "How the mass media influence perceptions of corporate reputation: Exploring agenda-setting effects within business news coverage," Ph.D. dissertation, 2004.
- [35] S. Meraz, "Using time series analysis to measure intermedia agenda-setting influence in traditional media and political blog networks," *Journalism & mass communication quarterly*, vol. 88, no. 1, pp. 176–194, 2011.
- [36] T. Rinker, "Package 'sentimentr'," *Retrieved*, vol. 8, p. 31, 2017.
- [37] O. O. Awe, "On pairwise granger causality modelling and econometric analysis of selected economic indicators," *Interstata journals. net/YEAR/2012/articles/1208002. pdf*, 2012.
- [38] M. Eichler, *Causal inference in time series analysis*. Wiley Online Library, 2012.
- [39] S. Lohmann, F. Heimerl, F. Bopp, M. Burch, and T. Ertl, "Concentri cloud: Word cloud visualization for multiple text documents," in *2015 19th International Conference on Information Visualisation*. IEEE, 2015, pp. 114–120.
- [40] F. Heimerl, S. Lohmann, S. Lange, and T. Ertl, "Word cloud explorer: Text analytics based on word clouds," in *2014 47th Hawaii International Conference on System Sciences*. IEEE, 2014, pp. 1833–1842.

A Volkswagen Emission Timeline



B Hypothetical model of corporate reputation. The RepTrak® System for Measuring Corporate by C. Fombrun L. J Ponzi W. Newbury [18]



C VW Twitter Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.318422697	0.895803264	-0.073893169	0.113080873	Open	-0.557956031	-0.292381955	-0.534855982	-0.277653624
High	0.188983224	0.844912322	-0.160707942	-0.0681263	High	-0.153820717	-0.189407079	-0.152401466	0.051064094
Low	0.39383244	0.86874967	-0.283050816	0.064244748	Low	-0.349699226	-0.260936033	-0.335462195	-0.096991575
Close	0.264170159	0.754995137	-0.208496577	-0.010987978	Close	-0.232037904	-0.101154451	-0.227794352	-0.079042538
Adj.Close	0.264169557	0.754995402	-0.208497582	-0.010989123	Adj.Close	-0.232040272	-0.101150002	-0.227797634	-0.079045581
Volume	-0.213175539	-0.966162532	0.627184093	0.278231696	Volume	0.171086202	-0.522705355	0.221396136	0.437016573

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.881629923	0.42148339	0.882964388	0.862983018	Open	0.682832146	-0.843451716	0.103447524	-0.489081914
High	0.847075127	0.631749889	0.956906654	0.947185651	High	0.714622595	-0.927573024	-0.161040255	-0.702031923
Low	0.89316554	0.589178514	0.97680943	0.965814823	Low	0.840599915	-0.792956406	0.208434195	-0.33719898
Close	0.732738466	0.725767216	0.931449139	0.923321735	Close	0.863029474	-0.78224407	-0.143272348	-0.559500806
Adj.Close	0.73273891	0.725766648	0.931449119	0.923321671	Adj.Close	0.863029452	-0.782244404	-0.143272528	-0.559501145
Volume	-0.687132994	-0.879360321	-0.947855905	-0.95901179	Volume	0.208054484	-0.663319384	-0.697244552	-0.885196408

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.207194808	-0.482362426	-0.299962174	-0.744155881	Open	-0.59551924	-0.106764914	0.501973441	-0.721754441
High	0.554583358	-0.631506743	-0.297735495	-0.84060428	High	-0.326090968	0.046183652	0.321483658	-0.428840999
Low	0.406233137	-0.853252298	0.037265545	-0.614481874	Low	-0.417183347	-0.091190103	0.354377064	-0.60328819
Close	0.235956417	-0.844490841	0.084277372	-0.551832007	Close	-0.245894925	-0.271473606	0.291692884	-0.533701534
Adj.Close	0.235956373	-0.844490973	0.084277673	-0.551831834	Adj.Close	-0.245895023	-0.271474114	0.291692719	-0.533702027
Volume	0.466196482	-0.013324811	-0.77147683	-0.729346895	Volume	0.440832085	0.308959589	0.085315013	0.854148883

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.439896042	-0.114685832	-0.718696095	0.02384839	Open	-0.084447808	-0.89676978	-0.145636393	-0.154990172
High	-0.888468363	-0.762305035	-0.417719083	-0.191322751	High	-0.305394905	-0.942469671	-0.171045736	-0.171670646
Low	-0.918931227	-0.524057658	-0.485153088	-0.778689661	Low	-0.14635455	-0.919479934	-0.027008021	0.014429012
Close	-0.954102125	-0.599407058	-0.419914636	-0.759098788	Close	-0.403295629	-0.893975491	-0.056107872	-0.089068501
Adj.Close	-0.954102582	-0.599408228	-0.419914462	-0.759097802	Adj.Close	-0.403295511	-0.893975455	-0.056107612	-0.089068159
Volume	-0.418939238	-0.809986955	0.255653062	0.336385311	Volume	-0.498839537	-0.369543433	-0.758982056	-0.964863116

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.701029228	0.686794436	0.635666077	0.747900198	Open	-0.864138622	0.570223884	-0.266832449	-0.868523587
High	-0.444253436	-0.47068123	-0.544196626	-0.404561466	High	-0.83946268	0.603323113	-0.248152879	-0.850820727
Low	0.636360503	0.736731882	0.664706014	0.763339448	Low	-0.732127925	0.652780881	-0.090883751	-0.763933797
Close	-0.604688934	-0.528208942	-0.61847406	-0.497731694	Close	-0.75291118	0.653076432	-0.097851255	-0.775623193
Adj.Close	-0.604688704	-0.528209049	-0.618474121	-0.497731686	Adj.Close	-0.752911404	0.653076026	-0.097851664	-0.775623464
Volume	-0.819060349	-0.941874923	-0.940804391	-0.903431041	Volume	0.057170329	-0.764479641	-0.659689999	0.081912699

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.708072429	0.279006825	-0.198030158	0.592897895	Open	-0.717031726	0.88142539	-0.707974407	-0.889042747
High	-0.594973979	-0.789540079	-0.897940786	-0.5978606	High	-0.595359242	0.907326708	-0.695273187	-0.817872174
Low	0.070104114	0.362916784	-0.497733263	0.667943635	Low	-0.65455889	0.887982484	-0.73094678	-0.878100738
Close	-0.825268399	-0.395048986	-0.752704021	-0.275958538	Close	-0.592475165	0.910200197	-0.665165294	-0.79334114
Adj.Close	-0.825266437	-0.395041813	-0.752704858	-0.275948895	Adj.Close	-0.592474976	0.910200349	-0.665165135	-0.793340832
Volume	-0.127472363	-0.559128611	-0.626006081	-0.299067953	Volume	-0.441480848	0.793362657	-0.602957261	-0.733752504

D VW News Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.17927774	-0.966203887	-0.984472985	-0.918205258	Open	-0.037475224	-0.241490403	0.492951687	0.317454203
High	0.088535088	-0.78925868	-0.857847589	-0.764829824	High	-0.238088532	-0.006308831	0.41342871	0.342076455
Low	-0.02859135	-0.7983978	-0.803618328	-0.801106047	Low	-0.157758175	-0.121518845	0.46681395	0.343923245
Close	0.076193965	-0.652812623	-0.714433157	-0.689824751	Close	-0.259747542	-0.134203331	0.268382225	0.178210329
Adj.Close	0.076195141	-0.652812596	-0.714432874	-0.689824054	Adj.Close	-0.259742278	-0.134201492	0.268384649	0.178212139
Volume	-0.22037133	0.914707552	0.738274544	0.566719681	Volume	-0.524974451	0.073954209	0.365547209	0.381504335

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.829870616	0.711221798	0.780353521	0.652362485	Open	0.649130748	-0.395703509	-0.1798152	0.485885637
High	0.824234326	0.856407526	0.911473679	0.804402042	High	0.592262174	-0.588543102	-0.418618625	0.351284243
Low	0.675812592	0.850365322	0.893524573	0.728421241	Low	0.542861146	-0.097011017	-0.034318478	0.578918446
Close	0.704946703	0.944638527	0.955806637	0.857131967	Close	0.521193334	-0.316977484	-0.312036897	0.415784576
Adj.Close	0.704948721	0.944638051	0.955806475	0.857132147	Adj.Close	0.521193363	-0.316977884	-0.312037183	0.415784465
Volume	-0.63329017	-0.954253644	-0.981067571	-0.90380432	Volume	0.159524875	-0.913991634	-0.809240346	-0.239753532

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.42246493	-0.270324989	-0.79772007	-0.38901646	Open	-0.928109343	-0.714668584	-0.624979421	-0.581803864
High	-0.44340774	-0.492176428	-0.791099443	-0.416048185	High	-0.834358127	-0.930562385	-0.817126929	-0.333153899
Low	-0.3015452	-0.429826014	-0.642380374	-0.287474273	Low	-0.877444508	-0.839330198	-0.739466025	-0.46248958
Close	-0.29772888	-0.347986318	-0.65226732	-0.28310109	Close	-0.756508144	-0.814967326	-0.672125635	-0.330127023
Adj.Close	-0.29772854	-0.347986106	-0.652267028	-0.283100755	Adj.Close	-0.756508079	-0.814966884	-0.672125291	-0.330127372
Volume	-0.9417012	-0.773725767	-0.936702618	-0.922558556	Volume	0.411597188	-0.103234254	0.05470525	0.742939573

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.047213431	-0.673005527	-0.668389337	-0.042739568	Open	-0.639470754	0.411313356	-0.115349293	-0.626316347
High	-0.15602198	-0.700239016	-0.468607144	-0.480243658	High	-0.810152649	0.432166258	-0.302529563	-0.796262777
Low	0.252308964	-0.428954006	0.185253362	-0.559524123	Low	-0.746089268	0.292374471	-0.277619103	-0.710252677
Close	0.135364385	-0.525688113	0.114396847	-0.641090087	Close	-0.89416005	0.317377569	-0.468668381	-0.872397913
Adj.Close	0.135363848	-0.525688188	0.114396001	-0.641090045	Adj.Close	-0.894160052	0.317377306	-0.468668489	-0.872397874
Volume	-0.52022696	-0.300591905	-0.450936635	-0.310233656	Volume	-0.285670861	0.831157097	0.126784045	-0.391675258

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.516592076	0.683923231	0.83364614	0.755578651	Open	-0.169501721	0.238808904	-0.376910462	-0.283223324
High	-0.32661467	0.773611121	-0.182819052	-0.16044021	High	-0.145458927	0.282639777	-0.402912546	-0.269050354
Low	0.488490933	0.518287045	0.880644681	0.716502746	Low	0.059380729	0.471979416	-0.267780714	-0.098605924
Close	-0.41437209	0.585446849	-0.254738736	-0.282970173	Close	0.024904149	0.43260313	-0.251052537	-0.107142914
Adj.Close	-0.41437196	0.585447508	-0.254738794	-0.282969967	Adj.Close	0.024904106	0.432603025	-0.251052821	-0.107143266
Volume	-0.60635156	0.254199948	-0.834695645	-0.652994761	Volume	-0.609358962	-0.810685317	-0.528744385	-0.666399106

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.667162272	0.186054156	-0.43685419	0.376584485	Open	0.518259703	0.322984251	-0.222217612	0.493786486
High	-0.75018858	-0.802989306	-0.665574532	-0.893128576	High	0.493526889	0.224172085	-0.238093536	0.456253645
Low	0.532359136	0.225752821	-0.151863345	0.247730094	Low	0.475484937	0.251381221	-0.26932844	0.445425763
Close	-0.53658129	-0.499273196	-0.240778746	-0.650562648	Close	0.522138062	0.239934601	-0.20185751	0.483692823
Adj.Close	-0.53657342	-0.499271048	-0.240780195	-0.650558597	Adj.Close	0.522138161	0.239934618	-0.201857296	0.483692899
Volume	-0.40044601	-0.860138445	-0.96087692	-0.716443672	Volume	0.459540285	0.076332262	-0.246730645	0.412777687

E VW Message Board Sentiment vs Stock values Weekly Correlation

01-09-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.996904105	-0.366468265	-0.546789499	0.015016583	Open	0.203884991	0.675247601	0.446083708	0.507528067
High	0.30584148	0.683499538	0.455964677	0.561634807	High	0.249038404	0.817438295	0.602078906	0.381552721
Low	0.1903522	0.842893008	0.706251249	0.05825271	Low	0.240209532	0.770003938	0.534164853	0.457125742
Close	0.016430222	0.903793726	0.751374978	0.346720417	Close	0.071180127	0.757527574	0.613214736	0.236530122
Adj.Close	0.016428185	0.903794363	0.751375922	0.34672083	Adj.Close	0.071181173	0.757529975	0.613218644	0.236532465
Volume	0.322352267	0.654820448	0.42137385	0.593919422	Volume	0.370109841	0.635275622	0.277155109	0.336788566
14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.657814014	-0.901174691	-0.453186796	-0.378989266	Open	-0.682122022	-0.434704016	0.348286396	-0.559291859
High	-0.722436954	-0.928323452	-0.66313167	-0.447397704	High	-0.805966253	-0.505162473	0.089469441	-0.667630385
Low	-0.56598259	-0.821490423	-0.642149867	-0.241864779	Low	-0.861792993	-0.240450172	0.118403217	-0.177385468
Close	-0.715920812	-0.873034969	-0.750592967	-0.38202051	Close	-0.891468454	-0.19726351	-0.180320126	-0.253828065
Adj.Close	-0.715922223	-0.873036342	-0.750592244	-0.382022375	Adj.Close	-0.891468631	-0.197263939	-0.180320093	-0.253828558
Volume	0.645659779	0.781084373	0.917133339	0.424834013	Volume	-0.501918272	-0.61667532	-0.326072409	-0.869753789
28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.261787208	-0.395103622	-0.149325058	-0.651444591	Open	-0.048968625	0.527258982	-0.555803341	-0.560247304
High	0.441937413	-0.593223894	-0.146926236	-0.589214005	High	-0.292661546	0.564394864	-0.78739124	-0.828223631
Low	0.695555345	-0.554781646	-0.29150851	-0.387942083	Low	-0.08776208	0.543470943	-0.713962691	-0.688948604
Close	0.663197189	-0.490372333	-0.342044324	-0.410666049	Close	-0.007105858	0.396088242	-0.798551771	-0.626757953
Adj.Close	0.663197478	-0.49037213	-0.342044192	-0.41066569	Adj.Close	-0.007104966	0.396088095	-0.79855145	-0.626757351
Volume	-0.396404491	-0.776429779	-0.363581051	-0.987394915	Volume	-0.889007231	-0.298587078	-0.17412249	-0.279515046
12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.308942519	0.462671251	0.59123974	0.445409717	Open	-0.407270064	-0.625969244	-0.796765807	-0.404410376
High	0.383184474	0.705810535	0.631719343	0.157848751	High	-0.161579005	-0.675441538	-0.682749538	-0.32375086
Low	0.889746158	0.915713113	0.932447441	0.572591112	Low	-0.160462019	-0.619832556	-0.660365031	-0.195521947
Close	0.85375344	0.949814529	0.927503804	0.57832513	Close	-0.013610613	-0.585542878	-0.535877144	-0.179212297
Adj.Close	0.853752556	0.94981419	0.927503177	0.578323571	Adj.Close	-0.013610399	-0.585542788	-0.535876981	-0.179211975
Volume	-0.357767514	0.062606791	-0.185320664	-0.615716587	Volume	-0.488560466	-0.449545217	-0.561518618	-0.905486528
26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.067811652	0.879505042	0.828322125	-0.357862759	Open	-0.143144244	0.411799932	-0.167187988	0.055624997
High	0.604428414	0.320952376	0.476262565	0.167865984	High	-0.074113281	0.439550389	-0.128094074	0.067838979
Low	-0.084512055	0.703914245	0.833864494	-0.236741211	Low	-0.119318628	0.400730084	-0.257728231	-0.113105526
Close	0.502726599	0.065183039	0.393281433	0.344259179	Close	-0.173108096	0.413893183	-0.26440138	-0.103397245
Adj.Close	0.502727136	0.065183681	0.393281558	0.344258828	Adj.Close	-0.17310788	0.413892739	-0.26440152	-0.103397242
Volume	0.590416978	-0.258446816	-0.27891832	0.307699925	Volume	0.591513829	-0.382426156	0.574680827	0.657735078
09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.287000823	0.111788944	-0.301420462	-0.69466589	Open	0.924527895	-0.538906033	0.974676361	0.741462968
High	-0.395143247	0.756796522	0.720914581	0.352695713	High	0.977313059	-0.481183569	0.944049494	0.837923251
Low	-0.240185419	0.038107188	-0.053464535	-0.673336767	Low	0.953203547	-0.549581506	0.958431176	0.796852079
Close	-0.531865977	0.464970218	0.546798567	0.26170907	Close	0.977287192	-0.441880903	0.945446971	0.835064142
Adj.Close	-0.531861632	0.464971526	0.546791663	0.261704203	Adj.Close	0.977287217	-0.441880572	0.945446856	0.835064203
Volume	0.349211614	0.967348594	0.137336865	0.328460145	Volume	0.983706084	-0.401969232	0.900055322	0.899830239

F Granger Test Result VW Twitter Sentiments against VW Stock Result

Test	Null Hypothesis Statement(i, e Ho)	Order1_P	Order1_conclusion	Order2_P	Order2_conclusion	Order3_P	Order3_conclusion	Order4_P	Order4_conclusion	Order5_P	Order5_conclusion	Order6_P	Order6_conclusion
6	Open / SentimentLM	0.227525014	Ho Accepted	0.427292162	Ho Accepted	0.031498445	Ho Rejected	0.061539197	Ho Accepted	0.081446869	Ho Accepted	0.042680317	Ho Rejected
8	Open / SentimentQDAP	0.829450102	Ho Accepted	0.248241785	Ho Accepted	0.084183915	Ho Accepted	0.134239189	Ho Accepted	0.213863036	Ho Accepted	0.043663842	Ho Rejected
14	High / SentimentLM	0.013090483	Ho Rejected	0.028798698	Ho Rejected	0.00286564	Ho Rejected	0.006308459	Ho Rejected	0.002371906	Ho Rejected	0.002621753	Ho Rejected
16	High / SentimentQDAP	0.053517183	Ho Accepted	0.013815416	Ho Accepted	0.021104172	Ho Rejected	0.041464644	Ho Rejected	0.022783721	Ho Rejected	0.00926571	Ho Rejected
17	SentimentGI / Low	0.008304073	Ho Rejected	0.022428609	Ho Rejected	0.088654593	Ho Accepted	0.096530653	Ho Accepted	0.177929456	Ho Accepted	0.269951875	Ho Accepted
18	low / SentimentGI	0.013124344	Ho Rejected	0.036451547	Ho Rejected	0.048759555	Ho Rejected	0.102822824	Ho Accepted	0.035714815	Ho Rejected	0.056513955	Ho Accepted
21	low / SentimentQDAP	0.598147569	Ho Accepted	0.016131049	Ho Rejected	0.013582619	Ho Rejected	0.005423582	Ho Rejected	0.006509442	Ho Rejected	0.006762747	Ho Rejected
24	low / SentimentQDAP	0.497433998	Ho Accepted	0.099827702	Ho Accepted	0.019285166	Ho Rejected	0.033174068	Ho Rejected	0.038337966	Ho Rejected	0.039735615	Ho Rejected
25	SentimentGI / Close	0.017898774	Ho Rejected	0.115434339	Ho Accepted	0.238774521	Ho Accepted	0.219964142	Ho Accepted	0.34908777	Ho Accepted	0.39907638	Ho Accepted
26	Close / SentimentGI	0.002681579	Ho Rejected	0.015620257	Ho Accepted	0.030319756	Ho Rejected	0.046750465	Ho Rejected	0.045690072	Ho Rejected	0.041444364	Ho Rejected
28	Close / SentimentHE	0.031594937	Ho Rejected	0.125271987	Ho Accepted	0.063615305	Ho Accepted	0.09498355	Ho Accepted	0.162358977	Ho Accepted	0.180165517	Ho Accepted
30	Close / SentimentLM	0.246803821	Ho Accepted	0.009547361	Ho Rejected	0.001557461	Ho Rejected	0.00248027	Ho Rejected	0.005199322	Ho Rejected	0.003428005	Ho Rejected
32	Close / SentimentQDAP	0.54653596	Ho Accepted	0.012099629	Ho Rejected	0.002892155	Ho Rejected	0.009145829	Ho Rejected	0.01695972	Ho Rejected	0.004586755	Ho Rejected
33	SentimentGI / Adj.Close	0.015249365	Ho Rejected	0.0976513	Ho Accepted	0.218670059	Ho Accepted	0.193413566	Ho Accepted	0.309683405	Ho Accepted	0.382601016	Ho Accepted
34	Adj.Close / SentimentGI	0.001804025	Ho Rejected	0.010247721	Ho Rejected	0.019298514	Ho Rejected	0.031642231	Ho Rejected	0.031312258	Ho Rejected	0.028689264	Ho Accepted
36	Adj.Close / SentimentHE	0.084333151	Ho Rejected	0.124426414	Ho Accepted	0.064065767	Ho Rejected	0.095218064	Ho Rejected	0.164134683	Ho Rejected	0.191136271	Ho Accepted
38	Adj.Close / SentimentLM	0.220121887	Ho Accepted	0.008619658	Ho Rejected	0.001580744	Ho Rejected	0.002761324	Ho Rejected	0.005854574	Ho Rejected	0.003855574	Ho Rejected
40	Adj.Close / SentimentQDAP	0.512327395	Ho Accepted	0.011186071	Ho Rejected	0.009273667	Ho Rejected	0.009714689	Ho Rejected	0.020280743	Ho Rejected	0.006376749	Ho Rejected
42	Volume / SentimentGI	0.50509442	Ho Accepted	0.048785927	Ho Rejected	0.066494027	Ho Accepted	0.127298532	Ho Accepted	0.198644403	Ho Accepted	0.146477269	Ho Accepted
44	SentimentHE / Volume	0.028186532	Ho Rejected	0.076517295	Ho Accepted	0.086674297	Ho Accepted	0.231190007	Ho Accepted	0.35627571	Ho Accepted	0.471306948	Ho Accepted
46	Volume / SentimentLM	0.021389511	Ho Rejected	0.050896972	Ho Accepted	0.062696539	Ho Accepted	0.07992613	Ho Accepted	0.12514743	Ho Accepted	0.112446098	Ho Accepted

Granger Test Result with Rejection in the VW Twitter Sentiments against VW Stock (9 Months)

7	SentimentQDAP / Open	0.058991671	Ho Accepted	0.067028664	Ho Accepted	0.030966075	Ho Rejected	0.079411979	Ho Accepted	0.129650408	Ho Accepted	0.208879356	Ho Accepted
8	Open / SentimentQDAP	0.764962104	Ho Accepted	0.479063212	Ho Accepted	0.336333364	Ho Accepted	0.277460231	Ho Accepted	0.189787301	Ho Accepted	0.032345192	Ho Rejected
18	Low / SentimentGI	0.416646484	Ho Accepted	0.419035927	Ho Accepted	0.65075138	Ho Accepted	0.118718113	Ho Accepted	0.185234164	Ho Accepted	0.094635747	Ho Rejected
23	SentimentQDAP / Low	0.094139554	Ho Accepted	0.077371399	Ho Accepted	0.030207929	Ho Rejected	0.031594175	Ho Rejected	0.07405477	Ho Accepted	0.127696277	Ho Rejected
41	SentimentGI / Volume	0.037746098	Ho Rejected	0.09454128	Ho Rejected	0.043357805	Ho Rejected	0.097676725	Ho Accepted	0.174424942	Ho Accepted	0.249042347	Ho Accepted
46	Volume / SentimentLM	0.324104803	Ho Accepted	0.031528342	Ho Rejected	0.015645662	Ho Rejected	0.020495892	Ho Rejected	0.042042297	Ho Rejected	0.066162582	Ho Accepted

Granger Test Result with Rejection in the VW Twitter Sentiments against VW Stock (3 Months)

G Granger Test Result VW News Sentiments against VW Stock Result

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
17	SentimentGI / Low	0.001446817	Ho Rejected	0.004677	Ho Rejected	0.016062	Ho Rejected	0.03926949	Ho Rejected	0.116622082	Ho Accepted	0.306071	Ho Accepted
20	Low / SentimentHE	0.035913976	Ho Rejected	0.601432	Ho Accepted	0.605778	Ho Accepted	0.723007814	Ho Accepted	0.890210523	Ho Accepted	0.943789	Ho Accepted
22	Low / SentimentLM	0.769578661	Ho Accepted	0.044944	Ho Rejected	0.055257	Ho Accepted	0.035204761	Ho Rejected	0.08546273	Ho Accepted	0.100044	Ho Accepted
23	SentimentQDAP / Low	0.002390205	Ho Rejected	0.004952	Ho Rejected	0.036042	Ho Rejected	0.104208807	Ho Rejected	0.182972151	Ho Accepted	0.327985	Ho Accepted
25	SentimentGI / Close	0.002404693	Ho Rejected	0.007645	Ho Rejected	0.030782	Ho Rejected	0.044121353	Ho Rejected	0.128849913	Ho Accepted	0.331043	Ho Accepted
28	Close / SentimentHE	0.020743327	Ho Rejected	0.404776	Ho Accepted	0.506597	Ho Accepted	0.735833982	Ho Accepted	0.657897704	Ho Accepted	0.684289	Ho Accepted
31	SentimentQDAP / Close	0.004672535	Ho Rejected	0.011669	Ho Rejected	0.079842	Ho Accepted	0.162940453	Ho Accepted	0.273040991	Ho Accepted	0.428238	Ho Accepted
33	SentimentGI / Adj.Close	0.020212879	Ho Rejected	0.006252	Ho Rejected	0.026437	Ho Rejected	0.039017276	Ho Rejected	0.116746144	Ho Accepted	0.307749	Ho Accepted
36	Adj.Close / SentimentHE	0.024808925	Ho Rejected	0.435396	Ho Accepted	0.554687	Ho Accepted	0.77477502	Ho Accepted	0.267292396	Ho Accepted	0.749264	Ho Accepted
39	SentimentQDAP / Adj.Close	0.004459942	Ho Rejected	0.010876	Ho Rejected	0.072584	Ho Accepted	0.152260758	Ho Accepted	0.267292396	Ho Accepted	0.416385	Ho Accepted
43	SentimentHE / Volume	0.069257363	Ho Accepted	0.024506	Ho Rejected	0.005267	Ho Rejected	0.003117233	Ho Rejected	0.006750814	Ho Rejected	0.009044	Ho Rejected
44	Volume / SentimentHE	0.009202261	Ho Rejected	0.006488	Ho Rejected	0.002247	Ho Rejected	0.008385061	Ho Rejected	0.015548773	Ho Rejected	0.043303	Ho Rejected
46	Volume / SentimentLM	0.00818586	Ho Rejected	0.008895	Ho Rejected	0.014361	Ho Rejected	0.013445077	Ho Rejected	0.010103484	Ho Rejected	0.014629	Ho Rejected
47	SentimentQDAP / Volume	0.036318583	Ho Rejected	0.033021	Ho Rejected	0.022785	Ho Rejected	0.027545201	Ho Rejected	0.048040231	Ho Rejected	0.044087	Ho Rejected
48	Volume / SentimentQDAP	0.009081599	Ho Rejected	0.010377	Ho Rejected	0.010023	Ho Rejected	0.022868727	Ho Rejected	0.039747287	Ho Rejected	0.035764	Ho Rejected

Granger Test Result with Rejection in the VW News Sentiments against VW Stock (9 Months)

Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
Open does not granger cause SentimentHE	0.039535574	Ho Rejected	0.013398587	Ho Rejected	0.031289572	Ho Rejected	0.021535195	Ho Rejected	0.040379609	Ho Rejected	0.073911464	Ho Accepted
Open does not granger cause SentimentQDAP	0.043255987	Ho Rejected	0.043346452	Ho Rejected	0.028584581	Ho Rejected	0.029190388	Ho Rejected	0.045696494	Ho Rejected	0.048930602	Ho Rejected
High does not granger cause SentimentHE	0.021379811	Ho Rejected	0.03891034	Ho Rejected	0.076086702	Ho Accepted	0.098032852	Ho Accepted	0.170174336	Ho Accepted	0.244345188	Ho Accepted
Low does not granger cause SentimentHE	0.011042536	Ho Rejected	0.013696017	Ho Rejected	0.014484306	Ho Rejected	0.019711746	Ho Rejected	0.044064022	Ho Rejected	0.054581089	Ho Accepted
Close does not granger cause SentimentHE	0.006337709	Ho Rejected	0.018297664	Ho Rejected	0.01021381	Ho Rejected	0.024901379	Ho Rejected	0.034220391	Ho Rejected	0.055957998	Ho Accepted
Adj.Close does not granger cause SentimentHE	0.001027667	Ho Rejected	0.018297623	Ho Rejected	0.010213831	Ho Rejected	0.024901449	Ho Rejected	0.034220673	Ho Rejected	0.055957998	Ho Accepted
Volume does not granger cause SentimentHE	0.001027667	Ho Rejected	0.000639408	Ho Rejected	0.001230272	Ho Rejected	0.002871822	Ho Rejected	0.004495055	Ho Rejected	0.009900584	Ho Accepted
SentimentLM does not granger cause Volume	0.173364192	Ho Accepted	0.032144806	Ho Rejected	0.009370657	Ho Rejected	0.004746922	Ho Rejected	0.00215262	Ho Rejected	0.006041654	Ho Rejected
Volume does not granger cause SentimentQDAP	0.031044636	Ho Rejected	0.074371114	Ho Accepted	0.089118418	Ho Accepted	0.092856321	Ho Accepted	0.143595517	Ho Accepted	0.09148161	Ho Accepted

Granger Test Result with Rejection in the VW News Sentiments against VW Stock (3 Months)

H Granger Test Result VW Message Board Sentiments against VW Stock Result

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
3	SentimentHE / Open	0.820151861	Ho Accepted	0.074017515	Ho Accepted	0.043333833	Ho Rejected	0.050785864	Ho Accepted	0.039498922	Ho Rejected	0.084900943	Ho Accepted
20	Low / SentimentHE	0.314474256	Ho Accepted	0.034994962	Ho Rejected	0.03271823	Ho Rejected	0.047950111	Ho Rejected	0.016251606	Ho Rejected	0.043451769	Ho Rejected
26	Close / SentimentGI	0.469966627	Ho Accepted	0.085123158	Ho Accepted	0.181265768	Ho Accepted	0.279601924	Ho Accepted	0.095430587	Ho Accepted	0.022026445	Ho Rejected
28	Close / SentimentHE	0.156725204	Ho Accepted	0.0429259916	Ho Rejected	0.018622185	Ho Rejected	0.036222577	Ho Rejected	0.02422665	Ho Rejected	0.0622221388	Ho Accepted
32	Close / SentimentQDAP	0.96625276	Ho Accepted	0.313270283	Ho Accepted	0.522236365	Ho Accepted	0.28614326	Ho Accepted	0.165093336	Ho Accepted	0.038645642	Ho Rejected
34	Adj.Close / SentimentGI	0.441938174	Ho Accepted	0.085033099	Ho Accepted	0.180879102	Ho Accepted	0.279667125	Ho Accepted	0.090064805	Ho Accepted	0.021150841	Ho Rejected
36	Adj.Close / SentimentHE	0.144887518	Ho Accepted	0.042028791	Ho Rejected	0.020369888	Ho Rejected	0.041758384	Ho Rejected	0.025221725	Ho Rejected	0.063259144	Ho Accepted
40	Adj.Close / SentimentQDAP	0.972810272	Ho Accepted	0.330059335	Ho Accepted	0.545161209	Ho Accepted	0.286408568	Ho Accepted	0.163097302	Ho Accepted	0.039668635	Ho Rejected
48	Volume / SentimentQDAP	0.017269863	Ho Rejected	0.074031351	Ho Accepted	0.106153346	Ho Accepted	0.193960893	Ho Accepted	0.281794243	Ho Accepted	0.320898628	Ho Accepted

Granger Test Result with Rejection in the VW Message Board Sentiments against VW Stock (9 Months)

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
7	SentimentQDAP / Open	0.02505095	Ho Rejected	0.00679801	Ho Rejected	0.022526205	Ho Rejected	0.011914068	Ho Rejected	0.010360004	Ho Rejected	0.015837082	Ho Rejected
15	SentimentQDAP / High	0.02623885	Ho Rejected	0.01498863	Ho Rejected	0.04573519	Ho Rejected	0.037582161	Ho Rejected	0.051988809	Ho Accepted	0.071952509	Ho Accepted
23	SentimentQDAP / Low	0.02434813	Ho Rejected	0.02201502	Ho Rejected	0.05878656	Ho Accepted	0.05662647	Ho Accepted	0.060004138	Ho Accepted	0.051624827	Ho Accepted
26	Close / SentimentGI	0.06148312	Ho Accepted	0.22159354	Ho Accepted	0.18986417	Ho Accepted	0.16192335	Ho Accepted	0.005659254	Ho Rejected	0.013923058	Ho Rejected
29	SentimentLM / Close	0.04354501	Ho Rejected	0.05873792	Ho Accepted	0.11512838	Ho Accepted	0.178300468	Ho Accepted	0.254870676	Ho Accepted	0.296101415	Ho Accepted
31	SentimentQDAP / Close	0.01554779	Ho Rejected	0.02409526	Ho Rejected	0.01466282	Ho Rejected	0.037261867	Ho Rejected	0.031529436	Ho Rejected	0.039147101	Ho Rejected
34	Adj.Close / SentimentGI	0.05148332	Ho Accepted	0.22159434	Ho Accepted	0.18986527	Ho Accepted	0.161923766	Ho Accepted	0.005659238	Ho Rejected	0.013923075	Ho Rejected
37	SentimentLM / Adj.Close	0.04354508	Ho Rejected	0.05873786	Ho Accepted	0.11512826	Ho Accepted	0.17830096	Ho Accepted	0.254871187	Ho Accepted	0.296102021	Ho Accepted
39	SentimentQDAP / Adj.Close	0.01554775	Ho Rejected	0.02409524	Ho Rejected	0.01466274	Ho Rejected	0.037261675	Ho Rejected	0.031529066	Ho Rejected	0.039146869	Ho Rejected
47	SentimentQDAP / Volume	0.03360005	Ho Rejected	0.10280581	Ho Accepted	0.1456513	Ho Accepted	0.249264968	Ho Accepted	0.3656093654	Ho Accepted	0.108684423	Ho Accepted

Granger Test Result with Rejection in the VW Message Board Sentiments against VW Stock (3 Months)

I Ford Twitter Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentim	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.662141359	0.232797827	0.272645478	-0.180960341	Open	0.713676638	0.517971063	0.354254481	0.589291039
High	0.514593263	0.260056944	0.369698256	0.158608238	High	0.774035634	0.52599088	0.572021757	0.771305021
Low	-0.479858151	-0.03632072	0.576569784	-0.227577254	Low	0.883569317	0.34632875	0.666610133	0.659726538
Close	0.686085692	0.218924014	0.652988387	0.471259746	Close	0.844289774	0.418631489	0.674786066	0.743924012
Adj.Close	0.686085692	0.218924014	0.652988387	0.471259746	Adj.Close	0.844289774	0.418631489	0.674786066	0.743924012
Volume	0.85253715	0.491633825	0.324280789	0.560087495	Volume	0.689564394	0.527269536	0.708799748	0.915832932

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentim	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.403614859	0.274464341	-0.040144694	0.158416529	Open	-0.059597681	-0.6386288	-0.5187245	-0.803162709
High	0.186216977	-0.124714426	-0.259256751	0.261612619	High	0.67006122	0.024247999	0.108847827	-0.110090505
Low	-0.276512769	0.057072318	0.098285246	0.040470174	Low	-0.721086115	-0.703061774	-0.67933914	-0.421987781
Close	0.685303489	-0.313277776	-0.197855554	0.000560354	Close	-0.190831954	-0.118184155	-0.098351099	0.176083483
Adj.Close	0.685303489	-0.313277776	-0.197855554	0.000560354	Adj.Close	-0.190831954	-0.118184155	-0.098351099	0.176083483
Volume	0.455412193	-0.144302647	-0.396166416	0.270865245	Volume	0.656702707	0.457937407	0.464620292	0.417373563

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentim	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.156894754	-0.205944907	-0.073610264	-0.14117402	Open	-0.086963867	-0.649461818	-0.230248642	-0.399929643
High	-0.338760366	-0.359661042	-0.149080978	-0.31929601	High	-0.058607593	-0.705690018	0.556457057	0.14091393
Low	-0.526880262	-0.506816052	-0.190420457	-0.504305238	Low	-0.840090294	-0.754557823	0.150804212	-0.9743664
Close	-0.420931885	-0.411668314	-0.168097033	-0.396328509	Close	-0.637355143	-0.695592995	0.983023697	-0.189928879
Adj.Close	-0.420931885	-0.411668314	-0.168097033	-0.396328509	Adj.Close	-0.637355143	-0.695592995	0.983023697	-0.189928879
Volume	0.62290108	0.560989863	0.568073071	0.59810782	Volume	-0.572209846	-0.49292555	0.996349604	-0.063563524

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentim	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.119747076	-0.791612219	-0.198875337	-0.347628081	Open	-0.233526229	-0.683102112	-0.383794734	-0.607582109
High	-0.013846832	-0.883941959	0.056519075	-0.396211698	High	-0.696593401	-0.958245396	-0.721635628	-0.869566413
Low	-0.438399793	-0.410463878	0.936261341	-0.660581103	Low	-0.434182288	-0.775976122	-0.568034678	-0.880287218
Close	-0.737621912	0.404194499	0.444983495	-0.430533466	Close	-0.387440821	-0.768351032	-0.541656925	-0.84161586
Adj.Close	-0.737621912	0.404194499	0.444983495	-0.430533466	Adj.Close	-0.387440821	-0.768351032	-0.541656925	-0.84161586
Volume	-0.459086996	0.250198455	-0.663083602	-0.007536701	Volume	-0.843079196	-0.52634266	-0.486471908	-0.372252782

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentim	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.634674345	-0.437815852	0.495606322	-0.756141942	Open	-0.038546615	-0.192826206	-0.692809576	-0.408228694
High	-0.232690489	-0.267302663	0.843232959	-0.677451357	High	0.243877429	-0.288415131	-0.894428637	-0.284886851
Low	-0.478319098	-0.154068934	0.558009453	-0.912990147	Low	0.047794663	-0.177308701	-0.700442307	-0.441505813
Close	-0.320846987	-0.196299726	0.767033333	-0.711604024	Close	0.305656542	-0.356190969	-0.937494668	-0.213357416
Adj.Close	-0.320846987	-0.196299726	0.767033333	-0.711604024	Adj.Close	0.305656542	-0.356190969	-0.937494668	-0.213357416
Volume	0.686798772	0.734569139	0.747346956	-0.393231215	Volume	0.322581164	-0.287953533	-0.910336035	-0.181897048

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentim	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.960626718	-0.605893623	-0.422468071	0.150840403	Open	0.466051957	0.329371556	0.527645224	-0.20194523
High	-0.763445748	-0.114355158	-0.352678413	-0.013468117	High	-0.242323069	-0.67557117	-0.435409516	-0.79752816
Low	-0.912638555	-0.257967125	-0.180504945	1.33E-05	Low	-0.270460474	0.048594447	0.359380899	-0.593986828
Close	-0.274499862	0.594359194	0.0997204	-0.406499413	Close	-0.157275159	-0.809580548	-0.564791645	-0.255773382
Adj.Close	-0.274499862	0.594359194	0.0997204	-0.406499413	Adj.Close	-0.157275159	-0.809580548	-0.564791645	-0.255773382
Volume	-0.492577009	0.040760346	-0.537684796	-0.385564862	Volume	-0.152618525	-0.818733446	-0.620670641	-0.758696099

J Ford News Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					08-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.029077992	0.521078299	-0.160285827	-0.025952782	Open	-0.232295603	0.426006032	0.149184902	-0.022431329
High	0.072593623	0.427540983	0.456848349	0.052325871	High	-0.491647929	0.235451125	-0.097718078	-0.288823473
Low	0.650684479	0.672051695	0.531041008	0.469030993	Low	-0.565508609	0.091876052	-0.214563865	-0.380884427
Close	0.371261456	0.182570772	0.464312775	0.052013799	Close	-0.593580249	0.102715798	-0.225512579	-0.405134962
Adj.Close	0.371261456	0.182570772	0.464312775	0.052013799	Adj.Close	-0.593580249	0.102715798	-0.225512579	-0.405134962
Volume	-0.316736527	0.048054087	-0.011375433	-0.402034506	Volume	-0.697289363	0.031070612	-0.329981139	-0.525562023

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.419510557	0.026083449	0.524892728	0.172579182	Open	0.427091226	-0.442741898	-0.619636604	-0.179580357
High	0.331277555	-0.202243842	0.012348325	-0.044778472	High	-0.455367533	-0.528090723	-0.452921366	-0.654902487
Low	0.306658389	0.079732657	0.187445965	0.072601439	Low	-0.423585208	-0.725285751	-0.684572766	-0.593778254
Close	-0.184114397	-0.114647937	-0.507436045	-0.497851318	Close	-0.858394098	-0.679214154	-0.44704529	-0.76772347
Adj.Close	-0.184114397	-0.114647937	-0.507436045	-0.497851318	Adj.Close	-0.858394098	-0.679214154	-0.44704529	-0.76772347
Volume	0.194540212	-0.26152776	-0.081425064	-0.23227371	Volume	-0.564633932	-0.126978	0.038887285	-0.382395247

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.373704957	-0.272756164	-0.571108811	-0.889286116	Open	0.144094512	-0.70186171	-0.988751951	0.094552506
High	-0.238106359	-0.397907899	-0.633185781	-0.886509002	High	-0.2934627	-0.810424152	-0.54871779	-0.662752107
Low	-0.046532417	-0.495255373	-0.630441497	-0.815111959	Low	-0.419431284	-0.480840514	-0.305099819	-0.014839295
Close	-0.187403271	-0.531633322	-0.675221678	-0.888512354	Close	-0.890779879	-0.577329561	0.086987823	-0.977178418
Adj.Close	-0.187403271	-0.531633322	-0.675221678	-0.888512354	Adj.Close	-0.890779879	-0.577329561	0.086987823	-0.977178418
Volume	-0.14224565	0.890545788	0.684910333	0.291065944	Volume	-0.861439043	-0.31130162	0.230506374	-0.983800515

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.881236878	-0.420988194	0.039161648	-0.744340435	Open	-0.775164464	-0.801878008	-0.57652407	-0.930869762
High	-0.86670798	-0.548387968	-0.062633015	-0.696619276	High	-0.687443525	-0.800862784	-0.336590362	-0.754174072
Low	-0.069444737	-0.271409653	0.251614114	0.17214592	Low	-0.745715815	-0.919555587	-0.664328173	-0.822971554
Close	0.558323944	0.260221554	0.384833513	0.580749955	Close	-0.764824925	-0.914414094	-0.684831381	-0.868803167
Adj.Close	0.558323944	0.260221554	0.384833513	0.580749955	Adj.Close	-0.764824925	-0.914414094	-0.684831381	-0.868803167
Volume	-0.028453198	0.328894338	0.319135911	-0.116532415	Volume	-0.010801795	-0.052225264	0.661990561	0.194024958

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.908695769	-0.316437023	-0.944544655	-0.231060457	Open	0.529375543	-0.254378798	0.231898774	0.836488668
High	-0.920771164	-0.648679424	-0.83054895	-0.620725384	High	0.798050005	-0.417561225	0.437312161	0.930303876
Low	-0.941719791	-0.344609735	-0.967421666	-0.248217597	Low	0.602521199	-0.20183214	0.303844853	0.858583521
Close	-0.945778568	-0.777146134	-0.725800797	-0.719118839	Close	0.84455169	-0.513438	0.447790714	0.878293319
Adj.Close	-0.945778568	-0.777146134	-0.725800797	-0.719118839	Adj.Close	0.84455169	-0.513438	0.447790714	0.878293319
Volume	-0.349827921	-0.790196004	-0.022759681	-0.813944077	Volume	0.822957971	-0.464517147	0.485023401	0.898927838

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.874841081	-0.796264713	-0.585626132	-0.985990277	Open	0.327238249	0.611717729	-0.62432444	0.452616127
High	-0.842137607	-0.034747791	-0.765150737	-0.62787427	High	-0.669983947	-0.293230817	-0.32934794	-0.068040338
Low	-0.913871226	-0.772202197	-0.829500862	-0.972640201	Low	0.028151495	0.372221956	-0.908269688	0.55569237
Close	-0.473675595	0.212107586	-0.830977659	-0.238186723	Close	-0.558343665	-0.820086424	0.006761245	-0.049899287
Adj.Close	-0.473675595	0.212107586	-0.830977659	-0.238186723	Adj.Close	-0.558343665	-0.820086424	0.006761245	-0.049899287
Volume	-0.553642785	0.242804239	-0.627707379	-0.390954164	Volume	-0.796611251	-0.456831339	-0.115861387	-0.245130781

K Ford Message Board Sentiment vs Stock values Weekly Correlation

01-09-2015 to 04-09-2015					08-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.886586503	-0.802059637	-0.815228318	-0.964832422	Open	-0.630524242	-0.434937344	0.491808382	0.077354971
High	0.573666706	0.06094421	0.080903002	0.496227585	High	-0.707752104	-0.688293416	0.563918994	-0.162016133
Low	-0.943640101	-0.561398195	-0.519657779	-0.740860886	Low	-0.552837799	-0.713146351	0.713818001	-0.016562825
Close	0.991786797	0.825157334	0.755055524	0.778421053	Close	-0.629980358	-0.758357271	0.662612587	-0.135615643
Adj.Close	0.991786797	0.825157334	0.755055524	0.778421053	Adj.Close	-0.629980358	-0.758357271	0.662612587	-0.135615643
Volume	0.844662137	0.297512913	0.232639434	0.500089759	Volume	-0.754546035	-0.876815123	0.508661426	-0.476737304

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.126115538	-0.545950795	-0.605546849	-0.482073228	Open	0.089967125	-0.648957877	-0.345298453	0.007095011
High	-0.029359414	-0.032960546	-0.829326858	-0.282740939	High	-0.3202824	0.407332025	0.768889263	-0.372537459
Low	-0.13731752	-0.449721044	-0.607434969	-0.489645169	Low	-0.757027914	-0.215782846	-0.733859973	-0.629188518
Close	-0.395377666	0.431330739	-0.697406833	0.276315126	Close	-0.959358949	0.569597347	-0.040715173	-0.674612275
Adj.Close	-0.395377666	0.431330739	-0.697406833	0.276315126	Adj.Close	-0.959358949	0.569597347	-0.040715173	-0.674612275
Volume	-0.049853157	0.199114133	-0.913141333	-0.017248275	Volume	-0.256716008	0.742424773	0.881670407	-0.232376146

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.50214528	-0.127765727	0.153183173	0.721900589	Open	0.767057086	0.518720204	0.970073932	0.833178285
High	0.516674608	-0.125152806	-0.007518398	0.750723662	High	0.325621085	0.730131356	0.601375647	0.661242895
Low	0.508682326	-0.134926221	-0.185393707	0.759932808	Low	0.832071738	-0.273082891	0.226712948	0.645873932
Close	0.579099623	-0.189377947	-0.18556828	0.700182094	Close	0.161485601	0.064927468	-0.078543314	0.489869491
Adj.Close	0.579099623	-0.189377947	-0.18556828	0.700182094	Adj.Close	0.161485601	0.064927468	-0.078543314	0.489869491
Volume	-0.227165598	0.001943956	0.859592935	0.173854496	Volume	-0.158364537	-0.067879568	-0.226143765	0.302644952

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.206233552	0.278624428	0.174006879	-0.184516675	Open	0.670823113	0.098939081	-0.38730791	0.975704727
High	-0.268041473	0.521424038	0.331949164	-0.301425851	High	0.392092405	0.314369119	-0.204932245	0.737873911
Low	0.142943383	0.205353576	0.458551294	-0.258369891	Low	0.715168743	0.600015665	0.124164333	0.798752356
Close	0.329203993	-0.738002581	-0.29667318	0.0044017	Close	0.744840922	0.500933199	0.026394844	0.866633653
Adj.Close	0.329203993	-0.738002581	-0.29667318	0.0044017	Adj.Close	0.744840922	0.500933199	0.026394844	0.866633653
Volume	0.168123757	-0.809042569	-0.544086369	0.259909405	Volume	-0.679614164	0.248522502	-0.04853385	-0.366092006

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.510192763	0.306199765	0.142158974	0.074103235	Open	0.700216754	-0.132651629	-0.086610429	0.002655138
High	0.696240477	0.140022592	-0.366487168	0.261842044	High	0.910306643	0.133369179	-0.475405106	-0.315698976
Low	0.288927273	0.037246636	0.086650037	-0.146019359	Low	0.730022714	-0.075709616	-0.166454532	-0.095319349
Close	0.734747106	0.012119236	-0.321245233	0.424124109	Close	0.919247469	0.25937617	-0.609617589	-0.417632597
Adj.Close	0.734747106	0.012119236	-0.321245233	0.424124109	Adj.Close	0.919247469	0.25937617	-0.609617589	-0.417632597
Volume	0.074136639	-0.78640445	-0.849392383	0.067979901	Volume	0.941764574	0.18175373	-0.55783675	-0.371455175

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.344467313	-0.275009875	0.039764368	0.719452406	Open	-0.216789346	0.744360588	0.570817466	0.724275869
High	-0.283748273	-0.869708441	0.273338229	0.826400254	High	0.035263981	-0.273980744	-0.170809819	-0.657986935
Low	-0.075101254	-0.357263378	0.057363091	0.893980906	Low	-0.099854051	0.543645941	0.483439711	-0.068701423
Close	0.356262255	-0.791142558	0.092062403	0.752888167	Close	0.616219079	-0.591890924	-0.111408513	-0.799069204
Adj.Close	0.356262255	-0.791142558	0.092062403	0.752888167	Adj.Close	0.616219079	-0.591890924	-0.111408513	-0.799069204
Volume	-0.015626431	-0.996974621	-0.080849843	0.693351388	Volume	0.079035333	-0.477240394	-0.332386331	-0.718917461

L Granger Test Result Ford Twitter Sentiments against Ford Stock Result

Test	Null Hypothesis Statement (i.e Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
1	SentimentGI / Open	0.050980892	Ho Accepted	0.018546608	Ho Rejected	0.021564032	Ho Rejected	0.029026181	Ho Rejected	0.068026	Ho Accepted	0.153057197	Ho Accepted
3	SentimentHE / Open	0.300809508	Ho Accepted	0.270961631	Ho Accepted	0.183599722	Ho Accepted	0.013291569	Ho Rejected	0.019689	Ho Rejected	0.009494529	Ho Rejected
4	Open / SentimentHE	0.045928659	Ho Rejected	0.283198281	Ho Accepted	0.165283846	Ho Accepted	0.25345639	Ho Accepted	0.280997	Ho Accepted	0.424621979	Ho Accepted
5	SentimentLM / Open	0.271623305	Ho Accepted	0.235614292	Ho Accepted	0.470123428	Ho Accepted	0.163707079	Ho Accepted	0.083196	Ho Accepted	0.022325703	Ho Rejected
11	SentimentHE / High	0.084650422	Ho Accepted	0.112777639	Ho Accepted	0.042574626	Ho Rejected	0.077307093	Ho Accepted	0.277001	Ho Accepted	0.018502878	Ho Rejected
32	Close / SentimentQDAP	0.456232511	Ho Accepted	0.089800721	Ho Accepted	0.046702282	Ho Rejected	0.036486132	Ho Accepted	0.077555	Ho Accepted	0.157430084	Ho Accepted
40	Adj.Close / SentimentQDAP	0.456232511	Ho Accepted	0.089800721	Ho Accepted	0.046702282	Ho Rejected	0.036486132	Ho Rejected	0.077555	Ho Accepted	0.157430084	Ho Accepted
43	SentimentHE / Volume	0.76452635	Ho Accepted	0.5474757106	Ho Accepted	0.7444125345	Ho Accepted	0.213933933	Ho Accepted	0.033428	Ho Rejected	0.0095561452	Ho Rejected

Granger Test Result with Rejection in the Ford Twitter Sentiments against Ford Stock (9 Months)

Test	Null Hypothesis Statement (i.e Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
3	SentimentHE / Open	0.376654226	Ho Accepted	0.473502418	Ho Accepted	0.442103382	Ho Accepted	0.049963167	Ho Rejected	0.033792855	Ho Rejected	0.040891301	Ho Rejected
5	SentimentLM / High	0.958625038	Ho Accepted	0.72377989	Ho Accepted	0.277162922	Ho Accepted	0.245546674	Ho Accepted	0.025070128	Ho Rejected	0.028651826	Ho Rejected
11	SentimentHE / High	0.209810691	Ho Accepted	0.331139006	Ho Accepted	0.08557091	Ho Accepted	0.159277222	Ho Accepted	0.216321172	Ho Accepted	0.031629653	Ho Rejected
20	Low / SentimentHE	0.68572764	Ho Accepted	0.001992698	Ho Rejected	0.005896624	Ho Rejected	0.015626188	Ho Rejected	0.017102594	Ho Rejected	0.008495978	Ho Rejected
28	Low / SentimentHE	0.650089259	Ho Accepted	0.04901313	Ho Rejected	0.126483452	Ho Accepted	0.183806925	Ho Accepted	0.202834201	Ho Accepted	0.112982138	Ho Accepted
36	Adj.Close / SentimentHE	0.650089259	Ho Accepted	0.04901313	Ho Rejected	0.126483452	Ho Accepted	0.183806925	Ho Accepted	0.202834201	Ho Accepted	0.112982138	Ho Accepted
42	Volume / SentimentGI	0.205830538	Ho Accepted	0.026137786	Ho Rejected	0.088658528	Ho Accepted	0.09998024	Ho Accepted	0.174912098	Ho Accepted	0.335687759	Ho Accepted
45	SentimentLM / Volume	0.906376142	Ho Accepted	0.586377848	Ho Accepted	0.315936446	Ho Accepted	0.047942943	Ho Rejected	0.11595398	Ho Accepted	0.069533562	Ho Accepted

Granger Test Result with Rejection in the Ford Twitter Sentiments against Ford Stock (3 Months)

M Granger Test Result Ford News Sentiments against Ford Stock Result

Test	Null Hypothesis Statement(Le Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
4)Open / SentimentHE	SentimentHE does not granger cause Open	0.586592791	Ho Accepted	0.034736394	Ho Rejected	0.032079453	Ho Rejected	0.130686	Ho Accepted	0.19248175	Ho Accepted	0.299010489	Ho Accepted

Granger Test with Rejection in the Ford News Sentiments against Ford Stock (9 Months)

Test	Null Hypothesis Statement(Le Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
1) SentimentGI / Open	Open does not granger cause SentimentGI	0.368191978	Ho Accepted	0.422944761	Ho Accepted	0.019241289	Ho Rejected	0.084605204	Ho Accepted	0.064528545	Ho Accepted	0.058989723	Ho Accepted
4) Open / SentimentHE	SentimentHE does not granger cause Open	0.505596048	Ho Accepted	0.006415068	Ho Rejected	0.00312107	Ho Rejected	0.039608099	Ho Rejected	0.044445059	Ho Rejected	0.073215732	Ho Accepted
9) SentimentGI / High	High does not granger cause SentimentGI	0.02950497	Ho Rejected	0.118150856	Ho Accepted	0.215420714	Ho Accepted	0.111220611	Ho Accepted	0.173072985	Ho Accepted	0.294569444	Ho Accepted
12) High / SentimentHE	SentimentHE does not granger cause High	0.042485395	Ho Rejected	0.004896924	Ho Rejected	0.04879014	Ho Rejected	0.068292042	Ho Accepted	0.080907616	Ho Accepted	0.134154348	Ho Accepted
20) Low / SentimentHE	SentimentHE does not granger cause Low	0.738765809	Ho Accepted	0.004589104	Ho Rejected	0.009790573	Ho Rejected	0.016235566	Ho Rejected	0.026547036	Ho Rejected	0.02946213	Ho Rejected
28) Close / SentimentHE	SentimentHE does not granger cause Close	0.030135942	Ho Rejected	0.011044679	Ho Rejected	0.067003692	Ho Accepted	0.09034797	Ho Accepted	0.1110898947	Ho Accepted	0.155608112	Ho Accepted
36) AdjClose / SentimentHE	SentimentHE does not granger cause AdjClose	0.030135942	Ho Rejected	0.011044679	Ho Rejected	0.067003692	Ho Accepted	0.09034797	Ho Accepted	0.1110898947	Ho Accepted	0.155608112	Ho Accepted

Granger Test with Rejection in the Ford News Sentiments against Ford Stock (3 Months)

N Granger Test Result Ford Message Board Sentiments against Ford Stock Result

Test	Null Hypothesis Statement (i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
11	SentimentHE / High	0.006284312	Ho Rejected	0.031308786	Ho Rejected	0.005859753	Ho Rejected	0.004963901	Ho Rejected	0.011828121	Ho Rejected	0.026275641	Ho Rejected
27	SentimentHE / Close	0.019729569	Ho Rejected	0.018133694	Ho Rejected	0.019099959	Ho Rejected	0.026405524	Ho Rejected	0.02483457	Ho Rejected	0.051916339	Ho Accepted
35	SentimentHE / Adj.Close	0.019729569	Ho Rejected	0.018133694	Ho Rejected	0.019099959	Ho Rejected	0.026405524	Ho Rejected	0.02483457	Ho Rejected	0.051916339	Ho Accepted
43	SentimentHE / Volume	0.013177305	Ho Rejected	0.048671597	Ho Rejected	0.036734246	Ho Rejected	0.040999414	Ho Rejected	0.081255607	Ho Accepted	0.138005234	Ho Accepted

Granger Test Result with Rejection in the Ford Message Board Sentiments against Ford Stock (9 Months)

Test	Null Hypothesis Statement (i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
7	SentimentQDAP / Open	0.025050955	Ho Rejected	0.006798017	Ho Rejected	0.022562051	Ho Rejected	0.011914068	Ho Rejected	0.010360004	Ho Rejected	0.015837082	Ho Rejected
15	SentimentQDAP / High	0.026238854	Ho Rejected	0.014988627	Ho Rejected	0.045735188	Ho Rejected	0.037582161	Ho Rejected	0.051986809	Ho Accepted	0.071952509	Ho Accepted
23	SentimentQDAP / Low	0.024848128	Ho Rejected	0.022015016	Ho Rejected	0.058786564	Ho Accepted	0.05662647	Ho Accepted	0.06004138	Ho Accepted	0.051624827	Ho Accepted
26	Close / SentimentGI	0.061483117	Ho Accepted	0.221593541	Ho Accepted	0.189864174	Ho Accepted	0.16192335	Ho Accepted	0.005659254	Ho Rejected	0.013923058	Ho Rejected
29	SentimentLM / Close	0.043545014	Ho Rejected	0.058737923	Ho Accepted	0.115128375	Ho Accepted	0.178300468	Ho Accepted	0.254870676	Ho Accepted	0.296101415	Ho Accepted
31	SentimentQDAP / Close	0.015547793	Ho Rejected	0.02409526	Ho Rejected	0.014662819	Ho Rejected	0.032761867	Ho Rejected	0.031529436	Ho Rejected	0.039147101	Ho Rejected
34	Adj.Close / SentimentGI	0.061483321	Ho Accepted	0.221594335	Ho Accepted	0.189865269	Ho Accepted	0.161923766	Ho Accepted	0.005659238	Ho Rejected	0.013923075	Ho Rejected
37	SentimentLM / Adj.Close	0.043545079	Ho Rejected	0.05873786	Ho Accepted	0.115128256	Ho Accepted	0.178300096	Ho Accepted	0.254871187	Ho Accepted	0.296102021	Ho Accepted
39	SentimentQDAP / Adj.Close	0.015547746	Ho Rejected	0.024095235	Ho Rejected	0.01466274	Ho Rejected	0.032761675	Ho Rejected	0.031529066	Ho Rejected	0.039146869	Ho Rejected
47	SentimentQDAP / Volume	0.033600046	Ho Rejected	0.1022805811	Ho Accepted	0.145651303	Ho Accepted	0.249264968	Ho Accepted	0.366093654	Ho Accepted	0.108684423	Ho Accepted

Granger Test Result with Rejection in the Ford Message Board Sentiments against Ford Stock (3 Months)

O Toyota Twitter Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentimer	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.575017356	0.599679467	0.421735185	0.768467094	Open	0.692296543	-0.007932671	0.371567887	0.533190516
High	0.616205812	0.621163886	0.456598335	0.756497589	High	0.572701585	-0.003479161	0.229364455	0.378557956
Low	0.527297556	0.584637442	0.352080861	0.826804669	Low	0.348303623	-0.135640686	-0.022806048	0.142076184
Close	0.597220654	0.682505815	0.379464592	0.860960144	Close	0.161813471	-0.136955119	-0.205283206	-0.065570524
Adj.Close	0.597219284	0.682505483	0.379463147	0.86096103	Adj.Close	0.161813829	-0.136956827	-0.205283073	-0.065569784
Volume	0.07339486	-0.496705911	0.192133661	-0.695221529	Volume	0.504510945	-0.451793053	0.500487382	0.703539598

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentimer	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.636484654	0.890151334	0.40044288	-0.784540753	Open	0.659256938	0.518645061	0.602955617	0.279904302
High	-0.732114463	0.81847799	0.541531448	-0.889382872	High	0.721037564	0.603288237	0.591798062	0.392326166
Low	-0.636151235	0.88739039	0.453796077	-0.79510413	Low	0.66556294	0.583933789	0.38208828	0.446595546
Close	-0.525681971	0.824590438	0.505222888	-0.745562213	Close	0.486431761	0.369328922	0.392979728	0.148220824
Adj.Close	-0.525683096	0.824589793	0.50522157	-0.745563186	Adj.Close	0.486426273	0.369328942	0.392982295	0.148211904
Volume	0.732578266	0.093778784	-0.045445992	0.501610867	Volume	-0.619505327	-0.15938405	-0.053619813	-0.620521265

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentimer	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.773360649	-0.26751631	-0.782743264	-0.822512467	Open	0.280755646	-0.079896369	-0.476026585	0.480424758
High	-0.592458696	-0.192384585	-0.856273455	-0.72611316	High	0.436314716	0.079557075	-0.436006558	0.641385229
Low	-0.463426687	-0.332021415	-0.873375168	-0.69703636	Low	0.456926603	0.028743644	-0.513036051	0.636143733
Close	-0.346514007	-0.263950648	-0.911736639	-0.632823629	Close	0.244592306	-0.07129217	-0.693957147	0.483929392
Adj.Close	-0.346514986	-0.263952004	-0.911736383	-0.632824417	Adj.Close	0.244599189	-0.071286013	-0.693952374	0.483935558
Volume	-0.042488869	0.382962502	-0.772236904	-0.265140789	Volume	0.36756547	0.528223561	0.708330713	0.277357098

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentimer	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.198983851	-0.310408948	0.912474115	0.231721767	Open	-0.156211678	0.194596053	-0.376577291	-0.722042032
High	0.166537979	-0.33316965	0.840941537	0.213061262	High	-0.029910376	0.063161782	-0.519277258	-0.765356106
Low	0.106821949	-0.260045124	0.827476175	0.236619951	Low	-0.153052472	0.169040857	-0.421252316	-0.723182641
Close	0.189241509	-0.355547164	0.752932562	0.214296576	Close	-0.330789282	0.165069452	-0.367891034	-0.734412076
Adj.Close	0.189242903	-0.355546622	0.752931853	0.214297791	Adj.Close	-0.33078774	0.165064411	-0.367894229	-0.734415317
Volume	-0.172466641	0.685581083	-0.001179178	0.628780338	Volume	-0.380865539	0.321857971	-0.306482389	0.309745998

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentimer	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.462760167	0.476878129	0.274622297	-0.272696755	Open	-0.475928842	-0.243977375	0.456119619	-0.351237178
High	-0.680855239	0.236535884	0.144170717	-0.505394788	High	-0.523711572	-0.202161367	0.551287835	-0.477742929
Low	-0.498733355	0.44955895	0.332224006	-0.335660869	Low	-0.441196231	-0.107581935	0.606858423	-0.457170333
Close	-0.683038637	0.158078866	0.049521802	-0.444431403	Close	-0.462745662	-0.120756701	0.593422846	-0.451380167
Adj.Close	-0.683038524	0.158078633	0.049522981	-0.444431433	Adj.Close	-0.462747749	-0.120752938	0.593424978	-0.451380789
Volume	0.562244947	-0.036006035	-0.388538915	0.77224642	Volume	0.709774656	0.858662718	0.385257482	0.171026194

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentime	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentimer	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.138580295	-0.906565423	-0.047399689	0.413785712	Open	-0.588850174	-0.76732926	-0.693191232	-0.690296575
High	-0.340797327	-0.947823687	-0.292947346	0.26034853	High	-0.738916918	-0.543478355	-0.511839734	-0.750025346
Low	-0.427073762	-0.91875906	-0.381401572	0.158217222	Low	-0.593267051	-0.771840518	-0.688802785	-0.685892766
Close	-0.496582783	-0.942858127	-0.582090299	0.227672358	Close	-0.712598682	-0.351330483	-0.440667024	-0.657596218
Adj.Close	-0.496586638	-0.942856629	-0.582094558	0.227669611	Adj.Close	-0.712600839	-0.351328898	-0.440665424	-0.657598211
Volume	0.586618914	0.808153699	0.29813815	-0.113057556	Volume	-0.592461557	0.081512225	0.397549029	-0.525654123

P Toyota News Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					08-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.19116956	-0.080921228	-0.542966349	-0.289195479	Open	0.157646951	0.138689692	0.686338032	0.741583419
High	-0.169472913	-0.051548445	-0.500856406	-0.277986603	High	0.041934579	0.024562573	0.542449792	0.606760091
Low	-0.147775228	-0.04937157	-0.569022342	-0.251996909	Low	-0.199580892	-0.001514748	0.341560372	0.420405322
Close	-0.057517029	0.045639562	-0.484308888	-0.216923974	Close	-0.337448208	-0.125891638	0.133017851	0.216680688
Adj.Close	-0.057517212	0.045639066	-0.484310157	-0.216924081	Adj.Close	-0.337448693	-0.125889549	0.133018972	0.216681863
Volume	0.21364196	0.270148145	0.665611846	0.34962996	Volume	0.24733991	0.90088942	0.775606082	0.764259431

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.72575396	-0.530030705	-0.630406709	-0.59907854	Open	-0.157750835	-0.174137502	0.116556894	0.505902593
High	-0.823189457	-0.658837267	-0.760006004	-0.732159307	High	-0.144934283	-0.129434658	0.152335787	0.529997068
Low	-0.729090348	-0.538714413	-0.646023747	-0.61255138	Low	-0.303021258	-0.298865108	-0.08582864	0.376613813
Close	-0.643658828	-0.442235231	-0.57566287	-0.536955285	Close	-0.347305331	-0.42024338	-0.177788169	0.293985307
Adj.Close	-0.643659943	-0.442236181	-0.575663563	-0.536956133	Adj.Close	-0.347307137	-0.420244911	-0.17778367	0.29398313
Volume	0.634599304	0.76495669	0.636749972	0.682825197	Volume	0.110898437	0.198227835	0.461498674	-0.296041458

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.599009347	0.786103344	0.659200442	0.510618226	Open	-0.902021059	-0.065460072	0.082958767	-0.880086957
High	-0.436090696	0.732348224	0.715324045	0.616741355	High	-0.847828376	0.059732442	0.272866588	-0.833844657
Low	-0.182173579	0.777040281	0.860045825	0.801142844	Low	-0.626696649	0.22173642	0.252607478	-0.644923275
Close	-0.116468092	0.714157957	0.833787703	0.786273334	Close	-0.593318886	-0.050424662	0.194143472	-0.671062515
Adj.Close	-0.116468086	0.714158917	0.833788477	0.786274018	Adj.Close	-0.593319016	-0.050418529	0.194149425	-0.671061717
Volume	-0.395978459	0.135088107	0.105543467	-0.003324006	Volume	-0.221200344	0.174258553	0.36450948	-0.06560872

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.085292678	0.522311492	-0.097129767	0.229862311	Open	-0.424140514	0.201822263	-0.61809641	-0.432930831
High	-0.03098409	0.499248092	-0.122910815	0.282449482	High	-0.533393266	0.138094854	-0.718047441	-0.54441488
Low	-0.127802208	0.494115112	-0.178872043	0.212783157	Low	-0.468617923	0.149986064	-0.65230465	-0.48199969
Close	0.082273565	0.497544372	-0.084312609	0.385643083	Close	-0.484391192	0.093821825	-0.647965817	-0.472056521
Adj.Close	0.08227514	0.497545475	-0.084310981	0.385644956	Adj.Close	-0.484394537	0.093820982	-0.647969077	-0.472058948
Volume	-0.498472593	0.444614543	-0.19959822	-0.014143476	Volume	-0.361913424	-0.779726485	-0.212919396	-0.546373678

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.893974907	-0.784178075	-0.78153533	-0.91152094	Open	-0.224616018	-0.075946434	0.022251664	-0.619572401
High	-0.849403772	-0.835533724	-0.839802987	-0.826062036	High	-0.337028026	-0.132846054	-0.03043679	-0.733220083
Low	-0.836789165	-0.779737184	-0.748900662	-0.857291315	Low	-0.427515152	-0.074319588	0.071934955	-0.761211896
Close	-0.876398334	-0.92827698	-0.907885193	-0.778683402	Close	-0.394648119	-0.05502638	0.059674325	-0.74400969
Adj.Close	-0.876397287	-0.928277222	-0.907884584	-0.778682073	Adj.Close	-0.394647547	-0.055495058	0.059675562	-0.744009354
Volume	0.053412927	0.086768125	0.088450998	0.239274605	Volume	-0.694947154	0.522211353	0.764432894	-0.112780267

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.661161889	0.621838649	0.521233269	0.59335598	Open	0.471190155	0.387931192	-0.354582072	0.299592324
High	0.624895861	0.561053223	0.297333169	0.451883421	High	0.622715926	0.601341004	-0.123783609	0.505582899
Low	0.579946297	0.49579736	0.177080986	0.357753964	Low	0.414028877	0.371409548	-0.334753549	0.325203419
Close	0.453667433	0.479980365	0.051582857	0.286537486	Close	0.698239245	0.665578935	-0.073719985	0.496714341
Adj.Close	0.453663361	0.479977026	0.051577393	0.286532943	Adj.Close	0.698243942	0.665582316	-0.073718335	0.49671591
Volume	-0.186137375	-0.192048683	-0.041361958	-0.109833869	Volume	0.202052152	0.472046143	0.634632914	0.739542867

Q Toyota Message Board Sentiment vs Stock values Weekly Correlation

01-09-2015 to 04-09-2015					08-09-2015 to 11-09-2015				
Stock/Sentimen	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.683453269	-0.673959364	-0.287020023	0.318279549	Open	0.853099597	-0.545528325	-0.936539115	0.340492169
High	-0.713319855	-0.655239323	-0.23995884	0.272769026	High	0.918435834	-0.688693985	-0.974840014	0.463668847
Low	-0.687771249	-0.625069953	-0.326435815	0.336958563	Low	0.985829317	-0.808588537	-0.994633519	0.667336962
Close	-0.826320644	-0.420897616	-0.164236902	0.141238134	Close	0.979915582	-0.907346881	-0.952951194	0.768129056
Adj.Close	-0.826320281	-0.420896892	-0.164237873	0.141238767	Adj.Close	0.979916	-0.907346074	-0.952951654	0.768129453
Volume	0.463287738	-0.565928273	0.005676155	0.189386262	Volume	-0.052254539	0.626670192	-0.048077601	-0.266753608

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentimen	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.435732842	-0.111299121	0.143292916	0.370094457	Open	0.083827775	0.328322138	-0.213019648	-0.220021583
High	0.272826838	0.026094214	0.073656067	0.398233211	High	0.189448424	0.421421404	-0.133469468	-0.100579251
Low	0.432146935	-0.118221491	0.099727371	0.34269304	Low	0.162563507	0.425947414	0.033286375	-0.059108732
Close	0.497814525	-0.122400036	0.090947385	0.3249734	Close	-0.097341318	0.194915544	-0.154236963	-0.352485436
Adj.Close	0.497813171	-0.122397582	0.090949719	0.324976054	Adj.Close	-0.097341522	0.194915403	-0.154240175	-0.352488934
Volume	0.859846279	-0.628559299	-0.038399957	-0.354097043	Volume	0.124748882	-0.060389956	-0.081678541	0.059306204

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentimen	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.20555364	0.140093577	-0.129968188	0.053774804	Open	-0.682610473	-0.847984752	-0.929524951	-0.724537073
High	-0.124901168	-0.036562962	-0.33569449	0.111975707	High	-0.649425937	-0.907382417	-0.943496768	-0.745279741
Low	0.140498636	-0.007486965	-0.386159489	0.358521707	Low	-0.46046936	-0.992775652	-0.798697796	-0.647379201
Close	0.143310079	-0.090542321	-0.526136333	0.358593253	Close	-0.107727471	-0.911693163	-0.593062771	-0.303446815
Adj.Close	0.143310907	-0.090541057	-0.526134969	0.358594139	Adj.Close	-0.107732877	-0.911694574	-0.593066646	-0.303452738
Volume	-0.494677787	-0.387962102	-0.857689348	-0.286622596	Volume	-0.727464826	0.343306813	-0.359825057	-0.530398959

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentimen	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.202066983	-0.148213303	-0.085766074	-0.045278014	Open	-0.762377441	0.715787773	0.445974712	-0.625648206
High	0.349989321	0.003208673	0.030480253	0.093818476	High	-0.677682775	0.62403	0.400662041	-0.510406037
Low	0.302078173	-0.041277269	-0.055441997	0.038321254	Low	-0.724788784	0.68109386	0.470590122	-0.602096728
Close	0.513007739	0.158377047	0.186531696	0.267516472	Close	-0.72655011	0.738975889	0.522167534	-0.732350366
Adj.Close	0.513009259	0.158377843	0.18653318	0.267518407	Adj.Close	-0.726549188	0.738975853	0.522165085	-0.732350115
Volume	0.223415128	-0.087050488	-0.331690122	0.133704034	Volume	0.369607941	-0.397582548	0.900005463	0.118113819

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentimen	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.549629223	0.423360369	0.000590122	-0.163199035	Open	0.386332666	0.52453976	0.480727768	0.875827225
High	-0.475371412	0.41135445	0.147115911	-0.209199977	High	0.418363235	0.569415374	0.494337233	0.824043773
Low	-0.561238991	0.482707088	-0.05038651	-0.248888194	Low	0.32234486	0.640240511	0.538499133	0.758066683
Close	-0.295765946	0.490482113	0.242449545	-0.033066796	Close	0.329932393	0.602813544	0.505910063	0.785498932
Adj.Close	-0.295765208	0.490484035	0.242448425	-0.033067335	Adj.Close	0.329929085	0.602807891	0.505903182	0.785500216
Volume	0.69479967	-0.083957185	0.24157448	0.897641742	Volume	-0.859516635	0.36767208	0.142341322	-0.755900159

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentimen	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.533771524	0.618934098	0.801959436	0.541532993	Open	0.122243789	-0.03771111	0.651169099	0.039717071
High	0.387785049	0.570422907	0.57802719	0.423697287	High	0.475827347	0.266947746	0.714192478	0.388151646
Low	0.291230811	0.530344469	0.441728186	0.332658996	Low	0.222381212	0.039764465	0.619721728	0.183961585
Close	0.405873014	0.522775355	0.435074733	0.465706172	Close	0.647109123	0.317627693	0.649331619	0.466550132
Adj.Close	0.405872207	0.522774825	0.435070863	0.465705037	Adj.Close	0.647106916	0.317627163	0.649334924	0.466546217
Volume	-0.688085281	-0.910657266	-0.688601138	-0.548299963	Volume	0.579384927	0.880265709	0.42900728	0.93113264

R Granger Test Result Toyota Twitter Sentiments against Toyota Stock Result

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
5	SentimentLM / Open	0.197297131	Ho Accepted	0.01063681	Ho Rejected	0.02565739	Ho Rejected	0.030091035	Ho Rejected	0.052597	Ho Accepted	0.07494022	Ho Accepted
10	High / SentimentGI	0.603235426	Ho Accepted	0.07651334	Ho Accepted	0.000433596	Ho Rejected	0.070045306	Ho Accepted	0.092364	Ho Accepted	0.08249975	Ho Accepted
13	SentimentLM / High	0.078377477	Ho Accepted	0.00355791	Ho Rejected	0.010149188	Ho Rejected	0.016770243	Ho Rejected	0.023685	Ho Rejected	0.04583152	Ho Rejected
16	High / SentimentQDAP	0.365351246	Ho Accepted	0.01297825	Ho Rejected	0.034169663	Ho Rejected	0.080565752	Ho Accepted	0.164513	Ho Accepted	0.15948201	Ho Accepted
17	SentimentGI / Low	0.022753613	Ho Rejected	0.00904448	Ho Rejected	0.02792601	Ho Rejected	0.006103572	Ho Rejected	0.012455	Ho Rejected	0.02230629	Ho Rejected
21	SentimentLM / Low	0.229790113	Ho Accepted	0.01806362	Ho Rejected	0.041967016	Ho Rejected	0.022484034	Ho Rejected	0.04759	Ho Rejected	0.05809247	Ho Accepted
23	SentimentQDAP / Low	0.109978989	Ho Accepted	0.0385182	Ho Rejected	0.053032276	Ho Accepted	0.038827738	Ho Rejected	0.077314	Ho Accepted	0.06433001	Ho Accepted
24	Low / SentimentQDAP	0.762935809	Ho Accepted	0.00814405	Ho Rejected	0.027086397	Ho Rejected	0.047098659	Ho Rejected	0.071388	Ho Accepted	0.05177934	Ho Rejected
25	SentimentGI / Close	0.029946289	Ho Rejected	0.04052734	Ho Rejected	0.10230646	Ho Accepted	0.040938078	Ho Rejected	0.056193	Ho Accepted	0.03326762	Ho Rejected
32	Close / SentimentQDAP	0.354463071	Ho Accepted	0.00457348	Ho Rejected	0.016324566	Ho Rejected	0.039126948	Ho Rejected	0.090432	Ho Accepted	0.10401038	Ho Accepted
33	SentimentGI / Adj.Close	0.027939789	Ho Rejected	0.03913381	Ho Rejected	0.101997575	Ho Accepted	0.044147339	Ho Rejected	0.062553	Ho Accepted	0.046692619	Ho Rejected
40	Adj.Close / SentimentQDAP	0.396620893	Ho Accepted	0.00400894	Ho Rejected	0.013692949	Ho Rejected	0.034977262	Ho Rejected	0.0802502	Ho Accepted	0.10106433	Ho Accepted
43	SentimentHE / Volume	0.047451986	Ho Rejected	0.11390593	Ho Accepted	0.179181012	Ho Accepted	0.266604801	Ho Accepted	0.075489	Ho Accepted	0.09973331	Ho Accepted
44	Volume / SentimentHE	0.855334858	Ho Accepted	0.89893717	Ho Accepted	0.29634475	Ho Accepted	0.016120229	Ho Rejected	0.034499	Ho Rejected	0.01608517	Ho Rejected
45	SentimentLM / Volume	0.242420981	Ho Accepted	0.13680709	Ho Accepted	0.098203916	Ho Accepted	0.116380006	Ho Accepted	0.066694	Ho Accepted	0.01822915	Ho Rejected

Granger Test Result with Rejection in the Toyota Twitter Sentiments against Toyota Stock (9 Months)

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
2	Open / SentimentGI	0.869602437	Ho Accepted	0.018304721	Ho Rejected	0.02088383	Ho Rejected	0.033727573	Ho Rejected	0.086224563	Ho Accepted	0.122534577	Ho Accepted
6	Open / SentimentLM	0.37782118	Ho Accepted	0.696916187	Ho Accepted	0.38438584	Ho Accepted	0.21202441	Ho Rejected	0.185765003	Ho Accepted	0.038879581	Ho Rejected
10	High / SentimentGI	0.724394644	Ho Accepted	0.010207814	Ho Rejected	0.01475759	Ho Rejected	0.019648872	Ho Rejected	0.046825722	Ho Rejected	0.062806162	Ho Accepted
18	Low / SentimentGI	0.526775124	Ho Accepted	0.021232509	Ho Rejected	0.0430915	Ho Rejected	0.054922276	Ho Accepted	0.099430322	Ho Accepted	0.077378622	Ho Accepted
26	Close / SentimentGI	0.197616784	Ho Accepted	0.013287781	Ho Rejected	0.02913841	Ho Rejected	0.030469105	Ho Rejected	0.064720429	Ho Accepted	0.04795856	Ho Rejected
34	Adj.Close / SentimentGI	0.19066717	Ho Accepted	0.009369697	Ho Rejected	0.02101833	Ho Rejected	0.017753636	Ho Rejected	0.039809331	Ho Rejected	0.028132855	Ho Rejected

Granger Test Result with Rejection in the Toyota Twitter Sentiments against Toyota Stock (3 Months)

S Granger Test Result Toyota News Sentiments against Toyota Stock Result

Test	Null Hypothesis Statement (I.e Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
SentimentHE / Open	Open does not granger cause SentimentHE	0.003213992	Ho Rejected	0.017514834	Ho Rejected	0.03434861	Ho Rejected	0.033082969	Ho Rejected	0.054193874	Ho Accepted	0.0951571	Ho Accepted
SentimentHE / High	High does not granger cause SentimentHE	0.038571764	Ho Rejected	0.10987339	Ho Accepted	0.1145234	Ho Accepted	0.063933875	Ho Accepted	0.094734572	Ho Accepted	0.165650665	Ho Accepted
SentimentQDAP / High	High does not granger cause SentimentQDAP	0.503449582	Ho Accepted	0.386987391	Ho Accepted	0.0569457	Ho Accepted	0.0393922876	Ho Rejected	0.048654708	Ho Rejected	0.02995128	Ho Rejected
SentimentHE / Low	Low does not granger cause SentimentHE	0.025034221	Ho Rejected	0.050608799	Ho Accepted	0.06521321	Ho Accepted	0.040273532	Ho Rejected	0.058635066	Ho Accepted	0.091760181	Ho Rejected
SentimentQDAP / Low	Low does not granger cause SentimentQDAP	0.956508277	Ho Accepted	0.680527274	Ho Accepted	0.09702427	Ho Accepted	0.032964474	Ho Rejected	0.055371767	Ho Accepted	0.044874695	Ho Rejected
SentimentHE / Close	Close does not granger cause SentimentHE	0.240817913	Ho Accepted	0.048101641	Ho Rejected	0.07375445	Ho Accepted	0.038870121	Ho Rejected	0.036166582	Ho Rejected	0.046671375	Ho Rejected
SentimentQDAP / Close	Close does not granger cause SentimentQDAP	0.738905176	Ho Accepted	0.390598582	Ho Accepted	0.16236801	Ho Accepted	0.080109576	Ho Rejected	0.052393708	Ho Accepted	0.041959996	Ho Rejected
SentimentLM / Volume	Volume does not granger cause SentimentLM	0.025665298	Ho Rejected	0.080399368	Ho Accepted	0.18369349	Ho Accepted	0.063102301	Ho Accepted	0.000262397	Ho Rejected	0.000869553	Ho Rejected
SentimentQDAP / Volume	Volume does not granger cause SentimentQDAP	0.090349605	Ho Accepted	0.176565105	Ho Accepted	0.3440928	Ho Accepted	0.362179081	Ho Accepted	0.014991863	Ho Rejected	0.060264029	Ho Accepted

Granger Test Result with Rejection in the Toyota News Sentiments against Toyota Stock (3 Months)

Test	Null Hypothesis Statement (I.e Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
3) SentimentHE / Open	Open does not granger cause SentimentHE	0.606229717	Ho Accepted	0.008353345	Ho Rejected	0.002153426	Ho Rejected	0.005242032	Ho Rejected	0.014355068	Ho Rejected	0.031746055	Ho Rejected
8) Open / SentimentQDAP	SentimentQDAP does not granger cause Open	0.585489567	Ho Accepted	0.550982303	Ho Accepted	0.742705885	Ho Accepted	0.518865429	Ho Accepted	0.271738042	Ho Accepted	0.023038983	Ho Rejected
11) SentimentHE / High	High does not granger cause SentimentHE	0.838215608	Ho Accepted	0.013371443	Ho Rejected	0.002559011	Ho Rejected	0.006171171	Ho Rejected	0.017325665	Ho Rejected	0.030947277	Ho Rejected
16) High / SentimentQDAP	SentimentQDAP does not granger cause High	0.795212503	Ho Accepted	0.4682081	Ho Accepted	0.708854037	Ho Accepted	0.448967249	Ho Accepted	0.286539913	Ho Accepted	0.037932186	Ho Rejected
19) SentimentHE / Low	Low does not granger cause SentimentHE	0.592644418	Ho Accepted	0.032102281	Ho Rejected	0.001827836	Ho Rejected	0.002930962	Ho Rejected	0.011180393	Ho Rejected	0.024550753	Ho Rejected
27) SentimentHE / Close	Close does not granger cause SentimentHE	0.32924127	Ho Accepted	0.019042821	Ho Rejected	0.002435645	Ho Rejected	0.005360345	Ho Rejected	0.015262707	Ho Rejected	0.027801818	Ho Rejected
35) SentimentHE / Adj/Close	Adj/Close does not granger cause SentimentHE	0.346382442	Ho Accepted	0.018982253	Ho Rejected	0.004688445	Ho Rejected	0.010065017	Ho Rejected	0.025262818	Ho Rejected	0.043234222	Ho Rejected
45) SentimentLM / Volume	Volume does not granger cause SentimentLM	0.439043243	Ho Accepted	0.535211263	Ho Accepted	0.7816835	Ho Accepted	0.28101237	Ho Accepted	7.67E-06	Ho Rejected	3.78E-05	Ho Rejected
47) SentimentQDAP / Volume	Volume does not granger cause SentimentQDAP	0.755915758	Ho Accepted	0.573316792	Ho Accepted	0.684964279	Ho Accepted	0.681983774	Ho Accepted	0.030346641	Ho Rejected	0.1035950638	Ho Accepted

Granger Test Result with Rejection in the Toyota News Sentiments against Toyota Stock (9 Months)

T Granger Test Result Toyota Message Board Sentiments against Toyota Stock Result

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_conc	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_conclusion
------	-----------------------------------	----------	--------------	----------	-------------	----------	--------------	----------	--------------	----------	--------------	----------	-------------------

Granger Test Result with Rejection in the Toyota Message Board Sentiments against Toyota Stock (9 Months)

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_conclusion
41	SentimentGI / Volume	0.704661468	Ho Accepted	0.116205493	Ho Accepted	0.100469277	Ho Accepted	0.01982859	Ho Rejected	0.048197605	Ho Rejected	0.094762687	Ho Accepted

Granger Test Result with Rejection in the Toyota Message Board Sentiments against Toyota Stock (3 Months)

U Audi Twitter Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.537600203	-0.808787168	0.024202667	0.559018454
High	0.18214933	-0.525880191	0.04872145	0.34030368
Low	0.207666621	-0.595344476	0.077647682	0.250644791
Close	0.002493243	-0.438467517	0.012897528	0.215255669
Adj.Close	0.002493637	-0.438466666	0.012898738	0.215254595
Volume	-0.80120814	0.462774888	-0.619887838	0.024764705

07-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.518317991	-0.695057209	-0.274861323	-0.34194072
High	-0.087912923	-0.388372506	0.160916909	-0.00196953
Low	-0.297579301	-0.559369155	-0.038988592	-0.176689229
Close	-0.160039178	-0.331403116	0.089380638	0.128735938
Adj.Close	-0.160040452	-0.331401355	0.089377442	0.12873607
Volume	0.156119109	-0.45845333	0.482839362	-0.119319415

14-09-2015 to 18-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.212817566	0.908048655	0.543069861	0.802042164
High	-0.002766435	0.821993495	0.697045955	0.662825105
Low	0.101375229	0.715930035	0.64579004	0.723083238
Close	-0.074471308	0.665272196	0.633161096	0.59102994
Adj.Close	-0.074471039	0.665274312	0.633161326	0.591030538
Volume	0.353092807	-0.506010792	-0.872386006	-0.321443807

21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.759901396	-0.389728291	0.40668906	-0.800208362
High	-0.748606702	-0.626412253	0.350571668	-0.934076149
Low	-0.975516153	-0.528180584	-0.043795601	-0.812314723
Close	-0.795996836	-0.750768345	0.028467618	-0.915304776
Adj.Close	-0.795996982	-0.750768508	0.028467752	-0.915305003
Volume	-0.194106129	-0.669053776	0.306405415	-0.674176339

28-09-2015 to 02-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.561551945	0.076428965	-0.69895356	-0.901176678
High	-0.685004778	0.162932261	-0.71779743	-0.805004357
Low	-0.431616915	-0.055580396	-0.781680145	-0.664431521
Close	-0.354939872	-0.145628505	-0.817463893	-0.714096736
Adj.Close	-0.354939611	-0.145628464	-0.817463747	-0.71409646
Volume	-0.889722079	-0.006398002	-0.604572736	-0.860999424

05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.823945255	0.848659106	-0.686503398	-0.711989536
High	-0.973302379	0.874548116	-0.812109801	-0.889492372
Low	-0.893364196	0.833792597	-0.703261556	-0.776680761
Close	-0.831781969	0.691343576	-0.553499361	-0.669339756
Adj.Close	-0.831781489	0.691343196	-0.553498753	-0.669339168
Volume	-0.106694038	-0.077779685	-0.211702027	-0.199457164

12-10-2015 to 16-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.698252149	-0.560651342	-0.89295174	-0.683678147
High	-0.628433716	-0.936641639	-0.398681421	-0.250373257
Low	-0.71526274	-0.918412084	-0.453517696	-0.399575288
Close	-0.661634288	-0.928955619	-0.448937221	-0.329701311
Adj.Close	-0.661634373	-0.92895626	-0.448936322	-0.329700736
Volume	0.062930408	-0.416019846	0.432543833	0.456867128

19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.251788048	0.492012739	0.034695506	-0.161984949
High	-0.126517373	0.711716842	0.311684537	0.108883902
Low	-0.230656206	0.654519767	0.235405114	-0.0239414
Close	-0.001209847	0.782660753	0.430586942	0.22384059
Adj.Close	-0.001209926	0.782660808	0.430587023	0.223840566
Volume	0.226428672	0.149817711	0.005696312	0.224343465

26-10-2015 to 30-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.616725799	-0.275270715	-0.143984597	-0.074911442
High	0.66190971	-0.733352499	-0.399173723	0.066648014
Low	0.420990644	-0.338986763	-0.186219554	-0.344640339
Close	0.453004545	-0.778261401	-0.418935379	-0.14907031
Adj.Close	0.453005276	-0.778261313	-0.418935291	-0.149069513
Volume	0.251675647	-0.286031693	-0.137813641	0.391815064

02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.866422656	-0.222266756	-0.610224794	-0.748937025
High	-0.890102481	-0.3067676	-0.681347105	-0.805976787
Low	-0.817011963	-0.42495973	-0.693252118	-0.828059631
Close	-0.818982492	-0.370090257	-0.649851883	-0.800780364
Adj.Close	-0.818982424	-0.370090072	-0.64985189	-0.800780246
Volume	0.27952973	0.497204666	0.249482296	0.503300194

09-11-2015 to 13-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.096198815	0.212644952	0.257190964	0.221899491
High	0.648560556	0.414445174	0.224364952	-0.470241162
Low	0.177881682	0.767442724	0.512091113	-0.574285937
Close	0.526640327	0.694377343	0.40163917	-0.813764063
Adj.Close	0.526644191	0.694385315	0.401647819	-0.813764996
Volume	0.872961029	0.33548229	0.493196418	0.201056382

16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.074639415	0.297930989	0.404688595	-0.857674461
High	0.041988382	0.47520355	0.488474984	-0.780704126
Low	-0.000327415	0.372785641	0.469748548	-0.827549926
Close	0.026085473	0.49239104	0.466628957	-0.767438553
Adj.Close	0.026085684	0.492391423	0.46662901	-0.767438433
Volume	0.044677402	0.577068056	0.480127756	-0.604808166

V Audi News Sentiment vs Stock values Weekly Correlation

31-08-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.374504463	-0.630422971	0.733752929	0.63733146	Open	0.692389847	0.239132811	0.430339889	0.301892525
High	-0.423598286	-0.388109577	0.423362455	0.206649188	High	0.937939027	0.610899276	0.757562319	0.658459829
Low	-0.322308454	-0.244704046	0.403359268	0.209715004	Low	0.848258619	0.451436162	0.62651691	0.510404609
Close	-0.401818147	-0.155486526	0.288418707	-0.003561021	Close	0.887397592	0.511295326	0.660702038	0.553273625
Adj.Close	-0.401817158	-0.155486704	0.288417681	-0.003561001	Adj.Close	0.88739765	0.511295013	0.660700955	0.553272419
Volume	-0.241314875	0.600775407	-0.242665452	-0.715351326	Volume	0.883634517	0.71007048	0.870504289	0.809221901

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.074608423	0.362216309	0.610587547	0.38287784	Open	0.320656879	-0.775734972	-0.757728149	0.034859128
High	0.282350624	0.573290547	0.788414805	0.602193884	High	0.272977679	-0.936727672	-0.912685937	-0.205415584
Low	0.308484539	0.640555389	0.784896126	0.626399052	Low	-0.070395938	-0.641087928	-0.473937163	0.163830545
Close	0.283655562	0.701970264	0.878899266	0.703053936	Close	0.025464541	-0.80571349	-0.655058434	-0.131790065
Adj.Close	0.283654506	0.701968609	0.878898582	0.70305271	Adj.Close	0.025464605	-0.805713801	-0.655058819	-0.131790297
Volume	-0.653951887	-0.874127994	-0.963567648	-0.902959362	Volume	0.231370565	-0.842584442	-0.935923998	-0.70461587

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.580798383	-0.331570825	-0.608141944	-0.32367767	Open	-0.960502274	-0.544192491	-0.379334543	-0.178657663
High	-0.627485252	-0.526404309	-0.639556304	-0.450384048	High	-0.925239276	-0.703210521	-0.625959953	-0.365806357
Low	-0.44982337	-0.521122094	-0.558702476	-0.338367749	Low	-0.961780394	-0.682926234	-0.556054119	-0.368411229
Close	-0.429023297	-0.463407803	-0.564644685	-0.291578181	Close	-0.888298138	-0.810295688	-0.684056338	-0.495252873
Adj.Close	-0.429022971	-0.463407614	-0.564644399	-0.291577891	Adj.Close	-0.888298083	-0.810295574	-0.684056088	-0.495253045
Volume	-0.984018061	-0.720666438	-0.895747006	-0.883010551	Volume	0.40786686	-0.02657819	-0.208286174	0.260321045

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.395696891	-0.599121753	-0.785653684	-0.52559986	Open	0.239071858	-0.203878037	-0.059769429	-0.458179126
High	-0.054256383	-0.611372628	-0.294787531	0.131064575	High	-0.013567373	0.035311116	-0.178128931	-0.684684972
Low	0.435762456	0.063380849	0.179393868	-0.010683648	Low	0.005952268	-0.131273203	-0.156556323	-0.631917454
Close	0.341370006	-0.013965081	0.166814575	-0.031468312	Close	-0.187969866	0.100451273	-0.137943341	-0.786861766
Adj.Close	0.341370002	-0.013966291	0.166814254	-0.031466713	Adj.Close	-0.187970045	0.100451161	-0.137943387	-0.786861838
Volume	-0.133064415	-0.660537668	-0.044058192	0.707878102	Volume	0.351102308	0.430794022	0.002851682	-0.097542345

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.420935086	0.780424763	0.719015427	0.073582556	Open	-0.730862741	-0.36351763	-0.59334195	-0.561191978
High	-0.533221342	0.121219531	-0.152383121	-0.779684952	High	-0.707675471	-0.340840064	-0.598049716	-0.54186834
Low	0.252303323	0.522852219	0.493765991	-0.046830003	Low	-0.548831318	-0.141497922	-0.462899323	-0.40634156
Close	-0.753369247	-0.199819491	-0.445867172	-0.926558993	Close	-0.57782511	-0.172676667	-0.460041294	-0.414989162
Adj.Close	-0.753368756	-0.199818639	-0.445866445	-0.926558713	Adj.Close	-0.577825239	-0.17267677	-0.460041609	-0.41498955
Volume	-0.567393565	-0.251930956	-0.44660383	-0.542493391	Volume	-0.148999156	-0.51396736	-0.359800774	-0.375357615

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.480658357	-0.321409927	-0.675607332	-0.194134698	Open	0.520001316	0.103066187	-0.118233546	0.418874595
High	-0.804474835	-0.622094445	-0.500643726	-0.928061098	High	0.48991269	-0.010426214	-0.145408345	0.377123662
Low	0.224494455	-0.201280933	-0.393394544	-0.393042726	Low	0.474790975	0.024057052	-0.170351513	0.366628188
Close	-0.61755173	-0.364420911	-0.155380606	-0.713184536	Close	0.517508912	0.006496171	-0.111502815	0.405113141
Adj.Close	-0.617543938	-0.364424906	-0.155385408	-0.713185238	Adj.Close	0.517509018	0.006496132	-0.111502599	0.405113249
Volume	-0.241093472	-0.974136856	-0.915245556	-0.764635813	Volume	0.437485114	-0.124111977	-0.199697842	0.311689733

W Audi Message Board Sentiment vs Stock values Weekly Correlation

01-09-2015 to 04-09-2015					07-09-2015 to 11-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	-0.603381435	-0.567607391	0.145050478	-0.609797717	Open	0.652356759	0.974208054	-0.428826361	0.668608181
High	-0.016777189	-0.801799477	-0.879123608	-0.058721227	High	0.554355576	0.78033228	-0.575890012	0.607085791
Low	0.417956542	-0.423667512	-0.904961387	0.382990741	Low	0.63207473	0.897249064	-0.531094672	0.6686662
Close	0.351674521	-0.525564644	-0.990398461	0.311895906	Close	0.435651738	0.789908624	-0.593104118	0.507466333
Adj.Close	0.351675425	-0.525563758	-0.99039874	0.311896818	Adj.Close	0.435649131	0.789910078	-0.593099662	0.507463251
Volume	-0.059448521	-0.826556565	-0.860873854	-0.101356412	Volume	0.756249873	0.526910463	-0.757194358	0.811664888

14-09-2015 to 18-09-2015					21-09-2015 to 25-09-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.26595015	0.059206161	-0.862900557	0.202136063	Open	-0.890290909	-0.712860532	0.682894114	-0.807656295
High	0.474967049	0.26726402	-0.935315365	0.390216804	High	-0.771092909	-0.492152655	0.503897407	-0.615133627
Low	0.5723702	0.275638216	-0.843066155	0.526509598	Low	-0.843406829	-0.531693742	0.663834778	-0.786158035
Close	0.594136207	0.259830959	-0.901921442	0.509774798	Close	-0.607059067	-0.082051095	0.396447181	-0.41893285
Adj.Close	0.594134281	0.259830074	-0.901922424	0.509772588	Adj.Close	-0.60705925	-0.08205145	0.396447227	-0.41893303
Volume	-0.807475806	-0.636688753	0.875708646	-0.715390585	Volume	-0.149177572	-0.018177062	-0.137091528	0.056487422

28-09-2015 to 02-10-2015					05-10-2015 to 09-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.049468905	0.181596044	0.613601472	-0.498668549	Open	-0.516513759	-0.777261724	0.032715427	-0.53090231
High	0.050981426	0.13966614	0.369583162	-0.310467777	High	-0.221502917	-0.539822903	0.190916879	-0.329986782
Low	-0.207016289	-0.09390135	0.524875992	-0.502398434	Low	-0.426339757	-0.628241058	0.214970128	-0.520425202
Close	-0.237550635	-0.095730328	0.674727063	-0.623433901	Close	-0.410539788	-0.547135645	0.396629209	-0.581319504
Adj.Close	-0.237550993	-0.09573071	0.674727081	-0.623434059	Adj.Close	-0.410540497	-0.547135675	0.396629485	-0.581320216
Volume	0.824137262	0.888426684	-0.024431982	0.334913851	Volume	0.981080221	0.285237179	-0.22563851	0.939752088

12-10-2015 to 16-10-2015					19-10-2015 to 23-10-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.621143492	-0.137909142	-0.64736455	0.806334906	Open	0.01255866	-0.544747343	0.733301709	-0.145223607
High	0.400203173	0.343537267	-0.07487141	0.722403966	High	0.086242379	-0.348851542	0.52690507	-0.10683024
Low	0.184825613	0.429877042	0.26212734	0.294380589	Low	0.042668419	-0.334566873	0.539061327	-0.032485069
Close	0.28092348	0.512258311	0.289128701	0.382423761	Close	0.213812479	-0.2604741	0.39129077	0.040381264
Adj.Close	0.280922993	0.51225831	0.289128589	0.382424115	Adj.Close	0.213812465	-0.260473902	0.391290603	0.040381447
Volume	0.011598251	0.328395661	0.156976945	0.356577224	Volume	0.080384087	-0.516052624	0.479653845	-0.508898076

26-10-2015 to 30-10-2015					02-11-2015 to 06-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.048707348	0.217006347	0.268745343	-0.215728085	Open	-0.117172359	0.260874927	0.759892905	0.110867108
High	-0.484931122	-0.049632205	-0.286764046	-0.710250287	High	-0.1261046	0.227309111	0.790440786	0.105602309
Low	0.122219009	0.37456648	-0.015950458	-0.088050187	Low	-0.317015864	0.027355385	0.870520484	-0.019249806
Close	-0.429365685	0.080645101	-0.580267003	-0.588074576	Close	-0.301497243	0.059510946	0.838398054	0.018463556
Adj.Close	-0.429365918	0.080644693	-0.580266167	-0.588075028	Adj.Close	-0.3014971	0.059511148	0.83839824	0.018463168
Volume	-0.467989435	-0.338560533	-0.142213015	-0.499533043	Volume	0.855066731	0.627778431	-0.563272722	0.082035673

09-11-2015 to 13-11-2015					16-11-2015 to 20-11-2015				
Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP	Stock/Sentiment	SentimentGI	SentimentHE	SentimentLM	SentimentQDAP
Open	0.865106893	0.671814849	-0.909950785	0.817274873	Open	-0.667873347	-0.280196039	0.767055947	-0.815404526
High	0.153337114	-0.145640221	-0.098150164	-0.341996264	High	-0.788306507	-0.398706127	0.8088424	-0.861764637
Low	0.914448715	0.455512109	-0.63227154	0.768298393	Low	-0.72816621	-0.358561776	0.808978668	-0.856054067
Close	0.150216081	-0.151929311	0.075974775	-0.18778376	Close	-0.792961432	-0.383789785	0.789056765	-0.848788438
Adj.Close	0.150224584	-0.151919517	0.07596603	-0.18777285	Adj.Close	-0.792961572	-0.383789867	0.789056716	-0.848788328
Volume	0.346559833	0.504448993	-0.65117875	0.113585112	Volume	-0.875682729	-0.471044213	0.776491099	-0.90465341

X Granger Test Result Audi Twitter Sentiments against Volkswagen Stock Result

Test	Null Hypothesis Statement(,ie Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
18	Low / SentimentGI	0.01511732	Ho Rejected	0.033498	Ho Rejected	0.071732464	Ho Accepted	0.04322271	Ho Rejected	0.049263	Ho Rejected	0.065838736	Ho Accepted
22	Low / SentimentLM	0.00245229	Ho Rejected	0.028202	Ho Rejected	0.018084946	Ho Rejected	0.027911418	Ho Rejected	0.074761	Ho Accepted	0.123215209	Ho Accepted
24	Low / SentimentQDAP	0.0005855976	Ho Rejected	0.036949	Ho Rejected	0.051966586	Ho Accepted	0.057464383	Ho Accepted	0.043347	Ho Rejected	0.0724771	Ho Accepted
30	Close / SentimentLM	0.016972317	Ho Rejected	0.052268	Ho Accepted	0.051701603	Ho Accepted	0.03806591	Ho Rejected	0.028129	Ho Rejected	0.034083276	Ho Rejected
32	Close / SentimentQDAP	0.016633921	Ho Rejected	0.089314	Ho Accepted	0.158394009	Ho Accepted	0.018202871	Ho Rejected	0.041584	Ho Rejected	0.060834971	Ho Accepted
38	Adj.Close / SentimentLM	0.016223864	Ho Rejected	0.051824	Ho Accepted	0.05682945	Ho Accepted	0.040670116	Ho Rejected	0.027323	Ho Rejected	0.03242482	Ho Rejected
40	Adj.Close / SentimentQDAP	0.015332964	Ho Rejected	0.081248	Ho Accepted	0.155916976	Ho Accepted	0.014816076	Ho Rejected	0.035513	Ho Rejected	0.052449877	Ho Accepted

Granger Test Result with Rejection in the Audi Twitter Sentiments against VW Stock (9 Months)

Test	Null Hypothesis Statement(,ie Ho)	Order1_P	Order1_conclu	Order2_P	Order2_conclu	Order3_P	Order3_conclu	Order4_P	Order4_conclu	Order5_P	Order5_conclu	Order6_P	Order6_conclu
2	Open / SentimentGI	0.133455247	Ho Accepted	0.208164891	Ho Accepted	0.047242561	Ho Rejected	0.017400658	Ho Rejected	0.020508848	Ho Rejected	0.055077634	Ho Accepted
25	SentimentGI / Close	0.175866596	Ho Accepted	0.047810487	Ho Rejected	0.118203606	Ho Accepted	0.172490069	Ho Accepted	0.293411784	Ho Accepted	0.462868679	Ho Accepted
33	SentimentGI / Adj.Close	0.175866596	Ho Accepted	0.0478103	Ho Rejected	0.118203171	Ho Accepted	0.172489597	Ho Accepted	0.293411189	Ho Accepted	0.462867978	Ho Accepted
42	Volume / SentimentGI	0.591632381	Ho Accepted	0.176127376	Ho Accepted	0.04626443	Ho Rejected	0.058137833	Ho Accepted	0.043611597	Ho Rejected	0.103675663	Ho Accepted
46	Volume / SentimentLM	0.004691651	Ho Rejected	0.005679931	Ho Rejected	0.019523213	Ho Rejected	0.044878342	Ho Rejected	0.080001422	Ho Accepted	0.059225842	Ho Accepted
48	Volume / SentimentQDAP	0.040705668	Ho Rejected	0.073607671	Ho Accepted	0.052536574	Ho Accepted	0.0788841769	Ho Accepted	0.072074017	Ho Accepted	0.1144443	Ho Accepted

Granger Test Result with Rejection in the Audi Twitter Sentiments against VW Stock (3 Months)

Y Granger Test Result Audi News Sentiments against Volkswagen Stock Result

Test	Null Hypothesis Statement(Le Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
3	SentimentHE / Open Open does not granger cause. SentimentHE	0.002398105	Ho Rejected	0.008522283	Ho Rejected	0.020538	Ho Rejected	0.035954764	Ho Rejected	0.086974697	Ho Accepted	0.126055005	Ho Accepted
4	Open / SentimentHE SentimentHE does not granger cause. Open	0.03627825	Ho Rejected	0.204614086	Ho Accepted	0.339069	Ho Accepted	0.20844357	Ho Accepted	0.320182317	Ho Accepted	0.287859267	Ho Accepted
6	Open / SentimentLM SentimentLM does not granger cause. Open	0.09636965	Ho Accepted	0.01778657	Ho Rejected	0.004372	Ho Rejected	0.006355977	Ho Rejected	0.011628602	Ho Rejected	0.004894934	Ho Rejected
11	SentimentHE / High High does not granger cause. SentimentHE	0.000523608	Ho Rejected	0.002824287	Ho Rejected	0.0036324	Ho Rejected	0.01333588	Ho Rejected	0.005739596	Ho Rejected	0.095150518	Ho Accepted
14	High / SentimentLM SentimentLM does not granger cause. High	0.013376882	Ho Rejected	0.002465649	Ho Rejected	0.004443	Ho Rejected	0.009748434	Ho Rejected	0.005397512	Ho Rejected	0.009859627	Ho Rejected
20	Low / SentimentHE SentimentHE does not granger cause. Low	0.000486954	Ho Rejected	0.133381219	Ho Accepted	0.151807	Ho Accepted	0.217079405	Ho Accepted	0.436615821	Ho Accepted	0.505393101	Ho Accepted
21	SentimentLM / Low Low does not granger cause. SentimentLM	0.078569732	Ho Accepted	0.025009233	Ho Rejected	0.060404	Ho Accepted	0.127748713	Ho Accepted	0.205458243	Ho Accepted	0.249486656	Ho Accepted
22	Low / SentimentLM SentimentLM does not granger cause. Low	0.786627484	Ho Accepted	0.003049094	Ho Rejected	0.000547	Ho Rejected	0.001560079	Ho Rejected	0.002424346	Ho Rejected	0.004360913	Ho Rejected
27	SentimentHE / Close Close does not granger cause. SentimentHE	0.410567149	Ho Accepted	0.034653399	Ho Rejected	0.03889	Ho Rejected	0.043340125	Ho Rejected	0.048948409	Ho Rejected	0.105117928	Ho Accepted
28	Close / SentimentHE SentimentHE does not granger cause. Close	8.94E-05	Ho Rejected	0.028018318	Ho Rejected	0.024441	Ho Rejected	0.057793845	Ho Accepted	0.134490847	Ho Accepted	0.206767228	Ho Accepted
29	SentimentLM / Close Close does not granger cause. SentimentLM	0.086918802	Ho Accepted	0.015690523	Ho Rejected	0.048334	Ho Rejected	0.122027848	Ho Accepted	0.180721111	Ho Accepted	0.232580069	Ho Accepted
30	Close / SentimentLM SentimentLM does not granger cause. Close	0.996663496	Ho Accepted	0.011251735	Ho Rejected	0.003334	Ho Rejected	0.003297201	Ho Rejected	0.006358303	Ho Rejected	0.010542609	Ho Rejected
35	SentimentHE / Adj.Close Adj.Close does not granger cause. SentimentHE	0.459259965	Ho Accepted	0.034731631	Ho Rejected	0.037308	Ho Rejected	0.041960414	Ho Rejected	0.04740195	Ho Rejected	0.095254776	Ho Accepted
36	Adj.Close / SentimentHE SentimentHE does not granger cause. Adj.Close	0.00010477	Ho Rejected	0.029579629	Ho Rejected	0.028186	Ho Rejected	0.066845306	Ho Rejected	0.152614726	Ho Rejected	0.218495965	Ho Accepted
37	SentimentLM / Adj.Close Adj.Close does not granger cause. SentimentLM	0.095095527	Ho Accepted	0.019447222	Ho Rejected	0.059574	Ho Accepted	0.145258325	Ho Accepted	0.208088021	Ho Accepted	0.260404548	Ho Accepted
38	Adj.Close / SentimentLM SentimentLM does not granger cause. Adj.Close	0.973482099	Ho Accepted	0.013019382	Ho Rejected	0.004024	Ho Rejected	0.004073568	Ho Rejected	0.007645689	Ho Rejected	0.014126462	Ho Rejected
43	SentimentHE / Volume Volume does not granger cause. SentimentHE	0.003729687	Ho Rejected	0.007819565	Ho Rejected	0.011965	Ho Rejected	0.001857826	Ho Rejected	0.000139837	Ho Rejected	0.000612377	Ho Rejected
44	Volume / SentimentHE SentimentHE does not granger cause. Volume	0.223984052	Ho Accepted	0.328370464	Ho Accepted	0.000693	Ho Rejected	0.003640811	Ho Rejected	0.008311784	Ho Rejected	0.002560312	Ho Rejected
46	Volume / SentimentLM SentimentLM does not granger cause. Volume	0.401497317	Ho Accepted	0.008171712	Ho Rejected	0.003288	Ho Rejected	0.007332065	Ho Rejected	0.014670456	Ho Rejected	0.008541753	Ho Rejected
47	SentimentQDAP / Volume Volume does not granger cause. SentimentQDAP	0.048837125	Ho Rejected	0.092396488	Ho Accepted	0.077915	Ho Accepted	0.088214332	Ho Accepted	0.088796628	Ho Accepted	0.137440126	Ho Accepted

Granger Test Result with Rejection in the Audi News Sentiments against VW Stock (9 Months)

Test	Null Hypothesis Statement(Le Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
3	SentimentHE / Open Open does not granger cause. SentimentHE	0.003770398	Ho Rejected	0.000659588	Ho Rejected	0.003659831	Ho Rejected	0.004527642	Ho Rejected	0.008209407	Ho Rejected	0.018905878	Ho Rejected
4	Open / SentimentHE SentimentHE does not granger cause. Open	0.021620358	Ho Rejected	0.138843397	Ho Accepted	0.082830998	Ho Accepted	0.102367095	Ho Accepted	0.100716377	Ho Accepted	0.056242765	Ho Accepted
7	SentimentQDAP / Open Open does not granger cause. SentimentQDAP	0.074420807	Ho Accepted	0.031203943	Ho Rejected	0.059688997	Ho Accepted	0.1055014	Ho Accepted	0.10820462	Ho Accepted	0.172479337	Ho Accepted
11	SentimentHE / High High does not granger cause. SentimentHE	0.000701838	Ho Rejected	0.001153545	Ho Rejected	0.006049671	Ho Rejected	0.010347415	Ho Rejected	0.021864326	Ho Rejected	0.056289061	Ho Accepted
15	SentimentQDAP / High High does not granger cause. SentimentQDAP	0.095508306	Ho Rejected	0.077082326	Ho Accepted	0.136276497	Ho Accepted	0.2185265	Ho Accepted	0.277889512	Ho Accepted	0.368535348	Ho Accepted
19	SentimentHE / Low Low does not granger cause. SentimentHE	0.001359952	Ho Rejected	0.00278807	Ho Rejected	0.004280406	Ho Rejected	0.006279991	Ho Rejected	0.008656578	Ho Rejected	0.025500104	Ho Rejected
27	SentimentLM / Close Close does not granger cause. SentimentLM	0.008911449	Ho Rejected	0.002146154	Ho Rejected	0.02082782	Ho Rejected	0.001797157	Ho Rejected	0.002613335	Ho Rejected	0.009204054	Ho Rejected
29	SentimentLM / Close Close does not granger cause. SentimentLM	0.048990223	Ho Rejected	0.053096576	Ho Accepted	0.059187101	Ho Accepted	0.087165414	Ho Accepted	0.138565735	Ho Accepted	0.199698312	Ho Accepted
35	SentimentHE / Adj.Close Adj.Close does not granger cause. SentimentHE	0.00089115	Ho Rejected	0.002146153	Ho Rejected	0.002082782	Ho Rejected	0.001797159	Ho Rejected	0.002613338	Ho Accepted	0.009204064	Ho Rejected
44	SentimentHE / Volume Volume does not granger cause. SentimentHE	0.026614767	Ho Rejected	0.002121388	Ho Rejected	0.009035672	Ho Rejected	0.014235598	Ho Rejected	0.026137414	Ho Rejected	0.051398559	Ho Accepted
46	Volume / SentimentLM SentimentLM does not granger cause. Volume	0.067466873	Ho Accepted	0.133330204	Ho Accepted	0.076074046	Ho Accepted	0.046200125	Ho Rejected	0.048769637	Ho Rejected	0.022116506	Ho Accepted
47	SentimentQDAP / Volume Volume does not granger cause. SentimentQDAP	0.004312085	Ho Rejected	0.024287824	Ho Rejected	0.045146237	Ho Rejected	0.091739042	Ho Accepted	0.172918854	Ho Accepted	0.245768119	Ho Accepted

Granger Test Result with Rejection in the Audi News Sentiments against VW Stock (3 Months)

Z Granger Test Result Audi Message Board Sentiments against Volkswagen Stock Result

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
3	SentimentHE / Open	0.56161875	Ho Accepted	0.0396332	Ho Rejected	0.037131068	Ho Rejected	0.04427844	Ho Rejected	0.03189357	Ho Rejected	0.072957354	Ho Accepted
21	SentimentLM / Low	0.821474602	Ho Accepted	0.0308932	Ho Rejected	0.017701871	Ho Rejected	0.0386217	Ho Rejected	0.09739974	Ho Accepted	0.110524404	Ho Accepted
29	SentimentLM / Close	0.86548718	Ho Accepted	0.1319111	Ho Accepted	0.261604377	Ho Accepted	0.053685488	Ho Accepted	0.06740681	Ho Accepted	0.034494764	Ho Rejected
37	SentimentLM / Adj.Close	0.877673742	Ho Accepted	0.1388589	Ho Accepted	0.277393027	Ho Accepted	0.06167395	Ho Accepted	0.07659056	Ho Accepted	0.042405063	Ho Rejected
45	SentimentLM / Volume	0.061344462	Ho Accepted	0.0055856	Ho Rejected	0.013525731	Ho Rejected	0.053647271	Ho Accepted	0.01082468	Ho Rejected	0.025199731	Ho Rejected
46	Volume / SentimentLM	0.033917979	Ho Rejected	0.0998269	Ho Accepted	0.330432865	Ho Accepted	0.415821761	Ho Accepted	0.46830425	Ho Accepted	0.741739214	Ho Accepted

Granger Test Result with Rejection in the Audi Message Board Sentiments against VW Stock (9 Months)

Test	Null Hypothesis Statement(i.e Ho)	Order1_P	Order1_concl	Order2_P	Order2_concl	Order3_P	Order3_concl	Order4_P	Order4_concl	Order5_P	Order5_concl	Order6_P	Order6_concl
2	Open / SentimentGI	0.51514388	Ho Accepted	0.101648211	Ho Accepted	0.00151586	Ho Rejected	0.004186792	Ho Rejected	0.010578391	Ho Rejected	0.010622335	Ho Rejected
4	Open / SentimentHE	0.405450457	Ho Accepted	0.356026306	Ho Accepted	0.039140323	Ho Rejected	0.079049419	Ho Accepted	0.089527403	Ho Accepted	0.144960546	Ho Accepted
8	Open / SentimentQDAP	0.579244581	Ho Accepted	0.240908831	Ho Accepted	0.017331834	Ho Rejected	0.020160102	Ho Rejected	0.040084506	Ho Rejected	0.056517647	Ho Accepted
10	High / SentimentGI	0.451269923	Ho Accepted	0.040465066	Ho Rejected	0.020179865	Ho Rejected	0.05656399	Ho Accepted	0.090061643	Ho Accepted	0.103671349	Ho Accepted
26	Close / SentimentGI	0.031242697	Ho Rejected	0.035019849	Ho Rejected	0.074763919	Ho Accepted	0.07615002	Ho Accepted	0.081993567	Ho Accepted	0.150705912	Ho Accepted
32	Close / SentimentQDAP	0.033356299	Ho Rejected	0.108481167	Ho Accepted	0.26351815	Ho Accepted	0.287908878	Ho Accepted	0.32135996	Ho Accepted	0.47086246	Ho Accepted
34	Adj.Close / SentimentGI	0.031242697	Ho Rejected	0.035019501	Ho Rejected	0.074763605	Ho Accepted	0.076149691	Ho Accepted	0.081993343	Ho Accepted	0.150705994	Ho Accepted
40	Adj.Close / SentimentQDAP	0.033356195	Ho Rejected	0.108480434	Ho Accepted	0.263517151	Ho Accepted	0.287907802	Ho Accepted	0.321358922	Ho Accepted	0.470861605	Ho Accepted
41	SentimentGI / Volume	0.042384657	Ho Rejected	0.101322565	Ho Accepted	0.220229896	Ho Accepted	0.286261694	Ho Accepted	0.113127621	Ho Accepted	0.285013924	Ho Accepted
46	Volume / SentimentLM	0.010007664	Ho Rejected	0.134518361	Ho Accepted	0.274539275	Ho Accepted	0.478813511	Ho Accepted	0.507843001	Ho Accepted	0.63876301	Ho Accepted

Granger Test Result with Rejection in the Audi News Sentiments against VW Stock (3 Months)

Licence

Non-exclusive licence to reproduce thesis and make thesis public

I, **Odeyinka Olubunmi T**,

1. herewith grant the University of Tartu a free permit (non-exclusive licence) to reproduce, for the purpose of preservation, including for adding to the DSpace digital archives until the expiry of the term of copyright,

Title of your thesis ...,

supervised by Rajesh Sharma and Darya Lapitskaya.

2. I grant the University of Tartu a permit to make the work specified in p. 1 available to the public via the web environment of the University of Tartu, including via the DSpace digital archives, under the Creative Commons licence CC BY NC ND 3.0, which allows, by giving appropriate credit to the author, to reproduce, distribute the work and communicate it to the public, and prohibits the creation of derivative works and any commercial use of the work until the expiry of the term of copyright.
3. I am aware of the fact that the author retains the rights specified in p. 1 and 2.
4. I certify that granting the non-exclusive licence does not infringe other persons' intellectual property rights or rights arising from the personal data protection legislation.

Odeyinka Olubunmi T

12/11/2020